Customer Energy Efficiency Program
Measurement and Evaluation Program

IMPACT EVALUATION OF PACIFIC GAS & ELECTRIC COMPANY'S 1995 AGRICULTURAL ENERGY EFFICIENCY INCENTIVES PROGRAMS: PUMPING AND RELATED END USE INDOOR LIGHTING END USE

PG&E Study ID numbers:
329: Pumping and Related End Use
331: Indoor Lighting End Use

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IMPACT EVALUATION OF PG&E's 1995 AGRICULTURAL EEI PROGRAMS

Pumping and Related End Use
Indoor Lighting End Use

FINAL REPORT

March 1, 1997

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1. EXECUTIVE SUMMARY

This section presents a summary of the results for the impact evaluation of the pumping and lighting end-use technologies offered to Pacific Gas & Electric's (PG&E's) agricultural customers under PG&E's Nonresidential Energy Efficiency Incentive (EEI) programs, referred to in this report collectively as the Ag Programs. The evaluation covers technologies rebated in 1995 that are covered by the Retrofit Express (RE), Retrofit Efficiency Options (REO), and Customized Incentives Programs. 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). A Request for Waiver was filed and approved to modify some aspects of the evaluation approach, as detailed in *Section 6, Request for Retroactive Waiver.* 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 (kWh, 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 effects).

Exhibit 1-1 presents the gross and net energy impact results, along with the realization rates.

Exhibit 1-1
Gross and Net Energy Impact Summary

End Use	Gross Program Impact (kWh)	Net to Gross Adjustment: Free Ridership (1-FR)	Net to Gross Adjustment: Spillover	Net Program Impact (kWh)
		EX ANTE		
Indoor Lighting	6,822,570	67%	10%	5,253,379
Ag Pumping	24,070,161	67%	10%	18,651,174
		EX POST		
Indoor Lighting	4,043,327	95%	0%	3,841,161
Ag Pumping	16,753,213	33%	9%	7,038,734
		REALIZATION RATE		
Indoor Lighting	59%	NA	NA	73%
Ag Pumping	70%	NA	NA	38%

The ex ante numbers presented above in Exhibit 1-1 and below in Exhibits 1-2 and 1-3 were obtained from PG&E's Management Decision Support System (MDSS), PG&E's participant database. The values presented are identical to those filed in Table E-3 of the Technical Appendix of the Annual Summary Report on Demand Side Management Programs in May of 1996, revised in December 1996.

Overall, the realization rate for indoor lighting was 0.59 for gross energy. In general, the evaluation found that operating hours tended to be less than those assumed for derivation of the ex ante estimates, which has the effect of reducing energy impacts. Several individual measures had extremely high or low realization rates, but these measures generally had low participation (fewer than 5 sites) and had little effect on kW or kWh impact.

For the pumping end use, the overall realization rate for gross energy was 0.70. This result is driven primarily by the pump retrofit and pump adjustment technologies, which contribute 36 and 4 percent of the pumping end use's total gross energy impact, respectively. Although the unadjusted engineering estimates and the ex ante estimates differed by only a few percent for pump retrofit, the energy engineering estimates were adjusted by the SAE coefficient of 0.72. The realization rate for the pump adjustment technology was only 0.13 due to the unrealistic ex ante impact estimate of an 11 percent reduction in energy use for each pump adjustment—an impact that would almost match the energy reduction from a much costlier pump repair/retrofit.

The ex ante NTG ratios of 0.77 for both end uses include a 10 percent adjustment for spillover. In the evaluation, spillover was only claimed for the pump retrofit measure, as indicated by the zero spillover for the lighting end use listed above in Exhibit 1-1. In addition, free-ridership rates were high for the pumping end use, especially within pumping retrofit and Customized Incentives Ag measures. This is probably a result of the maturity of the PG&E pump rebate programs. The overall realization rate on net energy of only 38 percent for the pumping end use is driven by this high free ridership rate found in the evaluation.

Exhibit 1-2 presents the gross and net demand impact results, along with the realization rates.

Exhibit 1-2
Gross and Net Demand Impact Summary

End Use	Gross Program Impact (kW)	Net to Gross Adjustment Free Ridership (1-FR)	Spillover	Net Program Impact (kW)
		EX ANTE		
Indoor Lighting	1,141	67%	10%	878
Ag Pumping	4,490	66%	10%	3,427
		EX POST		
Indoor Lighting	284	95%	0%	270
Ag Pumping	4,717	34%	8%	1,951
		REALIZATION RATE		
Indoor Lighting	25%	NA	NA	31%
Ag Pumping	105%	NA	NA	57%

Overall, the realization rate for indoor lighting was only 0.25 for gross demand. In general, the evaluation found that lamps installed through the program tended to have far lower peak operating factors than the ex ante assumed CDF of 0.67. In fact, it was found that the majority of the HID installations were made in ornamental nurseries, which used the technology for growing during off peak hours. The HID technology, which represents 85 percent of the ex ante demand impact, has a realization rate of only 0.10 for gross demand. These results also explain the low realization rate on net demand impacts.

For the pumping end use, the evaluation results were very similar to the ex ante results, as illustrated by the realization rate on gross energy of 1.05. The realized net demand impact, however, for the Ag pumping end use is only 57 percent of the projected ex ante estimates. This is primarily a result of the previously discussed high rate of free-ridership.

Exhibit 1-3 presents the gross and net therm impact results, along with the realization rates.

Exhibit 1-3
Gross and Net Therm Impact Summary

End Use	Gross Program Impact (Therm)	Net to Gross Adjustment Free Ridership (1-FR)	Spillover	Net Program Impact (Therm)
		EX ANTE		
Indoor Lighting	0	-	-	0
Ag Pumping	77,481	65%	10%	58,111
		EX POST		
Indoor Lighting	0	-	0%	0
Ag Pumping	77,481	34%	0%	25,956
		REALIZATION RATE		
Indoor Lighting	-	NA	NA	-
Ag Pumping	100%	NA	NA	45%

For all pumping measures with therm impacts, the ex ante was identical to the ex post estimate. Again, the high rates of free ridership in the pumping end use drives the low realization rate on net therm impacts.

Detailed presentation and discussion of these results can be found in *Section 4, Evaluation Results.*

1.2 MAJOR FINDINGS

Overall, the evaluation found that the most important end uses and measures in the Ag program have high free-ridership rates. Moreover, very little spillover was found, and spillover was claimed only for the pump retrofit measure. These findings had the effect of significantly reducing the net ex post impacts relative to the ex ante estimates.

In addition, typical operating schedules in the Ag sector for lighting measures with the highest potential impact lead to peak demand impacts that are far below connected load impacts. This had the effect of reducing gross ex post impacts relative to the ex ante estimates for lighting measures.

1.3 MAJOR RECOMMENDATIONS

1.3.1 Evaluation

General Issues for Quantifying Spillover Effects - Additional efforts need to be made to better quantify the effects of spillover. Because of small sample sizes, spillover efforts were concentrated on the pump retrofit measure, which was expected to provide the most significant contribution to overall spillover. Since sample sizes were also small for this measure, additional efforts should be made to more accurately estimate spillover.

Applicability of SAE Analysis - Due to the low level of participation in the Ag program and the limited ability of telephone survey data to provide measure-specific data (for example obtaining leaching requirements over the phone is difficult), it may be cost-effective to conduct *only* on-site audits to collect impact evaluation data, particularly to support implementation of an SAE. QC recommends that future Ag evaluation use SAE analysis only with on-site audit data.

1.3.2 Program Design

Apply the 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 using the results of the 1996 study conducted to calculate the CDF.

Apply Updated Overall Plant Efficiency (OPE) Ratios for Pump Retrofit Measure - The OPE ratio used in ex ante impact estimates should be updated to correspond to the 1993-1995 pump test values. This will decrease the OPE ratios for the medium horsepower bin from 0.21 to 0.13 and for the high horsepower bin from 0.19 to 0.11.

Use Segment-Specific Operating Hours and Operating Factors 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 lighting (CFL) technologies.

Other detailed recommendations concerning the above subjects and measures offered are covered in more detail in *Section 5, Recommendations*.

2. INTRODUCTION

This section presents a summary of the results for the impact evaluation of the pumping and lighting end-use technologies offered to Pacific Gas & Electric's (PG&E's) agricultural customers under PG&E's Nonresidential Energy Efficiency Incentive (EEI) programs, referred to in this report collectively as the Ag Programs. The pumping and lighting end-use technologies comprise 88 percent of the total Agricultural EEI Program avoided cost, as shown in Exhibit 2-1. The evaluation covers technologies rebated in 1995 that are covered by the Retrofit Express (RE), Retrofit Efficiency Options (REO), and Customized Incentives Programs.

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). A Request for Waiver was filed and approved to modify some aspects of the evaluation approach, as detailed in *Section 6, Request for Retroactive Waiver.*

2.1 THE RETROFIT EXPRESS PROGRAM

The RE program offered fixed rebates to nonresidential customers that installed specific gas or electric energy-efficiency equipment in their facilities. The program covered a number of energy saving measures relevant to the lighting and pumping end uses. Specific lighting measures included compact fluorescent lamps, incandescent to fluorescent retrofits, exit signs, efficient ballast changeouts, T-8 lamps and electronic ballasts, delamping of fluorescent fixtures, HID technologies, and lighting controls. These lighting measures were offered under the RE program in both 1994 and 1995.

Specific pumping measures included pump retrofit, pump adjustment, low pressure sprinkler nozzles, well water measurement devices, and energy efficient motors. All of these measures were offered under the RE program in 1994. Only the energy efficient motors measure was offered under the 1995 RE program.

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.

2.2 THE RETROFIT EFFICIENCY OPTIONS PROGRAM

The 1995 REO program only included two pumping measures: pump retrofit and low pressure sprinkler nozzles. Customers were required to submit calculations for the projected first-year energy savings along with their application prior to installation of the high efficiency equipment. PG&E representatives worked with customer to identify cost-effective improvements, with special emphasis on operational and maintenance measures at the customers' facilities. Marketing efforts were coordinated among PG&E Divisions, emphasizing local planning areas with high marginal electric costs to maximize program benefits.

Exhibit 2-1
Summary of Avoided Cost by End Use and Measure

End Use	PG&E Code **	Measure Description	Avoided Cost Dollars ($)	Avoided Cost % of Total
AG Pumping	A1	Pump Retrofit	3,224,333	17.7%
	A4	Pump Adjustment	614,451	3.4%
	A41/A42/A6	Low Pressure Nozzle	159,436	0.9%
	A5	Well Water Meas Device	360,133	2.0%
	M20-M38	Energy Efficient Motors	197,634	1.1%
	A0,AN0,P0	Customized Ag Measures	7,555,825	41.4%
	Ag Pumping End Use Total		12,111,812	66.4%
Indoor Lighting	L63-L65	Compact Fluorescent Lamps	121,560	0.7%
	L7	Incandescent to Fluorescent Fixtures	32,967	0.2%
	L6	Exit Signs	496	0.0%
	L14	Efficient Ballast Changeouts	283	0.0%
	L22-L24/L73-L75	T-8 Lamps and Electronic Ballasts	81,640	0.4%
	L17/L19/L20	Delamp Fluorescent Fixtures	113,493	0.6%
	L26/L27/L79/L81	High Intensity Discharge	3,575,576	19.6%
	L31/L36	Controls	827	0.0%
	Indoor Lighting End Use Total		3,926,842	21.5%
AG PUMPING Plus INDOOR LIGHTING			16,038,654	88.0%
HVAC End Use Total			622,036	3.4%
Outdoor Lighting End Use Total			42,063	0.2%
Refrigeration End Use Total			76,514	0.4%
Ag Other	A8/A9/A10	Green House	519,992	2.9%
	A2	Milk Pre-Cooler	8,091	0.0%
	A3	Desuperheater (Ag)	8,321	0.0%
	A11	Time Clock with Batt Backup	23,258	0.1%
	AG Other End Use Total		559,662	3.1%
Cooking Equipment End Use Total			354	0.0%
Process	550	Process Control	382,368	2.1%
	569	Process Change/Add Equip	144,309	0.8%
	589	Air Compresser Sys Chg/Modify	23,031	0.1%
	599	Process Other	340,511	1.9%
	Process End Use Total		890,218	4.9%
PROGRAM TOTAL			18,229,502	100.0%

Data Source: 1995 PG&E Frozen MDSS Database Received on July 25 1996.

* Applications with status code "Z" were excluded from the calculation.

** PG&E MDSS Measure or Action Code.

2.3 THE CUSTOMIZED INCENTIVES PROGRAM

The Customized Incentives Program offered financial incentives to nonresidential 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 Incentives 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 percent 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 percent of the incremental cost to make new processes or added systems energy efficient. Customers were paid 4¢ per kWh and 20¢ per therm for first-year annual energy impacts. A $200 per peak kW incentive for peak demand impacts required that savings be achieved during the hours PG&E experiences high power demand.

There was no Customized Incentives Program offered in 1995. However, due to the significant documentation and analysis involved in Customized Incentives Program measures rebates for a number of 1993 and 1994 measures were delayed until 1995. All equipment applied for under the program must have been installed and in operation by November 30, 1995. This evaluation covers those customers that received rebates in 1995. A total of 18 Customized Incentives agricultural participants fell into this category.

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, REO, and Customized Incentives programs and for which rebates were *paid* during calendar year 1995. 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 and 1995 agricultural program measures installed (paid during 1995) through PG&E's RE, REO, and Customized Incentives programs as required by the California Public Utilities Commission (CPUC) protocols.

- Determine first year net impacts (kW, kWh, and therms) of the 1994 and 1995 agricultural program measures installed (paid during 1995) through PG&E's RE, REO, and Customized Incentives 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 the free-ridership, spillover and net-to-gross ratios for the 1994 & 1995 agricultural program measures paid during 1995 through PG&E's RE, REO, and Customized Incentives programs.

- Create an impact sample subset of participants for future retention monitoring as required by the CPUC protocols.

- Complete Tables 6, 7 and 11 of the Protocols.

Results are segmented by technology type. Technologies are defined by measures offered by the RE, REO, and Customized Incentives programs. These technologies were then grouped into end uses, including pumping, other agricultural end uses, and traditional commercial end uses (i.e., indoor lighting, HVAC, outdoor lighting, refrigeration, food service, and 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 customers that would have installed energy-efficient measures even without the program (free-riders). Spillover rates, defined as energy efficient measures installed outside the program as a result of the presence of the program, were estimated, but were only claimed for the pump retrofit measure due to the low level of participant and nonparticipant spillover found among the other measures.

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 1995 Agricultural Impact Evaluation began in May of 1996, completed the planning stage in June 1996, executed data collection between early July and November 1996, and completed the analysis and reporting phase in February 1997.

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). The Protocols control most aspects of the evaluation, specifying the minimum sample sizes, the required precision, data collection techniques, certain minimum analysis approaches, and formats for documenting and reporting results to the CPUC. A Request for Waiver was filed and approved to modify some aspects of the evaluation approach, as detailed in *Section 6, Request for Retroactive Waiver*. The Request for Waiver was filed based on the evaluation of the 1994 PG&E Agricultural program, the reviews of that program, the limited size of the participant population, and the limited size of the PG&E agricultural sector in general.

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*. The Methodology of the evaluation is presented in *Section 3,* and supported in detail by *Volume One* of the *Technical Appendices.* Results are presented and discussed in *Section 4. Section 5* discusses and presents recommendations for improving the evaluation, the program measures, the program tracking system, and the CPUC Protocols. A Request for Waiver was filed and approved to modify some aspects of the evaluation approach, as detailed in *Section 6. Section 7* provides the protocol Tables 6 and 7. *Volume Two* of the *Survey Appendices* documents the data collection efforts undertaken during the evaluation.

3. EVALUATION METHODOLOGY

In this section, the methodology used in the evaluation of Pacific Gas & Electric's (PG&E's) Agricultural EEI Program (the Ag program) is presented. The evaluation was conducted only on customers who received rebates in 1995. An overview of the data sources and analysis methods is presented first. Details of the engineering, billing regression, and net-to-gross analyses follow.

3.1 INTEGRATED EVALUATION APPROACH OVERVIEW

3.1.1 Data Sources

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 applicable internal data and existing data available from PG&E and industry sources.

These primary existing data sources included program applications (paper files), the Management Decision Support System (MDSS) database for 1995, and the pump test database for 1993-1995. Also used were the program procedures documentation from the CIA Policy and Procedures Manual, CLASS Load Research data and PG&E's billing data.

In addition to these existing data sources, the QC Team gathered survey data from a number of different sources. A census of telephone surveys was attempted on the lighting and pumping participants. Altogether, 425 participant telephone surveys were conducted, which included 69 lighting end-use participants and 356 pump end-use participants. In addition, 540 nonparticipants were surveyed, 81 with lighting end uses and 530 with pumping end uses (71 had both end uses). A census of on-site surveys was attempted on program participants for Ag pumping, lighting and Customized Incentive sites. A total of 225 on-site surveys were collected.

Other data collection efforts included surveying 10 PG&E Ag representatives, 10 lighting vendors, and 39 pump dealer trade ally surveys. Trade ally surveys were conducted on dealers located in both California and Utah. Finally, employees from the California Irrigation Management Information Services, Department of Water Resources, and Western Regional Climate Center were surveyed.

All data collection efforts were 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). The Protocols control most aspects of the evaluation, including specifying the minimum sample sizes, the required precision, and data collection techniques.

The impact analysis plan is based upon a nested sample design to the extent possible, with a core on-site audit sample leveraged to a larger, less expensive, telephone survey. Data between these samples are leveraged through similar data elements collected in both the telephone survey and on the more accurate on-site audits.

3.1.2 Sampling Plan

The sampling plan for the Ag Evaluation was developed based upon program avoided cost for each of the program measures paid in 1995 and in recognition of the limited size of the participant population. As explained in *Appendix 6, Request for Retroactive Waiver*, the limited participant population necessitated an attempted census of participants who were expected to contribute data to the statistical analysis. The number of completed participant surveys discussed above reflects such an attempted census.

For nonparticpants, the number of completed surveys discussed in the data sources section above meets the protocol requirements for both pumping nonparticipants (in terms of total sample size) and lighting nonparticipants (in terms of matching the size of the participant population.) The final sampling survey sample therefore both complied with the protocols and met the program evaluation objectives described in *Section 2* of this report. Nonparticipants were selected from a random sample of PG&E's agricultural customers. Because the majority of customers with pumping accounts have descriptive (alpha) addresses rather than numeric addresses, customers with descriptive service addresses were sampled as likely nonparticipants for the pumping end use control group.

In addition, nonparticipants that were likely to have a lighting end use on their account were also selected to act as the control group for the lighting end use. This was done on the basis of SIC code. It was found that ornamental nurseries (SIC code 181) were the primary facility type which participated in the lighting end use. Therefore, nonparticipants with SIC code 181 were oversampled,. and were considered to be a likely candidate for having lighting on their account.

The MDSS database program application information is used to extrapolate 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.

3.1.3 Demand Estimates

Demand Estimates for the PG&E REO/RE/Customized Incentives programs are based on engineering models using on-site data, manufacturer and telephone survey data and review of ex ante algorithms and assumptions, as described in more detail in *Section 3.2*. The approach for demand is separated by end use, and has the following specific elements:

Pumping

For the subset of on-site visits where pre- and post-pump tests information is available, the engineering algorithms were adjusted using pump test data. These adjusted values were then used to correct the MDSS values for energy savings for each of the three horsepower (HP) levels recorded in the MDSS.

The variable which is most critical for the pumping demand is the coincident diversity factor (CDF). This parameter was analyzed and updated (see *Appendix A, Coincident Diversity Factor Report*), and the new value was used to calculate demand impacts.

Lighting

The on-site audits and telephone surveys determined self-reported operating hours and operating factors for the retrofit fixtures. This data provided a peak operating factor to be applied to the connected load impact for peak demand savings. In addition, both the on-site audits and phone surveys attempted to determine the fixtures which were taken out to more accurately create a difference in connected load.

All Measures

Net-to-gross (NTG) demand adjustments were made using the net-to-gross ratios (NGR) determined from the NTG analysis, as described in more detail in *Section 3.4*. The NTG adjustments compensate for free-ridership and spillover.

3.1.4 Energy Impact Estimates

The Energy Impact Estimates for the PG&E REO/RE/Customized Incentives programs are derived from a combination of engineering estimates and statistically adjusted engineering (SAE) estimates, discussed in *Section 3.3*. Similar to demand, the approach for energy is separated by end use, and has the following specific elements:

Pumping

The on-site inspections and telephone data were used to gather the parameters for an engineering estimate of pump usage for the pump repair measure of the REO program. In addition, the 18 Customized Incentives sites had impacts from the engineering review, along with data collected during on-site audits. All other pumping measures, which comprise less than on third of the ex ante gross energy impacts, had an engineering ex ante review.

The engineering energy impacts form the input to the SAE analysis, which is described in more detail in *Section 3.3*. In the SAE analysis, these estimates are compared to the billing data using regression analyses, in order to adjust for behavioral factors and as yet unaccounted for effects. The output for these segments are SAE estimates of savings.

Lighting

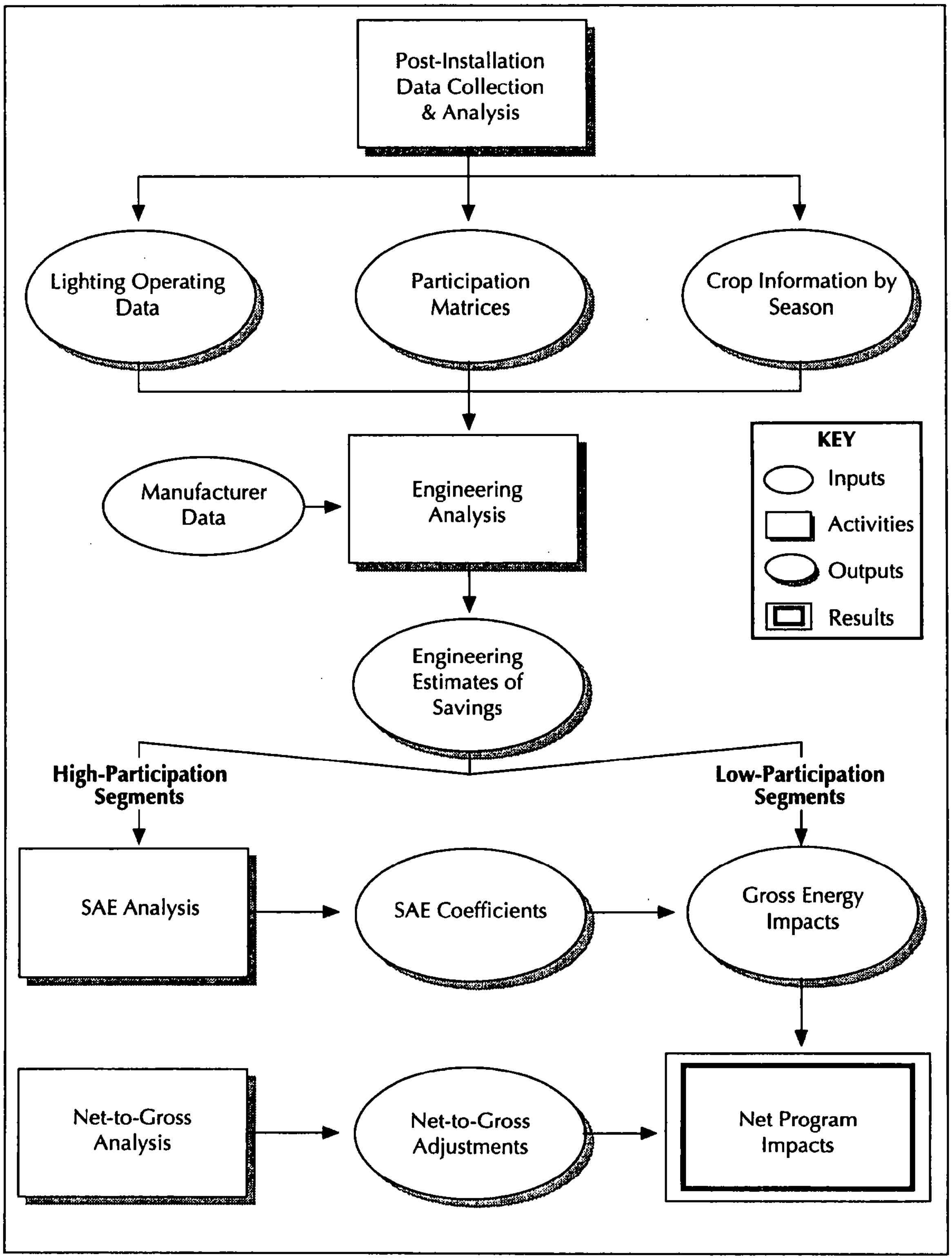
The on-site inspections and telephone data were used to develop RE lighting operating hours and operating factors. These self-report data were input into an engineering algorithm to determine energy impact. As above, the engineering energy impacts formed the input to the SAE lighting analysis. Since the SAE analysis could not be successfully performed, however, the engineering estimates of energy savings were used. This is described in more detail in *Section 3.3*.

