QUANTUM CONSULTING

IMPACT EVALUATION OF PACIFIC GAS & ELECTRIC COMPANY'S 1994 AGRICULTURAL PROGRAMS:

PUMPING AND RELATED MEASURES (STUDY ID #315)
ENERGY MANAGEMENT SERVICES (STUDY ID #318)
MISCELLANEOUS MEASURES (STUDY ID #321)

Submitted to

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Section 1

EXECUTIVE SUMMARY

This section presents a summary of the results for the impact evaluation of Pacific Gas & Electric's (PG&E's) 1994 agricultural customer participation in its Commercial, Industrial, and Agricultural (CIA) Retrofit programs. The evaluation covers the Retrofit Express (RE), Customized Incentives (Customized) and Energy Management Services (EMS) programs. The results are presented in three sections: evaluation results summary (covering the numerical results of the study), major findings and major recommendations.

1.1 Evaluation Summary

The evaluation results are summarized in terms of energy (MWh, therm), demand (kW) impacts, and realization rates [the ratio of the evaluation results (ex post) to the program design estimates (ex ante)]. These results are presented by end-use element on a gross and net basis (i.e., before and after accounting for free riders and spillover). Exhibit 1-1 presents the gross energy and demand impact summary.

Exhibit 1-1
Summary of Gross Evaluation Results

		Gross Program Impact		
	N	kWh	kW	Therm
Agricultural Pumping Total	2,555	43,619,032	7,951	0
Agricultural Miscellaneous Total	419	20,681,899	1,958	1,725,050
Agricultural Energy Efficiency Incentives Total	2,974	64,300,932	9,910	1,725,050
Agricultural EMS Program Total	5,380	NA	NA	NA

These results illustrate the following key points about the gross agricultural impact results:

- Agricultural pumping represents more than half of the gross energy impact for both Agricultural Energy Efficiency Incentives (AEEI) programs. Within the agricultural pumping end-use element, two measures, pump retrofit and low pressure sprinkler nozzles, contribute over 70 percent of the gross energy and demand impacts.

- The miscellaneous portion of the AEEI programs represented over a quarter of the total agricultural energy impacts. Lighting and refrigeration measures contributed over 90 percent of the gross energy impacts within the miscellaneous end-use element.

- All of the therm impacts occurred in the Agricultural Miscellaneous end-use element, with virtually all of these impacts being contributed by green house shell enhancement measures.

- No gross impacts are presented for the EMS program. All of the impacts are considered program spillover, since the primary purpose of the program is to encourage the customer to take action thereby creating spillover effects.

Exhibits 1-2 through 1-4 present the net energy and demand impact results, together with the net realization rates, at the same levels presented in Exhibit 1-1.

The following general statements can be made about the net-to-gross (NTG) adjustments that appear in Exhibits 1-2 through 1-4.

- The ex ante NTG ratios are between 0.73 and 0.79, depending upon the program and the type of impact (kWh, therms, kW). These values are obtained from the Management Decision Support System (MDSS), PG&E's participant database.

- The ex post NTG ratios vary between 0.66 and 0.91 depending upon the program and the type of impact (kWh, therms, kW).

- Free ridership rates were high for the pumping end-use element, contributing a 64 percent overall reduction in energy and demand impacts. This is probably a result of the maturity of the PG&E pump rebate programs.

- Participant spillover rates offset some of the free ridership in the pumping end-use element, contributing a 29 percent increase in impacts.

- Nonparticipant spillover effects were detected only for the pumping end-use element in this evaluation, contributing a 25 percent increase in estimated impacts for the pumping end-use element. This was primarily due to pump retrofits and installations of low pressure sprinkler nozzles outside of the program.

- The NTG adjustment value of 1.00 for the EMS end-use element recognizes that all of the impacts in the EMS program are spillover (i.e., program induced installations not receiving rebates under the program).

Exhibit 1-2 presents the net energy and demand impact results, along with the net realization rates, at the same levels presented in Exhibit 1-1.

Exhibit 1-2
Net Energy Impact Summary

Agricultural Technology Group	Gross	NTG Adjustments			Net	
	Gross Impact (MWh)	Free Ridership Adjustment (1-FR) (Unitless)	Participant Spillover Adjustment (Unitless)	Nonparticipant Spillover Adjustment (Unitless)	Net Impact without NP Spillover Adjustment (MWh)	Net Impact with NP Spillover Adjustment (MWh)
Ex Ante**						
Pumping	54,163	0.69	0.10		42,549	
Miscellaneous*	23,682	0.63	0.10		17,344	
AEEI Total	77,844	0.67	0.10		59,892	
EMS	NA	NA	NA	NA	13,192	
Ex Post						
Pumping	43,619	0.36	0.29	0.25	27,960	38,655
Miscellaneous*	20,682	0.72	0.00	0.00	14,846	14,846
AEEI Total	64,301	0.47	0.19	0.17	42,806	53,500
EMS	NA	0.00	1.00	0.00	13,831	NA
Realization Rates (ex post/ex ante)						
Pumping	0.81	NA	NA	NA	0.66	0.91
Miscellaneous*	0.87	NA	NA	NA	0.86	0.86
AEEI Total	0.83	NA	NA	NA	0.71	0.89
EMS	NA	NA	NA	NA	1.05	NA

*The Agricultural Miscellaneous category also includes lighting, HVAC, and additional end uses.
**The ex ante spillover adjustment estimates did not differentiate between participant and nonparticipant spillover.

The following are some of the specific points that can be extracted from the exhibit:

- The AEEI program net energy impacts averaged 89 percent of the projected ex ante estimates, with the majority of the impacts coming from the pumping end-use element.

- While the EMS program impacts were very nearly the same as the ex ante projected energy impact estimates, the majority of those impacts were derived from the purchase of low pressure sprinkler nozzles rather than from the originally projected pump retrofits.

Exhibit 1-3 presents the net Therm energy impact results, along with the net realization rates, at the same levels presented in Exhibit 1-1.

Exhibit 1-3
Net Therm Impact Summary

Agricultural Technology Group	Gross	NTG Adjustments	
	Gross Impact	NTG Ratio	Net Impact
	(Therms)	(Unitless)	(Therms)
Ex Ante			
Pumping	0	-	0
Miscellaneous	1,672	0.79	1,320
AEEI Total	1,672	0.79	1,320
EMS	0	-	0
Ex Post			
Pumping	0	-	0
Miscellaneous	1,725	0.79	1,362
AEEI Total	1,725	0.79	1,362
EMS	0.0	-	0
Realization Rates (ex post/ex ante)			
Pumping	NA	NA	NA
Miscellaneous	1.03	NA	1.03
AEEI Total	1.03	NA	1.03
EMS	NA	NA	NA

The following are some of the specific points relevant to the exhibit:

- Virtually all of the identified therm impacts are from greenhouse shell improvement measures that fall within the Agricultural Miscellaneous end-use element.
- The ex ante NTG adjustment was assumed for the ex post calculation since no evaluation NTG adjustment was identifiable through the evaluation data collection process.
- The adjustments resulting from the on-site inspections and engineering models resulted in a small (3 percent) increase in estimated net impact.

Exhibit 1-4 presents the net demand impact results, along with the net realization rates, at the same levels presented in Exhibit 1-1.

Exhibit 1-4
Net Demand Impact Summary

Agricultural Technology Group	Gross	NTG Adjustments			Net	
	Gross Impact (kW)	Free Ridership Adjustment (1-FR) (Unitless)	Participant Spillover Adjustment (Unitless)	Nonparticipant Spillover Adjustment (Unitless)	Net Impact without NP Spillover Adjustment (kW)	Net Impact with NP Spillover Adjustment (kW)
Ex Ante**						
Pumping	7,597	0.69	0.10		5,927	
Miscellaneous*	3,571	0.63	0.10		2,644	
AEEI Total	11,168	0.67	0.10		8,571	
EMS	NA	NA	NA	NA	3,712	
Ex Post						
Pumping	7,951	0.36	0.29	0.25	5,097	6,933
Miscellaneous*	1,958	0.66	0.00	0.00	1,288	1,288
AEEI Total	9,910	0.42	0.23	0.20	6,385	8,221
EMS	NA	0.00	1.00	0.00	3,205	NA
Realization Rates (ex post/ex ante)						
Pumping	1.05	NA	NA	NA	0.86	1.17
Miscellaneous*	0.55	NA	NA	NA	0.49	0.49
AEEI Total	0.89	NA	NA	NA	0.74	0.96
EMS	NA	NA	NA	NA	0.86	NA

*The Agricultural Miscellaneous category also includes lighting, HVAC, and additional end uses.
**The ex ante spillover adjustment estimates did not differentiate between participant and nonparticipant spillover.

These results illustrate the following key points about the net agricultural demand impact results:

- The realized net demand impact for the Pumping end use is 17 percent higher than anticipated. This is primarily a result of nonparticipant spillover which was detected for low pressure sprinkler nozzles.
- The Agricultural Miscellaneous end-use element results in a realization rate of approximately half of the anticipated ex ante impact. This is a result of anticipated demand impacts for lighting not materializing because the evaluation identified specific types of high participation lighting in nurseries that do not operate at peak times. Thus, both gross and net realization rates are low.
- The NTG adjustment for the Agricultural Miscellaneous demand category is different than the NTG adjustment for the Agricultural Miscellaneous energy category because a different mix of technologies contribute demand impacts than those included in the energy impacts.
- The EMS program net impacts are comparable to the ex ante estimates. However, the original impact estimate is based on projected pump retrofit installations, which occurred in small numbers. The impacts from other installed measures, mainly the low pressure sprinkler nozzles, made up this shortfall.

Detailed presentation and discussion of this data can be found in *Section 3.*

1.2 Major Findings

The key findings are best summarized as follows:

- The Agricultural programs have relatively high free ridership rates in conjunction with significant participant and nonparticipant spillover.
- Although the EMS evaluation results are closely aligned with the ex ante estimates, the impacts came from installation of low flow sprinkle nozzles rather than the anticipated pump retrofits.

1.3 Major Recommendations

1.3.1 Evaluation

- **General Issues for Quantifying Spillover Effects** - Because the nonparticipant market size is so large, including nonparticipant spillover effects in net-to-gross (NTG) calculations has a significant impact on the final NTG ratios. Therefore, the evaluation team recommends collecting additional data (such as trade ally surveys) every second or third year to gauge the program's market movement effects.

1.3.2 Program Design

- **Maintain a Wide Range of Recommendations During the EMS Audits** - The broadest base of recommendations allows growers to identify the measures that fit their needs, thus enhancing program impacts.
- **Update the Coincident Diversity Factor (CDF)** - This value was investigated during this evaluation, but no definitive CDF was agreed upon prior to this report. Additionally, PG&E should clarify the method for calculating the CDF for demand impact.

1.3.3 MDSS Tracking System

- **Make Installation Date a Mandatory Field** - PG&E should make the date that the retrofit occurred a mandatory field for the MDSS. This date is necessary to evaluate program savings accurately.

Other detailed recommendations concerning the above subjects, measures offered, and the CPUC Protocols are covered in more detail in *Section 4*.

Section 2

INTRODUCTION

This report covers the impact evaluation of the technologies offered to Pacific Gas & Electric Company's (PG&E's) agricultural customers under PG&E's 1994 Commercial, Industrial, and Agricultural (CIA) Retrofit Programs. These technologies are covered by three separate program options, the Retrofit Express (RE) Program, the Customized Incentives (Customized) Program, and the Energy Management Services Program (EMS). These programs are summarized below.

2.1 The Retrofit Express Program

The RE program offered fixed rebates to CIA customers that installed specific gas or electric energy-efficiency equipment in their facilities. The program covered the most common energy saving measures, including lighting, air conditioning, refrigeration, motors, agricultural applications, and food service. Customers were required to submit proof of purchase with their applications in order to receive rebates. The program was marketed primarily to small- and medium-sized commercial, industrial, and agricultural customers. The maximum rebate amount, including all measure types, was $300,000 per account. No minimum amount was required to qualify for a rebate.

Specifically, the program offered rebates on the following relevant technologies for the Agricultural sector:

- Pumping Measures
  - Pump retrofits
  - Pump adjustments
  - Well water measurement devices
  - Low pressure sprinkler nozzles[1]
  - Time clocks with battery backup

[1] See *Appendix J* for further discussion on this measure.

- Miscellaneous Measures
  - Heat curtains to reduce heating in greenhouse
  - Double-walled polyethylene to reduce heating in greenhouses
  - Rigid double-walled plastic to reduce heating in greenhouses
  - Milk pre-coolers
  - Refrigeration desuperheaters

In addition, measures from the commercial applications were applied in the agricultural segment. These include energy efficient motors, HVAC, food service, lighting, refrigeration, and process applications.

2.2 The Customized Incentives Program

The Customized program offered financial incentives to CIA customers who undertook large or complex projects that save gas or electricity. These customers were required to submit calculations for projected first-year energy impacts with their applications and prior to installation of the project. The maximum incentive amount for the Customized program was $500,000 per account, and the minimum qualifying incentive was $2,500 per project. The total incentive payment for kW, kWh, and therm savings was limited to 50% of direct project cost for retrofit of existing systems. Since the program also applied to expansion projects, the new systems incentive was limited to 100% of the incremental cost to make new processes or added systems energy efficient. Customers were paid 4 cents per kWh and 20 cents per therm for first-year annual energy impacts. A $200 per peak kW incentive and a $50 per peak kW early completion (October 31, 1994) bonus for peak demand impacts required that savings be achieved during the hours PG&E experiences high power demand.

