PACIFIC GAS & ELECTRIC'S CARRYOVER FOR PRE-1998 ENERGY EFFICIENCY INCENTIVES PROGRAM: AGRICULTURAL SECTOR IMPACT EVALUATION REPORT

Pumping and Related End Use (Study ID 405a), Refrigeration End Use (Study ID 405b), & Greenhouse Heat Curtain End Use (Study ID 405c)

March 1, 2000

Measurement and Evaluation
Customer Energy Efficiency Policy & Evaluation Section
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Pacific Gas & Electric's
Carryover for Pre-1998 Energy Efficiency Incentives Program: Agricultural Sector
Impact Evaluation Report
Pumping and Related End Use (Study ID No. 405A)
Refrigeration End Use (Study ID No. 405B)
Greenhouse Heat Curtain End Use (Study ID No. 405C)

Purpose of Study

The purpose of the attached studies are to document the level of ex post first-year gross and net energy and demand impacts of carryover for PG&E's Pre-1998 Energy Efficiency Incentives Program for the Agricultural Sector (AEEI). The AEEI Program promoted the purchase of energy efficient technologies to the agricultural sector through financial incentives paid to agricultural participants. As required, the 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 June, 1999, pursuant to Decisions 94-05-063, 94-10-059, 94-12-021, 95-12-054, 96-12-079, 98-03-063, and 99-06-052.

Methodology

The gross energy and demand impact estimates for the Carryover for Pre-1998 AEEI Program are based on engineering models. The evaluation of Pumping and Related End Use measures combined data from pre- and post-installation pump tests, PG&E's pump test database, and on-site data to determine impacts. The Refrigeration and Greenhouse Heat Curtain End Use measures incorporated on-site data, manufacturer data and a review of ex ante algorithms to estimate impacts. Algorithms were updated or replaced, as necessary, to assure accurate estimation of impacts. When its use could contribute to the accuracy of the estimates, electric and gas usage and demand data were used to support the analysis.

Net impacts are based on a CADMAC waiver allowing the application of a 0.75 net-to-gross ratio to the gross impacts in return for PG&E conducting a user based market needs study on PG&E's agricultural sector. The market needs study is underway and will be reported by March 30, 1999, as agreed in the waiver.

Study Results

The results of the analyses are summarized in the following three tables:

Pumping and Related End Use

Pumping and Related End Use	Gross Savings	Gross Realization Rate	Net To Gross	Net Savings	Net Realization Rate
EX ANTE					
kW	3,631	-	0.75	2,723	-
kWh	8,775,123	-	0.75	6,581,342	-
Therms	-	-	-	-	-
EX POST					
kW	2,855	0.79	0.75	2,141	0.79
kWh	8,273,580	0.94	0.75	6,205,185	0.94
Therms	12,258	NA	0.75	9,193	NA

Refrigeration End Use

Refrigeration End Use	Gross Savings	Gross Realization Rate	Net To Gross	Net Savings	Net Realization Rate
EX ANTE					
kW	440	-	0.75	330	-
kWh	2,465,187	-	0.75	1,848,890	-
Therms	-	-		-	-
EX POST					
kW	373	0.85	0.75	280	0.85
kWh	1,908,036	0.77	0.75	1,431,027	0.77
Therms	-			-	-

Greenhouse Heat Curtain End Use

Heat Curtain End Use	Gross Savings	Gross Realization Rate	Net To Gross	Net Savings	Net Realization Rate
EX ANTE					
kW	-	-		-	-
kWh	-	-		-	-
Therms	1,017,352	-	0.75	763,014	-
EX POST					
kW	-	-		-	-
kWh	-	-		-	-
Therms	1,028,685	1.01	0.75	771,514	1.01

Regulatory Waivers and Filing Variances

Retroactive waiver requests concerning the AEEI evaluations were approved by CADMAC on May 20, 1999 and October 20, 1999. These waivers are included in Section 6 of the appended report. The first of these waivers allowed (1) using a Simplified Engineering Model supported by telephone surveys and on-site data collection to estimate the gross impacts for the Refrigeration end-use, (2) reporting of results in more appropriate DUOMs for the Refrigeration end use, and (3) conducting of a market needs study in place of a net-to-gross analysis, applying a default net-to-gross ratio to the agricultural sector. The second waiver approved (1) using a Simplified Engineering Model supported by on-site data collection to estimate the gross impacts for the Greenhouse Heat Curtain end-use, and (2) reporting Greenhouse Heat Curtain end use results in appropriate DUOMs.

There were no E-Table variances.

Equipoise Consulting, Inc.

Energy Analysis

Project Management

Training

Final Report for

Pacific Gas & Electric's Carryover for Pre-1998 Energy Efficiency Incentives Program: Agricultural Sector Impact Evaluation

Submitted by:

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in association with
California AgQuest Consulting and
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PG&E Project Manager
Mary G. Dimit

February 25, 2000

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Table of Exhibits

1. EXECUTIVE SUMMARY

1.1 Evaluation Impact Summary

This report presents the results of Pacific Gas & Electric Company's (PG&E's) Carryover for Pre-1998 Energy Efficiency Incentives Program: Agricultural (Ag) Sector Impact Evaluation. The evaluation assessed the impacts for PG&E's agricultural customers who received rebates under the pre-1998 Nonresidential Energy Efficiency Incentive (EEI) programs and were paid in 1998. The evaluation of the carryover for pre-1998 Agricultural Energy Efficiency Incentives (AEEI) Programs covered three end uses – pumping and related, refrigeration, and greenhouse heat curtains. These end uses comprised 92% of the agricultural sector avoided costs. This executive summary is divided into three sections: evaluation impact summary, major findings, and major recommendations.

1.1.1 Overall Results

The overall net assessed (ex post) impacts were 90% of the predicted (ex ante) energy, 79% of the predicted demand, and 102% of the predicted therm estimates. A summary of these comparisons is shown in Exhibit 1.1.

Exhibit 1.1
Summary of Gross and Net Load Impacts
Pre-1998 Agricultural EEI Programs

Pre-1998 Agricultural Program	Gross Savings	Gross Realization Rate	Net To Gross	Net Savings	Net Realization Rate
EX ANTE					
kW	4,075	-	0.75	3,057	-
kWh	11,309,618	-	0.75	8,486,168	-
Therms	1,151,915	-	0.75	863,936	-
EX POST					
kW	3,233	0.79	0.75	2,425	0.79
kWh	10,250,923	0.91	0.75	7,692,147	0.91
Therms	1,175,506	1.02	0.75	881,630	1.02

As part of a retroactive waiver agreement with California Demand Side Management Advisory Group (CADMAC), PG&E is allowed to use a default net-to-gross ratio of 0.75 in return for conducting a telephone-survey based market needs study. The results of the market effects study will be presented in a separate report to be submitted to CADMAC by March 31, 2000.

1.1.2 AEEI Pumping and Related End Use Impacts

Exhibit 1.2 shows the results of the pumping and related end use impacts. This end use consisted of the pump repair, low-pressure sprinkler nozzles, and micro-irrigation conversion measures, plus one custom site.

Exhibit 1.2
Summary of Gross and Net Load Impacts
Pumping and Related End Use

Pumping and Related End Use	Gross Savings	Gross Realization Rate	Net To Gross	Net Savings	Net Realization Rate
EX ANTE					
kW	3,631	-	0.75	2,723	-
kWh	8,775,123	-	0.75	6,581,342	-
Therms	-	-	-	-	-
EX POST					
kW	2,855	0.79	0.75	2,141	0.79
kWh	8,273,580	0.94	0.75	6,205,185	0.94
Therms	12,258	NA	0.75	9,193	NA

The micro-irrigation conversion measure represents around 60% of the expected energy and more than three-quarters of the expected demand impacts. As such, its realized savings affected the demand impacts more than the energy impacts. Key impact-related points for the pumping and related end use are:

- The micro-irrigation conversion sites pumped less water than expected from the ex ante estimates. Additionally, the pressure differences between the pre- and post-retrofit systems were slightly lower than expected. Both trends decreased the energy impact and the latter affected demand impact for this measure.
- No demand impact was found for the pump repair measure, despite ex ante estimates that an impact existed. This finding, in conjunction with the demand impact found for the micro-irrigation conversion, resulted in a overall kW realization rate for this end use.

1.1.3 Refrigeration End Use

Exhibit 1.3 shows the results of the refrigeration end use. This end use consisted only of oversized condenser measures.

Exhibit 1.3
Summary of Gross and Net Load Impacts
Refrigeration End Use

Refrigeration End Use	Gross Savings	Gross Realization Rate	Net To Gross	Net Savings	Net Realization Rate
EX ANTE					
kW	440	-	0.75	330	-
kWh	2,465,187	-	0.75	1,848,890	-
Therms	-	-		-	-
EX POST					
kW	373	0.85	0.75	280	0.85
kWh	1,908,036	0.77	0.75	1,431,027	0.77
Therms	-			-	-

Key impact-related items for these applications are:

- The sites were variable in their realization rates. One site had substantially higher impacts than expected, which brought up the end use as a whole.
- There were fewer tons of refrigeration used, on average, than predicted. This decreased both the demand and energy impacts.

1.1.4 Greenhouse Heat Curtain End Use

Exhibit 1.4 shows the results of the greenhouse heat curtain end use. This end use consisted of the greenhouse heat curtain measure.

Exhibit 1.4
Summary of Gross and Net Load Impacts
Greenhouse Heat Curtain End Use

Heat Curtain End Use	Gross Savings	Gross Realization Rate	Net To Gross	Net Savings	Net Realization Rate
EX ANTE					
kW	-	-		-	-
kWh	-	-		-	-
Therms	1,017,352	-	0.75	763,014	-
EX POST					
kW	-	-		-	-
kWh	-	-		-	-
Therms	1,028,685	1.01	0.75	771,514	1.01

The key impact-related items are:

- The average night time temperature set points were very similar between the ex ante estimate and ex post impact.

- There were two sites with higher than expected impacts, which brought up the total realization rate.
- The evaluation team on-site audits found 89% of the rebated heat curtains.

1.2 Major Findings

The major findings from the evaluation are:

- Pump repairs do not save demand, only energy.

1.3 Major Recommendations

Based upon the findings, the major recommendations of the evaluation team are:

- Set the demand impact to zero for a pump repair for any future programs.
- Decrease the OPE ratio for the pump repair measure for pumps under 75 horsepower.
- For future evaluations, use the PG&E pump test database to target which pump repair sites should receive evaluation post installation pump tests. This was a successful strategy in this evaluation.
- For future evaluations, require on-site audits of greenhouse heat curtains and oversize condenser sites. Their complexity makes this approach mandatory.
- Greenhouse program documentation should identify the specific location of the square footage of heat curtain installed.
- Explore using an average capacity for the oversized condenser measure rather than a design capacity to keep from overestimating savings at sites that often run at a lower capacity.

2. INTRODUCTION

This section summarizes results of the results of Pacific Gas & Electric Company's (PG&E's) Carryover for Pre-1998 Energy Efficiency Incentives Program: Agricultural (Ag) Sector Impact Evaluation. The evaluation assessed the impacts for PG&E's agricultural customers who were paid rebates during 1998 under the pre-1998 Nonresidential Energy Efficiency Incentive (EEI) programs.

As illustrated in Exhibit 2.1, the Agricultural EEI (AEEI) participants who adopted pumping and related, refrigeration, and greenhouse heat curtain measures comprised 92% of the total agricultural sector avoided cost. Thus, these are the three AEEI end uses covered under this evaluation. 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 Ver 99-06-052" (the Protocols). The AEEI programs include agricultural sector incentives paid under the Retrofit Express (RE) program, Advanced Performance Options (APO) program, and the Retrofit Efficiency Options (REO) program. The RE measures were only in the miscellaneous end use category and were not analyzed in this evaluation.

Exhibit 2.1
Summary of Avoided Cost by
Agricultural Sector EEI Measure

End Use	PG&E Code *	Measure Description	N Items	Avoided Costs	Percent
Ag Pumping and Related	A1	Pump Retrofit	74	$ 659,432	7%
	A40	Low Pressure Nozzles	1	$ 5,712	0%
	A45 / A49 / A51 / A55	Sprinkler to Micro	48	$ 5,198,131	58%
	A0	Customized	1	$ 13,111	0%
	Ag Pumping End Use Total		124	$ 5,876,387	**66%**
Refrigeration	R18	High Capacity Condenser	6	$ 961,247	**11%**
Heat Curtain	A10	Greenhouse Heat Curtain	16	$ 1,422,547	**16%**
Ag Pumping, Refrigeration, and Heat Curtain End Uses			**146**	**8,260,180**	**92%**
AG Miscellaneous End Uses**			4	$ 701,421	8%
AEEI PROGRAM TOTAL			**150**	**$ 8,961,602**	**100%**

Data Source: Carryover for Pre-1998 PG&E Frozen MDSS Database - June 7, 1999
*PG&E MDSS Measure Codes
**The miscellaneous end uses are handled under Protocol Table C-9. They are not included in this evaluation.

2.1 End Uses by Program Year

There is one end use defined in the Protocols for the agricultural sector: pumping and related. Over the course of the last five years, the agricultural sector evaluations have pulled out specific measures from the miscellaneous end use to meet the requirement to evaluate the end uses representing the top 85% of measures (by avoided cost). The end uses evaluated by program year are shown in Exhibit 2.2.

The Miscellaneous end use was not evaluated per Decision 96-12-079.

Exhibit 2.2
End Uses Evaluated by Program Year

Program Year	Pumping & Related	Heat Curtain	Refrigeration	Lighting	Miscellaneous
1994	X				X
1995	X			X	
1996	X			X	
1997	X	X	X		
Pre-1998	X	X	X		

X = End Use Evaluated

Other utilities may have reported the heat curtain, refrigeration, and lighting measures differently than PG&E.

2.2 Descriptions of Programs Covered by the Evaluation

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

2.2.1 The Advanced Performance Options 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 pre-1998 agricultural sector evaluation included one APO project, a filtration system for a micro-irrigation system.

2.2.2 The Retrofit Efficiency Options Program

Agricultural sector customers participated in both the REO agricultural and refrigeration programs. The participation included five measures: pump repair, low-pressure sprinkler nozzles, sprinkler to micro-irrigation conversion, heat curtains (all in the REO Ag Program), and oversized condensers (REO Refrigeration Program). PG&E representatives worked with customers to identify cost-effective energy efficiency improvements, emphasizing local planning areas with high marginal electric costs to maximize program benefits.

2.3 Description of Evaluation

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 APO and REO programs and for which rebates were paid during calendar year 1998. The impact evaluation results in both gross and net impacts and compares these estimates to the program design estimates.

As part of a retroactive waiver agreement with California Demand Side Management Advisory Group (CADMAC), PG&E is allowed to use a default net-to-gross ratio of 0.75 in return for conducting a telephone-survey based market needs study. The results of the market needs study are presented in a separate report.

2.3.1 Objectives

The evaluation objectives, as originally stated in the Request for Proposal (RFP), were refined during the project initiation meeting and were further refined in discussions with the PG&E project manager. Those objectives are:

1. **Determine first-year gross and net impacts** (kW, kWh, and therms) for the agriculture sector of PG&E's AEEI programs. The AEEI programs include agriculture sector incentives paid under the Retrofit Express (RE) program, the Retrofit Efficiency Options (REO) program, and the Advanced Performance Options (APO) program. The evaluation will cover AEEI measures for which incentives were paid during the 1998 calendar year for the Ag pumping, refrigeration, and heat curtain end uses.
2. **Compare the evaluation results to PG&E's (ex ante) estimates** and explain discrepancies to support improvements in future ex ante estimates.
3. **Conduct a telephone-survey based market needs study of agricultural customers.** As part of a retroactive waiver agreed to with CADMAC, PG&E is allowed to use net-to-gross ratio of 0.75 in return for conducting a telephone-survey based market needs study of agricultural customers.
4. **Create a retention panel for the Carryover for Pre-1998 programs** 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 1996 Ag program.** Revisit sites to determine whether measures identified in the original 1996 retention panel are still in place and operable.
7. **Report results in accordance with Protocols and support AEAP process as requested**. This includes evaluation reporting, completion of the Protocol tables required for CPUC filings, and support during the AEAP process.

2.3.2 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, refrigeration, and heat curtain end uses that pertain to the agricultural sector. Since these three end uses encompass 90% of the ex ante resource value for the agricultural sector, they are the end uses analyzed in this report. The remaining measures are reported under the requirements of Table C-9 of the Protocols and are not part of this report.

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 this evaluation, the net-to-gross ratio used to determine net program impacts (0.75) was set by a retroactive waiver.

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 (i.e., ex post equals ex ante), 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.

2.3.3 Timing

The 1999-2000 evaluation of the pre-1998 AEEI programs commenced in June 1999, completed the planning stages in October 1999, conducted data collection from September through December 1999, and completed the reporting phase in February 2000.

2.3.4 Role of the Protocols

The Protocols 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 and approved (May 20, 1999) for the AEEI program evaluation. This waiver allows (1) the use of simplified engineering analysis for the refrigeration end use, (2) reporting on a per-project and relevant per-unit basis for the refrigeration end use, and (3) the use of a net-to-gross ratio of 0.75 conditioned on conducting a survey-based market needs study. A second waiver was submitted and approved (October 20, 1999) to allow the use of a simplified engineering analysis and a designated unit of measure that better fit the heat curtain end uses. Section 6 of this report contains the entire approved waivers.

2.4 Report Layout

This report is divided into seven sections plus the supporting appendices. These are:

Section 1. Executive Summary –supplies a synopsis of the report findings.

Section 2. Introduction – summarizes the report, introduces the programs, and presents a synopsis of the evaluation.

Section 3. Methodology – presents the approach used to analyze the data and derive the results.

Section 4. Evaluation Results – presents the impact findings and discusses discrepancies between the ex post impacts and the ex ante estimates.

Section 5. Recommendations – discusses recommendations emanating from the evaluation.

Section 6. CADMAC Waivers – documents the two waivers that were approved by CADMAC for the pre-1998 AEEI programs.

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

Appendix A. Engineering Detailed Computation Methods – presents a detailed explanation of the engineering analysis summarized in the body of the report.

Appendix B. Final On-site Instruments – supplies the final field data collection instruments for completeness.

Appendix C. Final Costing Period Allocation Tables – documents the distribution of the impact results into the appropriate PG&E costing periods.

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3. METHODOLOGY

This section first discusses the data sources used in the analysis, followed by the gross impact analysis methodology.

3.1 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 PG&E and industry sources.

3.1.1 Existing Data

The primary existing data sources were:

- The MDSS database for 1998 - This database contained information on the Advanced Performance Options (APO) and Retrofit Efficiency Options (REO) agricultural customer applications.
- PG&E Pump Test Database - This database contained information on pump tests conducted as part of the PG&E Energy Management Services program. Pump test information was assessed for 1992-1997 in the evaluation occurring in 1998. This evaluation assessed pump test information from the 1998 pump test database.
- PG&E program design documentation.
- PG&E billing data for 1996, 1997, 1998, and part of 1999.

3.1.2 Collected Data

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

- On-site pump tests for REO pump repair participants with previous known pump tests, and pump tests for a census of low-pressure sprinkler and micro-irrigation conversion sites.
- On-site audits for a census of the participants in all three end uses.
- “Irrigation Pumping Plants” by Blaine Hanson, UC Irrigation and Drainage Specialist, University of California Irrigation Program, Davis, California, 1994.
- “Using Reference Evapotranspiration (ETo) and Crop Coefficients to Estimate Crop Evapotranspiration (ETc) for Trees and Vines”, Cooperative Extension University of California Division of Agriculture and Natural Resources, Leaflet 21428.
- “Energy Conservation for Commercial Greenhouses”, Northeast Regional Agricultural Engineering Service, Cooperative Extension, NRAES-3, Third revision, July, 1989.
- “Energy Savings Using Greenhouse Shading/Insulating Screens Report”, Submitted to the California Energy Commission, Contract #400-92-010, November, 1994.

- "Refrigeration and Air Conditioning", Third Edition, Air-Conditioning and Refrigeration Institute, Prentice-Hall, 1998.
- Appendix A, Thermodynamic Property Tables, International Institute of Ammonia Refrigeration (IIAR), Ammonia Data Book, December, 1992,
- Appendix B, Ammonia Refrigeration Application Data, International Institute of Ammonia Refrigeration (IIAR), Ammonia Data Book, December, 1992,
- American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE) 1999 HVAC Applications Handbook.
- ASHRAE 1997 Fundamentals Handbook.
- ASHRAE 1998 Refrigeration Handbook.

The numbers of survey data points collected are shown in Exhibit 3.1. There was no analysis of the 1996 retention data points during this evaluation. These retention data points will be combined with the as-yet-to-be-gathered 1997 retention data points for an analysis in 2000.

Exhibit 3.1
Surveys Data Points Completed

Customer	Type of Survey	AEEI Program				Market Needs Study	1996 Retention	Total
		Pumping	Refrig.	Heat Curtain	Total			
Participant	On-site	123	6	15	144	0	103	247
Ag Sector Customer	Telephone	0	0	0	0	510	0	510

While the data collection for the Market Needs Study are presented in Exhibit 3.1, the findings will be reported in a separate study due to CADMAC by March 30, 2000.

3.1.3 Sample Design

The sample information, showing the population, sample frame, and final analysis sample sizes for the end uses analyzed are shown below in Exhibit 3.2.

Exhibit 3.2
Sample Summary

End Use	Population *	Sample Frame		Final Analysis Sample	
		On-Site	Metering**	On-Site	Metering
Pumping and Related	124	100	100	123	83
Refrigeration	6	6	0	6	0
Greenhouse Heat Curtain	16	16	0	15	0
Total Participant	146	122	100	144	83

*Participant sample was a census, population refers to number of applications.

**The exact number of sites for pump testing (metering) was unknown since micro-irrigation sites often use >1 test per application.

3.1.3.1 Overview

Data were collected via on-site surveys of a census of program participants. The data collected from these samples provided the information needed for the impact evaluation (i.e., engineering analysis for gross impact) models. The sampling plan for the PG&E agricultural evaluation, based on pre-1998 program participation data and experience in past evaluations, is presented in this section.

3.1.3.2 AEEI Participant Sample Frame

For this evaluation, the participant population for the AEEI program is small, and the entire population was needed to fulfill the sample sizes required by the Protocols. A nonparticipant sample frame was not used in this analysis.

3.1.3.3 Relative Precision of Sample

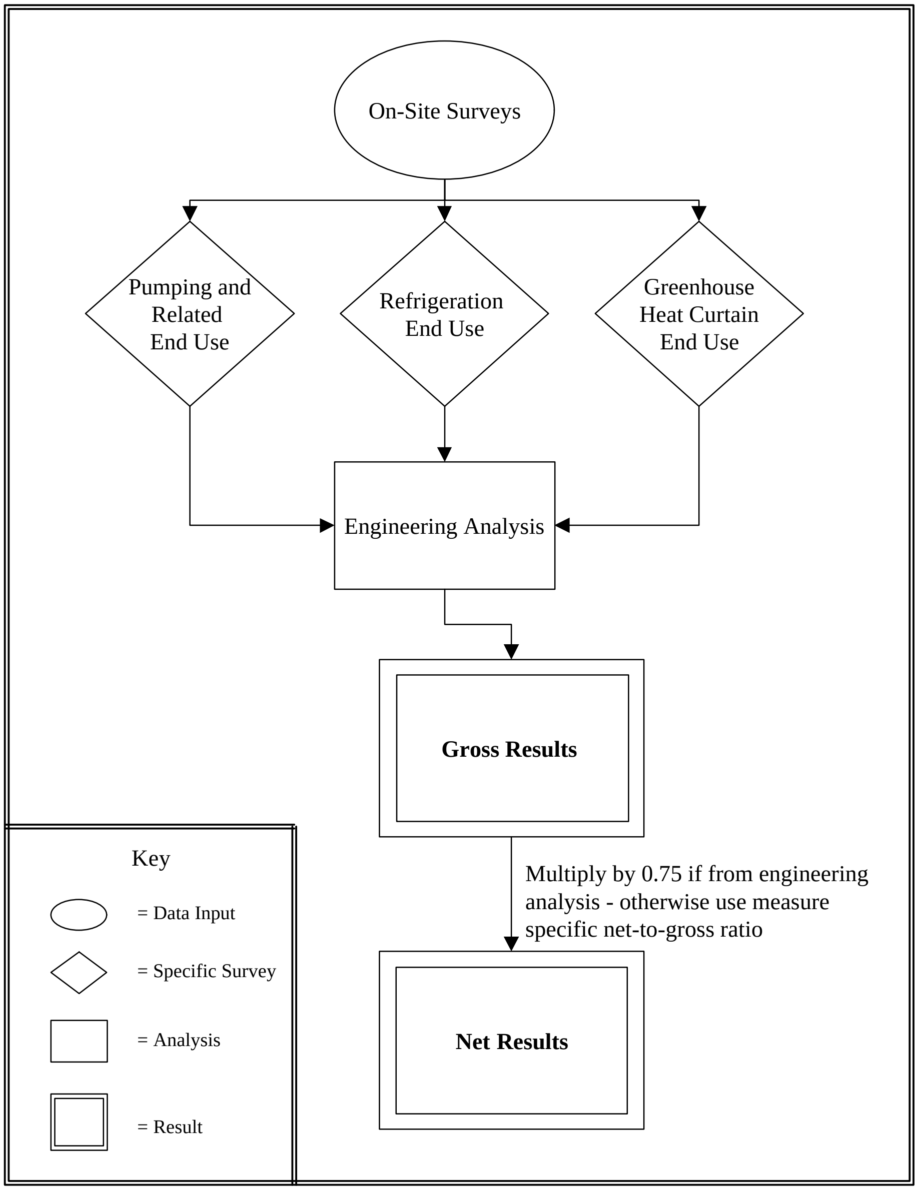
The relative precision of a given sample design, based on total annual energy use, reflects the uncertainty about whether the allocated sample sizes are large enough to control for the population annual energy usage variance.

