Customer Energy Efficiency Program
Measurement and Evaluation Program

IMPACT EVALUATION OF PACIFIC GAS & ELECTRIC COMPANY'S 1996 AGRICULTURAL PROGRAMS ENERGY EFFICIENCY INCENTIVES PROGRAM: PUMPING AND RELATED END USE INDOOR LIGHTING END USE & ENERGY MANAGEMENT SERVICES PROGRAM

PG&E Study ID numbers:
354: Pumping and Related End Use
385: Indoor Lighting End Use
360: Energy Management Services

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Impact Evaluation of PG&E's 1996 Agricultural Energy Efficiency Incentives and Energy Management Services Programs:
Pumping and Related End Use (Study ID No. 354)
Indoor Lighting End Use (Study ID No. 385)
Energy Management Services Program (Study ID No. 360)

Purpose of Study

These studies evaluated the gross and net energy and demand savings of PG&E's 1996 agricultural programs. The three studies used a combination of engineering and statistical analyses, telephone surveys and on-site visits for both participants and nonparticipants to verify key parameters regarding the estimated savings for PG&E's agricultural sector. The studies examined electric and gas usage and purchase decisions by program participants and nonparticipants. Four Agricultural Energy Efficiency Incentive (AEEI) programs, (Retrofit Express, Retrofit Efficiency Options, Customized Incentives, and Advanced Performance Options) promoted the sale of various energy efficient technologies through financial incentives paid to agricultural participants. The Agricultural Energy Management Services (AEMS) program offered pump tests and on-site audit services.

Methodology

These studies were conducted in compliance with the requirements specified in "Protocols and Procedures for the Verification of Costs, Benefits, and Shareholders Earnings from Demand-Side Management Programs", as adopted by California Public Utilities Commission Decision 93-05-063, revised January, 1997, pursuant to Decisions 94-05-063, 94-10-059, 94-12-021, 95-12-054, and 96-12-079. The study also complied with a retroactive waiver approved by the California DSM Measurement and Advisory Committee (CADMAC).

The evaluation of the 1996 AEEI agricultural programs combined data from pre- and post-installation water pump tests, PG&E's pump test database, and customer survey information. The gross energy and demand impact estimates for the agricultural programs are based on engineering models using on-site data, manufacturer and telephone survey data and review of ex ante algorithms and assumptions for both end uses.

To obtain net AEEI impact estimates, gross impact estimates were adjusted by free-ridership and spillover (for both end uses). The participant telephone surveys consisted of an attempted census of both end uses. There was also a telephone survey of nonparticipants.

The AEMS gross impact estimates were generated, as agreed in the waiver, by estimating pump repair rates through a telephone survey of participant and multiplying this rate by the AEEI pump repair measure gross per unit impact value. As approved in the waiver, a net-to-gross ratio of 0.75 was used for AEMS in return for conducting a Market Effects Study. This Market Effects study will be reported separately by April 30, 1998 as agreed in the waiver.

Study Results

The results of the analyses are summarized in the following three tables for the two AEEI targeted end uses and the AEMS program.

AEEI Targeted End Uses

Pumping and Related End Use	Gross Savings	Gross Realization Rate	Net-To-Gross			Net Savings	Net Realization Rate
			(1-FR)*	SO**	Combined		
EX ANTE							
kW	1,363	-	0.68	0.10	0.78	1,065	-
kWh	3,537,821	-	0.69	0.10	0.79	2,778,628	-
Therms	110,743	-	0.65	0.10	0.75	83,057	-
EX POST							
kW	852	0.63	0.39	0.15	0.54	461	0.43
kWh	4,897,300	1.38	0.39	0.29	0.68	3,323,010	1.20
Therms	110,743	1.00	0.39	0	0.39	43,190	0.52

*Actually calculated as NTG without spillover, FR=free ridership

**SO = spillover

Indoor Lighting End Use	Gross Savings	Gross Realization Rate	Net-To-Gross			Net Savings	Net Realization Rate
			(1-FR)*	SO**	Combined		
EX ANTE							
kW	609	-	0.67	0.10	0.77	469	-
kWh	3,640,704	-	0.67	0.10	0.77	2,803,342	-
Therms	-	-	-	-	-	-	-
EX POST							
kW	(32)	(0.05)	0.79	(0.04)	0.75	(24)	(0.05)
kWh	(38,928)	(0.01)	0.79	(0.34)	0.45	(17,591)	(0.01)
Therms	-	-	-	-	-	-	-

*Actually calculated as NTG without spillover, FR=free ridership

**SO = spillover

AEMS Program

Ag EMS	Gross Savings	Gross Realization Rate	Net-To-Gross			Net Savings	Net Realization Rate
			(1-FR)*	SO**	Combined		
EX ANTE							
kW	6,032	-	0.54	0	0.54	3,257	-
kWh	21,432,296	-	0.54	0	0.54	11,573,440	-
Therms	-	-	-	-	-	-	-
EX POST							
kW	0.0	0.0	0.75	0	0.75	0.0	0.0
kWh	7,172,261	0.33	0.75	0	0.75	5,379,196	0.46
Therms	-	-	-	-	-	-	-

*FR=Free ridership

**SO = spillover

Regulatory Waivers and Filing Variances

Retroactive waiver requests to modify some aspects of both evaluation approaches were filed and approved by CADMAC on July 22, 1997. Modifications to the EMS waiver were approved by CADMAC on November 21, 1997. These waivers are included in Section 5 of the appended report. There were no E-Table variances.

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EXECUTIVE SUMMARY

This report presents the results of the impact evaluation of Pacific Gas & Electric Company's (PG&E's) 1996 agricultural sector Customer Energy Efficiency (CEE) programs. The evaluation assessed savings achieved by PG&E's agricultural sector customers who (1) received rebates during 1996 under the Retrofit Express (RE), Retrofit Efficiency Options (REO), Customized Incentives (CI), Advanced Performance Options (APO) programs, or (2) received a pump test during 1996 under the Energy Management Services (EMS) program. Collectively, the agricultural sector participation in the RE, REO, CI, and APO programs are part of PG&E's Energy Efficiency Incentives (EEI) program. This executive summary is divided into three sections: evaluation impacts, major findings and major recommendations.

ES.1 Evaluation Impacts

The agricultural sector impact results are presented first by the two Agricultural Energy Efficiency Incentives (AEEI) end uses (pumping and related and indoor lighting), followed by the Agricultural Energy Management Services (AEMS) program.

ES.1.1 AEEI Pumping and Related End Use Impacts

Exhibit ES.1 summarizes the predicted (ex ante) and assessed (ex post) impacts from pumping and related measures.

Exhibit ES.1
PG&E's 1996 AEEI Programs
Summary of Evaluation Gross and Net Load Impacts
Pumping and Related End Use

Pumping and Related End Use	Gross Savings	Gross Realization Rate	Net-To-Gross (1-FR)*	Net-To-Gross SO**	Net-To-Gross Combined	Net Savings	Net Realization Rate
EX ANTE							
kW	1,363	-	0.68	0.10	0.78	1,065	-
kWh	3,537,821	-	0.69	0.10	0.79	2,778,628	-
Therms	110,743	-	0.65	0.10	0.75	83,057	-
EX POST							
kW	852	0.63	0.39	0.15	0.54	461	0.43
kWh	4,897,300	1.38	0.39	0.29	0.68	3,323,010	1.20
Therms	110,743	1.00	0.39	0	0.39	43,190	0.52

*Actually calculated as NTG without spillover, FR=free ridership
**SO = spillover

While the pumping and related end use includes other pumping-related measures, over two thirds of the participation and over half of the ex ante estimated energy savings result from the pump repair measure. Thus the end use results primarily reflect the trends in the pump repair measure.

The high ex post gross energy savings and the low ex post gross demand savings are both tied to the pump repair measure. The key impact-related points for the pumping and related end use are:

- The gross ex ante estimates of pump repair incorporated a realization rate of 0.7 based on a previous evaluation. This estimated reduction proved unwarranted as pump test results and higher average 1996 consumption resulted in gross ex post findings 38% higher than the ex ante estimate. This is the main reason that the net kWh realization rate exceeded 1.0.
- No demand impact was found for the pump repair measure, despite ex ante estimates that one existed. This significantly lowered the gross ex post kW for the end use.
- The pumping and related end use has high free-ridership (~60%) which was partially offset by spillover effects. The high free ridership is primarily due to the program being in place for many years.

ES.1.2 AEEI Indoor Lighting End Use Impacts

Exhibit ES.2 summarizes ex ante and ex post impacts from indoor lighting-related measures for agricultural sector customers.

Exhibit ES.2
PG&E's 1996 AEEI Programs
Summary of Evaluation Gross and Net Load Impacts
Indoor Lighting End Use

Indoor Lighting End Use	Gross Savings	Gross Realization Rate	Net-To-Gross (1-FR)*	Net-To-Gross SO**	Net-To-Gross Combined	Net Savings	Net Realization Rate
EX ANTE							
kW	609	-	0.67	0.10	0.77	469	-
kWh	3,640,704	-	0.67	0.10	0.77	2,803,342	-
Therms	-	-	-	-	-	-	-
EX POST							
kW	(32)	(0.05)	0.79	(0.04)	0.75	(24)	(0.05)
kWh	(38,928)	(0.01)	0.79	(0.34)	0.45	(17,591)	(0.01)
Therms	-	-	-	-	-	-	-

*Actually calculated as NTG without spillover, FR=free ridership

**SO = spillover

The indoor lighting end use impacts are controlled by the High-Intensity Discharge (HID) lighting measures. HIDs represented 80% of the ex ante impact and near 50% of the participation. The negative gross energy and demand savings, the low free-ridership, and the "negative" spillover are all connected to the HID applications. The key impact-related points for the indoor lighting end use are:

- High-wattage/high-output HID fixtures were installed in place of low-wattage lights, and in some cases were installed in previously unlit areas or new construction. These misapplications of the intended HID technology installations led to an overall negative gross impact for the indoor lighting end use.

- The growers would not have installed HIDs in the absence of the program.
- Spillover savings did exist among participants and was a positive value (i.e., spillover occurred in non-HID measures). However, the spillover savings merely lessened the negative impact.
- The indoor lighting end use has a negative gross and net effect on overall AEEI program impacts.

ES.1.3 AEMS Impacts

Exhibit ES.3 summarizes the ex ante and ex post impacts from the AEMS pumping test measure. The pump tests element of AEMS represents over 85% of the AEMS program and, as a result, is the only measure requiring evaluation under Protocol Table 6.

Exhibit ES.3
PG&E's 1996 AEMS Programs
Summary of Evaluation Gross and Net Load Impacts
Pump Test Measure

Ag EMS	Gross Savings	Gross Realization Rate	Net-To-Gross (1-FR)*	SO**	Combined	Net Savings	Net Realization Rate
EX ANTE							
kW	6,032	-	0.54	0	0.54	3,257	-
kWh	21,432,296	-	0.54	0	0.54	11,573,440	-
Therms	-	-	-	-	-	-	-
EX POST							
kW	0.0	0.0	0.75	0	0.75	0.0	0.0
kWh	7,172,261	0.33	0.75	0	0.75	5,379,196	0.46
Therms	-	-	-	-	-	-	-

*FR=Free ridership

**SO = spillover

The AEMS pump test measure analysis was conducted according to a CADMAC-approved retroactive waiver. This waiver allowed gross savings to be calculated based on survey estimates of installation rates combined with 1996 AEEI ex post estimates of savings per pump. The same waiver allowed a net-to-gross ratio of 0.75 if PG&E conducted a market effects study rather than a net-to-gross evaluation. The key impact-related points for the AEMS pump tests are:

- The number of pumps repaired by growers as a result of the AEMS pump test program is estimated by the evaluation to be 561, as compared to the ex ante estimate of 755.

- The savings per pump repaired were reduced from 28,374 kWh to 12,776 kWh. This was because the ex ante estimate used the 1990 - 1992 pump test data, while the ex post assessment used the 1995 and 1996 pump test data. The demand impact was set to zero per the ex post AEEI assessment.
- The net-to-gross ratio is higher for ex post (0.75) than ex ante (0.54) because the ex post value was agreed to through a retroactive waiver.

ES.2 Major Findings

The primary findings of the evaluation are:

- The AEEI pump repair measure once again demonstrated high free ridership rates, indicating that the this is a mature program with long term effects. The high free ridership was partially offset by participant and nonparticipant spillover effects.
- Growers are replacing lower-wattage lights with the high-output HID fixtures rebate under the AEEI program. This is having a dramatic negative effect on program savings.

ES.3 Major Recommendations

The following recommendations follow from the findings listed above:

- Retarget/redesign the pump repair measure or redirect the resources to other measures.
- Modify the application tracking and approval process to accept only AEEI HID applications that are replacing the correct baseline fixtures.

1 INTRODUCTION

This section summarizes results of the impact evaluation of Pacific Gas & Electric Company's (PG&E's) 1996 agricultural sector programs. The evaluation assessed the impacts for PG&E's agricultural customers who either received rebates during 1996 under the Nonresidential Energy Efficiency Incentive (EEI) program or received services, such as pump tests, under the Energy Management Services (EMS) program.

As illustrated in Exhibit 1.1, the Agricultural EEI (AEEI) participants who adopted pumping and related and indoor lighting measures comprised 88% of the total Agricultural sector avoided cost. Thus, these are the only two AEEI end uses evaluated under this project. The remaining agricultural customer EEI measures are accounted for as miscellaneous measures under Table C-9 of the "Protocols and Procedures for the Verification of Costs, Benefits, and Shareholder Earnings from Demand Side Management Programs" (the Protocols). The AEEI programs include agricultural sector incentives paid under the Retrofit Express (RE) program, the Retrofit Efficiency Options (REO) program, the 1994 Customized Incentives (CI) program, and the 1996 Advanced Performance Options (APO).

Exhibit 1.1
Summary of Avoided Cost by
Agricultural Sector EEI Measure

End Use	PG&E Code *	Measure Description	N Apps.	Avoided Cost	
				Dollars ($)	% of Total
Ag Pumping and Related	A1	Pump Retrofit	67	598,123	15.7%
	A4	Pump Adjustment	2	1,094	0.0%
	A41 / A42 / A43	Low Pressure Nozzles	3	33,607	0.9%
	A44 / A45 / A47 / A51 / A55	Sprinkler to Micro	11	750,569	19.7%
	AO	Customized Ag Measures	8	481,809	12.6%
	Ag Pumping and Related End Use Total		91	1,865,202	48.9%
Ag Indoor Lighting	L64 / L66 / L174 / L176	Compact Fluorescent Lamps	11	71,228	1.9%
	L6	Exit Signs	1	13,470	0.4%
	L23-L24 / L73-L75 / L160	T-8 Lamps and Electronic Ballasts	22	147,875	3.9%
	L19	Delamp Fluroescent Fixtures	1	4,110	0.1%
	L26 / L81	High Intensity Discharge	34	1,233,979	32.4%
	L31	Controls	1	13,470	0.4%
	Ag Indoor Lighting End Use Total		70	1,484,134	38.9%
AG PUMPING and RELATED Plus INDOOR LIGHTING			161	3,349,336	87.9%
Ag Miscellaneous End Uses**			45	462,407	12.1%
AEEI PROGRAM TOTAL			206	3,811,743	100.0%
AEMS PROGRAM TOTAL			4,721	-	-

Data Source: 1996 PG&E Frozen MDSS Database Received on May 16, 1997
*PG&E MDSS Measure Codes
**The miscellaneous end uses do not have to be evaluated per Decision 96-12-079.

For the Agricultural EMS (AEMS) participants, the evaluation assessed the number of implemented pumping measures resulting from participation in the AEMS pump test program, then multiplied these by the AEEI estimates of impact for pump repair. This approach has been approved as part of a California DSM Measurement and Advisory Committee (CADMAC) waiver. All AEMS measures other than pump tests fall into the miscellaneous measure category and are covered under Table C-9 of the Protocols. As a result, they were not analyzed as part of this evaluation.

1.1 Descriptions of Programs Covered by the Evaluation

Measures rebated under the following programs were evaluated as part of this project.

1.1.1 The Retrofit Express Program

The RE program offered fixed rebates to nonresidential customers to retrofit their facilities' gas or electric energy-efficiency equipment from a pre-specified list of measures. The program covered a wide range of energy saving measures in the lighting, air conditioning, motors, refrigeration, and food service end uses. Specific lighting measures included compact fluorescent lamps, incandescent to fluorescent retrofits, exit sign retrofits, efficient ballast replacements, T-8 lamps and electronic ballast replacements for T-12 lamps and standard-efficiency ballast, delamping of fluorescent fixtures, high-intensity discharge (HID) replacements for mercury vapor fixtures, and lighting controls. These lighting measures were offered under the RE program in 1994, 1995, and 1996.

Customers were required to submit proof of purchase with their applications in order to receive rebates. The program was marketed primarily to small- and medium-sized commercial, industrial, and agricultural customers. The maximum rebate amount, including all measure types, was $300,000 per account. No minimum amount was required to qualify for a rebate.

1.1.2 The Retrofit Efficiency Options Program

1996 agricultural sector participation in the REO program included three measures: pump repair, conversion from high-pressure sprinkler nozzles to low-pressure sprinkler nozzles, and sprinkler-nozzle to micro-irrigation conversion. PG&E representatives worked with customers to identify cost-effective improvements, with special emphasis on operation and maintenance measures for customers' facilities. Marketing efforts were coordinated among PG&E Divisions, emphasizing local planning areas with high marginal electric costs to maximize program benefits.

1.1.3 The Customized Incentives Program

The CI program offered incentives to nonresidential customers who installed large or complex projects that save gas or electricity. Prior to installation of the project, these customers were required to submit calculations for projected first-year energy impacts with their applications. The maximum incentive amount for the CI program was $500,000 per account, and the minimum qualifying incentive was $2,500 per project. The total incentive payment for kW, kWh, and therm savings was limited to 50% of direct project cost for retrofit of existing systems. Since the program also applied to expansion projects, the new systems incentive was limited to 100% of the incremental cost to make new processes or added systems energy efficient. Customers were paid 4 cents per kWh and 20 cents per therm for first-year annual energy impacts. A $200 incentive per kW of peak demand impacts required that savings be achieved during the hours of PG&E's peak period.

There was no CI program offered in 1995 or 1996. However, due to the significant documentation and analysis involved in CI program measure rebates and construction lead time, a number of 1993 and 1994 applications were delayed until 1996. This evaluation covers those customers who received rebates in 1996. A total of seven CI agricultural participants fell into this category.

1.1.4 The Advanced Performance Options Program

In 1996 the APO program replaced the CI program. The APO program provides assistance and financing for selected large and complex energy-efficiency retrofit projects not covered by the RE and REO programs. Under the APO program, PG&E engineers provide a detailed analysis of the energy savings potential for prospective energy projects. The analysis serves as the technical basis for the program application and incentive payment. Up to $300,000 per account is available for qualifying projects. The 1996 agricultural sector evaluation included one APO project, a produce pre-chilling facility.

1.1.5 The Energy Management Services Program

The EMS program offered information to commercial, industrial, and agricultural customers regarding energy-efficiency technologies and practices. The program offered two services, (1) a pump test free of cost to the customer, and (2) an energy-efficiency audit to identify energy-efficiency opportunities.

For the pump test portion, upon request by the customer, PG&E pump test specialists would perform a pump test at no cost to the customer. The pump performance would then be reported along with recommendations on possible pump repair and potential energy and dollar savings. The most common recommendations were pump adjustments or pump repairs. Where applicable, customers were advised to apply for a rebate under PG&E's retrofit programs.

For the energy survey portion, PG&E representatives worked with customers to identify cost-effective improvements, with special emphasis on operation and maintenance measures at the customer' facilities. For an agricultural customer, the services generally included a walk-through audit culminating in a written analysis and recommendations on the major energy-consuming systems at the customer site.

As stated earlier, this evaluation assessed only the impacts associated with pump repairs that resulted from participation in the pump test portion of the program and that were replaced outside other PG&E retrofit programs.

1.2 Evaluation Overview

This impact evaluation covers all measures installed at agricultural accounts, as determined by the Marketing Decision Support System (MDSS) sector code, that were included under the RE, REO, APO, and CI programs and for which rebates were paid during calendar year 1996. As a result, the evaluation includes measures offered under PG&E programs fielded in previous years. In addition, this evaluation addresses the impacts resulting from PG&E's EMS pump test program. The impact evaluation results in both gross and net impacts and compares these estimates to the program design estimates.

1.2.1 Objectives

The objectives of the evaluation were originally stated in the Request for Proposals (RFP), refined during the project initiation meeting, and documented in the evaluation research plan. These research objectives are as follows:

1.**Determine first-year gross and net impacts** (kW, kWh, and therms) for the agricultural sector of PG&E's AEEI and AEMS programs.

2. **Compare the evaluation results to PG&E's (ex ante) estimates** and explain discrepancies to support improvements in future ex ante estimates.

3. **Investigate, explain, and estimate free-ridership and market spillover** elements of the net-to-gross adjustments.

4. **Create a retention panel for the 1996 program** to allow follow-up persistence studies.

5. **Recommend improvements for future programs, evaluations, and the Protocols.**

6. **Assess equipment survival rates for equipment installed under the 1994 agricultural program.** Revisit sites to determine whether equipment identified in the original 1994 retention panel is still installed and operable. The results of this objective are the subject of a separate deliverable.

7. **Report results in accordance with the Protocols and support AEAP process as requested**. This includes project reporting, completion of the Protocol tables required for California Public Utility Commission (CPUC) filings, and support during the AEAP process.

1.2.2 Evaluation Results

The gross impact results from the evaluation are grouped by technology type to clearly illustrate the trends in participation. Each technology is defined by the measures (i.e., measure codes) offered by the programs. These technologies are then summarized into the pumping and related and indoor lighting end uses that pertain to the agricultural sector. Since these two end uses encompass over 85% of the ex ante resource value for the agricultural sector, they are the only two end uses analyzed in this report. The remaining measures are reported under the reporting requirements of Table C-9 of the Protocols.

The net program impacts are reported in the format indicated above for the gross impacts. Net program impacts are the result of adjusting the gross program impacts for the behavioral responses of the population to which the program was offered. These behaviors are termed free-ridership and spillover. The free-ridership adjustment reduces the gross impact to compensate for program participants who would have implemented the measure without the program incentive (would have done it anyway). The spillover adjustment increases the gross impact to compensate for customers who installed energy- efficient measures because of the program, but without receiving the program incentive.

In addition to reporting the impacts as assessed by the evaluation (ex post results), this report compares these results to the original program estimates (ex ante estimates) in the form of realization rates. The realization rates are simply the ratio of the ex post results to the ex ante estimates. Wherever realization rates diverge significantly from 1.0, the evaluation team attempts to explain the reasons for differences between the ex ante estimates and the ex post values. Based on these explained differences, recommendations are made for improvements in the program design, the evaluation approach, or the Protocols. These recommendations are aimed at improving future realization rates.

1.2.3 Evaluation Timing

The 1997 evaluation commenced in August 1997, completed the planning stages in September 1997, conducted data collection from August through November 1997, and completed the reporting phase in February 1998.

1.2.4 Role of the Protocols

The Protocols specify most aspects of the evaluation. They define minimum sample sizes, required precision, data collection techniques, acceptable analysis approaches, and formats for documenting and reporting results to the CPUC. The Protocol requirements may be modified through submission and approval of a Retroactive Waiver to CADMAC. A Retroactive Waiver was submitted for the AEMS program evaluation to allow use of the AEEI pump repair impacts along with the AEMS pump repair implementation rates to estimate gross impacts. In addition, the waiver allowed the use of a net-to-gross ratio of 0.75 if a market effects study was conducted instead of a net-to-gross analysis.

1.3 Report Layout

This report is divided into six sections in addition to the executive summary and the supporting appendices. These are:

Section 1. Introduction – summarizes the report, introduces the programs, and presents a synopsis of the evaluation.

Section 2. Methodology – presents the approach used to analyze the data and derive the results.

Section 3. Evaluation Results – presents the impact findings and discusses discrepancies between the ex post impacts and the ex ante estimates.

Section 4. Recommendations – discusses recommendations emanating from the evaluation.

Section 5. CADMAC Waiver – documents the waiver that was approved by CADMAC for the AEMS program.

Section 6. Protocol Tables 6 and 7 – supply the detailed Protocol Table data required to file the study with the CPUC.

A separately bound volume of appendices presents the details of the data collection and analysis summarized in the body of the report.

2 METHODOLOGY

This section first discusses the data sources used in the analysis, , followed by the gross and net-to-gross analysis methodology.

2.1 Data Sources

The key element to obtaining high accuracy in any evaluation is maximum use of all available data sources. The Equipoise team evaluated all applicable data available from Pacific Gas & Electric Company (PG&E) and industry sources.

2.1.1 Existing Data

The primary existing data sources were:

- The MDSS database for 1996 - This database contained information on the Retrofit Express (RE), Retrofit Efficiency Options (REO), Customized Incentives (CI), Advanced Performance Options (APO), and Energy Management Services (EMS) programs for all sectors. The agricultural sector information was used within the evaluation.
- Pump Test Database - This database contained information on pump tests conducted as part of the EMS program. Pump test information was assessed for 1995-1996.
- PG&E program design documentation.
- PG&E billing data for 1995 and 1996.
- 1995 Agricultural Sector Coincident Diversity Factor Analysis.

2.1.2 Collected Data

Additionally, information was gathered from the following data sources and data collection tasks:

- Telephone surveys of:
  - A census of the RE indoor lighting participants
  - A census of the REO participants.
  - A sample of AEMS participants.
  - A nonparticipants RE and REO comparison group
- On-site pump tests for a census of REO participants.
- On-site audits for a census of the RE indoor lighting participants, all CI, and all APO program participants in the pumping and related end use.
- "Irrigation Pumping Plants" by Blaine Hanson, UC Irrigation and Drainage Specialist, University of California Irrigation Program, Davis, California, 1994.

The numbers of survey data points collected are shown in Exhibit 2.1. The analysis of the 1994 retention data points will not be covered in this report.

Exhibit 2.1
Surveys Completed Data

Customer Type	AEEI Program			AEMS Program	1994 Retention	Total
	Pumping	Lighting	Total			
Telephone Surveys						
Participant	33	34	67	350	0	417
Nonparticipant	42	34	76	0	0	76
Total	**75**	**68**	**143**	**350**	**0**	**493**
On-Site Surveys						
Participant	74	42	116	0	0	116
Nonparticipant	68	0	68	0	0	68
Subtotal	*142*	*42*	*184*	*0*	*0*	*184*
1994 Retention	0	0	0	0	173	173
Total	**142**	**42**	**184**	**0**	**173**	**357**

The sample information, showing the population, sample frame, and final analysis sample sizes are shown below in Exhibit 2.2. The number of surveys conducted does not match the final telephone analysis sample because some telephone surveyed participants reported that they had taken multiple decisions. Therefore, the final telephone analysis sample represents the total number of decisions taken by the customers contacted, not the total number of surveys completed.

Exhibit 2.2
Sample Summary

Pumping and Related End Use	Population	Sample Frame			Final Analysis Sample		
		Telephone	On-Site	Metering	Telephone	On-Site	Metering
Participant*	91	55	91	91	49	74	66
Nonparticipant	86,474	35,571	35,571	35,571	42	68	68

Indoor Lighting End Use	Population	Sample Frame			Final Analysis Sample		
		Telephone	On-Site	Metering	Telephone	On-Site	Metering
Participant*	70	51	70	0	48	42	0
Nonparticipant	86,474	35,571	35,571	0	125	0	0

Pumping and Related and Indoor Lighting Total	Population	Sample Frame			Final Analysis Sample		
		Telephone	On-Site	Metering	Telephone	On-Site	Metering
Participant	161	106	161	91	97	116	66
Nonparticipant	86,474	35,571	35,571	35,571	167	68	68

Ag EMS	Population	Sample Frame			Final Analysis Sample		
		Telephone	On-Site	Metering	Telephone	On-Site	Metering
Participant	4,765	1,355	0	0	350	0	0
Nonparticipant	86,474	0	0	0	0	0	0

*Participant sample was a census

2.1.3 Sample Design

2.1.3.1 Overview

Data were collected via a combination of telephone interviews and on-site surveys from a sample of program participants and nonparticipants. The data collected from these samples provided the information needed for the impact evaluation (i.e., engineering analysis for gross impact and econometric analysis for net impact) models. The sampling plan for the PG&E agricultural evaluation, based on 1996 program participation data and experiences in the past evaluations, is presented in this section. Since timing for on-site surveys is crucial for agricultural customers, the brief summer evaluation period (August and September) did not allow adequate time to implement a nested sample design. However, the sample design for this study is in compliance with the Protocols. The sample design adopted for this study achieved the following:

- Fulfilled evaluation requirements of the Protocols,
- Allocated sufficient sample points to meet the net-to-gross evaluation objectives, and
- Reallocated available resources, whenever feasible, to focus on the measures and/or program features deemed most important by PG&E staff for future program redesign.