All Measures

The two sets of results (SAE results and engineering estimates) combine to represent the evaluation estimate of gross program energy savings. The program gross impacts will be presented by technology and segment. NTG adjustments will be made using the adjustments developed during the NTG analysis. The NTG adjustments compensate for free-ridership and spillover, as described in more detail in *Section 3.4*.

Exhibit 3-1 illustrates the overall approach to the energy impact analysis.

Exhibit 3-1
Method for Estimating Energy Impacts



The description of the overall demand and energy analysis is further developed in the sections on engineering and SAE analysis approaches that follow. *Section 3.2* discusses the engineering analysis is more detail, and *Section 3.3* presents the statistical analysis. *Section 3.4* discusses the development and application of the NTG ratios.

3.2 GROSS IMPACT ANALYSIS

3.2.1 Overview

The gross impact analysis consisted of an integration of engineering and statistical analysis for high participation segments, and only an engineering analysis in low participation segments. Exhibit 3-2 shows the overall approach to determining gross impacts for the Ag sector of the RE/REO/Customized Incentives programs.

An engineering algorithm based on ex post analysis was performed on the RE lighting measures and the REO Ag pump repair measure. For all other Ag sector measures, an engineering review of the ex ante algorithms and assumptions that go into the estimates of demand and the ex ante estimate were recalculated for the ex post impact.

Ex Post Criteria

The criteria used to segment agricultural measures are based on the shareholder incentives, measure participant numbers, and experience in performing the ex post analysis for the 1994 Ag evaluation. Approximately 80 percent of the avoided costs are from the indoor lighting, pump repair and Customized Incentives measures. As described above, the sample size for the Customized Incentives sites is too low to provide a statistically valid result for that subset of measures. However, an engineering review was performed on each site. A list of measures and the type of engineering analysis performed for each is presented in Exhibit 3-3.

Exhibit 3-2
Gross Impact Overview

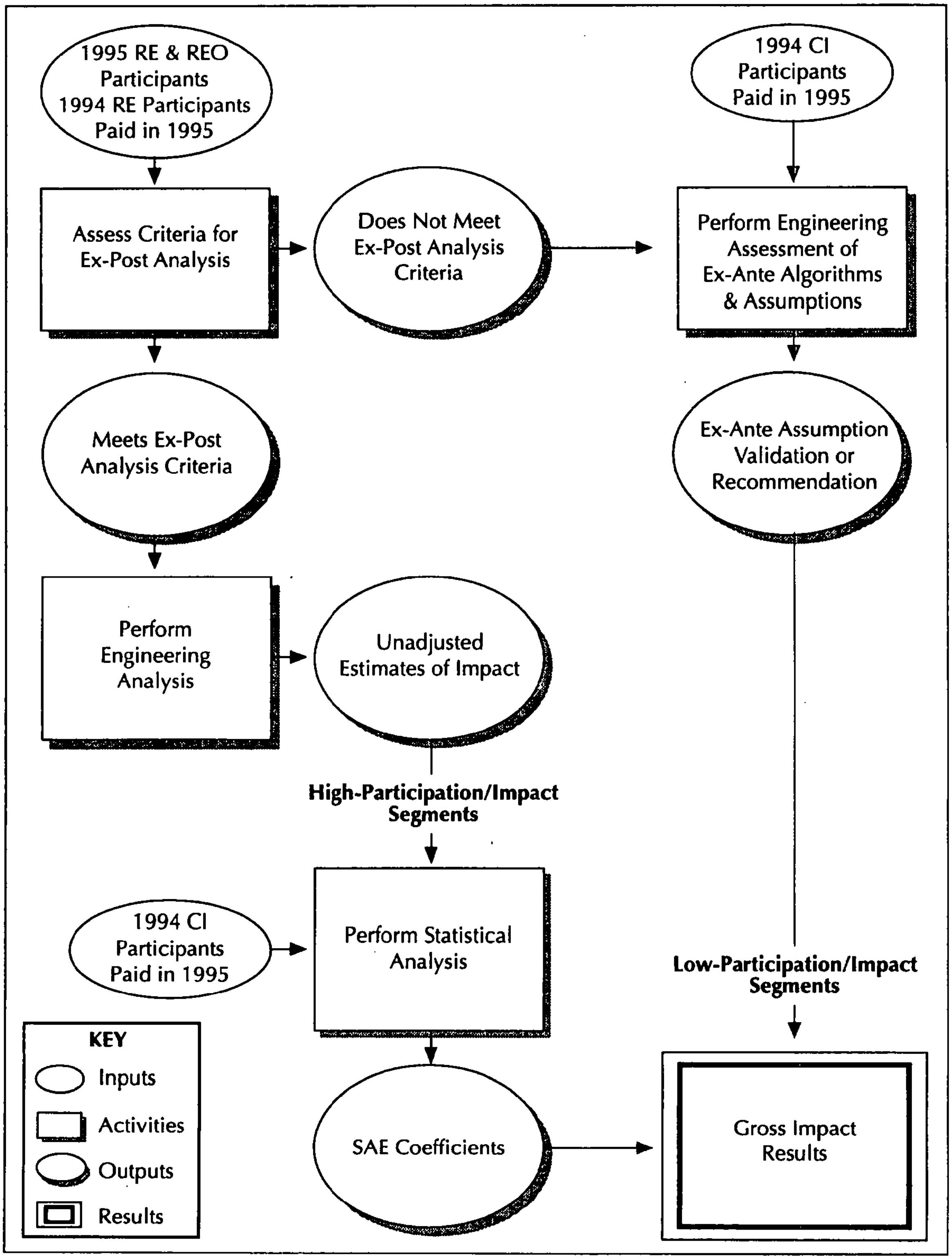


Exhibit 3-3
Measures Meeting Ex Post Analysis Criteria

Ex Post Analysis	Engineering Review of Ex Ante Estimates
A1 - Pump Retrofit	A4 -Pump Adjustment
L25-L30, L37, L79-L81 - High Intensity Discharge	A5 - Well Water Measurement Device
L63-L65 Compact Fluorescent Lamps	A6/A41/A42 Low-Pressure Sprinkler Nozzles
L22-L24/L73-L75 T-8 Lamps and Electronic Ballasts	All Energy Efficient Motors
L17/L27/L79/L89 Delamp Fluorescent Fixtures	All interior and exterior lighting measures not covered in ex post analysis
	All 18 Custom Participants

3.2.2 Engineering Assessment of Ex Ante Algorithms

For the measures listed in the right column in Exhibit 3-3, an engineering assessment of both the ex ante algorithm and assumptions made was completed. Any changes in the algorithms were applied to develop revised (ex post) estimates for the 1995 impact analysis.

There were two reviews performed in which the assumptions and algorithms were assessed. The first review was of applications submitted under the Ag Customized Incentives program. Eighteen separate Customized Incentives applications were thoroughly reviewed and the results written up in a memo to the program manager on November 20, 1996. That memo and the attachments to it are included in *Appendix B, Engineering Review of Ex Ante Estimates*.

The other review was of the Retrofit Efficiency Options (REO) and Retrofit Express (RE) Program. No Ag RE pumping measures were offered in the 1995 program. However, some 1994 RE measures were paid within 1995 and are included in this evaluation. Each of the Ag measures paid within the 1995 program was reviewed based upon the 1994 or 1995 ex ante documents. Additionally, there were 1995 Lighting RE measures installed within the Ag sector. The 3 measures representing 96 percent of avoided cost were reviewed. The results of the review are also discussed in *Appendix B, Engineering Review of Ex Ante Estimates*.

For three measures included in the pumping end use, telephone survey questions were asked specifically to improve the inputs into the ex ante algorithm or the algorithm itself. These three were low pressure sprinkler nozzle, well water measurement devices, and energy efficient motors.

A one- to two-page synopsis of the assessment was filled out for each measure reviewed, using the format shown in Exhibit 3-4. These assessments can be found in *Appendix B, Engineering Review of Ex Ante Estimates.*

Exhibit 3-4
Format of Ex Ante Analysis Results

Item: Measure name

Recommendation:

Technology Description:

Criteria for 1994 or 1995 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 is the per-application average cost for 1995 based on MDSS database *

Rebate: This is the per-application average rebate for 1995 based on MDSS database *

References:*

* These fields were not used for the Customized Incentives sites results unless applicable.

3.2.3 Engineering Analysis

A detailed engineering analysis was conducted for the pump repair and lighting measures. These measures were the focus of a more in-depth analysis because their combined level of avoided costs is almost 40 percent of the Ag program. Engineering estimates for these measures used an algorithm based upon information gathered through telephone surveys and on-site audits. The pump repair estimates will be discussed first, followed by the lighting estimates.

Engineering Methods for Pump Repair Measures

Information from multiple sources was used in calculating the engineering estimates. A complete list of references appears at the back of *Appendix C, Engineering Technical Analysis*.

For the engineering analysis, the PG&E service territory was segmented into six distinct regions based upon similar rainfall. Since this mapping is also somewhat geographical, when certain key inputs were missing (in the case of participants without pump tests) average values from the Pump Test Database were substituted since these values are thought to be relatively similar within regions when controlling for irrigation type and pump type.

Pumping kWh Estimate

The engineering pumping algorithm is shown below.

$$kWh_{yr} = AF/yr * kWh/AF = \sum_{m=1}^{12} \left(\frac{\frac{(ETc_m - Rain_m - Surf) * Pump\ Perc}{IE}}{1-LR} / 12 * Acres * \frac{1.0241 * TDH_i}{OPE_i} \right)$$

Where

AF	=	acre ft. of water pumped
m	=	month m
ETc	=	net seasonal crop water requirement (inches)
Rain	=	effective rainfall (inches)
Surf	=	delivered surface water
IE	=	seasonal irrigation efficiency (unitless)
Pump Perc	=	Water pumped by this pump for the crop
LR	=	leaching requirement (unitless)
TDH	=	total dynamic head (feet)
OPE	=	operating plant efficiency

The monthly engineering estimates generated for the statistical analysis covered the growing years of November 1993 - October 1994 (called year 1994), November 1994 - October 1995 (called year 1995), and November 1995 - October 1996 (called year 1996). A TMY engineering estimate was also created based upon a 30-year average of rainfall, to determine a weather-normalized TMY estimate. Detailed information was gathered on each of the above variables in the energy algorithm, as explained in detail in *Appendix B, Engineering Review of Ex Ante Estimates*.

Pumping kW Estimate

The engineering demand savings estimate were based upon the ex ante algorithm, with a few refinements. The algorithm used is shown below.

*kW Savings = HP * 0.746 * CDF * OPE Ratio*

Where the OPE ratio is a function of horsepower (HP).

The HP bins and values used in the 1995 ex ante algorithm were reviewed and modified based upon values in the 93-95 Pump Test Database to create new OPE ratios, as shown below. This will decrease the OPE ratios for the medium (0.21 to 0.13) and high (0.19 to 0.11) horsepower bins.

Bin Category	OPE Ratio	HP Used for kW Savings
5 - 15 HP	1-(47.5/59.1) = 0.20	10.33
15-75 HP	1-(55.6/63.7) = 0.13	44.16
75-400 HP	1-(60.4/67.9) = 0.11	156.27

Based on analysis performed during this year's evaluation, the coincident diversity factor (CDF) used was 0.78 (See *Appendix A, Coincident Diversity Factor Report*). Although the HP was not known directly from the MDSS, the HP bin could be determined based upon the ex ante kW savings estimate and the new implemented values.

Engineering Methods for Lighting Estimates

The engineering estimates of lighting impacts were based upon the on-site audits. The data were analyzed by facility and fixture type. Of the 85 unique sites within the program, a census of on-site audits were attempted with a result of 59 completed on-site audits. On-site audit data were used to determine average per-fixture peak demand and energy estimates. These averages were transferred to the remaining 26 non-audited sites to estimate adjusted demand and energy impacts. Per-fixture impact estimates were transferred at the finest level of detail possible, which, for most cases, was by fixture and facility type. Estimates of energy and demand impacts were calculated as described below.

Lighting kWh Estimates

The lighting energy analysis was based on change in connected load, self-reported hours of operation, and an average open and closed operating factor for the lights. The equation used to estimate energy impacts is shown below.

$$kWh_{impact} = \sum_{s=1}^{n} \left\{ \sum_{t=1}^{n} \Delta UOL_t * \left[Open\ Hours_s * OF_{open,s} + Closed\ Hours_s * OF_{closed,s} \right] \right\}$$

Where

UOL_t = Change in connected load for technology t

$Open\ Hours_s$ = Schedule Group Annual Hours Open

$OF_{open,s}$ = Open Operating Factor for Schedule Group, s

$Closed\ Hours_s$ = Schedule Group Annual Hours Closed

$OF_{closed,s}$ = Closed Operating Factor for Schedule Group, s

During on-site audits, the lighting at the site was classified into schedule groups - groups of lights using the same operating schedule. All fixture types within these groups were considered to have the same operating hours. Annual hours of operation were determined based on these schedule groups. The number of lights operating during these hours was also set from the data gathered during on-sites.

All fixtures were considered on during operating hours (i.e., $OF_{open,s} = 1$) and no fixtures were considered on during closed periods (i.e., $OF_{closed,s} = 0$). This is unusual for lighting evaluations, but the Ag sector on-sites indicated that 93 percent of all fixtures counted were in use during operating hours. Similarly, all the on-sites indicated that the closed operating factor was zero.

The change in connected load was estimated based on the post-retrofit wattage observed on-site and the estimated pre-retrofit wattage from the PG&E ex ante estimates.

Lighting kW Estimates

The lighting demand impact was also based on the site schedule and the estimated impact of the retrofit gathered during the on-site audit.

$$kW_{impact} = \sum_{s=1}^{n}\left[\sum_{t=1}^{n} \Delta UOL_t\right] * OF_{open,s,p}$$

Where

UOL_t = Change in connected load for technology, t

$OF_{open,s,p}$ = Open Operating Factor for Schedule Group, s, at time of peak, p

The change in connected load was the same as discussed earlier. The peak operating factor was determined from the self-reported schedules. Two periods were considered for the demand impact, the peak period of 12:00 PM - 6:00 PM and the peak hour of 3:00 PM - 4:00 PM. If lights in a particular schedule group were on during either of these two periods, it was given an OF value of 1, otherwise it was set to 0.

3.3 STATISTICAL BILLING ANALYSIS

The objective of the statistical billing analysis, also called the Statistically Adjusted Engineering (SAE) analysis, is to derive first-year gross impacts by using statistical techniques to assess billing data, and engineering estimates when available, to adjust for behavioral and other factors unaccounted for in the engineering energy impacts. 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 economy factors.

The pump repair measure group is the only case where a statistically significant impact can be detected from a SAE analysis. For other measures, impacts cannot be reliably determined in a statistical model for one of two reasons:

- **Low Expected Impacts.** Agricultural measures with low impacts (less than 5% 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.
- **Low Participation Level.** Impacts for measures with low participation are hard to determine due to insufficient sample sizes. Measures in this category include Customized Ag pumping measures (18 accounts) and low pressure sprinkler nozzles (23 accounts).

For the measures for which statistically significant estimates are not obtainable, the SAE analysis can still serve as a reality check or provide some indication for the range of the expected impacts and corroborate the engineering estimates.

3.3.1 Data Sources

The SAE analysis for the 1995 Ag Programs Evaluation used data from three primary data sources: the MDSS tracking database, the CIS billing database, and the telephone survey database. In addition, the analysis uses the engineering estimates for pump repair and lighting that are described in *Appendix C, Engineering Technical Analysis*. These estimates were derived from information collected in the telephone surveys and on-site audits, as well as other sources.

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

- **PG&E Billing Data**. The PG&E billing dataset used for the analysis was pro-rated monthly usage data, calculated by PG&E for each calendar month, and obtained from PG&E's Load Data Services. The dataset consisted only of customer accounts that were to be surveyed for this evaluation and covered the period from January 1992 to September 1996.

- **Telephone Survey Data**. The telephone survey supplies information on energy-related actions taken outside of PG&E programs, other end uses covered under each account, and other information not available in the MDSS database.

- **Engineering Estimates Derived from On-site Audit Data and Telephone Survey Data**. For the pump repair measure, the engineering estimates provided two sets of estimates of monthly usage. One set assumes that the pump is operating under the original plant efficiency and the other set assumes that the pump is operating under a new plant efficiency due to the repair. For the lighting measure, the engineering estimates provide estimates of the change in yearly usage due to the implementation of the lighting measures.

Selected items from all the data sources described above were merged to create analysis databases via a unique customer identifier—PG&E's customer control number.

3.3.2 Pump Repair Statistical Analysis

For the pump repair, participants are defined as those PG&E Ag customers who received PG&E rebates in the 1995 calendar year for installing at least one pump repair measure.

Segmentation of the participant population by whether or not the pumps were used for crops is necessary because the engineering models described in *Appendix C, Engineering Technical Analysis* assume that the pump is being used to provide water to crops. Without crop information, no engineering estimates were available. An estimation of the size of the two populations was made by classifying participants into three groups based on MDSS SIC code: (1) those who might use a pump for crops, (2) water supply and irrigation systems, and (3) others.

Exhibit 3-5
Pump Repair
Counts of Customer Control Numbers by Data Source

Category	Total	Crops	Water Districts	Other
Participants				
In MDSS	265	200	52	13
Completed Telephone Survey	169	126	41	4
Telephone Survey Engineering Estimate	94	94	0	0
Completed On-Site Audit	86	86	0	0
Audit Engineering Estimate	64	64	0	0
Nonparticipants				
Completed Telephone Survey	530	443	28	59
Telephone Survey Engineering Estimates	378	378	0	0

Exhibit 3-5 shows the counts of customer control numbers in total and by the three segmentation groupings. A total of 265 customers were identified in the MDSS. Of these, 75% were customers who raised crops, 20% were customers who were either water districts or irrigation systems, and the remaining 5% were customers who would not ordinarily have crops, such as dairy and livestock farms. Of the 200 customers likely to raise crops, 94 had engineering estimates based on telephone survey data and 64 had estimates based on the on-site audit data.

Our approach was to use separate regression models for two segment groupings of the population defined by the use of the pump for watering crops versus the use of the pump for other purposes. Regressions for the former group used the audit engineering estimates; regressions for the latter group used the billing pre-repair and post-repair usage in the absence of engineering estimates.

Estimation of Implementation Date

Customers' pump repair dates were estimated from the dates contained in the MDSS database, including the application date, the pre-inspection date, the post-inspection date, and the check issue date, as well as the survey and audit self-reported repair dates. A hierarchy of these dates and consistency among dates was established and applied to derive an estimate of each customer's repair date. Exhibit 3-6 shows the estimated date of pump repair for participants paid in 1995.

Exhibit 3-6
Pump Repair Participants
Distribution of Estimated Pump Repair Dates

Month/Year	Frequency	Percent	Cumulative Percent
Jan-94	1	1	1
Feb-94	1	1	1
Mar-94	3	2	3
Apr-94	6	4	7
May-94	5	3	9
Jun-94	4	2	12
Jul-94	6	4	15
Aug-94	4	2	18
Sep-94	3	2	20
Oct-94	5	3	22
Nov-94	9	5	28
Dec-94	66	39	67
Jan-95	7	4	71
Feb-95	2	1	72
Mar-95	7	4	76
Apr-95	0	0	76
May-95	1	1	77
Jun-95	4	2	79
Jul-95	7	4	83
Aug-95	2	1	85
Sep-95	3	2	86
Oct-95	11	7	93
Nov-95	11	7	99
Dec-95	1	1	100
Total	169	100	

For participants with crops, the implementation date is used explicitly in the regression model, as described in the next section. For participants without crops, the implementation date was merely used to verify that pump repairs had been performed in the 1995 growing year so that the billing data for the 1994 growing year can be regarded as a measure of pre-usage and the billing data for the 1996 growing year can be regarded as a measure of post-usage.

Model Specification and Results for Participants with Crops

The SAE analysis employing the engineering estimates was initially planned to be done in two stages: (1) conduct regressions using the engineering estimates derived from the on-site audits to take advantage of the improved data gathering that was a potential feature of the research design, and then (2) use the nested sample design to leverage the results of the on-site audit analysis to the engineering estimates derived from the telephone surveys.

The nested design also afforded the opportunity to compare the quality of the data going into the engineering estimates from the on-site audits and the telephone surveys by using the subgroup of participants for whom both estimates were available. The quality of the data collected in the on-site audits was so superior to that collected in the telephone surveys that the SAE analysis should rely solely on the on-site audit engineering estimates. The difference in the quality is attributed to more detailed and more reliable information collected in the on-site audits and to additional information collected in the on-site audits that were not, and probably could not be, collected in the telephone surveys.

An example of an item that was more refined and more accurately collected in the on-site audit than in the telephone survey was that of crops grown. The crop categories on the on-site audits could be much more detailed than those that could be used in the telephone survey and recollections of crops grown in the 1994 growing year are probably more accurate when collected on site. An example of data collected only in the on-site audits is the leaching requirement. It was collected for individual customers and crops in the on-site audits and was not collected at all in the telephone surveys. As a result, the leaching requirements used in the telephone survey had to be roughly approximated to derive the engineering estimates for this data source.

Of the 200 customers with crops, 64 had engineering estimates based on the on-site audits and 94 had engineering estimates based on the telephone survey. It was determined through analysis of bias that the tradeoff in the increase in quality of the on-site audit data more than made up for the decrease in the number of participants included in the analysis.

The regression analysis used monthly billing data for 1994, 1995, and 1996 as the dependent variable. Because on-site audits were conducted only for participants, the participant group served as its own control group. That is, the monthly analysis allowed for the estimation of impacts by examining the same customer both before and after the pump repair.

The on-site audit information concerning crops generally covered the 1994 and 1995 growing years. Therefore, months in these years were included for all participants. To decide whether 1996 monthly billing data should also be used, the crop with the highest reported acreage in 1995 as reported in the on-site audit was compared with the crop with the highest reported acreage in 1996 as reported in the telephone survey. If the crop categories corresponded and the reported acreage from the two sources was within 50 acres, the 1996 months were also included as well. All regression models were run with the 1996 data included and excluded.