For AEEI participants, a census was attempted for all end uses, and thus there was no need to measure the extent to which the sample reflects the population.

3.2 Overview of Analysis

The carryover of the pre-1998 agricultural programs evaluation analyzed three end uses – Ag pumping and related, refrigeration, and greenhouse heat curtains. A census of the applications were on-site audited to gather information for the engineering analyses used to estimate the gross impacts. A net-to-gross ratio of 0.75 was applied to all AEEI ex post gross impact estimates as agreed in the CADMAC waiver approved May 20, 1999. An overview of the impact method is shown in Exhibit 3.3. The ex ante net-to-gross ratio of the measures covered under the three end uses analyzed was also 0.75.

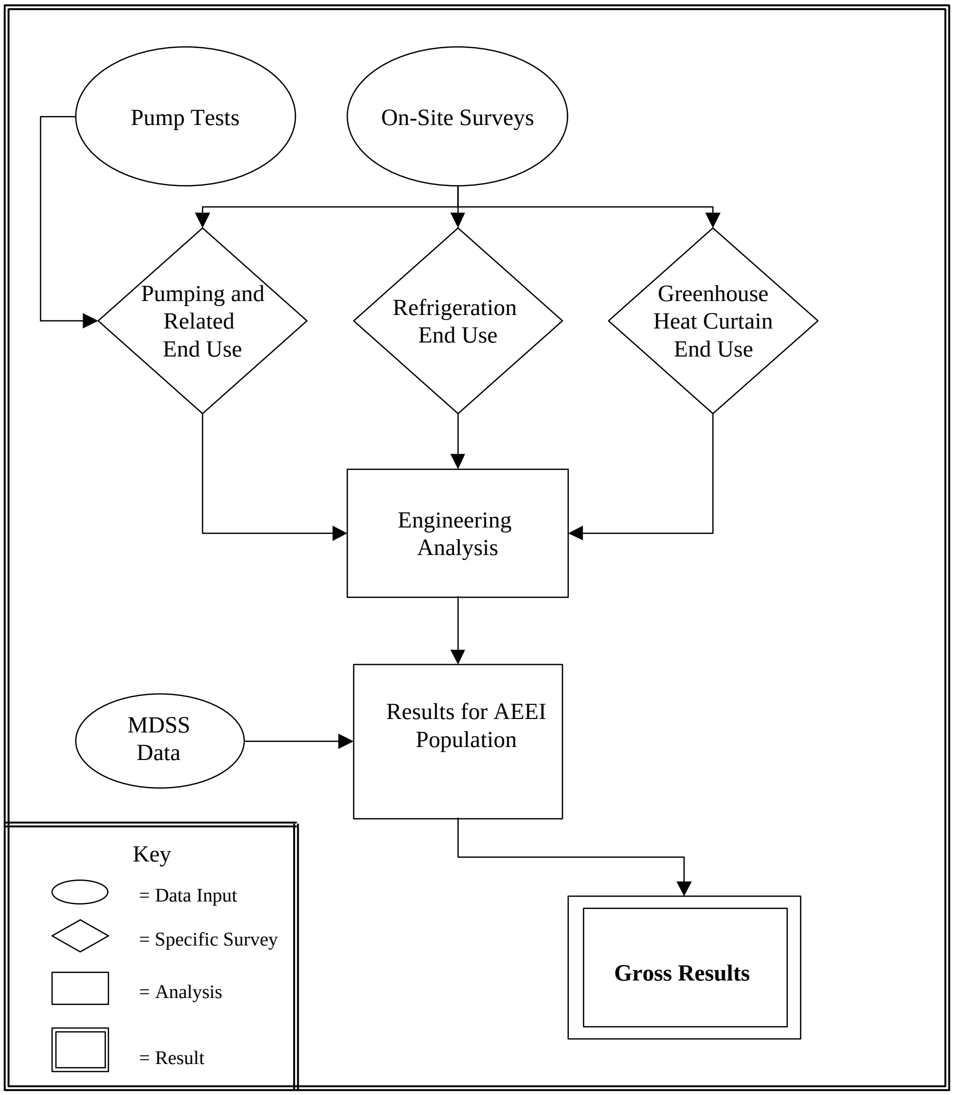
Exhibit 3.3
Overview of Impact Method



3.3 Gross Impact Analysis

While a census of measures was audited on-site, the pumping and related end use measures also collected data from pump tests performed during the evaluation. These pump tests were the core of the engineering analyses for this end use. The pump repair measure had pump tests performed for 43% of the paid applications (of which 81% of those tests provided good information). The micro-irrigation conversion applications averaged 1.1 pump tests per application, and the one low-pressure sprinkler nozzle measure was able to be tested with good results. A pump test was not used for the custom pumping site. Exhibit 3.4 shows the overview of the analysis of the gross impact.

Exhibit 3.4
Gross Impact Overview



The analysis approaches will now be discussed by end use.

3.3.1 Pumping and Related End Use

The pumping and related end used encompassed three pumping measures, pump repair, low-pressure sprinkle nozzles, and micro-irrigation conversion. The approach for each of these is presented separately below.

3.3.1.1 Pump Repair

There were 74 applications for this measure, representing 40 unique customers. In order for pump test results to identify the change in efficiency due to pump repairs, they must (1) be conducted both before and after the repair, and (2) be technically sound tests yielding good data. For example, if a well cannot be sounded for depth or does not have the proper length test section, the test gives poor and misleading results. The evaluation approach minimized evaluation cost yet continued to provide credible impact results for this measure by using the PG&E pump test database to select accounts carefully for post-repair pump tests. Only if the pump repair measure had a PG&E pump test performed before the repair, as determined from the pump test database, program applications, and discussions with the grower, was a post-installation pump test performed during the on-site audit. Analysis of the pump test database identified 52 pump tests that met those criteria for the pump repair measure. A census of these 52 pumps was attempted, resulting 32 completed post-repair pump tests. Of those 32 tests, 26 tests were rated as good or fair[1]. For other pump repair sites, only retention and use information was collected.

The algorithm shown in Exhibit 3.5 was used to determine the energy impacts for pump repairs.

Exhibit 3.5
Pump Repair Energy Impact Algorithm

$$\text{Impact} = \sum_{i=1}^{74} \text{kWh}_{99,i} * \left(1 - \frac{\text{OPE}_{\text{pre}}}{\text{OPE}_{\text{post}}}\right)_i$$

Essentially, there were two pieces of information required to apply the impact algorithm to each pump repaired. First, the 1998-99 kWh for each specific pump repaired must be known. Second, either the pre- and post OPE or the pump type and horsepower must be known to properly apply the second half of the algorithm – the OPE ratio.

On-site audits provided the information used to allocate the billing usage data among pumps and other loads on the accounts. Pump account number information were collected to be able to pull the 1998-99 billing data. However, even with this information, there were twelve accounts with missing kWh data. For these pumps, the 1997 data were located and used to determine the impact.

The horsepower of the other pumps on the meter and the percentage of time these pumps operated were also gathered during the on-site audits. Assuming the pumps were fully loaded when on, which is typical for pumping applications, the percentage of the kWh used by the repaired pump was calculated. The audit also provided the horsepower and pump type for correct application of the OPE ratio on sites where good pump tests were not achieved.

The evaluation team collected good post-repair OPE values from 26 pumps. These pumps had pre-repair OPE values already recorded in the PG&E pump test database. To increase the number of actual pre- and post-OPE paired values to be used for those pumps without pump test data, the 1998 PG&E pump test database was analyzed to identify pumps with pre- and post-pump repair results. Since there is a difference in the paired pre-to-post efficiency possible based on technology (e.g., turbine, centrifugal, or axial flow pump), these data were analyzed by pump type. Previous work of this type on the 1992-1997 PG&E pump test databases was also used to determine the average OPE ratios.

[1] For each pump test was rated good, fair, or poor by the pump tester. Only pump tests with ratings of good or fair were used in the analysis.

The demand impact was analyzed by using the horsepower input from pre/post repair tests. The differences in horsepower input pre- and post-repair for 32 pumps were analyzed using the 1998 PG&E database information to determine if there were demand impacts. On average, there was an increase of 1.7 horsepower (hp) due to the pump repair pre/post matches. However, the standard deviation around that value was large and included zero. The pre- and post-repair hp values were further analyzed using a single-tailed t-test. At the 90% confidence level, there were no significant differences between the pre- and post-repair hp (t=-0.151). Because of the results of the t-test, the demand impacts were set to zero for all the pump repair measures. This is consistent with the 1996 and 1997 PG&E agricultural sector evaluation findings.

3.3.1.2 Low-Pressure Sprinkler Nozzles

There was only one site rebated for this measure. The planned approach for analysis of this site assessed two types of data: whether the site had actually decreased the kWh/acre and pump test data. The grower had increased the acreage irrigated with the sprinklers and, therefore, was considered to have decreased the kWh/acre required to water his land. The pump test at this site provided good data and was used in the analysis.

The low-pressure sprinkler nozzle measure used an approach similar to the ex ante estimates, but with measured data from pump tests. The algorithms used for the demand impacts are shown in Exhibit 3.6.

Exhibit 3.6
Low-Pressure Sprinkler Nozzles Demand Impact Algorithms

(1) Delta hp = (GPM $_{\text{from pump test}}$) * delta TDH / (3960 GPM-Ft/hp* current OPE)

where GPM = gallons per minute

TDH = total dynamic head

OPE = operating plant efficiency

(2) Delta hp / acre = (1) above / acres irrigated

(3) Nozzles / acre = nozzles found at site / acres irrigated

(4) Delta kW / nozzle = (2) above * 0.746 kW/hp / (3)

(5) Peak kW / nozzle impact = (4) above * Coincident Diversity Factor of 0.78[2]

The following assumptions were made during the low-pressure sprinkler nozzle analysis. It was assumed that the OPE of the old and new systems was the same since there was no change in the pumping system. It was assumed that the irrigation efficiency (IE) of the old system and the new system was the same. Therefore, there was no assumed difference between the acre-feet (AF) of water pumped in 1998 and what would have been pumped with the old high-pressure sprinkler system. These assumptions result in conservative estimates. The nozzle pressure (shown as “P_N” in Exhibit 3.7) in pounds per square inch (psi) for the pre- and post-nozzles was based on grower self-report.

[2] Appendix A of “Impact Evaluation of Pacific Gas & Electric Company’s 1995 Agricultural Energy Efficiency Incentive Programs: Pumping and Related End use, Indoor Lighting End use. PG&E Study ID Numbers: 329: Pumping and Related End use. 331: Indoor Lighting End use”, Dated March 1, 1997.

The algorithms used to determine site-specific energy impact for the low-pressure sprinkler system are shown in Exhibit 3.7.

Exhibit 3.7
Low-Pressure Sprinkler Nozzle Energy Impact Algorithms

(1) Post-total dynamic head (TDH) from nozzles = $P_{N, post}$ (psi) * 2.31 ft/psi

(2) Post-TDH other than nozzles = Actual TDH from pump test – (1) above

(3) Pre-TDH = $P_{N, pre}$ (psi) * 2.31 ft/psi + (2) above

(4) AF = 1999 kWh / $(kWh/AF)_{from\ pump\ test}$

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

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

(7) kWh Impact = kWh 1999 – (6) above

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

The next section discusses the micro-irrigation conversion analysis.

3.3.1.3 Micro-irrigation Conversion

The participants for this measure represented 48 applications and 14 unique customers.

For the demand impacts, the micro-irrigation conversion measure used an approach similar to the ex ante estimates, only with pump test data. The on-site audits determined whether the system ran during peak periods. A coincident diversity factor (CDF) was applied on a site-specific basis. If the site ran 24 hours per day during watering sets, the CDF was set to one. If it was determined that there was a peak period lock out on the metering box or if the operators reported that they did not operate during peak period, the CDF was set to zero. The average CDF for the 48 applications was 0.87. The demand impact was calculated as shown in Exhibit 3.8.

Exhibit 3.8
Site-specific Micro-irrigation Demand Impact Algorithm

(1) kW Impact = GPM $_{from\ pump\ test}$ / 3960 GPM ft/hp * [(Pre TDH/Pre OPE) – (Post TDH/post OPE)] * 0.746 kW/hp * CDF

(2) kW Impact / acre = (1) above / acres converted

Micro-irrigation system conversion rebates were paid when a customer converted from a sprinkler irrigation system (either high-pressure or low-pressure) to a micro-irrigation system. There was one site that converted from a flood irrigation system. The demand and energy impacts at this site were set to zero. Additionally, there was one site that moved from electric to diesel booster. This site was also set to zero impact. There was one site that moved from an electric to a natural gas pump. Although no pump test was performed at this site, the average kWh/acre was used to determine potential impact and the kWh was converted to therm savings. There was no demand impact at this site.

In general, the pumping systems were renovated to allow the micro-irrigation to function properly. The impact of the retrofit both decreased the AF of water applied and changed the pumping system. The estimated pre- and post-pressures were based on grower self-reports.

Questions were asked during the on-sites regarding the previous irrigation system type. The irrigation efficiency value used to determine the AF/year that would have been applied without the micro-irrigation system was determined from two sources: (1) previous Ag evaluation data (irrigation efficiency results for sprinkler systems), and (2) an estimate of the current systems' irrigation efficiency as determined by the experts in the field. Taking these two sources into account, the analysis used an irrigation efficiency of 66% for the pre-retrofit irrigation systems, while the post-retrofit systems varied between 75% and 80%.

When a pump was replaced with a different type, the pre-OPE assigned to the pump was based on the previous pump type. For example, if the post-retrofit pump was a turbine booster pump and the pre-retrofit pump had been a centrifugal pump, the average OPE for "routine" tests within the PG&E pump test database was applied for the pre-retrofit OPE. If there was no change in the pump, the pre- and post-retrofit OPE were set to be identical. The site-specific energy impact algorithms are shown in Exhibit 3.9.

Exhibit 3.9
Site-Specific Micro-irrigation Energy Impact Algorithm

(1) Post-total dynamic head (TDH) from system = $P_{MI,\ post}$ (psi) * 2.31 ft/psi

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

(3) Pre-TDH = $P_{MI,\ pre}$ (psi) * 2.31 ft/psi + (2) above

(4) AF_{post} = 1998-99 kWh / $(kWh/AF)_{from\ pump\ test}$

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

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

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

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

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

In some cases, the system obtained irrigation water from more than one pump. Information was gathered during the on-sites to determine the total acres covered by the micro-irrigation system and the pumps/accounts that fed that system. The total kWh from all the pumps were used in algorithm (4) above.

There were multiple sites that installed micro-irrigation systems that also planted new deciduous orchards at the same time (i.e., almonds or pistachios). These sites were found to use substantially less AF/acre of water than what is used for a mature orchard. Based on how the analysis is performed, the first year of billing data does not reflect the impact that can be expected from these crops during subsequent years. Therefore, for the 17 applications with new deciduous crops (as determined from the on-site audit), the kWh impact was adjusted.

The adjustments were made based on UC Cooperative Extension documents that had the estimated AF/acre of water used per year for almonds or pistachios. The crop year was determined from the calculated AF/acre value using this years pump test data. The subsequent *impact* years were increased by a percentage specific to that crop for that crop year. For example, almonds tend to have 50% more water applied the second year of the crop over the first year and an additional 33% more water the third year over the second year. The majority of the crops in this analysis appeared to have been growing for at least two years (i.e., the AF/acre value was indicative of a second crop years water usage). The subsequent impact years were increased by the water needs of the crop for subsequent crop years (e.g., the second impact year may use the water level from the third crop year).

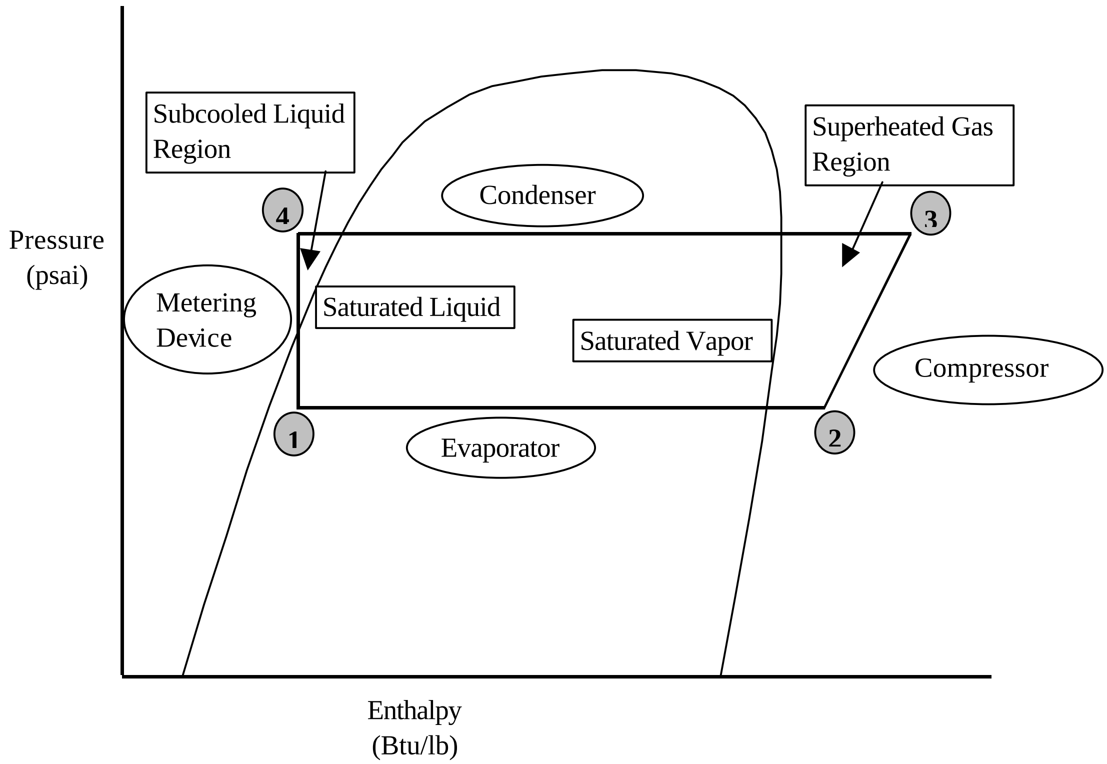
An average weighted kWh impact was calculated based on a 20 year effective useful life and was used as the ex post energy impact for these 17 sites. It was assumed that the crops would use the same amount of water as a mature orchard in the four year and beyond for almonds and the seventh year and beyond for pistachios.

For the other 31 applications, the estimate of energy impact used the algorithms in Exhibit 3.9.

3.3.2 Refrigeration End Use

There were six applications (representing six unique customers) and only one type of measure in the refrigeration end use – oversized condensers in ammonia refrigeration systems. To understand how this measure was analyzed, a short explanation of a typical refrigeration process is presented. Within a standard refrigeration system there are four distinct pieces of equipment: a condenser, a metering device, an evaporator, and a compressor. Exhibit 3.10 shows a typical pressure-enthalpy (enthalpy is the heat content of a refrigerant) diagram for a refrigeration system. Each piece of equipment is shown on this diagram based upon where it is used in the refrigeration cycle. The refrigerant goes through four stages, as represented by the four numbers in circles in the diagram. Each stage will be discussed.

Exhibit 3.10
Pressure-Enthalpy Diagram



At point 1, the refrigerant is a mixture of liquid and gas. As the refrigerant moves through the evaporator, it maintains the same pressure and absorbs heat from the space being cooled. The heat causes the liquid portion to boil and become a gas. The curved line on the right side of the diagram represents the point where the liquid phase ceases to exist and the vapor becomes fully saturated. After the refrigerant gets hotter than the saturated vapor state, it is a superheated vapor. In moving from point 1 to point 2, the enthalpy is steadily increasing, as shown in the diagram.

At point 2, the refrigerant is now a superheated gas as it enters the compressor. The compressor increases the pressure of the gas and adds some heat due to the compression (heat of compression). The impacts from the installed measure are realized at the compressor as the oversized condenser decreases the pressure to which the compressor must raise the refrigerant vapor. (i.e., the refrigerant moves from point 2 to a lower point 3 than with the pre-retrofit condenser).

From point 3, the refrigerant goes through the condenser. In the condenser, it steadily gives up heat to the atmosphere and condenses from a gas to a liquid. The condenser generally continues to cool refrigerant past the point where all of the gas becomes a liquid (the saturated liquid line). The refrigerant is now a sub-cooled liquid at point 4.

The refrigerant then moves through a metering device (often referred to as an expansion valve) from point 4 back to point 1. This device decreases the pressure, but keeps the same amount of heat (enthalpy) within the refrigerant. The refrigeration cycle is complete.

This short rendition of a refrigeration cycle does not take into account the real-world losses associated with any type of refrigeration cycle. It assumes perfect (isentropic) compression and perfectly functioning pieces of equipment. These assumptions were used in the analysis.

Because of the variations in ability of the site manager to provide the needed information, the analysis could not be conducted as projected in the research plan for all sites. As a result, a slightly different methodology was used to determine the kW impact. All site managers were able to provide pre- and post-retrofit discharge and suction temperatures for their refrigeration system. These values were used to determine the hp/ton and then the tons of refrigeration (as a percentage of total capacity) were used to calculate the horsepower required for that period of time. The kW impact for this measure was determined as shown in Exhibit 3.11.

Exhibit 3.11
Refrigeration Demand Impact Algorithm

$$kW_{tp} = \frac{hp/ton_{tp} * \text{Tons of Refrigeration}_{tp} * \text{Conversion from hp to kW}}{\text{Efficiency of Motor}}$$

$$kW_{tp} = \frac{\frac{hp}{ton}_{tp} * Tons_{tp} * \frac{0.746\ kW}{hp}}{h}$$

where:

hp/ton = value at provided saturated suction and discharge pressures

tp = time period as provided by site manager

The kW reduction for a specific refrigeration load was determined and the hours of operation were applied to determine the kWh impacts for that time period, as shown in Exhibit 3.12. The hours of operation were gathered on site from the plant manager.

Exhibit 3.12
Refrigeration Energy Impact Algorithm

$$\text{kWh savings} = \sum_{tp=1}^{n} \text{kW impact}_{tp} * \text{Hours of operation}_{tp}$$

3.3.3 Greenhouse Heat Curtain End Use

There were sixteen applications for greenhouse heat curtains paid in 1998. The applications represent ten different customers. All but one greenhouse site were audited for this evaluation (one customer refused the audit).

The greenhouses were constructed of many different materials, from glass to fiber-reinforced polyester to polyethylene film. The majority of the sites were multi-span buildings with many peaks. The heat curtains were installed to reduce the therm usage of natural gas heaters or boilers by minimizing the heated area and decreasing heat loss from the greenhouses at night. However, while nighttime heating savings were planned, the heat curtains were also used during the day to control day length, shade crops, and reduce daytime temperatures within the greenhouse.

The curtains were thin, movable, and attached to the greenhouse using various mechanisms. Research indicated that, in many areas of the U.S., 80% of the energy for heating of single-glazed structures is required at night.[3] Therefore, insulation that can allow for daytime sunlight and reduce nighttime heat loss should be moveable. The heat curtain measure, as implemented by PG&E, required the inclusion of tracks and a motor to deploy the heat curtain. All heat curtains met this requirement.

The heat curtains were most often placed at a slight upward angle into the middle of the peak from the join between the roof and wall. When closed, the curtain created a "new" ceiling, which was lower. Occasionally, the site installed the heat curtain to create a "new" ceiling that took out the entire peak area (i.e., the curtain went from the top of one wall to the top of the opposite wall). One site installed a double layer of heat curtain that did both.