2.1.3.2 Study Domain

A study domain is a segment of the project population for which separate impact estimates are to be derived from the sample. The domains for this study are defined for the estimates of gross impacts using engineering analysis of gross impacts and statistical analysis of net-to-gross ratio. These domains are defined for the participant population by the programs and categories of efficiency measures. There are two programs: (a) AEEI program and (b) EMS program. Under the AEEI program, the study domains are further defined by the two end use categories: (a) pumping and related and (b) indoor lighting. Under the AEMS program, the study domain covers only the pump test measure. These domains represent over 85% of the earnings claimed by each program. All other measures are covered under Protocol table C-9. The relative error of the estimates derived for each domain is determined by the size of the sample allocated to each domain**.** The three domains defined by programs and measure categories are shown in Exhibit 2.3 below.

Exhibit 2.3
Participant Study Domains

Study Domain
AEEI Program
Pumping and Related
Indoor Lighting
AEMS Program
Pump Tests

2.1.3.3 Population, Sample Frame, and Data Screening Criteria

The population includes all of the agricultural customers in PG&E's service territory. A sample of nonparticipants is not drawn from the population of agricultural customers. Rather, it is drawn from a sample frame. In general, the sample frame for nonparticipants includes only those customers who are program nonparticipants and are likely targets of the program, rather than all customers in the population. For developing a sample frame, a sample unit is a unique premise (site). A sample frame should be created for participants and nonparticipants for each of the study domains. Since a census was attempted for the AEEI program participants, no sample frame was required for AEEI participants. For EMS participants, a sample frame was created. Similarly, a sample frame was created for nonparticipants. The criteria for defining a sample frame for EMS participants and nonparticipants are discussed below. It is important to note that in both cases the same exclusion criteria are applied. Since they are applied sequentially, if accounts were excluded for one reason already, those accounts did not qualify for testing under another criteria.

2.1.3.4 EMS Participant Sample Frame.

The population of AEMS participants includes 4,765 unique control numbers. Of the total of 4,765 unique control numbers, 1,355 unique control numbers were included in the sample frame. Reasons for excluding the remaining 3,410 control numbers are:

- There were 137 control numbers that participated in PG&E's AEEI program and AEMS program under separate measure categories. These participants were excluded from the AEMS sample frame to avoid multiple contacts and the potential consequence of annoying customers.
- Missing or bad values for key aspects of billing data make it impossible to construct a reliable customer billing history. There were 755 control numbers that were excluded because the service address and/or the contact phone number changed between 1995 and 1996.
- After excluding customers with unreliable phone numbers or changes in phone numbers and/or address, an additional 104 control numbers were excluded due to changes in their corporate identification, electric meter number, starting date of the meter, or premise number between 1995 and 1996. Any such changes make it difficult to identify the customer who may have made the decision to participate and implement changes. Hence, they were excluded from the analysis.
- A further 316 control numbers were excluded because the annual usage in 1995 was found to be zero, or less than 50 kWh.
- An additional 169 control numbers were excluded because the SIC codes were missing or did not indicate that the control number is associated with an agricultural account, (i.e., either the SIC code is less than 100 or 3561, or 4221, or 4222, or 4941, or 4970).
- After excluding control numbers for above mentioned reasons, there were 3,277 EMS program participants who should have been included in the sample frame. However, in order to avoid multiple contacts with the same customer, we excluded accounts with

duplicate phone numbers. There were only 1,355 unique phone numbers associated with the 3,277 EMS participant control numbers. Thus, the EMS sample frame includes 1,355 control numbers.

2.1.3.5 Nonparticipant Sample Frame.

A population of PG&E's agricultural customers includes 94,010 unique control numbers representing 68,986 premises (sites). Of these premises, 7,536 control numbers were excluded since they represent the premises that participated in either PG&E's 1996 AEEI or 1996 EMS program. Thus, the nonparticipant population includes 86,474 unique control numbers. Of a total of for 86,474 unique control numbers, 35,571 were included in the nonparticipant sample frame. The reasons for excluding the remaining 50,903 control numbers are :

- Missing or bad values for key aspects of billing data make it impossible to construct a reliable billing history for a customer. There were 21,439 control numbers that were excluded since the service address and/or the contact phone number changed between 1995 and 1996.
- After excluding customers with unreliable phone numbers or changes in phone number and/or address, an additional 8,200 control numbers were excluded since either their corporate identification, electric meter number, or starting date of the meter, or premise number changed between 1995 and 1996. Any such changes make it difficult to identify the customer who may have made the decision to participate and implement changes and, hence, they were excluded from the analysis.
- An additional 10,196 control numbers were excluded since the SIC codes were missing or did not indicate that the control number is associated with agricultural account (i.e., either less than 100 or 3561, or 4221, or 4222, or 4941, or 4970.)
- After excluding control numbers for the above-mentioned reasons, there were 46,633 nonparticipating accounts that should have been included in the sample frame. However, in order to get accounts from unique premises, a representative account was selected from the premises that represented 46,633 accounts. Since 35,571 unique premises were represented by 46,633 accounts, we included 35,571 accounts in the nonparticipant sample frame.

Such exclusion criteria did not bias the randomness and, hence, did not bias the sample.

2.1.3.6 Sample Allocation, Sample Sizes, and Sample Selection

Sample allocation covers designating the number of elements to be selected from each domain and from each cell (stratum) within each study domain of the sampling frame. Allocation is influenced by project objectives, sampling error, and expected response rate. A sample designer would also direct more outbound elements to cells with lower expected response rates or higher variance, other considerations being equal.

Strata are mutually exclusive and collectively exhaustive cells from which the sample is drawn, allowing different sampling rates for different cells. The objective of stratification is to improve the overall reliability of estimates by reducing sampling error, controlling non-response bias, and providing larger sample sizes for the sub-populations of most interest to the study. Stratification allows the sample to emphasize certain portions of the population over other portions, as required by project objectives. For the AEMS program participant sample, four strata were defined using pre-program (1995) kWh usage of AEMS participants included in the sample frame. A sample was selected randomly from each stratum. For AEEI program nonparticipants, four strata were defined and customers were selected randomly from each strata. However, strata were defined using AEEI participant pre-program (1995) kWh usage rather than the nonparticipant kWh usage. This was done in order to match the nonparticipants to participants with respect to kWh usage.

The annual kWh usage categories were defined using the Dalenius and Hodges procedure for determining optimal stratum boundaries. That procedure defines the stratum boundaries that produce the greatest reduction in sampling error for a given number of strata. It divides the cumulative square root of frequencies from an equal interval of recorded distribution of usage into as many equal parts as there are strata.

The primary consideration in designing the sample size within each domain is to comply with the Protocols. In some cases, the limited population may restrict the sample size. For example, the AEEI participant population for pumping and related and indoor lighting measures is limited; therefore, the mirrored nonparticipant sample was also restricted. The sample size for the AEMS participants is determined by considering the sample size requirements in the Protocol. As shown in Exhibit 2.1, the PG&E agricultural evaluation consists of a telephone survey of 493 customers and on-site audit survey of 184 customers. The sample design complies with the Protocols and meets the program evaluation objectives.

2.1.3.7 AEEI Participant Sample Frame

For this evaluation, the participant population for the AEEI program is relatively small, and the entire population was needed to fulfill the sample sizes required by the Protocols.

2.1.3.8 Nonparticipant Sample Frame and AEMS Participant Sample Frame

For this evaluation, as noted earlier, sampling was focused on the EMS participants and AEEI nonparticipants. The sample frame and analysis sizes are shown above in Exhibit 2.2. The total surveys collected within the evaluation are shown in Exhibit 2.1.

For the AEMS participant and AEEI nonparticipant sample frames, customers were randomly selected from each stratum for the telephone survey. (See section 2.1.3.6 for stratum definitions.) The AEEI nonparticipant sample includes 28 customers in strata 1, 22 in strata 2, 7 in strata 3, and 19 in strata 4. The AEMS participant sample includes 161 customers in strata 1, 93 in strata 2, 51 in strata 3, and 45 in strata 4.

2.1.3.9 Relative Precision of Sample

The relative precision of a given sample design based on total annual energy use reflects the uncertainty regarding the extent to which the allocated sample sizes are large enough to control for the population variance in terms of annual energy usage.

For AEEI participants, a census was attempted and there was no sampling to measure the extent to which the sample reflects the population.

For an evaluation such as AEEI, where a census of the participant population is attempted, the Protocols only require a sample size that matches the participant sample. For AEEI nonparticipants, a sample of 76 accounts was surveyed that represented 35,571 nonparticipating accounts in the sample frame. The size of the nonparticipant sample is too small to fulfill the 90/10 relative precision expectations specified in the Protocols. However, in such cases the relative precision is to be calculated and reported. The relative precision for the AEEI nonparticipant sample is calculated as shown in Exhibit 2.4.

Exhibit 2.4
Relative Precision Algorithm

$$\begin{pmatrix} \text{RP} \\ \text{(Relative Precision)} \end{pmatrix} = \left[\frac{1.64 * \sqrt{\text{Variance}}\,(\textit{sample})}{\text{Mean kWh}(\textit{population})} \right]$$

Note: It is important to note that relative precision defined in this manner is in fact an index of imprecision. Since Variance is proportionately related to RP, it measures how imprecisely the sample reflects the population. Or, a lower value of RP reflects greater precision.

For a stratified sample this definition can be further explained as in Exhibit 2.5.

Exhibit 2.5
Stratified Sample Relative Precision Algorithm

$$\begin{pmatrix} \text{RP} \\ \text{(Relative Precision)} \end{pmatrix} = \left\{ \frac{1.64 * \sqrt{\sum_{i=1}^{4} [W_i^2 * (\text{Std Err}_i^2 (\textit{sample}) / n_i) * (1 - s_i/n_i)]}}{\text{Mean kWh}(\textit{population})} \right\}$$

Where

W_i = a ratio of number of accounts in strata_i/total population N that is weight n_i/N,

Std Err_i = the standard deviation of mean usage in $\text{strata}_{i,}$

$(1-s_i/n_i)$ = the correction factor for finite sample.

For AEEI nonparticipants;

- The denominator = Mean kWh $_{\text{(population)}}$ = 45,860
- The numerator is (1.64*2703) = 4432.9
- This gives us the relative precision of 9.7%.

For AEMS participants;

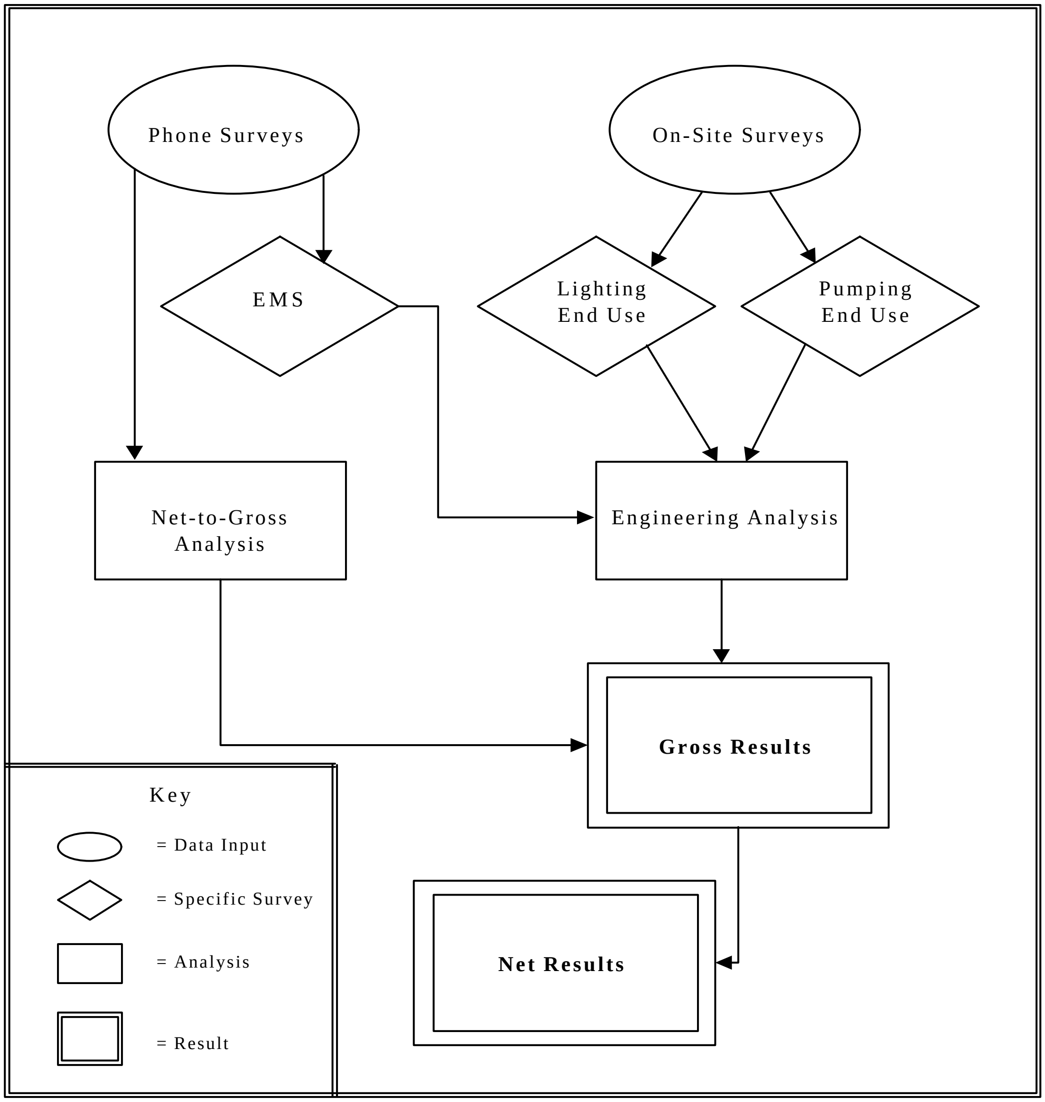
- The denominator = Mean kWh $_{\text{(population)}}$ = 91,981
- The numerator is (1.64*5,419) = 8,887
- This gives us the relative precision of 9.7%..

Thus the final achieved telephone survey samples for AEMS participants and AEEI nonparticipants yielded relative precision of less than 10% at the 90 % confidence level in terms of annual energy usage.

2.2 Overview of Analysis

Exhibit 2.6 illustrates the overall approach to the use of the survey data in the impact analysis.

Exhibit 2.6
Overview of Survey Data Use in Impact Analysis



The AEEI program encompasses the RE, REO, APO, and CI programs. The gross estimates of impact for the AEEI and AEMS programs were based upon engineering models using on-site data and a review of ex ante algorithms and assumptions. The net-to-gross estimates were based on a discrete choice analysis and participant spillover. The

AEEI programs are further divided into the pumping and related and indoor lighting end uses. Specifics of each end use and program are:

- **Pumping and Related End Use Gross Estimates-** For the subset of on-site audits where pre- and post-pump test information was available, the analysis used pump test motor load percentages to determine any change in demand. The on-site audits gathered pump test and other operating data for an engineering estimate of pump usage for the REO measures to determine energy savings. The PG&E pump test database information was used in the determination of energy savings as well.

  The pump adjustment measures used an engineering review of ex ante estimates allowed by the approved waiver.

  The CI and APO sites used the on-site audits to verify the engineering algorithms and assumptions used to estimate ex ante impacts. Any changes in algorithm or assumptions were incorporated in the ex post calculation of impact.

- **Indoor Lighting End Use Gross Estimates-** The on-site audits determined self-reported operating hours and counted the operating fixtures at the time of the audit to determine operating factors for the retrofit fixtures. This data provided a peak operating factor that was combined with the connected load information to compute peak demand savings. The operating factors and annual hours of operation were multiplied with the connected load information to calculate the energy impacts.

  The on-site audits determined the wattage of the fixtures that were removed to recreate more accurately a difference in connected load. The auditors were able to obtain this information for 93% of the fixtures audited.

- **AEMS Gross Estimates-** The AEMS evaluation assessed, via telephone survey, how many pump repairs the participants adopted. The impact of the pump repairs under the AEMS program were estimated based on the pump repair impacts determined within the AEEI analysis. This approach was approved through a retroactive waiver (see Section 5of this report).

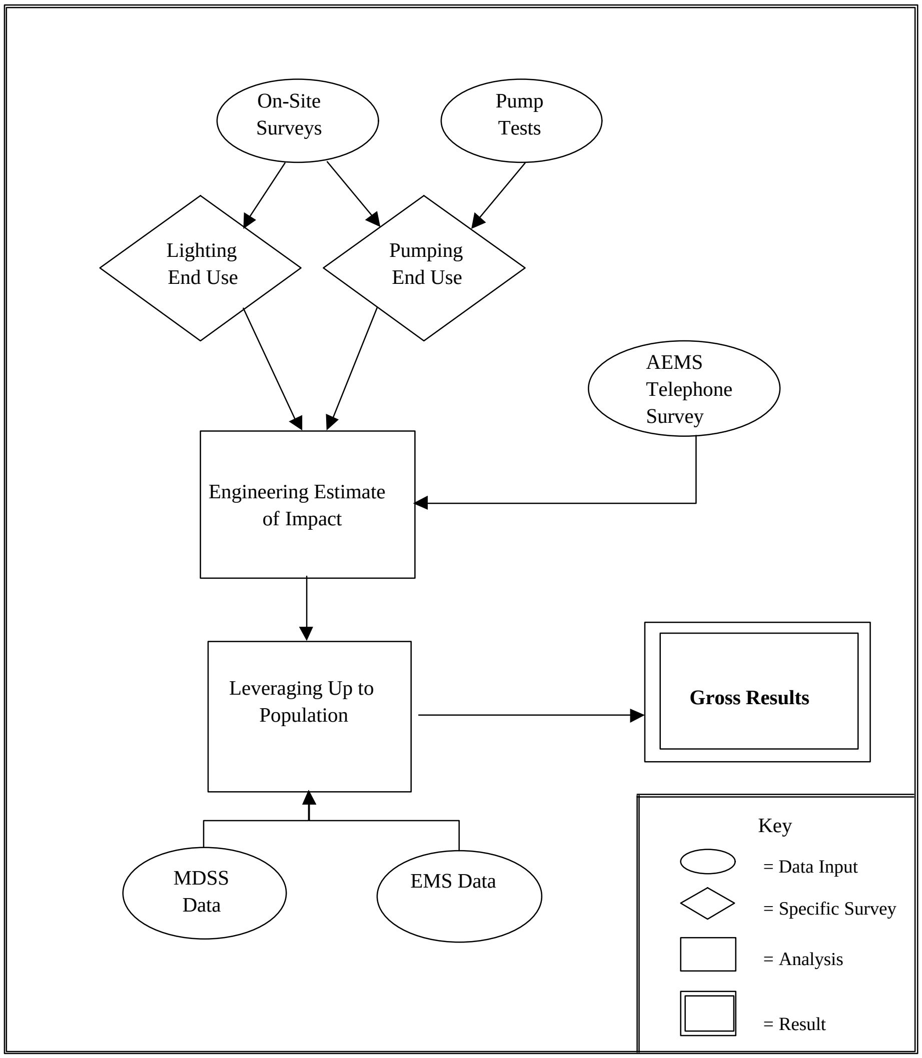
- **Net-to-Gross Estimates -** Net-to-gross adjustments for the AEEI program were developed by applying the net-to-gross ratios determined from the net-to-gross analysis. (These are discussed later in this report.) The AEMS net-to-gross ratio was set at 0.75 as per the retroactive waiver presented in Section 5. Participant and nonparticipant spillover were estimated; however, only participant spillover was included in the final net impact results.

2.3 Gross Impact Analysis

The following discussion of the gross impact analysis approach is presented by end use and program. This segmentation is dictated by the Protocol definitions of end uses within Tables C-6, C-9, and C-11.

The gross demand and energy impacts were the result of either calibrated or simplified engineering modeling. The overall gross impact method is shown in Exhibit 2.7.

Exhibit 2.7
Gross Impact Method



2.3.1 AEEI Pumping and Related End Use

An engineering approach was used to determine the pumping and related end use impacts. The pumping and related end use is actually a composite of pumping-related measures. These measures included pump repairs, low-pressure sprinkler nozzles, micro irrigation system conversion from the 1996 REO program, large pump-related retrofits from the 1994-95 CI program and the 1996 APO program, and a 1995 RE program measure of pump adjustments.

There were 91 applications for the pumping and related end use. These applications covered 67 pump repairs sites, 2 pump adjustments sites, 3 low-pressure sprinkler nozzles sites, 11 micro irrigation system conversion sites, and 8 custom sites. On-site audits were conducted for an attempted census of all pumping and related end use sites. All on-site audits for the pump repair, low-pressure sprinkler nozzles, or micro irrigation system measures included a post-installation pump test where possible.

Demand Impacts - As a pump is used, sand is pulled through the system along with the water and erodes the metal of the bowls and impeller. In addition, bearing wear, corrosion, and possibly deterioration due to cavitation, cause pump efficiency to drop over time. These phenomenon cause a decrease in the flow from the pump and a resultant decrease in the pump motor load. (Simultaneously, the pump efficiency, flow-rate, and pressure drop.) A pump repair most often refurbishes the bowls and impeller to the original specifications. When this occurs, the flow increases as does the pump motor load. For example, a pump with an eroded bowls/impeller system may draw only 85% of the rated motor horsepower, while the same system after repair will most likely draw 110% of the rated horsepower with an increase in flow of perhaps 35%. The analysis for pump repairs compared the pre- and post-repaired motor loads to determine if there was any increase or decrease in the demand.

The demand impact of low-pressure sprinkler nozzle and micro irrigation system conversion measures varied according to how the pressure/flow characteristics of the pump were changed to accommodate the updated system. The demand impacts were determined using information from the pump tests and the pre- and post-pressure requirements of the systems as shown in Exhibit 2.8.

Exhibit 2.8
Gross Pumping Demand Impact

$$kW_{impact} = \frac{GPM * \Delta TDH}{3960\,GPM\ Ft / hp * Post\ OPE} * 0.746\ kW/hp * CDF$$

Where:

GPM	=	Gallons per Minute from pump test
TDH	=	Difference in Total Dynamic Head pre- and post-retrofit
OPE	=	Operating Plant Efficiency from pump test
CDF	=	Agricultural coincidence diversity factor (0.78)

For micro drip systems, the ex ante assumption that the systems run 22 hours per day when in operation was used. Therefore, the peak kW equaled the kW impact, and no CDF was applied.

Since the analysis had data from two of the three low-pressure sprinkler nozzle applications and ten of the eleven micro conversion applications, moving to the population to estimate demand impacts created little problem. The low-pressure sprinkler nozzle site with no audited data used the weighted average of the kW/nozzle impact from the two known sites. For the micro conversion site with no audit, a realization rate between the ex ante and ex post estimate was determined for each of the ten applications, and the average realization rate was applied to the ex ante estimate.

Energy Impacts – The premise used in determining the energy impact is shown in Exhibit 2.9. Information from a pump test data could be combined with billing data to provide an estimate of the acre feet (AF) of water pumped in that year.

Exhibit 2.9
Gross Pumping Energy

$$kWh_{yr} = \frac{AF}{year} * \left[\frac{kWh}{AF}\right]_{Measured}$$

Where: AF/year = acre feet of water (one foot of water over one acre, 325,853 gallons) provided by the pump

$\left[\frac{kWh}{AF}\right]_{Measured}$ = determined using pump testing

The $[kWh/AF]_{Measured}$ portion of the equation is defined by the pump system. It is a function of the pressure required to lift the water to its final destination (total dynamic head or TDH) and the operating plant efficiency (OPE). Year to year, this value is relatively stable for any specific well/pump combination. It will change if the pressure requirement changes (e.g., pumping depth changes or irrigation pressure requirements are modified), or the efficiency of the system changes (e.g., through a pump repair or erosion of the bowls). Comparatively, the annual water consumption (AF/year) value is highly variable. It is a function of many factors including crop needs, precipitation, surface water supply, leaching requirements, and irrigation efficiency. If the kWh_{yr} and $[kWh/AF]_{Measured}$ values are known, then the most varied and difficult value to determine (AF/year) can be calculated by inverting the equation in Exhibit 2.9.

In order to get the best value from the measured data, multi-point pump tests were performed. Although it was slightly more time consuming than a single-point pump test, the information gathered was planned to allow an “apples to apples” comparison of efficiency. For example, if pre-repair pump test data were available, the TDH at a single-flow rate would be known. However, the pre-repair test may have been done in the spring when the aquifer was high due to spring run-off, while the post-repair pump test may have been done in August when the water level had dropped considerably. A multi-point test would allow development of a field pump curve. The efficiencies of the pre- and post-repair could then be compared under equivalent conditions. However, due to field constraints, not all pump tests could be done over multiple flow points. Additionally, many of the pump tests in PG&E’s pump test data base that were initially believed to have been done prior to pump repair turned out to be post-repair tests. In the end, there were few pre- and post-repair tests available for use in the analysis and the majority of those were single-point tests.

Each measure within the REO pumping group had a specific variation of this basic approach depending upon how the measure was implemented in the field and the data available within the evaluation. The specifics of the engineering approach for each measure with planned pump tests are provided next.

2.3.1.1 Pump Repair

Since this measure pays for repairing the impeller and bowl assembly, the repair would only significantly affect the energy use of pumps. The assumption was that there was one deep well per metered account. This turned out to be incorrect for the district water pumps using axial pumps to move large amounts of water with a low pressure differential, but fairly accurate for irrigation pumps which form the majority of the participant accounts. Additionally, some irrigation systems also had a booster pump in use. This booster pump was accounted for by separating out the percentage of time that the booster pump runs (e.g., the pump runs by itself 60% of the time, and together with the booster 40% of the time). The horsepower of the booster pump was determined during the on-site audit. The load factor of the booster pump was assumed to be 1.0. The billing data was apportioned to the pump based upon the horsepower of the deep well and booster pumps and the time schedule determined while on site. Similarly, if the repaired pump was one of many on an account, horsepower and time-of-use data were collected to perform a similar disaggregation of the account's billing data and energy use to each pump.

It was assumed there would be some degradation of pump efficiency over time; however, it was also assumed that the measurement error bounds around any determination of pump efficiency would encompass the original pump efficiency value. Therefore, the estimates are considered conservative and do not account for possible pump efficiency degradation within the impact measurement. The impact is the same as the change in efficiency.

There were 25 unique pump repair participants (representing 27 accounts) with PG&E pump tests. However, after determining the date of the pump repair during the on-site audits, it was found that only nine of the tests were actually done prior to the pump repair and only five of those could be considered pump tests with good or fair data quality. Therefore, much of the originally planned approach was re-evaluated. As much information was gleaned from the pump tests as possible and these data were supplemented with information from the PG&E pump test database. The OPE of 29 individual pumps were estimated for both the pre- and post-repair condition using data from both evaluation pump tests and the PG&E pump test database. The average pre- and post-OPE were applied to all pumps within the program. The population impact was determined as follows:

Exhibit 2.10
Pump Repair Energy Impacts

$$\text{Program Impact} = \sum_{i=1}^{67} kWh_{1996,\ i} * \left(1 - \frac{OPE_{pre}}{OPE_{post}}\right)$$

2.3.1.2 Low-Pressure Sprinkler Nozzles

To take full advantage of installing low-pressure sprinkler nozzles, a change in the pumping plant or pumping acreage should have been made (to reduce system pressure) at the time the sprinkler nozzles were installed. The auditors determined whether a change was made in either the pumping plant or acreage supplied. The reduction in system pressure or an increase in acreage supplied would decrease the kWh/AF value.