The variables used in the regressions were intended to capture effects related to the following:

- Pump repair measure
- Other program measures
- Actions taken outside the program
- Other end uses
- Multiple Pumps

The date of pump repairs used information from the MDSS as well as dates gleaned in the on-site audit and the telephone survey. The MDSS database was used to identify other program measures implemented by each customer, an approximation of the date of implementation, and the expected gross impact. Responses to telephone survey items were used to define the other variables listed. The specific variables for each of these effects are shown in Exhibit 3-7.

Exhibit 3-7
Pump Repair
Measures Regression
Detailed Definition of Variables

Variable Name	Indicator Definition	Date Used
MDSS Est. of Pump Adjustment Impact	meas_cod='A4'	check issue date
MDSS Est. of Motor Impact	meas_cod='M..'	check issue date
MDSS Est. of Well Water Device Impact	meas_cod='A5'	check issue date
Indicator of other pump repair	psp01 =1	psp02a-psp02d
Indicator of other pump retrofit	psp01=2	psp02a-psp02d
Indicator of other pump adjustment	psp01=3	psp02a-psp02d
Indicator of Other End Uses	max(dv007c, dv007d, dv007e, dv007f, dv007g, dv007m, dv007z)	N/A
Indicator of Multiple Pumps	dv007b > 1	N/A

A variety of regressions were run with different combinations of variables, intercepts, screening criteria, as well as inclusion and exclusion of 1996 months.

The definitive billing regression model for participants with crops takes the following functional form:

$$kWhc,m = \alpha\ Engoc,m + \beta\ \Delta Engc,m + \Sigma i\ \gamma i\ ProgImpactc,m,i + \Sigma j\ \eta j\ OthImpactc,m,j + \varphi\ OthEndc + \lambda\ MultPumpc + \varepsilon$$

Where

$kWh_{c,m}$ is the energy consumption for control ID c in month m.

$Engo_{c,m}$ is the engineering estimate of energy consumption for control ID c in month m assuming the original plant efficiency.

$\Delta Eng_{c,m}$ is the engineering estimate of impact due to program pump repair for control ID c in month m. For months prior to the program pump repair, it is equal to zero; for months after program pump repair, it is equal to the difference between engineering estimates that use original plant efficiency and the new plant efficiency ($\Delta Eng_{c,m} = Engo_{c,m} - Engn_{c,m}$).

$ProgImpact_{c,m,i}$ is the estimate of impact due to implementation of program measure i for control ID c in month m. For months prior to the implementation of the measure, it is equal to zero; for months after the implementation of the measure, it is equal to the MDSS first year gross kWh impact estimate for program measure i for control ID c.

$OthImpact_{c,m,j}$ is the estimate of impact due to implementation of measure i outside the program for control ID c in month m. For months prior to the implementation of the measure, it is equal to zero; for months after the implementation of the measure, it is equal to the 1993 average monthly energy consumption for control ID c.

$OthEnd_c$ is a weighted indicator of other end uses for control ID c. If any other end use was indicated in the Ag Program Telephone Survey, $OthEnd_c$ is equal to the 1993 average monthly energy consumption for control ID c; otherwise, it is zero.

$MultPump_c$ is a weighted indicator of multiple pumps on the account. If multiple pumps was indicated in the Ag Program Telephone Survey, $MultPump_c$ is equal to the 1993 average monthly energy consumption for control ID c; otherwise, it is zero.

ε is the error term that captures both random errors and errors introduced from the omission of factors not included in the model.

Of the 64 customer control identifiers with on-site audit engineering estimates, 27 qualified to have their 1996 monthly data included in addition to the 1994 and 1995 data. This provided a pool of 1,860 months of data across customers. Of these, 817 observations were used in the final model, 371 prior to pump repair and 446 after pump repair. The other observations were censored for the following reasons:

- No 1993 billing data to use as a scaling factor: 5 controls 120 observations
- Missing billing data: 21 observations
- Billing data = 0 or engineering estimates = 0: 1 control 950 observations

The results of the regression are shown in Exhibit 3-8. For each parameter in the model, this exhibit shows the values of the regression coefficient, the original t-statistic, and an adjusted t-statistic. Adjustment of the t-statistic is necessary because performing the regression at the monthly level violates the assumption that the error terms are independent. Autocorrelation is tested using the Durbin-Watson statistic. The positive autocorrelation indicates that the estimate of the error variance is too small and requires adjustment.

Exhibit 3-8
Pump Repair
SAE Model Results
Audited Customers with Crops

Parameter Description	Regression Coefficient	t-statistic	Adjusted t statistic*
Eng. Est. of kWh (orig. plant efficiency)	0.622	27.579	10.066335
Eng. Est. of Program Pump Repair Impact	-0.723	-6.396	-2.33454
MDSS Est. of Pump Adjustment Impact		-	
MDSS Est. of Motor Impact	1.414	5.184	1.89216
MDSS Est. of Well Water Device Impact	0.773	4.372	1.59578
Indicator of other pump repair	0.986	0.067	0.024455
Indicator of other pump retrofit	-	-	
Indicator of other pump adjustment	-1.121	-0.357	-0.130305
Indicator of Other End Uses	0.116	0.015	0.005475
Indicator of Multiple Pumps	0.534	5.934	2.16591
Number of Observations	817		
Adjusted R-square	0.66		
Durbin-Watson D	0.729		
First Order Autocorrelation	0.635		

*Adjusted t-statistic = t-statistic * (1 - first order autocorrelation) to adjust for autocorrelation.

The results indicate that the program pump repair impact is approximately 72% of that estimated by the engineering estimates. The adjusted t-statistic indicates that this is statistically significant. The only other coefficient that was found to be statistically significant was the indicator for multiple pumps.

Model Specification and Results for Participants Without Crops

Since participants without crops did not have engineering estimates, a different regression model was formulated for this group. The dependent variable was the sum of the billing data for the 1996 growing year (i.e., October, 1995 to September 1996), and the dependent variables were the sum of the billing data for the 1994 growing year and a weighted indicator of program participation. The regression in this case used all the non-crop participants and those participants who were identified as non-crop farm customers in the telephone survey. Examination of the SIC codes for these customers indicated that the great majority of these customers were either water districts or in the irrigation business (82% of participants and 71% of nonparticipants).

Covariates similar to those defined for the crop customers were defined for the non-crop customers. These included participation in other program measures, actions outside the program, other end uses, and multiple pumps. A variety of regressions were run, including using different covariates and different inclusion criteria. Examination of scatterplots of 1994 usage with 1996 usage indicated that relatively large customers, those whose usage was 3,000,000 kWh or more in either year, were substantially different from smaller users. Therefore, regressions were run both including all users and excluding large customers. None of the regressions resulted in statistically significant results.

The regression model that yielded typical, if not statistically significant, results for participants and nonparticipants without crops takes the following functional form:

$$kWhc,1996 = \alpha\, kWhc,1994 + \beta\, Retrtotc + \varepsilon$$

Where

$kWh_{c,1996}$ is the energy consumption for control ID c in the 1996 growing year.

$kWh_{c,1994}$ is the energy consumption for control ID c in the 1994 growing year.

$Retrtot_c$ is a weighted indicator of participation in the pump repair program. For participants, it is equal to energy consumption for the 1994 growing year; for nonparticipants, it is zero.

ε is the error term that captures both random errors and errors introduced from the omission of factors not included in the model.

Of the customer control identifiers that had telephone surveys, 67 qualified as non-crop customers (39 participants and 28 nonparticipants). Of these, 58 observations were used in the final model (31 participants and 27 nonparticipants). The other observations were censored for the following reasons:

- No 1993 billing data to use as a scaling factor: 1 participant
- Missing billing data: 1 participant
- yearly billing data for 1994 or 1996 > 3,000,000 kWh: 6 participants, 1 nonparticipant

The results of the regression are shown in Exhibit 3-9. The coefficient for the indicator of program participation was -0.12, but the t-statistic for the estimate indicates that it is not statistically significant.

Exhibit 3-9
Pump Repair
SAE Model Results
Non-Crop Customers

Parameter Description	Regression Coefficient	t-statistic
1994 total billing	0.96	18.621
Indicator of Program Participation	-0.122	-0.937
Number of Observations	58	
Adjusted R-square	0.87	

Final Results for Pump Repair

To obtain the realization rate for the participants with crops, a ratio estimate is applied to the estimated regression coefficient of impacts. Specifically, the following equation is used to derive the realization rate:

$$RR_{pop1} = RegCoeff_{samp} * Eng\_TMY_{samp} / MDSS\_gr1yrkwh_{samp}.$$

Where

RR_{pop1} is the population realization rate for participants with crops.

$RegCoeff_{samp}$ is the regression coefficient for the on-site audit engineering estimate of impact.

Eng_TMY_{samp} is the engineering estimate of impacts in a typical meteorological year for the on-site audit subgroup.

$MDSS\_gr1yrkwh_{samp}$ is the sum of gross first year kWh impacts for the on-site audit subgroup.

A similar equation would be used to obtain the realization rate for the participants without crops if the regression coefficient had been significant:

$$RR_{pop2} = RegCoeff_{samp} * Usage94_{samp} / MDSS\_gr1yrkwh_{samp}.$$

Where

RR_{pop2} is the population realization rate for participants without crops.

$RegCoeff_{samp}$ is the regression coefficient for the estimate of gross impact using 1994 usage.

$Usage94_{samp}$ is the sum of 1994 kWh usage for the non-crop subgroup.

$MDSS\_gr1yrkwh_{samp}$ is the sum of gross first year kWh impacts for non-crop subgroup.

Applying these equations resulted in a realization rate of 0.73 for the participants with crops, and a realization rate of 1.03 for the participants without crops. Because the non-crop regressions were not statistically significant, the more conservative, lower realization rate of 0.73 was applied to the entire pump repair participant population.

3.3.3 Indoor Lighting Statistical Analysis

For the indoor lighting measures, participants are defined as those PG&E agricultural customers who received PG&E rebates in the 1995 calendar year for installing at least one of the indoor lighting measures. Exhibit 3-10 shows the counts of customer control numbers relevant to the analysis. A total of 85 customers were identified in the MDSS. Of these customers, all had engineering estimates, and 81 had complete telephone survey data.

For the nonparticipant survey, 81 customer control numbers were identified with an indoor lighting end use. All indoor lighting participants and nonparticipants had matches with the billing dataset.

Exhibit 3-10
Indoor Lighting
Counts of Customer Control Numbers by Data Source

Category	Total
Participants	
In MDSS	85
Completed Telephone Survey	69
Engineering Estimate	85
Nonparticipants	
Completed Telephone Survey	81

Model Specification and Results

In all the regressions that were run the dependent variable was the sum of the monthly billings for the most recent 12 months (October 1995 to September 1996). Independent variables included the sum of 12 monthly billings for a similar pre-implementation period (October 1993 to September 1994), the sum of engineering estimates of gross change for participants across all indoor lighting measures as derived from the audit data, sum of the MDSS estimates of the gross impacts of other program measures for participants, and a weighted indicator of other end uses. The indicator of other end uses used the same telephone survey items to identify customers that had other end uses. The indicator was weighted by average monthly usage in 1993.

A variety of regressions were run with different combinations of variables, intercepts, and screening criteria. In addition, the robustness of the models was examined by identifying outliers and rerunning the models with outliers excluded. None of the models yielded results that were statistically significant.

The regression model that yielded typical, if not statistically significant, results for participants and nonparticipants takes the following functional form:

$$kWhc,1996 = \alpha\, kWhc,1994 + \beta\, Retrtotc + \eta\, OthImpactc + \varepsilon$$

Where

$kWh_{c,1996}$ is the energy consumption for control ID c in the 1996 growing year.

$kWh_{c,1994}$ is the energy consumption for control ID c in the 1994 growing year.

$Retrtot_c$ is the sum of engineering estimates of energy change for the 1996 growing year across all indoor lighting measures. This is zero for nonparticipants.

$OthImpact_c$ is the sum of MDSS first year gross kWh impact estimates for control ID c for all measures other than indoor lighting.

ε is the error term that captures both random errors and errors introduced from the omission of factors not included in the model.

Of the customer control identifiers, 155 qualified as indoor lighting customers (74 participants with engineering estimates of energy change and 81 nonparticipants with indoor lighting end uses). Of these, 140 observations were used in the final model (70 participants and 70 nonparticipants). The other observations, 4 participants and 11 nonparticipants, were censored because their 1994 or 1996 energy consumption exceeded 1,000,000 kWh.

The results of the regression are shown in Exhibit 3-11. The coefficient for the gross program impacts was 0.08 and was statistically insignificant. The coefficient for other program impacts was -1.47. This coefficient was significant.

Exhibit 3-11
Indoor Lighting
SAE Model Results

Parameter Description	Regression Coefficient	t-statistic
1994 total billing	0.99	44.862
Indoor Lighting Eng. Est. of Gross Impact	0.08	0.677
Other Program Measure MDSS Impacts	-1.47	-3.133
Number of Observations	140	
Adjusted R-square	0.94	

3.4 NET-TO-GROSS AND SPILLOVER METHOD

This section briefly covers the data sources and the general methods used to score free-ridership and spillover.

Data sources used in the NTG and spillover analysis include the following:

- 10 PG&E account representative surveys
- 29 PG&E service territory pump dealer surveys
- 10 Utah (control group) pump dealer surveys

- 10 PG&E service territory lighting vendor surveys (vendors serving the Ag market)
- US Census Data, Current Industrial Reports, MA36L Electric Lighting Fixtures, MQ36B Electric Lamps, and MQ36C Fluorescent Lamp Ballasts
- 425 Ag Program participant telephone surveys (a census), including
  - 69 lighting end-use participants (from a total of 81 sites)
  - 356 pumping end-use participants
- 540 nonparticipant telephone surveys, including
  - 81 lighting end-use nonparticipants
  - 530 pumping end-use nonparticipants
- 17 Customized Incentives participant on-site audits

The method used for coding free-ridership varied slightly for each measure and was an elaboration of the technique described in the work plan. In actuality, measures with greater ex ante impacts were accorded additional follow-up questions in the telephone survey. The questions available for the analysis are shown in Exhibit 3-12. Free-ridership rates for participants are weighted by avoided cost (AC).

Exhibit 3-12
Survey Questions Available for Self-Report Analysis

		Measure					
Work Plan	**Survey Question**	**Pump Repair**	**Pump Adjustment**	**LPSN**	**Motors**	**WWMD**	**Lighting**
1	Before knew about pgm, looked into ee action?	PR032	PA032	SP032	MT035A-C	WW032	LT032
2	Before knew of pgm, purchased same eff w/in 1 year?	PR033	PA033	SP033	MT032	-	LT033
3	Would have taken same eff action if no rebates?	PR034	PA035	SP034	-	WW034	LT034
	Would have taken same action in exactly the same manner if no rebates?	PR035	-	-	-	-	-
	What would you do differently	PR036	-	-	-	-	-
	Do you have pump adj annually?	-	PA034	-	-	-	-
	Would you have installed the same # of nozzles	-	-	SP035	-	-	-
	Installed standard psi nozzles instead?	-	-	SP036	-	-	-
	Spent less money on pump retro, down throttled, installed more lines?	-	-	SP037	-	-	-
	Before knew about pgm, more likely to rewind?	-	-	-	MT033	-	-
	Why didn't purchase other motors	-	-	-	MT037A-C	-	-
	What lighting would you have installed?	-	-	-	-	-	LT034A-E
	How did you become aware?	FS004	FS004	FS004	FS004	FS004	LD1
	Did pump tester recommend?	IS036	IS036	IS036	IS036	IS036	-

This remainder of this section presents the detailed methods and results for each Ag measure evaluated. Then, the net-to-gross ratios used in the evaluation are presented.

3.4.1 Customized Incentives (42 percent of Avoided Cost)

In this section, results of the NTG analysis using participant on-site audit data are presented.

Results Summary

The NTG estimate for Customized Incentives participants is 0.335. Because Custom sites constitute 42 percent of the avoided cost for the Ag programs, their relatively low NTG ratio has a significant effect of decreasing the overall program value. While Customized Incentives participants were queried about additional changes (in equipment or operation) that might affect usage, no formal attempt was made to classify or quantify any spillover effects. It should be noted that one customer reported expanding his irrigated acreage because of the program's benefit.

Free-Ridership Method

One-on-one interviews were conducted with Customized Incentives participants. The auditors who conducted the interviews followed a structured interview guide similar to the telephone survey, with additional probes designed to elicit more open-ended, qualitative information from the customer on the nature, extent, and timing of the retrofit. Two sets of questions were developed, one for irrigation systems and one for "general custom" changeouts. Participants who were planning to adopt a measure but were impelled by the program to adopt earlier than planned were scored as net participants (using a 0/1 scoring). Partial free-riders (those participants who would have made some change but not to the efficiency level undertaken through the program) were scored as pure free-riders. This was done because of the difficulty associated with assigning "anchored" (i.e., quantified and defensible) values to partial free-riders.

3.4.2 Lighting (21.5 percent of Avoided Cost)

In this section, results of lighting NTG analysis using participant self-reported data, market movement results from trade ally surveys, and preliminary unweighted spillover rate estimates are presented.

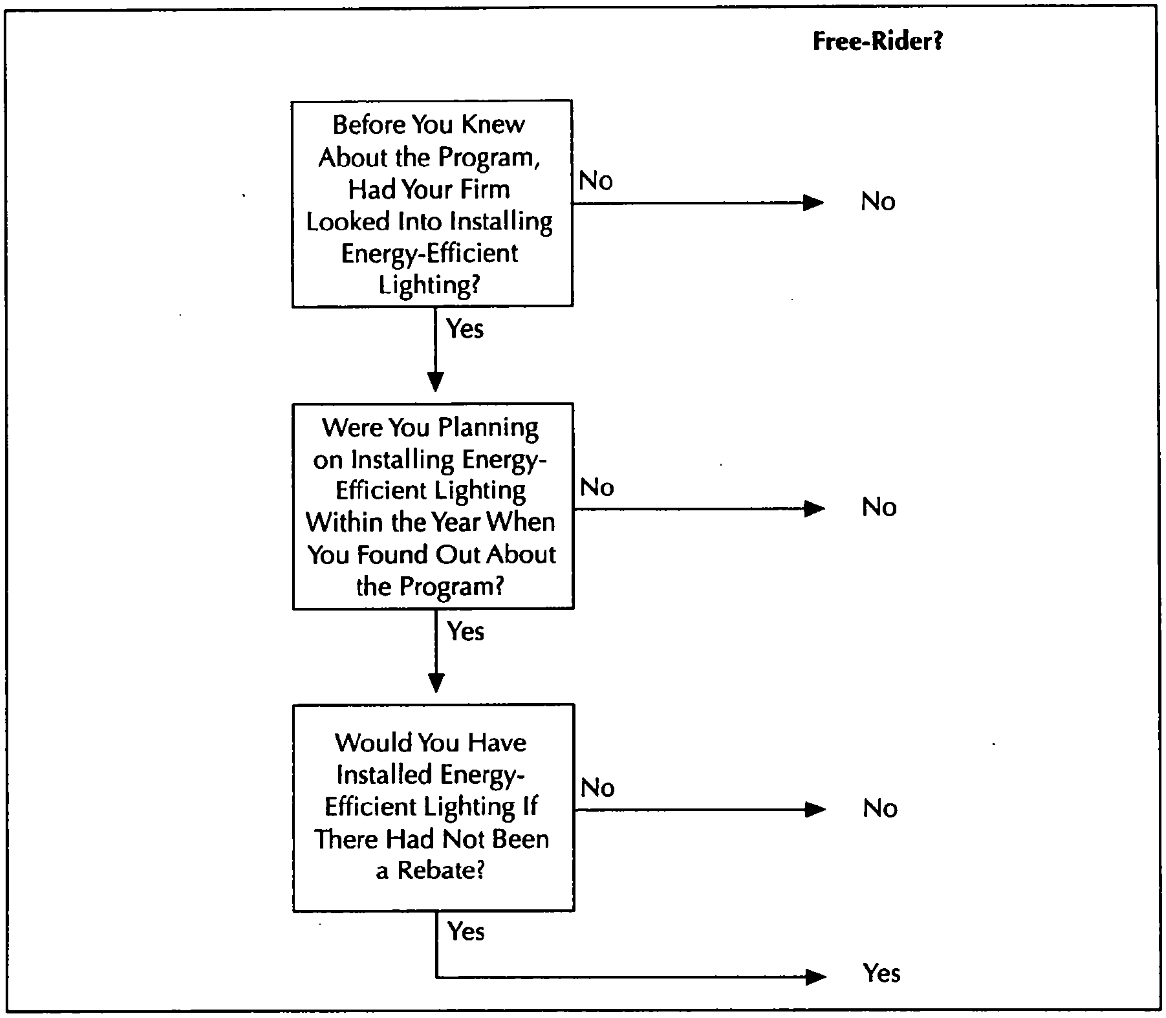
Results Summary

The net-to-gross estimate (based only on free-ridership) for lighting is 0.950. Vendor and Census data also point to high NTG for the lighting end use. Spillover rates are low. The lighting NTG estimate is much higher than all other measures except low-pressure sprinkler nozzles.

Free-Ridership Method

In the NTG analysis for lighting, a sequence of three survey questions is used (LT032, LT033, and LT034). Customers with responses of "don't know" or "refused" to any of the three free-rider questions are initially scored as free-riders. They can then be reclassified as net participants according to their responses to the set of questions. A customer must meet 3 conditions to be classified as a free-rider; he must have: (1) indicated he had been looking into installing energy-efficient lighting before becoming aware of the program; (2) stated he would have installed the energy-efficient lighting within the year; and (3) stated he would have installed energy-efficient lighting if the program had not existed. The NTG ratio for lighting is 0.950 using this method.

Exhibit 3-13
Lighting Free-Ridership Analysis



Market Movement Results—Trade Ally Data

In general, the trade ally data confirm preliminary conclusions drawn from the self-report data, namely that free-ridership is quite low among lighting participants.

None of the vendors reported any Ag customers within PG&E's service territory who purchased qualifying high-efficiency lighting equipment but did not participate in the program. Seven of the 10 surveyed lighting vendors thought the program increased overall sales of agricultural lighting equipment.

The three most common technologies installed through the program in 1995 were: (1) high-intensity discharge (HID) fixtures, (2) T-8 fluorescent lamps with electronic ballasts, and (3) compact fluorescent lamps. The existing technologies that each of these installed technologies replaced were: (1) mercury vapor lamps, (2) T-12 fluorescent lamps with magnetic ballasts, and (3) incandescent lamps.

The average age of the lighting fixtures replaced through the program, as reported by the surveyed lighting vendors, was 8.5 years.

Spillover Method and Results

Lighting spillover can be defined as lighting installed outside the program but influenced by the program. Preliminary estimates of lighting spillover rates were generated by analyzing responses to a combination of questions asked of 70 participants and 81 nonparticipants with lighting as an end use. This integrated approach to estimating Ag lighting spillover is summarized below.