While the curtains were sometimes deployed during the day, most of the actual therm energy impacts occurred at night. The impacts were dependent on the construction of the building, the infiltration of cold air into the greenhouse, how the heat curtain was installed, and the efficiency of the natural gas heater. During PG&E's evaluation of the 1994 agriculture sector impacts, an informal assessment of existing boiler efficiencies was conducted, and an average boiler efficiency of 70% was estimated. Therefore, for this evaluation, the efficiency was set at 70% for either individual heaters in the greenhouses or a central boiler. This efficiency is lower than the minimum efficiency (75% for central steam boiler and 74% for unit heaters) set by the California Energy Commission (CEC) and is a result of the age of the units and piping losses. The actual temperatures required in the greenhouses were dependent on the crop. The average temperature difference was based on values that showed at least three degrees difference between the thermostat setpoint and the hourly outdoor temperature (from the CEC typical meteorological year data for that climate zone). These values were used only if the heat curtain was closed. The impacts for heat curtains were determined using the algorithms shown in Exhibit 3.13 and Exhibit 3.14.

[3] Energy Conservation for Commercial Greenhouses, Northeast Regional Agricultural Engineering Service, NRAES-3, July, 1989.

Exhibit 3.13
Heat Curtain Impact Algorithm

$$\Delta Therms = \frac{\Delta Q_t * AnnualHrs * C1}{h}$$

Where:

ΔQ_t = Change in heat loss, Btu/hr
Annual Hrs = Annual Hours in Use, hr
C1 = Conversion for Therms, 1 therm/100,000 Btu
η = Efficiency of heater, unitless

The change in the heat loss of the greenhouses due to the addition of the heat curtain (Q_t) was determined by both the heat loss due to conduction (heat migrating through the materials from the higher temperature inside to the lower temperature outside) and the heat loss due to infiltration (heat loss through open areas in the construction). These two heat losses were determined as shown below in Exhibit 3.14.

Exhibit 3.14
Heat Loss Algorithm

$$\Delta Qt = \left[\left(\sum_{i=1}^{n} U_i * A_i\right) + c_p * Vol * ACH\right]_{pre} * \Delta T - \left[\left(\sum_{i=1}^{n} U_i * A_i\right) + c_p * Vol * ACH\right]_{post} * \Delta T$$

Where:

U_i = Heat transfer coefficient of each material *i*, Btu/hr-ft^2-°F
A_i = Area of each material *i*, ft^2
ΔT = Average inside to outside temperature difference, °F
c_p = volumetric specific heat of air, 0.018 Btu/ ft^3-°F
Vol = Volume of the greenhouse, ft^3
ACH = Air changes per hour, changes/hr

The impacts determined were greenhouse specific.

3.4 Net-to-Gross Analysis

3.4.1 Waiver Discussion

During 1999, PG&E submitted two waivers to CADMAC covering methods to be used in the evaluation. These waivers are presented in their entirety in Section 6. One of the waivers proposed that PG&E be allowed to use a net-to-gross ratio of 0.75 for the agricultural sector, subject to the condition that PG&E conduct a telephone-survey based “market needs” study that would help future program design yield the best returns. This waiver was approved by CADMAC on May 20, 1999. The market needs study will be reported under separate cover by March 30, 2000, as specified in the waiver.

3.5 Integration of Net-and-Gross Estimates

The gross impacts were simply multiplied by the net-to-gross ratio of 0.75 to determine the net impact results.

4. EVALUATION RESULTS

4.1 Gross Impacts

The gross impacts as determined by this evaluation are shown in Exhibit 4.1.

Exhibit 4.1
Gross Impacts

End Use	PG&E Code *	Measure Description	N Items	Ex Post Gross Savings kW	Ex Post Gross Savings kWh	Ex Post Gross Savings Therms
Ag Pumping and Related	A1	Pump Retrofit	74	0	1,504,790	1,974
	A40	Low Pressure Nozzles	1	10	3,554	-
	A45 / A49 / A51 / A55	Sprinkler to Micro	48	2,836	6,747,678	10,284
	A0	Customized	1	10	17,557	-
	Ag Pumping End Use Total		124	2,855	8,273,580	12,258
Refrigeration	R18	High Capacity Condenser	6	373	1,908,036	-
Heat Curtain	A10	Greenhouse Heat Curtain	16	-	-	1,028,685
Ag Pumping, Refrigeration, and Other End Uses			**146**	**3,228**	**10,181,615**	**1,040,943**
AG Miscellaneous End Uses**			**4**	**4**	**69,308**	**134,563**
AEEI PROGRAM TOTAL			**150**	**3,233**	**10,250,923**	**1,175,506**

Data Source: Carryover for Pre-1998 PG&E Frozen MDSS Database - June 7, 1999
*PG&E MDSS Measure Codes
**The miscellaneous end uses are evaluated under Protocol Table C-9. They are not included in this evaluation.

The differences between the ex ante and ex post gross impacts are discussed below in section 4.4.

4.2 Net-to-Gross Adjustments

The gross impacts were multiplied by 0.75 to determine the net impacts, as agreed under the CADMAC Waiver approved on May 20, 1999.

4.3 Net Impacts

The net impacts are shown in Exhibit 4.2.

Exhibit 4.2
Net Impacts

End Use	PG&E Code *	Measure Description	N Items	Ex Post Net Savings		
				kW	kWh	Therms
Ag Pumping and Related	A1	Pump Retrofit	74	0	1,128,593	1,480
	A40	Low Pressure Nozzles	1	7	2,666	-
	A45 / A49 / A51 / A55	Sprinkler to Micro	48	2,127	5,060,759	7,713
	A0	Customized	1	8	13,168	-
	Ag Pumping End Use Total		124	2,141	6,205,185	9,193
Refrigeration	R18	High Capacity Condenser	6	280	1,431,027	-
Heat Curtain	A10	Greenhouse Heat Curtain	16	-	-	771,514
Ag Pumping, Refrigeration, and Other End Uses			**146**	2,421	7,636,212	780,707
AG Miscellaneous End Uses**			**4**	4	55,936	100,922
AEEI PROGRAM TOTAL			**150**	2,425	7,692,147	881,630

Data Source: Carryover for Pre-1998 PG&E Frozen MDSS Database - June 7, 1999
*PG&E MDSS Measure Codes
**The miscellaneous end uses are evaluated under Protocol Table C-9. They are not included in this evaluation.

There was no net analysis to determine the net-to-gross ratio. Therefore, all the discussion regarding the evaluation differences between the ex ante estimates and ex post net results are in section 4.4, Gross Realization Rates.

4.4 Gross Realization Rates

The evaluation gross realization rates are shown in Exhibit 4.3. The overall program gross realization rates generally supported the ex ante estimates, posting realization rates of 0.79 and 0.77 for kW and kWh respectively, and 1.02 for therms. End use and measure level deviations from the ex ante estimates are discussed next.

Exhibit 4.3
Gross Realization Rates

End Use	PG&E Code *	Measure Description	N Items	Gross Realization Rates		
				kW	kWh	Therms
Ag Pumping and Related	A1	Pump Retrofit	74	0.00	0.78	NA
	A40	Low Pressure Nozzles	1	1.01	0.19	-
	A45 / A49 / A51 / A55	Sprinkler to Micro	48	0.92	0.99	NA
	A0	Customized	1	1.00	1.00	-
	Ag Pumping End Use Total		124	0.79	0.94	-
Refrigeration	R18	High Capacity Condenser	6	0.85	0.77	-
Heat Curtain	A10	Greenhouse Heat Curtain	16	-	-	1.01
Ag Pumping, Refrigeration, and Other End Uses			**146**	0.79	0.91	1.02
AG Miscellaneous End Uses**			**4**	1.00	1.00	1.00
AEEI PROGRAM TOTAL			**150**	0.79	0.91	1.02

Data Source: Carryover for Pre-1998 PG&E Frozen MDSS Database - June 7, 1999
*PG&E MDSS Measure Codes
**The miscellaneous end uses are evaluated under Protocol Table C-9. They are not included in this evaluation.

4.4.1 Pumping and Related End Use

4.4.1.1 Pump Repair

The ex post impacts were determined using the algorithm shown in Exhibit 3.5 and one year of data from the 1998-99 billing data. If the site had both a pre- and post-repair OPE value, it was used to determine the OPE ratio. If not, an average OPE ratio was applied based on pump type and horsepower. The total ex ante kWh billed from the MDSS was 14,979,213 kWh. This value represents the pre-repair pump usage for only the repaired pumps. Once the 1998-99 kWh data were analyzed to obtain the post-repair pump usage for the repaired pumps, it totaled 13,396,201 kWh. While there are many factors that can account for this decrease in usage (i.e., wetter season, different crops, etc.), this is a 10.5% reduction in usage. This is less than expected from the ex ante estimate of 21% reduction in usage for pumps with horsepower of 75 or less, and a 10.6% reduction for pumps over 75 horsepower. Taking a weighted average from the number of pumps and estimated reductions in usage, the ex ante estimates would expect about a 15% reduction.

There was one site that changed over to a natural gas pump. This site was given therm impact credit by using the previous year kWh value and an average OPE for the pump type and size and converting the kWh impact to therm. It is acknowledged that the efficiency of a natural gas pump is different than an electric motor (with the natural gas motor having a lower efficiency). However, it was felt that the estimate of savings would be conservative by using the efficiency of the electric motor, while the savings from the re-bowling of the pumping system would be sustained with the change in fuel.

There were six pumps that had their impacts set to zero for various reasons (see Appendix A for specific reasons). These pumps had an estimated 5% of the ex ante impact, causing the realization rate to be lower due to the loss of these pumps. A second reason for the low gross realization rate was the difference between the OPE ratios used for the ex ante and ex post analysis.

The ex ante analysis used two horsepower bins to determine OPE and did not distinguish between pump types. For comparison purposes only, Exhibit 4.4 compares the OPE values used for the ex ante and the ex post cases in the bins used in the ex ante estimates. These are not the bins used in the ex post analysis; however, Exhibit 4.4 does demonstrate that the ex post OPE values (i.e., the measured values) are lower for the Bin 1 pumps than the ex ante OPE estimates. The OPE ratio differences were the reason for the ex post energy impacts being lower than the ex ante estimate of impacts for those pumps of 75 horsepower and under.

For the pumps over 75 hp, the OPE ratio was actually larger, on average, than what was used in the ex ante impact. However, the kWh value to which the OPE ratio was applied was different between the ex ante and ex post analysis. The ex ante annual kWh usage was substantially higher than what was used for the ex post analysis annual usage. Since the on-site audits gathered the data to apportion the meter usage to the pump retrofitted, the ex post annual kWh estimate should be more accurate. Thus the ex post estimates are believed to be a better representation of usage and impact.

Exhibit 4.4
Ex Ante and Ex Post OPE Ratios

	Bin 1 (20-75 hp)	Bin 2 (Over 75 hp)
Ex Ante	0.210	0.106
Ex Post	0.176	0.126
N of Ex Post	31	43

4.4.1.2 Low-Pressure Sprinkler Nozzles

The evaluation team audited the one site rebated. The energy impact for this site was below the ex ante estimate however demand impact was about even with the ex ante estimate. This pump was used for both a low-pressure sprinkler system as well as for a micro-irrigation system. Since it was unknown how much time the pump was used for each irrigation system, the billing data for this site had to be apportioned in a reasonable way for the analysis. It was estimated that the low-pressure system used 40% of the energy from this pump based on the type and acreage of crops on both systems. Another check was performed to determine if this created an overly low or high estimate of usage. This check used the pump test data to calculate the acre-feet (AF) of water applied from the pump during the year. It was determined, after consultation with the Team's agricultural specialist, that the net AF of water was reasonable. Therefore, the ex post energy estimate of saving, while substantially less than the ex ante estimate of savings, was considered to be appropriate.

Since this is only one site, and the ex ante estimate of energy savings is based on averages across multiple crop types, it is not reasonable to expect that the ex post and ex ante energy impacts would necessarily be similar. However, the demand impacts are similar. Since both the ex ante and ex post impacts are based on a reduction in head pressure due to the new irrigation system. This was similar in both cases (and slightly higher in the ex post case), leading to a gross demand realization rate of 1.01.

The lower energy impact can be accounted by two factors: (1) the amount of water pumped and (2) the number of nozzles installed. Since the evaluation had no information on the amount of water actually pumped at this site, it is not possible to compare the water usage at this particular site to the ex ante estimate. However, there is information on the number of nozzles installed. This site installed a very high density 31.6 nozzles per acre. The system was a hand movable portable system. The ex ante estimates have two versions of the hand movable portable systems, a high density one with 21 nozzles per acre and a low density one with 4 nozzles per acre. While it is unclear what mix of these systems was used to create the one ex ante value for hand movable portable systems, it is very clear that this value has to be based on an average of less than 20 nozzles per acre. Since the one site assessed had at least 50% more nozzles per acre, this explains a large part of the lower ex post energy impact per nozzle. This same argument does not apply to the demand impact because the demand impact is based on the pressure difference pre/post.

4.4.1.3 Micro-irrigation Conversion

The forty-eight sites with micro-irrigation conversion rebates showed lower ex post energy impacts than predicted by the ex ante estimates. It was not possible to collect good pump test data for all sites. There were 12 sites to which the average of the other ex post analyses results of kWh/acre and kW/acre impacts were assigned. These impacts were assigned based on a grouping of type of system as determined from the application hardcopy (i.e., drip versus micro-sprinkler and measure type).

The ex post kWh impact is smaller than the ex ante estimate due to lower ex post findings for (1) the acre-foot per acre (AF/acre) of water applied and (2) pre-to-post pressure difference. The ex ante estimate assumes an average 2.7 AF/acre, while the ex post average finding was 2.2 AF/acre (even after the adjustment for new orchards). The ex ante estimate uses an acreage-weighted, average annual net irrigation requirement with various assumptions such as 33% of average annual gross rainfall as effective. The ex post findings used the 1998-99 kWh data for all pumps irrigating the acreage and kWh/AF from the site-specific pump test to determine the AF used on the crop in 1998-99. The AF value was then divided by the acreage watered by micro-irrigation to determine the AF/acre value.

The AF/acre value was critically reviewed to see if this was a reasonable finding. Many of the crops rebated were new almonds or pistachios. A real-world way that growers save water during the first years is to turn a micro-sprinkler up-side-down during the first year or two to create a smaller area of watering and use less water than expected for a mature crop. If the micro-irrigation system is comprised of emitters that can be placed within the tubing, the new crops often have fewer emitters in place than the mature crops. Because of this common practice, the adjustments discussed earlier were applied to the 17 applications with known new orchards. It was assumed that the analysis values for the AF/acre of water applied after this adjustment was reasonable based on the number of applications and the variety of interactions that can occur at these sites.

Another value that contributed in decreasing the ex post gross realization rate was the smaller ex post pressure differences. The ex ante estimates assumed a pressure difference of 36 psi between the pre- and post-retrofit systems, while the actual average ex post pressure difference found for the sites inspected was 32 psi. Coupled with the lower AF/acre value, the ex post energy impact was somewhat lower than the ex ante estimate. The ex post demand impact was only slightly lower than the ex ante since ex ante and ex post the pressure differences were very close and both used these values to determine kW impacts.

4.4.1.4 Custom

The custom site was audited and the current set-up of the filtration system for the micro-irrigation system was determined. While there were differences between the ex ante and ex post set-up, they were in favor of the ex ante analysis (i.e., a pump was removed at the site versus just being locked out). Based on these findings, the ex ante estimate of savings was used for the ex post finding of savings.

4.4.2 Refrigeration End Use

The ex post energy and demand impacts for oversized condensers were lower than the ex ante estimates. The ex post analysis found a lower value for the compressor total heat rejected (THR), based on how the site was using the refrigeration system. The ex ante average value was 1,263 tons THR, while the ex post average finding was 457 tons THR. The ex post estimated full load operating hours were higher (4,094 ex post versus 3,030 ex ante), which offset some of the lower THR in the ex post analysis. Additionally, the ex post analysis had a slightly lower condensing temperature difference pre-to-post than the ex ante (10.7 ex post versus 13.8 ex ante), leading to smaller impacts.

The differences were not surprising since the evaluation used the actual average operating pressures found at each site and the percentage of capacity at different times to determine the tons of refrigeration used (and therefore, the heat rejected). By comparison, the ex ante estimate used the tons of heat rejection between the pre- and post-retrofit estimate at design temperatures (i.e., design output conditions) These findings contribute to the explanation of why the ex post demand impacts are less than the ex ante estimates.

4.4.3 Greenhouse Heat Curtain End Use

The ex post findings of impacts were virtually identical to the ex ante estimate of impacts, with a gross realization rate of 1.01. Across the 16 sites, the site-specific gross realization rate varied from 0.45 to 2.74. There were two sites that kept the greenhouses at a very warm temperature (78 F) year round for their crop (orchids). These two sites helped to bring the realization rate up to its current 1.01. Without these two sites, the gross realization rate would have been 0.77.

The ex ante estimate of impacts used an average savings of 0.60 therms per square foot of heat curtain purchased. The ex post analysis average impacts were 0.68 therms per square foot of heat curtain installed. However, only 89% of the square footage rebated was found installed during the audit. Included in the therms/ft^2 value are all the differences between the ex ante and ex post analysis method and input assumptions. Some of these inputs are shown in Exhibit 4.5. These include a similar average nighttime temperature, a smaller reduction in air changes, differences in roof U-values, and fewer square feet of heat curtain found than was originally rebated.

Exhibit 4.5
Example of Ex Ante and Ex Post Heat Curtain Inputs

Input Item	Ex Ante	Ex Post
Nighttime Temperature	65 °F	Varied between 55 °F and 78 °F with an average of 66°F
Air Changes with Heat Curtain	33% reduction	12% reduction
Average Roof U-value No Heat Curtain	1.23	1.08
Average Roof U-value With Heat Curtain	0.45	0.42
Square Foot of Heat Curtain Installed	1,695,586	1,502,839

The ex post impacts averaged 22% of the pre-retrofit therm usage. Billing data were assessed for all but two of the sites, however, the pre/post-therm usage could not be correlated with billing data reductions because many sites had multiple greenhouses on one meter (and not all the greenhouses had heat curtains). The two sites had billing data that could not be located. The evaluation team believes the analysis appropriately reflects the actual impacts.

4.5 Net Realization Rates

Since the net-to-gross adjustments were the same for the ex ante and the ex post measures (0.75), the net realization rates are identical to the gross realization rates. For the sake of completeness, however, they are shown in Exhibit 4.6.

Exhibit 4.6
Net Realization Rates

End Use	PG&E Code *	Measure Description	N Items	Net Realization Rates kW	kWh	Therms
Ag Pumping and Related	A1	Pump Retrofit	74	0.00	0.78	NA
	A40	Low Pressure Nozzles	1	1.01	0.19	-
	A45 / A49 / A51 / A55	Sprinkler to Micro	48	0.92	0.99	NA
	A0	Customized	1	1.00	1.00	-
	Ag Pumping End Use Total		124	0.79	0.94	-
Refrigeration	R18	High Capacity Condenser	6	0.85	0.77	
Heat Curtain	A10	Greenhouse Heat Curtain	16	-	-	1.01
Ag Pumping, Refrigeration, and Other End Uses			**146**	0.79	0.91	1.02
AG Miscellaneous End Uses**			**4**	1.00	1.00	1.00
AEEI PROGRAM TOTAL			**150**	0.79	0.91	1.02

Data Source: Carryover for Pre-1998 PG&E Frozen MDSS Database - June 7, 1999
*PG&E MDSS Measure Codes
**The miscellaneous end uses are evaluated under Protocol Table C-9. They are not included in this evaluation.

4.6 Gross Per-Unit Impacts

The gross per-unit impacts are shown in Exhibit 4.7.

Exhibit 4.7
Gross Ex Post Per-Unit Impacts

End Use	Measure Description	DUOM	N of DUOM Electric	N of DUOM Gas	Ex Post Gross Per-Unit Impacts kWh	kW	Therms
Ag Pumping and Related	Pump Repair	AF of Water Pumped	52,128	-	29	0.000	-
	Low-Pressure Nozzles		62	-	58	0.155	-
	Micro-Irrigation Conv.		5,870	-	1,149	0.483	NA
	Custom		4		3,990	2.272	-
	Ag Pumping and Related End Use Total		58,065	-	142	0.049	-
Refrigeration Total	High-Capacity Condenser	Tons of Refrigeration	3,358	-	568	0.111	-
Greenhouse Heat Curtain Total	Greenhouse Heat Curtain	Square Foot of Heat Curtain	-	1,502,839	-	-	0.68

The filed Table E3 produced by PG&E used a designated unit of measure (DUOM) of the number of applications for the refrigeration and greenhouse heat curtains and a DUOM of unknown origin for the pumping and related end use. Because the DUOMs are different, the per-unit savings shown in Exhibit 4.7 are not directly comparable to ex ante estimates. However, if the ex post gross impacts use the ex ante DUOMs, the per-unit impacts can been directly compared . These direct comparisons of per-unit impacts are shown in Exhibit 4.8.

For the pumping and related end use, the ex ante per-unit estimate (shown in Exhibit 4.8) is lower than the ex post per-unit impact using the same number of units. It is unclear how the ex ante per-unit values were determined.

Exhibit 4.8
Comparison of Ex Ante and Ex Post Gross Per-Unit Impacts Using Ex Ante DUOM

End Use	DUOM	N of DUOM	Ex Ante Gross Per-Unit Impacts		
			kWh	kW	Therms
Ag Pumping and Related	From E-table	242,125 for kW and 100,933 for kWh	87	0.015	
Refrigeration	Application	6	410,865	73.0	-
Greenhouse Heat Curtain	Application	16	-	-	63,584

End Use	DUOM	N of DUOM	Ex Post Gross Per-Unit Impacts		
			kWh	kW	Therms
Ag Pumping and Related	From E-table	242,125 for kW and 100,933 for kWh	82	0.012	-
Refrigeration	Application	6	318,006	62.2	-
Greenhouse Heat Curtain	Application	16	-	-	64,293

End Use	DUOM	N of DUOM	Per-Unit Realization Rates		
			kWh	kW	Therms
Ag Pumping and Related	From E-table	242,125 for kW and 100,933 for kWh	0.94	0.79	-
Refrigeration	Application	6	0.77	0.85	-
Greenhouse Heat Curtain	Application	16	-	-	1.01

The per-unit realization rates shown in Exhibit 4.8 are identical to the gross realization rates since the ex ante DUOM values cancel out when calculating the per-unit realization rate.

4.7 Net Per-Unit Impacts

The net per-unit impacts are shown in Exhibit 4.9.

Exhibit 4.9
Net Per-Unit Impacts

End Use	Measure Description	DUOM	N of DUOM		Ex Post Net Per-Unit Impacts		
			Electric	Gas	kWh	kW	Therms
Ag Pumping and Related	Pump Repair	AF of Water Pumped	52,128	-	22	0.000	-
	Low-Pressure Nozzles		62	-	43	0.116	-
	Micro-Irrigation Conv.		5,870	-	862	0.362	NA
	Custom		4	-	2,992	1.704	-
	Ag Pumping and Related End Use Total		58,060	-	107	0.037	-
Refrigeration Total	High-Capacity Condenser	Tons of Refrigeration	3,358	-	426	0.083	-
Greenhouse Heat Curtain Total	Greenhouse Heat Curtain	Square Foot of Heat Curtain	-	1,502,839	-	-	0.513

Since the net-to-gross adjustments are the same for both the ex ante and ex post results, the explanations presented in section 4.6 apply here also.

The recommendation section is next.

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5. RECOMMENDATIONS

5.1 Evaluation Methods

The recommendations on the evaluation methods refer to the engineering analysis used for the gross impact analysis, since no net analysis was performed. The recommendations evolving from the evaluation are:

- The use of the PG&E pump test database to focus on which pump repair sites should be tested was very successful. It effectively targeted resources where they would provide the best information. One third of the pump repairs were able to have pump-specific impacts. This practice be continued in any future evaluation of this measure.
- Refrigeration sites that included oversized condensers tended to be large and complex. On-site audits are imperative for this measure in any future evaluation.
- Greenhouse heat curtains cover many peaks yet are often on the same meter with peaks that do not have heat curtains. For this reason, engineering analysis is the best approach. On-site audits are required to obtain the information needed for an engineering analysis.

5.2 Program Design

The overall recommendations regarding program design are:

- Set the demand impact to zero for pump repairs in all future projected savings.
- Decrease the OPE ratio for pumps under 75 horsepower to from 21% to 18%.
- Greenhouse program documentation should identify the specific location of the square footage of heat curtain installed. The last two evaluations have found about 10% less square footage of heat curtain installed than was rebated.
- PG&E should explore incorporating an average Total Heat Rejection (THR) in the incentive payment as opposed to using a design-level THR. This would help account for decreased savings due to low capacity use at the sites.

5.2.1 Protocols

The evaluation team makes no recommendations on the Protocols and the requirements set for the evaluation. Any variations from the Protocols can be made through the waiver process.

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6. CADMAC WAIVERS

Two requests for retroactive waivers were submitted to CADMAC for the pre-1998 AEEI programs.