The low-pressure sprinkler nozzles were installed on both moveable and permanent sprinkler systems. The 1996 program had two permanent system participants and one moveable system participant. The on-site audits were done at one permanent system site and one moveable system site. The third site declined participation in the on-site inspection process. The change in kWh/AF was determined from the evaluation pump test, 1996 billing information for all affected pumps, and reported pre- and post-pressure for the sprinklers. It was not feasible to perform a pump test on each pump to which the sprinkler system was attached, therefore, it was assumed that the change in kWh/AF was the same for each pump. The 1996 billing data for all affected pumps were summed and used to determine the total acre-feet pumped across all pumps.

Certain assumptions were made during the low-pressure sprinkler nozzle analysis. It was assumed that the OPE of the old and new system were the same because neither audited site changed their pumping system. It was also assumed that the irrigation efficiency (IE) of the old system and the new system were the same. Therefore, there was no assumed difference between the AF of water pumped in 1996 and what would have been pumped with the old high-pressure sprinkler system. These are conservative estimates. The nozzle pressure in pounds per square inch (psi) for the pre- and post-nozzles were based on grower self-reports. The algorithms used to determine site-specific impacts for the low-pressure sprinkler systems is shown in Exhibit 2.11.

Exhibit 2.11
Low-Pressure Sprinkler Nozzle Energy Impacts

(1) Post-total dynamic head (TDH) from nozzles = post psi * 2.31 ft/psi

(2) Post-TDH outside of nozzles = Actual TDH from pump test – (1)

(3) Pre-TDH = pre psi * 2.31 ft/psi + (2)

(4) AF = 1996 kWh / $(\text{kWh/AF})_{\text{from pump test}}$

(5) kWh / AF $_{\text{pre}}$ = 1.0241 * (3) / pre OPE

(6) kWh $_{\text{pre}}$ = (4) * (5)

(7) kWh Impact = kWh 1996 – (6)

(8) kWh / nozzle impact = (7) / nozzles installed

For population estimates, the two sites with actual data used the analysis estimate of savings. The one site with no audit data used an average kWh/nozzle impact, weighted by the number of nozzles installed, from the two known sites to determine energy impacts.

2.3.1.3 Micro Irrigation Conversions

Micro irrigation system conversion incentives were paid when a customer converted from a sprinkler irrigation system (either high-pressure or low-pressure) to a micro irrigation system. The pumping system should have been completely renovated to allow the micro irrigation to function properly. This type of system is not moveable. The impact of this retrofit is seen in both the decreased AF of water applied (due to increased irrigation efficiency) and the decreased pressure in the pumping system.

The on-site audit was done at ten of the eleven applications. Six of these sites had multiple pumps on one meter. All the pumps were tested, giving a total of eighteen tests across the ten applications. The analysis of the micro irrigation sites used the pump test information in a similar fashion to the low-pressure sprinkler nozzle analysis. The estimated pre- and post-pressure were based on grower self-reports. Expert auditors estimated the current system's IE in the field. The previous IE of the high-pressure system relied upon information from the previous two PG&E Agricultural Sector Program evaluations. All previous systems were high-pressure, and all were given the same pre-retrofit IE (0.76). All systems audited, except one, had changed out the pumps. The pre-OPE assigned to each pump was based on the previous pump type. If the post-retrofit pump was a turbine booster and the pre-retrofit pump had been a centrifugal pump, the average OPE for "routine" tests within the PG&E pump test was applied (0.55) for the pre-retrofit OPE. If the both the post-retrofit and pre-retrofit pumps were turbine booster pumps, it was assumed that the retrofit also enhanced the operation of the new pump. Based on the pump repair analysis, the pre-retrofit OPE was set to 8.5% less than the OPE found during the post installation (evaluation) pump test. The one site that made no change to the pump was assigned the same OPE pre- and post-conversion. The site-specific impact algorithms are shown in Exhibit 2.12.

Exhibit 2.12
Site-Specific Micro Irrigation Energy Impacts

(1) Post-total dynamic head (TDH) from system = post psi * 2.31 ft/psi

(2) Post-TDH outside of drip system = Actual TDH from pump test – (1)

(3) Pre-TDH = pre psi * 2.31 ft/psi + (2)

(4) AF_{post} = 1996 kWh / $(kWh/AF)_{from\ pump\ test}$

(5) AF_{pre} = AF_{post} * post IE / pre IE

(6) kWh / AF_{pre} = 1.0241 * (3) / pre OPE

(7) kWh_{pre} = (5) * (6)

(8) kWh Impact = kWh_{pre} – kWh_{post}

(9) kWh / Acre Impact = (8) / Acres converted

Since ten of the eleven applications had had an on-site audit and pump test, little leveraging was required to move to the population. For the ten audited applications, the kWh impact determined in the analysis was used for the program impact. For the one application with no audit, a realization rate was determined for each of the ten applications and the average realization rate was applied to the ex ante estimate.

2.3.1.4 Pump Adjustments

A waiver was approved by CADMAC allowing an engineering review of the ex ante algorithms and assumptions for this pumping measure due to the small overall impact.

There were only two pump adjustment applications. They were reviewed to determine what percentage of kWh had been applied for the ex ante savings. Previous evaluations of this measure (during the 1994 and 1995 program evaluation efforts), identified that an 11% savings was anticipated in the ex ante estimates. This value was considered too high. A more realistic estimate of savings due to pump adjustments is 1.5% to 2.0%. After review it was found that the ex ante estimates still used the 11% savings estimate. The kWh usage was backed out of the ex ante impact estimate and 1.5% savings was applied to provide the ex post savings estimate of energy savings. There were no estimated demand savings either ex ante or ex post for this measure.

2.3.1.5 Custom Sites

There were eight custom applications, representing six unique customers. All sites were audited on site. The custom applications were reviewed thoroughly prior to performing the on-site audit to determine relevant questions to ask to support the algorithms and assumptions in the application. The audits verified the installation of the paid equipment and, with only one exception, found no problems with the algorithms or assumptions used in the applications. The one exception appeared to have used a non-peak demand estimate from the billing data to estimate peak demand savings. A more detailed discussion of these sites is presented in the engineering technical appendix.

2.3.2 AEEI Indoor Lighting End Use

The indoor lighting end use used a simplified engineering model based upon on-site participant data. This approach, which had been approved by CADMAC through a retroactive waiver, is similar to the approach used in the 1995 evaluation. There were two primary technical issues for the indoor lighting end use: (1) the variation in use across business types, and (2) the difference between assumed and actual wattage of previous lamps.

For each business type, the lighting hours of operation are driven by the needs of the individual customer. For example, dairies run continuously, poultry farms tend to use four-week to six-week cycles of building use followed by two-week off periods, and ornamental nurseries vary their lighting hours based upon the crop they are growing. This wide variation makes it difficult to generalize across the agricultural sector. The unique business sector-specific criteria make in-person on-site data collection necessary for participants. Participant data were gathered during on-site interviews to maximize information and provide robust results for findings.

Previous experience in this sector indicated a high probability of one for one change-outs of low-wattage incandescent fixtures for high-wattage, high-intensity discharge (HID) fixtures. Because of this probability, every effort was made to determine the wattage of the previous fixtures and whether it was actually a one for one fixture change out. This was a successful effort, gathering 93% of the previous wattage at the audited sites. Additionally, data were collected to determine whether there was a change in productivity due to the lighting retrofit.

The on-site audit determined the connected load for each post-retrofit technology through visual identification of the wattage (if within visual range), examination of purchase orders (if not in visual range and purchase order is available), or discussion with the customer. Operating factors were determined on-site by counting fixtures that were on during the audit and, through discussion with the customer, creation of a schedule of how the retrofit lights were used.

Once the data were collected, the sites were divided into SIC code groups to determine the spread of sites possible for leveraging to the population. Then the data were cleaned and changes in operating load were determined for each audited fixture. The schedule information was used to determine the peak period operating factor. The algorithm for lighting demand impacts is shown in Exhibit 2.13.

Exhibit 2.13
Gross Indoor Lighting Demand Impact

$$kW_{impact} = \sum_{sic=1}^{18}\left[\sum_{t=1}^{6} \Delta UOL_{t,\,sic}\right] * OF_{open,\,p}$$

Where

$UOL_{t,sic}$	=	Change in connected load for technology, t within the SIC designation
$OF_{open,,p}$	=	Open Operating Factor at time of peak, p

The annual hours of operation were determined using the audited data and the algorithm in Exhibit 2.14. These values were used, along with the demand impact, to determine energy impacts. The energy impact algorithm is shown in Exhibit 2.15.

Exhibit 2.14
Indoor Lighting Annual Hours of Operation Algorithm

$$\text{Annual Hours of Operation} = \sum_{s=1}^{3}\left[\text{Open Hours}_s * OF_{open,\,s} + \text{Closed Hours}_s * OF_{closed,\,s}\right]$$

Where

Open $Hours_s$	=	Schedule Group Annual Hours Open
$OF_{open,s}$	=	Open Operating Factor for Schedule Group, s
Closed $Hours_s$	=	Schedule Group Annual Hours Closed
$Of_{closed,s}$	=	Closed Operating Factor for Schedule Group, s

Exhibit 2.15
Gross Indoor Lighting Energy Impact

$$kWh_{impact} = \sum_{sic=1}^{18} \left\{ \sum_{t=1}^{6} \Delta UOL_{t,\,sic} * \#\text{ of Paid Units}_{t,\,sic} * \text{Annual Hours of Operation}_{t,\,sic} \right\}$$

Where

$UOL_{t,sic}$ = Change in connected load for technology, t

Paid Units $_{t,sic}$ = Units paid under the program for technology, t

Annual Hours of Operation from Exhibit 2.14

2.3.3 Agricultural Energy Management Services

The AEMS analysis covered only those customers with a pump test. The site surveys were not analyzed within this evaluation. Past experience with evaluation of the agricultural sector indicated that, on the phone, the grower had great difficulty identifying which pump the telephone surveyor was asking about. Therefore, the plan did not narrow the questions to a specific pump, but queried the customer about all of the pumps at that business. The customer was asked if their business had repaired any deep well pumps since January 1996. If so, they were then asked how many. A follow-up question asked the customer to state how many of the pumps were "repaired simply as a result of equipment breakdown." This allowed isolation of pump repairs done simply to improve efficiency.

Using this approach entailed some cleaning of the PG&E pump test database since business names are not always entered exactly the same. All 9,689 agricultural sector pump test records were cleaned based on the business name and address. Multiple corporations with similar names often had the same address. Once cleaned, there were 1,446 businesses within the 1995/96 pump test database with pump tests in 1996. Since the telephone survey was conducted with the person responsible for all pumps across the corporation, any businesses with the same address were combined into one business.

The AEMS estimate of gross savings was based on the 350 participant telephone surveys, information from the PG&E pump test database, and the AEEI pump repair measure OPE ratio. The engineering algorithm used to determine savings is shown in Exhibit 2.16.

Exhibit 2.16
AEMS Engineering Algorithm

$$\text{kWh Impact} = \text{Participant Business Population} * \text{Percent of Pumps Repaired per Business} * \text{Average kWh Use} * \text{AEEI pump repair OPE Ratio}$$

This completes discussion of the gross impact estimation approach. The next section presents the net-to-gross analysis approach.

2.4 Net-to-Gross Analysis

2.4.1 Overview of Net Savings Analysis

The net effects attributable to Customer Energy Efficiency programs are, by definition, the difference between the energy consumption and demand that actually occurred with the program in place and the consumption and demand that would have occurred if the program had not been offered. Estimation of this effect is intrinsically difficult since the usage that would have occurred without the program is not observed. The purpose of estimating the net impact of a DSM program is to determine the extent to which the program induced customers to install efficient equipment beyond what they would have done without the program. Net savings differ from gross savings in two ways. First, efficient equipment that was installed under the program might have been installed even if the program had not been offered. The customers who installed efficient equipment under a program even though they would have installed efficient equipment without the program are called free-riders, and the savings are called naturally occurring savings. Second, savings from efficient equipment installed outside the program (by participants and nonparticipants) but due to the program (in the sense they would not have been implemented without the program) are called spillover effects. Therefore,

$$\begin{pmatrix}\text{Net Savings of}\\ \text{DSM Program}\end{pmatrix} = \begin{pmatrix}\text{kWh Gross}\\ \text{Savings}\end{pmatrix} - \begin{pmatrix}\text{Naturally Occurring}\\ \text{Savings}\end{pmatrix} + \begin{pmatrix}\text{Spillover}\\ \text{Effects}\end{pmatrix}$$

As a part of the PG&E AEEI evaluation, both free-ridership and spillover effects were analyzed. There are several methods commonly used to estimate free-ridership. For the AEEI program evaluation, two methods were used. One was a Discrete Choice Analysis (DCA) and the second was a self-report analysis of free-ridership. The Protocols require the use of a participant group and a comparison group in order to estimate net effects. However, only the DCA method uses a comparison group to estimate the net-to-gross ratio. Methods used to estimate free-ridership and spillover are discussed in detail following the discussion of data sources used in the net-to-gross analysis.

2.4.2 Methodology - Discrete Choice Analysis

One evaluation approach for estimating net effects uses a set of discrete choice models (Train, 1994). This approach focuses on the factors affecting the customer’s decision process, which in turn affect kWh consumption. With this approach, we follow the decision paths for choices made by customers (participants and nonparticipants) regarding program participation and measure implementation. For rebate programs such as AEEI, the relationship between participation and implementation is important to consider before observing the effect of these decisions on kWh consumption. This approach tries to answer the question of whether the customers participated in the program because they had already decided to implement program measures and simply wanted the program benefits, or the program actually induced them to implement. It does not compare participants with nonparticipants with respect to kWh consumption. Rather it disentangles the pattern of causation between program participation and measure implementation and therefore gives more importance to the interrelationship between the decision to participate in the program and the decision to implement program measures. This approach attempts to determine the reasons for the differences in implementation rate between participants and nonparticipants and has a flexible model structure that can be altered depending upon the nature of the program and the relationship between decision to participate in the program and decision to implement program measures.

The advantages of this approach are:

(i) *A snapshot of customer characteristics*. Information on customer characteristics at one point in time is less difficult to collect than reliable and detailed information over a period of time.

(ii) *Flexibility*. The model flexibility allows application to suit the program design. This is the only approach with a flexible model structure, allowing it to be altered depending upon the nature of the program and the relationship between the decision to participate in the program and the decision to implement program measures.

(iii) *Modeling by end use*. Models can be estimated separately for each end use. Energy savings can be calculated for each end use by applying end use-specific net-to-gross ratios to engineering estimates of gross kWh savings.

With this approach, a nested logit model is used to estimate net impacts of the AEEI program where implementation of energy-efficient measures is a precondition of participation.

Each customer has a choice among three options regarding an eligible measure under the AEEI program:

1. implement the measure within the program,
2. implement the measure outside the program, or
3. do not implement the measure.

The customer chooses the option that provides the greatest "utility." The utility the customer obtains from each option depends on the investment cost, energy savings, and other factors associated with the option. Participants are customers who choose option 1, while nonparticipants choose either option 2 or 3. To determine net savings, a DCA model is estimated that describes customer’s choices among these options, using data on the actual choices that customers made during the program period. Some factors that affect the utility of each option are observable (such as installation cost and expected savings). However, other factors are not. For example, the non-monetary “hassle” of making changes, which cannot meaningfully be measured, might affect the utility of options 1 or 2. The customer's uncertainty about cost and especially about savings can also be expected to affect the utility from options 1 and 2, but are not generally observed. Some unobserved factors affect the utility of option 1 but do not affect option 2. An example of this is the hassle of applying for a rebate or the cost and difficulty of documenting the installation and cost (which is usually needed to receive a rebate). In fact, it is because of these factors that a customer might choose option 2 over option 1 (i.e., implement the measure but not apply for a rebate).

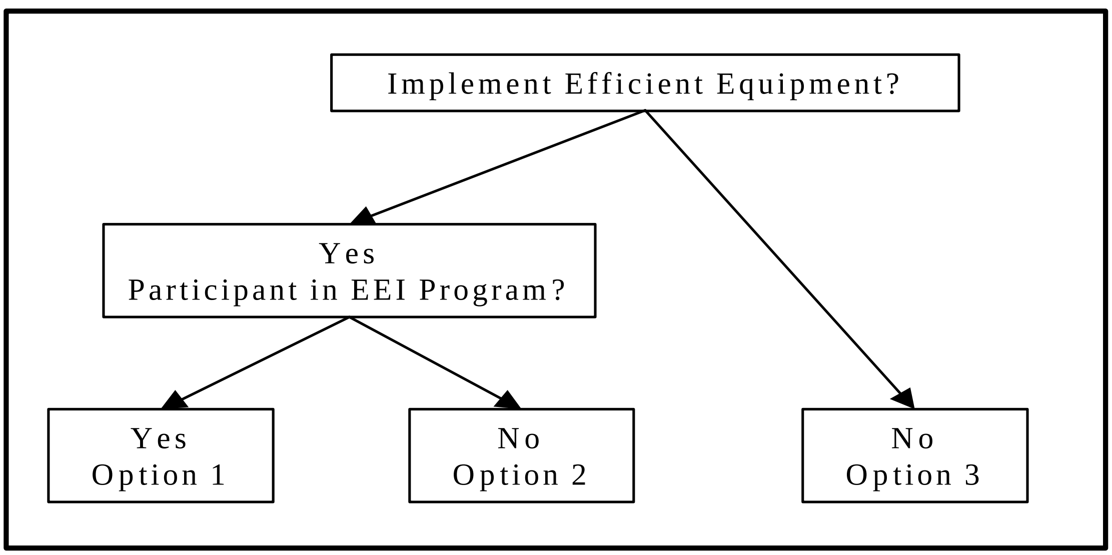
If the unobserved factors were independent over options, then a standard logit model could describe the probabilities. However, the unobserved factors are clearly not independent: unobserved factors relating to the installation of the measure enter the utility for both options 1 and 2, since both of these options entail implementing the measure. One model is required that recognizes the correlation between unobserved factors. Assuming no correlation of errors (as for a simple logit model) is equivalent to assuming that the implementation rate among customers who did not receive a rebate (i.e., who chose options 2 or 3) is the same as the implementation rate that rebated customers (i.e., those who chose option 1) would have had in the absence of rebates. This is essentially the same as saying that participants would have behaved like the nonparticipants if the program had not existed, which Train (1994) indicates is an inappropriate assumption for net savings analysis. Nested logit explicitly recognizes the correlation in unobserved factors over options.

With the nested logit, the two similar options—in this case options 1 and 2—are nested together. Thus, the model structure consists of two parts:

- A "top" model of customer's choice of whether to implement the measure and
- A "bottom" model of whether the customer participates in the program given that the customer implements the measure.

With the nested logit, the three-option model is estimated and the results are used to "forecast" what customers would have done if they had not had the option of implementing the measure with an incentive. The interrelationship between the customer's decision to participate and implement under the AEEI programs is shown in Exhibit 2.17.

Exhibit 2.17
AEEI Implementation and Participation Relationship



This structure does not imply that customers make decisions sequentially in this way; rather, the structure reflects the fact that unobserved factors of options 1 and 2 are correlated.

Once the three-option model is estimated, it is used to simulate the behavior of customers in a condition in which the first option was not available (that is, to "forecast" what customers would have done if they had not had the option of implementing the measure with an incentive.) This simulation indicates the extent to which customers would have implemented the measures without the program. By comparing predictions of customer behavior with and without the program, end use-specific net-to-gross ratios are derived.

Nested logit models were estimated sequentially. The procedure used within the net-to-gross analysis consisted of three steps: estimation of a participation model (the “bottom” model), estimation of an implementation model (the “top” model), and calculation of the net-to-gross ratio.

Step 1: "Bottom" Model.

First, a logit model was estimated for the customer's decision to participate in PG&E’s 1996 AEEI Program conditioned on his or her having implemented energy-efficiency measures. Since the customer decides whether to participate in the program, this decision is a discrete choice (yes or no) and can be represented by a logit model that takes the form shown in Exhibit 2.18.

Exhibit 2.18
“Bottom” Logit Model Algorithm

$$P_{pi} = \frac{\left(e^{(bZi)}\right)}{\left(1 + e^{(bZi)}\right)}$$

Where :

P_{pi} = the probability that customer participates (chooses option 1 over option 2) in the 1996 AEEI program,

Z_i = a vector of explanatory variables that include factors affecting customer i’s decision

β = a vector of estimated coefficients that maximizes P_{P_i}

The variables included in vector Z are "customer" characteristics that affect the decisions to participate. For example, they include the type of business, management type, whether PG&E contacted the customer, number of pumps, location of the customer, and importance of equipment reliability. The probability of participation was estimated for each customer who implemented a conservation measure of interest. Customer-specific probabilities were estimated using the actual choices made by the customer.

The Protocols dictate that net effects be estimated for pumping and related and indoor lighting end uses. In order to estimate net effects by end use, the participation model was estimated for each of these two end uses.

Using the estimated parameters on the set of Z variables, a Log Sum variable was calculated for all customers, both implementers and non-implementers using the algorithm in Exhibit 2.19.

Exhibit 2.19
Log Sum Variable Algorithm

$$\text{LS}i = \log\left(1 + e^{(bZi)}\right)$$

The Log Sum variable reflects the similarity (or dissimilarity) between options 1 and 2 as viewed by the customers. The way in which the implementers (i.e., all customers included in the participation model) view options 1 and 2 affects their decision to implement. Thus, the Log Sum variable is included as one of the explanatory variables in the implementation model.

Step 2: "Top" model.

Another discrete choice model was formulated to capture the customer's decision to implement a conservation measure. This model is shown below in Exhibit 2.20.

Exhibit 2.20
"Top" Logit Model Algorithm

$$\text{P}_{\text{Ii}} = \frac{\left(e^{(aLSi+dXi)}\right)}{\left(1+e^{(aLSi+dXi)}\right)}$$

Where:

P_{Ii} = the probability that customer i implements a measure (choosing option 1 or 2 over option 3)

X_i = a vector of explanatory variables corresponding to the i^{th} customer that affect the outcome of the choice

LS_i = a proxy indicating customer i's perception of the difference between options 1 and 2, using the participation model results

α and δ are estimated coefficients that maximize P_{Ii}

Once again, the customers' actual implementation decisions were used as the values of the dependent variable to estimate the model. The pool of information for vector Z in the participation model and vector X in the implementation model remains the same. In order to estimate net impacts for lighting and pumping and related end uses, end use-specific implementation models were estimated.

Step 3: Calculation of Net-to-Gross Ratio.

To calculate the net-to-gross ratio, the gross, naturally occurring, and net effects of the program were calculated. The gross effect is simply the probability of implementing a conservation measure under the program. The naturally occurring effect is the probability of implementing a conservation measure in the absence of the program. The net effect is the difference between the gross and naturally occurring effects. The net-to-gross ratio is the ratio of net and gross effects.

The gross effect of the program is the product of the probability of implementation and the probability of participation if implementing. Thus, the gross effect of the program is calculated as shown in Exhibit 2.21.

Exhibit 2.21
Gross Effects of Program Algorithm

$$\begin{pmatrix}\text{Gross Effect of}\\ \text{DSM Program}\end{pmatrix} = \sum \begin{pmatrix}\text{Probability of}\\ \text{Implementation}\end{pmatrix} * \begin{pmatrix}\text{Probability of participation}\\ \text{if implementing}\end{pmatrix}$$

Where the sum in Exhibit 2.21 is overall participating and nonparticipating customers.

The calculation used the probabilities of participation and implementation estimated in steps one and two. The effect that would have occurred naturally without the program was also estimated. If the program had not existed, then customers would not have had option 1 available: they would not have been able to implement the measure and receive a rebate. Their choice would have been to either implement the measure without a rebate (option 2) or not implement the measure (option 3). The effect that would have occurred without the program is the naturally occurring effect. The naturally occurring effect is estimated using the estimated parameters of the implementation model, assuming that the coefficient of LS is zero.

Net effect of the program was then calculated as shown in Exhibit 2.22.

Exhibit 2.22
Net Effect of Program Algorithm

$$\begin{pmatrix}\text{Net Effect of}\\ \text{DSM Program}\end{pmatrix} = \sum \begin{pmatrix}\text{Probability of}\\ \text{Implementation}\\ \text{Given the Program}\end{pmatrix} * \begin{pmatrix}\text{Probability of Implementation in}\\ \text{Absence of the Program}\end{pmatrix}$$

Again, with a summing over all participating and nonparticipating customers.

Finally, the net-to-gross ratio (excluding spillover) was calculated as shown below in Exhibit 2.23.

Exhibit 2.23
Net-to-Gross Ratio Algorithm

$$(\text{NTG Ratio}) = \frac{(\text{Net Effect of the Progam})}{(\text{Gross Effect of the Program})}$$

Gross and net effects for pumping and related and indoor lighting end uses were calculated in order to obtain end use-specific net-to-gross ratios. In addition to the DCA, a self-report analysis was done for the AEEI program.

2.4.3 Data Sources

Discrete choice analysis requires data on customer characteristics, including attitudes, beliefs, opinions about conservation, expected benefits from implementation, and exposure to and understanding of the program and its implementation. In particular, data are required for a sample of customers as to what measures each customer could have implemented, the cost and savings of each of these measures, and which of the measures the customer did implement. The information on the cost and benefits of the measures implemented by customers is very expensive to collect, and a comparative study demonstrates that the availability of such information is not a necessary condition for applying DCA to evaluate net effects (Parikh, 1995). It is important to note that billing analysis also requires the same information to estimate a customer's probability of participating. DCA requires information at a given point of time. However, billing analysis requires information that can explain the variation in energy usage over a period of time.

Separate participation models for two end uses were estimated, using in each model only a subset of customers (decision makers) who implemented efficient measures for that end use. The implementation models were estimated using all 173 customers for the indoor lighting end use. However, for the pumping and related end use, the implementation model was estimated using both participants for the pumping and related end use and eligible nonparticipants for the pumping and related end use. That is, customers with descriptive addresses were considered eligible pumping nonparticipants under the assumption that only a farm with a pump can have a descriptive address.

Two primary sources of information were used. The first source was the telephone surveys. For estimating participation and implementation models, it was important to capture the effects of customer characteristics on the decision to implement particular measure types. The combination of explanatory variables varied for end use-specific participation and implementation models. A set of customer characteristics was drawn from the information contained in telephone surveys for the sample of participants and nonparticipants. Repeated contact was avoided while collecting information via telephone survey. A total of 67 participants and 76 nonparticipants were interviewed (see Exhibit 2.1). Since 67 participants were involved in a total of 97 decisions (for both Lighting and Pumping Related end uses), using the 67 complete surveys, data for 97 decisions were simulated (see Exhibit 2.2). Thus, telephone survey information was available for a total of 173 customer decisions (97 participant decisions plus 76 nonparticipant decisions). The second source was the 1996 billing data. Billing data from PG&E provided information on the SIC code, kWh consumption, and the location of all the participants and nonparticipants. Billing data for the 173 surveyed customer decisions were pulled from the billing files provided by PG&E.

2.4.4 Methodology - Self-Report Analysis

The focus of this approach was to determine whether the program participants would have installed the measures in the absence of the programs. This approach used self-reported responses from telephone survey of AEEI participants to estimate free-ridership for both pumping and related and indoor lighting end uses. Self-report questions like, "If the PG&E rebate had not been available, how likely is it you would have installed the same energy efficient equipment?" and "How important would the availability of a rebate be in your decision to install high-efficiency equipment?" were asked during the telephone interview. Responses to these questions were then used to analyze the extent of free-ridership. The main feature of this approach is that it used stated intentions regarding the role played by the program in installing program measures combined with additional consistency checks that override stated intentions, where appropriate. However, since this method does not make use of a comparison group as required by the Protocols, it was not used.

2.4.5 Methodology – Spillover Analysis

Energy savings achieved because of demand side management programs, but occurring outside of formal program participation, are by definition spillover benefits. Such benefits result from the information dissemination and educational aspects of demand side management programs. There are two components of the spillover effect, participant and nonparticipant spillover.