The measures rebated under the Customized program varied widely. The two measure types that contributed most to the Customized impacts were water system improvements and refrigeration.

2.3 The Energy Management Services Program

The EMS program offered information to CIA customers regarding energy efficiency technologies and practices. PG&E representatives worked with customers to identify cost effective improvements with special emphasis on operational and maintenance measures at the customers' facilities. For agricultural customers the services generally include a pump test and a walk-through audit culminating in a list of recommendations for capital intensive or low-cost/no-cost energy efficiency improvements. The most common recommendations were for pump adjustments or retrofits. Where applicable, customers were advised to apply for a rebate under PG&E's retrofit programs.

The end uses addressed in the agricultural audits primarily included water pump tests, retrofits and adjustments. Other end uses addressed included lighting, crop water requirements, refrigeration compressor and HVAC electricity use.

2.4 Evaluation Overview

The impact evaluation described in this report covers all measures installed at agricultural accounts, as determined by the Management Decision Support System (MDSS) sector code, which were included under the RE, Customized, and EMS programs and for which rebates were *paid* during calendar year 1994. As a result, the evaluation includes measures offered under PG&E programs fielded in previous years.

The impact evaluation results in both gross and net impacts, and compares these estimates to the program design estimates.

2.4.1 Objectives

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

- Determine first year gross impacts (kW, kWh, and therms) of the 1994 agricultural program measures installed (paid during 1994) through PG&E's EMS, RE, and Customized programs as required by the California Public Utilities Commission (CPUC) protocols.

- Determine first year net impacts (kW, kWh, and therms) of the 1994 agricultural program measures installed (paid during 1994) through PG&E's EMS, Customized, and RE Programs as required by the CPUC protocols.

- Compare evaluation results with PG&E's (ex ante) estimates and identify the basis for discrepancies between the evaluation results and PG&E's estimated impacts.

- Determine and analyze EMS customer response to these PG&E programs and determine the degree to which participation in the EMS Program contributed to follow-on participation in the RE or Customized Program.

Results are segmented by technology type. Technologies are defined by measures offered by the RE and Customized programs. These technologies were then grouped into either pumping or miscellaneous [other agricultural end uses; and the traditional commercial type technologies (i.e., lighting, HVAC, refrigeration, food service, process)].

The difference between gross and net impacts is the behavior that affected customers' participation. Adjustments were made to the gross estimate of savings for (1) customers that would have installed energy-efficient measures even without the program (free-riders) and (2) customers that installed energy efficient measures as a result of the presence of the program, resulting in savings that were beyond the program-related gross savings of the participants (spillover).

The evaluation investigated and, where possible, explained differences between program design estimates and evaluation results. The evaluation also made recommendations for improving program design estimates (ex ante). This should result in future post-implementation evaluation savings (ex post) that are closer to ex ante estimated savings.

2.4.2 Timing

The 1994 Agricultural Impact Evaluation began in April of 1995, completed the planning stage in June 1995, executed data collection between late July and October 1995, and completed the analysis and reporting phase in January and February 1996.

2.4.3 Role of Protocols

This evaluation was conducted under the rules specified in the "Protocols and Procedures for the Verification of Cost, Benefits, and Shareholder Earnings from Demand Side Management Programs" (the Protocols), as adopted by CPUC Decision 93-05-063, Revised January 1995 Pursuant to Decisions 94-10-063, 94-10-059, and 94-12-021. To the extent it was possible during an ongoing evaluation, many of the consensus changes included in the July 14, 1995 Filing by the California DSM Measurement Advisory Committee (CADMAC) before the CPUC of the State of California were incorporated into the evaluation.

The Protocols control most aspects of the evaluation. They specify the minimum sample sizes, the required precision, data collection techniques, certain minimum analysis approaches, and formats for documenting and reporting results to the CPUC. This evaluation has endeavored to meet all Protocol requirements, and where possible, enhance evaluation techniques or results to supply added value to the developed estimates.

2.5 Report Layout

This report presents the results of the above evaluation. It is broken into five sections, plus appendices. *Sections 1* and *2* are the *Executive Summary* and the *Introduction*. *Section 3* presents detailed results and discussion. *Section 4* discusses and presents recommendations for improving the evaluation, the program measures, the program tracking, and the CPUC protocols. *Section 5* presents the Methodology of the evaluation. It is supported in detail by *Appendices A, B, C, J, P, Q,* and *R*. The remainder of the appendices document the data collection efforts undertaken during the evaluation.

Section 3

EVALUATION RESULTS SUMMARIES

This section summarizes the results of this evaluation, starting with the gross impact results, then discussing the net-to-gross (NTG) adjustments, and concluding with the program realization rates (ratio of evaluation findings to the ex ante program design estimates) on both a gross and net basis. Reasons for the deviations from the ex ante estimates are discussed along with the presentation of the realization rates. As has been discussed in *Section 2,* the impacts reviewed below are for measures paid during 1994, which means that they include measures that were offered under previous years' programs.

Results are segmented by end use. They are summarized as the combined Agricultural Energy Efficiency Incentives (AEEI) programs [Retrofit Express (RE) and Customized Incentives (Customized)] and the Energy Management Services Program (EMS). Additionally the results are subtotaled by: (1) Agricultural Pumping, representing all agricultural measures receiving rebates that are directly related to the pumping end use; (2) Agricultural Miscellaneous, representing nonpumping-related measures that received rebates in the agricultural sector under the AEEI programs; and (3) EMS, including all measures that were identified as having been installed because of the presence of the EMS program and which did not receive rebates under other Pacific Gas & Electric (PG&E) programs.

3.1 Gross Energy Impact Results

Exhibits 3-1 presents the gross energy, demand and therm impact results from the evaluation. The gross evaluation impacts for energy and demand by PG&E costing period are covered in *Appendix I.*

Exhibit 3-1
1994 Agricultural Program Gross Impacts

End Use	Action Code	N	Gross Program Impact kWh	kW	Therm
Agricultural - Pumping					
Agricultural Pumps Other	609	2	18,605	37	0
Agricultural Water System Equipment Change - ISS	610	3	130,736	93	0
Agricultural Water System Changes	629	8	5,172,445	800	0
Agricultural Change/Add Equipment	670	7	252,219	832	0
Pump Retrofit	A1	807	26,563,062	3,808	0
Time Clock with Battery Backup (Agricultural)	A11	52	484,770	0	0
Pump Adjustment	A4	1,380	999,900	0	0
Well Water Measurement Device	A5	118	1,453,383	266	0
Sprinkler Nozzle : Low Pressure	A6	69	8,036,293	2,055	0
Surge Valve	A7	3	108,528	0	0
Motors: Energy Efficient	M13-M38	102	395,093	62	0
Motors: Energy Efficient	M7-M8	4	3,999	1	0
Agricultural Pumping Total		2,555	43,619,032	7,951	0
Agricultural - Miscellaneous					
Agricultural Other	689	5	470,446	286	0
Greenhouse : Heat Curtain	A10	17	0	0	811,414
Milk Pre-Cooler	A2	15	506,163	0	0
Refrig : Desuperheater (Agricultural)	A3	4	71,178	0	0
Greenhouse : Rigid Double-Walled Plastic	A8	16	0	0	246,675
Greenhouse : Double-Walled Polyethylene	A9	16	0	0	647,826
Refrigeration		25	7,129,150	686	0
Food Service		1	1,681	0.10	0
Process		2	270,400	55	19,136
HVAC		14	161,897	94	0
Lighting Indoor		259	11,679,445	837	0
Lighting Outdoor		45	391,540	0	0
Agricultural Miscellaneous Total		419	20,681,899	1,958	1,725,050
Agricultural Energy Efficiency Incentives Total		2,974	64,300,932	9,910	1,725,050
Agricultural EMS Program Total		5,380	NA	NA	NA

The results illustrate the following findings:

- The pump retrofit measure represents about 40 percent of the AEEI program total impacts for energy and 38 percent for demand.
- Low pressure sprinkler nozzles, although representing only 2 percent of the accounts receiving rebates, represent 13 percent of the energy impact and 21 percent of the demand impact for the AEEI program.
- Although the pump adjustment measure had 46 percent of the accounts receiving rebates, it represented only 2 percent of the energy impact for the AEEI program.

- The Customized program (shown by those measures with a numerical action code) plays a small role in the energy impact with just over 10 percent of the AEEI program energy impacts. The Customized program plays a large role in the demand impact with approximately 41 percent of the AEEI program demand impacts being attributable to this program. As can be seen in Exhibit 3-1, this is primarily because many of the energy efficiency measures offered under the RE program (alpha numeric action codes) have minimal peak demand impacts, while all Customized measures (numeric action codes) and Miscellaneous (no action codes) measures all have peak impacts.

- No gross impacts are presented for the EMS program. All of the impacts are considered program spillover, since the primary purpose of the program is to encourage the customer to take action thereby creating spillover effects. Net results for the EMS program appear in Exhibit 3-3.

3.2 Net-to-Gross Adjustments

The NTG results account for all of the market spillover effects (free ridership, participant spillover and nonparticipant spillover). NTG estimates are supplied by measure and as an overall estimate for the program. The market analysis NTG approach, which will be discussed in *Section 5,* is the method that provided the highest reliability and could support measure level analysis.

Exhibit 3-2 presents the NTG values by measure, along with the 90 percent confidence intervals, without nonparticipant spillover and with nonparticipant spillover. The estimates are presented this way because of the large effect that nonparticipant spillover has on the NTG values.

Nonparticipant spillover accounts for customers who were not participants but installed high efficiency measures because of the presence of the program. This effect is determined by assessing the percentage of the nonparticipant population who installed high efficiency measures (such as occurred with low pressure sprinkler nozzles) because of the presence of the program and then multiplying this percentage by the nonparticipant population. Since the nonparticipant population is large, a small percentage of nonparticipant actions can create a large spillover effect relative to the program impact.

While QC computed and presents NTG estimates without and with nonparticipant spillover, we are convinced that nonparticipant spillover exists and that the values presented including nonparticipant spillover are the best estimates of the NTG adjustments.

Exhibit 3-2
Best Estimates of NTG Adjustments

	Without NP Spillover		
Measure	**Lower 90%**	**Midpoint**	**Upper 90%**
Pump Retrofit	0.59	0.69	0.78
Pump Adjustment	0.76	0.86	0.95
Low Pressure Sprinkler Nozzle	0.39	0.52	0.65
Water System Changeout	0.21	0.32	0.43
Custom Measures	0.21	0.33	0.46
Overall	0.51	0.60	0.69

	With NP Spillover		
Measure	**Lower 90%**	**Midpoint**	**Upper 90%***
Pump Retrofit	0.70	0.83	0.96
Pump Adjustment	0.89	1.29	1.68
Low Pressure Sprinkler Nozzle	0.52	1.42	2.00
Water System Changeout	0.32	0.32	0.32
Custom Measures	0.33	0.33	0.33
Overall	0.61	0.89	1.10

*Capped at 2.0

3.3 Net Impacts

Exhibit 3-3 presents the net energy, demand and therm impacts.

Exhibit 3-3
1994 Agricultural Program Net Impacts

			Net Program Impact		
End Use	**Action Code**	**NTG**	**kWh**	**kW**	**Therm**
Agricultural - Pumping					
Agricultural Pumps Other	609	0.33	6,140	12	0
Agricultural Water System Equipment Change - ISS	610	0.32	41,836	30	0
Agricultural Water System Changes	629	0.32	1,655,182	256	0
Agricultural Change/Add Equipment	670	0.33	83,232	274	0
Pump Retrofit	A1	0.83	22,047,341	3,160	0
Time Clock with Battery Backup (Agricultural)	A11	0.89	431,445	0	0
Pump Adjustment	A4	1.29	1,289,871	0	0
Well Water Measurement Device	A5	0.89	1,293,510	237	0
Sprinkler Nozzle : Low Pressure	A6	1.42	11,411,536	2,918	0
Surge Valve	A7	0.89	96,590	0	0
Motors: Energy Efficient	M13-M38	0.75	294,848	46	0
Motors: Energy Efficient	M7-M8	0.76	3,039	0	0
Agricultural Pumping Total		0.89	38,654,571	6,933	0
Agricultural - Miscellaneous					
Agricultural Other	689	0.33	155,247	94	0
Greenhouse : Heat Curtain	A10	0.79	0	0	641,017
Milk Pre-Cooler	A2	0.79	399,869	0	0
Refrig : Desuperheater (Agricultural)	A3	0.79	56,230	0	0
Greenhouse : Rigid Double-Walled Plastic	A8	0.79	0	0	194,873
Greenhouse : Double-Walled Polyethylene	A9	0.79	0	0	511,782
Refrigeration		0.65	4,633,948	446	0
Food Service		0.75	1,261	0.08	0
Process		0.73	196,040	40	13,874
HVAC		0.67	108,471	63	0
Lighting Indoor		0.77	8,993,172	644	0
Lighting Outdoor		0.77	301,486	0	0
Agricultural Miscellaneous Total		0.72	14,845,724	1,288	1,361,546
Agricultural Energy Efficiency Incentives Total		0.83	53,500,295	8,221	1,361,546
Agricultural EMS Program		1.00	13,831,040	3,205	NA

Overall, Exhibit 3-3 shows a 17 percent decrease in ex post program energy impacts, and demand impacts and a 21 percent decrease in therm impacts (when compared to Exhibits 3-1, gross impacts) as a result of the application of the NTG adjustments presented in Exhibit 3-2 and shown in the NTG column of Exhibit 3-3.[1]

[1] Ex ante NTG values were used for measures where no evaluation NTG result was generated.