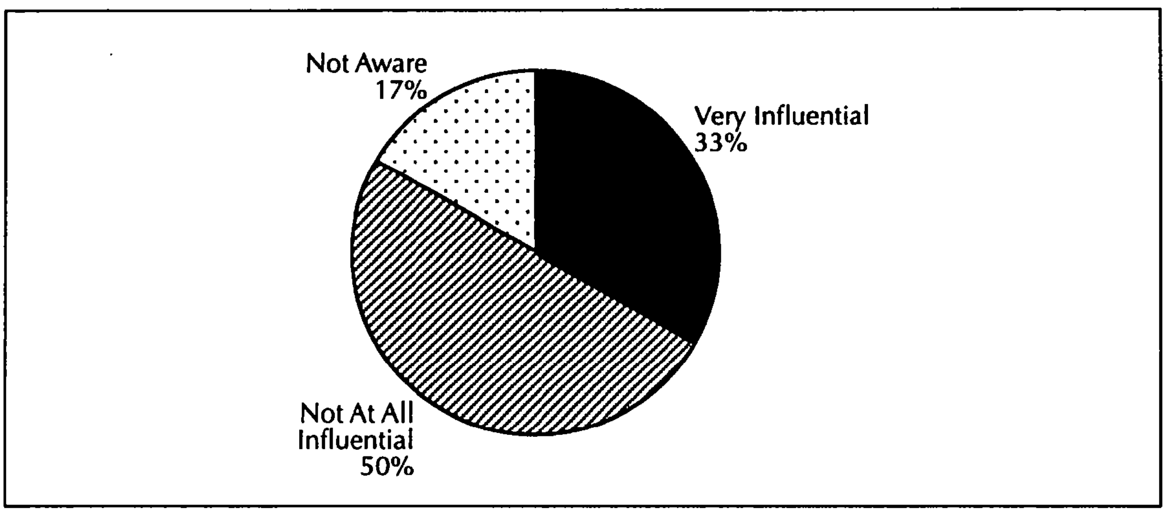
All surveyed respondents were asked if they had had any unrebated lighting fixture installations since January 1994. Participants who answered "yes" to the first question were asked if these changes were made after participating in the program. Nonparticipants, and participants who said the changes were made after participation, were asked if they submitted rebate applications for any of the work done.

Participants and nonparticipants who passed the first two screening questions and had not submitted a rebate application were asked how influential the program was in their decision. Those who said that the program had influenced their decision were included in the preliminary estimate of program spillover. The last step is to apply the survey-based estimates to the Ag lighting participant population and Ag nonparticipant population along with estimates of impact per site, resulting in a final spillover estimate.

Participants

The 1995 lighting spillover estimate of 1.35 percent was calculated. Ten surveyed participants reported that since January 1994 they had added lighting fixtures and had not received a rebate. Eighty percent had the additions done after participating in the program. Seventy percent did not submit a rebate application for the fixture additions. Twenty percent of these said the program influenced their additional lighting fixture installations. Of these two, one installed additional lighting in 1995. This 10 percent was then applied to the 10 of 74 participants who reported lighting as an end use to yield a spillover rate of 1.35 percent for 1995 [(1/10)*(10/74)].

Exhibit 3-14
Program Influence on Unrebated Lighting Fixture Installations Outside the 1995 Program
Program Participants



Half the participants who reported additional unrebated lighting fixture installations stated they were not influenced by the program. One-third stated the program was very influential and the rest were not aware of the program at the time of their retrofit.

Nonparticipants

Only one of the 17 nonparticipants who added lighting fixtures since 1994 was aware of the program before the purchase decision. None of the 81 surveyed nonparticipants who mentioned a lighting end use indicated lighting program spillover, according to our definition.

Summary

These low rates of adoption of energy-efficient lighting outside the program are consistent with vendor reports of market share and point to an emerging market with low free-ridership.

3.4.3 Pump Repair (17.3 percent of Avoided Cost)

In this section, results of pump repair NTG analysis using participant self-reported data, market movement results from trade ally surveys (PG&E service territory and Utah control group), account rep interviews, and spillover rate estimates are presented.

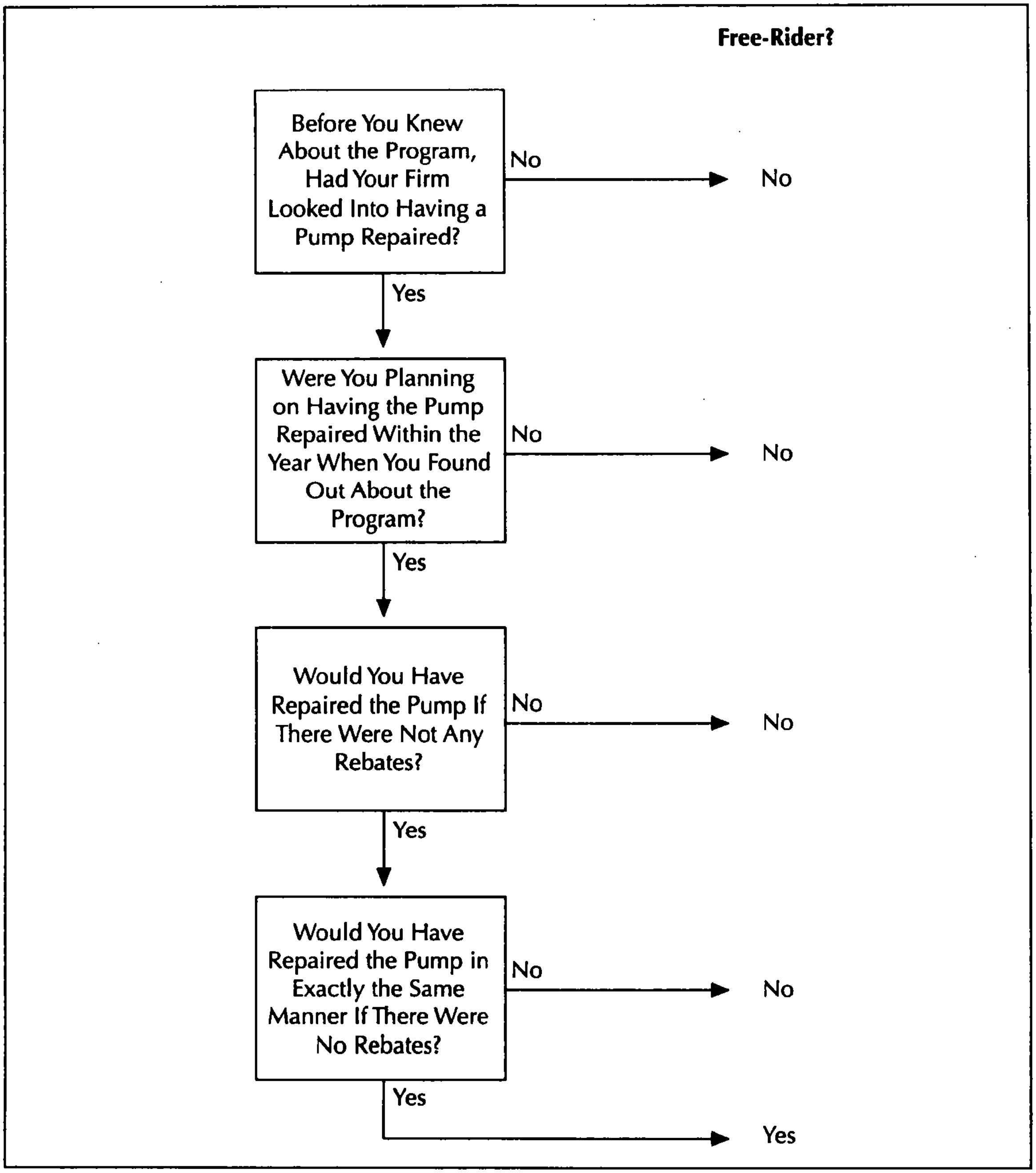
Results Summary

The net-to-gross estimate for pump repair is 0.495, which includes a contribution of 0.235 made by free ridership and 0.260 made by spillover. Pump repair has the highest free ridership estimate of all agricultural measures covered in this report, possibly due to the maturity of the measure in the Ag market. Vendor data point to a stable market that has undergone transformation.

Free-Ridership Method

In the NTG analysis for pump repair, a set of three survey questions is used (PR032, PR033, and PR034). A fourth question is analyzed as a consistency check (PR035). Customers with responses of "don't know" or "refused" to any of the initial three free-rider questions (PR032, PR033, and PR034) are initially scored as free-riders. They can then be reclassified as net participants according to their responses to the set of questions. The consistency check question (PR035) is then reviewed. A customer must meet four conditions to be classified as a free-rider; he must have: (1) indicated he had looked into having the pump repaired before becoming aware of the program; (2) stated he would have repaired the pump within the year; (3) stated he would have repaired the pump if the program had not existed; and (4) stated he would have repaired the pump in exactly the same manner if there were no rebates. The contribution to the NTG ratio made by free ridership for pump repair is 0.235.

Exhibit 3-15
Pump Repair Free-Ridership Analysis



Market Movement Results—Trade Ally Data

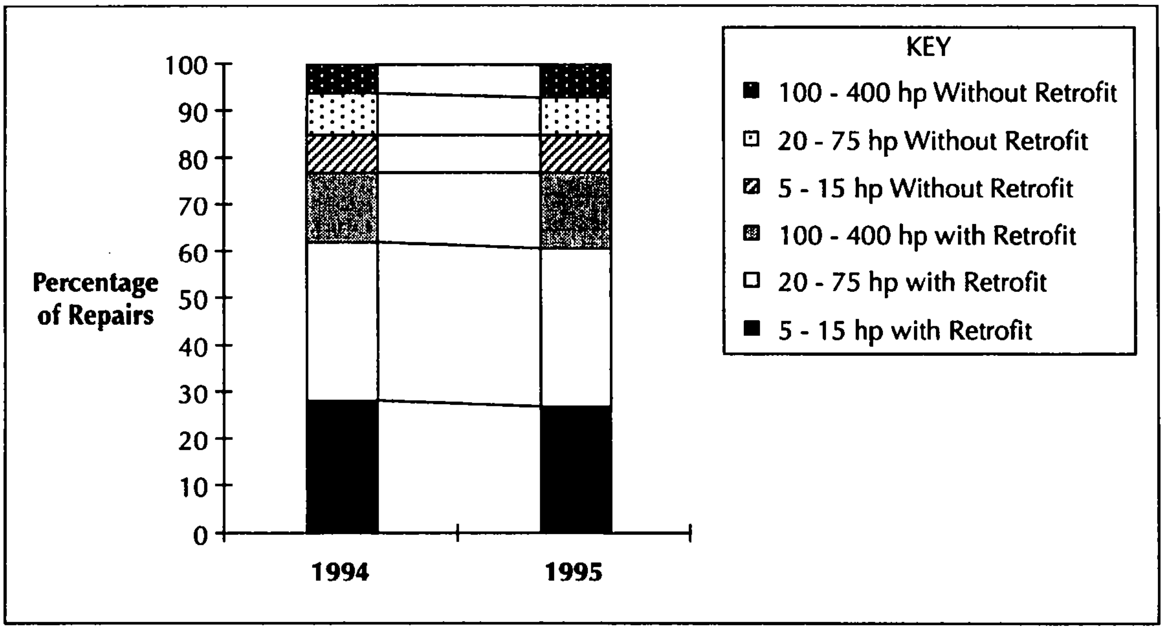
In general, the trade ally data confirm preliminary conclusions drawn from the self-report data, that free-ridership is relatively high among pump repair participants.

Twelve of the 29 (41 percent) surveyed pump vendors thought the program increased the overall volume of pump repairs for pumps with electric motors. Only one of the vendors reported he had customers within PG&E service territory who repaired their pumps to program standards but did not participate in the program. This vendor cited lack of awareness and paperwork as the primary reasons for not participating.

In 1995, the average percentage of program-qualifying pump repairs (pump repairs including a retrofit of the impeller and bowl) as reported by surveyed vendors was 53.8 percent. This is an increase from the 50.4 percent reported repaired in 1994. The Utah vendors reported 20.4 percent of their pump repairs included a retrofit of the impeller and bowl in 1995, up from 19.3 percent in 1994.

Five of the 29 vendors reported they performed an average of 9.4 percent of their 1995 pump repairs outside PG&E's service territory. None of these other service territories offered rebates.

Exhibit 3-16
Pump Repairs by Horsepower



As shown in Exhibit 3-16 above, pump repairs by horsepower and retrofit action as reported by the surveyed vendors indicate almost no change from 1994 - 1995. Pump repairs with retrofits of impellers and bowls account for almost 80 percent of all repairs, as reported by surveyed pump vendors. The Utah vendors reported that less than half of their pump repairs included retrofits of impellers and bowls. Approximately 34 percent of the PG&E service territory pump repairs fall into the category of 20 - 75 horsepower with retrofits of the impellers and bowls. Five to 15 horsepower with a retrofit is next highest, making up 28 percent of pump repairs, and the 100 - 400 horsepower with a retrofit category is third most common, making up 16 percent. Pump repairs without retrofits make up the remaining 22 percent of surveyed vendors' pump repairs. In Utah, pump repairs without retrofits make up the majority of the pump repairs completed in 1994 and 1995. This comparison could be an indication of successful market transformation in PG&E service territory.

Sixty-five percent of the vendors thought they influence their customers' choice of equipment and configuration. The remaining 34.5 percent said their customers primarily indicate what equipment to install.

Market Movement Results—PG&E Agricultural Account Rep Results

The reps reported an average of 51 percent of 1995 program participants would have implemented pump repairs even if they would not have received a rebate. Of these 51 percent, account reps believe an average of 77 percent accelerated their decision by a year or more because of the rebate.

Spillover Method and Results

Pump repair spillover can be defined as pump repairs undertaken outside the program that are influenced by the program. An estimate of pump repair spillover was calculated by analyzing responses to a combination of questions asked of 354 participants and 530 nonparticipants with pumping as an end use. This integrated approach to estimating program pump repair spillover is summarized below.

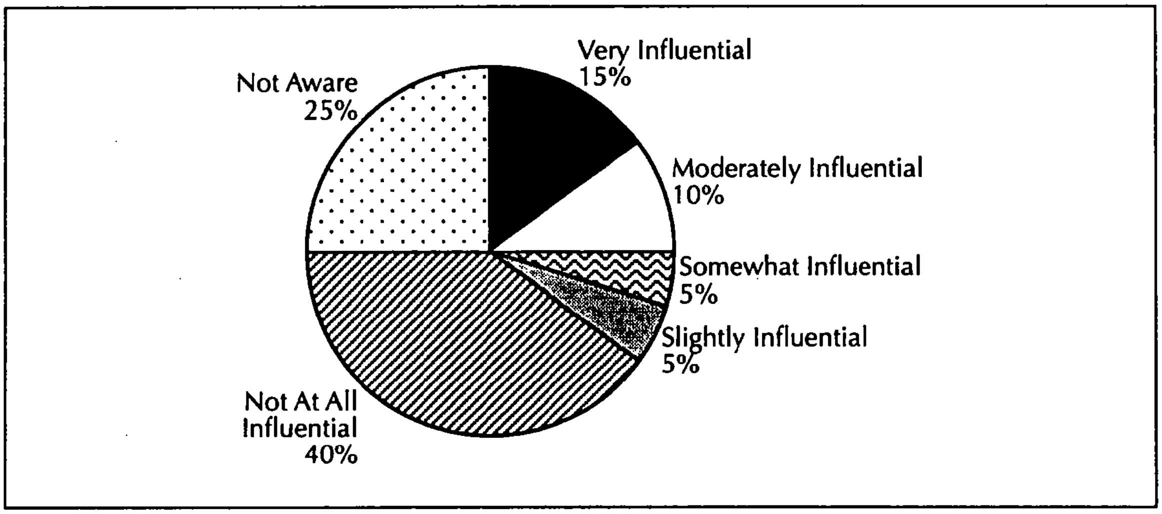
- All surveyed respondents were asked if they had had any additional unrebated program qualifying pump repairs since January 1994.
- Nonparticipants, and participants who said the changes were made were asked if they submitted rebate applications for any of the work done. (This is a verification step we have found useful in past studies.)
- Respondents who had not submitted a rebate application were asked how influential the program was in their decision.
- Those who said that the program had influenced their decision were included in the estimate of program spillover.
- The last step is to apply the survey-based estimates to the Ag pumping participant population and Ag nonparticipant population along with estimates of impact per site, resulting in a final spillover estimate.

Participants

A rate of 1995 pump repair participant spillover of 0.28 percent was calculated.

Six percent of the surveyed participants reported that since January 1994 they had had additional retrofits made on pumps, which were program qualifying (both the impeller and bowl were retrofited). Only 1.4 percent of the surveyed participants reported that they did not submit a rebate for a program-qualifying pump repair. Finally, 0.57 percent of the surveyed participants had unrebated, program-qualifying pump repairs performed and reported that this action was influenced by the program. Because this spillover rate spans a two year period, only half of this amount, or 0.28 percent, was claimed as participant spillover.

Exhibit 3-17
Program Influence on Unrebated Pump Repairs Outside the 1995 Program
Program Participants



Thirty percent of surveyed participant pumping customers who reported additional unrebated pump repairs stated the program was at least somewhat influential on their decision. Twenty-five percent said they were unaware of the program.

Nonparticipants

A rate of 1995 pump repair nonparticipant spillover of 26 percent was calculated.

Three percent of the surveyed nonparticipants reported that since January 1994 they had retrofited their pumps, which were program qualifying (both the impeller and bowl were retrofited). Only 2.5 percent of the surveyed nonparticipants reported that they did not submit a rebate for a program-qualifying pump repair. Finally, 0.19 percent of the surveyed nonparticipants had unrebated, program-qualifying pump repairs performed and reported that this action was influenced by the program. Because this spillover rate spans a two year period, only half of this amount, or 0.094 percent, was claimed towards nonparticipant spillover.

In PG&E's service territory, there are apporximately 72,000 pumping accounts. Therefore, a rate of 0.094 percent is equivalent to 68 nonparticipant pumping accounts. Relative to the 264 participant pumping accounts, this is equivalant to a nonparticipant spillover rate of 26 percent. This assumes that the impact corresponding to a nonparticipant pump retrofit is equivalent to one performed by a participant.

Because of the small sample size of nonparticipants making unrebated, program-qualifying, program-influenced pump repairs (i.e., the nonparticipants contributing to spillover), it was not possible to conduct a statisticly significant analysis of nonparticipant pump retrofit impact relative to the participant impact. Therefore, the assumption of equivalent impacts was made.

Summary

As will be discussed in the following sections, no other claim was made for nonparticipant spillover. Because the pump retrofit technology was the largest contributor to energy impacts among the RE and REO programs within the pumping end use (over 50 percent of RE/REO pumping energy impacts), more effort was made to claim spillover for this technology. Because spillover is claimed only for this technology, the overall spillover claim should be considered conservative.

3.4.4 Pump Adjustment (3.3 percent of Avoided Cost)

In this section, results of pump adjustment NTG analysis using participant self-reported data and preliminary unweighted spillover rate estimates are presented.

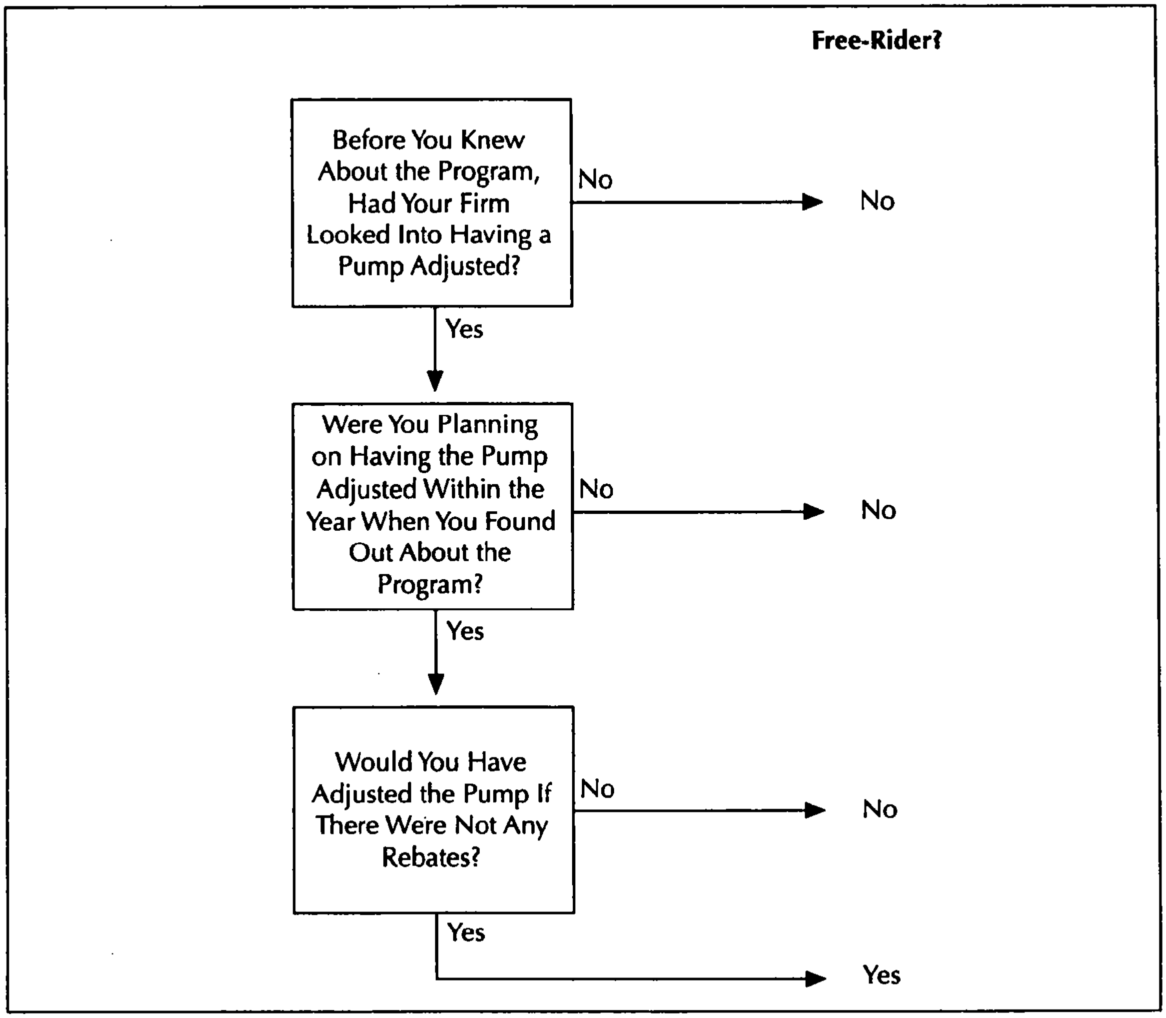
Results Summary

The net-to-gross estimate (based only on free-ridership) for pump adjustment is 0.467.

Free-Ridership Method

In the NTG analysis for pump adjustment, a set of three survey questions is used (PA032, PA033, and PA035). Customers with responses of "don't know" or "refused" to any of the three free-rider questions (PA032, PA033, and PA035) are initially scored as free-riders. They can then be reclassified as net participants according to their responses to the three free-rider questions. A customer must meet 3 conditions to be classified as a free-rider, he must have: (1) indicated he had been looking into having the pump adjusted before becoming aware of the program; (2) stated he would have adjusted the pump within the year; and (3) stated he would have adjusted the pump if the program had not existed. The NTG ratio for pump adjustment is 0.467.