With participant spillover, satisfied and newly aware program participants take additional conservation measures without incentives. Participant spillover was measured from the responses to a set of self-report questions in the telephone survey. Only if customers first learned about the equipment from contact with PG&E or their previous participation in PG&E's CEE programs was the implementation of that equipment counted as a spillover action. The participant spillover effect for each equipment type was then calculated as shown in Exhibit 2.24

Exhibit 2.24
Participant Spillover Algorithm

$$\begin{pmatrix}\text{Total Participant}\\ \text{Spillover}\\ \text{effect in kWh}\end{pmatrix} = \sum_{i=1}^{n} \begin{pmatrix}\text{Participant}\\ \text{Spillover Effect}\end{pmatrix}_i * \begin{pmatrix}\text{Total Participants}\\ \text{in the Program}\end{pmatrix}_i$$

Where,

$$\begin{pmatrix}\text{Participant}\\ \text{Spillover}\\ \text{Effect}\end{pmatrix}_i = \left(\frac{(\text{Participant Actions})_i}{\text{Number of Participants Interviewed}} \right) * \begin{pmatrix}\text{kWh Savings}\\ \text{Estimate}\\ \text{for Equipment}_i\end{pmatrix}$$

Nonparticipants who were influenced by the program may take conservation actions on their own. Awareness of conservation measures through a participant in the neighborhood, for example, may induce implementation of a conservation measure by a nonparticipant. However, to be conservative in attributing spillover effects to PG&E's CEE program, implementation of equipment was considered a spillover action if nonparticipants first learned about the equipment from contact with PG&E or their previous participation in PG&E's CEE programs. The nonparticipant spillover effect was calculated as shown below in Exhibit 2.25.

Exhibit 2.25
Nonparticipant Spillover Algorithm

$$\begin{pmatrix} \text{Total} \\ \text{Nonparticipant} \\ \text{Spillover} \\ \text{effect in kWh} \end{pmatrix} = \sum_{i=1}^{n} \begin{pmatrix} \text{Surveyed} \\ \text{Nonparticipant} \\ \text{Actions} \end{pmatrix}_i * \begin{pmatrix} \text{kWh Savings} \\ \text{Estimate} \\ \text{for Equipment} \end{pmatrix}_i$$

Estimation of spillover effects for the AEEI program dealt with two difficulties commonly observed in estimating spillover effects. First, spillover actions are usually estimated for the program as a whole. In this report, we estimated end use specific spillover actions. Second, spillover actions by participants and nonparticipants are assumed to yield the same kWh savings. In this study, we have been able to obtain the number of actions taken by both participants and nonparticipants. Thus, kWh savings together with the number of measures can be used to weight the actions taken by participants and nonparticipants, and it is not assumed that participant actions are the same as nonparticipant actions.

2.4.6 Model Diagnostics

As in estimation of any statistical models, a coefficient was estimated for each explanatory variable. A positive coefficient in the participation model indicated that the factor represented by the variable increased the probability the customer was a participant. A negative coefficient for a variable in the participation model indicates the factor represented by the variable decreased the probability the customer was a participant. Similarly, the signs of the coefficients in the implementation model indicate whether the factors represented by the variables increase (if positive) and decrease (if negative) the probability that the customer was an implementer. The four diagnostics used in this evaluation follow.

Wald Chi-square - As an indication of the explanatory power of each variable, a Wald-statistic was also produced for each coefficient. Wald Chi-square is computed as the square of the value obtained by dividing the parameter estimate by its standard error. As a general rule, the larger the magnitude of the Wald-statistic (Chi-square distribution), the greater the explanatory power of the variable. In particular, if the Wald-statistic has a magnitude exceeding 1.32, then the hypothesis that the coefficient is zero can be rejected at the 75% significance level.

Percentage of Probabilities correctly predicted – As part of the logistic procedures, SAS provides a “concordant” that reflects the percentage of probabilities correctly predicted. This statistic helps assess the quality of the logistic model. In a relative sense, a model with higher values for the concordant index has a better predictive ability than a model with lower values for the concordant index.

Max-rescaled Rsquare - A rescaled generalized coefficient of determination (Max-rescaled Rsquare) is a formal statistical test for the goodness-of-fit of the logistic regression model. It gives an objective measure of how well the specified model fits the data. The values of adjusted R-square can range between 0 and 1. As a general rule, a higher value of Max-rescaled Rsquare indicates a better fit.

Log Likelihood at zero and at convergence. - Generally, it is expected that a binary choice model without any explanatory variables has less explanatory power than a model with an appropriate combination of explanatory variables reflecting the customer's characteristics. Hence, it is expected that, for any model, Log Likelihood at convergence (that model with parameter estimates that maximize the likelihood function) will be higher than the Log Likelihood at zero (that model with all parameter estimates set to zero). As a result, we can judge how well a particular combination of explanatory variables describes the customers' choices by comparing the Log Likelihood at convergence with Log Likelihood at zero. The difference between these values indicates the explanatory power of the model: a higher difference suggests higher explanatory power.

The model results were compared with the results of the many other alternative model specifications on the basis of the above-mentioned criteria. The possibility of serious collinearity among any explanatory variables in all the models was also explored by examining the correlation matrix of the explanatory variables. The sensitivity of the results was tested for any possible collinearity. Variables with high correlation affected the estimated coefficients and the resultant net-to-gross ratios. Of the two variables with high correlation, one was selected primarily on the basis of two criteria: (1) the explanatory power of the variable as determined by the correlation with the dependent variable, and (2) the extremely high predictive power of the model as measured by the percentage correctly predicted. Of two highly correlated variables, the variable with higher explanatory power is preferred. The variable that contributes more to the predictive power as measured by concordant is preferred.

2.5 Integration of Net-and-Gross estimates

The net analysis provided a net-to-gross ratio for the pumping and related and indoor lighting end uses. Those values were applied to both the energy and demand impacts determined within the gross analysis. The participant spillover values determined within the net analysis were added to the net gross impact values. PG&E chose not to include estimated nonparticipant spillover in the net impact estimates.

3 EVALUATION RESULTS

3.1 Gross Impacts

The results of the analysis of gross savings, by end use and measure, are shown below in Exhibit 3.1.

Exhibit 3.1
Ex Post Gross Impact Results

End Use	PG&E Code *	Measure Description	N Apps.	Ex Post Savings		
				kWh	kW	Therms
Ag Pumping and Related	A1	Pump Retrofit	67	2,831,503	-	-
	A4	Pump Adjustment	2	3,777	-	-
	A41 / A42 / A43	Low Pressure Nozzles	3	463,617	42	-
	A44 / A45 / A47 / A51 / A55	Sprinkler to Micro	11	1,192,145	512	-
	AO	Customized Ag Measures	8	406,258	298	110,743
	Ag Pumping and Related End Use Total		91	4,897,300	852	110,743
Indoor Lighting	L64 / L66 / L174 / L176	Compact Fluorescent Lamps	11	143,976	31	-
	L6	Exit Signs	1	3,160	0	-
	L23-L24 / L73-L75 / L160	T-8 Lamps & Electr. Ballasts	22	95,001	5	-
	L19	Delamp Fluroescent Fixtures	1	8,096	1	-
	L26 / L81	High Intensity Discharge	34	(289,161)	(68)	-
	L31 / L36	Controls	1	-	-	-
	Indoor Lighting End Use Total		70	(38,928)	(32)	-
AG PUMPING and RELATED Plus INDOOR LIGHTING			**161**	**4,858,372**	**821**	**110,743**
AEMS PROGRAM TOTAL**			**4,721**	**7,172,261**	**-**	**-**

Data Source: 1996 PG&E Frozen MDSS Database Received on May 16, 1997
*PG&E MDSS Measure Code
**Pump Testing Only

The differences between the ex ante and ex post gross impact values are discussed below in section 3.4.

3.2 Net-to-Gross Adjustments

The summary of the net-to-gross adjustments used in the ex ante and ex post estimates of impact are shown in Exhibit 3.2. A discussion of how these values were determined follows the exhibit.

Exhibit 3.2
Summary of Net-To-Gross Adjustments

Pumping and Related End Use	Net-To-Gross (1-FR)*	Net-To-Gross SO**
EX ANTE		
kW	0.68	0.10
kWh	0.69	0.10
Therms	0.65	0.10
EX POST		
kW	0.39	0.15
kWh	0.39	0.29
Therms	0.39	0

Indoor Lighting End Use	Net-To-Gross (1-FR)*	Net-To-Gross SO**
EX ANTE		
kW	0.67	0.10
kWh	0.67	0.10
Therms	-	-
EX POST		
kW	0.79	(0.04)
kWh	0.79	(0.34)
Therms	-	-

Ag EMS	Net-To-Gross 1-FR	Net-To-Gross SO**
EX ANTE		
kW	0.54	-
kWh	0.54	-
Therms	-	-
EX POST		
kW	0.75	0
kWh	0.75	0
Therms	-	-

*Actually calculated as NTG without spillover, FR=free ridership

**SO = spillover

3.2.1 Discrete Choice Analysis Model Results

This section discusses the results of Discrete Choice Analysis.

Step One: Results of Participation Models

End use-specific logit models were estimated for customers’ decisions to participate in the program. The results of these models are discussed in this section for each end use.

Before selecting the model specification presented here, many alternative specifications were considered with fewer/more variables. Exclusion of a variable from the model is due to any of the following reasons: (1) to avoid loss of observations, (2) insignificant influence on the dependent variable, (3) to eliminate multicollinearity, or (4) deterioration in the predictive power of the model as measured by a concordant ratio.

3.2.1.1 Pumping and Related End Use Participation Model

To qualify for a rebate for pump repair, or low-pressure sprinkler nozzles, or micro irrigation systems, customers had to repair a pump or install efficient equipment. Information on pump repair or installation of efficient equipment was collected via telephone surveys. Exhibit 3.3 summarizes the final pumping and related end use participation model sample reduction.

Exhibit 3.3
Pumping and Related End Use Participation Model Sample Reduction

Sample Description	Total Complete Survey	Surveyed and are Pumping or Related	Surveyed & Took Pumping Action
Participants	97	49	49
Nonparticipants	76	42	17
Total	173	91	66
Missing Information For Explanatory Variables	-	-	-2
Final Sample for Participation Model	-	-	**64**

Of a total of 91 pumping and related end use participants 49 completed a telephone interview. In addition a telephone interviews were completed by 76 nonparticipants, of which 42 had a descriptive address. Empirical experience has shown that, for the agricultural sector, descriptive customers addresses represent pumping sites. From the 42 nonparticipant customers, there were 17 customers who either repaired their pump or installed low pressure sprinkler nozzles or micro irrigation systems outside the program, even though they could have qualified to participate in the program and receive rebates. We thus had a pool of 66 total customers(49 plus 17) who implemented any of the efficient pumping measures. Information on some of the explanatory variables was missing for two customers; so they were eliminated from the analysis. Thus the participation model was estimated for the pumping and related end use using the actual choices made by 64 customers (66 minus 2). The results of the participation model are presented below in Exhibit 3.4.

Exhibit 3.4
Results of Participation Model for the Pumping and Related End Use

Explanatory Variables	Parameter Estimates	Wald Chi-Square
Intercept	-1.37	0.52
Dummy=1 if a general farm	-2.71*	4.34
Importance of the reliability of current equipment.	4.06*	3.94
Dummy=1 if business is operated by company and not a family	-2.44*	2.85
Dummy=1 if customer was contacted by PG&E several times before 1996.	2.18*	3.47
Number of pumps	0.07*	6.87
Dummy=1 if located in Southern San Joaquin Valley	-4.64*	8.69
Number of observations	64	
Number of participants	47	
Number of nonparticipant implementers	17	
Percentage of probabilities correctly predicted (Concordant)	92.6	
Max-rescaled Rsquare	0.7	
-2(LLR-LLU)	40.4	

All the coefficients marked * are statistically different from zero at 95% significance level.

Results of the participation model for the pumping and related end use indicate that the model predicts the probability of participating correctly for 93% of the customers. Overall, the model indicated that:

The analysis identified the following categories of customers as <u>less</u> likely to participate in the AEEI pumping measures: (1) customer's (or a decision maker's) business who described themselves as a general farm. This is true even though on a farm, generally, energy consumption by the pumping and related end use is greater than the indoor lighting end use; (2) Customers who describe their businesses/organization as operated as a company; and (3) customers located in San Joaquin Valley.

The analysis identified that customers with a greater number of pumps are <u>more</u> likely to participate in the AEEI pumping measures. More pump repairs require greater investments. As a result, the awareness is higher about the market in general and PG&E's rebate offer in particular. Participation in these programs can reduce the financial burden of such investments. Similarly, if the reliability of the current equipment is important to the customer, the customer is more likely to be aware of different ways to maintain the high reliability of the equipment for a longer period at the least possible cost. This may result in installation of efficient equipment via the AEEI program.

In situations where a PG&E representative contacts the customer several times, the representative may urge the customer toward efficient equipment. The customer accumulates knowledge each time he or she is in contact with the representative and, as a result, is convinced of the benefits of efficient equipment. This results in eventual implementation of efficient equipment via the AEEI program.

3.2.1.2 Indoor Lighting End Use Participation Model

To qualify for rebates for lighting, customers had to replace a fixture with a compact fluorescent lamp, a T-8 lamp and electronic ballast fixture, HID fixture, or had to delamp a fluorescent fixture. The information on the quantity and type of lighting equipment installed by the customers was verified during the on-site audits. Exhibit 3.5 summarizes the final sample reduction for the Indoor Lighting Participation Model.

Of a total of 173 customer decisions, 48 received rebates from PG&E to install efficient lighting. Of the remaining 125 customer decisions, 17 installed efficient lighting outside the program, though they could have been qualified to participate in the program and receive rebates.

Exhibit 3.5
Indoor Lighting Participation Model Sample Reduction

Sample Description	**Total Complete Survey**	**Surveyed and are Indoor Lighting Applicable**	**Surveyed & Took Indoor Lighting Action**
Participants	97	48	48
Nonparticipants*	76	125	17
Total	173	173	65
Missing Information For Explanatory Variables	-	-	0
Final Sample for Participation Model	-	-	**65**

*Note: All survey completed as part of the evaluation were considered potential indoor lighting nonparticipants.

The participation model for the indoor lighting end use was estimated using the actual choices made by 65 customers. The results of the participation model are presented in Exhibit 3.6.

Exhibit 3.6
Results of Participation Model for the Indoor Lighting End Use

Explanatory Variables	Parameter Estimates	Wald Chi-Square
Intercept	0.41	0.19
Dummy=1 if business can be described as dairy farm, winery, packing plant, or a cold storage.	1.45*	2.74
Dummy=1 if business is operated by company and not a family	0.91	1.71
Dummy=1 if primary source of advice/information is PG&E	1.87*	6.25
Importance of improving the resale value of the property.	-0.93	1.51
Usage category based on the annual kWh usage.	-0.42	1.49
Number of observations	65	
Number of participants	48	
Number of nonparticipant implementers	17	
Percentage of probabilities correctly predicted (Concordant)	80.3	
Adjusted R square	0.3	
-2(LLR-LLU)	15.4	

All the coefficients are significantly different from zero at 75% significance level. Those marked * are statistically different from zero at 95% significance level.

Results of the participation model for the indoor lighting end use indicate that the model predicts the probability of participating correctly for 80% of the customers. The results indicated that:

Customers involved with dairy farms, wineries, packing plants or cold storage facilities are more likely to participate in the program. Unlike the pumping and related end use, businesses that are operated as a company rather than a family are more likely to participate. Similarly, those customers who seek advice/information from PG&E when planning to invest in energy-using equipment are more likely to implement lighting equipment via the AEEI program. In other words, implementation of lighting measures is induced by PG&E for these customers.

However, customers with greater annual usage are not likely to participate. Likewise, customers who consider improving the resale value of their property as an important factor in their decision to install high-efficiency equipment do not participate in AEEI programs. It is interesting to observe that customers who are conscious of improving the resale value of their property do not consider implementing efficient measures. This could be because the customers do not think that implementing efficient lights would actually improve the resale value of their property. This could happen because of high energy costs, at least in the short run, or due to better performance but higher energy costs as a result of implementing energy-efficient lighting.

3.2.1.3 Derivation of Log Sum Variables

Using the estimated coefficients in the participation model and actual values/responses of all the customers (including nonparticipants), Log Sum variables for both end uses were calculated. Though the coefficients were estimated for participant and nonparticipant implementers only, the estimated coefficients were also used to forecast the value of the Log Sum variable in nonparticipant non-implementers. The Log Sum indicates how customers view participation (implementing efficient measures with or without rebates). The way in which customers view these options affects their decision to implement. For example, if all customers viewed implementation with rebates as equivalent to implementation without rebates, the estimated coefficient of Log Sum variable would be zero and the program would have no effect. Since the view of participation, as represented by Log Sum, affects the customer's decision to implement, Log Sum was calculated so that it could be included in the implementation model as an explanatory variable.

3.2.1.4 Pumping and Related End Use Implementation Model

End use-specific logit models were estimated for the customer's decision to implement efficient pumping measures. As described earlier, it is inappropriate to include customers who do not have any use for pumps or related measures in their businesses to represent pumping nonparticipants. Therefore, customers with descriptive addresses were assumed to have a farm with a pump or requirement for a pump or related measures. As illustrated in Exhibit 3.7, 91 customers had descriptive addresses and 49 of those were participants. Of a total of 91 eligible customers for pumping and related end use, information was missing for 9 customers. Therefore, these 9 customer decisions were eliminated from the analysis. Of the remaining 82 customers, 58 had either repaired a pump, or implemented low-pressure sprinkler nozzles or micro irrigation systems. The pumping and related end use implementation model was estimated using the actual choices made by these 82 customers.

Exhibit 3.7
Pumping and Related End Use Implementation Model Sample Reduction

Sample Description	Total Complete Survey	Surveyed and are Pumping or Related	Surveyed & Took Pumping Action	Surveyed & Did Not Take Actions
Participants	97	49	49	0
Nonparticipants	76	42	17	25
Total	173	91	66	25
Missing Information For Explanatory Variables	-	-9	-8	-1
Final Sample for Implementation Model	-	**82**	**58**	**24**

The results of the implementation model are presented in Exhibit 3.8.

Exhibit 3.8
Results of Implementation Model for the Pumping and related end use

Explanatory Variables	Parameter Estimates	Wald Chi-Square
Intercept	-8.46*	8.41
Dummy = 1 if a general farm	2.45*	5.49
Dummy=1 if the customer categorize the business small	-1.24	1.62
Dummy=1 if located in Sacramento Valley	-4.55*	7.54
Importance of low purchase cost in the decision to install efficient equipment	3.95*	3.46
Importance of improving the resale value of the property in the decision to install efficient equipment	2.15*	4.72
Dummy=1 if primary source of information/advice for energy efficient equipment is general media like TV, radio or newspaper	2.22*	2.97
Dummy =1 if a group decision process at the business when deciding to install energy-efficient improvements	2.3*	2.97
Dummy=1 if participated in PG&E's Customer Energy Efficiency program previously	1.76*	4.73
Log Sum	1.1*	8.92
Number of observations	82	
Number of implementers	58	
Number of non-implementers	24	
Percentage of probabilities correctly predicted (Concordant)	93.7	
Adjusted R square	0.7	
-2(LLR-LLU)	50.6	

All the coefficients are significantly different from zero at 75% significance level. Those marked * are statistically different from zero at 95% significance level.

Results of the implementation model for pumping and related end use indicate that the model correctly predicts the probability of implementing for 94% of the customers. Other indications are that:

If customers' businesses can be described as a general farm, they are more likely to implement energy-efficient measures in the pumping and related end use. It is important to note that the same category of customer is less likely to participate but is more likely to implement. This indicates that these customers are convinced of the benefits of a pump repair, micro irrigation systems, or low-sprinkler nozzles; therefore, they do not need the financial incentives to implement the measures. At the same time, it is possible that the hassles of participating in the program are greater than the financial benefits and, hence, these customers are discouraged from participating in the program.

If customers considered the business/organization as small when compared to similar businesses, they are less likely to implement the measure. This may imply that the benefits of energy-efficient equipment are small compared to the investment and these customers may require financial incentives to implement efficient measures in the pumping and related end use. Also, customers located in the Sacramento valley are less likely to implement efficient measures in the pumping and related end use.

Customers who consider the low purchase cost or improving the resale value of their property is important in their decision to install high-efficient equipment, are more likely to implement efficient measures in the pumping and related end use.

If in a business/organization, the decision to install energy-efficient improvements is made by a group of people rather than just the owner, farm manager, or engineers, the business/organization is more likely to implement efficient measures. The chance is greater that at least someone in a group has heard of or experienced the benefits of efficient equipment and are therefore more likely to implement efficient equipment.

The primary information source is an important factor. If a customer learned of efficient equipment through the general media, such as television, radio, or the newspaper, he or she is more likely to implement efficient equipment. Customers who previously participated in PG&E's demand-side management programs are more likely to get their pumps repaired or install micro irrigation systems or low-pressure sprinkler nozzles. Satisfied program participants are likely to implement efficient measures.

The estimated coefficient of the Log Sum variable is one, suggesting that the way in which the participants viewed the option to participate was not very different from nonparticipants.

3.2.1.5 Indoor Lighting End Use Implementation Model

The breakdown of the sample for the Indoor Lighting Implementation Model is presented in Exhibit 3.9. Information on some of the explanatory variables for the lighting implementation model was missing for 13 customers and eliminated them from the analysis. Of the remaining total of 160 customers, 62 implemented efficient lighting and 98 did not. The lighting implementation model was estimated using the actual choices made by these 160 customers.

Exhibit 3.9
Indoor Lighting Implementation Model Sample Reduction

Sample Description	Total Complete Survey	Surveyed and are Indoor Lighting Applicable	Surveyed & Took Indoor Lighting Action	Surveyed & Did Not Take Actions
Participants	97	48	48	0
Nonparticipants*	76	125	17	108
Total	173	173	65	108
Missing Information For Explanatory Variables	-	-13	-3	-10
Final Sample for Implementation Model	-	**160**	**62**	**98**

*Note: All survey completed as part of the evaluation were considered potential indoor lighting nonparticipants.

Results of this model are presented in Exhibit 3.10.

Exhibit 3.10
Results of Implementation Model for the Indoor lighting end use

Explanatory Variables	Parameter Estimates	Wald Chi-Square
Intercept	-1.58	0.9
Dummy = 1 if business has been operating at this location for more than 10 years	-0.72*	2.49
Dummy =1 if a group decision process at the business when deciding to install energy-efficient improvements	-0.8*	2.99
Dummy =1 if contacted by PG&E prior to implementation decision in 1996	-0.51	1.35
Dummy = 1 if primary source of information is a brochure in the mail or a bill insert	0.69*	2.55
Dummy = 1 if primary source of information regarding efficient equipment is vendor or contractor	0.47	1.22
Importance of improving the efficiency of the equipment	1.79*	1.8
Importance of low performance of current equipment	-1.25	1.74
Dummy=1 if the customer categorizes the business medium	0.55	1.62
Dummy=1 if a general farm, ranch, ornamental nursery, indoor crops, vineyard	(-0.45)	0.98
Log Sum	0.98*	14.16
Number of observations	160	
Number of implementers	62	
Number of non-implementers	98	
Percentage of probabilities correctly predicted (Concordant)	77.8%	
Adjusted R square	0.3	
-2(LLR-LLU)	41.0	

All the coefficients without brackets are significantly different from zero at 75% significance level. Those marked * are statistically different from zero at 95% significance level.

Results of the lighting implementation model indicate that the model correctly predicts the probability of implementing for 78% of the customers. Other indications are that:

If the business or organization has been operating at the same location for more than 10 years, or if the implementation decision is made by a group, customers are less likely to implement efficient lighting. This may be an indication that experienced agricultural customers are not concerned about lighting equipment either because lighting is not a very important component in energy use or because they are not convinced of the overall net benefits of efficient lighting. The hypothesis about the lack of concern is reinforced by a negative coefficient of the variable labeled "importance of low performance of current equipment." The negative coefficient indicates that even if the low performance of the current lighting is important to customers, they are not likely to implement efficient lighting. The hypothesis regarding lack of confidence among agricultural customers as to the benefits of efficient lighting is also reinforced by the negative coefficient of previous contact by PG&E representatives. This indicates that although the customer was contacted by a PG&E representative prior to his or her decision in 1996, the customer is not likely to implement efficient lighting equipment.

On the other hand medium-sized customers, or those who seek advice or information from vendors or contractors about efficient equipment, or those who believe that improving the efficiency of equipment at their site is important, are more likely to implement any of the efficient lighting measures.

The estimated coefficient of the Log Sum variable is statistically different from zero at a 99% significance level. This suggests that participants do not consider the option of implementing efficient measures with rebates the same as implementing without rebates. Customers were unlikely to implement efficient lighting if they were not offered a rebate.

3.2.1.6 Calculation of Net-to-Gross Ratios

To calculate the net-to-gross ratios, first the gross, naturally occurring, and net effects of the program were calculated. The gross effect is the probability of implementing an energy-efficient measure under the program. The naturally occurring effect is the probability of a customer implementing a measure in the absence of the program. The net effect is the difference between the gross and naturally occurring effects. Finally, the net-to-gross ratio is the ratio of net and gross effects. This ratio is without units and can be applied to estimates of gross savings in order to calculate net savings.

As a part of the net-to-gross ratio calculation, we also calculated a confidence interval around the point estimate. The confidence interval reflects the fact that the true net-to-gross ratio may be different from the point estimate. The interval represents a range of values the true net-to-gross ratio could reasonably have. Since the point estimate of the net-to-gross ratio is a complex function of probabilities derived from two nested equations, there is no straight forward method to calculate confidence interval. However, the confidence interval is calculated by taking the standard error of one of the most important coefficients (for example, the coefficient of the Log Sum variable), and calculating the maximum and minimum net-to-gross ratio at the 90% significance level. The gross and net effects for pumping and related and indoor lighting end uses are calculated using end use-specific participation and implementation models to obtain end use-specific net-to-gross ratios. The net-to-gross ratio estimates and 90% confidence intervals around the point estimates for pumping and related and indoor lighting end use are given in Exhibit 3.11 below.

Exhibit 3.11
End Use Specific Net-To-Gross Ratios (without spillover) Using Discrete Choice Analysis

	Pumping	Lighting
Estimate of net-to-gross Ratio (DCA)	39%	79%
90% Confidence Interval (DCA)	27%---45%	65%---88%

The effectiveness of the program varies across the two end uses. Approximately six of ten customers would have implemented efficient pumping measures without any incentive, whereas only two of ten customers would have implemented efficient lighting measures. The confidence interval around the net-to-gross ratio for the pumping and related end use is slightly narrower than for the indoor lighting end use.

A comparison of these results to the two previous PG&E agricultural evaluation programs indicates that the program years have very similar net effects for the pumping and related end use when the 39% for 1996 is compared to the program effects in past years (1-FR for 1994 was 36% and for 1995 was 32%). While this is the case, we should still expect variations from year to year. First of all, we must recognize that estimates of net-to-gross ratios for a given program year or over multiple program years is not independent of changes in the mix of customers or changes in the program design, or, most importantly, changes in the percentage of nonparticipants who had some direct contact with the program and market transformation. As programs become mature, the changes in the market penetration of efficient pumping and lighting equipment leads to actions by customers independent of the program. Even though the program threshold for equipment efficiency is set higher each year, awareness of the program increases each year and leads to higher indirect effects and lower direct effects, as measured in terms of net effects.

However, for lighting measures the net-to-gross ratio is lower than past years (1-FR not evaluated for Indoor Lighting in 1994 and was 95% in 1995). It is important to note that evaluation in the past two years did not involve a comparison of participants with nonparticipants. This year, the survey of nonparticipants indicated that 13.6% (17 out of 125, Exhibit 3.9) of lighting nonparticipants implemented efficient lighting outside the program. This rate is much lower than the implementation rate of 40.5% (17 out of 42, Exhibit 3.7) among nonparticipants for the pumping and related end use. The net-to-gross ratio for both end uses can also be compared with the net-to-gross ratios using another approach. In the next section, the self-reports approach and results are discussed followed by a comparison of net-to-gross ratios from both approaches.

3.2.1.7 Self-Report Analysis Results

It is important to note that the choice of the question to reflect free-ridership is very subjective. However, after defining a customer as either a free-rider or not a free-rider, a logistic model predicting free-ridership was developed using self-report data. Detailed discussion of the self-report model results is provided in Appendix A. Net-to-gross ratios were estimated using the predicted probability of free-ridership. The net-to-gross ratio was derived as 1-(Average predicted probability of free-ridership). Where the average is over participants for each end use. Estimated net-to-gross ratios for two end uses are presented in Exhibit 3.12.