Close examination of these results identifies the following findings:

- **Pump Retrofits** - The impact decreased by 17 percent, as a result of the 0.83 NTG adjustment factor. Since this measure had the largest percent of the gross impact, this NTG adjustment impacted the program total.

- **Pump Adjustments** - This measure was one of two with a NTG ratio above 1.0. However since the gross number contribution was small, the NTG ratio of 1.29 made little impact on increasing the total net number.

- **Low Pressure Nozzles** - The low pressure nozzle NTG value was the other measure with a NTG ratio above 1.0. This NTG value of 1.42 moved this measure from 12 percent of the total gross impact to 21 percent of the total net impact.

- **EMS Program** - The impacts for the EMS program were determined by using the number of customers who installed a measure due to the EMS program, and who stated that they would not have done this without the EMS program and the auditor's recommendation. Because this is the definition of spillover, the NTG ratio is 1.0.

3.4 Gross Realization Rates

Exhibit 3-4 presents the gross realization rates for energy, demand and therm impacts by measure.

Exhibit 3-4
1994 Agricultural Program Gross Realization Rates

		Realization Rates		
End Use	**Action Code**	**kWh**	**kW**	**Therm**
Agricultural - Pumping				
Agricultural Pumps Other	609	1.00	1.00	NA
Agricultural Water System Equipment Change - ISS	610	1.00	1.00	NA
Agricultural Water System Changes	629	1.00	1.00	NA
Agricultural Change/Add Equipment	670	1.00	1.00	NA
Pump Retrofit	A1	0.97	0.81	NA
Time Clock with Battery Backup (Agricultural)	A11	1.00	NA	NA
Pump Adjustment	A4	0.07	NA	NA
Well Water Measurement Device	A5	0.77	NA	NA
Sprinkler Nozzle : Low Pressure	A6	1.81	1.94	NA
Surge Valve	A7	1.00	NA	NA
Motors: Energy Efficient	M13-M38	1.00	1.00	NA
Motors: Energy Efficient	M7-M8	1.00	1.00	NA
Agricultural Pumping Total		0.81	1.05	NA
Agricultural - Miscellaneous				
Agricultural Other	689	1.00	1.00	NA
Greenhouse : Heat Curtain	A10	NA	NA	1.22
Milk Pre-Cooler	A2	1.00	NA	NA
Refrig : Desuperheater (Agricultural)	A3	1.00	NA	NA
Greenhouse : Rigid Double-Walled Plastic	A8	NA	NA	0.73
Greenhouse : Double-Walled Polyethylene	A9	NA	NA	1.00
Refrigeration		1.00	1.00	NA
Food Service		1.00	1.00	NA
Process		1.00	1.00	1.00
HVAC		1.00	1.00	NA
Lighting Indoor		0.80	0.34	NA
Lighting Outdoor		1.00	NA	NA
Agricultural Miscellaneous Total		0.87	0.55	1.03
Agricultural Energy Efficiency Incentives Total		0.83	0.89	1.03
Agricultural EMS Program Total		NA	NA	NA

These realization rate values represent, by measure, the ratio of gross impact evaluation findings to the gross ex ante program design estimate of impacts. They illustrate how well the ex ante estimates were at predicting actual impacts, before taking into account customer behavioral effects both inside and outside the program.

Overall, Exhibit 3-4 shows that the ex ante energy estimates are 17 percent above the ex post estimates for the AEEI programs (RE and Customized) with a realization rate of 0.83.

The results presented in Exhibit 3-4 can be explained using information from the review of the ex ante estimates (*Appendix J*) in conjunction with the impact analysis results. Explanations of the results by measure are:

3.4.1 Pumping

- **Pump Retrofit** - The gross ex ante estimate and the gross ex post estimate were close for energy (3 percent) and slightly farther apart for demand (19 percent). The ex post estimate of lower demand impact is due to the decreased efficiency ratios used from the 1993/94 pump test database.
- **Pump Adjustment** - The realization rate of 0.07 is due to the unrealistic ex ante impact estimate. The ex ante estimate uses an 11 percent impact for each pump adjustment. Experts in the field state that if a pump adjustment decreases the energy use by 2 percent, the grower is satisfied with the results and that a 1.5 percent impact is more likely to occur. Additionally the ex post estimate is based on the 1992 energy consumption for each account, while the ex ante estimate is based on a fixed value per adjustment (see *Appendix J*).
- **Well Water Measurement Device** - The energy realization rate is 0.77, due to a decrease in the impact per foot installed as estimated in the engineering analysis of this measure. This measure has a demand component to it which has been implemented in the gross ex post estimate. Since the ex ante estimate had no demand component, the realization rate is not applicable (see *Appendix J*).
- **Low Pressure Sprinkler Nozzles** - Evaluation results on the application of sprinkler system types, sprinkler differences by region, and the irrigation efficiency of sprinkler systems created an increase in the ex post per nozzle energy and demand impacts. Therefore, the ex post energy and demand estimates are higher than the ex ante estimates (see *Appendix J*).

3.4.2 Miscellaneous

- **Greenhouse Measures** - Of the greenhouse measures, only the heat curtain showed an evaluation impact greater than the ex ante estimate. This was offset by the lower than expected impacts for the rigid double-wall measures. Overall the greenhouse shell measures had a realization rate of 1.03, thus agreeing with the ex ante estimates.

- **Indoor Lighting** - The hours of operation for the indoor lighting were reviewed and changed, which caused the realization rate to be 0.80 for energy and 0.34 for demand. This was mainly due to the High Intensity Discharge (HID) technology, which was installed in nursery greenhouses and had fewer hours of operation than the ex ante algorithm assumed. Also, this technology was not used during the summer peak period and therefore, the demand impact could not be credited to the program.

3.4.3 EMS

- No gross impacts are presented for the EMS program. All of the impacts are considered program spillover, since the primary purpose of the program is to encourage the customer to take action thereby creating spillover effects.

3.5 Net Realization Rates

The net energy realization rates are presented in Exhibit 3-5. These values represent, by measure, the ratio of net ex post evaluation impact to the net ex ante program design estimate of impact. The net realization rates illustrate how well the ex ante estimates predict ex post impacts, after taking into account customers' actions within the agricultural market. As shown in the equation below, the realization rates can be broken down into two components: one that considers the relationship between the ex post and ex ante measures of gross impact and a second that compares the ex post and ex ante NTG values.

$$RR = \left(\frac{Ex\ \ Post\ \ Gross}{Ex\ \ Ante\ \ Gross}\right) * \left(\frac{Ex\ \ Post\ \ NTG}{Ex\ \ Ante\ \ NTG}\right)$$

where

RR = the realization rate.

The difference between the gross and net realization rates is varied. Since many of the gross realization rates were near 1.0, differences in the net realization rates stem mainly from differences between the ex ante and the ex post estimates of the NTG adjustment. The ex ante NTG estimates varied between 0.65 and 0.76[2], depending on the measure. As can be seen from Exhibit 3-3 above, the evaluation NTG estimates vary between 0.32 and 1.42, dependent upon the measure.

[2] These numbers were taken from the MDSS.

There is an overall net realization rate of 0.89 for energy and 0.96 for demand for the AEEI programs (RE and Customized). For Pumping Measures the net realization rate is 0.91 for energy and 1.17 for demand. For Agricultural Miscellaneous measures, the net realization is 0.86 for energy, 0.49 for demand and 1.03 for therms. Realization rates for the EMS program are 1.05 for energy and 0.86 for demand. Results are described in more detail below.

Exhibit 3-5
1994 Agricultural Program Net Realization Rates

		Realization Rates		
End Use	**Action Code**	**kWh**	**kW**	**Therm**
Agricultural - Pumping				
Agricultural Pumps Other	609	0.44	0.44	NA
Agricultural Water System Equipment Change - ISS	610	0.44	0.44	NA
Agricultural Water System Changes	629	0.43	0.43	NA
Agricultural Change/Add Equipment	670	0.44	0.44	NA
Pump Retrofit	A1	1.02	0.85	NA
Time Clock with Battery Backup (Agricultural)	A11	1.13	NA	NA
Pump Adjustment	A4	0.12	NA	NA
Well Water Measurement Device	A5	0.87	NA	NA
Sprinkler Nozzle : Low Pressure	A6	3.25	3.49	NA
Surge Valve	A7	1.13	NA	NA
Motors: Energy Efficient	M13-M38	0.99	0.99	NA
Motors: Energy Efficient	M7-M8	1.00	1.00	NA
Agricultural Pumping Total		0.91	1.17	NA
Agricultural - Miscellaneous				
Agricultural Other	689	0.45	0.45	NA
Greenhouse : Heat Curtain	A10	NA	NA	1.22
Milk Pre-Cooler	A2	1.00	NA	NA
Refrig : Desuperheater (Agricultural)	A3	1.00	NA	NA
Greenhouse : Rigid Double-Walled Plastic	A8	NA	NA	0.73
Greenhouse : Double-Walled Polyethylene	A9	NA	NA	1.00
Refrigeration		1.00	1.00	NA
Food Service		1.00	1.00	NA
Process		1.00	1.00	1.00
HVAC		1.00	1.00	NA
Lighting Indoor		0.80	0.34	NA
Lighting Outdoor		1.00	NA	NA
Agricultural Miscellaneous Total		0.86	0.49	1.03
Agricultural Energy Efficiency Incentives Total		0.89	0.96	1.03
Agricultural EMS Program Total		1.05	0.86	NA

As discussed previously, some of the results presented in Exhibit 3-5 can be explained using information from the review of the ex ante estimates (*Appendix J*) and the evaluation engineering, billing regression and NTG analyses. Most of the comments discussed in relation to the gross realization rate estimates apply to the net realization rates. Some are repeated here for completeness. Specific comments and justifications for the net realizations presented in Exhibit 3-5 are:

3.5.1 Pumping

- **Low Pressure Sprinkler Nozzles** - The energy realization rate increased (from 1.81 gross to 3.25 net) with the increase in NTG from ex ante value 0.79 to ex post value of 1.42. This measure had the largest single impact on the overall net realization results.

- **Pump Adjustment** - This energy realization rate increased (from 0.07 gross to 0.12 net) with the increase in NTG from ex ante value 0.76 to ex post value of 1.29. The energy impact gained from this measure, however, were minimal because of the relatively small contribution of this measure to the total program impacts.

3.5.2 Miscellaneous

- **Custom Measures** - The custom measures had a gross realization rate of 1.0, but with a NTG substantially lower than the ex ante estimate of 0.73 or 0.75, these measures show a net realization rate between 0.43 and 0.45.

- **Therm and Lighting Measures** - The gross and net realization rates for indoor lighting measures and measures which showed therm impacts are identical since the evaluation did not develop ex post NTG adjustments for these measures.

3.5.3 EMS Program

- The EMS ex post net estimate is based on a large occurrence of nonparticipants who installed low pressure nozzles outside of the RE or Customized program, because of the EMS program. The ex ante estimate is based on 16 percent of the EMS participants retrofitting a pump. This ex ante assumption about pump retrofits was incorrect, since less than 10 percent of EMS customers retrofitted a pump outside of the program as a result of the EMS program. The unanticipated nozzle retrofit impact, however, offset the lower than expected pump impact. This result indicates the wisdom of the offering a wide range of recommendations during the EMS inspections and letting the market decide which measure fits its needs.

3.6 Overview of Realization Rates

The realization rates are the ex post impact divided by the ex ante impact. Thus they incorporate both the ex post and the ex ante NTG adjustments. Since the ex ante and ex post NTG adjustments are similar, the NTG adjustments had only a small upward effect on the realized impacts (compare the gross and net realization rates).

The net energy and demand realization rates range from 0.86 to 1.17, with the exception of Agricultural Miscellaneous demand which is 0.49 because of a specific measure. However, individual measures deviate significantly from the ex ante impact estimates. A high net realization rate happens to coincide with a high impact measure for low pressure sprinkler nozzles, resulting in high program net realization rates. On the other hand, low gross realized impacts for Customized measures in nursery lighting applications resulted in low realization rates for these segments.

The bottom line is that the PG&E ex ante estimate of net energy impact is 11 percent above the ex post estimate of net energy impacts for the AEEI programs overall (9 percent above for Pumping and 14 percent above for Miscellaneous) and 5 percent below the ex post estimate of net energy impacts for the EMS program. The ex ante estimate of demand impact is 4 percent above the ex post estimate of net for the AEEI programs overall (17 percent below for Pumping and 51 percent above for Miscellaneous) and 16 percent above the ex post estimate of net demand impacts for the EMS program.

Section 4

RECOMMENDATIONS

Recommendations that enhance future program performance and evaluations are presented in this section. Recommendations regarding evaluation methods are followed by those affecting the program's design. Finally, recommendations regarding the Protocols are offered.

4.1 Evaluation Methods

The evaluation team offers the following comments and recommendations regarding methods used in the 1994 evaluation:

- **General Issues for Quantifying Spillover Effects** - Because the nonparticipant market size is so large, including nonparticipant spillover effects in net-to-gross (NTG) calculations has a significant impact on the final NTG ratios. The nonparticipants affect the 1994 net evaluation results by as much as 25 percent of the gross impact. Therefore, the evaluation team recommends collecting additional data (such as trade ally surveys) every second or third year to gauge the program's market movement effects. This second source of data will help support the program's cost recovery claims for spillover effects.