The first AEEI waiver was approved May 20, 1999. This waiver allowed:

- A simplified engineering model supported by telephone and field data collection to estimate the impacts for the refrigeration end use.
- Reporting on per-project and relevant per-unit bases for the refrigeration end use. The proposed per-unit DUOM is "Load impacts per ton of refrigeration affected" for the refrigeration end use.
- Use of a net-to-gross ratio of 0.75 for the Ag sector conditioned on conducting a survey-based market needs study.

The second AEEI waiver was approved October 20, 1999. This waiver allowed:

- Allow simplified engineering model supported by field data collection to estimate the impacts for the Greenhouse Heat Curtain end use.
- Reporting on per-project and relevant per-unit bases for the greenhouse heat curtain end use. The proposed per-unit DUOM is "Load impacts per-square foot of heat curtain installed".

The following pages present the waivers in their entirety for those readers requiring detail.

PACIFIC GAS & ELECTRIC COMPANY REQUEST FOR RETROACTIVE WAIVER FOR PRE-1998 CARRYOVER AGRICULTURAL SECTOR ENERGY EFFICIENCY INCENTIVES (EEI) PROGRAMS

Study ID #s: 405a (Pumping and Related), 405b (Refrigeration)
Date Approved: May 20, 1999

Summary of PG&E Request

This waiver requests deviations from, or clarifications of, the Protocols[4] by PG&E for the Pre-1998 Carryover Agricultural Sector Energy Efficiency Incentives (EEI) Evaluation[5]. 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 the Refrigeration end use, (2) allow reporting of results in more appropriate DUOMs for the Refrigeration end use, and (3) conduct a market needs study in place of a net-to-gross analysis, applying a default net-to-gross ratio to the sector.

Each of these requests evolve from the evaluation of the 1994 through 1997 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 Refrigeration end use.

Parameters and Protocol Requirements

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".

Rationale

PG&E's Pre-1998 Carryover PG&E agricultural program includes a limited number of refrigeration sites 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 a participant-based engineering model supported by field data collection for a census of all participants to estimate the impacts for these sites.

Similar waivers were granted for the 1995 (approved October 1996), 1996 (approved July 22, 1997), and 1997 (approved June 17, 1998) PG&E's Agricultural Sector evaluations.

(2) Allow reporting of results in more appropriate DUOMs for the Refrigeration end use. PG&E wishes to report the results for this end use on a per project basis and on a relevant per unit basis. For the Refrigeration end use, the proposed per unit DUOM would be "Load impacts per ton of refrigeration affected".

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[4] Protocols and Procedures for the Verification of Costs, Benefits, and Shareholder Earnings for Demand-Side Management Programs, Ver 98-03-063

[5] The first year earnings claim for the Carryover for Pre-1998Agricultural Sector is approximately $400,000.

Parameters and Protocol Requirements

The current DUOM for Protocol Table C-6 are "Load impacts per acre foot of water pumped".

Rationale

PG&E's Pre-1998 Carryover PG&E agricultural program includes a limited number of refrigeration sites representing approximately 12 percent of the agricultural sector avoided cost. Reporting results for refrigeration projects on a "Load impacts per acre foot of water pumped" would make no sense. PG&E proposes to report them on a per project basis (as is done in the Industrial Process end use in Table C-5) and on a per unit basis. This should maximize the usefulness of the results to users of the reports.

Similar waivers were granted for the Lighting end use in PG&E's 1996 (approved July 22, 1997), and the Greenhouse Heat Curtains and Refrigeration end uses in PG&E's 1997 (approved January 20, 1999) Agricultural Sector EEI evaluation.

(3) Instead of a net-to-gross study, allow the use of a default net-to-gross ratio of 0.75 for the agricultural sector, subject to the condition that PG&E conduct a "market needs" study that would help future program design to yield the best returns. A more complete description of the market needs study is attached. The final report for this study would be submitted to CADMAC by March 31, 2000.

Parameters and Protocol Requirements

Table 5, item B.2. requires the estimate of net impacts. In the Agricultural Sector this has been accomplished by estimating a gross impact and multiplying it by an estimated Net-to-Gross ratio.

Rationale

Allowing PG&E to substitute a forward-looking market needs study for the Protocol required net-to-gross assessment would (1) make the best use of current funding by processing current statewide information into an easily usable form for future administrators, (2) collect key information not currently available to fill in gaps in the information picture, and (3) put that information in the context of the current agricultural market so that decisions can be made on future program design.

This trade-off of a net-to-gross study with a market-based type of study is similar to waivers granted for PG&E's 1996 Agricultural Sector EMS Program evaluation (approved July 22, 1997, modified November 21, 1997) and PG&E's 1997 Agricultural Sector EEI Program evaluation (approved June 17, 1998).

Conclusion

PG&E is seeking retroactive waivers to clearly define, in advance, acceptable methods for performing the Pre-1998 Carryover 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 allowing the reporting of results in more appropriate DUOMs for the refrigeration end use maximizes the usefulness of the results to users of the report. The waiver allowing a market needs study rather than conducting a net-to-gross analysis seeks to maximize information useful to future programs.

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 refrigeration end use.	Small number of sites makes use of LIRM or regression method impossible. End use metering is prohibitively expensive for the complex sites and effort is disproportionate to savings.
Designated Unit of Measure	Load impacts per acre foot of water pumped	Allow reporting on a per project basis and on a relevant per unit basis for the refrigeration end use. The proposed per unit DUOM would be "Load impacts per ton of refrigeration affected".	The Pumping DUOM is the only one specified in Table C-6. It does not make sense for other end uses. Reporting the results on both a per project and the proposed per unit basis will make results more useful.
Net Load Impacts	Study-based Net Load Impacts	Use of a NTG ratio of 0.75 for sector conditioned on conducting a survey-based market needs study of the pumping and related end use in the EEI Programs.	A market needs study would supply information that is more useful to future agricultural program design.

PROPOSED AGRICULTURAL MARKET NEEDS STUDY

PG&E proposes conducting a market needs study designed to facilitate the transition from the past PG&E Agricultural program structures to a market transformation type of program structure.

From prior evaluation experience, PG&E recognizes the need to study the market before designing new programs or altering existing programs. For example, the market effect study of 1997 proved that the value of information and incentives programs differ from one segment to the other. To get the best results out of any program, it is necessary to understand the customers' market needs. PG&E proposes to identify these needs for the agricultural market and build a basis to help future program design yield the best returns.

This proposed Pre-1998 Carryover Agricultural Sector Study would draw on (1) the previous two PG&E market effects studies, along with similar studies done by other California utilities, (2) additional end user data collection, and (3) statewide firmographic data along with utility data. The study would combine these information sources to identify the market sectors that would most benefit from agricultural energy efficiency programs, the types of programs that would likely be the most effective in developing actual savings and transforming the markets, and the projected potential impacts by market sector. This information could then be directly applied by the future program administrators to move swiftly to final program design and implementation.

We believe that the proposed 1998 Agricultural Sector Study would (1) make the best use of current funding by processing current statewide information into an easily usable form for future administrators, (2) collect key information not currently available to fill in gaps in the information picture, and (3) put all of that information in the context of the current agricultural market so that decisions can be made on future program design.

PACIFIC GAS & ELECTRIC COMPANY
REQUEST FOR RETROACTIVE WAIVER FOR
PRE-1998 CARRYOVER AGRICULTURAL SECTOR
ENERGY EFFICIENCY INCENTIVES (EEI) PROGRAMS

Study ID #s: 405c
Date Approved: October 20, 1999

Summary of PG&E Request

This waiver requests deviations from, or clarifications of, the Protocols[6] by PG&E for the Pre-1998 Carryover Agricultural Sector Energy Efficiency Incentives (EEI) Evaluation[7]. As a result of recent reviews of participation data, the Greenhouse Heat Curtain end use needs to be evaluated to meet the 85 percent minimum coverage for the agricultural sector. PG&E seeks approval to: (1) use a Simplified Engineering Model supported by on-site data collection to estimate the gross impacts for the Greenhouse Heat Curtain end use, and (2) report Greenhouse Heat Curtain end use results in appropriate DUOMs.

The request to use simplified engineering modeling is the result of the limited size of the participant population for this end use. The request for use of alternate DUOMs is because the current DUOM for the agriculture sector does not make sense for this end use. Both waivers have precedents in previous CADMAC waivers.

Proposed Waiver

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

Allow the use of Simplified Engineering Models (as specified in Appendix A, page A-2 of the Protocols) supported by census on-site data collection to estimate gross impacts for the Greenhouse Heat Curtain end use.

Parameters and Protocol Requirements

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".

Rationale

PG&E's Pre-1998 Carryover agricultural program includes a limited number of Greenhouse Heat Curtain sites (12 or fewer) representing approximately 14 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 a participant-based engineering model supported by field data collection for a census of all participants to estimate the gross impacts for these sites.

Similar waivers were granted for the 1995 (approved October 1996), 1996 (approved July 22, 1997), and 1997 (approved June 17, 1998) PG&E's Agricultural Sector evaluations.

(2) Allow reporting of results in more appropriate DUOMs for the Greenhouse Heat Curtain end use. PG&E wishes to report the results for this end use on a per project basis and on a relevant per unit basis. For the Greenhouse Heat Curtain end use, the proposed per unit DUOM would be "Load impacts per square foot of heat curtain installed".

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[6] Protocols and Procedures for the Verification of Costs, Benefits, and Shareholder Earnings for Demand-Side Management Programs, Ver 99-06-052

[7] The first year earnings claim for the Carryover for Pre-1998 Agricultural Sector is approximately $400,000.

Parameters and Protocol Requirements

The current DUOM for Protocol Table C-6 are “Load impacts per acre foot of water pumped”.

Rationale

Reporting results for greenhouse heat curtain projects on a “Load impacts per acre foot of water pumped” would make no sense. PG&E proposes to report them on a per project basis (as is done in the Industrial Process end use in Table C-5) and on a per unit basis. This should maximize the usefulness of the results to users of the reports.

Similar waivers were granted for the Lighting end use in PG&E’s 1996 (approved July 22, 1997) Agricultural Sector EEI evaluation, the Greenhouse Heat Curtains and Refrigeration end uses in PG&E’s 1997 (approved January 20, 1999) Agricultural Sector EEI evaluation, and the Refrigeration end use for the Pre-1998 Carryover Agricultural Sector (approved May 20, 1999).

Conclusion

PG&E is seeking retroactive waivers to clearly define, in advance, acceptable methods for performing the Pre-1998 Carryover 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 allowing the reporting of results in more appropriate DUOMs maximizes the usefulness of the results to users of the report.

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 field data collection to estimate the impacts for the Greenhouse Heat Curtain end use.	Small number of sites makes use of LIRM or regression method impossible. End use metering is prohibitively expensive and effort is disproportionate to savings.
Designated Unit of Measure	Load impacts per acre foot of water pumped	Allow reporting on a per project basis and on a relevant per unit basis for the Greenhouse Heat Curtain end use. The proposed per unit DUOM would be “Load impacts per square foot of heat curtain installed”.	The Pumping DUOM is the only one specified in Table C-6. It does not make sense for other end uses. Reporting the results on both a per project and the proposed per unit basis will make results more useful.

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7. PROTOCOL TABLES 6 AND 7

7.1 Protocol Table 6, Pumping End Use

Protocol Table 6 (Items 1-5)
Results of Impact Measurement Study
PG&E Pre-1998 Agricultural Sector
Agricultural Pumping and Related End Use
Study ID 405A

Table Item		Agricultural Sector		
Item Number Number	Result Description	Estimate	Confidence Interval* 90%	80%
1.A	Pre-installation Average kWh (Participant)	143,703	-	-
	Pre-installation Average kWh (Comparison)	NA	-	-
	Pre-installation Per-Unit kWh (Participant)	334	-	-
	Pre-installation Per-Unit kWh (Comparison)	NA	-	-
1.B	Average Impact Year kWh (Participant)	116,925	-	-
	Average Impact Year kWh (Comparison)	NA	-	-
	Impact Year kWh/Unit (Participant)	220	-	-
	Impact Year kWh/Unit (Comparison)	NA	-	-
2.A	Average Gross Peak kW Impact	23.03	-	-
	Average Gross Annual kWh Impact	66,722	-	-
	Average Gross Annual Therm Impact	-	-	-
	Average Net Peak kW Impact	17.27	-	-
	Average Net Annual kWh Impact	50,042	-	-
	Average Net Annual Therm Impact	-	-	-
2.B	Per-Unit Gross Peak kW Impacts	0.049	-	-
	Per-Unit Gross Annual kWh Impacts	142	-	-
	Per-Unit Gross Annual Therm Impacts	-	-	-
	Per-Unit Net Peak kW Impacts	0.037	-	-
	Per-Unit Net Annual kWh Impacts	107	-	-
	Per-Unit Net Annual Therm Impacts	-	-	-
2.C	Percent change in usage of the participant group	-18.6%	-	-
	Percent change in usage of the comparison group	NA	-	-
2.D.1	Gross Demand Realization Rate	0.79	-	-
	Gross Energy Realization Rate	0.94	-	-
	Gross Therm Realization Rate	-	-	-
	Net Demand Realization Rate	0.79	-	-
	Net Energy Realization Rate	0.94	-	-
	Net Therm Realization Rate	-	-	-
2.D.2	Per-Unit Gross Demand Realization Rate	3.28	-	-
	Per-Unit Gross Energy Realization Rate	1.64	-	-
	Per-Unit Gross Annual Therm Realization Rate	-	-	-
	Per-Unit Net Demand Realization Rate	3.28	-	-
	Per-Unit Net Energy Realization Rate	1.64	-	-
	Per-Unit Net Therm Realization Rate	-	-	-
3.A	NTG Ratio Based on Average kWh Impacts	0.75	-	-
	NTG Ratio Based on Average kW Impacts	0.75	-	-
	NTG Ratio Based on Average Therm Impacts	-	-	-
3.B	NTG Ratio Based on Per-Unit Average kWh Impact	0.75	-	-
	NTG Ratio Based on Per-Unit Average kW Impacts	0.75	-	-
	NTG Ratio Based on Per-Unit Average Therm Impa	-	-	-
3.C	NTG Ratio Based on Percent change in kWh usage relative to base kWh usage	NA	-	-
4.A	Pre Average AF Water Pumped (Participant)	468	-	-
	Pre Average AF Water Pumped (Comparison)	NA	-	-
4.B	Post Average AF Water Pumped (Participant)	468	-	-
	Post Average AF Water Pumped (Comparison)	NA	-	-

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

The DUOMs used in the above table are shown next.

Protocol Table 6 (Item 6)
Results of Impact Measurement Study
PG&E Pre-1998 Agricultural Sector
Agricultural Pumping and Related End Use
Study ID 405A

Measure	Designated Unit of Measure (DUOM)	Participant Group	Program Population
Pump Repair	AF Water Pumped	52,128	52,128
Low-Pressure Sprinkler Nozzle	AF Water Pumped	62	62
Micro-drip Conversion	AF Water Pumped	5,870	5,870
Custom	AF Water Pumped	4	4
Total		58,060	58,060

7.2 Protocol Table 6, Refrigeration End Use

Protocol Table 6 (Items 1-5)
Results of Impact Measurement Study
PG&E Pre-1998 Agricultural Sector
Refrigeration End Use
Study ID 405B

Table Item		Agricultural Sector			
Item Number	Result	Estimate	Estimate	Confidence Interval*	
Number	Description	DUOM=THR	DUOM=Site	90%	80%
1.A	Pre-installation Average kWh (Participant)	2,469,757	2,469,757	-	-
	Pre-installation Average kWh (Comparison)	NA	NA	-	-
	Pre-installation Per-Unit kWh (Participant)	4,413	2,469,757	-	-
	Pre-installation Per-Unit kWh (Comparison)	NA	NA	-	-
1.B	Average Impact Year kWh (Participant)	1,890,543	1,890,543	-	-
	Average Impact Year kWh (Comparison)	NA	NA	-	-
	Impact Year kWh/Unit (Participant)	3,378	1,890,543	-	-
	Impact Year kWh/Unit (Comparison)	NA	NA	-	-
2.A	Average Gross Peak kW Impact	62.19	62.19	-	-
	Average Gross Annual kWh Impact	318,006	318,006	-	-
	Average Gross Annual Therm Impact	-	-	-	-
	Average Net Peak kW Impact	46.64	46.64	-	-
	Average Net Annual kWh Impact	238,504	238,504	-	-
	Average Net Annual Therm Impact	-	-	-	-
2.B	Per-Unit Gross Peak kW Impacts	0.111	62.19	-	-
	Per-Unit Gross Annual kWh Impacts	568	318,006	-	-
	Per-Unit Gross Annual Therm Impacts	-	-	-	-
	Per-Unit Net Peak kW Impacts	0.083	46.64	-	-
	Per-Unit Net Annual kWh Impacts	426	238,504	-	-
	Per-Unit Net Annual Therm Impacts	-	-	-	-
2.C	Percent change in usage of the participant group	-23.5%	-23.5%	-	-
	Percent change in usage of the comparison group	NA	NA	-	-
2.D.1	Gross Demand Realization Rate	0.85	0.85	-	-
	Gross Energy Realization Rate	0.77	0.77	-	-
	Gross Therm Realization Rate	-	-	-	-
	Net Demand Realization Rate	0.85	0.85	-	-
	Net Energy Realization Rate	0.77	0.77	-	-
	Net Therm Realization Rate	-	-	-	-
2.D.2	Per-Unit Gross Demand Realization Rate	0.002	0.85	-	-
	Per-Unit Gross Energy Realization Rate	0.001	0.77	-	-
	Per-Unit Gross Annual Therm Realization Rate	-	-	-	-
	Per-Unit Net Demand Realization Rate	0.002	0.85	-	-
	Per-Unit Net Energy Realization Rate	0.001	0.77	-	-
	Per-Unit Net Therm Realization Rate	-	-	-	-
3.A	NTG Ratio Based on Average kWh Impacts	0.75	0.75	-	-
	NTG Ratio Based on Average kW Impacts	0.75	0.75	-	-
	NTG Ratio Based on Average Therm Impacts	-	-	-	-
3.B	NTG Ratio Based on Per-Unit Average kWh Impact	0.75	0.75	-	-
	NTG Ratio Based on Per-Unit Average kW Impacts	0.75	0.75	-	-
	NTG Ratio Based on Per-Unit Average Therm Impa	-	-	-	-
3.C	NTG Ratio Based on Percent change in kWh usage relative to base kWh usage	NA	NA	-	-
4.A	Pre Average kWh (Participant)	-	2,469,757	-	-
	Pre Average kWh (Comparison)	-	NA	-	-
4.B	Post Average kWh (Participant)	-	1,890,543	-	-
	Post Average kWh (Comparison)	-	NA	-	-

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

The DUOMs used in the above table are shown next.

Protocol Table 6 (Item 6)
Results of Impact Measurement Study
PG&E Pre-1998 Agricultural Sector
Refrigeration End Use
Study ID 405B

Measure	Designated Unit of Measure (DUOM)	Participant Group	Program Population
High-Capacity Condenser	Compressor Total Heat of Rejection (THR)	3,358	3,358
High-Capacity Condenser	Site	6	6

7.3 Protocol Table 6, Greenhouse Heat Curtain End Use

Protocol Table 6 (Items 1-5)
Results of Impact Measurement Study
PG&E Pre-1998 Agricultural Sector
Greenhouse Heat Curtain End Use
Study ID 405C

Table Item		Agricultural Sector			
Item Number Number	Result Description	Estimate DUOM=Sq Ft	Estimate DUOM=Site	Confidence Interval* 90%	80%
1.A	Pre-installation Average Therm (Participant)	294,524	294,524	-	-
	Pre-installation Average Therm (Comparison)	NA	NA	-	-
	Pre-installation Per-Unit Therm (Participant)	3.14	294,524	-	-
	Pre-installation Per-Unit Therm (Comparison)	NA	NA	-	-
1.B	Average Impact Year Therm (Participant)	394,735	394,735	-	-
	Average Impact Year Therm (Comparison)	NA	NA	-	-
	Impact Year Therm/Unit (Participant)	4.20	394,735	-	-
	Impact Year Therm/Unit (Comparison)	NA	NA	-	-
2.A	Average Gross Peak kW Impact	-	-	-	-
	Average Gross Annual kWh Impact	-	-	-	-
	Average Gross Annual Therm Impact	64,293	64,293	-	-
	Average Net Peak kW Impact	-	-	-	-
	Average Net Annual kWh Impact	-	-	-	-
	Average Net Annual Therm Impact	48,220	48,220	-	-
2.B	Per-Unit Gross Peak kW Impacts	-	-	-	-
	Per-Unit Gross Annual kWh Impacts	-	-	-	-
	Per-Unit Gross Annual Therm Impacts	0.68	64,293	-	-
	Per-Unit Net Peak kW Impacts	-	-	-	-
	Per-Unit Net Annual kWh Impacts	-	-	-	-
	Per-Unit Net Annual Therm Impacts	0.51	48,220	-	-
2.C	Percent change in usage of the participant group	34.0%	34.0%	-	-
	Percent change in usage of the comparison group	NA	NA	-	-
2.D.1	Gross Demand Realization Rate	-	-	-	-
	Gross Energy Realization Rate	-	-	-	-
	Gross Therm Realization Rate	1.01	1.01	-	-
	Net Demand Realization Rate	-	-	-	-
	Net Energy Realization Rate	-	-	-	-
	Net Therm Realization Rate	1.01	1.01	-	-
2.D.2	Per-Unit Gross Demand Realization Rate	-	-	-	-
	Per-Unit Gross Energy Realization Rate	-	-	-	-
	Per-Unit Gross Annual Therm Realization Rate	1.14	1.01	-	-
	Per-Unit Net Demand Realization Rate	-	-	-	-
	Per-Unit Net Energy Realization Rate	-	-	-	-
	Per-Unit Net Therm Realization Rate	1.14	1.01	-	-
3.A	NTG Ratio Based on Average kWh Impacts	-	-	-	-
	NTG Ratio Based on Average kW Impacts	-	-	-	-
	NTG Ratio Based on Average Therm Impacts	0.75	0.75	-	-
3.B	NTG Ratio Based on Per-Unit Average kWh Impact	-	-	-	-
	NTG Ratio Based on Per-Unit Average kW Impacts	-	-	-	-
	NTG Ratio Based on Per-Unit Average Therm Impa	0.75	0.75	-	-
3.C	NTG Ratio Based on Percent change in kWh usage relative to base kWh usage	NA	NA	-	-
4.A	Pre Average Therm (Participant)	-	294,524	-	-
	Pre Average Therm (Comparison)	-	NA	-	-
4.B	Post Average Therm (Participant)	-	394,735	-	-
	Post Average Therm (Comparison)	-	NA	-	-

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

The DUOMs used in the above table are shown next.

Protocol Table 6 (Item 6)
Results of Impact Measurement Study
PG&E Pre-1998 Agricultural Sector
Greenhouse Heat Curtain End Use
Study ID 405C

Measure	Designated Unit of Measure (DUOM)	Participant Group	Program Population
Greenhouse Heat Curtain	Square Foot of Heat Curtain	1,502,839	1,502,839
Greenhouse Heat Curtain	Site	16	16

7.4 Protocol Table 7 – Pumping and Related End Use (Study #405A)

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.

7.4.1 Overview Information

7.4.1.1 Study Title and Study ID Number

Study Title: Pacific Gas & Electric's
Carryover For Pre-1998 Energy Efficiency Incentives Program:
Agricultural Sector Impact Evaluation Report

Study ID Number: 405A

7.4.1.2 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 1998 Calendar Year.

Program Description: Refer to Section 2.1 for a detailed description of the program.

7.4.1.3 End Uses and/or Measures Covered

End Use Covered: Agricultural Pumping Technologies
Measures Covered: Pump Repair
Low-pressure Sprinkler Nozzles
Sprinkler to Micro Irrigation Conversion

7.4.1.4 Methods and Models Use

The PG&E AEEI Program evaluation consisted of an engineering analysis of gross energy and demand impacts. A retroactive waiver had been accepted by CADMAC to allow the evaluation team to replace the net analysis with a market needs study. A default net-to-gross ratio of 0.75 was used in place of the net analysis.

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 – The default net-to-gross ratio of 0.75 was used.

7.4.1.5 Participant and Comparison Group Definition

Participant - Participants are defined as those PG&E agricultural customers who received PG&E rebates in the 1998 calendar year for installing at least one pumping measure under the AEEI Program.

Comparison Group – Nonparticipant pre- and post-retrofit pump test data were used to support the analysis.

7.4.1.6 Analysis Sample Size

Gross impact – a census was attempted for the participants.