Exhibit 3.12
End Use Specific Net-To-Gross Ratios (without spillover) Using Self-Report Analysis

	Pumping	Lighting
Estimate of net-to-gross (Self-Report Analysis)	38%	59%
Confidence Interval* (Self-Report Analysis)	35%---92%	6%---98%

*Confidence interval around Self-Report net-to-gross is derived using consistency and inconsistency of the responses.

The net-to-gross ratios for both end uses are very different. Six of ten customer decisions would have been to install an efficient pumping measure without any incentive, and, four of ten customer decisions would have been to install an efficient lighting measure without any incentive. The net-to-gross ratio for the indoor lighting end use is higher than that of the pumping and related end use. The confidence interval is very large for both end uses. The range within which the net-to-gross ratios vary is from 57% for the pumping and related end use and 92% for the indoor lighting end use.

Comparing the net-to-gross ratios from DCA and self-report analysis indicate that:

- The range of net-to-gross ratios from self-report analysis for both pumping and related and indoor lighting end uses is greater than the range of net-to-gross ratios for both the end uses using DCA.
- The DCA net-to-gross estimate is within the self-report range, and the self-report estimate is within the DCA range. Thus, both estimates converge more for pumping measures than lighting measures.

There are three reasons for using the DCA net-to-gross ratios for both end uses. One, the Protocols require that the estimation procedure use a comparison group, and DCA uses a comparison group. Second, the range around the net-to-gross estimate is narrower and, hence, indicates greater stability. Third, the point estimate is within the range of self-report estimates.

The net-to-gross ratio from the DCA model results was used in conjunction with spillover to determine the net impacts of the program.

3.2.2 Estimation of Spillover

From the analysis of the information collected via telephone survey of 67 unique participants and 76 unique nonparticipants, a total of 12 participants and 24 nonparticipants implemented conservation measures (lighting or pumping) outside the program. However, they learned about the installed equipment via PG&E or their previous participation in PG&E's CEE or EMS programs. The spillover actions among participants and nonparticipants by equipment type is presented in Exhibit 3.13.

Exhibit 3.13
Participant and Nonparticipant Spillover Actions

Equipment Type	Units	Participant Actions	Nonparticipant Actions
Deep well pumps repaired	Pumps	23	43
Low-pressure sprinkler nozzles	Nozzles	1000	615
Acres converted to/installed new micro irrigation system	Acres	192	201
Compact fluorescent lamps	Lamps	5	0
Fluorescent fixtures delamped	Fixtures	0	4
T-8 lamp and electronic ballast fixtures	Fixtures	166	0
HID fixtures	Fixtures	2	0
Total number of unique customers interviewed	Customers	67	76

The results of spillover effects indicate:

- Participant and nonparticipant spillover effect for the pumping and related end use is higher than that for the indoor lighting end use.
- Nonparticipant spillover effect for the pumping and related end use is higher than participant spillover effect for the pumping and related end use, whereas, the nonparticipant spillover effect for the indoor lighting end use is less than the participant spillover effect for the indoor lighting end use.

This is a result of two factors. One, customers may use the pumping and related end use more than the indoor lighting end use. Therefore, they are more aware of the latest technology and better ways to save energy. Two, the benefits of conservation measures in the pumping and related end use are far more convincing and therefore a greater proportion of customers take conservation measures in the pumping and related end use.

Since the spillover effects are the consequence of conservation measures that are implemented outside the program but as a result of program influence, they should be incorporated in estimating overall net effects of the program. However, spillover estimation faces three issues:

- First, it is extremely difficult to estimate year-specific spillover effects or effects associated with programs in any particular year. Estimation of year-specific spillover effects is possible only if customers can reliably state whether they would have implemented the measure in absence of the 1996 rebate program. For mature programs like the AEEI programs, it is impossible to obtain a reliable answer regarding which year's program was the primary source of information for the customer.

- Second, it is difficult to estimate program-specific spillover effects. Since customers can participate in both AEMS and AEEI programs in the same year, it is difficult to differentiate whether a customer implemented a conservation measure outside the program as a result of the AEEI or the AEMS program. Therefore, it is possible that spillover effects of the AEMS program in the same year are not separate from the spillover effects of the AEEI program in 1996 alone.
- Third, because of the issue of lagged effects, it is equally possible that a participant in the 1996 AEEI program may have participated in previous years' AEMS programs. The spillover actions in 1996, outside the 1996 AEEI program, may have been a result of participation in previous years.

For these reasons, it is rather difficult to estimate spillover effects at the same level of precision at which we have estimated net-to-gross ratios without spillover for the AEEI program.

Considering these issues, PG&E has chosen to include in the net impacts only savings as a result of spillover actions by (1) the participants and (2) nonparticipants that were actually surveyed. The information provided by the surveyed participants was leveraged up to the participant population by the number of applications to provide a total number of implemented measures. Nonparticipant spillover estimates were <u>not</u> leveraged to the population. Only actual measures reported by nonparticipants during the nonparticipant surveys were claimed in the spillover calculation. Participant spillover impacts per measure in kWh are calculated as shown below in Exhibit 3.14. The nonparticipant spillover algorithm is shown in Exhibit 2.25.

Exhibit 3.14
Participant Spillover Impacts in kWh Algorithm

$$\begin{pmatrix}\text{Total Participant}\\ \text{Spillover}\\ \text{Impact in kWh}\end{pmatrix} = \sum_{i=1}^{n} \begin{pmatrix}\dfrac{\text{Number of Actions by Participants}}{\text{Number of Participants interviewed}}\end{pmatrix}_i * \begin{pmatrix}\text{Total}\\ \text{Participants}\\ \text{in the Program}\end{pmatrix}_i * \begin{pmatrix}\text{Gross kWh per unit}\\ \text{savings estimated}\\ \text{for AEEI Program}\end{pmatrix}_i$$

Per-unit impact values from the AEEI analysis were used to determine the total spillover impacts. These are presented in Exhibit 3.15.

Exhibit 3.15
Spillover Impacts for Participants and Nonparticipants

Participants

Measure	Participants Surveyed	Participants Rate Implemented	Participants Total	Units of Measure	kWh per Unit	kW per Unit	Population Impact kWh	Population Impact kW
Deep Wells repaired	23	0.35	43	Pump	12,776	-	547,623	-
Low sprinkler Nozzles *	1000	15.15	1,864	Nozzle	18.4	0.002	34,291	4
Micro Irrigation system *	192	2.91	358	Acres	484	0.220	173,184	79
				Total Pumping and Related			*755,098*	*83*
Compact Fluorescent	5	0.08	9	Lamp	53	0.023	489	0.21
Number of fluorescent fixtures delamped	0	0.00	-	Fixtures	184	0.031	-	-
Number of T-8 lamp and electronic ballast fixtures *	166	2.52	309	Fixtures	44	0.005	13,457	2
Number of HID fixtures	2	0.03	4	Fixtures	(408)	(0.189)	(1,520)	(0.70)
				Total Indoor Lighting			*12,426*	*1*

* Information missing for 1 account

Nonparticipants

Measure	Nonparts. Surveyed	Units of Measure	kWh per Unit	kW per Unit	Nonparticipant Impact kWh	Nonparticipant Impact kW
Deep Wells repaired	43	Pump	12,776	-	549,365	-
Low sprinkler Nozzles *	615	Nozzle	18.4	0.002	11,316	1
Micro Irrigation system *	201	Acres	484	0.220	97,284	44
		Total Pumping and Related			*657,965*	*46*
Compact Fluorescent	0	Lamp	53	0.023	-	-
Number of fluorescent fixtures delamped	4	Fixtures	184	0.031	736	0
Number of T-8 lamp and electronic ballast fixtures *	0	Fixtures	44	0.005	-	-
Number of HID fixtures	0	Fixtures	(408)	(0.189)	-	-
		Total Indoor Lighting			*736*	*0*

* Information missing for 1 account

3.3 Net Impacts

End use specific net impacts with no spillover were calculated as shown in Exhibit 3.16.

Exhibit 3.16
End Use Net Impact with No Spillover Algorithm

$$(\text{Net Impact in kWh})_e = (\text{Gross kWh})_e * (\text{Net - To - Gross Ratio})_e$$

Where the subscript “e” indicates the end use.

Whereas overall net impacts for each end use was calculated as shown in Exhibit 3.17. As indicated in the algorithm, the gross estimates were multiplied by the net-to-gross values from the DCA analysis and the participant and nonparticipant spillover values added in to obtain the ex post net impacts shown in Exhibit 3.18.

Exhibit 3.17
Combined Net Impact Algorithm

$$\begin{pmatrix} \text{Overall} \\ \text{Net Impact} \\ \text{in kWh} \end{pmatrix}_e = \left[(\text{Gross kWh})_e * (\text{Net - To - Gross Ratio})_e \right] + \begin{bmatrix} \text{Spillover Savings} \\ \text{in kWh} \end{bmatrix}_e$$

Exhibit 3.18
Ex Post Net Impact Results

End Use	PG&E Code *	Measure Description	N Apps.	Ex Post Savings kWh	kW	Therms
Ag Pumping and Related	A1	Pump Retrofit	67	1,104,286	-	-
	A4	Pump Adjustment	2	1,473	-	-
	A41 / A42 / A43	Low Pressure Nozzles	3	180,811	16	-
	A44 / A45 / A47 / A51 / A55	Sprinkler to Micro	11	464,936	200	-
	AO	Customized Ag Measures	8	158,441	116	43,190
	Participant Spillover		-	755,098	83	-
	Nonparticipant Spillover		-	657,965	46	-
	Ag Pumping and Related End Use Total		91	3,323,010	461	43,190
Indoor Lighting	L64 / L66 / L174 / L176	Compact Fluorescent Lamps	11	113,741	24	-
	L6	Exit Signs	1	2,496	0	-
	L23-L24 / L73-L75 / L160	T-8 Lamps & Electr. Ballasts	22	75,051	4	-
	L19	Delamp Fluroescent Fixtures	1	6,396	1	-
	L26 / L81	High Intensity Discharge	34	(228,438)	(54)	-
	L31 / L36	Controls	1	-	-	-
	Participant Spillover		-	12,426	1	-
	Nonparticipant Spillover		-	736	0	
	Indoor Lighting End Use Total		70	(17,591)	(24)	-
AG PUMPING and RELATED Plus INDOOR LIGHTING			**161**	**3,305,419**	**437**	**43,190**
AEMS PROGRAM TOTAL**			**4,721**	**5,379,196**	**-**	**-**

Data Source: 1996 PG&E Frozen MDSS Database Received on May 16, 1997
*PG&E MDSS Measure Code
**Pump Testing Only

The combined net-to-gross ratio is the ratio between the ex post net with the spillover included and the ex post gross impacts. Because the energy and demand spillover do not have a similar percentage applied, the combined net-to-gross ratios are different for the energy and demand. For example, combined net-to-gross ratio is calculated as shown in Exhibit 3.19.

Exhibit 3.19
Combined Net-to-Gross Algorithm

$$\begin{pmatrix} \text{Combined} \\ \text{Net - To - Gross} \\ \text{Ratio} \end{pmatrix}_e = \frac{\left[(\text{Overall Net Savings in kWh})_e \right]}{(\text{Gross kWh})_e}$$

And the end use specific spillover ratio reported in the executive summary is calculated as shown in Exhibit 3.20.

Exhibit 3.20
Spillover Ratio Algorithm

$$\begin{pmatrix}\text{Spillover Ratio} \\ \text{(SO)}\end{pmatrix}_e = (\text{Overall Net-To-Gross Ratio})_e - (\text{Net-To-Gross Ratio})_e$$

These values are shown in the executive summary.

Differences between the ex ante and ex post net values are discussed below in section 3.5.

3.4 Gross Realization Rates

The realization rates were determined by dividing the ex post gross estimates by the ex ante gross estimates. These values are shown in Exhibit 3.21.

Exhibit 3.21
Gross Impact Realization Rates

End Use	PG&E Code *	Measure Description	N Apps.	Gross Realization Rates		
				kWh	kW	Therms
AG Pumping and Related	A1	Pump Retrofit	67	1.52	-	-
	A4	Pump Adjustment	2	0.28	-	-
	A41 / A42 / A43	Low Pressure Nozzles	3	2.00	1.11	-
	A44 / A45 / A47 / A51 / A55	Sprinkler to Micro	11	1.16	0.74	-
	AO	Customized Ag Measures	8	1.00	0.95	1.00
	Ag Pumping and Related End Use Total		91	1.38	0.63	1.00
Indoor Lighting	L64 / L66 / L174 / L176	Compact Fluorescent Lamps	11	0.29	0.37	-
	L6	Exit Signs	1	1.00	1.00	-
	L23-L24 / L73-L75 / L160	T-8 Lamps & Electr. Ballasts	22	0.65	0.21	-
	L19	Delamp Fluroescent Fixtures	1	1.00	0.47	-
	L26 / L81	High Intensity Discharge	34	(0.10)	(0.14)	-
	L31 / L36	Controls	1	-	-	-
	Indoor Lighting End Use Total		70	(0.01)	(0.05)	-
AG PUMPING and RELATED Plus INDOOR LIGHTING			**161**	**0.68**	**0.42**	**1.00**
AEMS PROGRAM TOTAL**			**4,721**	**0.33**	**-**	**-**

Data Source: 1996 PG&E Frozen MDSS Database Received on May 16, 1997
*PG&E MDSS Measure Code
**Pump Testing Only

The reasons the realization rates deviate from 1.0 are:

Pump Repair – The evaluation estimate for the pump repair measure used the operating pump efficiency from on-site pump tests, together with some data from the pump test database, to determine an operating plant efficiency ratio of 14.1%. This operating plant efficiency ratio was applied regardless of pump horsepower. The operating plant efficiency ratio was applied to the 1996 kWh usage from the billing data. The evaluation operating plant efficiency ratio is lower than the ex ante operating plant efficiency ratio assumption of around 19%. However, the measure shows an energy realization rate of 1.52. This is due primarily to a realization rate of 0.7 being applied to the ex ante estimate of impact as a result of a previous evaluation. Without this realization rate, the gross realization rate would have been 1.07.

The usage increased between 1995 and 1996 for the participants. Why the usage increased is open to speculation. It could be due to less canal water being available to the growers or to an increased price for the water. Crop needs may have changed between the two years as well. Another possibility is that it simply resulted from a different mix of participants between 1995 and 1996. When using the billing data, it was assumed that one account represented one pump, with no other loads. However, the on-site audits indicated which accounts have more than one pump on the meter. These extra loads were taken out of the billing data for the known on-site audited accounts. For those accounts with no on-site audits (31%), the original hypothesis was maintained. Using this method, the summed 1995 usage from billing data compared to the MDSS kWh usage (the previous 12-month usage) is quite close (1995 billing data is 98% of MDSS data). Therefore, this method was deemed valid for using the 1996 billing data to determine savings. The analysis, based on measure pump loads, indicated no demand savings attributable to pump repair. The kW demand savings were set to zero across the population.

Pump Adjustment – The per-unit ex ante pump adjustment came from applying an 11% savings to an average kWh usage of 125,909 kWh and then multiplying it by a realization rate of 0.7. Based on previous evaluations, typical savings from a pump adjustment is more likely to be around 1.5%. The ex ante kWh usage was multiplied by 1.5% to obtain the ex post impact. The ex ante gross impact estimate of 13,573 kWh was divided by the ex post savings to bring the realization rate down to 0.28.

Low-Pressure Sprinkler Nozzles – There are only three customer applications in this measure category. The evaluation went on-site for two of the three applications. One site did not reduce pressure in an acceptable way (i.e., used a butterfly valve), and thus lost all savings. The estimate of savings for the audited sites were applied to each site separately, and the weighted average impact per nozzle was applied to the one remaining application.

The one audited site that showed an impact had an operating plant efficiency that was around 25% more efficient than ex ante estimates (0.55 ex ante versus 0.70 ex post). This site also used fewer nozzles per acre than estimates for a solid-set system. While the site was paid for a solid set system, the irrigation nozzles were placed in the ground in May and taken out in September, prior to harvest. So while many solid set systems averaged together may use about 35 nozzles per acre, this site used 16.7 nozzles per acre. These differences between the ex ante and ex post variables account for much of the higher realization rate seen in this measure.

While the ex post estimate of savings indicates a realization rate of 2.00, this does not signify that assumptions that used the ex ante impact estimates should be changed for any future programs. The ex ante estimate of savings used large population averages of acreage, crops grown, and sprinkler system types to determine the savings. It is not surprising that when three individual sites are averaged, they are not close to the averages used within the ex ante estimates. For a larger population of rebated measures, the ex ante estimates would most likely fall closer to the ex post than seen in this evaluation.

Micro-Drip Irrigation Conversion – Similar to the low-pressure sprinkler nozzle measure, this measure has few applications (11) within the program and represented only six unique customers. The on-site audits visited ten of the eleven application sites and five of the six unique customers. The analysis determined a kWh and kW impact for each of these sites and applied them individually. The last site used an average realization rate of the ten audited sites applied to the ex ante estimate to determine savings.

While the average kWh/acre seen in the evaluation was less than the ex ante kWh/acre value (590 versus 644), there were a few applications with greater kWh impact than the ex ante estimate. The two with the greatest differences showed an AF/acre value that was quite a bit higher than the ex ante estimate (e.g., 2.38 ex ante versus 3.79 ex post). That variable, combined with a higher OPE ex post than ex ante, most likely accounts for the majority of differences.

Similar to the low-pressure sprinkler nozzle measure, the realization rate of 1.16 for gross savings does not indicate that the ex ante assumptions or algorithms should be changed for any future programs.

Customized Ag Measures – There were eight custom sites within the program. All were audited. Each audit found that the equipment is in place and functioning properly. Paperwork review indicates that all applications except one have assumptions that are reasonable and algorithms that are properly implemented. One site had the peak demand pulled incorrectly from the billing data and this slightly decreased the ex post kW savings.

Compact Fluorescent and T8 lamps – These two measures (a summing of multiple PG&E measure codes), have a kWh realization rate below 1.0 primarily due to the average hours applied within the evaluation being lower than the ex ante value (2,301 and 2,313 ex post respectively versus 4,000 hours for the ex ante). The peak operating factor for the hours from 3 PM to 4 PM is 0.47, lower than the ex ante estimated peak operating factor of 0.67. This accounts for the difference between the ex ante and ex post kW estimates of savings.

Exit Signs, Delamped Fluorescent Fixtures, and Controls –There was no known previous fixture type for the exit signs, so the ex ante estimate was applied for both kWh and kW savings. The delamped sites were not visited during the on-site audits. The ex ante kWh was used for the ex post kWh estimate, while the ex post kW peak operating factor was applied to the ex ante kW. The controls measure was audited and found to be not operating as it should (lights were left on 24 hours a day), so no savings were applied for this measure.

High-Intensity Discharge – Buildings of Uniform Building Code groups I and U do not have the California Energy Standards applied to them.[1] These groups include buildings such as hospitals, daycare, nursing homes, prisons, private garages, and agricultural buildings. Therefore, agricultural buildings (UBC group U) do not have to follow any set pattern for lighting their buildings. The ex ante assumptions are based on commercial and industrial buildings with energy standards applied to maintain specified lumens and watts per square foot. For the audited growers, this often resulted in replacement of 60 to 100 watt incandescent lights with new 400 watt HID fixtures. Anecdotal evidence based on

[1] Nonresidential Manual, California Energy Commission, Effective July 1995 and Updated March 1996, p. 2-2.

conversations between the auditor and owners indicated that they were all quite happy with the level of light currently in their buildings.

One of these sites installed all new lighting in an existing building that previously had no lights, another site built a larger building in which new lights were installed, and one site installed lighting in a renovated building. Using the screening for possible rebate measure influence on output[2], these sites were considered new and the measure was assumed to fit into the "did not cause the change" bin. Within this bin, the gross savings are defined to be: "(Consumption of the affected systems in the post-installation conditions at the observed post-installation output level) minus (consumption that would have occurred if the unimproved system had been used to achieve the same level of output)." Since there was no way the old system could have been used to achieve the same level of output without actual installation of more lights, the impact was set to zero for these two sites. Growers at these two sites were contacted to ask why they installed HID fixtures rather than other possible technologies. One stated, "After looking at both mercury vapor and incandescent fixtures, we decided that HIDs provided the best light wavelength for our crop." The other stated, "I looked at similar fixtures at neighbors buildings and liked the HID fixtures the best. Plus they seemed to be the most energy efficient."

While many growers were thinking that more light in their buildings would be nice, it was the program incentive that appeared to cause them to purchase the additional wattage fixtures. Therefore, the increase in load seen by many with HID fixtures installed was considered to have resulted from the program and was applied as a negative impact. Although some of the fixtures were installed on a one-for-one change-out, others installed fewer HID fixtures than the lower wattage fixtures previously installed. This was accounted for in the average change in connected load variable applied to each fixture. It should be noted that the increased level of service was achieved using more efficient technology than would have been installed in the absence of the program.

There was only one SIC designation without HID audits performed. The HID per fixture impact for this group was transferred from a similar SIC code designation (deciduous tree fruit SIC code used the same per-fixture impact as the tree nuts SIC code). Other than this one group, each HID group used the information gathered during the on-site audits to determine the program level impacts.

AEMS - The difference between the ex ante and ex post values for the AEMS program is due to the difference in the assumed number of pumps repaired and the savings per repair. The ex ante estimate assumes that 16% of the pumps that were tested were repaired. In the ex post estimate of savings, each telephone surveyed customer represented a business. While striving for 350 unique corporate IDs within the survey, 340 were actually surveyed. The customers were then asked how many pumps they repaired in 1996 (and for which they did not receive payment under the REO program). Additionally, each pump was further qualified as "broken" or "not broken.". The assumption was that a broken pump will be fixed, regardless of any pump test result (or whether a pump test could even

[2] Agenda Supplement for December 12, 1997 Meeting of CADMAC Modeling and Base Efficiency Subcommittees.

have been successfully completed). The customers were not asked to limit their responses to only the pumps tested (due to the time- tested belief that the grower would not be able to remember exactly which pumps were tested), but were allowed to respond for the whole corporation. Although there were 0.39 pumps repaired per business (corporate ID), the number of actual unique corporate IDs within the pump test database is 1,446 (down from 4,721 control numbers). This decreased the number of estimated pumps repaired from 755 (the ex ante estimate of 4,721 * 0.16) to 561. Additionally, each pump repair represented less ex post kWh savings per repair (the ex ante kWh/repair is 28,374, while the ex post kWh/repair is 12,776). Both kWh usage estimates (to which the percentage saved is applied) come from averages within the pump test database. However, the ex post pump test database represented pumps tested in 1995 and 1996, while the ex ante estimates come from 1990 through 1992 pump tests.

3.5 Net Realization Rates

The net realization rates were calculated by dividing the ex post net impacts by the ex ante net impacts. They are shown in Exhibit 3.22. Due to how the spillover was included in the end use, the end use total realization rates include spillover, while the measure specific realization rates do not.

Exhibit 3.22
Net Realization Rates

End Use	PG&E Code *	Measure Description	N Apps.	Net Realization Rates		
				kWh	kW	Therms
Ag Pumping and Related	A1	Pump Retrofit	67	0.75	-	-
	A4	Pump Adjustment	2	0.14	-	-
	A41 / A42 / A43	Low Pressure Nozzles	3	0.99	0.55	-
	A44 / A45 / A47 / A51 / A55	Sprinkler to Micro	11	0.57	0.37	-
	AO	Customized Ag Measures	8	0.52	0.49	0.52
	Ag Pumping and Related End Use Total**		91	1.20	0.43	0.52
Indoor Lighting	L64 / L66 / L174 / L176	Compact Fluorescent Lamps	11	0.30	0.38	-
	L6	Exit Signs	1	1.03	1.03	-
	L23-L24 / L73-L75 / L160	T-8 Lamps & Electr. Ballasts	22	0.67	0.22	-
	L19	Delamp Fluroescent Fixtures	1	1.03	0.49	-
	L26 / L81	High Intensity Discharge	34	(0.10)	(0.14)	-
	L31 / L36	Controls	1	-	-	-
	Indoor Lighting End Use Total**		70	(0.01)	(0.05)	-
AG PUMPING and RELATED Plus INDOOR LIGHTING**			**161**	**0.59**	**0.28**	**0.52**
AEMS PROGRAM TOTAL***			**4,721**	**0.46**	**-**	**-**

Data Source: 1996 PG&E Frozen MDSS Database Received on May 16, 1997
*PG&E MDSS Measure Code
**Total End Use includes spillover
***Pump Testing Only

As expected, the net realization rates for the pumping and related end use are lower than the gross realization rates, due to the low net-to-gross ratio of the evaluation compared to the ex ante net-to-gross ratio. The realization rates for the indoor lighting end use indicate a slight increase within each measure, since the ex post net-to-gross ratio was slightly higher than the ex ante net-to-gross ratio. The end use total realization rates indicate a change within the third decimal place and, as such, are not reflected in the table.

The AEMS program ex ante net-to-gross ratio was 0.54. The ex post net-to-gross ratio, as specified under the CADMAC waiver (Section 5), was 0.75. This accounts for the increase between the gross and net realization rates.

3.6 Gross Per-Unit Impacts

The gross per-unit impacts are shown in Exhibit 3.23. The units for the pumping and related and indoor lighting end uses are the designated unit of measure (DUOM) from the Protocols. For pumping, the DUOM is AF water pumped. For lighting, the DUOM is square foot per 1000 hours of operation. The AEMS program used the number of measures shown in the table as the unit of measure. Because the per-unit impacts for the AEEI program are based upon DUOMs which are quite different, no program per-unit impacts are calculated.

Exhibit 3.23
Gross Per-Unit Impacts

End Use	PG&E Code *	Measure Description	N of DUOM		Ex Post Per Unit Savings		
			Electric	Gas	kWh	kW	Therms
Ag Pumping and Related	A1	Pump Retrofit	48,545	-	58	-	-
	A4	Pump Adjustment	1,011	-	4	-	-
	A41 / A42 / A43	Low Pressure Nozzles	3,619	-	128	0.01	-
	A44 / A45 / A47 / A51 / A55	Sprinkler to Micro	1,196	-	997	0.43	-
	AO	Customized Ag Measures	1,860	13,759	218	0.16	8.05
	Ag Pumping and Related End Use Average		11,246	13,759	87	0.015	8.05
Indoor Lighting	L64 / L66 / L174 / L176	Compact Fluorescent Lamps	426,974	-	0.34	0.00007	-
	L6	Exit Signs		-	-	-	-
	L23-L24 / L73-L75 / L160	T-8 Lamps & Electr. Ballasts	726,814	-	0.13	0.00001	-
	L19	Delamp Fluroescent Fixtures	14,636	-	0.55	0.00004	-
	L26 / L81	High Intensity Discharge	133,763	-	(2.16)	(0.00051)	-
	L31 / L36	Controls		-	-	-	-
	Indoor Lighting End Use Average		325,547	-	(0.03)	(0.00004)	-
AG PUMPING and RELATED Plus INDOOR LIGHTING			-	-	-	-	-
AEMS PROGRAM TOTAL**			4,721	-	1,519	-	-

Data Source: 1996 PG&E Frozen MDSS Database Received on May 16, 1997
*PG&E MDSS Measure Code
**Pump Testing Only

The pumping and related end use per-unit kWh value is higher than the ex ante value of 60 for the same reasons that the gross impacts are higher. Similarly, the ex post per-unit kW value is much less than the ex ante value of 0.0168 due to the loss of all demand impacts for the pump repair measure. The therm per-unit impacts are substantially higher that the ex ante per-unit value of 0.28. This is because the ex ante per-unit values were based on a DUOM of square foot of green house measures installed, not a pumping AF value. The therm impacts for the 1996 program came directly from measures installed on pumps which used natural gas fuel. As such, an AF pumped DUOM could be applied. This change is shown in Exhibit 6.1.

The indoor lighting end use per-unit values are all negative due to the negative ex post gross impacts.

While the AEMS program applied a net value to the number of pump tests, the gross savings could be calculated based on the inputs to the net per-unit value. This was done within the evaluation, but the more telling comparison is between the net per-unit values.

3.7 Net Per-Unit Impacts

The net per-unit impacts are shown in Exhibit 3.24.