Exhibit 3-18
Pump Adjustment Free-Ridership Analysis



Spillover Method and Results

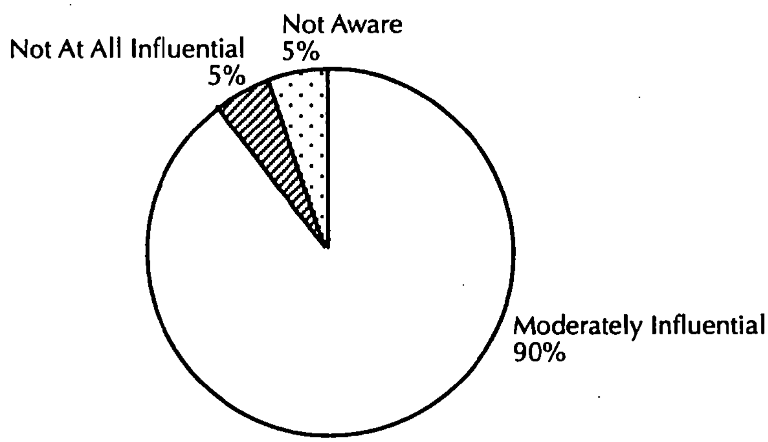
Pump adjustment spillover can be defined as pump adjustments undertaken outside the program that were influenced by the program. A preliminary estimate of pump adjustment spillover was calculated by analyzing responses to a combination of questions asked of 354 participants and 530 nonparticipants with pumping as an end use. This integrated approach to estimating program pump adjustment spillover is summarized below.

All surveyed respondents were asked if they had had any additional program-qualifying, pump adjustments since January 1994. Nonparticipants, and participants who said the changes were made after participation, were asked if they submitted rebate applications for any of the work done. Respondents who had not submitted a rebate application were asked how influential the program was in their decision. Those who said that the program had influenced their decision were included in the estimate of program spillover. The last step is to apply the survey-based estimates to the Ag pumping participant population and Ag nonparticipant population along with estimates of impact per site, resulting in a final spillover estimate.

Participants

The 1995 pump adjustment spillover rate was estimated at 2.58 percent. Twenty-two surveyed participants reported that since January 1994 they had had additional adjustments made on pumps. Of these 18 said they did not submit a rebate application for the adjustment and that the program influenced their decision. Nine of these 18 reported additional pump adjustments in 1995. Nine out of the total 349 surveyed participants who reported pumping as an end use yields a participant spillover rate of 2.58 percent.

Exhibit 3-19
Program Influence on Unrebated Pump Adjustments Outside the 1995 Program
Program Participants



Ninety percent of participants who reported additional unrebated pump adjustments stated the program was moderately influential in their decision. The remaining customers were split between not influential and not aware of the program.

Nonparticipants

Nine nonparticipants reported that since January 1994 they had adjustments made on their pumps. None of the 530 surveyed nonparticipants who mentioned a pumping end use indicated being influenced by the program to make an adjustment to their pump. Therefore, no nonparticipant spillover can be claimed.

3.4.5 Well Water Measurement Device (WWMD) (1.9 percent of Avoided Cost)

In this section, results of WWMD NTG analysis using participant self-reported data are presented. No spillover data on this measure were collected.

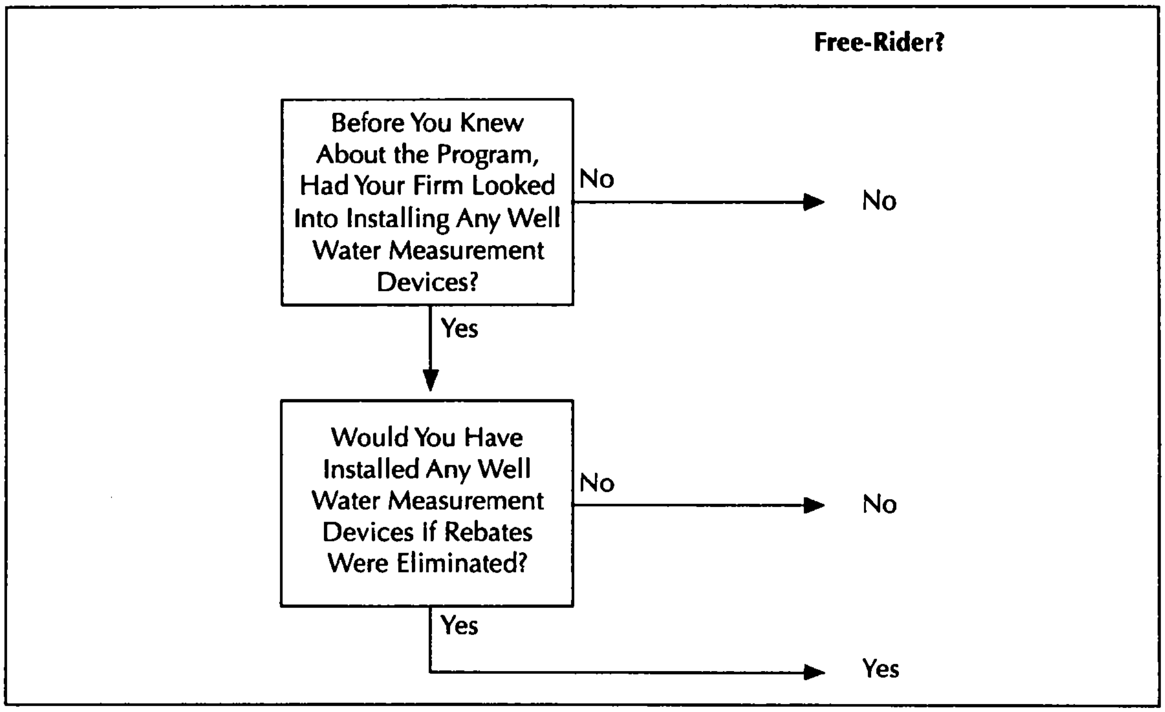
Results Summary

The net-to-gross estimate (based only on free-ridership) for WWMD is 0.338.

Free-Ridership Method

In the NTG analysis for WWMD, responses to two survey questions are used (WW032 and WW034). Customers with responses of "don't know" or "refused" to the two free-rider questions (WW032 and WW034) are initially scored as free-riders. They can then be reclassified as net participants according to their responses to the two free-rider questions. To be scored as a free-rider, a customer must have: (1) looked into installing WWMD before knowing about the program and, (2) said he would have installed WWMD if rebates were eliminated. The NTG ratio for WWMD is 0.338.

Exhibit 3-20
WWMD Free-Ridership Analysis



3.4.6 Motors (1.1 percent of Avoided Cost)

In this section, results of motors NTG analysis using participant self-reported data are presented. No spillover data on this measure were collected.

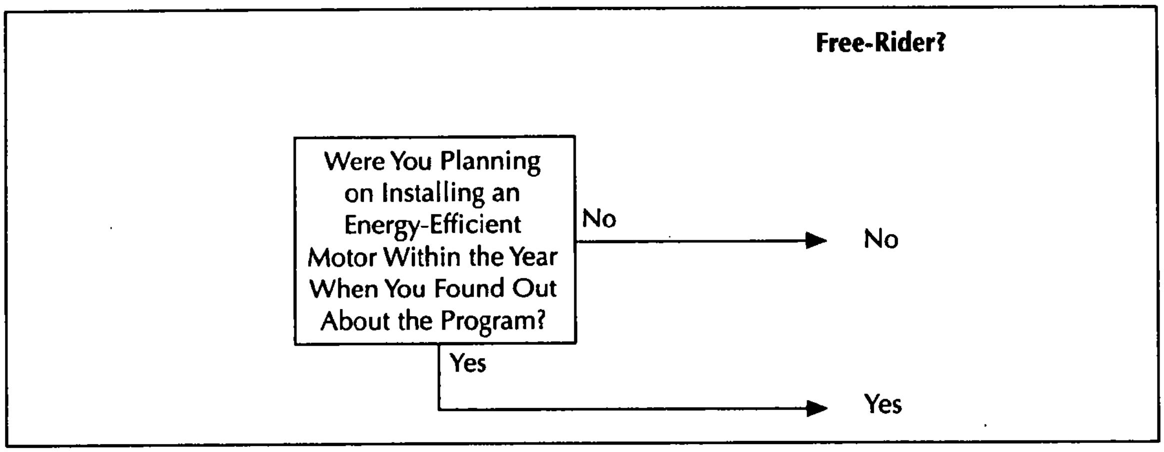
Results Summary

The net-to-gross estimate (based only on free-ridership) for motors is 0.438.

Free-Ridership Method

In the NTG analysis for motors (a measure with 1.1 percent of avoided cost), responses to two survey questions are used (MT032 and MT037). Customers with responses of "don't know" or "refused" to the initial free-rider question (MT032) are scored as free-riders. They can then be reclassified as net participants if their responses to the consistency check question (MT037) contradict their response to MT032. A customer must have said he was planning on installing an energy-efficient motor within the year when he found out about the program. As a consistency check, any customer who stated in the open-ended question (MT037) that he was planning on installing a standard-efficiency motor is coded as a net participant. The NTG ratio for motors is 0.438

Exhibit 3-21
Motors Free-Ridership Analysis



3.4.7 Low-Pressure Sprinkler Nozzles (LPSN) (0.9 percent of Avoided Cost)

In this section, results of the LPSN NTG analysis using participant self-reported data, market movement results from trade ally surveys, and preliminary unweighted spillover rate estimates are presented. Because of the potential effect of LPSN spillover on program net impacts, more resources were allocated to this measure in spite of its small percentage of avoided cost.

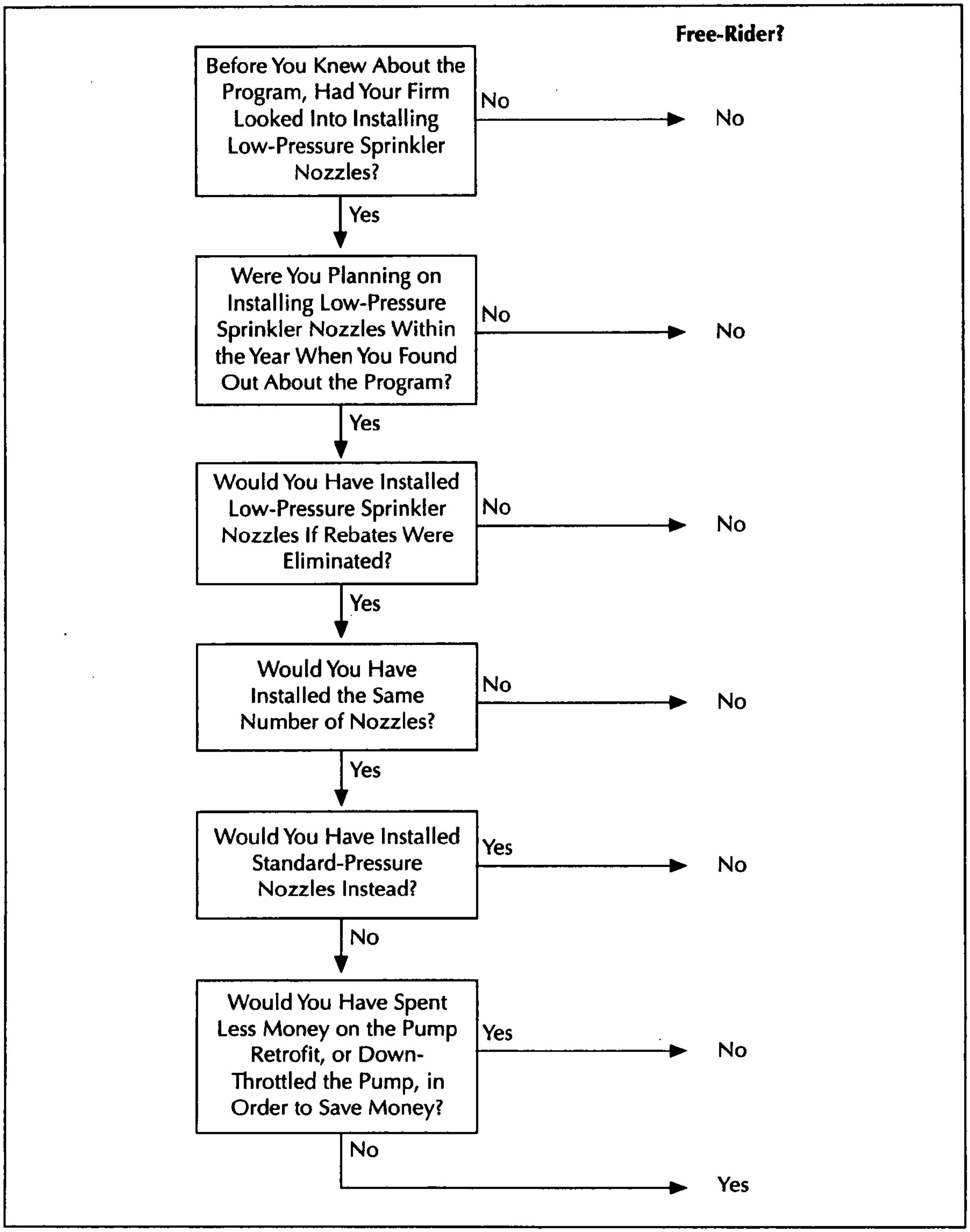
Results Summary

The NTG estimate (based only on free-ridership) for LPSN is 0.770. The NTG estimate for LPSN is higher than all other agricultural measures covered in this memo except lighting.

Free-Ridership Method

In the NTG analysis for LPSN, a set of three survey questions is used (SP032, SP033, and SP034). In addition, three survey questions are analyzed as a consistency check (SP035, SP036, SP037). Customers with responses of "don't know" or "refused" to any of the first three free-rider questions (SP032, SP033, and SP034) are initially scored as free-riders. A customer must have met the following conditions to be classified as a free-rider; he must have: (1) indicated he had looked into installing LPSN before becoming aware of the program; (2) stated he would have installed LPSN within the year; and (3) stated he would have installed LPSN if the program had not existed. Consistency check questions are used to verify that customers who said they would have (1) installed the same number of nozzles and (2) prepped the pump in the same way to accommodate the new nozzles are coded as free-riders. Finally, customers who said they would have installed standard pressure nozzles if rebates were eliminated are coded as net participants. The NTG ratio for LPSN is 0.770.

Exhibit 3-22
LPSN Free-Ridership Analysis



Market Movement Results—Trade Ally Data

The pump dealers offer insights into the market for LPSN. Ten of the 29 (34 percent) PG&E service territory pump vendors surveyed reported installations of LPSN. None of these sold or installed LPSN outside PG&E's service territory. Fifty percent of these vendors believe the program has increased their overall sales of LPSN. Five of the 10 (50 percent) surveyed Utah pump dealers reported LPSN sales.

In 1995 37.1 percent of surveyed pump vendors' LPSN installations included a pump repair (i.e., were most likely program-qualifying installations). This result is an increase from 30.7 percent in 1994. The Utah vendors reported 21.2 percent of their LPSN installations included a pump retrofit, up from 19.2 percent in 1994.

PG&E service territory pump vendors had very little trouble with the availability of LPSN. All of the vendors reported that in 1995, LPSN were "almost always or always available." Two vendors reported that in 1994, LPSN were "often available," with all other vendors reporting "almost always or always available." Utah vendors reported that LPSN were, on average, "often available" in 1995 and "available about half the time" in 1994.

Exhibit 3-23
Percentage Breakdown of LPSN Sales

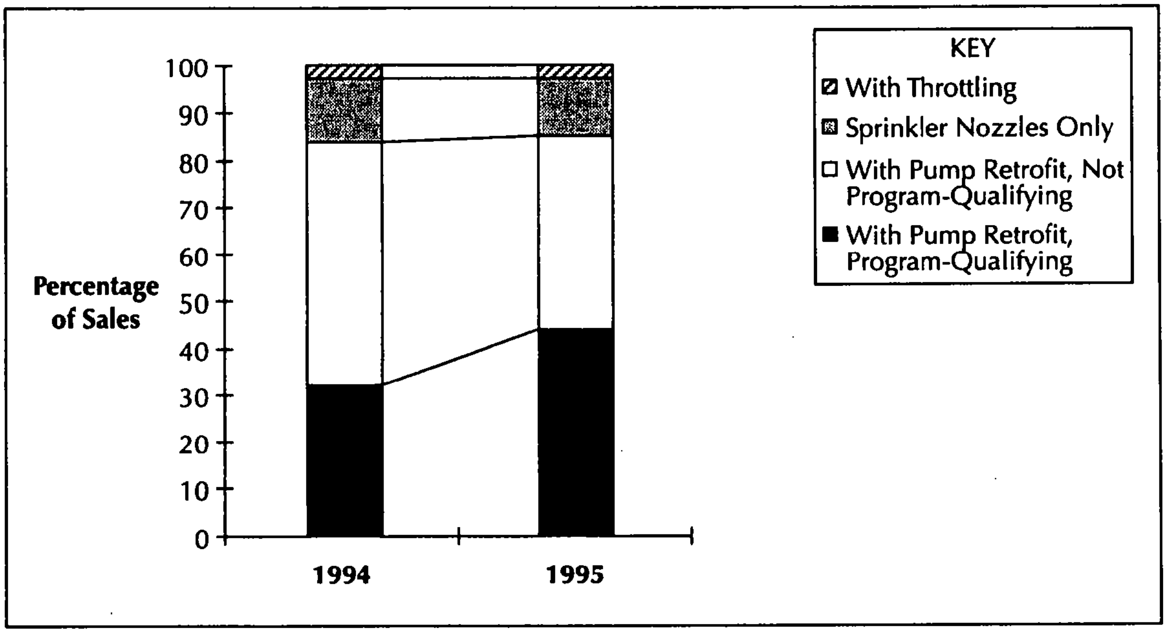


Exhibit 3-23 shows the percentage breakdown of LPSN sales for 1994 and 1995 in PG&E service territory and Utah, with a trend toward increased sales of LPSN with pump repairs in PG&E service territory over time. Vendors reported their sales of program-qualifying LPSN with pump repairs increased 12 percent from 1994 to 1995, from an average of 32 percent in 1994 to 44 percent in 1995. In Utah, approximately 20 percent of LPSN sales included pump repairs. While program-qualifying sales increased from 1994 to 1995 in PG&E service territory, sales of LPSN alone and LPSN with down-throttling remained constant from 1994 to 1995 (13 percent and 3 percent, respectively). In Utah, the percentage of vendors reporting just sprinkler nozzles or throttling in considerably higher than in PG&E service territory. This is an indication that possible market transformation to LPSN with pump repair has occurred in PG&E service territory.

Market Movement Results—PG&E Agricultural Account Rep Results

The reps reported that, on average, 51 percent of 1995 program participants would have implemented LPSN even if they would not have received a rebate. Among these 51 percent, vendors believe 81 percent accelerated their decision by a year or more because of the rebate. If the deferred free-riders[1] are counted as net participants, the NTG based on rep data is 90 percent (0.49+(0.81*0.51), consistent with participants' self-reports. Increasing sales from year to year point to a developing market where one might expect to see low NTG.

The most commonly mentioned (9 out of 10) reason that customers do not submit rebate applications for sprinkler nozzles is lack of awareness. Eight reps mentioned they thought it was "too much of a hassle" and two mentioned it was "just not worth it to the customer." One rep said it is a "communication problem between PG&E and customers" and that the "application process should be made simpler."

Six of the surveyed reps reported they typically advise customers to also do a pump repair with a sprinkler nozzle installation.

It was the reps' opinion that approximately 24 percent of customers who purchased sprinkler nozzles use them on multiple accounts. When asked what percentage use them at multiple premises, that average dropped to 14 percent.

Five of the reps thought the MDSS fields that capture how the sprinkler is used were not accurate. Only two of the reps thought they were accurate. The remaining three did not know. The reps who reported trends in the mobility of sprinkler equipment said it is more a factor of multiple sites, rather than size of customer. It is true, however, that the larger customers tend to have multiple sites.

Nine of the reps believe there are many customers installing LPSN outside the program. However, according to vendors, many of these installations are probably not program-qualifying.

Spillover Method and Results

At this time, LPSN spillover cannot be estimated because only 1 participant reported additional unrebated LPSN installations. Only 15 surveyed participants commented on LPSN.

Five of the 27 nonparticipants who installed LPSN were aware of the program before their purchase decision. None of the 530 surveyed nonparticipants who mentioned a pumping end use indicated LPSN program spillover.

Summary

Increases from year to year in the market share of program-qualifying installations point to an underdeveloped LPSN market, therefore NTG is likely to be high. In other words, low market saturation should result in high NTG ratios after an initial rollout of the measure. This seems to be happening.

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[1] Deferred free-riders are those who were planning on installing energy-efficient equipment prior to becoming aware of the program but whose purchase was accelerated by the program.

3.4.8 Summary of Results

Because the extent of spillover found among program participants and nonparticipants was so low for most measures, the ex post NTG ratios used to calculate net impacts are based exclusively on the level of self-reported free-ridership, with one exception. Since the pump retrofit technology was the largest contributor to energy impacts among the RE and REO programs within the pumping end use (over 50 percent of RE/REO pumping energy impacts), more effort was made to claim spillover for this technology. Therefore, spillover is only claimed for the pump retrofit measure. Because spillover is claimed only for this technology, the overall spillover claim should be considered conservative.

Exhibit 3-24 summarizes the net-to-gross ratios used, by technology.

Exhibit 3-24
NTG Weighted by Avoided Cost

End Use	LIGHTING	PUMPING						
Program	RE	RE/REO Measures						Custom
Technology	Overall	Pump Repair	Pump Adj	LPSN	Motors	WWMD	Overall	Overall
N	70	168	128	15	29	40	354	17
% Avoided Cost	21.50%	17.30%	3.30%	0.90%	1.10%	1.90%	24.50%	42.00%
Net-to-Gross Ratio	0.950	0.495	0.467	0.770	0.438	0.338	0.487	0.335

4. EVALUATION RESULTS

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 1995, which means that they include measures that were offered under previous years' programs.

Results are segmented by end use and technology, for indoor lighting and agricultural pumping.

4.1 GROSS ENERGY IMPACT RESULTS

Exhibit 4-1 presents the gross energy, demand and therm impact results from the evaluation.

Exhibit 4-1
Ex Post Gross Impacts by End Use and Technology

End Use	PG&E Code*	Measure Description	N	Gross Program Impact kWh	kW	Therm
Indoor Lighting	L63-L65	Compact Fluorescent Lamps	12	883,081	146	0
	L7	Incandescent to Fluorescent Fixtures	2	186,673	0	0
	L6	Exit Signs	1	999	0	0
	L14	Efficient Ballast Changeouts	1	854	0	0
	L22-L24/L73-L75	T-8 Lamps and Electronic Ballasts	22	100,052	20	0
	L17/L19/L20	Delamp Fluorescent Fixtures	4	43,535	18	0
	L26/L27/L79/L81	High Intensity Discharge	52	2,824,960	100	0
	L31/L36	Controls	4	3,173	0	0
	Indoor Lighting End Use Total		85	4,043,327	284	0
AG Pumping	A1	Pump Retrofit	264	6,050,772	1,394	0
	A4	Pump Adjustment	396	751,393	0	0
	A41/A42/A6	Low Pressure Nozzle	23	719,029	325	0
	A5	Well Water Meas Device	65	889,953	0	0
	M20-M38	Energy Efficient Motors	48	400,317	58	0
	A0	Customized Ag Measures	18	7,941,748	2,939	77,481
	Ag Pumping End Use Total		755	16,753,213	4,717	77,481

Note: Applications with status code "Z" were excluded from the calculation. Paid 1st year life time was used to calculate the impacts.
* PG&E MDSS Measure or Action Code.

Within the indoor lighting end use, HIDs account for 70 percent of energy impacts, but only 35 percent of demand. The low demand impact for HIDs is due to the fact that technology is generally installed for growing applications during the off peak evening hours. This HID result also drives the relatively low overall demand impacts, relative to energy.