Exhibit 7.1
Sample Summary – Pumping and Related End Use

		Sample Frame		Final Analysis Sample	
End Use	Population *	On-Site	Metering**	On-Site	Metering
Pumping and Related	124	100	100	123	83
Refrigeration	6	6	0	6	0
Greenhouse Heat Curtain	16	16	0	15	0
Total Participant	146	122	100	144	83

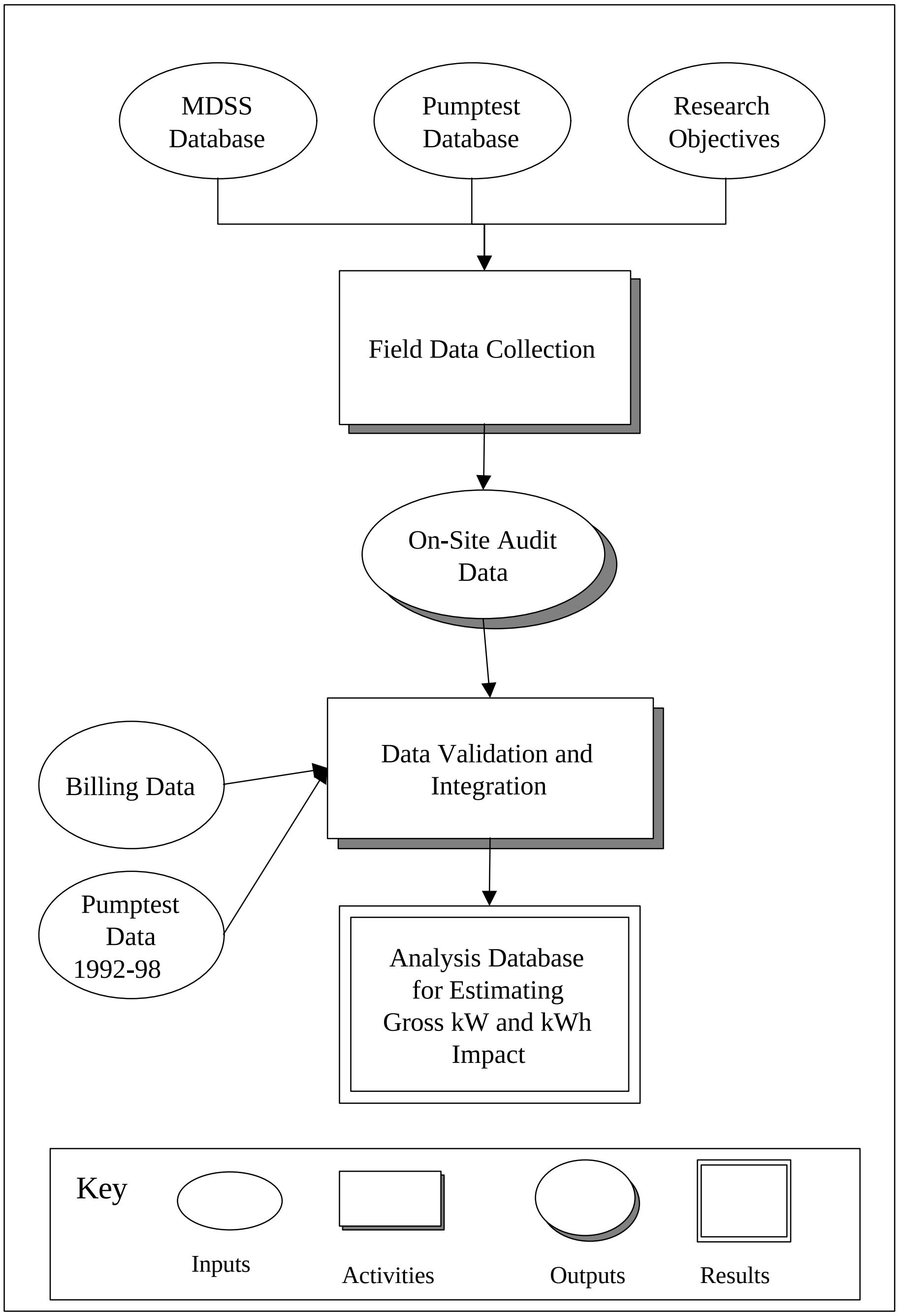
*Participant sample was a census, population refers to number of applications
**The exact number of sites for pump testing (metering) was unknown since micro-irrigation sites often use >1 test per application

7.4.2 Database Management

7.4.2.1 Data Description and Flow Chart

On-site survey data were collected for a census of participants. Sample design was not required since a census is included in the analysis. After the on-site survey of participants, the analysis database was created using the program data, billing data and on-site survey data. Exhibit 7.2 illustrates how each key data element was used to create the final analysis database for the evaluation.

Exhibit 7.2
Final Analysis Database Creation – Pumping and Related End Use



7.4.2.2 Specific Data Sources

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.

PG&E Pump Test Database – This database, maintained by PG&E, contains data from pump tests performed throughout the service territory.

On-Site Audit Data - On-site audit data were collected as part of this evaluation for the participant group. The on-site audit was designed to support the engineering analysis by providing key inputs such as acreage and pump operating plant efficiency.

Other data elements include PG&E program marketing data, program procedural manuals and other industry standard data sources.

7.4.2.3 Data Attrition Process

All data elements mentioned above were first validated and then merged together to form the final analysis dataset. Most data points collected during the on-site audits were kept. If a pump test was considered "poor", it was not used in the analysis.

7.4.2.4 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 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 survey data collection and data analysis, data quality assurance procedures were in place to insure that all usage data used in analysis and all on-site survey data collected was of high quality.

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

7.4.2.5 Unused Data Elements

All data collected specifically for the Evaluation were utilized in the analysis.

7.4.3 Sampling

7.4.3.1 Sampling Procedures and Protocols

The limited participant population necessitated an attempted census of participants who were expected to contribute data to the engineering analysis. The number of completed participant surveys as mentioned above in section 1.f., reflects such an attempted census.

7.4.3.2 Survey Information

On-site audit instruments are presented in Appendix B.

7.4.3.3 Statistical Descriptions

There were no statistical models used in this analysis.

7.4.4 Data Screening and Analysis

A detailed discussion of the approach used to estimate the engineering impact for the pumping and related measures is described in Appendix A.

7.4.4.1 Outliers and Missing Data

When data was unavailable or was as outlier, an average from the rest of the measure was used.

7.4.4.2 Background Variables

There were no background variables modeled.

7.4.4.3 Data Screening Process

No data was screened from the engineering analysis.

7.4.4.4 Regression Statistics

There were no regression models used in this evaluation.

7.4.4.5 Model Specification

There were no statistical models used in this evaluation.

7.4.4.6 Measurement Errors

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 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.

7.4.4.7 Autocorrelation

This is not applicable to an engineering analysis.

7.4.4.8 Heteroskedasticity

This is not applicable to an engineering analysis.

7.4.4.9 Collinearity

This is not applicable to an engineering analysis.

7.4.4.10 Influential Data Points

This is not applicable to an engineering analysis.

7.4.4.11 Missing Data

When data was unavailable, an average from the rest of the measure was used.

7.4.4.12 Precision

Since the engineering estimate of gross 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.

7.4.4.13 Engineering Analysis

The Protocols allow a simplified engineering model to be used for the pumping and related end use. The analysis performed for this evaluation used pump test data from either the PG&E pump test database or site specific tests as inputs into the engineering models. All the savings were seen at one or more pumps with no other loads interacting.

7.4.4.14 Comparison Group Not Used for Net Analysis

A waiver allowed the evaluation team to use a default net-to-gross ratio of 0.75.

7.4.5 Data Interpretation and Application

A waiver allowed the evaluation team to use a default net-to-gross ratio of 0.75. This value was applied to all gross impact estimates at the measure level.

7.5 Protocol Table 7 – Refrigeration End Use (Study #405B)

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.

7.5.1 Overview Information

7.5.1.1 Study Title and Study ID Number

Study Title: Pacific Gas & Electric's
Carryover For Pre-1998 Energy Efficiency Incentives Program:
Agricultural Sector Impact Evaluation Report

Study ID Number: 405B

7.5.1.2 Program, Program Year and Program Description

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

Program Year: Rebates Received in the 1998 Calendar Year.

Program Description: Refer to section 2.1 for a detailed description of the program.

7.5.1.3 End Uses and/or Measures Covered

End Use Covered: Refrigeration Technologies Used in the Agricultural Sector
Measures Covered: Oversized Condenser

7.5.1.4 Methods and Models Use

The PG&E AEEI Program evaluation consisted of an engineering analysis of gross energy and demand impacts. A retroactive waiver had been accepted by CADMAC to allow the evaluation team to replace the net analysis with a market effects study. A default net-to-gross ratio of 0.75 was used in place of the net analysis.

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

Net effect – The default net-to-gross ratio of 0.75 was used.

7.5.1.5 Participant and Comparison Group Definition

Participant - Participants are defined as those PG&E agricultural customers who received PG&E rebates in the 1998 calendar year for installing at least one refrigeration measure under the AEEI Program.

Comparison Group – There was no comparison group used in the engineering analysis. This was allowed by the waiver shown in Section 6.

7.5.1.6 Analysis Sample Size

Gross impact – a census was attempted for the participants.

Exhibit 7.3
Sample Summary – Refrigeration End Use

End Use	Population *	Sample Frame		Final Analysis Sample	
		On-Site	Metering**	On-Site	Metering
Pumping and Related	124	100	100	123	83
Refrigeration	6	6	0	6	0
Greenhouse Heat Curtain	16	16	0	15	0
Total Participant	146	122	100	144	83

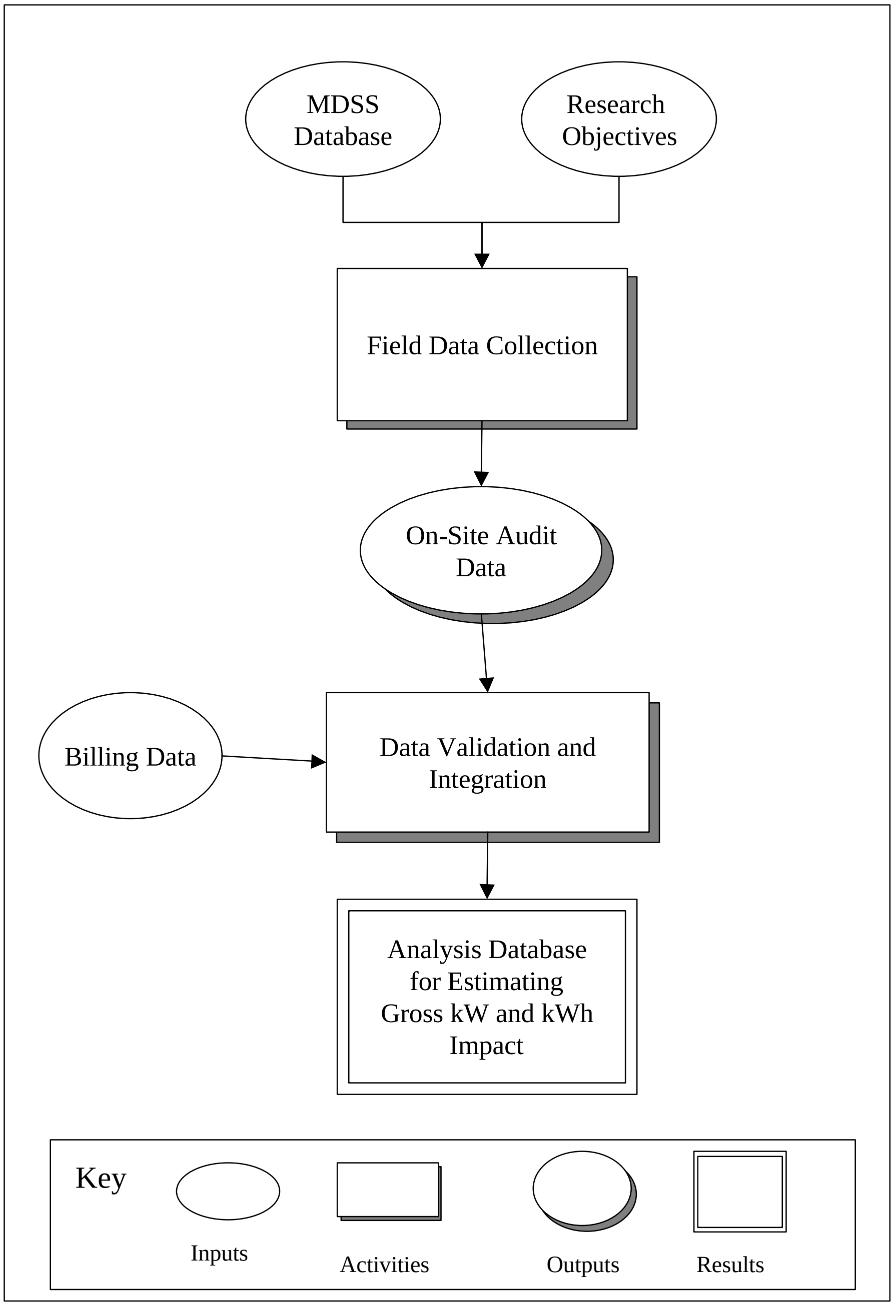
*Participant sample was a census, population refers to number of applications
**The exact number of sites for pump testing (metering) was unknown since micro-irrigation sites often use >1 test per application

7.5.2 Database Management

7.5.2.1 Data Description and Flow Chart

On-site survey data were collected for a census of participants. Sample design was not required since a census is included in the analysis. After the on-site survey of participants, the analysis database was created using the program data, billing data and on-site survey data. Exhibit 7.2 illustrates how each key data element was used to create the final analysis database for the evaluation.

Exhibit 7.4
Final Analysis Database Creation – Refrigeration End Use



7.5.2.2 Specific Data Sources

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.

On-Site Audit Data - On-site audit data were collected as part of this evaluation for the participant group. The on-site audit was designed to support the engineering analysis by providing key inputs such as compressor horsepower and refrigeration capacity.

Other data elements include PG&E program marketing data, program procedural manuals and other industry standard data sources.

7.5.2.3 Data Attrition Process

All data elements mentioned above were first validated and then merged together to form the final analysis dataset. All data points collected during the on-site audits were kept.

7.5.2.4 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 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 survey data collection and data analysis, data quality assurance procedures were in place to insure that all usage data used in analysis and all on-site survey data collected was of high quality.

7.5.2.5 Unused Data Elements

All data collected specifically for the Evaluation were utilized in the analysis.

7.5.3 Sampling

7.5.3.1 Sampling Procedures and Protocols

The limited participant population necessitated an attempted census of participants who were expected to contribute data to the engineering analysis. The number of completed participant surveys as mentioned above in section 1.f., reflects a census.

7.5.3.2 Survey Information

On-site audit instruments are presented in Appendix B.

7.5.3.3 Statistical Descriptions

There were no statistical models used in this analysis.

7.5.4 Data Screening and Analysis

A detailed discussion of the approach used to estimate the engineering impact for the refrigeration measures is described in Appendix A.

7.5.4.1 Outliers and Missing Data

When data was unavailable or was as outlier, all other data from the site and engineering judgement was used to determine the best data point.

7.5.4.2 Background Variables

There were no background variables modeled.

7.5.4.3 Data Screening Process

No data was screened from the engineering analysis.

7.5.4.4 Regression Statistics

There were no regression models used in this evaluation.

7.5.4.5 Model Specification

There were no statistical models used in this evaluation.

7.5.4.6 Measurement Errors

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 included an instrument pre-test and the use of a single auditor to collect the data.

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

7.5.4.7 Autocorrelation

This is not applicable to an engineering analysis.

7.5.4.8 Heteroskedasticity

This is not applicable to an engineering analysis.

7.5.4.9 Collinearity

This is not applicable to an engineering analysis.

7.5.4.10 Influential Data Points

This is not applicable to an engineering analysis.

7.5.4.11 Missing Data

When data was unavailable, an estimate based on all other available data for the site and engineering judgement was used.

7.5.4.12 Precision

Since the engineering estimate of gross 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.

7.5.4.13 Engineering Analysis

The waiver allowed a simplified engineering model to be used for the refrigeration end use. The savings seen by the measures were not interactive with any other loads.

7.5.4.14 Comparison Group Not Used for Net Analysis

A waiver allowed the evaluation team to use a default net-to-gross ratio of 0.75.

7.5.5 Data Interpretation and Application

A waiver allowed the evaluation team to use a default net-to-gross ratio of 0.75. This value was applied to all gross impact estimates at the measure level.

7.6 Protocol Table 7 – Greenhouse Heat Curtain End Use (Study #405C)

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.

7.6.1 Overview Information

7.6.1.1 Study Title and Study ID Number

Study Title:	Pacific Gas & Electric's Carryover For Pre-1998 Energy Efficiency Incentives Program: Agricultural Sector Impact Evaluation Report
Study ID Number:	405C

7.6.1.2 Program, Program Year and Program Description

Program:	PG&E Agricultural EEI Program, Agricultural Sector Greenhouse Heat Curtain End Use.
Program Year:	Rebates Received in the 1998 Calendar Year.
Program Description:	Refer to section 2.1 for a detailed description of the program.

7.6.1.3 End Uses and/or Measures Covered

End Use Covered:	Heat Curtains Used in the Agricultural Sector
Measures Covered:	Heat Curtains

7.6.1.4 Methods and Models Use

The PG&E AEEI Program evaluation consisted of an engineering analysis of gross energy impacts. A retroactive waiver had been accepted by CADMAC to allow the evaluation team to replace the net analysis with a market effects study. A default net-to-gross ratio of 0.75 was used in place of the net analysis.

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

Net effect – The default net-to-gross ratio of 0.75 was used.

7.6.1.5 Participant and Comparison Group Definition

Participant - Participants are defined as those PG&E agricultural customers who received PG&E rebates in the 1998 calendar year for installing at least one heat curtain measure under the AEEI Program.

Comparison Group – There was no comparison group used in the engineering analysis. This was allowed by the waiver shown in Section 6.

7.6.1.6 Analysis Sample Size

Gross impact – a census was successfully attained for the participants.

Exhibit 7.5
Sample Summary – Greenhouse Heat Curtain End Use

End Use	Population *	Sample Frame		Final Analysis Sample	
		On-Site	Metering**	On-Site	Metering
Pumping and Related	124	100	100	123	83
Refrigeration	6	6	0	6	0
Greenhouse Heat Curtain	16	16	0	15	0
Total Participant	146	122	100	144	83

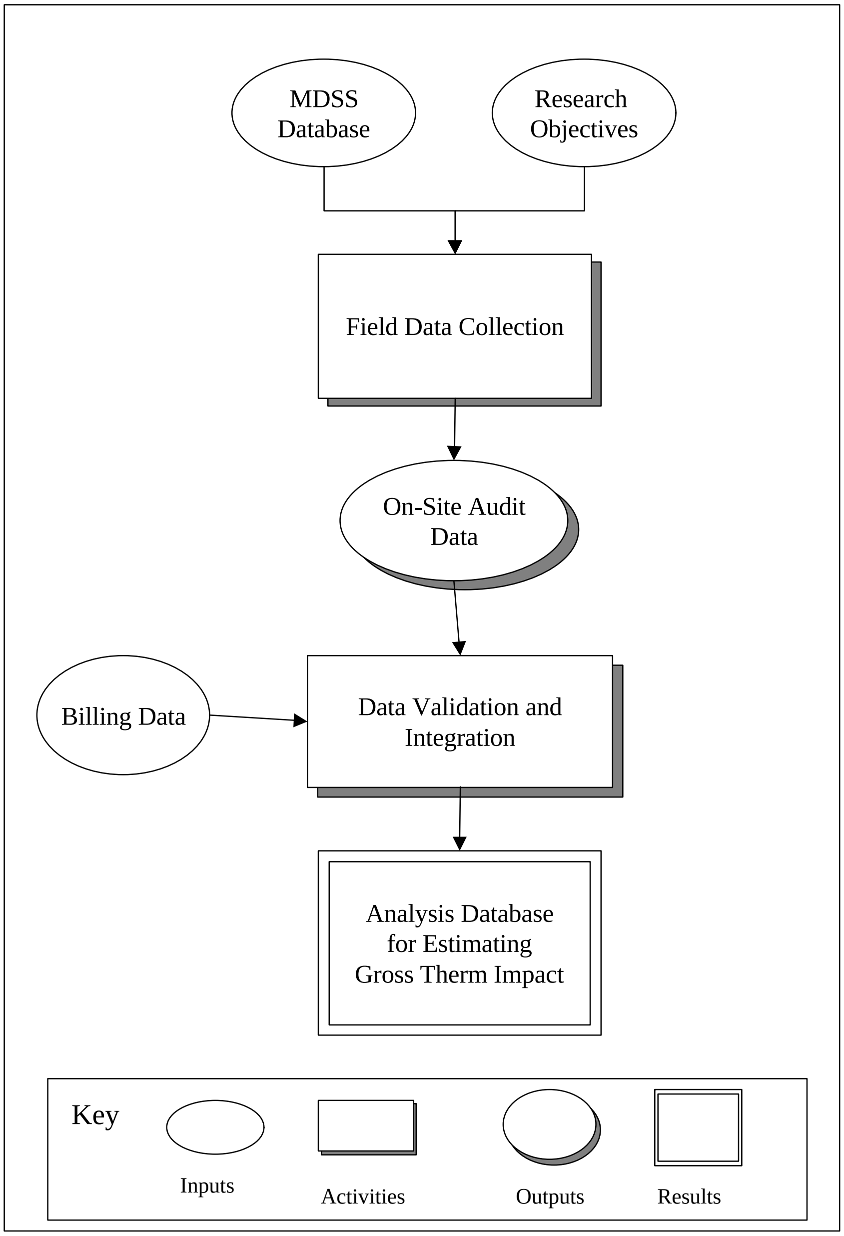
*Participant sample was a census, population refers to number of applications
**The exact number of sites for pump testing (metering) was unknown since micro-irrigation sites often use >1 test per application

7.6.2 Database Management

7.6.2.1 Data Description and Flow Chart

On-site survey data were collected for a census of participants. Sample design was not required since a census is included in the analysis. After the on-site survey of participants, the analysis database was created using the program data, billing data and on-site survey data. Exhibit 7.2 illustrates how each key data element was used to create the final analysis database for the evaluation.

Exhibit 7.6
Final Analysis Database Creation – Greenhouse Heat Curtain End Use



7.6.2.2 Specific Data Sources

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.

On-Site Audit Data - On-site audit data were collected as part of this evaluation for the participant group. The on-site audit was designed to support the engineering analysis by providing key inputs such as number of peaks and square footage.

Other data elements include PG&E program marketing data, program procedural manuals and other industry standard data sources.

7.6.2.3 Data Attrition Process

All data elements mentioned above were first validated and then merged together to form the final analysis dataset. All data points collected during the on-site audits were kept.

7.6.2.4 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 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 survey data collection and data analysis, data quality assurance procedures were in place to insure that all usage data used in analysis and all on-site survey data collected was of high quality.

7.6.2.5 Unused Data Elements

All data collected specifically for the Evaluation were utilized in the analysis.

7.6.3 Sampling

7.6.3.1 Sampling Procedures and Protocols

The limited participant population necessitated an attempted census of participants who were expected to contribute data to the engineering analysis. The number of completed participant surveys as mentioned above in section 1.f., reflects a census.

7.6.3.2 Survey Information

On-site audit instruments are presented in Appendix B.

7.6.3.3 Statistical Descriptions

There were no statistical models used in this analysis.

7.6.4 Data Screening and Analysis

A detailed discussion of the approach used to estimate the engineering impact for the heat curtain measure is described in Appendix A.

7.6.4.1 Outliers and Missing Data

When data was unavailable or was as outlier, all other data from the site and engineering judgement was used to determine the best data point.

7.6.4.2 Background Variables

There were no background variables modeled.

7.6.4.3 Data Screening Process

No data was screened from the engineering analysis.

7.6.4.4 Regression Statistics

There were no regression models used in this evaluation.

7.6.4.5 Model Specification

There were no statistical models used in this evaluation.

7.6.4.6 Measurement Errors

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 included an instrument pre-test and use of a single auditor to collect the information.

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

7.6.4.7 Autocorrelation

This is not applicable to an engineering analysis.

7.6.4.8 Heteroskedasticity

This is not applicable to an engineering analysis.

7.6.4.9 Collinearity

This is not applicable to an engineering analysis.

7.6.4.10 Influential Data Points

This is not applicable to an engineering analysis.

7.6.4.11 Missing Data

When data was unavailable, an estimate based on all other available data for the site and engineering judgement was used.

7.6.4.12 Precision

Since the engineering estimate of gross 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.

7.6.4.13 Engineering Analysis

The waiver allowed a simplified engineering model to be used for the heat curtain end use. The savings seen by the measure were not interactive with any other loads.

7.6.4.14 Comparison Group Not Used for Net Analysis

A waiver allowed the evaluation team to use a default net-to-gross ratio of 0.75.

7.6.5 Data Interpretation and Application

A waiver allowed the evaluation team to use a default net-to-gross ratio of 0.75. This value was applied to all gross impact estimates at the measure level.

This concludes the report on the evaluation of the Pre-1998 Agricultural Sector Programs.