Exhibit 3.24
Net Per-Unit Impacts

End Use	PG&E Code *	Measure Description	N of DUOM		Ex Post Per Unit Savings		
			Electric	Gas	kWh	kW	Therms
Ag Pumping and Related	A1	Pump Retrofit	48,545	-	40	-	-
	A4	Pump Adjustment	1,011	-	3	-	-
	A41 / A42 / A43	Low Pressure Nozzles	3,619	-	87	0.01	-
	A44 / A45 / A47 / A51 / A55	Sprinkler to Micro	1,196	-	676	0.23	-
	AO	Customized Ag Measures	1,860	13,759	148	0.09	3.14
	Ag Pumping and Related End Use Total		11,246	13,759	59	0.01	3.14
Indoor Lighting	L64 / L66 / L174 / L176	Compact Fluorescent Lamps	426,974	-	0.15	0.00005	-
	L6	Exit Signs		-	-	-	-
	L23-L24 / L73-L75 / L160	T-8 Lamps & Electr. Ballasts	726,814	-	0.06	0.00001	-
	L19	Delamp Fluroescent Fixtures	14,636	-	0.25	0.00003	-
	L26 / L81	High Intensity Discharge	133,763	-	(0.98)	(0.00038)	-
	L31 / L36	Controls		-	-	-	-
	Indoor Lighting End Use		325,547	-	(0.01)	(0.00003)	-
AG PUMPING and RELATED Plus INDOOR LIGHTING			-	-	-	-	-
AEMS PROGRAM**			4,721	-	1,139	-	-

Data Source: 1996 PG&E Frozen MDSS Database Received on May 16, 1997
*PG&E MDSS Measure Code
**Pump Testing Only

The pumping and related end use per-unit impacts differ from the ex ante per-unit impacts for the same reasons that the net values are different as discussed in section 3.3. Spillover is equally spread across all measures within this table since the gross per-unit values were simply multiplied by the combined net-to-gross ratio for each end use.

The AEMS ex post per-unit value is less than the ex ante value of 2,452 kWh/pump test for the reasons stated above in sections 3.4 and 3.5.

4 RECOMMENDATIONS

The following evaluation recommendations are proffered (1) to promote program designs resulting in high ex post gross and net energy and demand savings, and (2) to streamline evaluation efforts by improving evaluation approaches and clarifying the Protocols. This recommendation section is divided into two subsections: program recommendations and evaluation recommendations.

4.1 Program Recommendations

The Equipoise team offers the following recommendations on program design and operation. The recommendations are not intended as a criticism of the program or the program staff who have done a good job of fielding large and complex programs. Rather, they are targeted toward improvements in program design, which were not visible prior to evaluation, that will lead to higher program realization rates in the future. The recommendations are intentionally written as if current programs will continue, despite the fact that a new administrator might well choose to substantially modify current programs or eliminate entire programs. This information should be valuable for PG&E's 1998 programs and potential follow-on programs.

4.1.1 Recommendations for Increasing Gross Savings

Monitor and Control High-Intensity Discharge (HID) Applications in the Agricultural Sector. The HID measures are supposed to replace higher wattage mercury vapor lamps as the baseline (ex ante) technology. Because Uniform Building Code does not apply to agricultural sector buildings, no minimum pre-retrofit light levels are required. In many cases, the HID fixtures offering incentives under the program replaced lower wattage lamps, resulting in negative impacts. In some cases, the fixtures were being placed in locations where no pre-existing fixtures existed (unlit spaces), and in a couple of cases the installations were simply additions or new construction. All of these situations led to a considerable negative impact for this measure, which was the highest participation agricultural sector lighting measure. The evaluation team recommends that practices be put in place to adequately assess whether agricultural applicants are replacing high wattage mercury vapor lamps prior to PG&E approving the rebate application.

Apply the 1994 Evaluation Pump Adjustments Values to the Ex Ante Projections. The 1994 Agricultural Sector evaluation identified that the ex ante estimate of 11% savings for the pump adjustment was too high and that an estimate of 1.5% was more appropriate. The ex ante estimate of 11% is still being used. While there were only two applications in 1996, this value should be changed.

Require a Pre- and Post-Pump Test as Part of the Pump Repair Measure. PG&E should require both a pre- and post-pump test on all pump repair measures offering incentives. This would allow PG&E to screen out pumps that (1) are broken and would have been replace or repaired anyway, (2) have a high initial operating plant efficiency and are being replaced for other reasons, and (3) pumps that are being replaced with higher horsepower pumps. This approach would have three added benefits: (1) it would promote installation of pump setups that are configured to allow valid testing, (2) if the information was entered into the pump test database it would greatly enhance the information available to evaluators, and (3) it would allow the field representatives to work more closely with customers and could potentially lead to lower free-ridership. Higher program costs could possibly be offset by higher realization rates.

Eliminate Demand Reduction Claim for Pump Repairs. Pump repairs should theoretically lead to an increased electrical demand when the pump is operating. It has been theorized that decreased operation time resulted in a lower number of pumps operating at system peak. The data from this evaluation showed no decrease occurred. It is recommended that PG&E not claim a peak demand reduction in the future.

Require a Minimum Pressure Reduction for the Low-Pressure Sprinkler Nozzle Measure. Some sites were given rebates for low-pressure sprinkler nozzles despite small incremental reductions in nozzle pressure and predictably low energy savings. This could be easily avoided by setting minimum reduction criteria. For example, PG&E could offer incentives only to those applications that reduce pressure by more than 20 psi, or 30% of the pre-installation pressure. These suggested minimum levels are derived from the evaluation team experience.

Track System Redesign on Pressure-Reducing Measures More Closely. Some low-pressure sprinkler nozzles and micro irrigation systems sites reduced pressure by throttling the pump discharge or re-circulating water to the pump inlet. These approaches do not save energy. The program currently requires the applicant to modify the pump to supply lower pressure, but mechanisms to track compliance to this requirement appear to be inadequate. Post installation field inspection may be required.

Continue Offering the AEMS Program. The results of the AEEI program net-to-gross analysis and the AEMS market transformation analysis have indicated that repeated contact with the PG&E program and its representatives is an important factor in growers implementing energy-efficiency measures. These data recognize the not surprising fact that savings are not always recognized in the year the program is implemented, but often comes later, as a result of repetitive exposure.

4.1.2 Recommendations for Increasing Net Savings

The net-to-gross ratio for lighting applications was close to 1.0, so no action is recommended for that end use. The net-to-gross ratio for the pumping and related end use was highly dependent upon the pump repair measure, since it represented over two-thirds of the applications. The free-ridership for this measure is high (about 60%) because the measure has been offered for many years. The most significant factor in the pumping and related end use net-to-gross ratio analysis is the size of the company/operation. Large growers, who have been targeted for many years, are the highest proportion of participants and are also the most likely to implement pump repair measures in the absence of the program. This suggests that the market (if it is defined as the large consumers) has been successfully transformed and should be left to drive itself. However, the same data suggest that the smaller pumping consumer seldom participates and is less likely to repair a pump in the absence of the program. This suggests two possible alternative recommendations for the pump repair measure:

Retarget the Pump Repair Measure to the Smaller Consumers. The Pump Repair measure, as currently applied, appears to be addressing a mature market. PG&E or the new administrator should analyze whether the small growers represent a large enough market segment to justify pursuing, and if so, the measure should be redesigned to target that market.

or

Discontinue the Pump Repair Measure and Target Other Higher Return Pumping Measures. Other pumping-related measures such as sprinkler to micro-irrigation and low-pressure sprinkler nozzles show very high energy and demand savings potential and are only currently being widely adopted. Re-targeting resources to these or other measures should result in high gross <u>and</u> net realization rates.

4.2 Evaluation Recommendations

The following recommendations are intended to improve the data availability and evaluation methodology. There are no recommendations for improvements in the Protocols because they have now been applied for ex post analysis over the past three years and many of the issues have been resolved, either through changes to the Protocols or through use of the retroactive waiver process.

The 1996 agricultural sector analysis was the first to use an engineering/calibrated model approach to assess the pump repair and lighting impacts. While this approach demonstrated its viability, it also shows good potential for assessing the impacts of small participant populations such as the agricultural sector. Its future success lies in the availability of some key data.

Require a Measure Implementation Date in the MDSS. A critical factor in determining what data are available and what data need to be collected is the date upon which the measure was actually implemented. The 1996 analysis suffered from an inability to discern, until too late, that many of the pump tests in the Pump Test Database were actually conducted <u>after</u> the pump was repaired. This lead to a substantial reduction in the actual number of paired comparisons available from the evaluation data.

Require a Pre- and Post-Pump Repair Pump Test. Pre- and post-pump repair tests would improve program implementation as discussed above and would substantially enhance evaluators' ability to estimate savings for all measures involving a pump repair measure. Even a requirement that all pumps have a pre-retrofit test result submitted with the application would be a substantial improvement. Then post-pump repair tests could by conducted by the evaluation team on a carefully selected sample of the participants. As mentioned before, the higher program costs for the pre-installation pump test would most likely be offset by the higher program realization rates. However, PG&E or any follow on organization considering implementation of this recommendation should conduct a thorough economic analysis.

This concludes the recommendations section.

5 CADMAC WAIVERS

Request for Retroactive Waivers were submitted to CADMAC for the AEEI and AEMS programs.

The AEEI waiver was approved July 22, 1997. This waiver allowed:

- The use of simplified engineering models supported by telephone surveys for the indoor lighting end use and the Customized Incentives Program.
- Use of an ex ante algorithm review to estimate the gross impact for pump adjustments..
- Use of a discrete choice model for net-to-gross.
- Use of the same Designated Unit of Measure (DUOM) for AEEI lighting as used in commercial lighting.

The original AEMS Retroactive waiver was approved July 22, 1997. This version allowed:

- Use of the AEEI pump repair impacts in combination with the AEMS pump repair implementation rates to estimate gross impacts.
- Use of a net-to-gross ratio of 0.75 if a market effects study was conducted instead of a net-to-gross analysis.

The final version of the AEMS Retroactive Waiver request that was approved on November 21, 1997 extended the deadline for reporting of the market effects study to April 30th 1998. This extension was requested because the market effects study would benefit from the additional time and was not required for the March 1st impact filing.

The complete waiver is reproduced on the following pages for readers interested in the detailed wording.

PACIFIC GAS & ELECTRIC COMPANY

REQUEST FOR RETROACTIVE WAIVER FOR

1996 AGRICULTURAL SECTOR

ENERGY EFFICIENCY INCENTIVE (EEI) PROGRAMS

Study ID: 354 (Pumping) and ~~357~~ 385 (Lighting)

Date Approved: July 22, 1997

Summary of PG&E Request

This waiver requests deviations from, or clarifications of, the Protocols[3] by PG&E for the 1996 Agricultural Sector Energy Efficiency Incentives (EEI) Evaluation[4]. PG&E seeks approval to: (1) use a Simplified Engineering Model supported by telephone surveys and on-site data collection to estimate the gross impacts for indoor lighting end-use and Customized Incentive (CI) Program measures, (2) perform an ex ante algorithm review to estimate the gross impact for pump adjustments which represent less than 0.1% of the pumping end-use avoided cost, (3) use discrete choice analysis including participant and nonparticipant survey data, backed up with self-report analysis, to estimate net-to-gross effects, and (4) specify the Designated Unit of Measure (DUOM) for agricultural indoor lighting to be the same as commercial lighting for agricultural Energy Efficiency Incentive (EEI) measures for the 1996 first year evaluation. (Note that items (1) through (4) above are referred to in each of the following sections by their item number.)

All of these requests result from the evaluation of the 1994 and 1995 PG&E Agricultural programs, the reviews of those program evaluations, the limited size of the participant population, and the limited size of the PG&E agricultural sector in general.

Proposed Waiver

PG&E seeks CADMAC approval to: (see Table A for Summary)

(1) Allow the use of Simplified Engineering Models (as specified in Appendix A, page A-2 of the Protocols) supported by census telephone survey and on-site data collection to estimate impacts for the indoor lighting end-use and the CI Program portion of the pumping end-use.

<u>Parameters and Protocol Requirements</u>

Table C-6 is unclear as to the method required to compute gross impacts. Under "Participant Group", item 2 would suggest that a Simplified Engineering Model would be adequate, while item 4 suggests that if billing analysis is not used, "the analysis will rely on direct end-use metering".

<u>Rationale</u>

PG&E's agriculture program includes eight CI Program applications representing approximately 12 percent of the agricultural sector avoided cost. Metering of these sites would be prohibitively expensive and is unlikely to result in improved estimates of savings. Therefore, PG&E seeks approval to use an engineering modeling/field data collection approach for these eight sites.

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[3] Protocols and Procedures for the Verification of Costs, Benefits, and Shareholder Earnings for Demand-Side Management Programs

[4] The first year earnings claim for the 1996 Agricultural Sector is slightly over $600,000.

Also, the 1996 PG&E agricultural program also includes 75 indoor lighting sites that represent approximately 38 percent of the agricultural sector avoided cost. Multiple studies have shown that on-site and telephone data produce estimates similar to metered data collection for lighting applications. Therefore PG&E proposes to use such an analysis for the Ag lighting sites.

(2) Perform an ex ante algorithm review to estimate the gross impact for the pump adjustment measure which is part of the pumping end-use.

<u>Parameters and Protocol Requirements</u>

Table C-6 is requires either a Simplified Engineering Model or direct end-use metering, as discussed in the point above, if billing analysis is not used.

<u>Rationale</u>

This measure represents less than 0.1% of the pumping end-use avoided cost and only two customer applications. Because of the type of measure, neither telephone nor on-site data collection would add any information to contribute to an improved gross impact estimates. End-use metering would only be useful if pre-adjustment data were available, but would be prohibitively expensive if applied. The 1994 and 1995 evaluations supplied a reasonable estimate of the savings which can be used along with a review of the ex ante algorithm to assess this measure.

(3) Allow the use of discrete choice analysis including participant and nonparticipant survey responses to estimate net-to-gross effects instead of regression-based approach. A self-report analysis will be conducted as a backup. This approach will allow the calculation of NTG ratios while avoiding "unreasonable costs or adverse customer impacts".

<u>Parameters and Protocol Requirements</u>

Table 5, item B.1. states that "the primary purpose of the comparison group is to represent what would have happened in the absence of the program." Comparison group customers appear in load impact regression models to provide the data used for calculating net load impacts.

<u>Rationale</u>

This is a small program with less than 120 participating sites, where approximately half of the impacts come from CI and lighting measures. Based on the last two year's evaluation results for this sector, the low levels of participation and diversity of measures, application of an LIRM will not yield a stable model.

PG&E's Agricultural sector population is relatively small (approximately 60,000 accounts). Data collection efforts required to locate retrofitting comparison group members and measure their impacts accurately through a billing analysis would place undue burden on the customer population, resulting in adverse customer impacts. We will survey a nonparticipant sample to obtain self-report information on nonparticipant spillover.

Self-report net-to-gross estimates will also be developed. At a minimum these results will be compared and contrasted to the discrete choice estimates. Should the discrete choice approach not result in a stable model, then the self-report values will be used as the best estimate of net-to-gross adjustments.

The net-to-gross estimates for the past two evaluations of PG&E's agricultural sector have been based on analysis of self-reports of participants.

(4) Use the same DUOM used in commercial lighting (Protocols Table C-4: load impacts per square foot per 1000 hours of operation, where the square foot term refers to retrofitted square feet and the hours term refers to reported facility hours of operation) for agricultural lighting.

Parameters and Protocol Requirements

Table C-6 specifies the DUOM for all agricultural measures as "Load impacts per acre foot of water pumped".

Rationale

This waiver was requested and granted for PG&E's 1995 Agricultural Sector evaluation. Since the only existing DUOM for agriculture is "Load impacts per acre foot of water pumped", this DUOM clearly is not applicable to agricultural lighting. The commercial lighting DUOM is appropriate for this end use.

Conclusion

PG&E is seeking retroactive waivers to clearly define, in advance, acceptable methods for performing the 1996 Agricultural impact evaluation of the EEI programs. Recommendations in this waiver are designed to maximize the quality and value of evaluation results. The proposed waiver allowing engineering modeling clarifies the protocol requirements while supporting reasonable estimations of gross program impacts. The waiver to review the ex ante algorithm as a means of assessing gross impact for pump adjustments imposes a rational approach for a low participation measure. The waiver allowing the use of discrete choice backed up by self-report net-to-gross analysis reflects a realization that agricultural sector variability and sample sizes do not support other proposed approaches. The waiver on the use of the commercial lighting DUOM seeks to apply reasonable interpretation of the written protocol.

TABLE A

IMPACT MEASUREMENT REQUIREMENTS - TABLE C-6 AND TABLE 5			
Parameters	**Protocol Requirements**	**Waiver Alternative**	**Rationale**
End-Use Consumption and Load Impact Model	LIRM or CE (calibrated engineering) or Simplified Engineering Model	Allow Simplified Engineering Model supported by telephone and field data collection to estimate the impacts for the lighting end-use and CI pumping measures.	A) Lighting: Previous studies support the use of simplified engineering models with field data as appropriate for lighting. B) CI sites: end-use metering prohibitively expensive for the complex sites.
End-Use Consumption and Load Impact Model	LIRM or CE (calibrated engineering) or Simplified Engineering Model	Allow the use of an ex ante algorithm review to estimate the gross impact for the pump adjustment measure which is part of the pumping end-use.	This is a low participation low impact measure. Because of the type of measure, additional data collection would not improve the estimate of savings.
Net Load Impacts	Comparison Group used in LIRM	Discrete choice analysis of participant and nonparticipant survey data with Participant Self-Report as a backup.	Data collection efforts required place undue burden on customer population, resulting in adverse customer impacts.
Lighting DUOM	Impact per acre foot of water pumped	Use impact per square foot per 1000 hours of operation.	Agricultural DUOM does not make sense for Agricultural lighting.

PACIFIC GAS & ELECTRIC COMPANY
REQUEST FOR RETROACTIVE WAIVER FOR
1996 AGRICULTURAL SECTOR
ENERGY MANAGEMENT SERVICES (EMS) PROGRAM

Study ID: 360

Date Approved: July 22, 1997

Final Report Submittal Date Modification: Approved November 21, 1997

Summary of PG&E Request

This waiver requests deviations from, or clarifications of, the Protocols[5] by PG&E for the 1996 Agricultural Sector Energy Management Services (EMS) Evaluation[6]. PG&E seeks approval to: (1) estimate gross impacts using telephone surveys collection to determine installation rates, then multiply these rates by the average EEI impact for the same measures, and (2) use discrete choice analysis including participants and nonparticipants, backed up with self-report analysis, to estimate net-to-gross effects.

Each of these requests result from the findings of the evaluation of the 1994 Agricultural EMS program, the reviews of that program evaluation and the limited size of the PG&E agricultural sector in general.

Proposed Waiver

PG&E seek CADMAC approval to: (see Table A for Summary)

(1) Allow the telephone survey data collection combined with transfer of measure impacts from the PG&E EEI Programs evaluation to estimate gross impacts for pumping and other agricultural EMS program end uses.

Parameters and Protocol Requirements

Table C-11, point 2, requires the use of "…a load impact regression model, CE (Calibrated Engineering model), or regression model, supplemented by engineering models…". Additionally, Table C-11, point 3, requires the use of on-sites to determine usage levels.

Rationale

This is a small program. The savings per measure will be established in the EEI program using engineering algorithms supported by telephone and on-site data. The telephone surveys conducted as part of the EMS evaluation will collect data on usage patterns and the number of measures installed. This information, combined with the transferred EEI per unit estimates will result in appropriate estimates of savings. This is the same approach that was applied in PG&E's 1994 EMS evaluation.

(2) Instead of a regression based billing analysis approach to net-to-gross, allow either (1) the use of discrete choice analysis including participants and nonparticipants, backed up by a self-

[5] Protocols and Procedures for the Verification of Costs, Benefits, and Shareholder Earnings for Demand-Side Management Programs

[6] The first year earnings claim for the 1996 Agricultural Sector is slightly under $63,000.

report analysis, or (2) use of a default net-to-gross ratio of 0.75, subject to the condition that PG&E conduct a survey based discrete choice analysis of the key energy purchase decisions for participants in the program.

Parameters and Protocol Requirements

Table 5, item B.1. states that "the primary purpose of the comparison group is to represent what would have happened in the absence of the program." Comparison group customers appear in load impact regression models to provide the data used for calculating net load impacts.

Rationale

This is a program with small and highly variable per participant savings. It was realized from the 1994 evaluation for this program, that small savings per participant, high variability in kWh consumption and impossibility to collect precise information to explain this high variability in kWh consumption, does not allow an LIRM approach to yield a stable model.

PG&E's Agricultural sector population is relatively small (approximately 60,000 accounts). Data collection efforts required to locate retrofitting comparison group members and measure their impacts accurately through a billing analysis would place undue burden on the customer population, resulting in adverse customer impacts. We will survey a nonparticipant sample to obtain self-report information on nonparticipant spillover.

Self-report net-to-gross estimates will also be developed. At a minimum these results will be compared and contrasted to the discrete choice estimates. Should the discrete choice approach not result in a stable model the self-report values will be used as the best estimate of net-to-gross adjustments.

The net-to-gross estimate for the past evaluation of PG&E's agricultural EMS sector was based on analysis of self-reports.

As an alternative, PG&E may choose to use a default net-to-gross ratio of 0.75 in combination with PG&E conducting an analysis of customer self-reported market transformation effects, and reporting those results to the Market Effects Subcommittee.

(3) Change in Submittal Date from March 1, 1998 to April 30, 1998

PG&E requests permission to submit the market effects study report by April 30, 1998. The results of the study are not necessary for the AEAP filing and PG&E believes that the market effects study would benefit from the additional sixty days to assess results.

Conclusion

PG&E is seeking retroactive waivers to clearly define, in advance, acceptable methods for performing the 1996 impact evaluation of the Agricultural EMS program. Recommendations in this waiver are designed to maximize the quality and value of evaluation results. The proposed waiver allowing transfer of the EEI per unit engineering values for use with telephone response data will result in reasonable estimations of gross program impacts. The waiver allowing the use of discrete choice backed up by self-report net-to-gross analysis reflects a realization that agricultural sector variability and sample sizes do not support other proposed approaches.

TABLE A

IMPACT MEASUREMENT REQUIREMENTS – TABLE C-6 AND TABLE 5			
Parameters	**Protocol Requirements**	**Waiver Alternative**	**Rationale**
End-Use Consumption and Load Impact Model	LIRM or CE (calibrated engineering) Model based upon on-site data. Table C-11, item 2 and 3	Allow the use of transferred EEI per unit impacts combined with EMS customer telephone responses to estimate the gross impacts for EMS measures.	This is a small program. Use of estimates computed using telephone and on-site data for the EEI program will result in acceptable estimates of savings and is an appropriate use of resources.
Net Load Impacts	Comparison Group used in LIRM Table 5, Item B.1	Discrete choice model backed up by Participant Self-Report or default NTG of 0.75 with study of market transformation effects reported to Market Effects Subcommittee.	Data collection efforts required place undue burden on customer population, resulting in adverse customer impacts. LIRM effort unlikely to produce usable result based upon 1994 Ag EMS evaluation. The alternative market transformation study would concentrate on future issues rather that historical issue.

6 PROTOCOL TABLES 6 AND 7

Exhibit 6.1
Protocol Table 6 – Pumping and Related End Use (Study #354) – Items 1-5

Table Item		Agricultural Sector		
Item Number Number	**Result Description**	**Estimate**	**Confidence Interval***	
			90%	**80%**
1.A	Pre-installation Average kWh (Participant)	181,041	-	-
	Pre-installation Average kWh (Comparison)	266,437	-	-
	Pre-installation Per-Unit kWh (Participant)	364	-	-
	Pre-installation Per-Unit kWh (Comparison)	356	-	-
1.B	Average Impact Year kWh (Participant)	182,415	-	-
	Average Impact Year kWh (Comparison)	288,211	-	-
	Impact Year kWh/Unit (Participant)	249	-	-
	Impact Year kWh/Unit (Comparison)	356	-	-
2.A	Average Gross Peak kW Impact	9.80	-	-
	Average Gross Annual kWh Impact	56,291	-	-
	Average Gross Annual Therm Impact	27,686	-	-
	Average Net Peak kW Impact	5.29	(4.12) - (5.88)	(4.22) - (5.78)
	Average Net Annual kWh Impact	38,196	(31,441) - (41,573)	(32,004) - (41,010)
	Average Net Annual Therm Impact	10,797	(7,475) - (12,459)	(7,752) - (12,182)
2.B	Per-Unit Gross Peak kW Impacts	0.015	-	-
	Per-Unit Gross Annual kWh Impacts	87	-	-
	Per-Unit Gross Annual Therm Impacts	8	-	-
	Per-Unit Net Peak kW Impacts	0.008	(0.006) - (0.009)	(0.007) - (0.009)
	Per-Unit Net Annual kWh Impacts	59	(48.6) - (64.3)	(49.5) - (63.4)
	Per-Unit Net Annual Therm Impacts	3	(3.8) - (6.3)	(4.0) - (6.2)
2.C	Percent change in usage of the participant group	0.8%	-	-
	Percent change in usage of the comparison group	8.2%	-	-
2.D.1	Gross Demand Realization Rate	0.63	-	-
	Gross Energy Realization Rate	1.38	-	-
	Gross Therm Realization Rate	1.00	-	-
	Net Demand Realization Rate	0.43	-	-
	Net Energy Realization Rate	1.20	-	-
	Net Therm Realization Rate	0.52	-	-
2.D.2	Per-Unit Gross Demand Realization Rate	0.90	-	-
	Per-Unit Gross Energy Realization Rate	1.46	-	-
	Per-Unit Gross Annual Therm Realization Rate	28.75	-	-
	Per-Unit Net Demand Realization Rate	0.63	-	-
	Per-Unit Net Energy Realization Rate	1.26	-	-
	Per-Unit Net Therm Realization Rate	14.95	-	-
3.A	NTG Ratio Based on Average kWh Impacts	0.68	0.56 - 0.74	0.57 - 0.73
	NTG Ratio Based on Average kW Impacts	0.54	0.42 - 0.60	0.43 - 0.59
	NTG Ratio Based on Average Therm Impacts	0.39	0.27 - 0.45	0.28 - 0.44
3.B	NTG Ratio Based on Per-Unit Average kWh Impacts	0.68	0.56 - 0.74	0.57 - 0.73
	NTG Ratio Based on Per-Unit Average kW Impacts	0.54	0.42 - 0.60	0.43 - 0.59
	NTG Ratio Based on Per-Unit Average Therm Impacts	0.39	0.27 - 0.45	0.28 - 0.44
3.C	NTG Ratio Based on Percent change in kWh usage relative to base kWh usage	9.77	-	-
4.A	Pre Average AF Water Pumped (Participant)	867	-	-
	Pre Average AF Water Pumped (Comparison)	1,016	-	-
4.B	Post Average AF Water Pumped (Participant)	1,280	-	-
	Post Average AF Water Pumped (Comparison)	1,099	-	-

*No confidence intervals are provided for gross impacts since they were point estimates

Exhibit 6.2
Protocol Table 6 – Pumping and Related End Use (Study #354) – Item 6

Measure	Unit of Measure	Number Installed		
		Participant Group	Program Population	Comparison Group*
Pump Repair	Pump	46	67	43
Low Pressure Sprinkler Nozzle	Nozzle	18,900	21,720	615
Micro-drip Conversion	Acre	353	1,664	201
Pump Adjustment	Pump	-	2	-
Custom Sites	Application	8	8	-
Total		19,307	23,461	859