Within the pumping end use, pump retrofits and Customized Incentive measures account for 84 percent of the energy impacts, 92 percent of the demand impacts and all of the therm impacts. The 18 accounts that installed customized measures, although representing only 2 percent of the accounts receiving rebates, represent almost half of the total program energy impact, 62 percent of demand impact and all of the therm impact. Although the pump adjustment measure had 43 percent of the accounts receiving rebates, it represents only 3 percent of the energy impact for the Ag program.

4.2 NET-TO-GROSS ADJUSTMENTS

The net-to-gross (NTG) estimates are presented by measure in Exhibit 4-2. The weighted average NTG for Ag program measures for which NTG values were calculated, is 0.95 for lighting and 0.42 for pumping. The lighting NTG estimate does not include any adjustment for spillover. The pumping NTG estimate only includes an adjustment for spillover for the pump retrofit measure. Section 3-4 discusses the net-to-gross analysis in more detail.

Exhibit 4-2
NTG Weighted by Avoided Cost

End Use	LIGHTING	PUMPING						
Program	RE	RE/REO Measures						Custom
Technology	Overall	Pump Repair	Pump Adj	LPSN	Motors	WWMD	Overall	Overall
N	70	168	128	15	29	40	354	17
% Avoided Cost	21.50%	17.30%	3.30%	0.90%	1.10%	1.90%	24.50%	42.00%
Net-to-Gross Ratio	0.950	0.495	0.467	0.770	0.438	0.338	0.487	0.335

4.3 NET IMPACTS

Exhibit 4-3 presents the net energy, demand, and therm impacts obtained by applying the NTG ratios described above to the gross ex post impact estimates. The NTG ratios used in the calculation are presented in the exhibit below, with the free ridership and spillover effects separated out to emphasize the fact that spillover was only claimed for the pump retrofit measure.

Exhibit 4-3
Ex Post Net Impacts by End Use and Technology

End Use	PG&E Code*	Measure Description	NTG (1-FR)	NTG Spillover	Net Program Impact kWh	kW	Therm
Indoor Lighting	L63-L65	Compact Fluorescent Lamps	0.95	0.00	838,927	138	0
	L7	Incandescent to Fluorescent Fixtures	0.95	0.00	177,340	0	0
	L6	Exit Signs	0.95	0.00	949	0	0
	L14	Efficient Ballast Changeouts	0.95	0.00	811	0	0
	L22-L24/L73-L75	T-8 Lamps and Electronic Ballasts	0.95	0.00	95,050	19	0
	L17/L19/L20	Delamp Fluorescent Fixtures	0.95	0.00	41,358	17	0
	L26/L27/L79/L81	High Intensity Discharge	0.95	0.00	2,683,712	95	0
	L31/L36	Controls	0.95	0.00	3,015	0	0
	Indoor Lighting End Use Total		0.95	0.00	3,841,161	270	0
AG Pumping	A1	Pump Retrofit	0.24	0.26	2,997,553	691	0
	A4	Pump Adjustment	0.47	0.00	350,901	0	0
	A41/A42/A6	Low Pressure Nozzle	0.77	0.00	553,652	251	0
	A5	Well Water Meas Device	0.34	0.00	300,804	0	0
	M20-M38	Energy Efficient Motors	0.44	0.00	175,339	25	0
	A0	Customized Ag Measures	0.34	0.00	2,660,486	985	25,956
	Ag Pumping End Use Total		0.33	0.09	7,038,734	1,951	25,956

Note: Applications with status code "Z" were excluded from the calculation. Paid 1st year life time was used to calculate the impacts.
* PG&E MDSS Measure or Action Code.

Overall, Exhibit 4-3 shows a five and 58 percent decrease in ex post program energy impacts for lighting and pumping respectively, as a result of the application of the NTG adjustments.

The high free ridership rate of 0.765 (1-0.235) for pump retrofit reduced the total energy impact for the Ag program by 4.5 million kWh and the demand impact by more than 1 MW. In addition, Customized Incentives participants had a low NTG value (0.335). Because of the large contribution to gross ex post energy and demand impacts made by these two measures, their low NTG significantly reduces the overall total net numbers.

4.4 GROSS REALIZATION RATES

The gross realization rate values represent, by measure, the ratio of gross ex post impact evaluation findings to the gross ex ante program design estimate of impacts. They illustrate how well the ex ante estimates predicted actual impacts, before taking into account customer actions with and without the program. Exhibit 4-4 presents the gross realization rates for energy, demand and therm impacts by measure.

Exhibit 4-4
Gross Impact Realization Rates by End Use and Technology

End Use	PG&E Code *	Measure Description	N	Realization Rates		
				kWh	kW	Therm
Indoor Lighting	L63-L65	Compact Fluorescent Lamps	12	1.35	1.33	NA
	L7	Incandescent to Fluorescent Fixtures	2	3.49	0.00	NA
	L6	Exit Signs	1	1.15	1.15	NA
	L14	Efficient Ballast Changeouts	1	1.87	3.69	NA
	L22-L24/L73-L75	T-8 Lamps and Electronic Ballasts	22	0.76	0.90	NA
	L17/L19/L20	Delamp Fluorescent Fixtures	4	0.24	0.57	NA
	L26/L27/L79/L81	High Intensity Discharge	52	0.49	0.10	NA
	L31/L36	Controls	4	1.00	NA	NA
	Indoor Lighting End Use Total		85	0.59	0.25	NA
AG Pumping	A1	Pump Retrofit	264	0.73	1.02	NA
	A4	Pump Adjustment	396	0.13	NA	NA
	A41/A42/A6	Low Pressure Nozzle	23	1.25	2.69	NA
	A5	Well Water Meas Device	65	0.71	NA	NA
	M20-M38	Energy Efficient Motors	48	1.00	1.00	NA
	A0	Customized Ag Measures	18	1.00	1.00	1.00
	Ag Pumping End Use Total		755	0.70	1.05	1.00

Note: Applications with status code "Z" were excluded from the calculation. Paid 1st year life time was used to calculate the impacts.
* PG&E MDSS Measure or Action Code.

Overall, Exhibit 4-4 shows that the ex post energy estimates are 41 and 30 percent below the ex ante estimates for lighting and pumping, respectively. The ex post demand estimates, however, are 75 percent lower for lighting and 5 percent higher for pumping. Therm estimates, which were calculated using verified ex ante assumptions, are unchanged.

The results presented in Exhibit 4-4 can be explained using information from the review of the ex ante estimates (*Appendix B, Engineering Review of Ex Ante Estimates*) in conjunction with the impact analysis results. Discussions of significant results, by measure, are presented below.

4.4.1 Indoor Lighting

Overall, the realization rate for indoor lighting was 0.59 for energy and only 0.25 for demand. In general, the evaluation found that lamps installed through the program tended to have far lower peak operating factors than the ex ante assumed CDF of 0.67. In addition, operating hours tended to be less than those assumed for derivation of the ex ante estimates, which has the effect of reducing energy impacts. Several individual measures had extremely high or low realization rates, but these measures generally had low participation (fewer than 5 sites) and had little effect on kW or kWh impact.

Among the measures with significant participation:

Compact fluorescent lamps (CFLs) were often lower wattage than assumed by the ex ante estimate. Specifically, audits of some of the larger installations found that it was common to install 5 watt CFLs, while the ex ante estimate assumes a 13 watt connected load for all CFLs in the 5-13 watt range. Overall, evaluation demand impacts were 33 percent higher than the ex ante estimates. Operating hours were found to be lower than the 4,000 assumed for the ex ante estimates, but this only partly offset the greater than expected difference in connected load, resulting in a realization rate of 1.35 on energy.

T-8 lamps and electronic ballasts had ex post gross impacts that differed from the ex ante estimates by only 24 percent for energy and 10 percent for demand. These differences are due to some fixtures having larger post installation wattage than the ex ante assumptions, as well as operating hours being slightly reduced relative to the ex ante assumptions.

High intensity discharge (HID) lamps drive the overall realization rates for the indoor lighting end use. The energy realization rate of 0.49 can be explained by the difference between assumed and observed operating hours. For the most common HID measures—400 watt metal halide lamps—the ex ante estimates assumed 2,480 annual operating hours, or about 6.8 hours every day. In the largest audited HID installation, hours of operation were found to be only 4-6 hours per day, which would reduce energy impacts. The extremely low demand realization rate reflects the operating characteristics of ornamental nurseries, which accounted for most of the HID installations. The evaluation found that these nurseries use the installed HIDs almost exclusively to extend their growing hours into the evening, so that the lights are never on during the peak hour. As a result the demand realization rate for the HID measure as a group is only 0.10.

4.4.2 Ag Pumping

Four measures had realization rates that differed significantly from the ex ante estimates.

Pump Retrofit - The unadjusted engineering estimates and the ex ante estimates differed by only a few percent for this measure. The energy engineering estimates were, however, adjusted by the SAE coefficient of 0.72, which explains almost all of the difference between the ex post and ex ante estimates.

Pump Adjustment - The realization rate of 0.13 is due to the unrealistic ex ante impact estimate of an 11 percent reduction in energy use for each pump adjustment—an impact that would almost match the energy reduction from a much costlier pump repair/retrofit. 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 actual energy consumption for each account, while the ex ante estimate is based on a fixed value per adjustment (see *Appendix B, Engineering Review of Ex Ante Estimates*).

Well Water Measurement Device - The energy realization rate is 0.71. In this case, the ex post estimate used the same algorithm as the ex ante estimate, but applied different values for key parameters. Specifically, the ex post average kWh per year used is almost 30,000 kWh less than the ex ante assumption. In addition, the average lift per pump used in the algorithm was raised from 194.6 feet in the ex ante to 211 feet in the ex post, further reducing estimated energy savings and reducing the realization rate (see *Appendix B, Engineering Review of Ex Ante Estimates*).

Low-Pressure Sprinkler Nozzles - The ex ante estimate algorithm for this measure was deemed appropriate and applied to the ex post estimate, with two exceptions. First, the updated coincident diversity factor (CDF) of 78 percent was used rather than the old CDF of 53 percent (see *Appendix A, Coincident Diversity Factor Report)*. In addition, the ex ante estimates did not vary the impacts by region, while the 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 B, Engineering Review of Ex Ante Estimates*).

4.5 NET REALIZATION RATES

The net energy realization rates are presented in Exhibit 4-5. 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.

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

where

RR = the realization rate.

There is an overall net realization rate of 0.73 and 0.38 for energy, and 0.31 and 0.57 for demand, for lighting and pumping respectively. For therms, there is an overall realization rate of 0.45 for pumping. On average, the net realization rates for pumping measures are lower than the gross realization rates described previously because of the generally lower ex post than ex ante NTG ratios. For the lighting end use, however, net impact realization rates are higher because of the 0.95 ex post NTG ratio.

Exhibit 4-5
Net Impact Realization Rates by End Use and Technology

End Use	PG&E Code*	Measure Description	N	Realization Rates kWh	kW	Therm
Indoor Lighting	L63-L65	Compact Fluorescent Lamps	12	1.66	1.64	NA
	L7	Incandescent to Fluorescent Fixtures	2	4.31	0.00	NA
	L6	Exit Signs	1	1.42	1.42	NA
	L14	Efficient Ballast Changeouts	1	2.31	4.56	NA
	L22-L24/L73-L75	T-8 Lamps and Electronic Ballasts	22	0.93	1.12	NA
	L17/L19/L20	Delamp Fluorescent Fixtures	4	0.29	0.71	NA
	L26/L27/L79/L81	High Intensity Discharge	52	0.60	0.13	NA
	L31/L36	Controls	4	1.23	NA	NA
	Indoor Lighting End Use Total		85	0.73	0.31	NA
AG Pumping	A1	Pump Retrofit	264	0.46	0.64	NA
	A4	Pump Adjustment	396	0.08	NA	NA
	A41/A42/A6	Low Pressure Nozzle	23	1.21	2.62	NA
	A5	Well Water Meas Device	65	0.31	NA	NA
	M20-M38	Energy Efficient Motors	48	0.58	0.58	NA
	A0	Customized Ag Measures	18	0.45	0.45	0.45
	Ag Pumping End Use Total		755	0.38	0.57	0.45

Note: Applications with status code "Z" were excluded from the calculation. Paid 1st year life time was used to calculate the impacts.
* PG&E MDSS Measure or Action Code.

As discussed previously, some of the results presented in Exhibit 4-5 can be explained based on the gross impact realization rates. Comments below focus specifically on the contribution from the NTG ratios.

4.5.1 Pumping

For Ag Pumping measures overall, the net realization rates are very low: 0.38 for energy, 0.57 for demand, and 0.45 for therms. Underlying these low realization rates (and the low overall net impact realization rate) is the high rate of free-ridership for two Ag Pumping measures that accounted for a large share of program avoided cost: pump repair and custom measures. These and other specific measures are discussed below.

Pump Repair/Retrofit - This measure, which accounted for over one-third of the ex post gross energy impact, was found to have a NTG ratio of only 0.50, since most pump repair participants would have undertaken this action even without the program. As a result, the ex post gross impact (already reduced by the SAE analysis) was cut further to 46 percent of the ex ante estimated value.

Customized Ag Measures - The 18 sites that received rebates for custom measures in 1995 reported a strong likelihood that they would have installed these measures anyway. Free-ridership was estimated at approximately two-thirds, resulting in a NTG ratio of 0.335. Since customized measures accounted for the largest share of both avoided cost and ex post gross impact of any single measure, the low NTG for this measure category alone reduced total program net energy impacts by 5 million kWh.

Low Pressure Sprinkler Nozzles - LPSN had a higher NTG ratio than any other pumping measure, as well as a gross realization rate that was greater than 1.0. While it had net realization rates of 1.21 for energy and 2.62 for demand, its overall contribution to program impacts was far too small to offset the effects of the pump retrofit and custom Ag measures.

4.5.2 *Lighting*

Because a single NTG ratio of 0.95 was calculated and applied to all lighting measures, the effects of the individual measures were no different than those discussed in detail in the gross realization rates section (see *Section 4.4*, above).

4.6 *SUMMARY OF REALIZATION RATES*

The bottom line is that the evaluation ex post estimate of net energy impacts is only 73 and 38 percent as large as the PG&E ex ante estimate of net energy, respectively, for the lighting and pumping end uses. For demand, the net ex post impact of the program is only 31 and 57 percent as large as the ex ante estimate for lighting and pumping, respectively. Exhibit 4-6 summarizes all of the gross and net demand impacts and realization rates. Recommendations that could help improve the net realization rates are discussed next, in *Section 5*.

Exhibit 4-6
Net Impact Realization Rates by End Use and Technology

End Use	Measure Description	N	Gross Program Impact			NTG Adjustment		Net Program Impact		
			kWh	kW	Therm	(1-FR)	Spillover	kWh	kW	Therm
EX ANTE										
Indoor Lighting	Compact Fluorescent Lamps	12	655,380	109	0	0.67	0.10	504,643	84	0
	Incandescent to Fluorescent Fixtures	2	53,424	9	0	0.67	0.10	41,136	7	0
	Exit Signs	1	867	0	0	0.67	0.10	668	0	0
	Efficient Ballast Changeouts 1		456	0	0	0.67	0.10	351	0	0
	T-8 Lamps and Electronic Ballasts	22	132,302	22	0	0.67	0.10	101,873	17	0
	Delamp Fluorescent Fixtures	4	183,752	31	0	0.67	0.10	141,489	24	0
	High Intensity Discharge	52	5,793,216	970	0	0.67	0.10	4,460,776	747	0
	Controls	4	3,173	0	0	0.67	0.10	2,443	0	0
	Indoor Lighting End Use	85	6,822,570	1,141	0	0.67	0.10	5,253,379	878	0
AG Pumping	Pump Retrofit	264	8,238,209	1,372	0	0.69	0.10	6,508,185	1,084	0
	Pump Adjustment	396	5,660,495	0	0	0.69	0.10	4,471,791	0	0
	Low Pressure Nozzle	23	577,326	121	0	0.69	0.10	456,088	96	0
	Well Water Meas Device	65	1,252,062	0	0	0.67	0.10	958,095	0	0
	Energy Efficient Motors	48	400,317	58	0	0.65	0.10	300,703	44	0
	Customized Ag Measures	18	7,941,748	2,939	77,481	0.65	0.10	5,956,311	2,204	58,111
	AG Pumping End Use	755	24,070,161	4,490	77,481	0.67	0.10	18,651,174	3,427	58,111
EX POST										
Indoor Lighting	Compact Fluorescent Lamps	12	883,081	146	0	0.95	0.00	838,927	138	0
	Incandescent to Fluorescent Fixtures	2	186,673	0	0	0.95	0.00	177,340	0	0
	Exit Signs	1	999	0	0	0.95	0.00	949	0	0
	Efficient Ballast Changeouts 1		854	0	0	0.95	0.00	811	0	0
	T-8 Lamps and Electronic Ballasts	22	100,052	20	0	0.95	0.00	95,050	19	0
	Delamp Fluorescent Fixtures	4	43,535	18	0	0.95	0.00	41,358	17	0
	High Intensity Discharge	52	2,824,960	100	0	0.95	0.00	2,683,712	95	0
	Controls	4	3,173	0	0	0.95	0.00	3,015	0	0
	Indoor Lighting End Use	85	4,043,327	284	0	0.95	0.00	3,841,161	270	0
AG Pumping	Pump Retrofit	264	6,050,772	1,394	0	0.24	0.26	2,997,553	691	0
	Pump Adjustment	396	751,393	0	0	0.47	0.00	350,901	0	0
	Low Pressure Nozzle	23	719,029	325	0	0.77	0.00	553,652	251	0
	Well Water Meas Device	65	889,953	0	0	0.34	0.00	300,804	0	0
	Energy Efficient Motors	48	400,317	58	0	0.44	0.00	175,339	25	0
	Customized Ag Measures	18	7,941,748	2,939	77,481	0.34	0.00	2,660,486	985	25,956
	AG Pumping End Use	755	16,753,213	4,717	77,481	0.33	0.09	7,038,734	1,951	25,956
REALIZATION RATES										
Indoor Lighting	Compact Fluorescent Lamps	12	1.35	1.33	NA	-	-	1.66	1.64	NA
	Incandescent to Fluorescent Fixtures	2	3.49	0.00	NA	-	-	4.31	0.00	NA
	Exit Signs	1	1.15	1.15	NA	-	-	1.42	1.42	NA
	Efficient Ballast Changeouts 1		1.87	3.69	NA	-	-	2.31	4.56	NA
	T-8 Lamps and Electronic Ballasts	22	0.76	0.90	NA	-	-	0.93	1.12	NA
	Delamp Fluorescent Fixtures	4	0.24	0.57	NA	-	-	0.29	0.71	NA
	High Intensity Discharge	52	0.49	0.10	NA	-	-	0.60	0.13	NA
	Controls	4	1.00	NA	NA	-	-	1.23	NA	NA
	Indoor Lighting End Use	85	0.59	0.25	NA	-	-	0.73	0.31	NA
AG Pumping	Pump Retrofit	264	0.73	1.02	NA	-	-	0.46	0.64	NA
	Pump Adjustment	396	0.13	NA	NA	-	-	0.08	NA	NA
	Low Pressure Nozzle	23	1.25	2.69	NA	-	-	1.21	2.62	NA
	Well Water Meas Device	65	0.71	NA	NA	-	-	0.31	NA	NA
	Energy Efficient Motors	48	1.00	1.00	NA	-	-	0.58	0.58	NA
	Customized Ag Measures	18	1.00	1.00	1.00	-	-	0.45	0.45	0.45
	AG Pumping End Use	755	0.70	1.05	1.00	-	-	0.38	0.57	0.45

5. RECOMMENDATIONS

Recommendations that enhance future performance and evaluations of PG&E's Agricultural EEI Programs (the Ag programs) are presented in this section. Recommendations regarding evaluation methods are followed by those affecting the program's design and tracking system.

5.1 EVALUATION METHODS

The evaluation team offers the following comments and recommendations regarding methods used in the 1995 evaluation:

General Issues for Quantifying Spillover Effects - Additional efforts need to be made to better quantify the effects of spillover. Because of small sample sizes, spillover efforts were concentrated on the pump retrofit measure, which was expected to provide the most significant contribution to overall spillover. Since sample sizes were also small for this measure, additional efforts should be made to more accurately estimate spillover.

Applicability of SAE Analysis - The diversity of the agricultural sector, as described elsewhere in this evaluation, poses analytical challenges to the application of statistically adjusted engineering (SAE) analysis using telephone survey data. Due to the low level of participation and the limited ability of telephone survey data to provide measure-specific data (for example obtaining leaching requirements over the phone is difficult),, it may be cost-effective to conduct *only* on-site audits. The more detailed, more accurate audit data collected for this evaluation did support successful implementation of an SAE modeling for pump repair: a single, well-defined end use. However, very little leveraging of on-site audit data to the telephone survey population was possible. QC recommends that future Ag evaluation use SAE analysis only with on-site audit data. In addition, due to the quality of the data collected on site, a smaller number of on-sites relative to telephone surveys could be collected. Although the protocols require a minimum of 350 surveys, it is recommended that a retroactive waiver be submitted to reduce this number to a more cost-effective number of on-sites.

5.2 PROGRAM DESIGN

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

5.2.1 Program Design Estimates

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

Apply the Updated the Coincident Diversity Factor (CDF) - The CDF—used in predicting demand during the on-peak season at the system peak hour—should be updated using the results of the 1996 study conducted to calculate the CDF. This study used load research data for the years 1992-1995 to estimate a CDF of 0.78. This value was found to be robust over the four-year period studied, and should be used in future ex ante impact calculations.

Apply Updated Overall Plant Efficiency (OPE) Ratios for Pump Retrofit Measure - The OPE ratio used in ex ante impact estimates should be updated to correspond to the 1993-1995 pump test values. This will decrease the OPE ratios for the medium horsepower bin from 0.21 to 0.13 and for the high horsepower bin from 0.19 to 0.11.

Revise Input Assumptions for Heat Curtains - While the basic algorithm used to determine ex ante impacts is appropriate, several changes are recommended in the values used in the algorithm. Based on a review of current information sources, as described in *Appendix B, Engineering Review of Ex Ante Estimates*, it is recommended that assumed U-values be updated (from 1.1 to 1.22 Btu/hr-ft^2 °F) to take construction into account and that the heating degree-day value be reduced from 2,650 to 2,092. These modifications would change the ex ante therm savings for this measure from 0.545 to 0.516 therms/ft^2 year.

Use Segment-Specific Operating Hours and Operating Factors 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 Lighting (CFL) technologies. Analysis during this evaluation showed that these two technologies make up over 90 percent of the impact for lighting measures. Program design impacts for CFLs in the Agricultural sector were based on 4000 operating hours. The Ag Evaluation found that this substantially overstates the hours of operation for CFLs, and it is recommended that the assumed number of hours of operation be reduced to 3,100. Investigation into where the HID technology was installed for the 1995 program also showed that the ex ante hours of operation were greatly overestimated for this technology. More important, however, the evaluation found that HIDs installed in ornamental nurseries (which accounted for the majority of HID installations) were rarely or never on during the system peak hour. As a result, gross peak demand impacts for this measure across all facilities were less than 8 percent of the change in connected load.

Require Post-Installation Pump Test - A post-installation test of repaired/retrofitted pumps could serve as the basis for payment of program rebates, thereby helping to ensure that measures for which rebates are paid are actually capable of delivering the promised impact.

5.2.2 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 4* allow for the identification of measures that either exceed or fall below expectations. It should be noted that results for both the overall program and for measures that represented over 80 percent of program avoided cost fell far below expectations. In the case of pump repair and custom measures, the low realization rates resulted from high rates of free ridership. For lighting measures, NTG ratios were high but gross impacts (particularly demand impacts) were far lower than expected because of the off-peak operation typical for HID lighting in the Ag sector. Based on these results, it is unlikely that measures offered to Ag customers will prove cost effective. The Ag Program should therefore be limited or redesigned to improve its net impacts.