TECHNICAL APPENDICES

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Table of Exhibits

Appendix A Engineering Detailed Computation Methods

A.1 Overview

The pre-1998 agricultural programs evaluation analyzed three end uses – Ag Pumping and Related Measures, Refrigeration, and Greenhouse Heat Curtains. These three end uses represented 92% of the ex ante avoided costs for the pre-1998 Agricultural Energy Efficiency Incentive Program (AEEI). A census of the applications had on-site audits performed to gather information for the engineering analyses, as shown in Exhibit A.1.

Exhibit A.1
On-Site Audits Performed

End Use	PG&E Code *	Measure Description	Number of Applications	Applications Audited	Percent Audited
Ag Pumping and Related	A1	Pump Retrofit	74	74	100%
	A40	Low Pressure Nozzles	1	1	100%
	A45 / A49 / A51 / A55	Sprinkler to Micro	48	47	98%
	A0	Customized	1	1	100%
	Ag Pumping and Related End Use Total		124	123	99%
Refrigeration	R18	High-Capacity Condenser	6	6	100%
	Refrigeration End Use Total		6	6	100%
Greenhouse Heat Curtain Total	A10	Greenhouse Heat Curtain	16	15	94%
Ag Pumping, Refrigeration, and Greenhouse Heat Curtain End Uses			**146**	**144**	99%
AG Miscellaneous End Uses**			**4**	-	0%
AEEI PROGRAM TOTAL			**150**	**144**	96%

*PG&E MDSS Measure Codes
**The miscellaneous end uses are evaluated under Protocol Table C-9. They are not included in this evaluation.

The on-site audits forms are included in Appendix B. The gross impact estimates for each end use are discussed by measure in the following sections.

A.2 Ag Pumping and Related Measures Analysis

A.2.1 Pump Repair

There were 74 applications for this measure, representing 40 unique customers. The analysis of this measure relied on the in-field testing of pumps. In order for pump test results to identify the change in efficiency due to pump repairs, they must (1) be conducted both before and after the repair, and (2) be technically sound tests yielding good data. For example, if a well cannot be sounded for depth or does not have the proper length test section, the test gives poor and misleading results. The evaluation approach minimized evaluation cost yet continued to provide credible impact results for this measure by using the PG&E pump test database to select accounts carefully for post-repair pump tests. Only if the pump repair measure had a PG&E pump test performed before the repair, as determined from the pump test database, program applications, and discussions with the grower, was a post-installation pump test performed during the on-site audit. Analysis of the pump test database identified 52 pump tests that met those criteria. A census of these 52 pumps was attempted with 32 completed test and 26 of those 32 completed as good tests. For other pump repair sites, only retention and use information was collected.

The algorithm shown in Exhibit A.2 was used to determine the energy impacts for pump repairs.

Exhibit A.2
Pump Repair Energy Impact Algorithm

$$\text{Impact} = \sum_{i=1}^{74} \text{kWh}_{99,i} * \left(1 - \frac{\text{OPE}_{\text{pre}}}{\text{OPE}_{\text{post}}}\right)_i$$

Essentially, there were two pieces of information required to apply the impact algorithm to each pump repaired. First, the 1998-99 kWh for the site must be known for only the specific pump repaired. Second, the pump type and horsepower must be known to properly apply the second half of the algorithm – the OPE ratio.

On-site audits provided the information used to allocate the billing data usage. Pump account number data were collected to be able to pull the 1998-99 billing data. However, even with this information, there were twelve accounts with missing kWh data. For these pumps, the 1997 data was located and used to determine the impact.

The horsepower of the other pumps on the meter and the percentage of time these pumps operated were also gathered during the on-site audits. Assuming the pumps were fully loaded when on, the percentage of the kWh used by the repaired pump was calculated. The audit also provided the horsepower and pump type for correct application of the OPE ratio.

The evaluation team collected good post-repair OPE values from 26 pumps. These pumps had pre-repair OPE values already recorded in the PG&E pump test database. To increase the number of actual pre- and post-OPE paired values to be used in the average for those pumps without pump test data, the 1998 PG&E pump test database was analyzed to identify pumps with pre- and post-pump repair results. Since there is a difference in the paired pre-to-post efficiency possible based on technology (e.g., turbine, centrifugal, or axial flow pump), these data were analyzed by pump type. Previous work of this type on the 1992-1997 PG&E pump test databases was also used to determine the average OPE ratios. The results are shown in Exhibit A.3.

Exhibit A.3
Ex Post OPE Values

Data Source	N of Data	Pump Type	hp Bin*	Pre-OPE	Post-OPE	OPE Ratio
Evaluation of Pre-1998 Pumps	14	Axial/Propeller	All	0.44	0.54	0.18
Review of 1998 PG&E Pump Test Database	2			0.60	0.70	0.15
Review of 1992-1997 PG&E Pump Test Databas	18			0.45	0.52	0.13
Weighted Average OPE for Axial/Propeller Pumps				**0.46**	**0.54**	**0.15**
Evaluation of Pre-1998 Pumps	0	Centrifugal, Booster	All	-	-	-
Review of 1998 PG&E Pump Test Database	4			0.56	0.54	-0.02
Review of 1992-1997 PG&E Pump Test Databas	1			0.69	0.74	0.06
Weighted Average OPE for Centrifugal Booster Pumps				**0.58**	**0.58**	**0.00**
Evaluation of Pre-1998 Pumps	1	Submersible	All	0.66	0.67	0.02
Review of 1998 PG&E Pump Test Database	0			0.00	0.00	0.00
Review of 1992-1997 PG&E Pump Test Databas	17			0.43	0.53	0.19
Weighted Average OPE for Submersible Pumps				**0.44**	**0.54**	**0.18**
Evaluation of Pre-1998 Pumps	5	Turbine, Well	1	0.40	0.55	0.25
Review of 1998 PG&E Pump Test Database	19			0.54	0.64	0.16
Review of 1992-1997 PG&E Pump Test Databas	162			0.52	0.60	0.13
Weighted Average OPE for Deep Well Turbine Pumps from 20-75 hp				**0.52**	**0.61**	**0.14**
Evaluation of Pre-1998 Pumps	6	Turbine, Well	2	0.59	0.67	0.12
Review of 1998 PG&E Pump Test Database	16			0.60	0.68	0.13
Review of 1992-1997 PG&E Pump Test Databas	48			0.53	0.63	0.16
Weighted Average OPE for Deep Well Turbine Pumps from Over 75 hp				**0.55**	**0.64**	**0.15**

*1=20-75 hp, 2=Over 75 hp

There was sufficient data to apply the results by pump type, with the exception of centrifugal pumps. The average turbine pre- and post-efficiency for motors under 75 hp were applied to centrifugal pumps.

For the 26 pumps with known pre- and post-OPE values, the pump-specific pre- and post-repair OPE values were used to determine the impact. There were 6 pumps with zero impact. The reasons for these pumps being set to a zero impact are shown in Exhibit A.4. All other pumps (41) used the weighted average OPE ratio shown in Exhibit A.3, based on the pump type and hp.

Exhibit A.4
Reasons for 6 Pumps with Zero Impact

Pump Audit Number	Reason Why Zero Impact
107	Unit changed from electric to diesel in 8/99
159	The customer was paid for a retrofit, but installed a new pump of higher horsepower.
164	Electric power had not been restored since flooding in 6/98
174	This site had the motor 30 feet away from the piping and a plate welded over the pipe.
176	This well had been abandoned in late 1998 and had no motor.
183	The well was caved in.

There was one site that changed over to a natural gas pump. This site was given therm impact credit by using the previous year kWh value and an average OPE for the pump type and size and converting the kWh impact to therm. It is acknowledged that the efficiency of a natural gas pump is different than an electric motor (with the natural gas motor having a lower efficiency). However, it was felt that the estimate of savings would be conservative by using the efficiency of the electric motor while the savings from the re-bowling of the pumping system would be sustained with the change in fuel.

The demand impact was analyzed by using the horsepower input from pre/post repair tests. The difference in horsepower input pre- and post-repair for 32 pumps were analyzed using the 1998 PG&E database information to determine if there were demand impacts. On average, there was an increase of 1.7 horsepower (hp) due to the pump repair pre/post matches. However, the standard deviation around that value was large and included zero. The pre- and post-repair hp values were further analyzed using a single-tailed t-test. At the 90% confidence level, there were no significant difference between the pre- and post-repair hp (t=-0.151). Because of the results of the t-test, the demand impacts were set to zero for all the pump repair measures. This is consistent with the 1996 and 1997 PG&E agricultural sector evaluation findings. The gross impacts for pump repair measures are shown in Exhibit A.5.

Exhibit A.5
Pump Repair Gross Impacts

	Ex Ante	Ex Post	Gross Realization Rate
Energy (kWh)	1,917,729	1,504,790	0.78
Demand (kW)	522	0	0
Therm	0	1,974	NA

A.2.1.1 Reasons for Realization Rate Discrepancies

The ex post impacts were determined using the algorithm shown in Exhibit A.2 and one year of data from the 1998-99 billing data. If the site had both a pre- and post-repair OPE value, it was used to determine the OPE ratio. If not, an average OPE ratio was applied based on pump type and horsepower. The total ex ante kWh billed from the MDSS was 14,979,213 kWh. This value represents the pre-repair pump usage for only the repaired pumps. Once the 1998-99 kWh data were analyzed to obtain the post-repair pump usage for the repaired pumps, it totaled 13,396,201. While there are many factors that can account for this decrease in usage (i.e., wetter season, different crops, etc.), this is a 10.5% reduction in usage. This is less than expected from the ex ante estimate of 21% reduction in usage for pumps with horsepower of 75 or less and a 10.6% reduction for pumps over 75 horsepower.

The ex ante analysis used two horsepower bins to determine OPE and did not distinguish between pump types. For comparison purposes only, Exhibit A.6 compares the OPE values used for the ex ante and the ex post cases in the bins used in the ex ante estimates. These are not the bins used in the ex post analysis; however, Exhibit A.6 does demonstrate that the ex post OPE values are lower for the Bin 1 pumps than the ex ante OPE estimates. The OPE ratio differences were the reason for the ex post energy impacts being lower than the ex ante estimate of impacts for those pumps 75 and under in horsepower.

For the pumps over 75 hp, the ex post OPE ratio was actually larger, on average, than what was used in the ex ante impact. However, the kWh value to which the OPE ratio was applied was different between the ex ante and ex post analysis. The ex ante annual kWh usage was substantially higher than what was used for the ex post analysis annual usage. Since the on-site audits gathered the data to apportion the meter usage to the pump retrofitted, the ex post percentages were used to apportion the meter usage. This was considered appropriate for the evaluation.

Exhibit A.6
Ex Ante and Ex Post OPE Ratios

	Bin 1 (20-75 hp)	Bin 2 (Over 75 hp)
Ex Ante	0.210	0.106
Ex Post	0.176	0.126
N of Ex Post	31	43

A.2.2 Low-Pressure Sprinkler Nozzles

There was only one site rebated for this measure. The planned approach for analysis of this site looked at two types of data, whether the site had actually decreased the kWh/acre and pump test data. The grower had increased the acreage irrigated with the sprinklers and, therefore, was considered to have decreased the kWh/acre required to water his land. The pump test at this site provided good data and was used in the analysis.

The low-pressure sprinkler nozzle measure used an approach similar to the ex ante estimates, but with measured data from pump tests. The algorithms used for the demand impacts are shown in Exhibit A.7.

Exhibit A.7
Low-Pressure Sprinkler Nozzles Demand Impact Algorithms

(1) Delta hp = (GPM $_{\text{from pump test}}$) * delta TDH / (3960 GPM-Ft/hp* current OPE)
where GPM = gallons per minute
TDH = total dynamic head
OPE = operating plant efficiency

(2) Delta hp / acre = (1) above / acres irrigated

(3) Nozzles / acre = nozzles found at site / acres irrigated

(4) Delta kW / nozzle = (2) above * 0.746 kW/hp / (3)

(5) Peak kW / nozzle impact = (4) above * Coincident Diversity Factor of 0.78[1]

Certain assumptions were made during the low-pressure sprinkler nozzle analysis. It was assumed that the OPE of the old and new systems was the same since there was no change in the pumping system. It was assumed that the irrigation efficiency (IE) of the old system and the new system was the same. Therefore, there was no assumed difference between the acre-feet (AF) of water pumped in 1998-99 and what would have been pumped with the old high-pressure sprinkler system. These assumptions result in conservative estimates. The nozzle pressure (shown as “P_N” in Exhibit A.8) in pounds per square inch (psi) for the pre- and post-nozzles was based on grower self-report. The

[1] Appendix A of “Impact Evaluation of Pacific Gas & Electric Company’s 1995 Agricultural Energy Efficiency Incentive Programs: Pumping and Related End-use, Indoor Lighting End-use. PG&E Study ID Numbers: 329: Pumping and Related End-use. 331: Indoor Lighting End-use”, Dated March 1, 1997.

algorithms used to determine site-specific energy impact for the low-pressure sprinkler system is shown in Exhibit A.8.

Exhibit A.8
Low-Pressure Sprinkler Nozzle Energy Impact Algorithms

(1) Post-total dynamic head (TDH) from nozzles = $P_{N,post}$ (psi) * 2.31 ft/psi

(2) Post-TDH other than nozzles = Actual TDH from pump test – (1) above

(3) Pre-TDH = $P_{N,pre}$ (psi) * 2.31 ft/psi + (2) above

(4) AF = 1999 kWh / $(kWh/AF)_{from\ pump\ test}$

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

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

(7) kWh Impact = kWh 1999 – (6) above

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

The results of the low-pressure sprinkler analysis are shown in Exhibit A.9.

Exhibit A.9
Low-Pressure Sprinkler Nozzle Ex Post Impacts

		Ex Ante Impact		Ex Post Impact		Realization Rate	
Audit	Impact Decision	kWh	kW	kWh	kW	kWh	kW
196	Use pump test data for analysis	19,140	9.5	3,554	9.6	0.19	1.01
	Total	19,140	9.5	3,554	9.6	0.19	1.01

A.2.2.1 Reasons for Realization Rate Discrepancies

The evaluation team audited the one site rebated. The energy impact for this site was below the ex ante estimate and about even with the ex ante estimate of demand impact. This pump was used for both a low-pressure sprinkler system as well as for a micro-irrigation system. Since it was unknown how much time the pump was used for each irrigation system, the billing data for this site had to be apportioned in a reasonable way for the analysis. It was estimated that the low-pressure system used 40% of the energy from this pump based on the type and acreage of crops on both systems. Another check was performed to determine if this created an overly low or high estimate of usage. This check used the pump test data to calculate the acre-feet (AF) of water applied from the pump in the year. It was determined, after consultation with the Team's agricultural specialist, that the net AF of water was reasonable. Therefore, the ex post energy estimate of saving, while substantially less than the ex ante estimate of savings, was considered to be appropriate.

Since this is only one site, and the ex ante estimate of energy savings is based on averages across multiple crop types, it is not reasonable to expect that the ex post and ex ante energy impacts would necessarily be similar. However, the demand impacts are similar. Both the ex ante and ex post impacts are based on a reduction in head pressure due to the new irrigation system. This was similar in both cases (and slightly higher in the ex post case), leading to a gross demand realization rate of 1.01.

The lower energy impact can be accounted by two factors: (1) the amount of water pumped and (2) the number of nozzles installed. Since the evaluation had no information on the amount of water actually pumped at this site, it is not possible to compare the water usage at this particular site to the ex ante estimate. However, there is information on the number of nozzles installed. This site installed a high density 31.6 nozzles per acre. The system was a hand movable portable system, but was installed such that the system covered the entire acreage (i.e., was not moved). The ex ante estimates have two versions of the hand movable portable systems that assumes that the nozzles are moved (a high density one with 21 nozzles per acre and a low density one with 4 nozzles per acre). Since the one site assessed had at least 50% more nozzles per acre, this explains a large part of the lower ex post energy impact per nozzle. This same argument does not apply to the demand impact because the demand impact is based on the pressure difference pre/post.

A.2.3 Advanced Performance Options

The custom site was audited and the current set-up of the filtration system for the micro-irrigation system was determined. While there were differences between the ex ante and ex post set-up, they were in favor of the ex ante analysis (i.e., a pump was removed at the site versus just being locked out). Based on these findings, the ex ante estimate of savings was used for the ex post finding of savings.

A.2.4 Micro-irrigation Conversion

The participants for this measure represented 48 applications and 14 unique customers. As shown in Exhibit A.1, the evaluation team was able to perform audits for 47 applications.

For the demand impacts, the micro-irrigation conversion measure used an approach similar to the ex ante estimates, only with pump test data. The on-site audits determined whether the system ran during peak periods. A coincident diversity factor (CDF) was applied on a site-specific basis. If the site ran 24 hours per day during watering sets, the CDF was set to one. If it was determined that there was a peak period lock out on the metering box or the irrigation sets were for 12 hours or less and did not include the peak hour, the CDF was set to zero. The average CDF for the 48 applications was 0.87. The demand algorithm is shown in Exhibit A.10.

Exhibit A.10
Site-specific Micro-irrigation Demand Impact Algorithm

(1) kW Impact = $GPM_{\text{from pump test}}$ / 3960 GPM ft/hp * [(Pre TDH/Pre OPE) – (Post TDH/post OPE)] * 0.746 kW/hp * CDF

(2) kW Impact / acre = (1) above / acres converted

Micro-irrigation system conversion rebates were paid when a customer converted from a sprinkler irrigation system (either high-pressure or low-pressure) to a micro-irrigation system. There was one site that converted from a flood irrigation system. The demand

and energy impacts at this site were set to zero. Additionally, there was one site that moved from electric to diesel booster. This site was also set to zero impact. There was one site that moved from an electric to a natural gas pump. Although no pump test was performed at this site, the average kWh/acre impact was used to determine potential impact and the kWh was converted to therm savings. There was no demand impact at this site.

In general, the pumping systems were renovated to allow the micro-irrigation to function properly. The impact of the retrofit both decreased the AF of water applied and changed the pumping system. The estimated pre- and post-pressures were based on grower self-reports.

Questions were asked in the field regarding the previous irrigation system type. The irrigation efficiency value used to determine the AF/year that would have been applied without the micro-irrigation system was determined from two sources: (1) previous Ag evaluation data (irrigation efficiency results for sprinkler systems) and (2) an estimate of the current systems' irrigation efficiency as determined by the experts in the field. Taking these two sources into account, the analysis used an irrigation efficiency of 66% for the pre-retrofit irrigation systems while the post-retrofit systems varied between 75% and 80%.

The on-site auditors also questioned the growers about the flow rate of the water pumped (in GPM) of the system before the retrofit. In all but a few cases, the grower did not know this value. While it is acknowledged that there most likely was a difference in the GPM between the two systems, this could not be found in the field and the post water flow rate was used in the analysis (a conservative approach).

When a pump was replaced with a different type, the pre-OPE assigned to the pump was based on the previous pump type. For example, 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 database was applied for the pre-retrofit OPE. If there was no change in the pump, the pre- and post-retrofit OPE were set to be identical. The site-specific energy impact algorithms are shown in Exhibit A.11.

Exhibit A.11
Site-Specific Micro-irrigation Energy Impact Algorithm

(1) Post-total dynamic head (TDH) from system = $P_{MI,post}$ (psi) * 2.31 ft/psi

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

(3) Pre-TDH = $P_{MI,pre}$ (psi) * 2.31 ft/psi + (2) above

(4) AF_{post} = 1998-99 kWh / (kWh/AF) $_{\text{from pump test}}$

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

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

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

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

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

In some cases, the system obtained irrigation water from more than one pump. Information was gathered during the on-sites to determine the total acres covered by the micro-irrigation system and the pumps/accounts that fed that system. The total kWh from all the pumps were used in algorithm (4) above.

There were multiple sites that installed micro-irrigation systems that also planted new deciduous orchards at the same time (i.e., almonds or pistachios). These sites were found to use substantially less AF/acre of water than what is used for a mature orchard. Based on how the analysis is performed, the first year of billing data does not reflect the impact that can be expected from these crops during subsequent years. Therefore, for the 17 applications with new deciduous crops (as determined from the on-site audit), the kWh impact was adjusted.

The new crops rebated were either almonds or pistachios. A real world way that growers save water during the first years is to turn a micro-sprinkler up-side-down during the first year or two to create a smaller area of watering and use less water than expected for a mature crop. Additionally, applied water is much less for new plantings due to irrigation scheduling. If the micro-irrigation system is comprised of emitters which can be placed within the tubing, the new crops often have less emitters in place than the mature crops. Because of this often used practice, adjustments were applied to the 17 applications with known new orchards. It was assumed that the analysis values for the AF/Ac of water applied after this adjustment were reasonable based on the number of applications and the variety of interactions that can occur at these sites.

The adjustments were made based on UC Cooperative Extension documents that had the estimated AF/acre of water used per year for almonds or pistachios. The crop year was determined from the calculated AF/acre value using this years pump test data. The subsequent *impact* years were increased by a percentage specific to that crop for that crop year (shown in Exhibit A.12 and Exhibit A.13). For example, almonds tend to have 50% more water applied the second year of the crop over the first year and an additional 33% more water the third year over the second year. The AF / acre/ year of water usage as determined from the evaluation pump test was used to decide what year was the crop year. For example, if the almonds showed 1.8 AF / acre year, then the crop year was number two. Subsequent increases in water were based on the starting point of the crop.

The analysis used the following data to determine the percentage increase between crop years for pistachios and almonds

Exhibit A.12
Increase in Water Usage for Pistachios

Crop Year	AF / acre /year	Increase over the previous year of water
1	0.2	-
2	0.9	350%
3	1.6	78%
4	1.6	0%
5	2.3	44%
6	2.3	0%
7+	3.7	61%

UC Cooperating Extension Publication PI-SJ-96.

Exhibit A.13
Increase in Water Usage for Almonds

Crop Year	AF / acre /year	Increase over the previous year of water
1	0.83	-
2	1.67	100%
3	2.50	50%
4+	3.33	33%

UC Cooperating Extension Publication AM-VN-99-2.

An average weighted kWh impact was calculated based on a 20 year effective useful life and was used as the ex post energy impact for these 17 sites. It was assumed that the crops would use the same amount of water as a mature orchard in the four year and beyond for almonds and the seventh year and beyond for pistachios.

For the other 31 applications, the estimate of energy impact used the algorithms in Exhibit A.11.

The results are shown in Exhibit A.14.

A perusal of the acres paid and irrigated shows that the paid acres and what was found during the on-site audit did not always match up. However, since the acres irrigated by a specific pump were found during the on-site audits, those acres were used in the analysis.