*From NP Telephone Survey

Exhibit 6.3
Protocol Table 6 – Indoor Lighting End Use (Study #385) – Items 1-5

Table Item		Agricultural Sector		
Item Number Number	Result Description	Estimate	Confidence Intervals 90%	80%
1.A	Average Pre-installation Usage	432,127	-	-
	Average Pre-installation Per-Unit Usage	36	-	-
1.B	Average Impact Year Usage (Participant)	479,832	-	-
	Average Impact Year Per-Unit Usage (Participant)	26	-	-
2.A	Average Gross Peak kW Impacts	(0.45)	-	-
	Average Gross Annual kWh Impacts	(556)	-	-
	Average Gross Annual Therm Impacts	-	-	-
	Average Net Peak kW Impacts	(0.34)	(0.28) - (0.38)	(0.29) - (0.38)
	Average Net Annual kWh Impacts	(251)	(173) - (301)	(185) - (296)
	Average Net Annual Therm Impacts	-	-	-
2.B	Per-Unit Gross Peak kW Impacts	(0.000037)	-	-
	Per-Unit Gross Annual kWh Impacts	(0.030)	-	-
	Per-Unit Gross Annual Therm Impacts	-	-	-
	Per-Unit Net Peak kW Impacts	(0.000028)	(0.000023) - (0.000032)	(0.000024) - (0.000031)
	Per-Unit Net Annual kWh Impacts	(0.014)	(0.009) - (0.016)	(0.010) - (0.016)
	Per-Unit Net Annual Therm Impacts	-	-	-
2.C	Percent change in usage of the participant and comparison groups	NA	-	-
2.D.1	Gross Demand Realization Rate	(0.05)	-	-
	Gross Energy Realization Rate	(0.01)	-	-
	Gross Therm Realization Rate	-	-	-
	Net Demand Realization Rate	(0.05)	-	-
	Net Energy Realization Rate	(0.01)	-	-
	Net Therm Realization Rate	-	-	-
2.D.2	Per-Unit Gross Demand Realization Rate	(0.54)	-	-
	Per-Unit Gross Energy Realization Rate	(0.03)	-	-
	Per-Unit Gross Annual Therm Realization Rate	-	-	-
	Per-Unit Net Demand Realization Rate	(0.52)	-	-
	Per-Unit Net Energy Realization Rate	(0.02)	-	-
	Per-Unit Net Annual Therm Realization Rate	-	-	-
3.A	NTG Ratio Based on Average kWh Impacts	0.45	0.34 - 0.54	0.33 - 0.53
	NTG Ratio Based on Average kW Impacts	0.75	0.64 - 0.84	0.63 - 0.83
3.B	NTG Ratio Based on Per-Unit Average kWh Impacts	0.45	0.34 - 0.54	0.33 - 0.53
	NTG Ratio Based on Per-Unit Average kW Impacts	0.75	0.64 - 0.84	0.63 - 0.83
3.C	Percent change in usage relative to base usage	NA		
4.A	Pre Square Feet per 1000 hours Operation (Participant)	830,979	-	-
	Pre Square Feet per 1000 hours Operation (Comparison)	NA	-	-
4.B	Post Square Feet per 1000 hours Operation (Participant)	1,302,186	-	-
	Post Square Feet per 1000 hours Operation (Comparison)	NA	-	-

*No confidence intervals are provided for gross estimates since they were point estimates

Exhibit 6.4
Protocol Table 6 – Indoor Lighting End Use (Study #385) – Item 6

Measure	Unit of Measure	Number Installed		
		Participant Group	Program Population	Comparison Group*
Compact Fluorescent Lamps	Fixture	2,638	2,743	-
T8 and Electronic Ballasts	Fixture	1,133	2,185	-
High Intensity Discharge	Fixture	1,212	1,247	-
Other	Fixture	12	56	4
Total		4,995	6,231	4

*From NP Telephone Survey

Exhibit 6.5
Protocol Table 6 – AEMS Program (Study #360) – Items 1-5

Table Item		Agricultural Sector		
Item Number Number	**Result Description**	**Estimate**	**Relative Precision***	
			90%	**80%**
1.A	Average Pre-installation Usage	NA		
	Average Pre-installation Per-Unit Usage	NA		
1.B	Average Impact Year Usage (Participant)	NA		
	Average Impact Year Per-Unit Usage (Participant)	NA		
2.A	Average Gross Peak kW Impacts	-	-	-
	Average Gross Annual kWh Impacts	1,519	-	-
	Average Gross Annual Therm Impacts	-	-	-
	Average Net Peak kW Impacts	-	-	-
	Average Net Annual kWh Impacts	1,139	-	-
	Average Net Annual Therm Impacts	-	-	-
2.B	Per-Unit Gross Peak kW Impacts	-	-	-
	Per-Unit Gross Annual kWh Impacts	1,519	-	-
	Per-Unit Gross Annual Therm Impacts	-	-	-
	Per-Unit Net Peak kW Impacts	-	-	-
	Per-Unit Net Annual kWh Impacts	1,139	-	-
	Per-Unit Net Annual Therm Impacts	-	-	-
2.C	Percent change in usage of the participant and comparison groups	NA	-	-
2.D.1	Gross Demand Realization Rate	-	-	-
	Gross Energy Realization Rate	0.33	-	-
	Gross Therm Realization Rate	-	-	-
	Net Demand Realization Rate	-	-	-
	Net Energy Realization Rate	0.46	-	-
	Net Therm Realization Rate	-	-	-
2.D.2	Per-Unit Gross Demand Realization Rate	-	-	-
	Per-Unit Gross Energy Realization Rate	0.33	-	-
	Per-Unit Gross Annual Therm Realization Rate	-	-	-
	Per-Unit Net Demand Realization Rate	-	-	-
	Per-Unit Net Energy Realization Rate	0.46	-	-
	Per-Unit Net Annual Therm Realization Rate	-	-	-
3.A	NTG Ratio Based on Average Load Impacts	0.75	-	-
3.B	NTG Ratio Based on Per-Unit Average Load Impacts	0.75	-	-
3.C	Percent change in usage relative to base usage	NA	-	-
4.A	NA	-	-	-
	NA	NA	-	-
4.B	Average Impact per Participant (Participant)	1,519	-	-
	Average Impact per Participant (Comparison)	NA	-	-

*There is no relative precision since the gross impacts are point estimates and there was no NTG analysis

Exhibit 6.6
Protocol Table 6 – AEMS (Study #360) – Item 6

Measure	Unit of Measure	Number Tested		
		Participant Group	Program Population	Comparison Group*
Pump Test	Pump Test	350	4,721	-
Total		350	4,721	-

*No Comparison Group Values Gathered

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6.1 Protocol Table 7 – Pumping and Related End Use (Study #354)

1996 Agricultural EEI Program
Evaluation of Pumping and Related End Use
PG&E Study ID # 354

The purpose of this section is to provide the documentation for data quality and processing as required in Table 7 of the California Public Utility Commission (CPUC) Evaluation and Measurement Protocols (the Protocols). Major topics are organized and presented in the same order as they are listed in Table 7 for ease of reference and review. When responses to the items are discussed in detail elsewhere in the report, only a brief summary will be given in this section to avoid redundancy.

A. Overview Information

1. Study Title and Study ID Number

Study Title:	Evaluation of PG&E's 1996 Agricultural Energy Efficiency Incentives (AEEI) Program for Agricultural Sector Pumping and related end use Technologies.
Study ID Number:	354

2. Program, Program Year and Program Description

Program:	PG&E Agricultural EEI Program, Agricultural Sector Pumping and related end use Technologies.
Program Year:	Rebates Received in the 1996 Calendar Year.
Program Description:	Refer to section 1.1 for a detailed description of the program.

3. End Uses and/or Measures Covered

End Use Covered:	Agricultural Pumping Technologies
Measures Covered:	Pump Repair Pump Adjustment Low Pressure Sprinkler Nozzles Sprinkler to Micro-drip Irrigation Conversion Customized Incentives Advanced Performance Options

4. Methods and Models Use

The PG&E AEEI Program evaluation consisted of three key analysis components: (1) engineering analysis of gross energy and demand impacts; (2) Discrete Choice Analysis (DCA) of net-to-gross ratio of the program; and (3) participant and nonparticipant spillover effects. This integrated approach reduces a complicated problem to manageable components, while incorporating the comparative advantage of each analysis method. This approach describes net effects in kWh for a given measure type as follows:

$$\begin{pmatrix}\text{Net Effects of}\\ \text{AEEI Program in}\\ \text{terms of kWh}\end{pmatrix} = \sum_{i=1}^{5}\begin{pmatrix}\text{kWh Gross}\\ \text{Savngs using}\\ \text{Engineering}\\ \text{Analysis}\end{pmatrix}_i * \begin{pmatrix}\text{Net - To - Gross}\\ \text{Ratio}\\ \text{Using DCA}\end{pmatrix} + \begin{pmatrix}\text{Spillover}\\ \text{Effects}\end{pmatrix}$$

Gross Impact - The gross estimates of impact for the pumping and related end use were based upon engineering models using on-site data and a review of ex ante algorithms and assumptions.

Net effect - Using Discrete Choice Analysis, Net-to-Gross ratio was derived for pumping and related end use. A group of participants and nonparticipants were included to analyze whether customers participated in the program because they had already decided to implement program measures and simply wanted the program benefits, or did the program actually induce them to implement the program measure. DCA used information from a telephone survey of participants and nonparticipants. The approach is presented in detail in section 2.4.2.

5. *Participant and Comparison Group Definition*

Participant - Participants are defined as those PG&E agricultural customers who received PG&E rebates in the 1996 calendar year for installing at least one pumping measure under the AEEI Program.

Comparison Group - For a customer to be included in the comparison group, following conditions should be fulfilled;

(1) should be a PG&E agricultural customer who is an eligible pumping account,

(2) who did not receive any pumping and related end use rebates in the 1996 calendar year under the AEEI Program,

(3) and who did not participate in the 1996 EMS Program,

(4) and who share as many characteristics as possible with the agricultural sector participant group in terms of annual usage.

Customers who participated in the previous years are eligible for the comparison group.

6. *Analysis Sample Size*

Gross impact – a census was attempted for the on-site audits.

Net-to-Gross ratio - A telephone interview was attempted for a census of AEEI participants of pumping and related end use. The sample information, showing the population, sample frame, and final analysis sample sizes are shown below in Exhibit 6.7. Multiple decisions were taken by telephone surveyed participants. Therefore, the final telephone analysis sample represents the total number of decisions taken.

Exhibit 6.7
Sample Summary – Pumping and Related End Use

Pumping and Related End Use	Population	Sample Frame			Final Analysis Sample		
		Telephone	On-Site	Metering	Telephone	On-Site	Metering
Participant*	91	55	91	91	49	74	66
Nonparticipant	86,474	35,571	35,571	35,571	42	68	68

Indoor Lighting End Use	Population	Sample Frame			Final Analysis Sample		
		Telephone	On-Site	Metering	Telephone	On-Site	Metering
Participant*	70	51	70	0	48	42	0
Nonparticipant	86,474	35,571	35,571	0	125	0	0

Pumping and Related and Indoor Lighting Total	Population	Sample Frame			Final Analysis Sample		
		Telephone	On-Site	Metering	Telephone	On-Site	Metering
Participant	161	106	161	91	97	116	66
Nonparticipant	86,474	35,571	35,571	35,571	167	68	68

Ag EMS	Population	Sample Frame			Final Analysis Sample		
		Telephone	On-Site	Metering	Telephone	On-Site	Metering
Participant	4,765	1,355	0	0	350	0	0
Nonparticipant	86,474	0	0	0	0	0	0

*Participant sample was a census

B. Database Management

1. Data Description and Flow Chart

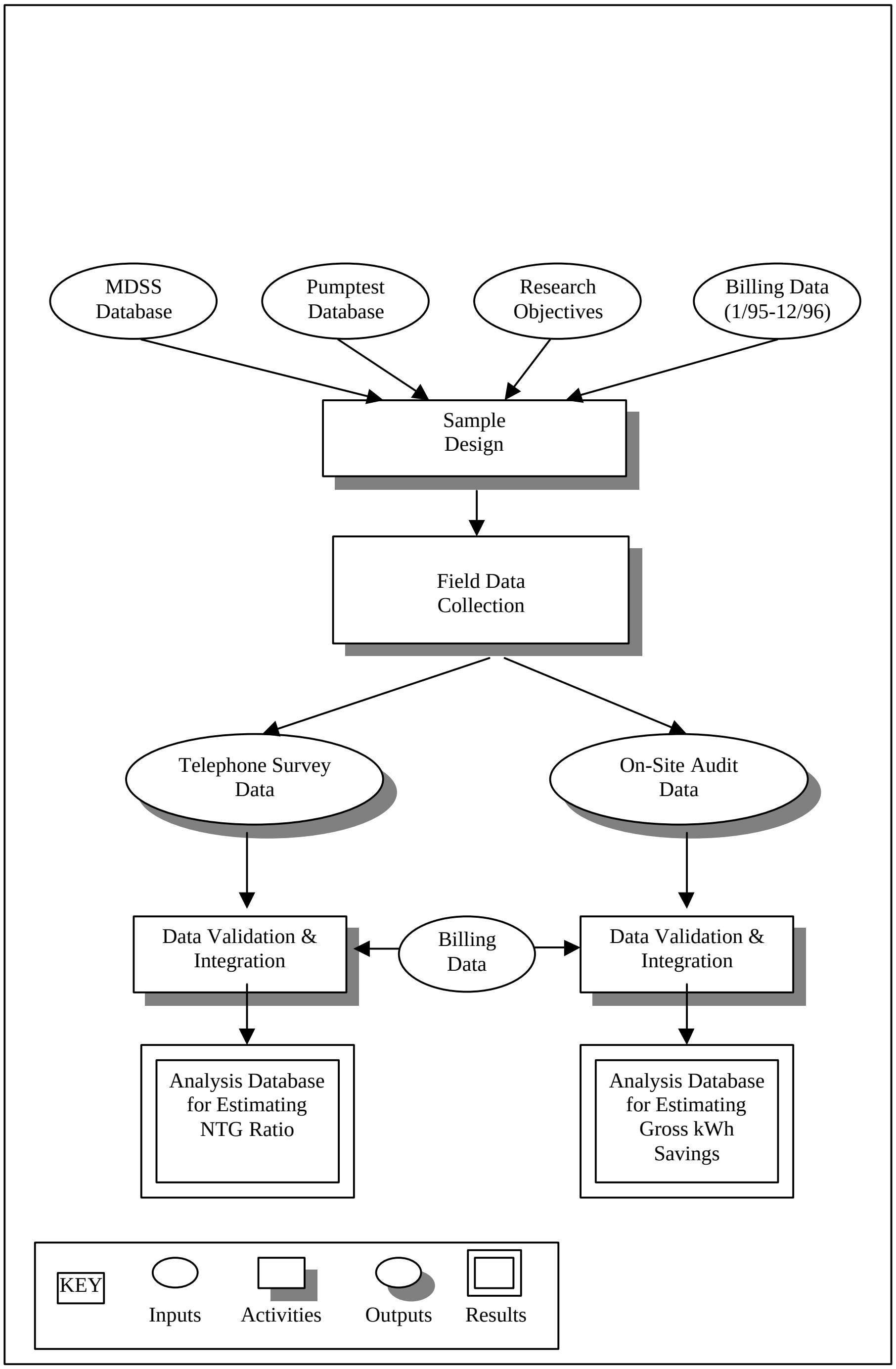
Survey data were collected for participants and nonparticipants. For the participant group, sample design was not required since a census is included in the analysis. For nonparticipants, the sample design is described in detail in section 2.1.3.5.

Information was collected via two different types of surveys: (1) telephone survey and (2) on-site survey. A census of participants was attempted under both the surveys. A sample of nonparticipants was contacted for on-site survey and a telephone survey.

First of all, program data along with the billing data were used to create the analysis dataset for nonparticipant sample allocation. After telephone survey and on-site survey of participants (a census) and nonparticipants (sample of nonparticipants), analysis database was created for net-to-gross analysis using the program data, billing data and telephone survey data. Similarly, analysis dataset for Gross impact was created using the program data, billing data and on-site survey data.

All data elements mentioned above were linked using unique PG&E control number and account number. For this evaluation, the analysis database served as a centralized tracking system for each customers' billing history, program participation, and sampling status, which helped to reduce data problems such as account mismatch, double counting, or repeated customer contacts. Exhibit 6.8 illustrates how each key data element was used to create the final analysis database for the evaluation.

Exhibit 6.8
Final Analysis Database Creation – Pumping and Related End Use



2. Data Description and Flow Chart

The key analysis data elements and their sources are listed below:

MDSS Tracking Database. - This database, maintained by PG&E, contains program application, rebate, and technical information about installed measures, including measure descriptions, quantities, rebate amounts, and ex ante demand, energy, and therm saving estimates.

PG&E Billing Data - The PG&E billing dataset used for the analysis was pro-rated monthly usage data, calculated by PG&E for each calendar month, and obtained from PG&E's Load Data Services.

Telephone Survey Data - The telephone survey supplies information on general characteristics of the customers, on energy-related actions taken outside of PG&E programs, other end uses covered under each account for participants and nonparticipants. The survey was designed to support the statistical models to estimate net-to-gross ratios for the end uses.

On-Site Audit Data - On-site audit data were collected as part of this evaluation for participant and nonparticipant group. The on-site audit is designed to support the engineering analysis by providing key inputs such as acreage and crop type.

Other data elements include PG&E program marketing data, PG&E internal SIC code mapping/segmentation scheme, program procedural manuals and other industry standard data sources.

3. Data Attrition Process

All data elements mentioned above were first validated and then merged together to form the final analysis dataset. Records with out-of-range or questionable data were not included in the analysis. This includes excluding two participant accounts from the analysis due to missing billing data. Data attrition before sample section is explained in section 2.1.3.3.

4. Internal Data Quality Procedures

The Evaluation contractor of this project, Equipoise Consulting along with subcontractors, have performed extensive data quality control on all categories of program data, including utility billing data, program tracking data, telephone survey data, and on-site data. The data quality procedures are consistent with PG&E's internal guidelines and the guidelines established in the Protocols.

Throughout the course of sample design and creation, survey data collection, and data analysis, several data quality assurance procedures were in place to insure that all energy usage data used in analysis and all telephone survey data collected was of high quality. The two stages of data validation undertaken are explained below.

Pre-survey Usage and Account Characteristic Data Validation. - The goal of data validation at this stage was to screen out customers who had unreasonable or unreliable usage data, or who had changes in key elements of their billing data over the three year 1995-1997 period. Accounts for which changes were observed in account numbers, service addresses, SIC codes, electric rate schedules, electric meter numbers, or corporation and premise identification variables, were excluded from sample eligibility. Usage data reliability screening eliminated from nonparticipant sample accounts, which experienced service interruptions.

On-site Survey Data Validation. – The on-site audits were validated by an agricultural engineer prior to data entry.

5. Unused Data Elements

Without exception, all data collected specifically for the Evaluation were utilized in the analysis. The nonparticipant pump tests were not used as planned.

C. Sampling

1. Sampling Procedures and Protocols

As explained in section 2.1.3.3, the limited participant population necessitated an attempted census of participants who were expected to contribute data to the statistical analysis. The number of completed participant surveys as mentioned in Appendix B, reflects such an attempted census.

The sampling plan for nonparticipants is discussed in detail in section 2.1.3.8. Nonparticipants were stratified based on usage, to match the participants, and within each stratum, a sample was randomly selected. Because the majority of customers with pumping accounts have descriptive addresses rather than numeric addresses, customers with descriptive service addresses were sampled as likely nonparticipants for the pumping and related end use control group.

2. Survey Information

Telephone survey instruments are presented along with the frequencies in Appendix B for participants and in Appendix C for nonparticipants.

On-site audit instruments are presented in Appendix F.

3. Statistical Descriptions

Complete sets of participant and comparison group customer's response frequencies are presented in Appendix B and C.

D. Data Screening and Analysis

A detailed discussion of the approach used to estimate net-to-gross ratio for pumping measures is described in section 2.4.2.

1. Missing Data

As discussed in more detail in section 2.1.2, 49 participants completed the telephone survey, and 42 eligible nonparticipants with descriptive address completed the telephone survey. Thus, a group of 91 customers including participants and a comparison group were included while estimating models. However, information on some variables was missing for 9 out of 91 customers therefore, those 9 customers were excluded from the analysis.

2. Background Variables

Background variables, such as interest rates, unemployment rates and other economic factors, were not explicitly modeled in the final model.

3. Data Screen Process

Section 2.1.3 describes all of the data screening criteria.

4. Model Statistics

The results of the model are presented in section 3.2.

5. Model Specification

Alternative model specifications and diagnostics are explained in section 2.4.6. Specific model specification issues are further discussed below:

Self-selection. - When usage of participants is compared with that of the comparison group, the issue of self-selection arises. The basis of Discrete Choice Analysis is to disentangle the pattern of causation between participation and implementation. The main purpose of the approach is to correct for the self-selection bias in the decisions itself.

Net Impact. - Net-to-Gross ratios derived using Discrete Choice Analysis were applied to the engineering analysis of gross kWh impacts in order to calculate net impact of the program.

6. Measurement Errors

For the statistical analysis of the net-to-gross ratio, the main source of measurement errors is the telephone survey. For the engineering analysis of Gross kWh impact, the main source of measurement errors is the on-site survey. Our approach has been to proactively stop the problem before it happens so that statistical corrections are kept to a minimum.

Measurement errors are a combination of random and non-random error components that plague all survey data. The non-random error frequently takes the form of systematic bias, which includes, but is not limited to, ill-formed or misleading questions and miscoded study variables. In this project, we have implemented controls to reduce the systematic bias in the data. These steps include (1) thorough auditor/coder training, and (2) instrument pre-test.

The random measurement error, such as data entry error, has no impact on estimating mean values because the errors are typically unbiased.

7. Autocorrelation

The autocorrelation problem exists if the residuals in one time period are correlated with the residuals in the previous time period. Since the approach used in this study (DCA) does not use data over a period of time, problem of autocorrelation is not applicable.

8. Heteroskedasticity

The logistic models used in this analysis typically deal with cross-sectional data. Heterogeneous responses are expected from heterogeneous group of people. Since usage is not the dependent variable, such heterogeneity does not cause a problem with respect to the stability of the model. In addition, in order to recognize the unique individuality of each decision taken by all customers, decision specific intercepts are used in the model.

9. Collinearity

The possibility of serious collinearity among any explanatory variables in all the models was also explored by examining the correlation matrix of the explanatory variables. The sensitivity of the results was tested for any possible collinearity. Variables with high correlation affected the estimated coefficients and the resultant net-to-gross ratios. Of the two variables with high correlation, one of the two variables was selected primarily on the basis of two criteria: (1) explanatory power of the variable as determined by the correlation with the dependent variable, and (2) the extremely high predictive power of the model as measured by the percentage correctly predicted. Out of two highly correlated variables, the variable with higher explanatory power is preferred. The variable that contributes more to the predictive power as measured by concordant is preferred.

10. Influential Data Points

Estimating the same model on different samples for which there were no missing data tested influence of the data points. Both models presented in section 3.2 were found to be stable.

11. Missing Data

Any data that were omitted for designing the sample are described in section 2.1.3. While estimating participation and implementation models, there were nine sample points i.e., customer decisions for which survey data were missing for one or the other explanatory variables and therefore they were excluded from the model.

12. Precision

There are three different components of the net impact analysis. One, the net-to-gross ratio, second, gross kWh impact and third the spillover effect.

Precision for net-to-gross ratios is represented by the 80% and 90% confidence interval. The procedure is explained in section 3.2.

Since engineering estimate of gross kWh savings is a point estimate for any customer, and is calculated for all participants for whom on-site data were available, there is no sampling error associated with it and systematic measurement error is avoided by proactive actions. Thus, the engineering estimate is considered 100% precise.

Similarly, spillover effect is estimated using the number of measures installed by participants and nonparticipants outside the program. Spillover effects are not estimated statistically. Therefore the level of precision is considered as high as 100%.

Since two out of three components are considered as precise as 100%, the 80% and 90% confidence intervals are applied only to the net kWh impacts in order to get 80% and 90% confidence interval. These are presented in Protocol Table 6.

E. Data Interpretation and Application

The program net-to-gross analysis was conducted based on Discrete Choice Analysis. For a detailed net-to-gross analysis, see section 2.4.

There were three approaches considered in this study to estimate net-to-gross ratios.

(1) Billing analysis that compares participants and nonparticipants with respect to kWh consumption. There were two reasons for not using this approach in this study. First, PG&E's 1994 and 1995 Agricultural Programs Impact Evaluations using the billing analysis approach failed to provide reliable estimates of net savings attributable to the utility's CEE program. Past experiences indicate that small savings are difficult to identify in the absence of information on the factors that affect consumption over a period of time. Second, this approach ignores the interrelationship between the participation and implementation decision. We think that it is not just the participation decision that indicates whether customers would have implemented the same measure outside the program or not. In fact, the implementation decision is equally important and is ignored by this approach.

(2) Self report analysis that uses only participant responses to survey questions regarding the timing of and reasons for equipment replacement actions. This approach does not make use of a comparison group as required by the Protocols. Though the method and analysis are presented in Appendix A, we recommend using the results of Discrete Choice Analysis.

(3) Discrete Choice Analysis that uses a participant group and a comparison group and that disentangles the pattern of causation between participation and implementation. The method is described in section 2.4. The results are discussed in section 3.2.

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6.2 Protocol Table 7 – Indoor Lighting End Use (Study #385)

1996 Agricultural EEI Program Evaluation of Indoor Lighting End Use
PG&E Study ID #385

The purpose of this section is to provide the documentation for data quality and processing as required in Table 7 of the California Public Utility Commission (CPUC) Evaluation and Measurement Protocols (the Protocols). Major topics are organized and presented in the same order as they are listed in Table 7 for ease of reference and review. When responses to the items are discussed in detail elsewhere in the report, only a brief summary will be given in this section to avoid redundancy.

A. Overview Information

1. Study Title and Study ID Number

Study Title: Evaluation of PG&E's 1996 Agricultural Energy Efficiency Incentives (AEEI) Program for Agricultural Sector Indoor Lighting End Use Technologies.

Study ID Number: 385

2. Program, Program Year and Program Description

Program: PG&E Agricultural EEI Program, Agricultural Sector Indoor Lighting End Use Technologies.

Program Year: Rebates Received in the 1996 Calendar Year.

Program Description: Refer to section 1.1.

3. End Uses and/or Measures Covered

End Use Covered: Agricultural Indoor Lighting Technologies

Measures Covered: Compact Fluorescent Lamps
Exit Signs
T-8 Lamps and Electronic Ballast
Delamp Fluorescent Fixtures
Lighting Controls
High Density Discharge

4. Methods and Models Use

The PG&E AEEI Program evaluation consisted of three key analysis components: (1)engineering analysis of gross kWh impacts; (2) Discrete Choice Analysis (DCA) of net-to-gross ratio of the program; and (3) participant and nonparticipant spillover effects. This integrated approach reduces a complicated problem to manageable components, while incorporating the comparative advantage of each analysis method. This approach describes net effects in kWh for a given measure type as follows:

$$\begin{pmatrix} \text{Net Effects of} \\ \text{AEEI Program in} \\ \text{terms of kWh} \end{pmatrix} = \sum_{i=1}^{5} \begin{pmatrix} \text{kWh Gross} \\ \text{Savngs using} \\ \text{Engineering} \\ \text{Analysis} \end{pmatrix}_i * \begin{pmatrix} \text{Net - To - Gross} \\ \text{Ratio} \\ \text{Using DCA} \end{pmatrix} + \begin{pmatrix} \text{Spillover} \\ \text{Effects} \end{pmatrix}$$

Gross Impact - The gross estimates of impact for the indoor lighting end use were based upon engineering models using on-site data.

Net effect. - Using Discrete Choice Analysis, the net-to-gross ratio was derived for the indoor lighting end use. A group of participants and nonparticipants were included to analyze whether customers participated in the program because they had already decided to implement program measures and simply wanted the program benefits, or did the program actually induce them to implement the program measure. The DCA used information from a telephone survey of participants and nonparticipants. The approach is presented in detail in section 2.4.2.

5. Participant and Comparison Group Definition

Participant - Participants are defined as those PG&E agricultural customers who received PG&E rebates in the 1996 calendar year for installing at least one indoor lighting measures under the AEEI Program.

Comparison Group - For a customer to be included in the comparison group, following conditions were fulfilled;

(1) a PG&E agricultural customer,

(2) did not receive any indoor lighting end use rebates in the 1996 calendar year under the AEEI Program,

(3) did not participate in the 1996 EMS Program,

(4) and who share as many characteristics as possible with the agricultural sector participant group in terms of annual usage.

Customers who participated in the previous years were eligible for the comparison group.

6. Analysis Sample Size

Gross impact – a census was attempted for the on-site audits.

Net-to-Gross ratio - A telephone interview was attempted for a census of AEEI participants of indoor lighting end use. The final analysis dataset has 173 observations since there were complete telephone surveys for 173 customer decisions. Out of a total of 173, 48 were indoor lighting end use participants and the remaining 125 served as a comparison group (76 nonparticipants and 49 pumping participants). The sample information, showing the population, sample frame, and final analysis sample sizes are shown below in Exhibit 6.9.