- **Spillover Effects for Low Pressure Sprinkler Nozzles** - In order to calculate spillover effects and NTG ratios more accurately, the evaluation team recommends collecting the number of sprinkler nozzles installed outside the program (for spillover effects). The team also recommends detailed questioning regarding the set of accounts which may be affected by the sprinkler nozzles. In this evaluation, customers were only asked if they had installed low pressure sprinkler nozzles, not how many were installed. This data would be useful in adjusting nonparticipants spillover impacts.

- **Assess Demand Impact of Outdoor Lighting** - Program design demand impact estimates for exterior lighting systems assume no operation during daylight hours, and thus generally predict zero demand during the summer on-peak hour. Although the PG&E Commercial/Industrial Lighting Evaluation showed that some exterior lights are actually on during the peak hours, this finding was not implemented in this evaluation because of the belief that the use patterns in the commercial and industrial sectors are not similar to those in the agricultural sector. We recommend that this be explored further in future evaluations.

4.2 Program Design

The program design discussion is separated into three subject areas: program design estimates, measures offered, and program tracking.

4.2.1 Program Design Estimates

The evaluation team offers the following comments and recommendations regarding the methods used to generate program design estimates:

- **Update the Coincident Diversity Factor (CDF)** - The CDF — used in predicting demand during the on-peak season at the system peak hour — should be updated prior to the next evaluation. This value was investigated during this evaluation, but no definitive new CDF was agreed upon prior to this report. PG&E should clarify the method for calculating the CDF for demand impact.

  The agricultural CDF is particularly unstable compared to the Commercial/ Industrial CDF because: (1) the Agricultural peak occurs at a distinctly different time than the system peak (11:00 AM versus 3:00 PM or 4:00 PM); (2) it is much more dependent upon *annual* weather and rainfall (rather than weather in the previous two or three days, which is more important to system peak); and (3) the annual Agricultural peak can occur on a different day, or even in a different month, than the system peak.

  As far as QC can determine, the diversity factor used in the current ex ante agricultural demand estimate was developed using 1991 data and is the product of a coincidence factor and a diversity factor for that year. QC has not been able to determine the actual combination of these two factors used to compute the 1991 CDF of 0.53.

  In our opinion, there are two key concepts that would assist PG&E in creating a more stable and defensible CDF for the ex ante estimate. First, the coincidence portion of the CDF should be developed using historical data from as many years as possible in order to arrive at an estimate that represents the "average" value. Second, for the diversity estimate, we suggest that PG&E attempt to maximize the number of accounts included in the computation, while being sure to limit those used in the computation to pumping only accounts. This could be accomplished by using data PG&E has collected over the past five to ten years and weighting the diversity factor developed for each year by the number of points in each year's dataset.

  These two approaches should limit variation in the Agricultural CDF estimate, while at the same time creating a defensible CDF for presentation to the California Public Utilities Commission (CPUC).

- **Clarify and Separate Various Heat Curtain Measures** - On-site audits identified that two separate measures were actually rebated under the heat curtain measure code, the thermal heat curtain and a volume reduction measure based on installation of artificial ceilings made of single-sheet polyethylene plastic. Based upon on-site audit data, we recommend PG&E ascertain how the heat curtain measure is currently being implemented in the field. QC recommends that PG&E split the heat curtain measure into two distinct measures to account for: (1) thermal curtains, and (2) the decreased volume of an added single-sheet polyethylene plastic roof. Since these will create differing savings, there should be separate algorithms to account for the savings of each measure.

- **Use Segment Specific Operating Hours for Agricultural Lighting Measures** - We recommend that the ex ante estimates use hours of operation that are related to the type of business for the HID and Compact Fluorescent technologies. Analysis during this evaluation showed that these two technologies are located in three business groups and make up 95 percent of the impact for lighting measures. Program design impacts for all lighting technologies of the Agricultural sector were based on 4000 operating hours. Investigation into where the HID technology was installed for the 1994 program showed that the ex ante hours of operation were greatly overestimated for this technology.

4.2.2 Measures Offered

The realization rate estimates (ratio of the evaluation estimated savings to the ex ante savings on a gross and net basis) in *Section* 3 allow for the identification of measures that either exceed or fall below expectations.

Of the agricultural measures evaluated for the 1994 program, only three (pump retrofit, low pressure sprinkler nozzle and heat curtain) are being offered for the 1995 program. The nozzle and heat curtain measures exceeded program design expectations on both a gross and net basis. This is primarily a result of the evaluation estimates resulting in higher ex post impacts than originally anticipated during program design. In the case of low pressure sprinkler nozzles, significant participant and nonparticipant spillover also contributed to the high net realization rates. The pump retrofit measure had realization rates between 0.81 and 1.02, illustrating that the ex ante estimates are conservative.

Exhibits 3-4 and 3-5 allow identification of measures that should be reassessed in terms of their viability. This does not imply that these measures are not valuable, but rather that the original estimate of design savings was higher than that actually achieved. The 1995 program only encompasses the measures of pump retrofit, low pressure nozzle, heat curtain, lighting and HVAC. Of these measures, only the lighting measures indicated that there were net and gross ex post decreases compared to the ex ante estimates.

Measures with low realization rates are discussed and explained in *Section 3, Evaluation Results Summaries.*

4.2.3 Program Tracking

Three key recommendations regarding the MDSS are offered here. The first is, by far, the most important recommendation.

- **Make Installation Date a Mandatory Field** - PG&E should make the date that the retrofit occurred a mandatory field for the MDSS. This date is necessary to evaluate program savings accurately. For the current evaluation, because of missing data in the MDSS, the installation date was set as the date when the rebate check was issued. The actual changeout may have occurred three, six, or sometimes even twelve months earlier. Choosing analysis periods that will meet the Protocol requirements of having twelve months pre- and nine months post-installation billing data for a load impact regression model (LIRM) is problematic, since the twelve months pre-installation billing data may actually represent energy use with the retrofit already in place. The timeliness of the analysis is driven by having at least nine months of post-installation billing data. Currently, this means that one must have January through September billing data available prior to any statistically adjusted engineering (SAE) analysis. For weather-driven analyses, where actual weather data is required, it is difficult, if not impossible, to obtain weather data with a one month turn-around. If the date of retrofit were known, a sample could be drawn that would allow the analysis to meet the needs of the Protocols and provide better quality impact estimates.

- **Collect Pump Horsepower and Enter in MDSS** - QC recommends that the horsepower of the pump being retrofitted be included as a mandatory field for entry in the MDSS. The actual horsepower of the pump retrofitted is now a field within the 1995 REO program application form and should be checked to be sure that what is entered is not the horsepower bin, but the actual pump horsepower. This inclusion, if used in the demand impact estimates for the pumping will provide a better estimates of actual energy and demand impact. It would also facilitate identification of the correct account when interviewing growers, since growers can often identify their pumps by horse power. This, in turn, would provide a better mapping of retrofitted pumps to crops and watering patterns, thus helping the impact analysis.

- **Populate Inspection Date Fields** - Pre- and post-inspection dates should be entered into the MDSS, where applicable. Key program dates are important in verifying installation dates and estimating program impacts. The 1994 Agricultural Program records from the 1994 MDSS are missing the following data:

  - Pre-inspection dates: 80 percent (2,480 records) were unpopulated.

- Post-inspection dates: 59 percent (1,809 records) were unpopulated.

It is unclear whether only 20 percent of program participants had a pre-installation inspection (or 40 percent had a post-installation inspection), or more participants had inspections with dates that were not entered into the MDSS. If installation date becomes a mandatory field (as suggested above) the presence of back-up data in the form of these two dates becomes less important.

4.3 Protocols

After working with the ex post application of the Protocols for over a year, QC offers the following recommendations:

- **Rationalize Sample Size Constraints to Reflect the Data Collection Success Rates - Table 5, Section C** - Sample Design for First Year Load Impact: Third bullet states "If the number of program participants is greater than 450, a sample must be randomly drawn and be sufficiently large to achieve a minimum precision of plus/minus 10 percent at the 90 percent confidence level, based on total annual energy use. A minimum of 450 must be included in the analysis dataset for each end use." This specification requires that a minimum of 450 participants must be included in the analysis dataset even if there are only 500 participants, or as in the case of the Agricultural program, 1,400 unique premises. Over the years, QC has completed more than 40,000 surveys, and expects, for most projects, only a 25 percent completion rate. For the Agricultural program, the response rate was unusually high, at approximately 35 percent, which allowed completion of the survey with 450 completed surveys. This was due to the fact that the growers were extremely helpful. Had this not been the case, it would have been impossible to complete the survey effort. Additionally, it should be noted that PG&E usually specifies its evaluations based upon telephone surveys as the primary data collection mechanism.

  There is an alternative approach for programs with greater than 450 participants, based upon using on-sties as the primary method of site-specific data collection, which allows fewer than 450 participants in the final dataset. However, this approach is based upon a different analysis/sample design approach, focused primarily upon on-site data collection.

  QC recommends that the Protocols be modified to include language indicating that the analysis dataset should include "450 or a census" for programs with participation levels of less than 2,000 unique participants, when the primary data collection mechanism is telephone surveys.

- **Change the Designated Unit for Agricultural Measures - Table 6 - 2B, 3B** - Table 6.2B and 6.3B ask for the average load impacts per designated unit of measurement, kWh/AF for the Agricultural Pumping measures. This unit of measure depends on specific knowledge of not only the efficiency of the pumping unit, but the depth of the water pumped. Since the total lift required of the pumping unit is highly variable item in terms of time and geography, this value will be difficult to track and compare. While the evaluation team is unclear about the purpose of the designated unit, it recommends using a more trackable normalizing unit. One possibility would be to use the unit of installation tracked by the utilities (e.g. number of nozzles purchased, number of pumps retrofitted, etc.) as the normalization factor for designated units. Overall clarification of the purpose of the designated unit would assist evaluators in supplying consistent meaningful results.

- **Clarify the Sample Size for the Retention Panel - Table 9A** - Table 9A states as part of the footnote that "The utility should select the top ten measures ranked by net resource value or the number of measures that constitute the first 50 percent of the estimated resource value, whichever number of measures is less." The Protocols do not specify the size of the sample required to satisfy this "top ten or 50 percent" requirement. PG&E has specified a retention panel size of 150 sites (probably based upon the number of on-sites that are being executed). Without a Protocol-based sample size, it is always a guessing game between the consultant and PG&E as to what will satisfy the Protocol requirements for Table 9A.

- **Coordinate Table 11 and Table 6** - The new Table 6 and Table 11 are inconsistent in their application in that Table 11 does not include the footnote indicating the optional nature of some of the inclusions. Tables 6 and 11 should be made consistent with the rest of the Protocols.

Section 5

EVALUATION METHODOLOGY

This section presents the evaluation methodology. An overview of the data sources and analysis methods is presented first. Details of the engineering, billing regression, and net-to-gross analyses follow.

5.1 Integrated Evaluation Approach Overview

One of the keys to obtaining the greatest accuracy from an evaluation is maximum utilization of all available data sources. The Quantum Consulting (QC)/Crop Care Services (CCS) Team used all existing data available from Pacific Gas & Electric (PG&E) and industry sources. The primary existing data sources divide into program documentation, prior evaluations, and PG&E customer data including customer applications:

- Program documentation sources include:
  - Program procedures documentation from the Commercial/Industrial/ Agricultural (CIA) Policy and Procedures Manual;
  - PG&E program designers and implementors and documentation on the program design estimates;
- Prior evaluations contributed:
  - 16 agricultural program reports on previous evaluations or assessments (see Exhibit 5-4 later in this report)
  - Supporting data from the 1994 Commercial/Industrial (C/I) Lighting evaluation (for lighting measures)
- PG&E customer data included:
  - Management Decision Support System (MDSS) database
  - Pump test database for 1993 and 1994
  - Program applications (paper files) from participating customers
  - CLASS Load Research data
  - PG&E billing data

In addition to the above data sources, the following new primary data and secondary data sources are incorporated into the evaluation:

- Primary data, in accordance with the Protocols, include:
  - 250 on-site surveys of program participants
  - 450 telephone surveys of Retrofit Express (RE) and Customized Incentive (Customized) Program participants
  - 450 telephone surveys of Energy Management Services (EMS) Program participants
  - 450 telephone surveys of nonparticipants
- The following secondary data sources also provided key inputs, particularly weather data, in the analysis:
  - California Irrigation Management Information Services
  - Department of Water Resources
  - Western Regional Climate Center
  - U.C. Cooperative Extension, Division of Agriculture and Natural Resources

The impact analysis plan is based upon a nested sample design, with a core on-site audit sample leveraged to a larger, less expensive, telephone survey. Data between these samples are leveraged through "overlapping items" between the telephone and on-site instruments. The MDSS database program application information is used to leverage results to the entire participant population. This approach results in the efficient use of all information to contribute to the final impact results. For both demand and energy, the application and program design data were used to create a data collection plan which guided the evaluation data collection efforts.

Demand Estimates for the PG&E RE and Customized Programs are based on engineering models using the 1993/94 pump test database. The approach for demand is separated into two categories, pumping and other measures. The pumping measures analysis covered the following tasks:

- The engineering analysis consisted of updating the efficiencies of the pre-change pump and post-change pump. Pumps are binned into three horsepower bins based on the MDSS value. Updated pre- and post-installation pump efficiencies are used to estimate the level of anticipated maximum demand.
- QC worked with the PG&E project manager to attempt to update the estimated coincident diversity factor (CDF); however, because no revised number could be determined, the historic CDF of 0.53 was used.