Exhibit A.14
Micro Irrigation Conversion Ex Post Impacts

		Ex Ante Estimates			Ex Post Impacts					Gross Realization Rate	
Audit Num	P Measure Code	Paid Acres	kWh	kW	Acres Irrigated	kWh	kW	Coincident kW	Therm	kWh	Coin. kW
101	A55	204	84,743	40	204	84,972	74	0		1.00	0
105	A45	8	6,510	3	8	2,832	2	2		0.44	0.84
106	A45	50	43,088	19	150	123,672	29	29		2.87	1.53
115	A49	80	65,520	30	180	16,606	5	5		0.25	0.18
116	A55	148	61,379	29	148	0	0	0		0	0
117	A55	742	307,835	147	750	0	0	0	10,284	0	0
121	A45	35	30,380	13	35	13,218	11	0		0.44	0
122	A51	900	596,700	236	900	1,023,736	373	373		1.72	1.58
123	A49	280	229,320	106	198	182,271	93	93		0.79	0.88
124	A49	320	262,080	122	305	296,103	145	145		1.13	1.19
125	A49	320	262,080	122	308	308,528	161	161		1.18	1.33
126	A49	400	327,600	152	341	78,463	158	158		0.24	1.04
127	A49	320	262,080	122	256	262,831	125	125		1.00	1.03
128	A49	160	131,040	61	184	100,540	72	72		0.77	1.18
129	A49	340	278,460	129	305	302,489	164	164		1.09	1.27
130	A49	240	196,560	91	232	232,742	63	63		1.18	0.69
131	A49	300	245,700	114	324	273,979	149	149		1.12	1.31
133	A49	284	232,596	108	227	191,954	62	62		0.83	0.57
134	A49	322	263,718	122	306	340,657	60	60		1.29	0.49
135	A49	322	263,718	122	306	173,442	73	73		0.66	0.59
136	A49	480	393,120	182	607	479,341	166	166		1.22	0.91
137	A49	235	192,465	89	375	32,709	110	110		0.17	1.23
141	A51	233	154,612	61	234	150,931	49	49		0.98	0.81
142	A51	82	54,300	21	79	93,160	34	34		1.72	1.58
143	A51	122	80,555	32	117	116,678	72	72		1.45	2.26
144	A51	165	109,395	43	159	134,061	77	77		1.23	1.77
147	A49	300	245,700	114	249	213,846	101	101		0.87	0.88
148	A49	320	262,080	122	304	332,381	166	166		1.27	1.36
149	A49	317	259,623	120	304	259,990	119	119		1.00	0.99
150	A51	147	97,461	39	158	0	0	0		0	0
166	A45	35	30,380	13	33	12,463	10	0		0.41	0
187	A49	706	578,542	268	650	720,710	184	184		1.25	0.69
195	A51	41	27,183	11	52	150,836	24	24		5.55	2.24
196	A45	57	49,042	21	57	18,420	25	0		0.38	0
197	A49	165	135,135	63	265	23,115	79	0		0.17	0
Total		***9,179***	***6,820,697***	***3,089***	***9,309***	***6,747,678***	***3,036***	***2,836***	***10,284***	***0.99***	***0.92***

New Crop Sites (shaded audit numbers: 106, 123, 124, 125, 127, 128, 129, 130, 131, 133, 134, 135, 136, 147, 148, 149, 187)

A.2.4.1 Reasons for Realization Rate Discrepancies

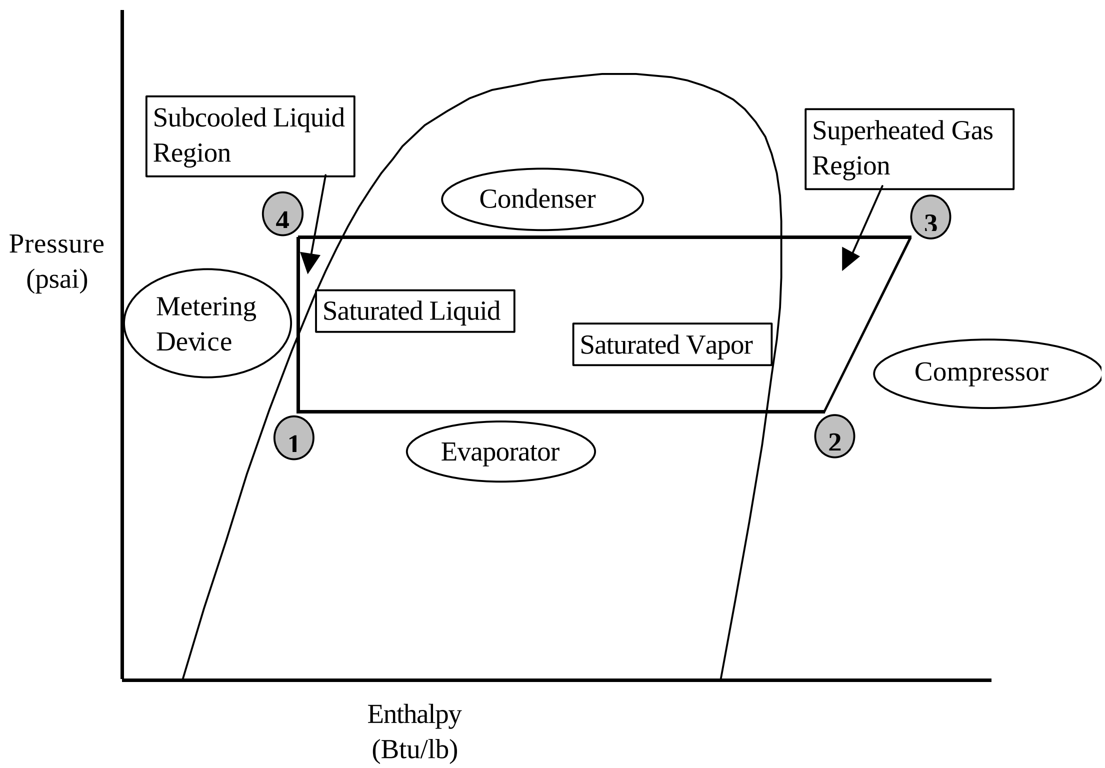
The forty-eight sites with micro-irrigation conversion rebates showed only slightly lower ex post energy impacts than predicted by the ex ante estimates. As such, the difference in energy will not be discussed. However, it was not possible to collect good pump test data for all sites. There were twelve sites to which the average of the other ex post analyses results of kWh/acre and kW/acre impacts were assigned. These impacts were assigned based on a grouping of type of system as determined from the application hardcopy (i.e., drip versus micro-sprinkler and measure type).

The ex ante assumed a pressure difference of 36 psi between the pre- and post-retrofit systems, while the actual average ex post pressure difference found for the sites inspected was 32 psi. The ex post demand impact was only slightly lower than the ex ante since the pressure differences were very close to each other and both the ex ante and ex post used these values to determine impacts.

A.3 Refrigeration Analysis

There were six applications (representing six unique customers) and only one type of measure in the refrigeration end use – oversized condensers in ammonia systems. To understand how this measure was analyzed, a short explanation of a typical refrigeration process is presented. Within a standard refrigeration system there are four distinct pieces of equipment: a condenser, a metering device, an evaporator, and a compressor. Exhibit A.15 shows a typical pressure-enthalpy (enthalpy is the heat content of a refrigerant) diagram for a refrigeration system. Each piece of equipment is shown on this diagram based upon where it is used in the refrigeration cycle. The refrigerant goes through four stages, as represented by the four numbers in circles in the diagram. Each stage will be briefly discussed.

Exhibit A.15
Pressure-Enthalpy Diagram



At point 1, the refrigerant is a mixture of liquid and gas. As the refrigerant moves through the evaporator, it maintains the same pressure and absorbs heat from the space being cooled. The heat causes the liquid portion to boil and become a gas. The curved line on the right side of the diagram represents the point where the liquid phase ceases to exist and the vapor becomes fully saturated. After the refrigerant gets hotter than the saturated vapor state, it is a superheated vapor. Moving from point 1 to point 2, the enthalpy is steadily increasing, as shown in the diagram.

At point 2, the refrigerant is now a superheated gas as it enters the compressor. The compressor increases the pressure of the gas and adds some heat due to the compression (heat of compression). The impacts from the installed measure are realized at the compressor as the oversized condenser decreases the pressure to which the compressor must raise the refrigerant. (i.e., the refrigerant moves from point 2 to a lower point 3 than with the pre-retrofit condenser).

From point 3, the refrigerant goes through the condenser. In the condenser, it steadily gives up heat to the atmosphere and condenses from a gas to a liquid. The condenser generally continues to cool refrigerant past the point where all of the gas becomes a liquid (the saturated liquid line). The refrigerant is now a sub-cooled liquid at point 4.

The refrigerant then moves through a metering device (often referred to as an expansion valve) from point 4 back to point 1. This device decreases the pressure, but keeps the same amount of heat (enthalpy) within the refrigerant. The refrigeration cycle is complete.

This short rendition of a refrigeration cycle does not take into account the real-world losses associated with any type of refrigeration cycle. It assumes perfect (isentropic) compression and perfectly functioning pieces of equipment. These assumptions were used in the analysis.

Because of the variations in ability of the site manager to provide the needed information, the analysis could not be conducted as projected in the research plan for all sites. As a result, a slightly different methodology was used to determine the kW impact. All site managers were able to provide pre- and post-retrofit discharge and suction temperatures for their refrigeration system. These values were used to determine the hp/ton and then the tons of refrigeration (as a percentage of total capacity) were used to calculate the horsepower required for that period of time. The kW impact for this measure was determined as shown in Exhibit A.16.

Exhibit A.16
Refrigeration Demand Impact Algorithm

$$kW_{tp} = \frac{hp/ton_{tp} * \text{Tons of Refrigeration}_{tp} * \text{Conversion from hp to kW}}{\text{Efficiency of Motor}}$$

$$kW_{tp} = \frac{\frac{hp}{ton}_{tp} * Tons_{tp} * \frac{0.746\ kW}{hp}}{h}$$

where:

hp/ton = value at provided saturated suction and discharge pressures

tp = time period as provided by site manager

n = efficiency of reciprocating compressor motor (0.91)

The input, tons of refrigeration, was determined in by asking the manager the total refrigeration capacity of the system. All site managers except one knew this total capacity and what percentage of the total capacity was used on average during different time periods. For the one site without the ability to recall the total capacity, a rough calculation of one horsepower per ton of refrigeration was used. The table *Figure B-8, High Stage Isentropic Power Per Ton in Appendix B, Ammonia Refrigeration Application Data,* *Ammonia Data Book, December, 1992* provided the hp per ton based upon the saturated discharge and suction temperatures. The last input to determine for the kW level was motor efficiency. The motors used for the compressors have an efficiency that can vary from 0.75 to 0.98, depending on the size and age of the motor. Reciprocating compressors tend to be 100 hp or smaller. Screw compressors are larger, with motors up to 700 hp. The efficiency of the motors was divided into reciprocating compressor motors (125 hp and under) and screw compressor motors (over 125 hp). Standard efficiencies were averaged for these motors from data within MotorMaster+[2]. The efficiencies used were 0.91 for reciprocating motors and 0.95 for screw motors. In this analysis, there were no screw compressors and only the value of 0.91 was used.

The kW reduction for a specific refrigeration load (as a percent of total capacity) was determined and the hours of operation were applied to determine the kWh impacts for that time period, as shown in Exhibit A.17. The hours of operation were gathered on site from the plant manager.

Exhibit A.17
Refrigeration Energy Impact Algorithm

$$\text{kWh savings} = \sum_{tp=1}^{n} \text{kW impact}_{tp} * \text{Hours of operation}_{tp}$$

Once the kWh impacts were determined, a check of reasonableness was applied by using the 1998-99 kWh data. The impacts as a percentage of the total account kWh were calculated and analyzed. The results are shown in Exhibit A.18. The impact varied from 5% to 22.2% of the 1998-99 kWh. The notes section indicates the reasoning of the evaluation team.

Exhibit A.18
Impact as Percentage of 1998-99 kWh Results

AUDITID	Ex post Billing kWh	Ex Post kWh Iimpact	Ex Post Impact as Percent of 1998-99 kWh	Notes
401	2,346,300	165,022	7.0%	Measure probably added load since more compressors running post. This percentage does not appear too low.
402	5,976,000	297,440	5.0%	There seems to be other loads on this meter other than this refrigeration system. This accounts for the low percentage
403	1,788,320	340,517	19.0%	Assume this is a reasonable percentage.
404	4,123,200	914,311	22.2%	This site runs at a high capacity for long hours. Would expect condenser to make a large difference here.
405	830,400	65,607	7.9%	It's possible that the analysis is a little low, but the project manager at the site could provide no better information.
406	735,600	125,138	17.0%	Assume this is a reasonable percentage.

[2] MotorMaster+, Version 1.0. Washington State Energy Office, Department of Energy, United States of America, 1996.

The results of the kW and kWh analyses for the refrigeration end use are shown in Exhibit A.19.

Exhibit A.19
Refrigeration Ex Post Impacts

	Ex-Ante		Ex-Post		Gross Realization Rate	
Audit ID	kWh	kW	kWh	kW	kWh	kW
401	743,904	132.8	165,022	37.7	0.22	0.28
402	365,736	65.3	297,440	46.2	0.81	0.71
403	442,882	79.1	340,517	54.7	0.77	0.69
404	551,936	98.6	914,311	191.2	1.66	1.94
405	226,800	40.5	65,607	14.8	0.29	0.37
406	133,930	23.9	125,138	28.5	0.93	1.19
Total	2,465,187	440.2	1,908,036	373.1	0.77	0.85

A.3.1 Reasons for Realization Rate Discrepancies

The ex post energy and demand impacts for oversized condensers were lower than the ex ante estimates. The ex post analysis found a lower value for the compressor total heat rejected (THR), based on how the site was using the refrigeration system. The ex ante average value was 1,263 tons THR, while the ex post average finding was 457 tons THR. The ex post estimated full load operating hours were higher (4,094 ex post versus 3,030 ex ante), which offset some of the lower THR in the ex post analysis. Additionally, the ex post analysis had a slightly lower condensing temperature difference pre-to-post than the ex ante (10.7 ex post versus 13.8 ex ante), leading to smaller impacts.

The differences were not surprising since the evaluation used the actual average operating pressures found at each site and the percentage of capacity at different times to determine the tons of refrigeration used (and therefore, the heat rejected). By comparison, the ex ante estimate used the tons of heat rejection between the pre- and post-retrofit estimate at design temperatures. These findings contribute to the explanation of why the ex post demand impacts are less than the ex ante estimates.

A.4 Greenhouse Heat Curtain Analysis

There were sixteen applications for greenhouse heat curtains paid in 1998. The applications represent ten different customers. All but one greenhouse sites were audited for this evaluation (one customer refused the audit), and two applications were covered under one audit for a total of fifteen different audits.

A.4.1 Overview

The greenhouses were constructed of many different materials, from glass to fiber-reinforced polyester to polyethylene film. The majority of the sites were multi-span buildings with many peaks. The heat curtains were installed to reduce the therm usage of natural gas heaters or boilers by minimizing the heated area and decreasing heat loss from the greenhouses at night. However, while nighttime heating savings were planned, the heat curtains were also used during the day to control day length, shade crops, and reduce daytime temperatures within the greenhouse.

The curtains were thin, movable, and attached to the greenhouse using various mechanisms. Research indicated that, in many areas of the U.S., 80% of the energy for heating of single-glazed structures is required at night.[3] Therefore, insulation that can allow for daytime sunlight and reduce nighttime heat loss should be moveable. The heat curtain measure, as implemented by PG&E, required the inclusion of tracks and a motor to deploy the heat curtain. All heat curtains met this requirement.

The heat curtains were most often placed at a slight upward angle into the middle of the peak from the join between the roof and wall. When closed, the curtain created a "new" ceiling which was lower. Occasionally, the site installed the heat curtain to create a "new" ceiling that took out the entire peak area (i.e., the curtain went from the top of one wall to the top of the opposite wall). One site installed a double layer of heat curtain that did both.

While the curtains were sometimes deployed during the day, most of the actual therm energy impacts occurred at night. The impacts were dependent on the construction of the building, the infiltration of cold air into the greenhouse, how the heat curtain was installed, and the efficiency of the natural gas heater. Based on previous experience, the determination of the efficiency of heaters in greenhouses can be quite difficult. Therefore, for this evaluation, the efficiency was set at 70% for either individual heaters in the greenhouses or a central boiler. This efficiency is lower than the minimum efficiency (75% for central steam boiler and 74% for unit heaters) set by the California Energy Commission (CEC) and accounts for the age of the units and piping losses. The actual temperatures required in the greenhouses were dependent on the crop. The average temperature difference was based on values that were at least three degrees different between the thermostat setpoint and the hourly outdoor temperature (from the CEC typical meteorological year data for that climate zone). These values were used only if the heat curtain was closed. The impacts for heat curtains were determined using the algorithms shown in Exhibit A.20 and Exhibit A.21.

Exhibit A.20
Heat Curtain Impact Algorithm

$$\Delta Therms = \frac{\Delta Q_t * AnnualHrs * C1}{h}$$

Where:

ΔQ_t	=	Change in heat loss, Btu/hr
Annual Hrs	=	Annual Hours in Use, hr
C1	=	Conversion for Therms, 1 therm/100,000 Btu
η	=	Efficiency of heater, unitless

The change in the heat loss of the greenhouses due to the addition of the heat curtain (Q_t) was determined by both the heat loss due to conduction (heat migrating through the materials from the higher temperature inside to the lower temperature outside) and the

[3] Energy Conservation for Commercial Greenhouses, Northeast Regional Agricultural Engineering Service, NRAES-3, July, 1989.

heat loss due to infiltration (heat loss through open areas in the construction). These two heat losses were determined as shown below in Exhibit A.21.

Exhibit A.21
Heat Loss Algorithm

$$\Delta Qt = \left[\left(\sum_{i=1}^{n} U_i * A_i\right) + c_p * Vol * ACH\right]_{pre} * \Delta T - \left[\left(\sum_{i=1}^{n} U_i * A_i\right) + c_p * Vol * ACH\right]_{post} * \Delta T$$

Where:

U_i	=	Heat transfer coefficient of each material *i*, Btu/hr-ft^2-°F
A_i	=	Area of each material *i*, ft^2
ΔT	=	Average inside to outside temperature difference, °F
c_p	=	volumetric specific heat of air, 0.018 Btu/ ft^3-°F
Vol	=	Volume of the greenhouse, ft^3
ACH	=	Air changes per hour, changes/hr

The impacts determined were site specific and, in some cases, greenhouse specific. Each element within the algorithms used to determine impacts is covered in detail in the next section.

A.4.2 Details

A.4.2.1 Heat Loss Algorithm

The details of the heat loss algorithm (Exhibit A.21) are presented first. There were fifteen materials to which a U-value was assigned. Some of the U-values were based on page 8 of *Energy Conservation for Commercial Greenhouses*, Northeast Regional Agricultural Engineering Service, NRAES-3, July, 1989. This document states that almost all single- layer materials have a heat transfer (U-value) between 1.0 and 1.2 Btu/hr-ft^2-°F and almost all double layer materials have a U-value between 0.6 and 0.7 Btu/hr-ft^2-°F. The American Society of Heating, Refrigerating, and Air Conditioning Engineers (ASHRAE) 1999 HVAC Applications Handbook and the 1997 ASHRAE Fundamentals Handbook were also referenced to determine U-values for the materials. If the ASHRAE Handbook had a more specific value than the NRAES-3, it was used. The materials found during the on-site audits, the assigned U-values, and where the U-values came from are shown below in Exhibit A.22.

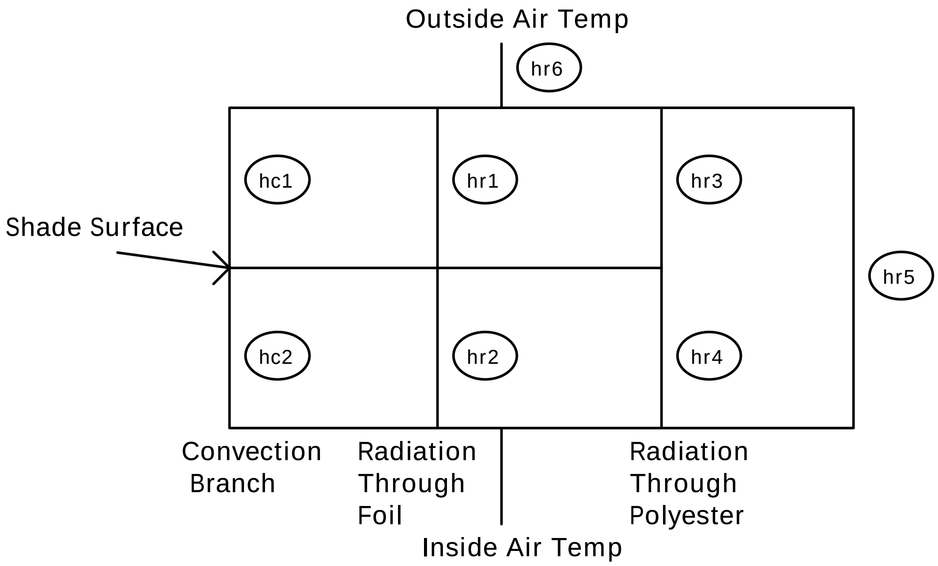
Exhibit A.22
U-values for Greenhouse Materials

Material	U-value	Notes
4 mil Polyethylene Film - double with air gap	0.65	From Energy Conservation for Commercial Greenhouses
4 mil Polyethylene Film - single	1.20	From ASHRAE 1999 Applications Handbook, p.21.11, Table 2
6 mil Polyethylene Film- single	1.15	From ASHRAE 1999 Applications Handbook, p.21.11, Table 2
Acrylic	1.10	From Energy Conservation for Commercial Greenhouses
Double-pane Glass	0.70	From ASHRAE 1999 Applications Handbook, p.21.11, Table 2
Fiber-reinforced Polyester	1.20	From ASHRAE 1999 Applications Handbook, p.21.11, Table 2
Fiber-reinforced Polyester and 6 mil Poly	0.59	Summing R values and inversing
Laminated Acrylic/Polyester Film	0.72	From ASHRAE 1999 Applications Handbook, p.21.11, Table 2
Polycarbonate	1.10	From Energy Conservation for Commercial Greenhouses
Polycarbonate with 1.25" thermax sheathing	0.12	Polycarbonate + R of 5.8 per inch for Thermax Sheathing
Single Pane Glass and 6 mil Poly	0.57	Summing R values and inversing
Single-pane Glass	1.13	From ASHRAE 1999 Applications Handbook, p.21.11, Table 2
Single-pane Glass with 1.25" thermax sheathing	0.12	Single Pane Glass + R of 5.8 per inch for Thermax Sheathing
Weatherable polyester film	1.20	From ASHRAE 1999 Applications Handbook, p.21.11, Table 2
Wood Panel Board	0.82	From ASHRAE 1997 Fundamentals Handbook, p.24.4, Table 4 (used high density hardboard)

The areas for each type of material were determined from the information gathered on site. More than one site had differing materials on the walls. Each different material's U-value was determined and then multiplied by the corresponding area to create a total UA for the greenhouse.

The total UA was determined with and without the heat curtain in place. All heat curtains were either constructed by a company called Ludwig Svensen or manufactured by a competitor with very similar construction. These heat curtains are of a porous weave with differing levels of aluminum incorporated into the weave. The aluminum reflects the heat back into the space. However, because of how the material is made, there is no specific U-value for the material. Instead, a complex heat transfer circuit was used to determine the heat transfer conductance through the roof with the screens in place. The analysis for the heat transfer was taken directly from *Energy Saving Using Greenhouse Shading/Insulating Screens Report*, CEC Contract #400-92-010, November, 1994. The work in this report had been performed by the Irrigation Training and Research Center in California Polytechnic State University. The heat transfer circuit used is shown below in Exhibit A.23.

Exhibit A.23
Heat Transfer Circuit



Where:

hc1 = convection conductance between screen and roof glazing
hc2 = convection conductance between inside air and screen
hr1 = radiation conductance between the foil portion of the screen and the roof glazing
hr2 = radiation conductance between the foil portion of the screen and the ground/biomass
hr3 = radiation conductance via clear polyester part of the screen
hr4 = radiation conductance via clear polyester part of the screen (equal to hr3)
hr5 = radiation conductance directly from ground/biomass to the roof glazing via clear polyester portion of screen
hr6 = heat transfer conductance from inside surface of roof glazing to the outside environment

One site used double layering of the heat curtain. For this site, a second layer was added to the calculation (i.e., hc2, hr2, and hr4 were added twice).The overall resistance of the roof with the heat curtain in place was determined using the equation shown in Exhibit A.24.

Exhibit A.24
Overall Resistance Equation

$$\text{Rwithscreen} = \frac{1}{hr5 + \dfrac{1}{\dfrac{1}{hc1 + hr1 + hr3} + \dfrac{1}{hc2 + hr2 + hr4}}} + \frac{1}{h6}$$

The radiation portion of the equation varied based on the percentage of foil within the screen. Telephone conversations with n engineer at Ludwig Svensen that took place during the previous evaluation (of the 1997 Agricultural Sector Programs) clarified the differences between the labeling of the heat curtain material and the percentage of aluminum in the foil. While not exact, each heat curtain material was assigned a percentage of aluminum. The hr6 value was determined based on the specific roofing material at the site and the overall resistance was calculated for each different roofing/heat curtain combination. The resistance was then inverted to determine a U-value for the roof with heat curtain in place for each greenhouse. The materials by the competitor were assigned values similar to the Ludwig Svensen material based on conversations with the vendor of the heat curtain. The results of the specific roof/heat curtain combinations are shown in Exhibit A.25.

Exhibit A.25
Roof U-value With and Without Heat Curtain

Roof	U without heat curtain	Heat Curtain	U with heat curtain
4 mil Polyethylene Film - double with air gap	0.65	LS15	0.34
Acrylic	1.1	LS15	0.43
Fiber-reinforced Polyester	1.2	LS15	0.44
Fiber-reinforced Polyester	1.2	LS15 Double Layer	0.39
Fiber-reinforced Polyester	1.2	LS18F	0.55
Polycarbonate	1.1	LS15	0.43
Polycarbonate	1.1	LS15 Double Layer	0.38
Single Pane Glass and 6 mil Poly	0.57	LS15	0.31
Single-Pane Glass	1.13	LS15	0.43

The frame type affects the heat conductance of the structure. The greenhouses had wood and galvanized steel framing. A construction multiplier was assigned based on the type of frame. These are shown in Exhibit A.26 below. The total UA was multiplied by the construction multiplier to determine the overall UA of the structure.

Exhibit A.26
Construction Multipliers

Frame Type	Construction Multiplier
Wood	1.00
Galvanized Steel	1.03

The volume of the greenhouse was calculated both with and without the heat curtain in place based on data collected at the sites. The air changes per hour (ACH) were assigned based on the ASHRAE 1999 HVAC Applications Handbook (p. 21.11, Table 4). The ACH varied by new or old construction and good or poor maintenance. Greenhouses which were older than five years were considered old. Determination of good or poor maintenance was based on the auditors' judgement. The ACH values applied are shown in Exhibit A.27.

Exhibit A.27
ACH Values

Age and Maintenance	ACH
Old (>= 5 years), Poor	3.0
Old (>= 5 years), Good	1.5
New (< 5 years), Good	1.0

The ACH will change when the heat curtain is in place. However, most of the heat curtains left areas open for ventilation. Because of this, the ACH with the heat curtain in place was decreased only by the average decrease in volume (12%).