More detailed discussions of measures with low realization rates are presented in *Section 4, Evaluation Results*.

5.2.3 Program Tracking

Two of the recommendations regarding the MDSS offered here were first made in the evaluation of the 1994 Ag Program. They are repeated here because they have not been implemented to date, however PG&E plans on implementing one of them.

Make Installation Date a Mandatory Field - As a result of previous recommendations, PG&E has decided to make the date that the retrofit occurred a mandatory field for the 1997 MDSS.

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, but are often not filled out in the MDSS. However, because the installation date will become a mandatory in 1997, the presence of back-up data in the form of these two dates is less important.

6. *REQUEST FOR RETROACTIVE WAIVER*

A Request for Waiver was filed and approved to modify some aspects of the evaluation approach. The Request for Waiver was filed based on the evaluation of the 1994 PG&E Agricultural program, the reviews of that program, the limited size of the participant population, and the limited sample size of the PG&E agricultural sector in general. The Request for Waiver is presented in the remainder of this section.

PACIFIC GAS & ELECTRIC COMPANY

REQUEST FOR RETROACTIVE WAIVER FOR

1995 AGRICULTURAL SECTOR RETROFIT PROGRAM

Summary of PG&E Request

This waiver requests deviations from the Protocols[1] by PG&E for the 1995 Agricultural Sector Evaluation[2]. PG&E seeks approval to: (1) use a Simplified Engineering Model supported by telephone and field data collection to estimate the gross impacts for measures; (2) use self-report and trade ally survey analysis results to estimate net-to-gross effects; (3) clearly define that a census will be used for the Pumping and Lighting end uses; (4) specify the Designated Unit of Measure (DUOM) for agricultural lighting to be the same as commercial lighting; and (5) define the approach that will be used to report the DUOMs for agricultural pumping measures for the 1995 first year evaluation. (Note that items (1) through (5) above are referred to in each of the following sections by their item number.)

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

Proposed Waiver

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

(1) Allow the use of Simplified Engineering Models (as specified in Appendix A, page A-2 of the Protocols) supported by telephone and field data collection to estimate impacts for lighting and pumping end-use measures, if the billing analysis does not yield robust[3] results. If applicable, two Table 6s will be prepared and filed.

Parameters and Protocol Requirements

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

Rationale

The agricultural sector is a notoriously difficult area to evaluate because of the large number of variables affecting the actual impact. When this is combined with the fact that the program is divided among a large number of measures, it means that the sample sizes are not adequate to support a statistical billing analysis. Furthermore, given the diversity of measures and the

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

[2] The shareholder incentives earnings target for the 1995 Agricultural Sector is slightly under $3.5 million.

[3] See Rationale for criteria.

variability of the factors controlling the impact, application of end-use metering as an evaluation approach (the alternative proposed in the Protocols) would be prohibitively expensive.

Based on our experience with last year's evaluation in this sector, we have reason to believe that the billing analysis will yield indeterminate results. If, after following procedures that are generally accepted as best practices for developing statistical models (see Table 7 of the Protocols) we are unable to build a reliable impact model, we propose reverting to the simplified engineering estimates. Procedures used for testing alternative model specifications, weighting, and data censoring will follow established standards. Examples of conditions that could lead to the rejection of the SAE model approach might include the following: (1) a small number of observations control the model results; (2) intractable collinearity; or (3) intractable nonsignificant t statistics. Based on our experience with this sector, we believe these problems (and possibly others) are very likely to materialize. The prevailing criterion for assessing this decision would be that a verification study or peer review would lead to a similar conclusion.

(2) Allow the use self-reported survey analysis results to estimate net-to-gross (adjusted for free-ridership and spillover) effects instead of regression-based approach for all measures. Use data from trade ally surveys to corroborate respondent self-reports. This approach will allow the calculation of NTG ratios while avoiding "unreasonable costs or adverse customer impacts".

Parameters and Protocol Requirements

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

Rationale

This is a small program where much of the impacts come from custom measures. Based on last year's evaluation results for this sector, we believe the low levels of participation and diversity of measures will increase the statistical "noise" in the LIRMs to a point where neither gross nor net impacts will be detectable.

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

(3) Use an attempted census in the situations described above, for the Pumping and Agricultural Lighting end-use elements.

Parameters and Protocol Requirements

Table 5, Item C.1 does not clearly define that an attempted census is adequate if (a) the participant population of an end use is greater than 350 (under the new CADMAC Consensus understanding) but not sufficiently large to allow recruitment of the minimum of 350 before a census has been achieved; or (b) the participant population of an end use is less than 350, and a census of participants results in less than 150 in the final analysis dataset.

Rationale

For the Pumping end use a total of only 755 unique sites participated in 1995. Given 1994 survey success rates, PG&E anticipates that a census will be attempted in this end use without reaching the 350 sample size required by the protocols. Similarly, for the agricultural lighting end use, only

85 unique sites participated in 1995. This makes it impossible to achieve the minimum sample size of 150. We would like to use the analysis dataset that results from the attempted census.

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

Parameters and Protocol Requirements

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

Rationale

For the first time, the agricultural lighting end use was moved out of miscellaneous due to the new 85 percent end-use coverage per customer sector requirement. Since the only existing DUOM for agriculture is "Load impacts per acre foot of water pumped", this DUOM clearly is not applicable to agricultural lighting. The commercial lighting DUOM is a reasonable DUOM for this end use.

(5) For the Pumping end use, use the same "load impacts per acre foot of water pumped" value used in the denominator[4] for PG&E's 1996 AEAP Table E-3 submission for the 1995 Program Year Agricultural Energy Efficiency Incentives for computing the load impacts per acre foot of water pumped estimates for the Table 6 Item 2.B submission. Additionally PG&E will conduct further research during this evaluation to try to clarify the viability of collecting the information necessary to compute reliable "load impacts per acre foot of water pumped" value for the Pumping end use element for future evaluations.

Parameters and Protocol Requirements

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

Rationale

CADMAC has recently conducted studies that confirm the difficulty of collecting data and computing meaningful estimates of the DUOM for the Pumping end use. By using the same denominator used in the ex ante estimate for the ex post Table 6.2.B reported estimate, PG&E presents the DRA with comparable ex ante and ex post numbers. Meanwhile, PG&E will conduct additional data collection and research, as part of the 1995 agricultural sector evaluation. This will contribute to the effort of determining a meaningful and useful DUOM for the agricultural Pumping end use.

Conclusion

PG&E is seeking a retroactive waiver to clearly define, in advance, acceptable methods for performing the 1995 Agricultural impact evaluation. Recommendations in this waiver are designed to maximize the quality and value of evaluation results. The proposed waiver allowing engineering modeling clarifies the protocol requirements while supporting reasonable estimations of gross program impacts. The waiver allowing the use of self-report analysis reflects a realization that agricultural sector variability and sample sizes do not support other proposed approaches. The waiver on the use of census and the lighting DUOM seek to apply reasonable interpretation of the written protocol. The waiver concerning the pumping end use DUOM is intended to supply useful comparative numbers in the short term, while trying to supply useful input to resolve a long-term issue.

[4] The acre-feet in the denominator is based on average 1994 net impacts for agricultural pumping.

TABLE A

IMPACT MEASUREMENT REQUIREMENTS - TABLE C-6 AND TABLE 5			
Parameters	**Protocol Requirements**	**Waiver Alternative**	**Rationale**
End Use Consumption and Load Impact Model	LIRM or CE (calibrated engineering) or Simplified Engineering Model	Allow Simplified Engineering Model supported by telephone and field data collection to estimate the impacts for lighting and pumping end use measures	A) difficult area to evaluate: large number of variables affect the actual impact B) diversity/variability make end-use metering prohibitively expensive
Net Load Impacts	Comparison Group used in LIRM	Participant Self-Report and Trade Ally survey data	Data collection efforts required place undue burden on customer population, resulting in adverse customer impacts
Sample Sizes	350 for greater than 350 participants 150 for greater than 150 participants.	Use a census if that is all that can possibly be collected.	If the total number of participants is less than approximately 3 times the number of points required, it is not possible to achieve the desired sample sizes.
Lighting DUOM	Impact per acre foot of water pumped	Use impact per square foot per 1000 hours of operation	Agricultural DUOM does not make sense for Agricultural lighting.
Pumping DUOM	Impact per acre foot of water pumped	Compute using a common denominator (same as used in ex ante).	CADMAC agrees current Agricultural DUOM problematic. Proposal supplies common denominator to ex ante and ex post values.

7. PROTOCOL TABLES 6 AND 7

1995 AGRICULTURAL ENERGY EFFICIENCY INCENTIVES PROGRAM EVALUATION OF PUMPING AND LIGHTING END USES

PG&E STUDY ID #S 329, 331

This Section presents Tables 6 and 7 for the above referenced study as required under the "Protocols and Procedures for the Verification of Cost, Benefits, and Shareholder Earnings from Demand Side Management Programs" (the Protocols), as adopted by the California Public Utility Commission (CPUC) Decision 93-05-063, Revised January 1996 Pursuant to Decisions 94-05-063, 94-10-059, 94-12-021, and 95-12-054.

7.1 PROTOCOL TABLE 6 -- PUMPING END USE

Table 6 Assumptions

In some instances, interpretation of the protocols allows for a variety of results to be presented. For the pumping end use, the interpretation of these terms are:

- Item 1.A, 1.B: The evaluation of base usage was only conducted for the Participant Group.
- Item 2.B: The per-unit gross and net impacts required by the protocols specify only one term in the denominator, the acre feet of water pumped. The interpretation of this term is:
  - Acre Feet was derived from calculated energy values in the MDSS. Consequently, only Participant Group values were determined.
- Item 2.C: The mean value of percent change (relative to base usage) was calculated based on the percent change of each control number in the MDSS.
- Item 7: This table is not required for Agricultural studies.

The Table 7 synopsis of analytical methods applied is presented in *Section 7.3*.

Exhibit 7-1
Protocol Table 6
Items 1-5
Ag Pumping Study ID #329

Table Item			Relative Precision	
Item Number	Description	Estimate	90% Confidence	80% Confidence
1.A†	Pre-installation usage	119,245	21.2%	16.5%
	Base usage	125,664	22.5%	17.5%
	Base usage per designated unit* of measurement	0.44769	22.5%	17.5%
1.B†	Impact Year usage	110,245	22.5%	17.5%
	Impact year usage per designated unit* of measurement.	0.39276	22.5%	17.5%
2.A	Gross Peak kW (Demand) Impacts	4,717	102%	80%
	Gross MWh (Energy) Impacts	16,753,213	70%	55%
	Gross Thm (Therm) Impacts	77,481	102%	80%
	Net Peak kw (Demand) Impacts	1,951	103%	80%
	Net MWh (Energy) Impacts	7,038,734	71%	55%
	Net Thm (Therm) Impacts	25,956	103%	80%
2.B	Per designated unit* Gross Demand Impacts	0.01680	102%	80%
	Per designated unit* Gross Energy Impacts	59.69	70%	55%
	Per designated unit* Gross Therm Impacts	0.28	102%	80%
	Per designated unit* Net Demand Impacts	0.00695	103%	80%
	Per designated unit* Net Energy Impacts	25.08	71%	55%
	Per designated unit* Net Therm Impacts	0.09	103%	80%
2.C	Percent change in usage (relative to base usage) of the participant group.	-12.1%	15.8%	12.3%
	Percent change in usage (relative to base usage) of the comparison group.			
2.D	Gross Demand Realization Rate	1.05	102%	80%
	Gross Energy Realization Rate	0.70	70%	55%
	Gross Therm Realization Rate	1.00	102%	80%
	Net Demand Realization Rate	0.57	103%	80%
	Net Energy Realization Rate	0.38	71%	55%
	Net Therm Realization Rate	0.45	103%	80%
3.A	Net-to-Gross ratio based on Avg. Load Impacts	0.42	10%	8%
3.B	Net-to-Gross ratio based on Avg. Load Impacts per designated unit* of measurement.	0.42	10%	8%
3.C	Net-to-Gross ratio based on Avg. Load Impacts as a percent change from base usage	0.60	78%	61%
4.A	Pre-installation Avg. (mean) Acre Foot (participant group)	829	49.1%	38.3%
	Pre-installation Avg. (mean) Acre Foot (comparison group)			
4.B	Post-installation¥ Avg. (mean) Acre Foot (participant group)	829	49.1%	38.3%
	Post-installation¥ Avg. (mean) Acre Foot (comparison group)			

† Participant group only.

* The per designated unit used was Acre Feet.

¥ Pre- and post-values are assumed to be the same.

Shaded cells indicate analysis activities that were not completed because appropriate survey data was not available.

Exhibit 7-2
Protocol Table 6
Item 6
Ag Pumping Study ID #329

Program and Technology Group Description	Number of Measures Paid in 1995*		
	All Participants (Item 6.B)	Participant Sample (Item 6.A)	Comparison Group (Item 6.C)†
Retrofit			
Pump Retrofit	295	197	19
Pump Adjustment	535	145	9
Low Pressure Nozzle	57,972	39,998	27
Well Water Measuring Device	27,348	15,659	
Energy Efficient Motors	81	62	
Total for Retrofit Programs:	**86,231**	**56,061**	**55**
Customized			
Customized AG Measures	17	0	
Total for Customized Incentives:	**17**	**0**	**0**
TOTAL:	**86,248**	**56,061**	**55**

Shaded cells indicate technology groups where survey data was not available.

* Based on MDSS variable, PNUMPUR1, number of measures purchased. MDSS received on July 25, 1996.

7.2 PROTOCOL TABLE 6 -- LIGHTING END USE

Table 6 Assumptions

In some instances, interpretation of the protocols allows for a variety of results to be presented. For the lighting end use, the interpretation of these terms are:

- Item 2.B: The per-unit gross and net impacts required by the protocols specify two terms in the denominator, square footage and hour of fixture operation. The interpretation of these terms are:
  - Square footage estimates of the lighted area were derived using the square foot variable in the MDSS (for the participant group only). This is the total area of the facility, not just the retrofit area..
  - Hours of fixture operation were based upon a weighted mean of each lighting measure's hours of operation (as reported in Table C-13 of the Technical Appendices).
- Item 7,: This table is not required for Agricultural studies.

The Table 7 synopsis of analytical methods applied is presented in *Section 7.4*.

Exhibit 7-3
Protocol Table 6
Items 1-5
Ag Lighting Study ID #331

Table Item			Relative Precision	
Item Number	**Description**	**Estimate**	**90% Confidence**	**80% Confidence**
1.A†	Pre-installation usage, Base usage, and Base usage per designated unit of measurement.	N/A	N/A	N/A
1.B†	Impact Year usage, Impact year usage per designated unit of measurement.	N/A	N/A	N/A
2.A	Gross Peak kW (Demand) Impacts	284	165%	128%
	Gross MWh (Energy) Impacts	4,043,327	165%	128%
	Net Peak kW (Demand) Impacts	270	165%	128%
	Net MWh (Energy) Impacts	3,841,161	165%	128%
2.B	Per designated unit* Gross Demand Impacts	0.00007	165%	128%
	Per designated unit* Gross Energy Impacts	1.06	165%	128%
	Per designated unit* Net Demand Impacts	0.00007	165%	128%
	Per designated unit* Net Energy Impacts	1.01	165%	128%
2.C†	Percent change in usage (relative to base usage) of the participant group and comparison group.	N/A	N/A	N/A
2.D	Gross Demand Realization Rate	0.25	165%	128%
	Gross Energy Realization Rate	0.59	165%	128%
	Net Demand Realization Rate	0.31	165%	128%
	Net Energy Realization Rate	0.73	165%	128%
3.A	Net-to-Gross ratio based on Avg. Load Impacts	0.95	5%	4%
3.B	Net-to-Gross ratio based on Avg. Load Impacts per designated unit* of measurement.	0.95	5%	4%
3.C†	Net-to-Gross ratio based on Avg. Load Impacts as a percent change from base usage	N/A	N/A	N/A
4.A	Pre-installation Avg. (mean) Sq. Foot (participant group)	31,973	42.3%	32.9%
	Pre-installation Avg. (mean) Sq. Foot (comparison group)			
	Pre-installation Avg. Hours of Operation¥ (participant group)	2,838	31.0%	24.2%
	Pre-installation Avg. Hours of Operation¥ (comparison group)			
4.B	Post-installation Avg. (mean) Sq. Foot (participant group)			
	Post-installation Avg. (mean) Sq. Foot (comparison group)			
	Post-installation Avg. Hours of Operation¥ (participant group)	2,838	31.0%	24.2%
	Post-installation Avg. Hours of Operation¥ (comparison group)			

† The change model estimates of impact did not require an evaluation of base usage.
* The per designated unit used was Sq. Ft. 1000 hours of operation.
¥ Hours of operation are based purely upon survey self-report. It is assumed that pre- and post-retrofit operation schedules are the same for most estimates.
Shaded cells indicate analysis activities where survey data was incomplete.

Exhibit 7-4
Protocol Table 6
Item 6
Ag Lighting Study ID #331

Program and Technology Group Description	Number of Measures Paid in 1995* All Participants (Item 6.B)	Participant Sample (Item 6.A)	Comparison Group (Item 6.C)†
Retrofit			
Compact Fluorescent Lamps	3,641	3,441	0
Incandescent to Fluorescent Fixtures	63	63	
Exit Signs	3	3	0
Efficient Ballast Changeouts	6	6	0
T-8 Lamps and Electronic Ballasts	1,924	1,087	4
Delamp Fluorescent Fixtures	898	588	0
High Intensity Discharge	2,967	2,829	12
Controls	8	8	0
TOTAL:	9,510	8,025	16

† Non-participant survey results reported higher participation, this measure count reflects only installed measures that would have qualified.
Shaded cells indicate technology groups where survey data was not available.
* Based on MDSS variable, PNUMPUR1, number of measures purchased. MDSS received on July 25, 1996.

7.3 *PROTOCOL TABLE 7 -- PUMPING END USE*

1995 AGRICULTURAL EEI PROGRAM
EVALUATION OF PUMPING END USE
PG&E STUDY ID #329

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

A. OVERVIEW INFORMATION

1. Study Title and Study ID Number

Study Title: Evaluation of PG&E's 1995 Nonresidential Energy Efficiency Incentives (EEI) Program for Agricultural Sector Pumping End Use Technologies.

Study ID Number: 329

2. Program, Program Year and Program Description

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

Program Year: Rebates Received in the 1995 Calendar Year.

Program Description:

The Nonresidential EEI Program offered by PG&E has three components: the Retrofit Express (RE) Program, the Retrofit Efficiency Options (REO) Program and the Customized Incentive Program.

The RE program offered fixed rebates to nonresidential customers that installed specific gas or electric energy-efficiency equipment in their facilities. The program covered a number of energy saving measures relevant to the pumping end use. Specific pumping measures included pump retrofit, pump adjustment, low pressure sprinkler nozzles, well water measurement devices, and energy efficient motors.

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.

The 1995 REO program included two pumping measures: pump retrofit and low pressure sprinkler nozzles. These measures were only offered in 1995. Customers were required to submit calculations for the projected first-year energy savings along with their application prior to installation of the high efficiency equipment. PG&E representatives worked with customers to identify cost-effective improvements, with special emphasis on operational and maintenance measures at the customers' facilities. Marketing efforts were coordinated among PG&E Divisions, emphasizing local planning areas with high marginal electric costs to maximize program benefits.

The Customized Incentives Program offered financial incentives to 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 Incentives 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 percent 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 percent of the incremental cost to make new processes or added systems energy efficient. Customers were paid 4¢ per kWh and 20¢ per therm for first-year annual energy impacts. A $200 per peak kW incentive for peak demand impacts required that savings be achieved during the hours PG&E experiences high power demand.

There was no Customized Incentives Program offered in 1995. However, due to the significant documentation and analysis involved in Customized Incentives Program measures rebates for a number of 1993 and 1994 measures were delayed until 1995. All equipment applied for under the program must have been installed and in operation by November 30, 1995. This evaluation covers those customers that received rebates in 1995. A total of 18 Customized Incentives agricultural participants fell into this category.

3. *End Uses and/or Measures Covered*

End Use Covered: Agricultural Pumping Technologies

Measures Covered: For the list of measures covered in this evaluation, see above.

4. *Methods and Models Used*

The PG&E Agricultural EEI Program Evaluation consisted of three key analysis components: engineering analysis, billing data regression analysis, and net-to-gross analysis. This integrated approach reduces a complicated problem to manageable components, while incorporating the comparative advantages of each analysis method. This approach describes per-unit net impacts as follows:

Net Impact = (Gross Impact) x (SAE Realization Rate) x (Net-to-Gross)

Gross impact – The gross impact estimates were modeled using distinct approaches for the RE/REO and Customized Incentives Programs. The majority RE/REO measure impacts were estimated based on a review and subsequent revisions to the engineering algorithms used by PG&E to develop ex ante impacts (algorithms were taken from the 1995 Advice Filing). A detailed discussion of the RE gross impact approach is provided in *Appendix B*.

A detailed engineering analysis was conducted for the pump repair measure. This measure was the focus of a more in-depth analysis because of the large contribution of avoided cost made by this measure. Engineering estimates for this measure used an algorithm based upon information gathered through telephone surveys and on-site audits. A detailed discussion of the pump repair analysis is provided in *Appendix C*.

Customized Incentives impacts were estimated based on a thorough review of applications submitted under the Ag Customized Incentives program. Eighteen separate Customized Incentives applications were thoroughly reviewed and the results written up in a memo to the program manager on November 20, 1996. That memo and the attachments to it are included in *Appendix B, Engineering Review of Ex Ante Estimates*.

SAE Realization Rates – The SAE Realization Rates were estimated only for the pump repair measure. The SAE Realization Rates are based on an Statistically Adjusted Engineering (SAE) analysis using cross-sectional time series data and incorporating prior engineering estimates. As a result, the SAE realization rates could be defined as the percentage of a savings estimate that is detected or realized in the statistical analysis of actual changes in energy usage. The SAE realization rates were then applied to an impact estimate based upon the program baseline, equipment purchased under the program, and typical weather. A detailed discussion of the final SAE model specification can be found in *Section 3.3.*

Net-to-Gross – The net-to-gross (NTG) ratio adjusts the program baseline, derived using estimates of free-ridership and spillover (associated with the program). The pumping end-use NTG ratio's were calculated based on survey self-report using a representative nonparticipant sample to account for naturally occurring conservation. Vendor and Ag representative surveys were also used to verify the findings of the NTG analysis. The NTG analysis approach is presented in detail in *Section-3.4,* and a thorough discussion surrounding the methods used to score those results is provided in *Appendix D.*

5. Participant and Comparison Group Definition

Participant

Participants are defined as those PG&E agricultural customers who received PG&E rebates in the 1995 calendar year for installing at least one pumping measure under the Nonresidential EEI Program.

Comparison Group

The comparison group for this study is defined as a group of PG&E agricultural customers who did not receive any pumping end-use rebates in the 1995 calendar year under the Nonresidential EEI Program, and who share as many characteristics as possible with the agricultural sector participant group in terms of annual usage and facility distribution. Customers who participated in the previous years or those who simply participated by installing a non-pumping end-use measure, are eligible for the comparison group.

6. Analysis Sample Size

The final analysis dataset has 886 observations based upon 886 telephone survey completes (of which 356 were pumping end-use participants, and the remaining 530 served as a comparison group for that sample). In addition, 169 on-site audits were conducted at pumping end-use participant sites.