- CLASS Load Research data, time-of-use (TOU) and demand rate class data were used to investigate a Statistically Adjusted Engineering (SAE) load analysis. The SAE load analysis was unable to provide statistically significant results, therefore the engineering demand estimates were used for the first-year impacts.

Features of the analysis for other measures included:

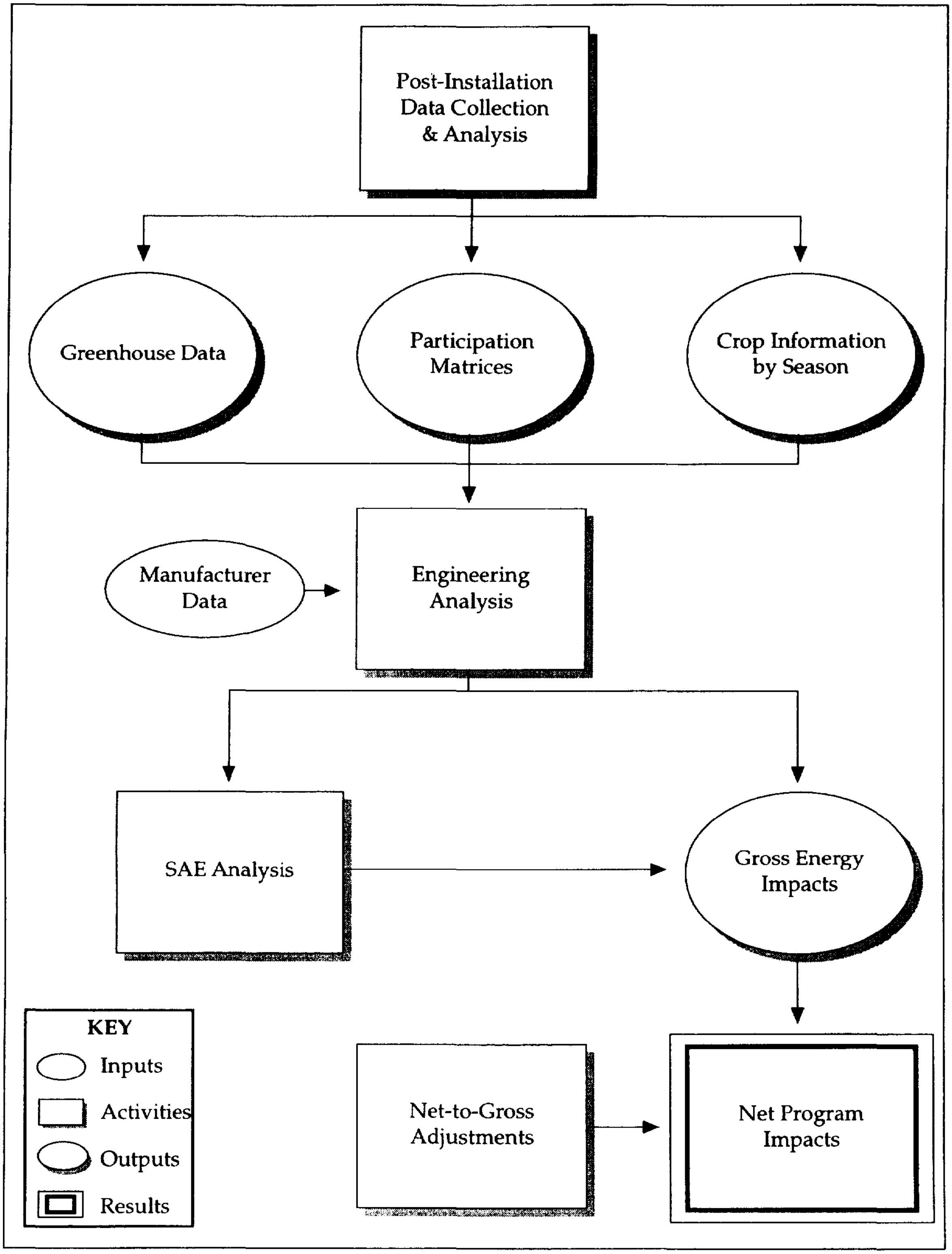
- Where impacts are small and on-site data were not available, ex ante estimates were reviewed and manufacturer information and engineering judgment were used to adjust assumptions and algorithms, as necessary.

- The per-unit demand impacts are combined with the units installed per hp classification, from the participation data, to calculate the evaluation estimate of demand impact for each segment.

Net-to-gross adjustments are developed using self-report data from the telephone survey. A self-report decision analysis model was used. The net-to-gross adjustments compensate for free-riders (participants who would have done it anyway) and spillover (reductions in energy or demand due to the presence of the program, beyond the program-related gross savings of the participants).

The *Energy Impact* estimates for the PG&E RE and Customized Programs are derived from a combination of engineering and SAE estimates. Exhibit 5-1 illustrates the overall approach to the energy impact analysis.

Exhibit 5-1
Method for Estimating Energy Impacts



- The per-unit engineering estimates for high participation/impact measures (pump retrofit and pump adjustment) are functions of weather, cropping patterns, soil leaching rate, acres watered, well depth and surface water availability. Engineering estimates for low participation/impact measures are based on a careful review and adjustment, as necessary, of the ex ante algorithms. Engineering estimates result in per-unit engineering energy impacts for the low participation segments and per-participant energy impacts for the high participation measures.
- The engineering energy impacts normally form the input to the SAE analysis *for segments with sufficient participation/impact.*
  - Engineering estimates are calculated based on ideal watering behavior for specific crops and technologies; they do not depend on actual usage information. This approach provides a deterministic algorithm that can be transferred to any weather conditions, including Typical Meteorological Year (TMY). These estimates track expected impacts for the participant population; however, on a specific customer basis, the engineering estimates have weaker correlation with the year-to-year usage changes than actual pre-participation usage. As a result, the pre-installation consumption was used as the proxy for the post-installation energy consumption. Therefore, the billing data analysis resulted in a direct estimate of actual customer-specific impacts. These billing data regression-based estimates are used to compute the equivalent of SAE realization rates by dividing these estimates by the engineering evaluation estimates. In this way, results could be transferred from this analysis to impacts characterizing typical weather conditions.
  - *For segments with participation/impact levels* too small to support statistical analysis, the adjusted engineering estimates were used directly as the evaluation estimate. All segments, as shown in Exhibit 5-1, enter into the billing data regression models; however, only the realization rates that are significant are used in computing the final evaluation estimates.
  - The two sets of results combined to represent the evaluation estimate of program savings. Both per-unit, and program gross impacts are presented by technology.
- Gross energy impacts are computed for each program participant using the per-unit impacts either adjusted by the SAE analysis or derived from calibrated models. In this way, a gross program realization rate can be computed relative to corresponding MDSS estimates that are available for each participant.
- Net-to-gross adjustments were developed based upon customer self report information collected during the telephone survey. A self-report decision analysis model was employed. The net-to-gross adjustments compensate for free-ridership and spillover. (See *Section 5.3.*)

5.2 Gross Impact Analysis

The gross impact analysis consisted of an integrated engineering and statistical analysis for the pump retrofit and pump adjustment measures, and an engineering analysis other measures. Exhibit 5-2 shows the overall approach to determining gross impacts for the RE and Customized Programs. The on-site audits focused on the customers who participated in both the EMS and either RE or Customized Programs.[1]

The EMS impact evaluation element concentrated on using the telephone survey to identify the rate at which customers performed an Agricultural measure as a result of their participation in the EMS program. These rates of measure adoption were then multiplied by the RE impact estimate for the respective measure, and ratioed to total participation levels to derive the program impact.

The RE and Customized Programs were divided into measures for which statistical impact analysis was feasible and measures for which it was not feasible, based upon levels of participation and ex ante impact. The measures for which a statistical analysis was attempted were pump retrofit, pump adjustment, low pressure sprinkler nozzle retrofits, and water system improvements. The billing data regression models were estimated, however, using the entire analysis sample so that the parameters of these models reflected the information of a representative sample. Of these four, only pump retrofit ended up with a viable statistical analysis result. For those measures that did not meet that criteria, an in depth engineering review of the algorithms and assumptions that went into the ex ante estimates of demand and energy impacts was performed. Each review was documented and modifications to the algorithms recommended with sources document. The ex ante estimate for the measure was then re-calculated.

The 1994 Customized Program had 30 agricultural participants. Each participant application underwent a detailed engineering review of the estimate used and assumptions made in the application for rebate. Estimates of savings would have been substituted had the original application estimates been determined to be insupportable. However, no changes in the savings estimates were done as the Customized savings were supported by the data provided with the applications.

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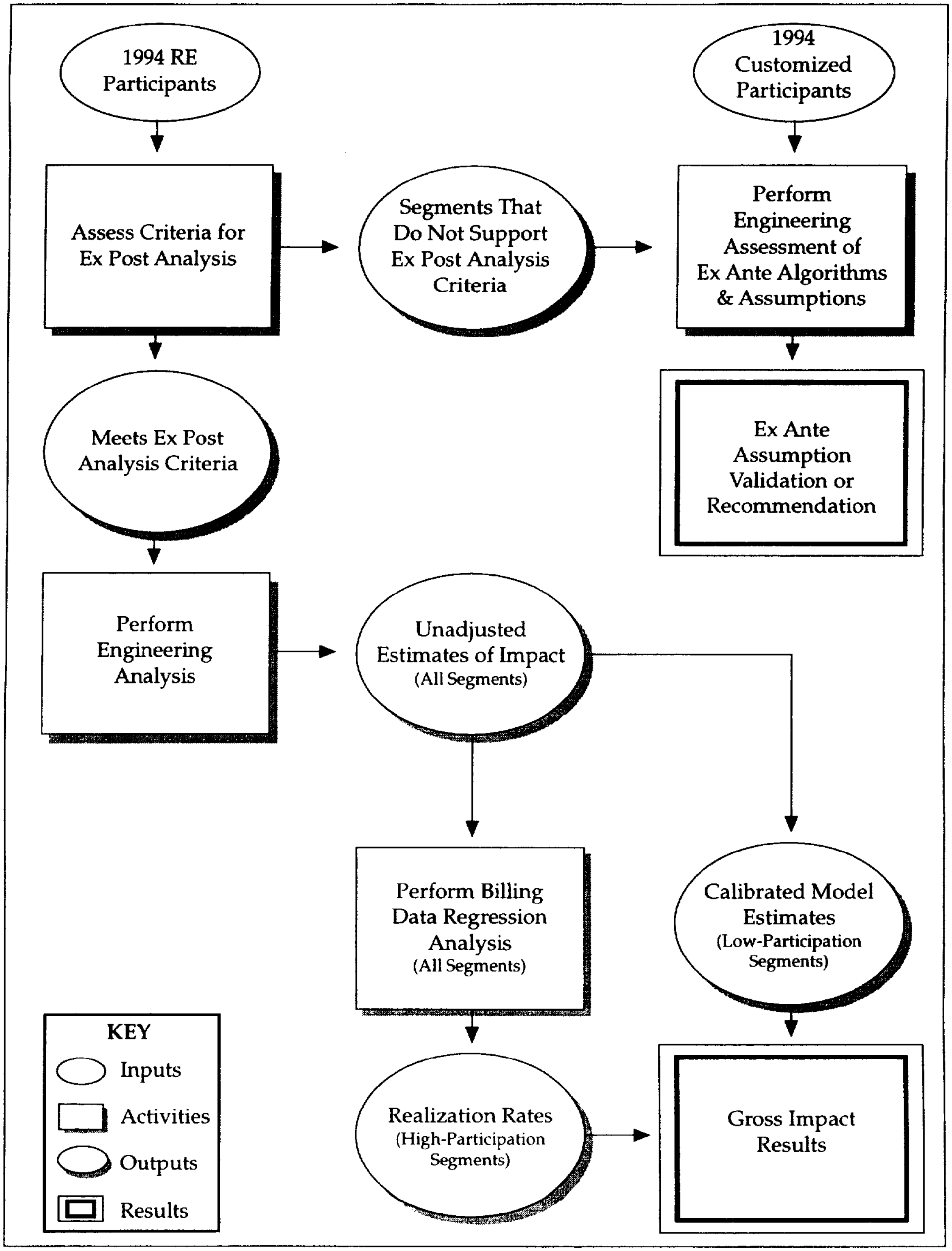
[1] Approximately 600 out of 2,400 RE/CI Pumping participants also participated in an EMS pump test in 1994.

Exhibit 5-2
Gross Impact Overview



5.2.1 Ex Post Criteria

Agricultural measure segmentation was based on net benefits to shareholders. Exhibit 5-3 below lists the measures included along with the method of ex post analysis applied. The approach to each of these analysis types is discussed next, starting with the ex ante review, then the engineering, then moving to the SAE analysis.

5.2.2 Engineering Assessment of Ex Ante Algorithms

For the measures listed in the right column in Exhibit 5-3, an engineering assessment of both the ex ante algorithm and assumptions controlling those algorithms was completed. In addition to using all QC resources available, QC engineers reviewed the reports shown in Exhibit 5-4 for relevant information to support or improve the engineering estimates. Changes in the algorithms were then applied to the final 1994 impact estimates for the evaluation.