Exhibit 6.9
Sample Summary – Indoor Lighting End Use

Pumping and Related End Use	Population	Sample Frame Telephone	Sample Frame On-Site	Sample Frame Metering	Final Analysis Sample Telephone	Final Analysis Sample On-Site	Final Analysis Sample Metering
Participant*	91	55	91	91	49	74	66
Nonparticipant	86,474	35,571	35,571	35,571	42	68	68

Indoor Lighting End Use	Population	Sample Frame Telephone	Sample Frame On-Site	Sample Frame Metering	Final Analysis Sample Telephone	Final Analysis Sample On-Site	Final Analysis Sample Metering
Participant*	70	51	70	0	48	42	0
Nonparticipant	86,474	35,571	35,571	0	125	0	0

Pumping and Related and Indoor Lighting Total	Population	Sample Frame Telephone	Sample Frame On-Site	Sample Frame Metering	Final Analysis Sample Telephone	Final Analysis Sample On-Site	Final Analysis Sample Metering
Participant	161	106	161	91	97	116	66
Nonparticipant	86,474	35,571	35,571	35,571	167	68	68

Ag EMS	Population	Sample Frame Telephone	Sample Frame On-Site	Sample Frame Metering	Final Analysis Sample Telephone	Final Analysis Sample On-Site	Final Analysis Sample Metering
Participant	4,765	1,355	0	0	350	0	0
Nonparticipant	86,474	0	0	0	0	0	0

*Participant sample was a census

B. Database Management

1. Data Description and Flow Chart

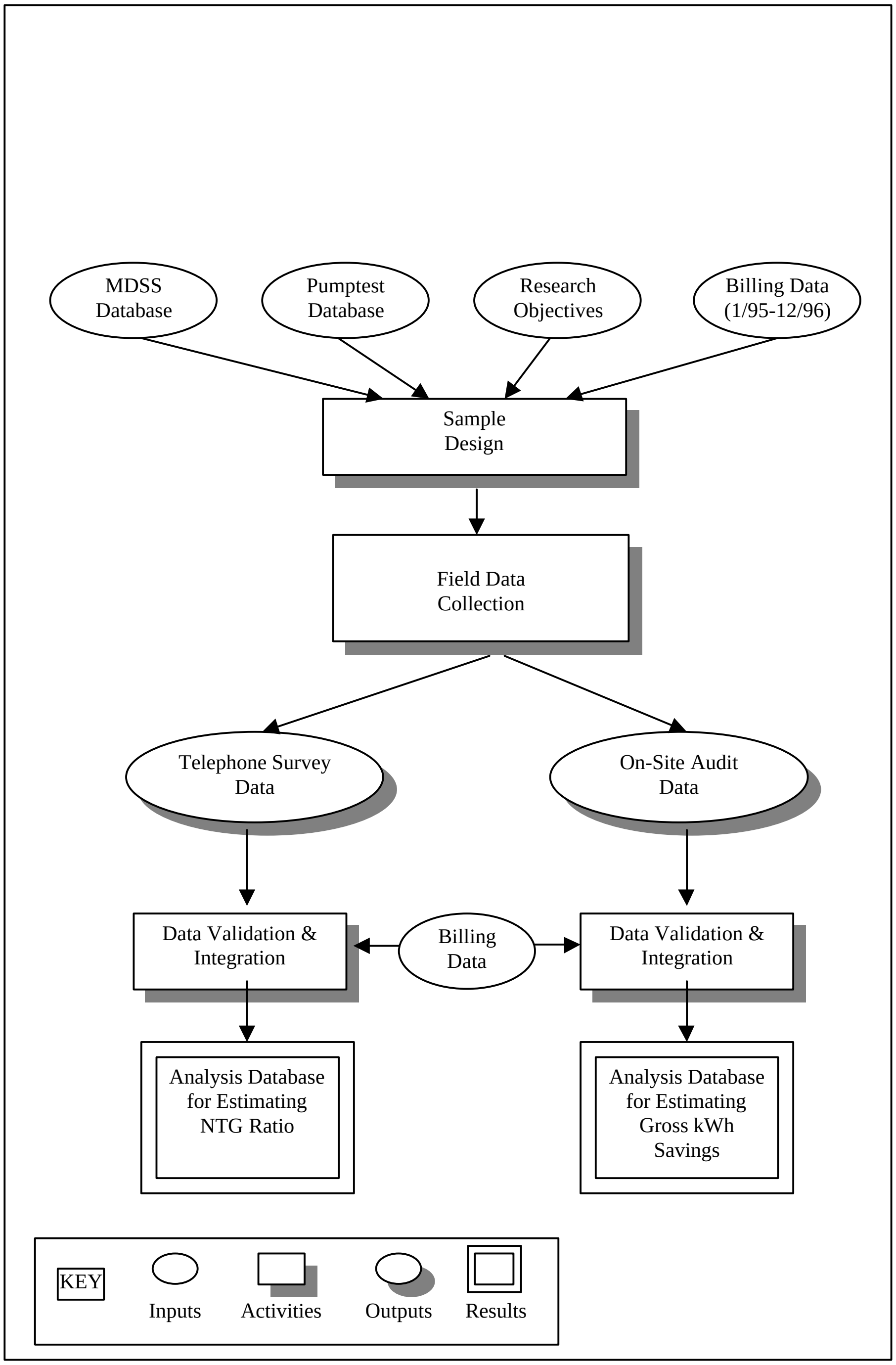
Survey data were collected for participants and nonparticipants. For the participant group, sample design was not required since a census is included in the analysis. For nonparticipants, the sample design is described in detail in section 2.1.3.5.

Information was collected via two different types of surveys: (1) telephone survey and (2) on-site survey. A census of participants was attempted under both the surveys. A sample of nonparticipants was contacted for a telephone survey.

First of all, program data along with the billing data were used to create the analysis dataset for the nonparticipant sample allocation. After the telephone survey and the on-site survey of participants (a census) and nonparticipants (sample of nonparticipants), the analysis database was created for the net-to-gross analysis using the program data, billing data and telephone survey data. Similarly, analysis dataset for the gross impact analysis was created using the program data, billing data, and on-site survey data.

All data elements mentioned above were linked using unique PG&E control number and account number. For this evaluation, the analysis database served as a centralized tracking system for each customers' billing history, program participation, and sampling status, which helped to reduce data problems such as account mismatch, double counting, or repeated customer contacts. Exhibit 6.10 illustrates how each key data element was used to create the final analysis database for the evaluation.

Exhibit 6.10
Final Analysis Database Creation – Indoor Lighting End Use



2. Data Description and Flow Chart

The key analysis data elements and their sources are listed below:

MDSS Tracking Database. - This database, maintained by PG&E, contains program application, rebate, and technical information about installed measures, including measure descriptions, quantities, rebate amounts, and ex ante demand, energy, and therm saving estimates.

PG&E Billing Data - The PG&E billing dataset used for the analysis was pro-rated monthly usage data, calculated by PG&E for each calendar month, and obtained from PG&E's Load Data Services.

Telephone Survey Data - The telephone survey supplies information on general characteristics of the customers, on energy-related actions taken outside of PG&E programs, other end uses covered under each account for participants and nonparticipants. The survey was designed to support the statistical models to estimate net-to-gross ratios for the end uses.

On-Site Audit Data - On-site audit data were collected as part of this evaluation for participant group. The on-site audit is designed to support the engineering analysis by providing key inputs such as connected load and operating hours.

Other data elements include PG&E program marketing data, PG&E internal SIC code mapping/segmentation scheme, program procedural manuals and other industry standard data sources.

3. Data Attrition Process

All data elements mentioned above were first validated and then merged together to form the final analysis dataset. Records with out-of-range or questionable data were not included in the analysis. This includes excluding two participant accounts from the analysis due to missing billing data. Data attrition before sample section is explained in section 2.1.3.3.

4. Internal Data Quality Procedures

The Evaluation contractor of this project, Equipoise Consulting along with subcontractors, have performed extensive data quality control on all categories of program data, including utility billing data, program tracking data, telephone survey data, and on-site data. The data quality procedures are consistent with PG&E's internal guidelines and the guidelines established in the Protocols.

Throughout the course of sample design and creation, survey data collection, and data analysis, several data quality assurance procedures were in place to insure that all energy usage data used in analysis and all telephone survey data collected was of high quality. The two stages of data validation undertaken are explained below.

Pre-survey Usage and Account Characteristic Data Validation. - The goal of data validation at this stage was to screen out customers who had unreasonable or unreliable usage data, or who had changes in key elements of their billing data over the three year 1995-1997 period. Accounts for which changes were observed in account numbers, service addresses, SIC codes, electric rate schedules, electric meter numbers, or corporation and premise identification variables, were excluded from sample eligibility. Usage data reliability screening eliminated accounts which experienced service interruptions from the nonparticipant sample.

On-site Survey Data Validation. – The on-site audits were validated by an agricultural engineer prior to data entry.

5. Unused Data Elements

Without exception, all data collected specifically for the lighting evaluation were utilized in the analysis.

C. Sampling

1. Sampling Procedures and Protocols

As explained in section 2.1.3.3, the limited participant population necessitated an attempted census of participants who were expected to contribute data to the statistical analysis. The number of completed participant surveys as mentioned in Appendix B, reflects such an attempted census.

The sampling plan for nonparticipants is discussed in detail in section 2.1.3.8. Nonparticipants were stratified based on usage, to match the participants, and within each stratum, a sample was randomly selected. Since the telephone survey asked questions to nonparticipants with respect to their facility/business and not only to a particular account, it was more appropriate to include all nonparticipants as a comparison group.

2. Survey Information

Telephone survey instruments are presented along with the frequencies in Appendix B for participants and in Appendix C for nonparticipants.

On-site audit instruments are presented in Appendix F.

3. Statistical Descriptions

Complete sets of participant and comparison group customers' response frequencies are presented in Appendix B and C.

D. Data Screening and Analysis

A detailed discussion of the approach used to estimate the net-to-gross ratio for indoor lighting measures is described in section 2.4.2. Model results are discussed in detail in section 3.2.1.

1. Missing Data

As discussed in more detail in section 2.1.2, 48 participants completed the telephone survey, and 125 nonparticipants completed the telephone survey. Thus, a group of 173 customers including participants and a comparison group were included while estimating models. However, information on some variables was missing for 13 out of 173 customers therefore, those 13 customers were excluded from the analysis.

2. Background Variables

Background variables, such as interest rates, unemployment rates and other economic factors, were not explicitly modeled in the final model.

3. Data Screen Process

Section 2.1.3 describes all of the data screening criteria.

4. Model Statistics

The results of the model are presented in section 3.2.

5. Model Specification

Alternative model specifications and diagnostics are explained in section 2.4.6. Specific model specification issues are further discussed below:

Self-selection. - When usage of participants is compared with that of comparison group, the issue of self-selection arises. The basis of the Discrete Choice Analysis is to disentangle the pattern of causation between participation and implementation. The main purpose of the approach is to correct for the self-selection bias in the decisions itself.

Net Impact. - Net-to-gross ratios derived using Discrete Choice Analysis plus participant and nonparticipant spillover were applied to the engineering analysis of gross kWh impacts in order to calculate net impact of the program.

6. Measurement Errors

For the statistical analysis of the net-to-gross ratio, the main source of measurement errors is the telephone survey. For the engineering analysis of the gross kWh impact, the main source of measurement errors is the on-site survey. Our approach has been to proactively stop the problem before it happens so that statistical corrections are kept to a minimum.

Measurement errors are a combination of random and non-random error components that plague all survey data. The non-random error frequently takes the form of systematic bias, which includes, but is not limited to, ill-formed or misleading questions and miscoded study variables. In this project, we have implemented controls to reduce the systematic bias in the data. These steps include (1) thorough auditor/coder training, and (2) instrument pre-test.

The random measurement error, such as data entry error, has no impact on estimating mean values because the errors are typically unbiased.

7. Autocorrelation

The autocorrelation problem exists if the residuals in one time period are correlated with the residuals in the previous time period. Since the approach used in this study (DCA) does not use data over a period of time, problem of autocorrelation is not applicable.

8. Heteroskedasticity

The logistic models used in this analysis typically deal with cross-sectional data. Heterogeneous responses are expected from a heterogeneous group of people. Since usage is not the dependent variable, such heterogeneity does not cause a problem with respect to the stability of the model. In addition, in order to recognize the unique individuality of each decision taken by all customers, decision specific intercepts are used in the model.

9. Collinearity

The possibility of serious collinearity among any explanatory variables in all the models was also explored by examining the correlation matrix of the explanatory variables. The sensitivity of the results was tested for any possible collinearity. Variables with high correlation affected the estimated coefficients and the resultant net-to-gross ratios. Of the two variables with high correlation, one of the two variables was selected primarily on the basis of two criteria: (1) explanatory power of the variable as determined by the correlation with the dependent variable, and (2) extremely high predictive power of the model as measured by the percentage correctly predicted. Out of two highly correlated variables, the variable with higher explanatory power is preferred. The variable that contributes more to the predictive power as measured by concordant is preferred.

10. Influential Data Points

Estimating the same model on different samples for which there were no missing data tested influence of the data points. Both models presented in section 3.2 were found to be stable.

11. Missing Data

Any data that were omitted for designing the sample are described in section 2.1.3. While estimating participation and implementation models, there were 13 customer decisions i.e., customer decisions for which survey data were missing for one or the other explanatory variables and therefore they were excluded from the model.

12. Precision

There are three different components of the net impact analysis. One, the net-to-gross ratio, second, gross kWh impact and third the spillover effect.

Precision for net-to-gross ratios is represented by the 80% and 90% confidence interval. The procedure is explained in section 3.2.

Since engineering estimate of gross kWh savings is a point estimate for any customer, and is calculated for all participants for whom on-site data were available, there is no sampling error associated with it and systematic measurement error is avoided by proactive actions. Thus, the engineering estimate is considered 100% precise.

Similarly, spillover effect is estimated using the number of measures installed by participants and nonparticipants outside the program. Spillover effects are not estimated statistically. Therefore the level of precision is considered as high as 100%.

Since two out of three components are considered as precise as 100%, the 80% and 90% confidence intervals are applied only to the net kWh impacts in order to get 80% and 90% confidence interval. These are presented in Protocol Table 6.

E. Data Interpretation and Application

The program net-to-gross analysis was conducted based on a Discrete Choice Analysis. For a detailed net-to-gross analysis, see section 2.4.

There were three approaches considered in this study to estimate net-to-gross ratios.

(4) Billing analysis that compares participants and nonparticipants with respect to kWh consumption. There were two reasons for not using this approach in this study. First, PG&E’s 1994 and 1995 Agricultural Programs Impact Evaluations using the billing analysis approach failed to provide reliable estimates of net savings attributable to the utility’s CEE program. Past experiences indicate that small savings are difficult to

identify in the absence of information on the factors that affect consumption over a period of time. Second, this approach ignores the interrelationship between the participation and implementation decision. We think that it is not just the participation decision that indicates whether customers would have implemented the same measure outside the program or not. In fact, the implementation decision is equally important and is ignored by this approach.

(5) Self report analysis that uses only participant responses to survey questions regarding the timing of and reasons for equipment replacement actions. This approach does not make use of a comparison group as required by the Protocol and hence though the method and analysis are presented in Appendix A, we recommend using the results of Discrete Choice Analysis.

(6) Discrete Choice Analysis that uses participant group and a comparison group and that disentangles the pattern of causation between participation and implementation. The method is described in section 2.4 and the results are discussed in section 3.2.

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6.3 Protocol Table 7 – AEMS Program (Study #360)

1996 Agricultural EMS Program Evaluation
PG&E Study ID #360

The purpose of this section is to provide the documentation for data quality and processing as required in Table 7 of the California Public Utility Commission (CPUC) Evaluation and Measurement Protocols (the Protocols). Major topics are organized and presented in the same order as they are listed in Table 7 for ease of reference and review. When responses to the items are discussed in detail elsewhere in the report, only a brief summary will be given in this section to avoid redundancy.

A. Overview Information

1. Study Title and Study ID Number

Study Title: Evaluation of PG&E's 1996 Agricultural Energy Management Services (EMS) Program.

Study ID Number: 360

2. Program, Program Year and Program Description

Program: PG&E Agricultural EMS Program, Agricultural Sector.

Program Year: Pump Tests Received in the 1996 Calendar Year.

Program Description: Refer to section 1.1.

3. End Uses and/or Measures Covered

End Use Covered: Pumping

Measures Covered: Agricultural Pump Tests

4. Methods and Models Use

The PG&E EMS Program evaluation for agricultural customers consisted of three key analysis components: (1) calculating gross kWh savings, (2) calculating the number of pump repairs after participation in EMS program excluding break downs; and (3) applying 0.75 net-to-gross ratio. This approach describes net effects in kWh as follows:

$$\begin{pmatrix}\text{Net Effecs of}\\ \text{EMS Program in}\\ \text{terms of kWh}\end{pmatrix} = \begin{pmatrix}\text{kWh Gross}\\ \text{Savings per repair using}\\ \text{Engineering}\\ \text{Analysis}\end{pmatrix} * \begin{pmatrix}\text{Number of}\\ \text{Pump repairs}\\ \text{by Participants}\end{pmatrix} * \begin{pmatrix}\text{Predetermined}\\ \text{Net - To - Gross}\\ \text{Ratio (i.e. 0.75)}\end{pmatrix}$$

Gross Impact. – The EMS program for agricultural customers involved pump tests. It was required to calculate kWh gross savings from the pump repairs as a result of the pump tests under AEMS program. The kWh gross savings from a pump repair remain the same irrespective of whether it was done as a part of EEI program or EMS program. Therefore, we used the gross kWh savings from a pump repair estimated for EEI program. The approach is explained in section 2.3.3.

Net effect. - As per the CADMAC waiver shown in section 5, a net-to-gross ratio of 75% was used for AMS Program. A group of participants were contacted via a telephone survey and information was collected regarding number of pumps repaired and number of broken pumps. By excluding the number of broken pumps from the total pump repairs, number of pump repairs by participants was derived.

5. Participant and Comparison Group Definition

Participant Group - Participants are defined as those PG&E agricultural customers with pump tests who participated in EMS program in 1996.

Comparison Group - Since the net-to-gross ratio for this program was already predetermined by the waiver process, a comparison group was not included in any analysis for this program.

6. Analysis Sample Size

Gross impact. – A telephone survey gathered pump repair information on 350 participants.

Net-to-Gross ratio – The default value of 0.75 was used as per the waiver.

B. Database Management

1. Data Description and Flow Chart

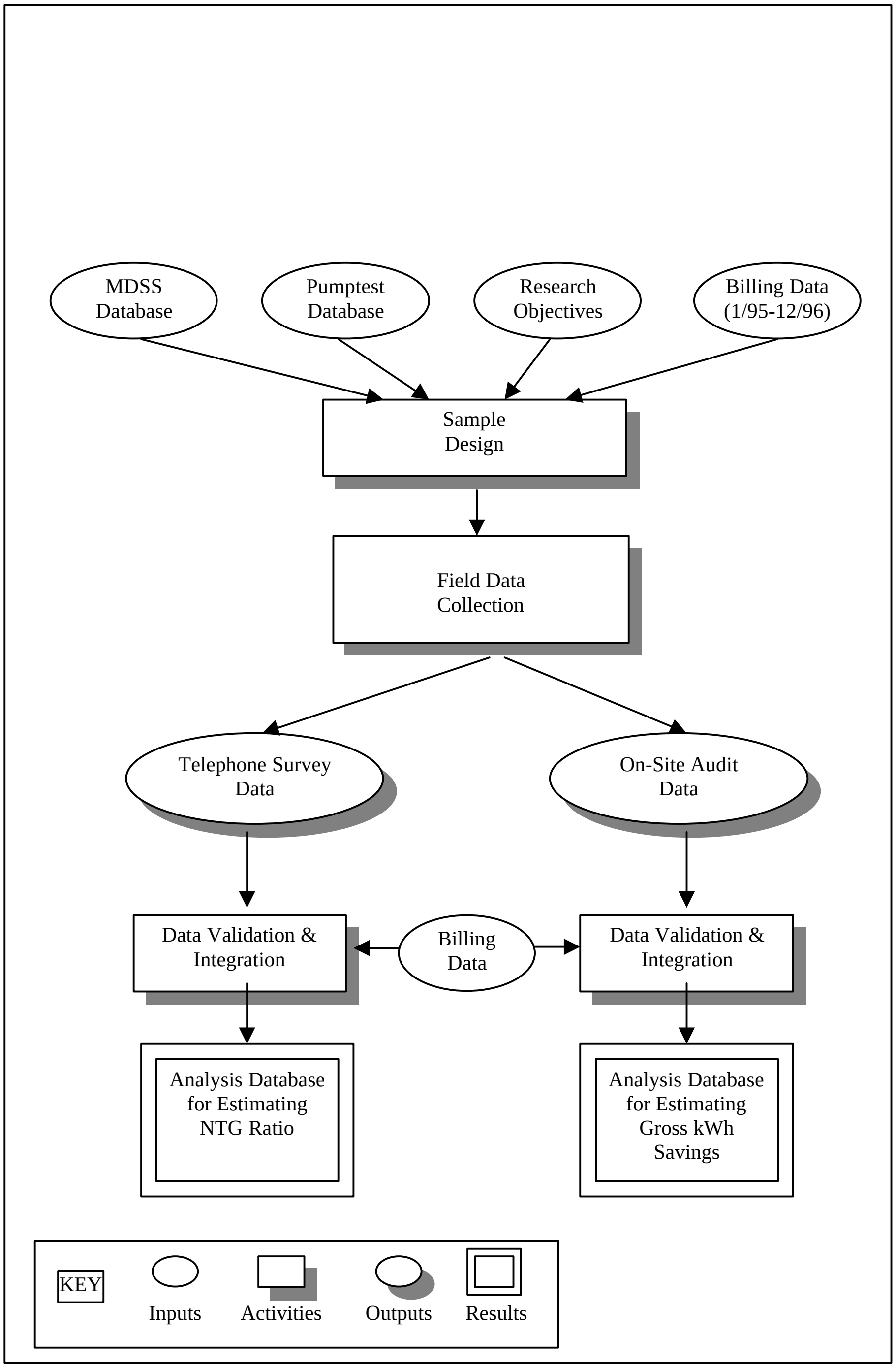
Survey data were collected for participants. For the participant group, a stratified random sample of 350 customers was selected. Using a Dalenius and Hodges approach, and annual kWh usage of participants, the participants were divided in four groups. A random sample was selected from each stratum.

Information was collected via a telephone survey. A sample of 350 participants was contacted via a telephone survey.

First of all, program data along with the billing data were used to create the analysis dataset for participant sample allocation. After telephone survey of participant sample, analysis database was created to calculate number of pump repairs by participants. net-to-gross ratio of 75% was then applied to derive net impact (in kWh) of the program.

All data elements mentioned above were linked using unique PG&E control number and account number. For this evaluation, the analysis database served as a centralized tracking system for each customers' billing history, program participation, and sampling status, which helped to reduce data problems such as account mismatch, double counting, or repeated customer contacts. Exhibit 6.11 illustrates how each key data element was used to create the final analysis database for the evaluation.

Exhibit 6.11
Final Analysis Database Creation – AEMS Program



2. Data Description and Flow Chart

The key analysis data elements and their sources are listed below:

MDSS Tracking Database. - This database, maintained by PG&E, contains program application, rebate, and technical information about pump tests and installed measures, including measure descriptions, quantities, rebate amounts, and ex ante demand, energy, and therm saving estimates.

PG&E Billing Data - The PG&E billing dataset used for the analysis was pro-rated monthly usage data, calculated by PG&E for each calendar month, and obtained from PG&E's Load Data Services.

Telephone Survey Data - The telephone survey supplies information on number of pump repairs and number of broken pumps.

3. Data Attrition Process

All data elements mentioned above were first validated and then merged together to form the final analysis dataset. Data attrition before sample section is explained section 2.1.3.3.

4. Internal Data Quality Procedures

The Evaluation contractor of this project, Equipoise Consulting along with subcontractors, have performed extensive data quality control on all categories of program data, including utility billing data, program tracking data, and telephone survey data. The data quality procedures are consistent with PG&E's internal guidelines and the guidelines established in the Protocols.

Throughout the course of sample design and creation, survey data collection, and data analysis, several data quality assurance procedures were in place to insure that all energy usage data used in analysis and all telephone survey data collected was of high quality. The two stages of data validation undertaken are explained below.

Pre-survey Usage and Account Characteristic Data Validation. - The goal of data validation at this stage was to screen out customers who had unreasonable or unreliable usage data, or who had changes in key elements of their billing data over the three year 1995-1997 period. Accounts for which changes were observed in account numbers, service addresses, SIC codes, electric rate schedules, electric meter numbers, or corporation and premise identification variables, were excluded from sample eligibility. Usage data reliability screening eliminated accounts which experienced service interruptions from the nonparticipant sample.

Survey Data Validation. – Random data inputs were checked by the survey supervisor.

5. Unused Data Elements

Without exception, all data collected specifically for the AEMS evaluation were utilized in the analysis.

C. Sampling

1. Sampling Procedures and Protocols

Using stratified random sampling, 350 participants were selected from a group of 4,765 participants. The questions and its frequencies are presented in Appendix D.

The sampling plan for participants is discussed in detail in section 2.1.3.

2. Survey Information

Telephone survey instruments are presented along with the frequencies in Appendix D for participants.

3. Statistical Descriptions

Complete sets of participant response frequencies are presented in Appendix D.

D. Data Screening and Analysis

A detailed discussion of the approach used to calculate gross impact is given in section 2.3.3 and number of pump repairs by participants is described in section 3.1.

1. Missing Data

Number of pump repairs by 350 participants was calculated from the information via a telephone survey.

2. Background Variables

Background variables, such as interest rates, unemployment rates and other economic factors, were not explicitly modeled in the final analysis.

3. Data Screen Process

Section 2.1.3 describes all of the data screening criteria.

4. Model Statistics

Since a predetermined net-to-gross ratio is used, there are no statistical models estimated or reported.

5. Model Specification

As mentioned above, since a predetermined net-to-gross ratio is used, there are no statistical models estimated or reported.

Self-selection. - Since there was no statistical analysis performed, we did not deal with self-selection bias. However, applying 75% net-to-gross ratio implicitly deals with self-selection.

Net Impact. - As mentioned earlier, net-to-gross ratio of 75% is applied to the gross kWh impact and the number of pump repairs by participants to derive total net impact in kWh.

6. Measurement Errors

The main source of measurement errors is the telephone survey. Our approach has been to proactively stop the problem before it happens so that statistical corrections are kept to a minimum.

Measurement errors are a combination of random and non-random error components that plague all survey data. The non-random error frequently takes the form of systematic bias, which includes, but is not limited to, ill-formed or misleading questions and miscoded study variables. In this project, we have implemented controls to reduce the systematic bias in the data. These steps include (1) thorough auditor/coder training, and (2) instrument pre-test.

The random measurement error, such as data entry error, has no impact on estimating mean values because the errors are typically unbiased.

7. Autocorrelation

The autocorrelation problem exists if the residuals in one time period are correlated with the residuals in the previous time period. Since there was no statistical analysis performed, this is not applicable.

8. Heteroskedasticity

Since there was no statistical analysis performed, this is not applicable

9. Collinearity

Since there was no statistical analysis performed, this is not applicable

10. Influential Data Points

Since there was no statistical analysis performed, this is not applicable

11. Missing Data

Since there was no statistical analysis performed, this is not applicable

12. Precision

There are three different components of the net impact analysis; 1) a predetermined net-to-gross ratio of 75%, 2) gross kWh impact and 3) the calculation of number of pump repairs by participants.

Precision for the net-to-gross ratio is 0% since it is predetermined.

Since the engineering estimate of gross kWh savings is a point estimate for any customer, and is calculated for all participants for whom on-site data were available, there is no sampling error associated with it and systematic measurement error is avoided by proactive actions. Thus, the engineering estimate is considered 100% precise.

Similarly, number of pump repairs is calculated as the sum of pump repairs excluding broken pumps. They are estimated statistically. Therefore the level of precision is considered as high as 100%.

All of three components are considered as precise as 100%.

E. Data Interpretation and Application

Since net-to-gross ratio analysis was not performed, this is not applicable.

This concludes the report on the evaluation of the 1996 Agricultural Sector Programs.