A.4.2.2 Impact Algorithm

The change in heat loss, as calculated in Exhibit A.21, was multiplied by the site-specific annual hours in use. These hours were determined based on the WYEC2 weather data for the zone in which the site was located and the specific greenhouse temperature set point. All sites were in CEC Zone 3. (This zone based on the CEC Nonresidential Manual, updated March 1996.)

Information gathered during the on-site audit was used to determine a thermostat set point and hours of use of the heat curtain. A non-typical use of the deadband concept was used in the analysis. The heating did not come on unless the temperature outside was three degrees lower than the thermostat set point. While the typical use of a deadband is the range in which the thermostat turns itself on and off, based on the sensed temperature, this analysis did not employ a dynamic model which could determine the heat flows through the space to the thermostat. The value of three degrees was set based on engineering judgement.

Each hour of the year was analyzed to determine first, if the heat curtain was expanded (open and working as a heat barrier), and second, if the temperature outside was less than the set point. If both criteria were met, the outside temperature was subtracted from the set point to determine a delta temperature. A summation of the hours when the heat curtain was expanded provided the annual hours of operation. The average delta temperature was used for both the pre- and post-retrofit calculation in Exhibit A.21. The analysis, then, provided impacts based on typical weather.

The annual hours of operation varied from a low of 2,442 hours to a high of 5,401 hours, with a mean of 4,336 hours of use. The average delta temperature ranged from a low of 8.2° F to a high of 24.3° F, with a mean of 13.4 °F.

The ex post impacts are shown in Exhibit A.28.

Exhibit A.28
Greenhouse Heat Curtain Ex Post Impacts

Audit	Ex Ante	Ex Post	Gross Realization Rate	Reasons for Gross RR
301	40,637	111,381	2.74	Site has a temp of 78 year round (orchids)
302	43,183	48,328	1.12	Site has an average temperature set point of
303	73,678	63,529	0.86	Site is missing 15% of installed square footage - temperature of 68.5 for part of the
304	81,376	49,608	0.61	Function of low RR on square foot
305	114,968	104,218	0.91	No comment
306	92,758	66,809	0.72	Site has relatively good U-value pre and has low delta T for one of the ranges
307	19,051	21,975	1.15	Temperature setpoint of 68
308	105,656	106,833	1.00	This site refused and the ex post has been set to the ex ante multiplied by the gross realization rate for the population
309	130,019	127,285	0.98	No comment
310	130,886	109,611	0.84	This site used a double layer of heat curtains and also had a 20% of the square footage of the curtains missing
311	8,748	7,262	0.83	This site had a low U-value difference as well as having no reduction in ACH since it already was very good construction.
312	60,000	111,439	1.86	Site has a temp of 78 year round (orchids)
313	80,827	77,997	0.96	No comment
314	20,318	15,556	0.77	Low delta T and subsequent low hours for heating
315	15,246	6,854	0.45	Low delta T and subsequent low hours for heating, original greenhouse had low U-value This site purchased more HC, but evaluation only was done for the incented amount
Total	1,017,352	1,028,685	1.01	

A.4.2.3 Reasons for Realization Rate Discrepancies

The ex post findings of impacts were virtually identical to the ex ante estimate of impacts with a gross realization rate of 1.01. Across the fifteen audits, the site-specific gross realization rate varied from 0.45 to 2.74. There were two sites that kept the greenhouses at a very warm temperature (78 F) year round for their crop (orchids). These two sites helped to bring the realization rate up to its current 1.01. Without these two sites, the gross realization rate would have been 0.77.

The ex ante estimate of impacts used an average savings of 0.60 therms per square foot of heat curtain purchased. The ex post analysis average impacts were 0.68 therms per square foot of heat curtain installed. However, only 89% of the square foot installed was found during the audit. Included in the therms/ft^2 value are all the differences between the ex ante and ex post analysis method and input assumptions. Some of these inputs are shown in Exhibit A.29. These include a similar average nighttime temperature, a smaller reduction in air changes, differences in roof U-values, and fewer square feet of heat curtain found than was originally rebated.

Exhibit A.29
Example of Ex Ante and Ex Post Heat Curtain Inputs

Input Item	Ex Ante	Ex Post
Nighttime Temperature	65 °F	Varied between 55 °F and 78 °F with an average of 66°F
Air Changes with Heat Curtain	33% reduction	12% reduction
Average Roof U-value No Heat Curtain	1.23	1.08
Average Roof U-value With Heat Curtain	0.45	0.42
Average Roof U-value Difference	0.78	0.66
Square Foot of Heat Curtain Installed	1,695,586	1,502,839 (89% of ex ante)

The ex post impacts averaged 43% of the estimated greenhouse-specific pre-retrofit estimated therm usage. While the pre/post-therm usage could not be correlated with billing data reductions because many sites had multiple greenhouses on one meter, billing data were looked at for some of the sites. The estimated usage for a few of the specific greenhouses was not unreasonably large or small compared to the actual therm usage (the impact averaged 20% of the actual usage). Therefore, the evaluation team believes the analysis appropriately reflects the actual impacts.

This concludes the engineering appendix for the Pre-1998 Agricultural Programs evaluation.

Appendix B Final On-Site Audits

Data Class: ______ 1= Good

2= Marginal

Customer Name: _____________________________________ 3= Bail Out

Customer Business Name: _____________________________________ 4= Refused

Customer Address: _____________________________________ 5= Can't Contact

_____________________________________ 6= Duplicate

Customer Phone: _____________________________________

PG&E Account Number: ___________________ Verified?___________

New Account Number: ___________________ (1=Yes, 2=No)

PG&E Meter Number: ___________________ Verified?___________

New Meter Number: ___________________ (1=Yes, 2=No)

Location/Directions (include major cross streets):

____
____
____
____
____

Type of Measure

Y/N	Meas #	Measure Name
______	1	Pump Repair (REO)
______	3	Low Pressure Sprinkler Nozzle Conversion (REO)
______	4	Micro Irrigation System Conversion (REO)
______	5	Heat Curtain (REO)
______	6	Custom (APO)
______	7	1996 Retention Panel Verification

This on-site survey conducted by: _____________________ On: ______________

Note: Verify PG&E Account Number from copy of customer's bill.

Exhibit B.1 – Pump Repair Audit

Pump Repair Audit (page 1 of 1)

1. Normal Pumping Plan Configuration (from pump tester's notes):
2. Was this pump worked on in: 1 = 1998 or 1999, 2 = Not worked on ____________

If Yes:

a) When was this work done (Month/Year)? /______

b) What work was done? _____________

(1=pump rebuilt/replaced, 2=well casing cleaned, 3=pump rebuilt & casing cleaned)

c) Was this pump re-tested after the repairs were made (1=Yes, 2=No)? _________

If Yes

c1) when was it re-tested _____/_____

c2) what was the plant efficiency?

3. Other electrical load on this meter? (1=Yes, 2=No, 3=Unable to determine) _____

If NO, then stop audit here; if Booster, go to #4, if OTHER, go to #5

4. *If Booster Pump*, then complete the following:

_____ What is the horsepower of the booster pump?

_____ Do the booster and deep well pump always run at the same time? (1=Yes, 2=No)

If yes, then STOP here

If NO, then ? (These last 3 questions should add to 100%)

i) ______ % of the time does the booster run by itself?

ii) ______ % of the time does the booster run with the deep well pump?

iii) ______ % of the time does the deep well pump run by itself

If Other Loads, then what portion of the year do they run and what are their horsepowers?

Tested Pump ______ % of year run:

Other Load #1______ % of year run and ______ Horsepower

Other Load #2______ % of year run and ______ Horsepower

Other Load #3______ % of year run and ______ Horsepower

Other Load #4______ % of year run and ______ Horsepower

Pump Repair Retention Panel Information

Information for the retention portion of this audit are collected above (location of pump) and during the pump test (horsepower of pump).

Customer Contact By: ______________ On: _______ Forward To Tester On: ________

Pump Test Work Sheet (Page 1 of 2)

Field Pump Test

Location Description (major cross streets and location from intersection; include HP):

____

____

____

Normal Pumping Plant Configuration (How is it usually used):

____ Single deep well pump with open discharge

____ Single deep well pump with pressurized discharge:

____ Low (1-20 psi) or ____ High (20+ psi)

____ Single deep well pump in conjunction with electric booster pump

____ Single deep well pump in conjunction with diesel booster pump

____ Deep well joined with other deep well pumps

____ Axial / Propeller pump (low head)

____ Other: ____

PG&E Meter Number (in program yr) ____________________ Verified? __________

New Meter Number (if changed)________________________ (1-Yes, 0=No)

Are their other electrical loads on this meter? _____ (1=Yes, 0=No)

If Yes, what is the other load: [ ] Booster, [ ] Other ______________________

Sketch of Pumping Configuration:

Pump Test Work Sheet (Page 2 of 2)

Field Pump Test

Comments (include pumping plant configurations used other than the "normal" one):

____

____

Pump Test Conducted By: ___________________________ On: ____________________

Pump Test Data Review By: _____________ On: __________ Data Classification: ___

Exhibit B.2 – Low-Pressure Sprinkler Nozzle Audit

Low Pressure Sprinkler Nozzle (page 1 of 3)

The information here, unless otherwise noted, is specific to the site audited.

1. The low pressure sprinkler nozzles were placed in a system which is a:

   1 = Permanently Installed System 2 = Hand Moved System

   Total number of rebated nozzles *throughout company* - ___________

   Total number of rebated nozzles *at this site* - ___________

2. The nozzles are used across _____ pumping accounts.
3. Is the pumping pressure reduced? (1=Yes, 2=No)

   If yes, how was the pressure reduced:

   ____

   ____

4. What was the approximate psi of the previous high pressure sprinkler system? ______
5. What is the configuration of the pumping system being tested?

   a)_____Deep well pump only.

   b)_____ Deep well pump in conjunction with booster pump that boosts directly from the deep well.

   Booster pump is _______ (1=Electric, 2=Diesel)

   c)_____ Deep well pump in conjunction with booster pump with the booster pump pulling water from a reservoir or canal.

   Booster pump is _______ (1=Electric, 2=Diesel)

   d)_____ No deep well pump. Electric booster used to pull water from canal.

6. *If booster pump used*, what is the current horsepower? _____
7. *If booster pump was changed* with addition of low-pressure sprinkler nozzles, what was the horsepower of the old booster pump? _____

Low Pressure Sprinkler Nozzle (page 2 of 3)

8. *If moveable sprinkler system*, complete the following information for the pumps to which the irrigation system is attached. The assumption is that all rebated nozzles are on this system. If not, make a note of where they all are. Circle the pump number of the pump that has been tested.

Pump Number	Account Number	Pump Type (Booster, Deep Well, Combined)	Pump HP	Acres Irrigated with Pump	% of time Pump Used (column adds to 100%)
1					
2					
3					
4					
5					
Total	NA	NA	NA		100

1. *If permanent sprinkler system*, complete the following information for the pumps to which the irrigation system is attached. The assumption is that the grower spread out the rebated number of nozzles across more than one account. Circle the pump number for the pump that has been tested.

Pump Number	Account Number	Pump Type (Booster, Deep Well, Combined)	Pump HP	Number of Nozzles on Pump System	Acres Irrigated with Pump
1					
2					
3					
4					
5					
Total	NA	NA	NA		

Low Pressure Sprinkler Nozzle (page 3 of 3)

Low Pressure Sprinkler Retention Panel Information

Sprinkler Brand: ______________________________________

Sprinkler Model: ______________________________________

Nozzle Manufacturer: ______________________________________

Nozzle Size: ______________________________________(Inches or Model Number)

Note: Other retention information is gathered earlier (location of fields, number of nozzles, type of irrigation system).

Exhibit B.3 – Micro Irrigation Conversion Audit

Micro Irrigation Conversion **(page 1 of 2)**

1. What was the previous irrigation system?

   ____ Big Gun sprinklers of approximately _____ psi

   ____ High Pressure sprinklers of approximately ___ psi

   ____ Low Pressure sprinklers of approximately ___ psi

   ____ Other

____

2. Current estimated psi ________________
3. Current estimated irrigation efficiency ____________
4. Previous estimated flow (GPM) _____________
5. Complete the following information for the pumps to which the irrigation system is attached. Circle the pump number for the pump that has been tested.

Pump Number	Account Number	Pump Type (booster, deep well, both)	Pump HP	Acres Irrigated with Pump
1				
2				
3				
4				
5				
Total	NA	NA	NA	

1. At the time of the conversion to a micro system, was:

   a) _____ the deep well replaced or rebuilt (1=Yes, 2=No)?

   b) _____ the booster replaced or rebuilt (1=Yes, 2=No)?

7. If new pump, what was the old pump:

   a) _____ Type b) _____ horsepower

8. *If retrofit*, what was done to the pump? _________________________________
9. Micro-Irrigation Schedule: Does the system have a peak-period lock-out on the meter? ________ (1=Yes, 2=No)

Continue if #9 answer is No

When the system is turned on, how many hours per day does it run (on average)? _____

When are those hours? ____

Micro Irrigation Conversion (page 2 of 2)

Crop Type (collect for normalization with CIMIS data)

____

____

____

Micro-Irrigation Retention Panel Information

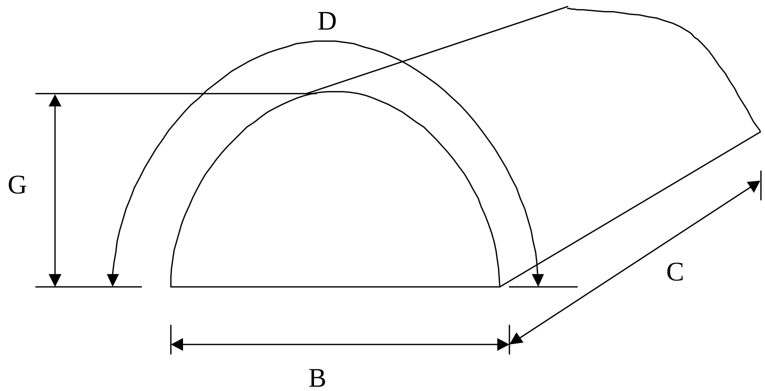
Type of micro irrigation system (e.g., drip tape, drip tubing, micro sprinklers)

Exhibit B.4 – Greenhouse Heat Curtain Audit

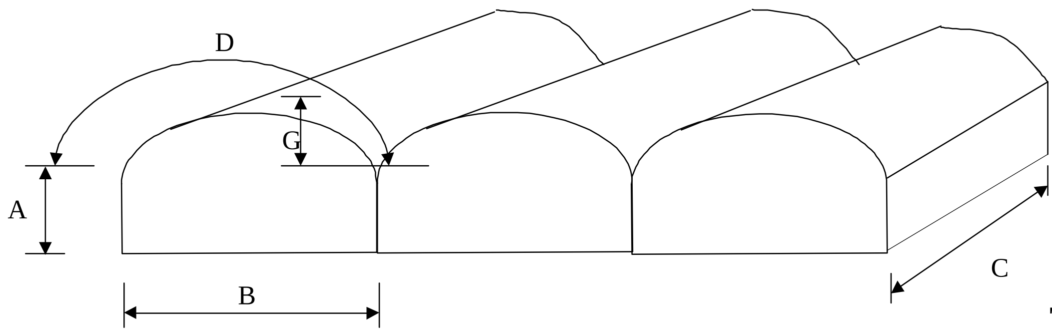
Greenhouse Heat Curtain **(page 1 of 5)**

Greenhouse Volume

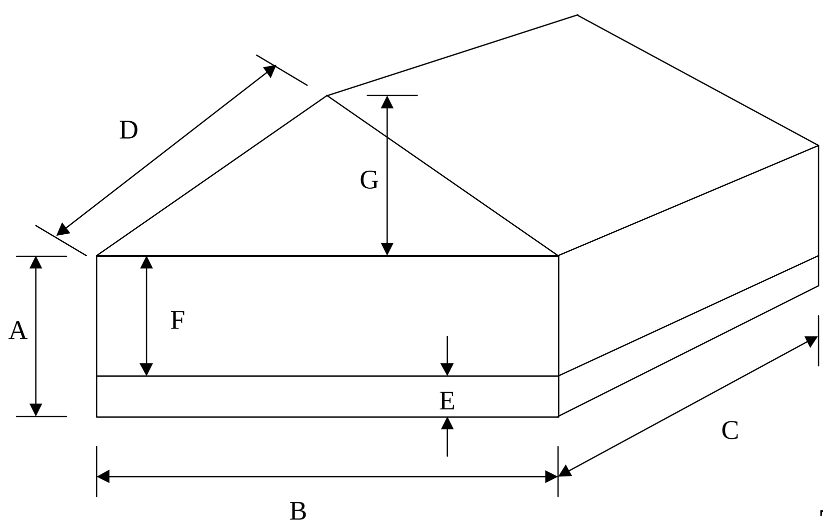
If the greenhouse being audited does not have one of the shapes shown below, draw it on the next page and label the lengths provided. Draw how the heat curtain has been installed. Measure dimensions in feet and include on Page 3.



Type: Quonset (Q)



Type: Multi-Span (M)



Type: Rectangular (R)

Greenhouse Heat Curtain (page 2 of 5)

Greenhouse Volume (cont.)

Sketch of Other Type (if required):

Greenhouse Heat Curtain (page 3 of 5)

Greenhouse #___					
Number the Same =					
GreenhouseType (Q,M,R,O) =					
	Meas.	Material	Heat Curtain*		
Location	Feet	Type	Length AND	Width OR	Area
A Wall height					
B House Width					
C House Length					
D Rafter Length					
E Lower Wall Height					
F Upper Wall Height					
G Gable Height					

Greenhouse #___

Heating Thermostat Setpoint: ______

Heating Schedule: (Months heating available and hours used if programmable thermostat)____

____
____
____
____
____
____

Comments: ____________________________
____
____
____
____
____

*If there are more than one greenhouse the same, the heat curtain is assumed to be the same in each greenhouse.

Cloth Type: LS14 LS15 LS15F LS16 PH1 PH98 Other
(Circle One or More)

Other:____

Circle the type of framing materials in the greenhouse:
Wood Aluminum Galvanized Steel
Other: ____

Circle the Construction Age: New Construction (less than 5 years) Old Construction (>=5 years)

Circle the Maintenance: Good Maintenance Poor Maintenance

Greenhouse Heat Curtain (page 4 of 5)

Greenhouse Construction

Use the Material Number to indicate Material Type on Page 3.

Material Number	***General Material Type***	***Typical Trade Name***
1	Glass	Double Strength Insulated Units Low Iron
2	Acrylic	Plexiglass Lucite Acrylite Double Wall Exolite Acrylite SDP
3	Polycarbonate	Lexan Tuffak A Tuffack Twinwall Qualex
4	Fiber Reinforced Polyester	Lascolite Filon Glasteel Kalwall
5	Laminated Acrylic/Polyester Film	Flexigard
6	Polyethylene Film	Visqueen Tufflite II Monsanto 602 or 603
7	Weatherable Polyester Film	Llumar Mylar Melinex

If the glazing construction material is not on this list, number it, state below what it is and refer to it as that number on page 3.

____

____

____

____

Greenhouse Heat Curtain (page 5 of 5)

Comments on Greenhouse Audit not covered elsewhere.

Exhibit B.5 – Refrigeration Audit

Refrigeration Measures – Page 1 of 4

Data Class: ______ 1= Good

2= Marginal

Customer Name: ____ 3= Bail Out

Customer Business Name: ____ 4= Refused

Customer Address: ____ 5= Can't Contact

____ 6= Duplicate

Customer Phone: ____

PG&E Account Number: ____________________ Verified?___________

New Account Number: ____________________
(1=Yes, 2=No)

Location/Directions (include major cross streets) of Site:

____

____

____

____

This on-site survey conducted by: ______________________ On: _______________

Refrigeration Measures – Page 2 of 4

On-Site Audit Number: _____________
Auditor: ________________________

Refrigerant: Ammonia (R717) Halocarbon (R22)

Refrigeration	Compressors*					
Line	Manuf.	Model	hp	Suction Temp (F)	Pressure	
						psia psig
						psia psig
						psia psig
						psia psig
						psia psig
						psia psig
						psia psig

*Obtain the average compressors and cylinders running during off-peak and on-peak periods

Refrigeration Components

Total Refrigeration ________ Btuh Tons Lbs.
Flow ________ lb/min

	Maximum	Average
Pre-Retrofit Suction Pressure or Temperature		
Pre-Retrofit Condensing Pressure or Temperature		
Post-Retrofit Suction Pressure or Temperature		
Post-Retrofit Condensing Pressure or Temperature		

Refrigeration Measures – Page 3 of 4

On-Site Audit Number: _____________
Auditor: ________________________

	Condensers								
Number	Manuf.	Model	Condensing Temp (F)	Pressure		Number of Fans	Fan hp	Number of Pumps	Pump hp
1					psia psig				
2					psia psig				
3					psia psig				
4					psia psig				
5					psia psig				
6					psia psig				
7					psia psig				

Location of Condenser ____

____

Fan Control Schedule ____

____

Refrigeration Measures – Page 4 of 4

Operating Hour Schedule for Plant

Gather information on seasonal, weekly hours of operation and coincident peak periods - use July and August 3-4PM as CP

Exhibit B.6 – 1996 Ag Program Retention Audit

1996 Ag Program Retention Questionnaire

Customer Name		Audit Num:
Business Name		Orig CAQ Surveyor
Customers Address		Division
City		Assigned To:
Phone		Old Audit ID:
New Contact Name		Date Customer Talked To:
New Phone Number	Area Code	Is a Site Visit Necessary?
PG&E Audit Acct.		Date Site Visited
New PGE Acct.		
1996 Measure:	Measure Code	Measure Description

Pump Repair
Low-Pressure Sprinkler Nozzle
Micro-Drip Conversion
Indoor Lighting

Location Description – Pumping & Related Location Description – Lighting

Is the 1996 measure still present (yes/no) ____________

If not present, explain why not

Was the measure used in 1999?

If no, explain why not

Approximate date removed from service ____________________________

Continue for Lighting Audits ONLY

Num Fixtures	**Group Descriptions**	**Lamp Fixture**	**Watt**

What % of the equipment from this measure is still in use? ________________

When was the unused portion removed from service? (approx.) ________________

Why was it removed from service?

Auditors Comments: ____

Appendix C Costing Period Allocation Tables

Exhibit C.1
Gross Demand and Energy Savings by Costing Period For the AEEI Program – Pumping and Related End Use

Pumping and Related End Use				
PG&E Cost Period	Program kW Savings Coincident with System Max in Period	kW H-Factor	kWh Savings	kWh H-Factor
Summer On-Peak: May 1 to October 31 12:00 - 6:00 PM Weekdays	2,855.25505	1.00000	1,105,019.28578	0.13356
Peak: May 1 to October 31 8:30 AM - 12:00 PM 6:00 PM - 9:30 PM Weekdays	2,905.25057	1.01751	1,334,942.06170	0.16135
Summer Off-Peak: May 1 to October 31 Other	3,402.97863	1.19183	3,657,004.90048	0.44201
Winter Partial-Peak: Nov 1 to April 31 8:30 AM - 9:30 PM Weekdays	1,135.07809	0.39754	918,284.59516	0.11099
Winter Off-Peak: Nov 1 to April 31 Other	663.87535	0.23251	1,258,245.97920	0.15208

The AEEI Pumping and Related End Use H-factors referenced above are from the evaluation of PG&E's 1996 Agricultural Programs reported in March of 1998.

Exhibit C.2
Gross Demand and Energy Savings by Costing Period For the AEEI Program – Refrigeration End Use

Refrigeration End Use				
PG&E Cost Period	Program kW Savings Coincident with System Max in Period	kW H-Factor	kWh Savings	kWh H-Factor
Summer On-Peak: May 1 to October 31 12:00 - 6:00 PM Weekdays	373.13645	1.00000	280,862.86737	0.1472
Peak: May 1 to October 31 8:30 AM - 12:00 PM 6:00 PM - 9:30 PM Weekdays	348.25571	0.93332	304,942.27897	0.15982
Summer Off-Peak: May 1 to October 31 Other	324.37871	0.86933	701,432.11484	0.36762
Winter Partial-Peak: Nov 1 to April 31 8:30 AM - 9:30 PM Weekdays	150.20235	0.40254	302,690.79674	0.15864
Winter Off-Peak: Nov 1 to April 31 Other	175.37786	0.47001	318,088.64552	0.16671

The AEEI Refrigeration End Use H-factors referenced above are from the evaluation of PG&E's 1996 Agricultural Programs reported in March of 1998. The indoor lighting end use H-factors used in the 1996 programs evaluation are actually H-factors for the "Ag Other" segment. Therefore, the use of these H-factors for the refrigeration end use is appropriate for the Pre-1998 Agricultural Programs evaluation.