Exhibit 5-3
Methods of Ex Post Analysis by Measure Type

SAE Ex Post Analysis	Engineering Ex Post Analysis	Engineering Review/Adjustment of Ex Ante Estimates
A1 - Pump Retrofit	A8 - Greenhouse, Rigid Double Walled Plastic	A2 -Milk Pre-cooler
	A9 - Greenhouse, Double Walled Polyethylene Plastic	A3 - Refrig: Desuperheater
	A10 - Greenhouse, Heat Curtain	A5 - Well Water Measurement Device
	L25-L30, L37, L79-L81 - High Intensity Discharge Lighting Fixtures	A6 - Sprinkler Nozzle: Low Pressure
	L3, L4, L63-L68 - Compact Fluorescent Lighting Fixtures	A11 - Time Clock with Battery Back-up
	A4 - Pump Adjustment	Other Lighting Measures
		All 30 Customized Participants

Exhibit 5-4
Outside Reports Reviewed for Engineering Background

Report	Report Number	Date
CIA Direct Rebate Engineering Study - Phase 1	CIA-91-S02	Dec. 91
CIA Rebate Evaluation Scoping Study	CIA-91X01	Dec. 91
Short Term Comm. Metering Project Site Report	-	Mar. 92
CIA Direct Rebate Programs - Hours of Operation Study	CIA-95-H06	Aug. 92
Customized Rebate Program On-Site Validation	CIA-95-A05	May 93
CIA Retrofit Rebate Program Final Report	CIA-93-X01	Sept. 93
CIA Retrofit Rebate Program - Billing Analysis	CIA-93-X01A	Sept. 93
Double Ratio Analysis Final Report	CIA-93-X01B	Sept. 93
HSEM Analysis - Final Report	CIA-93-X01C	Sept. 93
Final Short-Term Monitoring Results Report	CIA-93-X01D	Sept. 93
Net-to-Gross Ratios for CIA Rebate Program	CIA-93-X01E	Sept. 93
Net-to-Gross Ratios for CIA Rebate Program	CIA-93-X01F	Sept. 93
Net-to-Gross Ratios for CIA Rebate Program	CIA-93-X01G	Sept. 93
Net-to-Gross Ratios for CIA Rebate Program	CIA-93-X01H	Sept. 93
Impact Eval of 1990-92 NonRes EMS Programs	CEQ-93-A01	Dec. 93
Design Methodology for Agricultural Measurement and Evaluation	CIA-94-B03	Sept. 94
Agricultural CLASS Load Study	N/A	May 93

Exhibit 5-5 presents an overview of the results of the ex ante algorithm review.

Exhibit 5-5
Overview of Ex Ante Engineering Analysis

Item	Description	Ex Ante Assumptions Valid?	Ex Ante Algorithm Valid?	Recommendations
A1	Pump Retrofit	○	●	●
A2	Milk Pre-cooler	●	●	○
A3	Refrig: Desuperheater	●	●	○
A4	Pump Adjustment	○	○	●
A5	Well Water Measurement Dev.	●	○	●
A6	Sprinkler Nozzle: Low Pressure System	○	●	●
A8	Greenhouse, Rigid Double Walled Plastic	○	●	●
A9	Greenhouse, Double Walled Polyethylene Plastic	○	●	●
A10	Greenhouse, Heat Curtain	○	●	●
A11	Time Clock with Battery Back-up	●	●	○

●= Yes or ○= No

The specifics of the review are summarized in a one- to two-page synopsis for each measure in the format shown in Exhibit 5-6. The reviews are located in *Appendix J*.

Exhibit 5-6
Format of Ex Ante Analysis Results

Item: This will be the item name
Recommendation:
Technology Description:
Criteria for 1994 Program Participation:
Ex Ante Assumption:
Assessment of Assumption (kWh, kW, therm):
Ex Ante Impact Algorithm:
Assessment of Algorithm (kWh, kW, therm):
Expected Service Life: *
Incremental Cost: This will be the per-application average cost for 1994 based on MDSS database *
Rebate: This will be the per-application average rebate for 1994 based on MDSS database *
References:*

* These fields will not be used for the Customized results unless applicable.

This same assessment form was also completed for each of the 30 Customized participants. These results were summarized, by measure groupings, in the format illustrated above. These are also located in *Appendix J*.

5.2.3 Engineering Analysis

For those items that had an ex post analysis, the engineering analysis encompassed demand and energy impacts. Data was drawn from the tracking system, the pump test database, on-site surveys, telephone surveys and available weather and used in some portion of the engineering analysis. The demand results for the pumping portion of the RE and Customized Programs came exclusively from the engineering analysis. For ex post therm impacts, the engineering analysis created unadjusted estimates of impact based upon a DOE-2 model and an updated ex ante algorithm. Due to unresolvable conflicts within the DOE-2 analysis, the values for therm impacts for this evaluation came from the updated algorithm.

Engineering Energy Analysis - After consideration of other options, the engineering algorithm detailed in *"Design Methodology for Agricultural Measurement and Evaluation,"* PG&E Report # CIA-94-B03 was chosen to determine an unadjusted engineering energy estimate for the pumping measures. The algorithm is shown in Exhibit 5-7.

Exhibit 5-7
Engineering Energy Impact Algorithm

$$kWh_{impact} = kWh_{pre\,year} - kWh_{post\,year}$$

$$kWh_{yr} = AF / yr * kWh / AF = \frac{\frac{ET_c - Rain}{IE} - Surf}{1 - LR} * Acres * \frac{1.0241 * TDH_i}{OPE_i}$$

Where:

ETc	=	seasonal crop water requirement
Rain	=	effective rainfall
IE	=	seasonal irrigation efficiency
Surf	=	delivered surface water
LR	=	leaching requirement
TDH	=	total dynamic head
OPE	=	operating efficiency

The seasonal crop requirement came from *"Water Conservation & Management Handbook,"* January 1985. There is considerable research data on seasonal crop requirements, and the values used here are considered accurate to ± 10 percent. The effective rainfall is a function of when the rain actually falls and its usefulness to the crop. This value was determined by gathering actual rainfall data from the Western Regional Climate Center (WRCC) for as many of the PG&E local offices as possible. The effectiveness of the rainfall was weighted monthly. The seasonal irrigation efficiency was determined during the on-site surveys. These data were averaged to create an average seasonal efficiency based upon irrigation type. Due to sample size, no regional averages were determined. The delivered surface water was set based upon grower self-report. The leaching requirement was determined on-site by determining the crop requirements and doing a salinity check on the irrigation water if the water was being pumped. Otherwise, the leaching requirement was estimated based upon the expertise of the auditors. The acres value was taken from the grower's self-report. TDH and OPE values were used directly from the pump test database for those participants who had a pump test. If there was no test available, the average TDH and OPE were used based upon the participants regional location, irrigation type and pump type. Post-pump change efficiencies may be seen with a set of post-change pump tests. However, an analysis of the pre-to-post pump test was inconclusive, and the estimated post-change efficiencies were used.

The nested sample design of the telephone and on-site audit surveys set the stage for leveraging the more expensively gathered on-site information to the less expensively gathered telephone information, and eventually out to the 1994 RE

Program population. The algorithm in Exhibit 5-7 was applied to all the on-site and telephone survey participants with reasonable data. Information gathered from the telephone survey were used to adjust "ETc", "Surf" and "acres" for each participant. The seasonal irrigation efficiency average from the on-site surveys were used for the telephone survey participants. Effective rainfall for each participant's location was determined based upon the general area in reference to the available precipitation data.

Engineering Demand Analysis. The engineering analysis for peak demand impact consisted of applying the algorithm shown in Exhibit 5-8 to all pumps in the 1993 and 1994 pump test databases. Based upon the pump database hp and efficiencies, an average per-pump kW impact was determined for those pumps that have been retrofitted (A1) for each of the three horsepower categories. These average kW impacts were used in place of the current values (i.e., 0.82, 3.67 and 11.74) and multiplied to the number of pumps changed by horsepower bin, as recorded in the program database.

Exhibit 5-8
Engineering Peak Demand Impact Algorithm

$$kW = hp \ * \left[1 - (OPE_{pre} \ / \ OPE_{post})\right] * CDF * 0.746$$

Where:

hp	=	hp of changed pump
OPEx	=	pre- and post-efficiency
CDF	=	agricultural coincidence diversity factor (0.53)
0.746	=	conversion from hp to kW

Engineering Therm Analysis - Greenhouse measures were the only measures with therm impacts. The engineering analysis for these measures took two paths. The ex ante assumptions and algorithms were assessed and updated if required and the measures were modeled via the computer simulation, DOE-2. The on-site audits were used to create a "typical" greenhouse and then changing the construction of the shell to the post-retrofit construction. The greenhouse model was simulated with DOE-2 using California Energy Commission climate zone weather files. The pre-installation construction assumptions came from the ex ante program assumptions. Although a census of greenhouses was performed, there could be no mapping of peaks to accounts for a calibration of DOE-2 (as originally planned) since information was not gathered about the non-retrofit peaks or about which peaks were on which meter.

According to the PG&E 1994 RE program of ex ante assumptions, "In greenhouses, the addition of thermal blankets [heat curtains] to the greenhouse interior decreases heat losses resulting from radiation, convection and infiltration. Thermal blankets also reduce air stratification and the amount of space to be heated.". What the auditors found in the field was the implementation of a single piece of clear polyethylene film to create a flat ceiling and decrease the volume of space to be heated. This is what was simulated in DOE-2 for the heat curtain measure.

The DOE-2 files were simulated with three weather files corresponding the areas with the most greenhouse growing, CTZ03 (Oakland), CTZ04 (Sunnyvale) and CTZ12 (Sacramento). The results from each run were averaged together by construction, and the impact was determined by subtracting the new therms from the old therms. The results mapped well with the updated ex ante estimates except for the heat curtain measure which was substantially different between the two methods. The main reason for this difference is the decrease in volume required for heating as implemented in the DOE-2 simulations and not accounting for this in the algorithm. However, because of the uncertainties in the modeling of the heat curtain measure in DOE-2, the updated ex ante algorithms were used in determining the ex post savings for the greenhouse measures.

5.2.4 Billing Regression Analysis

The objectives of the billing regression analysis are (1) to determine the first-year gross impacts of high impact pumping measures, and (2) to provide information and feedback to improve engineering estimates on measures that are not suitable for a deterministic statistical estimation.

Modeling customers' energy usage patterns in the agricultural sector is a challenging task due to often large year-to-year and customer-to-customer usage changes associated with weather variation, crop rotation, irrigation system reconfiguration, and other agricultural economic factors. These factors confound the detection of impacts because of the large difference between the pre-participation period (i.e., 1992, a dry year) and the post-participation period (i.e., 1995, a record wet year). The data used in this analysis have a lower signal to noise ratio resulting in insignificant or low-significance parameter estimates The pump retrofit measure group is the only case where a statistically significant impact can be detected from a billing regression analysis. For other measures, impacts cannot be readily determined in a statistical model for one of two reasons:

- **Low Expected Impacts** - Agricultural measures with low impacts (less than 5 percent of usage) are difficult to model because their expected impacts are mixed with modeling errors of the same or even greater magnitude. Measures in this category include pump adjustment (RE), pump testing (EMS), low cost/no cost pumping measures (EMS).

- **Low Participation Levels** - Impacts for measures with low participation are hard to estimate with insufficient small sample sizes. Measures in this category include Customized water system upgrade measures (9 accounts) and low pressure sprinkler nozzles (29 accounts in the survey).

For the measures for which statistically significant estimates are not available, the billing regression analysis can still serve as a reality check or provide some indication for the range of the expected impacts and corroborate the engineering estimates. One such example is the pump adjustment measure where the original MDSS impact estimate is calculated as 11 percent of a fixed per-account annual usage of 134,000 kWh. The billing regression analysis found that 11 percent is likely too high because different regression models show a range of 0 percent - 5 percent (although statistically insignificant). In addition, the average annual usage estimate of 134,000 kWh is also too high for the pump adjustment participants in 1994 which have an average usage around 50,000 kWh from the billing data. These two factors result in a revised engineering impact estimate using 1.5 percent[2] of the annual usage.

Data and Sample - The billing regression analysis for the 1994 Agricultural Programs Evaluation uses data from three primary data sources: the MDSS tracking database, the Customer Information Systems (CIS) billing database and the telephone survey data specifically collected for this evaluation. A summary of the data elements used in the regression analysis are presented below, and a more detailed discussion can be found in *Appendices A* and *C*.

- **Program Participant Tracking System** - The participant tracking system for the RE and Customized programs was maintained as part of the PG&E MDSS. It contains program application, rebate, and technical information about installed measures, including measure description, quantity, rebate amount, and ex ante demand, energy, and therm saving estimates. The MDSS database is linked to the billing database and other program databases through the PG&E's customer control numbers.

- **PG&E Billing Data** - For this evaluation, the PG&E billing data were obtained from two PG&E data sources. The original nonresidential billing dataset contains monthly energy usage for all nonresidential accounts in the PG&E service territory, and was used in the sample design as described in *Appendix A*. The second billing dataset, which consists only of customer accounts in the surveyed dataset, was later obtained from PG&E's Load Data Services.[3] Since the second billing dataset has many useful fields not included in the first dataset, a decision was made to use the second billing dataset to conduct the statistical analysis. The billing series used in the analysis is the PG&E prorated monthly usage data, and included a pre-impact period spanning June 1992-September 1992 and a 1995 post-impact period covering the same months.

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[2] This estimate is consistent with a consensus estimate from various sources.

[3] A preliminary analysis has concluded that the monthly usage and bill read date information in these two datasets are consistent.

- **Telephone Survey Data** - The three telephone survey samples (466 RE/Customized participants, 455 EMS only participants and 453 comparison group customers) were collected as part of this Evaluation. They were designed to be representative of the participant population for each program. The telephone survey supplies information on energy-related changes at each site for the billing period covered by the billing regression analysis. The final telephone sample distribution is presented in Exhibit 5-9.

Exhibit 5-9
Final Telephone Survey Sample by Program and Key Measures

Sample		Sample Size
RE/Customized Program Participant	Pump Retrofit	286
	Pump Adjustments	151
	Sprinkler Nozzles	29
	Customized Water System	9
	EMS Participant	114
	Total*	466
EMS Only Participant		455
Comparison Group		453
Total		1,374

* Sum may exceed the total due to multiple measure participation.

In addition to the three data sources discussed below, the billing regression analysis also utilized the engineering analysis results. The original research plan also proposed to use the PG&E agricultural class load research data, however, the overlap of the load research sample with the program participant population only consists of 28 accounts, and this sample was judged to be too small to run a robust regression given the volatile nature of the agricultural sector.

Model Specification and Results - To determine the gross energy impact that can be attributed to the pump measures of the RE and Customized Programs, a cross-sectional billing regression analysis model was used to estimate program impacts by fitting customer-specific post-installation usage to estimated impacts (impact priors) for each key pump measure and premise-specific variables obtained from the telephone surveys. Two different sets of impact priors were considered in the model specification stage— the engineering estimates of impact and the actual usage in the pre-installation period. When engineering estimates are used, the output of the model will be called SAE realization rates and they represent the fractions of engineering estimates that are "realized" or "detected" in a billing regression analysis. On the other hand, when the pre-installation usage is used in the model, the estimated impacts will be represented as a percentage of this value. If the original engineering estimates are calculated as a fraction of usage (such as the ex ante estimates of pump retrofit impact in the MDSS database), these two priors will yield the same results.

Actual pre-installation usage was used in the final billing regression analysis for two reasons:

- As discussed in the engineering analysis section, engineering estimates are calculated based on ideal watering behavior for specific crops and technologies, and they do not depend on actual usage information. This approach provides a deterministic algorithm that can be transferred to any weather conditions, including TMY. These estimates track expected impacts for the participant population; however, on a specific customer basis, the engineering estimates have weaker correlation with the year-to-year usage changes than actual pre-participation usage.
- The engineering analysis can only be reliably performed on two-thirds of the total sample due to lack of acreage and crop information. Therefore, an SAE model would immediately exclude one-third of the sample from the analysis.

Analysis Period - For this evaluation, participants are defined by the "paid date" instead of "installation date". Although the accurate installation dates could not be determined due to inadequate data in the MDSS database, customers' installation dates were estimated based on an analysis of the inspection dates (when populated), rebate check issue dates, and the survey self-reported installation dates. The billing regression models, using the approximated installation date, were conducted on monthly, seasonal, and annual energy usage. The final model uses a fixed summer season comparison approach based on customer usage patterns in the agricultural sector. The summer season model resulted in the most stable results. The two summer seasons used in the final models are June 1992 - September 1992 as the pre-installation period and June 1995 - September 1995 as the post-installation period.

Data Segmentation and Sample Weighting - Three basic segmentation schemes were used in the billing regression analysis: (1) usage segment which is defined based on customers' PG&E electric rate schedule and is consistent with the segments used in the net-to-gross analysis; (2) geographic segments based on weather regions which are the same segmentation defined and used in the engineering analysis; and (3) year-to-year usage changes based on their utilization factors which are developed to capture the radical usage shifts among sample observations. The final model is a weighted Ordinary Least Square (OLS) model using usage segment weights. A detailed discussion on sample segmentation and sample distribution can be found in *Appendix C*.

Model Output - The results of the billing regression analysis for the RE/Customized Programs are presented in the following exhibit. The dependent variable is the summer usage in 1995 and the independent variables are listed below. For a detailed description on different variable definitions, see *Appendix C*.

Exhibit 5-10
RE/Customized Programs Billing Regression Model Results

Parameter Description	Parameter Estimate	t-statistic
Region-Specific Intercept		
Region 1	5,256	3.2
Region 2	7,235	3.3
Region 3	2,839	1.6
Region 4	2,709	1.0
Slopes on Pre-Usage by Utilization Segment		
Normal to Normal	1.00	39.0
Normal to Low	0.00	0.1
Low to Normal	4.46	6.9
Low to Low	0.52	1.7
Impacts as Percentage of Pre-Usage		
Pump Retrofit	-0.12	3.6
Pump Adjustment	-0.06	0.6
RE/Customized with EMS	-0.03	0.9
Low Pressure Sprinkler and Nozzles	-0.07	0.6
Customized Measures	-0.06	0.8
Change Variables (Multiplied by Pre-Usage)		
Outside Program Retrofit	0.026	0.7
Outside Program Adjustment	0.055	1.0
Outside Program Nozzles	-0.243	1.0
Other Outside Program Measures	-0.055	0.8
Implement EMS Recommendations	-0.055	0.8
Acreage Changes	-0.25	5.7
Other End-Use Changes	0.283	0.6

Number of Observations: 907
R-Squared: 0.83

As discussed in the overview, most of the impact coefficients in the model are not statistically significant with the exception of the pump retrofit measures, which show an impact of 12 percent on the pre-installation usage level. The 90 percent confidence interval around this estimate is ±5 percent. The model does provide indications of the expected impacts on EMS and pump adjustments as support for the engineering estimates.

The impacts estimated in the billing regression analysis reflect the expected energy impacts under actual 1995 weather conditions. In order to calculate the impacts under TMY weather conditions, the estimated 1995 impacts were adjusted by a TMY-to-Actual weather adjustment factor by using the ratio of these estimates calculated in the engineering analysis.

EMS Program - The billing regression analysis conducted for EMS participants and the comparison group resulted in statistically insignificant impacts. However, the coefficient estimate of -2.3 percent[4] is consistent with the program design estimates and the estimates shown in the previous RE/Customized model. In order to determine the first year program impact for the EMS Program, an EMS spillover analysis was conducted based on the telephone survey data to determine the adoption rates for each energy efficient measure in the agricultural sector that can be attributed to the EMS Program. The impact estimates from the RE/Customized Programs are then transferred to the same measures to calculate the total EMS program impact.

Demand Analysis - While the use of TOU and load research demand data to support a similar SAE demand model was investigated, insufficient load data were available to support such an analysis. The demand analysis conducted for this evaluation is based solely upon the engineering analysis.

5.3 Net-To-Gross Analysis

The approach used to calculate program net effects uses self-reported responses from telephone survey data to estimate free ridership and spillover for Agricultural Pumping program participants, and spillover effects for nonparticipants. Results from each separate subanalysis are combined to generate NTG ratios. NTG ratios for Agricultural Miscellaneous came from ex ante estimates. Methods for quantifying EMS spillover (i.e., the EMS NTG methods) appear in *Appendix Q* and are similar to those employed for Agricultural Pumping program participants.

NTG adjustments are made for pump retrofits, pump adjustments, and low pressure sprinkler nozzles at the measure level. For other pumping measure groups, available data were insufficient to generate measure-specific estimates. Therefore, Agricultural Pumping program-wide estimates of free ridership are used instead for water system changeouts and custom measures.

5.3.1 Free Ridership

A logistic regression model predicting free ridership was developed using self-report data in a pooled model incorporating data from all surveyed Agricultural program participants.[5] The multi-item model was chosen as a more robust, and possibly superior, alternative to single-item indices of free ridership.

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[4] For details on the EMS impact regressions, see *Appendix C.*

[5] Given the number of variables planned to be included in the initial models, we felt the logistic regressions would be under-powered if they were run separately for each measure group. Using a rule of thumb of 20 observations per model variable, only the pump retrofit (N=281) could have supported its own logistic regression. Additionally, we believed that the behavioral model should hold for all

Question PD002 asks customers, directly, if they would have adopted the measure if the program had not existed. Because this type of survey question is prone to "social desirability" effects (i.e., the survey respondent thinks "yes" is the "correct" answer from PG&E's perspective), estimates of free ridership based on this type of question tend to provide inflated upper bounds. In addition to social desirability effects, PD002 does not discriminate between decision-accelerated program participants and free riders. There is a second reason why we believe PD002 overestimates free ridership. A customer may respond affirmatively to PD002 (i.e., he would have adopted the measure without the program), but the retrofit could have been accelerated by the program, in which case the customer is considered a net participant and not a free rider. Question PD007, which was the dependent variable in the regression model, provides a straight forward index of free ridership that controls for decision acceleration.

Exhibit 5-11
Self-Reported Free Ridership: Superset of Model Variables

Model Variable	Wording of Question (or Group)	Predicted Direction		Variables Included in Final Model
		Net Participant	Free Rider	
PD002	Would you have <taken the measure> if the program did not exist?	no	yes	
PD003	How long would you have waited to <take the measure> without the program?	long period	short period	X
PD004	How long were you considering <the measure> before you heard about the program?	short-moderate	long period	X
PD005	How long did you take to decide to participate after becoming aware of program?	long period	short period	
PD008B	Did you consider purchasing standard-efficiency equipment? (For low pressure sprinkler nozzles only)	yes	no	
PD009	Did an EMS pump tester recommend that you participate in ...the Agricultural Program?	yes	no	X
APPROACH	(Did the customer approach a contractor or PG&E rep?)	no	yes	X
REBATE	(Did the customer mention the rebate?)	yes	no	X
BILLS	(Did the customer mention bill savings?)	yes	no	X
BROKEN	(Did the customer mention broken equipment?)	yes	no	X
EMSPART	(Did the customer also participate in the EMS Program?)	no	yes	
PD007	Before you knew about the program, which of the following statements best describes your company's plans to <take the measure>?	had considered, but no plans	do it within the next 12 months	X

purchase decisions, regardless of technology, since decision-making processes should be consistent across technologies.

5.4 Variables Included in Free Ridership Model

The dependent variable in the regression model was a recoded version of PD007 (customer-reported plans in the absence of the program), set to "1" for those customers who reported plans to have the work completed within the year when they became aware of the Agricultural program, and "2" for others.[6] Independent (explanatory) variables included in the initial model are also shown, along with their predicted effects, in Exhibit 5-11.

Exhibit 5-11 includes "yes" or "no" questions that were intended to be entered into the model as dummy variables. Responses to one such question (PD002), "Would you have adopted the measure if the program did not exist," were so strongly associated with responses to PD007 that the question was dropped from the multiple logistic regression prior to the model-building process.[7]

Some customers may have been motivated to adopt the measure as a result of recommendations made by an EMS pump tester. If so, these customers are unlikely free riders, as the auditor could have strongly influenced their decision. For this reason, a variable addressing EMS recommendations (PD009, "Did the pump tester recommend participating?") was included in the logistic model. Customers receiving a recommendation to participate were coded with a "1," and others were coded with a "0."

Since a subset of customers who receive an EMS pump test and then go on to participate in the Agricultural program may be those customers with a predisposition to seek energy-efficiency information or measures, a self-selection variable was included in the model to see whether having an EMS audit was associated with free ridership. A program status variable was included in the logistic regression to test for this self-selection effect. This variable was coded "1" for Agricultural participants who were also EMS participants, and "0" for others.

Three questions addressing the decision-making process and the length of time[8] spent in various decision-making stages were also included in the telephone survey. A question addressing length of time spent considering various equipment options, before becoming aware of the program, was included in the model. Customers spending less time researching equipment before becoming aware of the program can be distinguished from free riders who had researched and chosen products before becoming aware of the program. While risk-averse customers may also have spent considerable time considering options, net participants (as a group) should spend less time seeking information than free riders.

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[6] Customers who accelerated a decision to retrofit were considered net participants.

[7] Since this question is also an upper bound index of free ridership, univariate responses are presented along with logistic regression model results in *Section 3* of the Process Report.

[8] Measured in months

A second question addressing the length of time the customer spent considering the benefits provided by the program was also included in the model. Free riders, because they have essentially already made up their minds, should spend a short period of time assessing the benefits provided by the program. When presented with the option to install equipment or take some other efficiency action through the program, they are eager to do so. Contractor-driven net participants may also spend a relatively short period of time reaching a decision, but taken as a whole, net participants are expected to take more time to reach a decision to participate than free riders.

The third decision-making question included in the model addressed the number of months a customer would have delayed the equipment retrofit had the program not existed. This question is intended to differentiate decision-accelerated net participants from free riders.

Program marketing efforts create a market for pumping retrofits and influence customer plans. Many customers indicated that they were drawn into the market by program marketing efforts. Program participants, more so than nonparticipants who adopted measures, were more likely to echo program marketing messages such as a desire for bill savings or the program rebate. These customers were drawn into the program by key program benefits that provide the necessary motivation for customers who might not otherwise adopt program qualifying measures. These variables should be associated with a decreasing likelihood of free ridership.

An indicator of whether or not the customer found out about the program indirectly, through a contractor or PG&E representative, was also included in the model, with the understanding that customers who seek out information may tend to be free riders.

Details of the model-building process and final model selection appear in *Appendix E*. Pooled model results (the regression coefficients) were used to generate average free ridership rates for each measure group.

5.4.1 Spillover

The program spillover estimate contains two main components: a contribution from program participants and a contribution from nonparticipants.

Participants - Spillover effects were measured through simple self-report questions such as, "Since participating in the program, have you adopted any additional energy-efficiency recommendations?" The interviewers asked customers about specific program-qualifying measures, as shown in Exhibit 5-12. Responses were tallied, and the rates of the actions in the participant population were calculated and multiplied by ex post estimates of measure savings (average percentage reductions in usage per account). These were then credited to the RE and Customized programs as additional program kWh savings. This was done for each customer segment and the program as a whole.

Exhibit 5-12
Example: Spillover Effects Used for Pump Retrofits

Technology	Spillover Effects Participants' Within Measure Spillover	Participants' Other Measure Spillover	Nonparticipants' Spillover
Pump Retrofit	12%		12%
Pump Adjustment		2%	
Low Pressure Sprinkler Nozzle		39%	

Nonparticipants - The nonparticipant, free drivership analysis focused on the extent to which program-aware nonparticipants adopted the same program-qualifying measures. These estimates provide a lower bound on program educational effects. Because the survey was written to probe for changes since January 1993, and was conducted during September and October 1995, the rates of implementation were reduced to reflect an average, typical year's worth of installations. Implementation rates were then multiplied by the nonparticipant market size -- or approximately 77,000 accounts.[9]

General Methods - All intermediate effects were expressed as percentage reductions in annual usage. These were multiplied by each groups' average annual account size[10], and the impacts (in kWh) were summed to yield a final net kWh. This was then divided by the ex post gross kWh estimate to yield the final NTG ratio. Exhibit 5-12 shows an example of the spillover effects included pump retrofits. Percentages shown in the exhibit are annual usage reductions used in the net energy calculations. Note the participant spillover effects (in this case pump retrofits) apply to the NTG for the technology under which a customer participated.[11]

Nonparticipant spillover was restricted to pump retrofits, pump adjustments, and low pressure sprinkler nozzles.

Issues Surrounding Low Pressure Sprinkler Nozzles - Because sprinkler nozzles may be moved from one location to another on a given property, and because respondents may have had difficulty isolating the account to which the measure was applied, spillover effects for low pressure sprinkler nozzles were adjusted by a premise-to-accounts multiplier. For nonparticipants this number was 0.96.[12]

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[9]Based on telephone survey results, 85 percent of nonparticipants contacted had pumps on their accounts. As of February 1996, there were 92,723 active agricultural electric accounts. The eligible market was defined as 85% of (92,723 total accounts - 2349 participant accounts), or 76,818 accounts in the remaining market.

[10] using 1992 as a pre-program base year. Participant spillover effects were calculated as percentage reductions multiplied times the average *post-program* annual usage.

[11] Customers who installed multiple measures were categorized based on the measure that supplied the greatest impact on avoided cost.

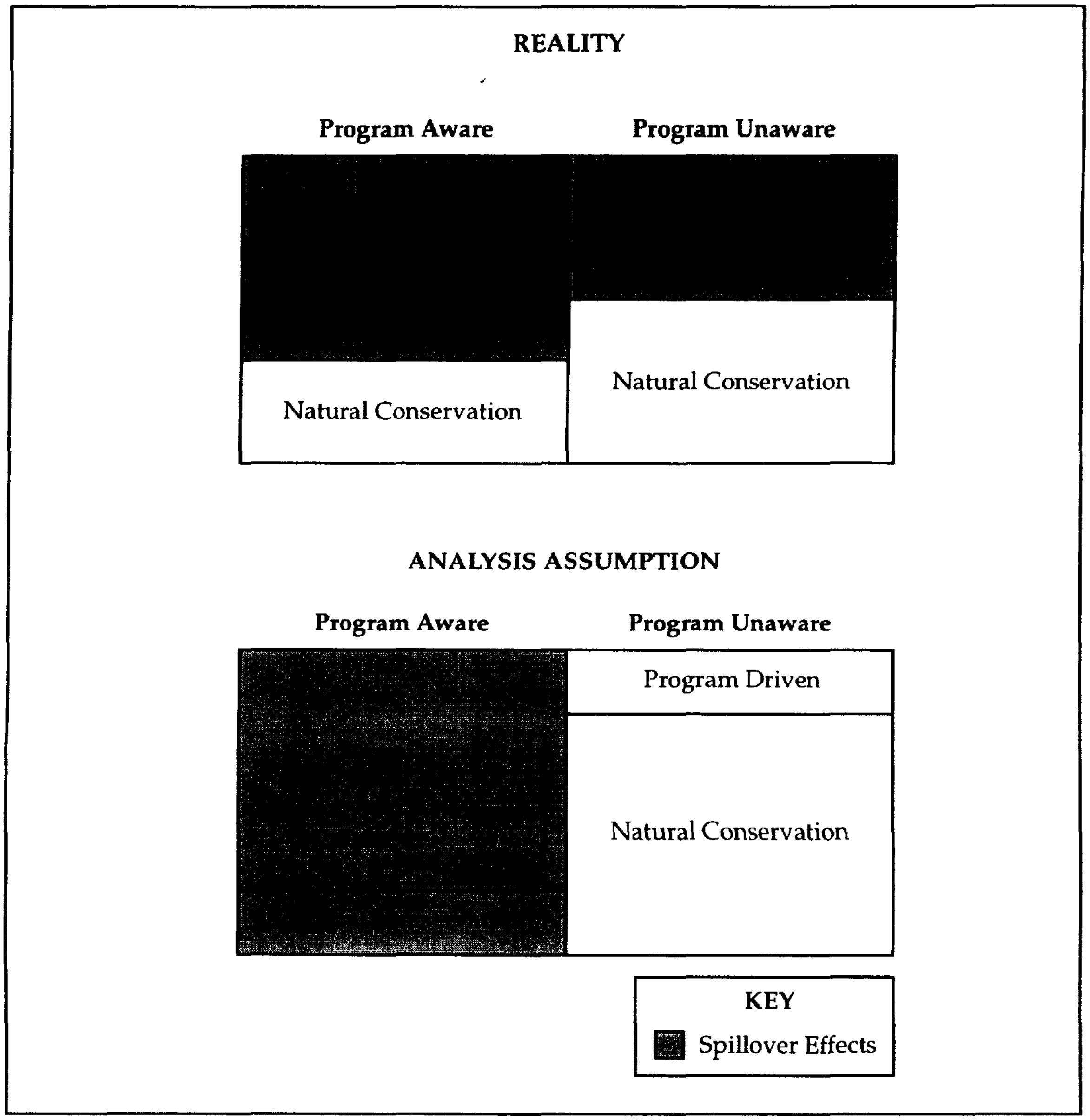
[12]Because of the small nonparticipant sample size, the premise-to-accounts multiplier was derived from participants' billing records, and that multiplier was applied to nonparticipants.

An additional adjustment was made for nonparticipant spillover effects due to low pressure sprinkler nozzles. Because the percentage reduction in usage among participants was estimated at approximately 39 percent, sprinkler nozzle installations among nonparticipants *and participants* have a profound effect on the NTG ratio for this measure. Since the survey did not probe for the number of sprinkler nozzles installed[13], we decided to cap the upper 90 percent NTG ratio at 2.0 (or ± 100 percent). This conservative upper bound was used because of uncertainty surrounding the spillover contribution. If on-site audits had been used to verify extra-program installations, we would feel more comfortable claiming all of the spillover contribution to NTG. Since this was not the case, we opted for a more conservative estimate of the contribution.

Caveats - By basing the program's market movement effects on the self-reports of aware nonparticipants we are both underestimating natural conservation among aware nonparticipant adopters and overestimating it among unaware nonparticipant adopters. Exhibit 5-13 shows how purchases outside the program can be divided into those reflecting the program's market movement effects and those reflecting natural conservation. The first box, Reality, shows that there is a mix of program driven effects and natural conservation among all nonparticipant measure adopters. The second box, Analysis Assumptions, show the simplifying assumptions used in this analysis.

[13]the median number installed among participants was 1160 per account

Exhibit 5-13
Representation of Nonparticipant Spillover Effects



In order to accurately measure the program's market effects, data from additional sources, in addition to self-reports, would be required. This stems from a major drawback of self-report data: namely, that there is no reason to believe that customers who made program qualifying retrofits outside the program would be able to accurately gauge the program's effect on structuring their choices. In other words, nonparticipants who make a program qualifying purchase[14] may have no idea of the program's effect on the pricing and availability of equipment they purchase outside the program The same can be said of nonparticipants or participants who report that they "would have adopted the measure without the program". This is a common dilemma in measuring program net effects when relying solely on self-reports. The solution to the problem does not lie in increasingly detailed probes of participants and nonparticipants. Rather the solution lies in looking elsewhere for data and in adopting multi-level models or approaches that capture the program's macro level effects on the distribution, availability, and pricing of energy efficiency options.

5.4.2 Combined Best-Estimate of NTG Adjustments

The final step in constructing the NTG ratio is to sum up all contributing effects into one index. Program gross impacts are adjusted for free ridership and spillover to produce the combined best-estimate of program net impacts. These net impacts are estimated by adding together the net effect of program participants,[15] program participant spillover effects, and nonparticipant spillover effects, as follows:

$$NTG = \frac{GI * (1 - FR) + Spillover_{Part} + Spillover_{NonPart}}{GI}$$

where,

NTG	=	the Net-to-Gross Ratio
GI	=	the Program Gross Impact
FR	=	the Free Ridership Rate
SpilloverPart	=	the estimated impact of participants' nonprogram energy conservation actions
SpilloverNonPart	=	the estimated impact of nonparticipants' program-influenced energy conservation actions

Because of the size of the remaining market (approximately 77,000 accounts) and its effect on NTG ratios, results shown in *Section 3* are given for four separate estimates of the nonparticipant contribution. First NTG ratios excluding nonparticipant

[14]regardless of their program awareness

[15] Taking free ridership into consideration

contributions[16] are given. These are followed by NTG estimates that include the lower bound estimate of nonparticipant contributions, the midpoint, and the 90 percent upper bound nonparticipant spillover contribution. Summary tables in *Section 1* show the decomposition of the final program NTG ratio into the following components:

- 1-FR
- Participant Spillover Effects
- Nonparticipant Spillover Effects

The effects are first generated for RE and Customized separately, distributed among the three components and then weighted[17] up to the program total to yield the breakdown of the overall program NTG ratio into constituent parts. The process of applying the NTG adjustments to the gross energy and demand impacts is illustrated in Exhibits 5-14 and 5-15 below. The second column presents a summary of the gross ex ante impacts, and the gross ex post (evaluation) impacts. These three impacts are then adjusted, on a row-by-row basis, by summing the appropriate free rider, participant spillover, or nonparticipant spillover adjustments and multiplying the sum times the gross impacts, to derive the net impacts in the two net columns. The realization rates, in the bottom section, are then generated by dividing the ex post impact by the ex ante impact.

While Exhibits 5-14 and 5-15 present results by end-use elements, the same method is used to estimate gross and net impact estimates that are presented by technology group in *Section 3, Evaluation Results Summaries.*

[16] but including participant spillover

[17] using the distribution of gross program impacts among RE and CI participants

Exhibit 5-14
Net Energy Impact Summary

Agricultural Technology Group	Gross: Gross Impact (MWh)	NTG Adjustments: Free Ridership Adjustment (1-FR) (Unitless)	NTG Adjustments: Participant Spillover Adjustment (Unitless)	NTG Adjustments: Nonparticipant Spillover Adjustment (Unitless)	Net: Net Impact without NP Spillover Adjustment (MWh)	Net: Net Impact with NP Spillover Adjustment (MWh)
Ex Ante**						
Pumping	54,163	0.69	0.10		42,549	
Miscellaneous*	23,682	0.63	0.10		17,344	
AEEI Total	77,844	0.67	0.10		59,892	
EMS	NA	NA	NA	NA	13,192	
Ex Post						
Pumping	43,619	0.36	0.29	0.25	27,960	38,655
Miscellaneous*	20,682	0.72	0.00	0.00	14,846	14,846
AEEI Total	64,301	0.47	0.19	0.17	42,806	53,500
EMS	NA	0.00	1.00	0.00	13,831	NA
Realization Rates (ex post/ex ante)						
Pumping	0.81	NA	NA	NA	0.66	0.91
Miscellaneous*	0.87	NA	NA	NA	0.86	0.86
AEEI Total	0.83	NA	NA	NA	0.71	0.89
EMS	NA	NA	NA	NA	1.05	NA

*The Agricultural Miscellaneous category also includes lighting, HVAC, and additional end uses.

**The ex ante spillover adjustment estimates did not differentiate between participant and nonparticipant spillover.

Exhibit 5-15
Net Demand Impact Summary

Agricultural Technology Group	Gross: Gross Impact (kW)	NTG Adjustments: Free Ridership Adjustment (1-FR) (Unitless)	NTG Adjustments: Participant Spillover Adjustment (Unitless)	NTG Adjustments: Nonparticipant Spillover Adjustment (Unitless)	Net: Net Impact without NP Spillover Adjustment (kW)	Net: Net Impact with NP Spillover Adjustment (kW)
Ex Ante**						
Pumping	7,597	0.69	0.10		5,927	
Miscellaneous*	3,571	0.63	0.10		2,644	
AEEI Total	11,168	0.67	0.10		8,571	
EMS	NA	NA	NA	NA	3,712	
Ex Post						
Pumping	7,951	0.36	0.29	0.25	5,097	6,933
Miscellaneous*	1,958	0.66	0.00	0.00	1,288	1,288
AEEI Total	9,910	0.42	0.23	0.20	6,385	8,221
EMS	NA	0.00	1.00	0.00	3,205	NA
Realization Rates (ex post/ex ante)						
Pumping	1.05	NA	NA	NA	0.86	1.17
Miscellaneous*	0.55	NA	NA	NA	0.49	0.49
AEEI Total	0.89	NA	NA	NA	0.74	0.96
EMS	NA	NA	NA	NA	0.86	NA

*The Agricultural Miscellaneous category also includes lighting, HVAC, and additional end uses.

**The ex ante spillover adjustment estimates did not differentiate between participant and nonparticipant spillover.