B. DATABASE MANAGEMENT

1. Data Description and Flow Chart

The Evaluation of PG&E Agricultural Pumping Technologies was based on a nested sample design approach. The main feature of this approach is that it consists of three groups of customers subsetted according to the availability of detailed evaluation data (within each group). The largest customer group included all of the agricultural customers who received rebates for eligible pumping technologies in 1995 (the "participant population") with monthly PG&E billing data and participant tracking data. The smallest group included the participants with the most comprehensive information available -- on-site audit data, telephone survey, participant tracking data, and billing data. A similar nested sample design was also implemented for the comparison group, the exception being that on-site data were not collected for the comparison group. The advantage of the nested sample design was that it yielded overlapping samples which were used to compute bias in many of the intermediate engineering parameters derived.

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

2. Key Data Elements and Sources

A complete list of data elements and their sources can be found in *Appendix C*. The key analysis data elements and their sources are listed below:

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

PG&E Billing Data. The PG&E billing dataset used for the analysis was pro-rated monthly usage data, calculated by PG&E for each calendar month, and obtained from PG&E's Load Data Services. The dataset consisted only of customer accounts that were to be surveyed for this evaluation and covered the period from January 1992 to September 1996.

Telephone Survey Data. The telephone survey supplies information on energy-related actions taken outside of PG&E programs, other end uses covered under each account, and other information not available in the MDSS database.

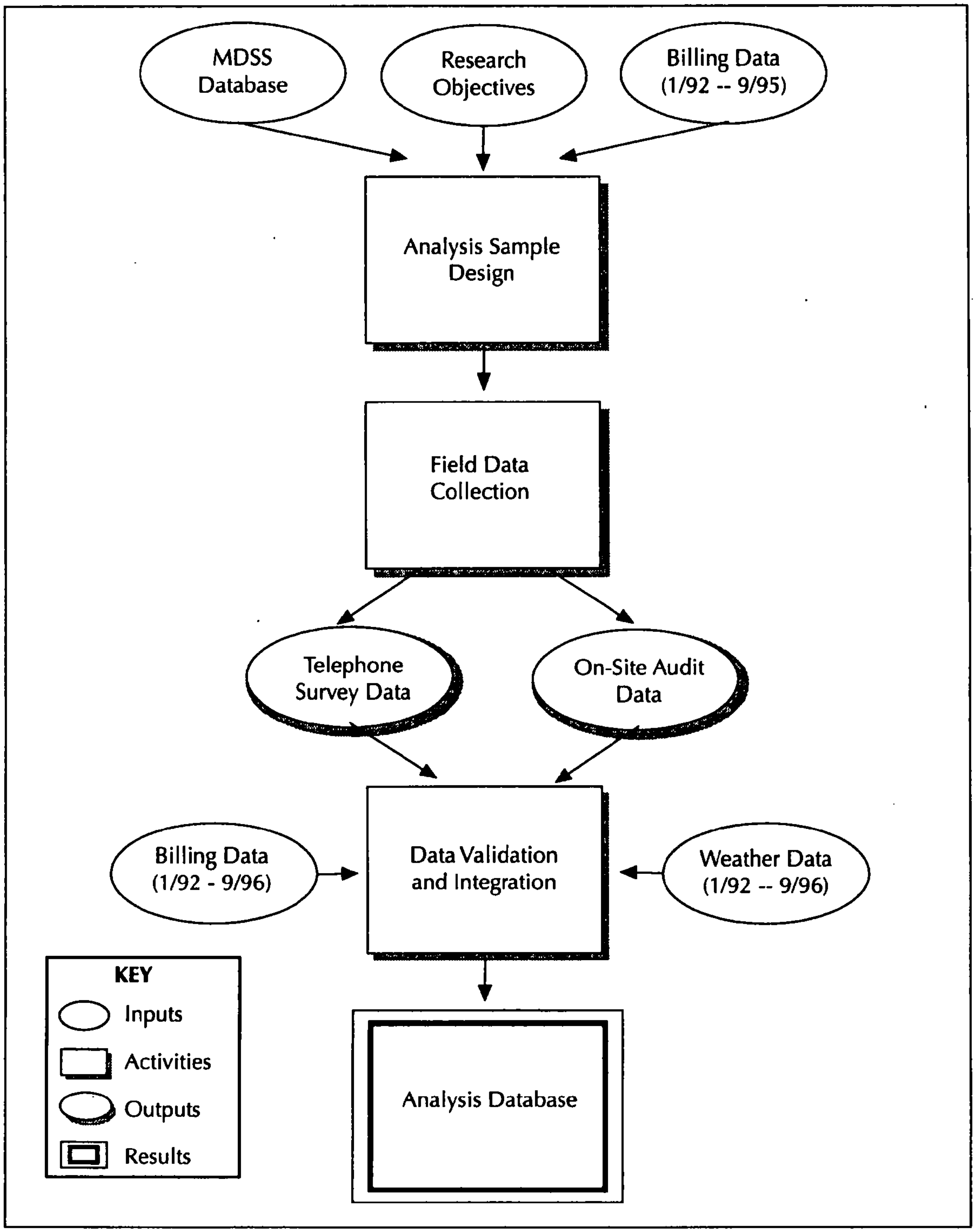
On-Site Audit Data. On-site audit data were collected as part of this evaluation for the participant group. The on-site audit is designed to support the engineering analysis by providing key inputs such as acreage and crop type.

Vendor and Ag Representative Surveys. Vendor and Ag representative surveys were used to verify the findings of the NTG analysis.

Weather Data. The hourly dry bulb temperature collected for 25 PG&E load research weather sites is used in the billing regression analysis to calculate total monthly cooling and heating degree days for each month in the analysis period. For each customer in the analysis dataset, the appropriate weather site is linked to that customer by using the PG&E-defined weather site to PG&E's local office mapping.

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

Exhibit A
Analysis Database Development



3. Data Attrition Process

All data elements mentioned above were first validated and then merged together to form the final analysis dataset. Records with out-of-range or questionable data were either deleted or flagged to ensure that only those records with sufficient data, both in terms of data quality and representativeness, were used in the analysis. The key data attrition decisions are summarized in *Section 3.3.*

4. Internal Data Quality Procedures

The Evaluation contractor of this project, Quantum Consulting Inc. (QC), has performed extensive data quality control on all categories of program data, including utility billing data, program tracking data, telephone survey data, and on-site audit data. QC's data quality procedures are consistent with PG&E's internal database guidelines and the guidelines established in the Protocols.

Throughout the course of sample design and creation, survey data collection, and data analysis, several data quality assurance procedures were in place to insure that all energy usage data used in analysis and all telephone survey data collected was of high quality and would prove useful in later analysis. The stages of data validation undertaken and the methods employed are detailed below:

Pre-Survey Usage and Account Characteristic Data Validation. The goal of this stage of data validation was to screen out customers who had unreasonable or unreliable usage data, or who had changes in key elements of their billing data over the 1992 to 1995 period. Accounts for which changes were observed in account numbers, service addresses, SIC codes, electric rate schedules, electric meter numbers, or corporation and premise identification variables, were excluded from sample eligibility. Usage data reliability screening first eliminated from sample accounts which experienced service interruptions, exhibited inconsistent read dates, or for which bills were estimated. Additionally, based on comparisons of account usage between years, and between different months in the same year, customers with unusual usage patterns such as unusually high variation in monthly or yearly usage were given special attention and, in some cases, excluded from the sample frame.

Real Time Survey Data Validation. Survey data collection was performed using QC's 24 station Computer Aided Telephone Interviewing (CATI) center. Data entry applications, programmed using SAS/AF software, employed logical branching routines and real-time data validation procedures to insure that survey questions were appropriate for each customer's situation and that recorded responses were reasonable and logical. Data entry applications also performed real time range checks and field protection for out of range values during the data collection process thereby affording an additional means of ongoing data validation. Finally, because SAS/AF was used to program the data collection software, the survey data was on-line in the form of a SAS dataset continuously throughout the course of data collection. This allowed for the generation of frequency distributions and cross-tabs on data at regular stages throughout the survey fielding to facilitate QC's internal early detection and correction of data entry errors.

Final Survey Data Validation. Following the completion of survey data collection, all data was subjected to a final stage of validation and cleaning during which illogical responses were identified and corrected or flagged, and corrections were made to any mis-coding of data not detected in earlier stages of cleaning and validation. All activities undertaken in the course of survey were documented in accordance with QC's Enumerated Quality Assurance Logs and Standards (EQUALS) survey data collection documentation protocols.

5. Unused Data Elements

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

C. SAMPLING

1. Sampling Procedures and Protocols

The sampling plan for the Ag Evaluation was developed based upon program avoided cost for each of the program measures paid in 1995 and in recognition of the limited size of the participant population. As explained in *Section 6, Request for Retroactive Waiver*, the limited participant population necessitated an attempted census of participants who were expected to contribute data to the statistical analysis. The number of completed participant surveys discussed above reflects such an attempted census.

For nonparticipants, the number of completed surveys discussed in the data sources section above meets the protocol requirements for pumping nonparticipants. The final sampling survey sample therefore both complied with the protocols and met the program evaluation objectives described in *Section 2* of this report. Nonparticipants were selected from a random sample of PG&E's agricultural customers. Because the majority of customers with pumping accounts have descriptive (alpha) addresses rather than numeric addresses, customers with descriptive service addresses were sampled as likely nonparticipants for the pumping end use control group.

2. Survey Information

Telephone survey instruments are presented in the *Volume II of the Appendix, Appendix F* (for participants) and *Appendix G* (for comparison group customers). Participant and comparison group customer's survey response frequencies are presented in *Appendix M and N,* respectively.

On-site audit instruments are presented in *Appendix H.*

3. Statistical Descriptions

As mentioned above, a complete set of participant and comparison group customer's responses frequencies are presented in *Appendix M and N*. In addition, statistics on usage and engineering impact variables that were used in the billing data regression models are also presented in *Section 3.3* and *Appendix C.*

D. DATA SCREENING AND ANALYSIS

A detailed discussion of the billing data regression data analysis is presented in *Section 3.3*. Specific procedures and modeling issues are discussed below.

1. Outliers, Missing Data and Weather Adjustment

As discussed in more detail in Section 3.3, of the 64 customer control identifiers eligible for the billing analysis, 27 qualified to have their 1996 monthly data included in addition to the 1994 and 1995 data. This provided a pool of 1,860 months of data across customers. Of these, 817 observations were used in the final model, 371 prior to pump repair and 446 after pump repair. The other observations were censored for the following reasons:

• No 1993 billing data to use as a scaling factor:	5 controls	120 observations
• Missing billing data:		21 observations
• Billing data = 0 or engineering estimates = 0:	1 control	950 observations

2. *Background Variables*

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

3. *Data Screen Process*

Section 3.3 of the report and Section 1 above describe all of the data screening criteria.

4. *Regression Statistics*

The results of the regression are shown in Exhibit B. For each parameter in the model, this exhibit shows the values of the regression coefficient, the original t-statistic, and an adjusted t-statistic. Adjustment of the t-statistic is necessary because performing the regression at the monthly level violates the assumption that the error terms are independent. Autocorrelation is tested using the Durbin-Watson statistic. The positive autocorrelation indicates that the estimate of the error variance is too small and requires adjustment.

The results indicate that the program pump repair impact is approximately 72% of that estimated by the engineering estimates. The adjusted t-statistic indicates that this is statistically significant. The only other coefficient that was found to be statistically significant was the indicator for multiple pumps.

5. *Model Specification*

The model specifications are presented in *Section 3.3*. Specific model specification issues are further discussed below:

Cross-sectional Variation. The final model specification recognizes the potential heterogeneity problem in the model and uses the following procedures to eliminate the impacts of the cross-sectional variation: (1) observations with highest usage values were removed in the model to reduce the overall variance of the sample in terms of usage and size; and (2) independent variables were all intercepted with the pre-installation usage to ensure that change of independent variable will be proportional to the usage value.

Time Series Variation. As mentioned above, background variables, such as interest rates, unemployment rates and other economic factors, were not explicitly modeled in the final model.

Self-selection. Self-selection is not treated explicitly in the billing regression analysis.

Collinearity. Various statistical tests (such as COLLIN and VIF options in SAS) were used to check multiple collinearity problem among independent variables in the model to ensure that the final parameter estimates are robust.

Net Impact. A gross billing analysis model was used and adjusted by a net-to-gross ratio using self report methods. Vendor and Ag representative surveys were also used to verify the findings of the self report methods.

Exhibit B
Pump Repair
SAE Model Results

Parameter Description	Regression Coefficient	t-statistic	Adjusted t statistic*
Eng. Est. of kWh (orig. plant efficiency)	0.622	27.579	10.066335
Eng. Est. of Program Pump Repair Impact	-0.723	-6.396	-2.33454
MDSS Est. of Pump Adjustment Impact		-	
MDSS Est. of Motor Impact	1.414	5.184	1.89216
MDSS Est. of Well Water Device Impact	0.773	4.372	1.59578
Indicator of other pump repair	0.986	0.067	0.024455
Indicator of other pump retrofit	-	-	
Indicator of other pump adjustment	-1.121	-0.357	-0.130305
Indicator of Other End Uses	0.116	0.015	0.005475
Indicator of Multiple Pumps	0.534	5.934	2.16591
Number of Observations	817		
Adjusted R-square	0.66		
Durbin-Watson D	0.729		
First Order Autocorrelation	0.635		

*Adjusted t-statistic = t-statistic * (1 - first order autocorrelation) to adjust for autocorrelation.

6. Measurement Errors

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

Measurement errors are a combination of random and non-random error components that plague all survey data. The non-random error frequently takes the form of systematic bias, which includes, but is not limited to, ill-formed or misleading questions and mis-coded study variables. In this project, we have implemented several controls to reduce the systematic bias in the data. These steps included (1) thorough auditor/coder training; (2) instrument pretest; and (3) cross-validation between on-site audit data and telephone survey responses.

The random measurement error, such as data entry error, has no impact on estimating mean values because the errors are typically unbiased. For the measures that were modeled in the billing regression analysis, the impact of random unbiased measurement errors was accounted for as part of the overall standard variance in the parameter estimate.

7. Autocorrelation

The autocorrelation problem exists if the residuals in one time period are correlated with the residuals in the previous time period. Since there was an indication of some autocorrelation, as was confirmed by examining the Durbin-Watson statistic for these models, the resulting t-statistics were appropriately adjusted by one minus the first order autocorrelation.

8. Heteroskdasticity

The final model specification recognizes the potential heterogeneity problem in the model and uses the following procedures to eliminate the impacts of the cross-sectional variation: (1) observations with highest usage values were removed in the model to reduce the overall variance of the sample in terms of usage and size; and (2) independent variables were all intercepted with the pre-installation usage to ensure that change of independent variable will be proportional to the usage value.

9. Collinearity

Various statistical tests (such as COLLIN and VIF options in SAS) were used to check multiple collinearity problem among independent variables in the model. No problems with collinearity were identified.

10. Influential Data Points

Various SAS diagnostics were used to test for influential data points, such as COOKD, theCook's D influence statistic, the DFFITS standard influence of observation on predicted values, and the RSTUDENT studentized residual test. In addition, the observations with highest usage values were removed, which tended to have significant influence over the model.

11. Missing Data

Any data that were omitted are described in *Section D, Data Screening and Analysis.*

12. Precision

Relative precision's for net estimates were calculated using the following procedure:

- First, NTG ratios, N_i, were computed for all technology groups that were represented in the telephone survey.
- Then, the program level NTG and program level standard error for the NTG were calculated using the classic stratified sample techniques. The program level NTG was a weighted average of technology level NTG values with adjusted gross impacts per technology group providing the weights.[1] The functional relation can be best described in the following equations:

$$\overline{N} = \Sigma_i w_i * \overline{N}_i \text{ with } w_i = MWh_i$$

$$StdErr_{NTG} = \sqrt{\Sigma_1\left((w_i)^2 * StdErr_i^2\right)}$$

[1] Technology groups with no standard errors were excluded from this calculation.

where

N = Net-to-Gross Value

i = Technology Group

w = Weight

- Then, the relative precision[2] for the program NTG value for energy was calculated and combined with the relative precision of the gross energy impact to yield an overall relative precision for the net energy impacts:

$$RP_{NTG\_Energy} = \frac{t_{\alpha=10} * StdErr}{NetMWH}$$

$$RP_{NetEnergy} = \sqrt{RP^2{}_{NTG\_Energy} + RP^2{}_{GrossEnergy}}$$

- Finally, the relative precision net demand impacts was calculated using a scaled version of the relative precision for the net energy impact. The sample sizes of the on-site audits and telephone surveys served as the scalars:

$$RP_{NetDemand} = RP_{NetEnergy} * \sqrt{\frac{N_{OnSite}}{N_{Telephone}}}$$

- Per-unit NTG relative precision's appearing in Table 6 (Items 1-5) were calculated in a similar fashion.

E. DATA INTERPRETATION AND APPLICATION

The program net-to-gross analysis was conducted based on a survey self-report analysis. For a detailed NTG analysis discussion, see *Section 3.4*.

The self-report method used to score free-ridership uses participant responses to survey questions regarding the timing of and reasons for equipment replacement actions. As described in *Section 3.4*, a series of questions was posed to program participants. If the customer indicated that he had not been shopping for new equipment before becoming aware of the program, he was scored initially as a net participant. A customer was then classified as a free-rider if he (1) stated that he would have installed high-efficiency equipment within the year and had already selected the equipment; and (2) stated that he would have purchased high-efficiency equipment if the program had not existed.

For all measures except pump retrofit, the net-to-gross ratio using the self-report method relied only on free ridership and did not include any estimate of spillover. The results of the NTG analysis were also verified based on the analysis of vendor and Ag representative surveys, as discussed in *Section 3.4*.

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[2] The example shown is for the 90 percent confidence level. Relative precision was also calculated at the 80 percent confidence level.

7.4 PROTOCOL TABLE 7 -- LIGHTING END USE

1995 AGRICULTURAL EEI PROGRAM
EVALUATION OF LIGHTING END USE
PG&E STUDY ID #331

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

A. OVERVIEW INFORMATION

1. Study Title and Study ID Number

Study Title: Evaluation of PG&E's 1995 Nonresidential Energy Efficiency Incentives (EEI) Program for Agricultural Sector Indoor Lighting End Use Technologies.

Study ID Number: 331

2. Program, Program Year and Program Description

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

Program Year: Rebates Received in the 1995 Calendar Year.

Program Description:

The Nonresidential EEI Program offered by PG&E has one component: the Retrofit Express (RE) Program. No measures were offered under the Retrofit Efficiency Options (REO) Program or the Customized Incentive Program.

The RE program offered fixed rebates to nonresidential customers that installed specific gas or electric energy-efficiency equipment in their facilities. The program covered a number of energy saving measures relevant to the lighting end use. Specific lighting measures included compact fluorescent lamps, incandescent to fluorescent retrofits, exit signs, efficient ballast changeouts, T-8 lamps and electronic ballasts, delamping of fluorescent fixtures, HID technologies, and lighting controls.

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.

3. End Uses and/or Measures Covered

End Use Covered: Indoor Lighting Technologies

Measures Covered: For the list of measures covered in this evaluation, see above.

4. Methods and Models Used

The PG&E Agricultural EEI Program Evaluation consisted of three key analysis components: engineering analysis, billing data regression analysis, and net-to-gross analysis. This integrated approach reduces a complicated problem to manageable components, while incorporating the comparative advantages of each analysis method. This approach describes per-unit net impacts as follows:

Net Impact = (Gross Impact) x
(SAE Realization Rate) x (Net-to-Gross)

or

= {[(Operating Impact) x (Operating Factor)]
(SAE Realization Rate) x (Net-to-Gross)

or

= {[(ΔUOL x U) x (OF_t x T)]
(SAE Realization Rate) x (Net-to-Gross)

Operating impact – The technology level change in connected kW associated with a particular measure, which is defined as the load impact coincident with a specific hour, given that the equipment is operating. This approach relies on the engineering analysis to simulate operating equipment performance independent of premise size and customer behavioral factors. This term captures the per-unit difference in connected load between program installed (retrofit) high efficiency lighting measures and the existing equipment (ΔUOL), the number of units installed (U), and includes an adjustment for the probability of lamp burnout for both the retrofit and existing fixture. A detailed discussion of the operating impact calculation can be found in the *Appendix C*.

Operating factor – The percentage of full load (OF_t) used by a group of fixtures during a prescribed time period (T). This term reflects both the equipment's operating schedule and the percentage of lights operating (which is dependent upon whether the schedule reflects an open- or closed-period). The schedule was estimated using the on-site audits. A detailed discussion of the operating factor approach can be found in *Appendix C*.

SAE Realization Rates – As discussed in *Section 3.3*, an SAE model was attempted, but no statistically significant results was found. Therefore, the SAE realization rate was set to one in order to calculate net impacts.

Net-to-Gross – The net-to-gross (NTG) ratio adjusts the program baseline, derived using estimates of free-ridership and spillover (associated with the program). The lighting end-use NTG ratio's were calculated based on survey self-report using a representative nonparticipant sample to account for naturally occurring conservation. The NTG analysis approach is presented in detail in *Section-3*.

5. Participant and Comparison Group Definition

Participant

Participants are defined as those PG&E agricultural customers who received PG&E rebates in the 1995 calendar year for installing at least one lighting measure under the Nonresidential EEI Program.

Comparison Group

The comparison group for this study is defined as a group of PG&E agricultural customers who did not receive any lighting end-use rebates in the 1995 calendar year under the Nonresidential EEI Program, and who share as many characteristics as possible with the agricultural sector participant group in terms of annual usage and facility distribution. Customers who participated in the previous years or those who simply participated by installing a non-lighting end-use measure, are eligible for the comparison group.

6. Analysis Sample Size

The final analysis dataset has 150 observations based upon 150 telephone survey completes (of which 69 were lighting end-use participants, and the remaining 81 served as a comparison group for that sample). In addition, 59 on-site audits were conducted at lighting end-use participant site. The distribution of the sample by facility and measure is presented in *Appendix C*.

B. DATABASE MANAGEMENT

1. Data Description and Flow Chart

The Evaluation of PG&E Agricultural Lighting Technologies was based on a nested sample design approach. The main feature of this approach is that it consists of three groups of customers subsetted according to the availability of detailed evaluation data (within each group). The largest customer group included all of the agricultural customers who received rebates for eligible lighting technologies in 1995 (the "participant population") with monthly PG&E billing data and participant tracking data. The smallest group included the participants with the most comprehensive information available -- on-site audit data, telephone survey, participant tracking data, and billing data. A similar nested sample design was also implemented for the comparison group, the exception being that on-site data were not collected for the comparison group. The advantage of the nested sample design was that it yielded overlapping samples which were used to compute bias in many of the intermediate engineering parameters derived.

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

2. Key Data Elements and Sources

A complete list of data elements and their sources can be found in *Appendix C*. The key analysis data elements and their sources are listed below:

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Telephone Survey Data. The telephone survey supplies information on energy-related actions taken outside of PG&E programs, other end uses covered under each account, and other information not available in the MDSS database.

On-Site Audit Data. On-site audit data were collected as part of this evaluation for the participant. The on-site audit is designed to contributes site-specific equipment details, and better estimates of operating hours and operating factors.

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

3. Data Attrition Process

All data elements mentioned above were first validated and then merged together to form the final analysis dataset. Records with out-of-range or questionable data were either deleted or flagged to ensure that only those records with sufficient data, both in terms of data quality and representativeness, were used in the analysis. The key data attrition decisions are summarized in *Section 3.3.*

4. Internal Data Quality Procedures

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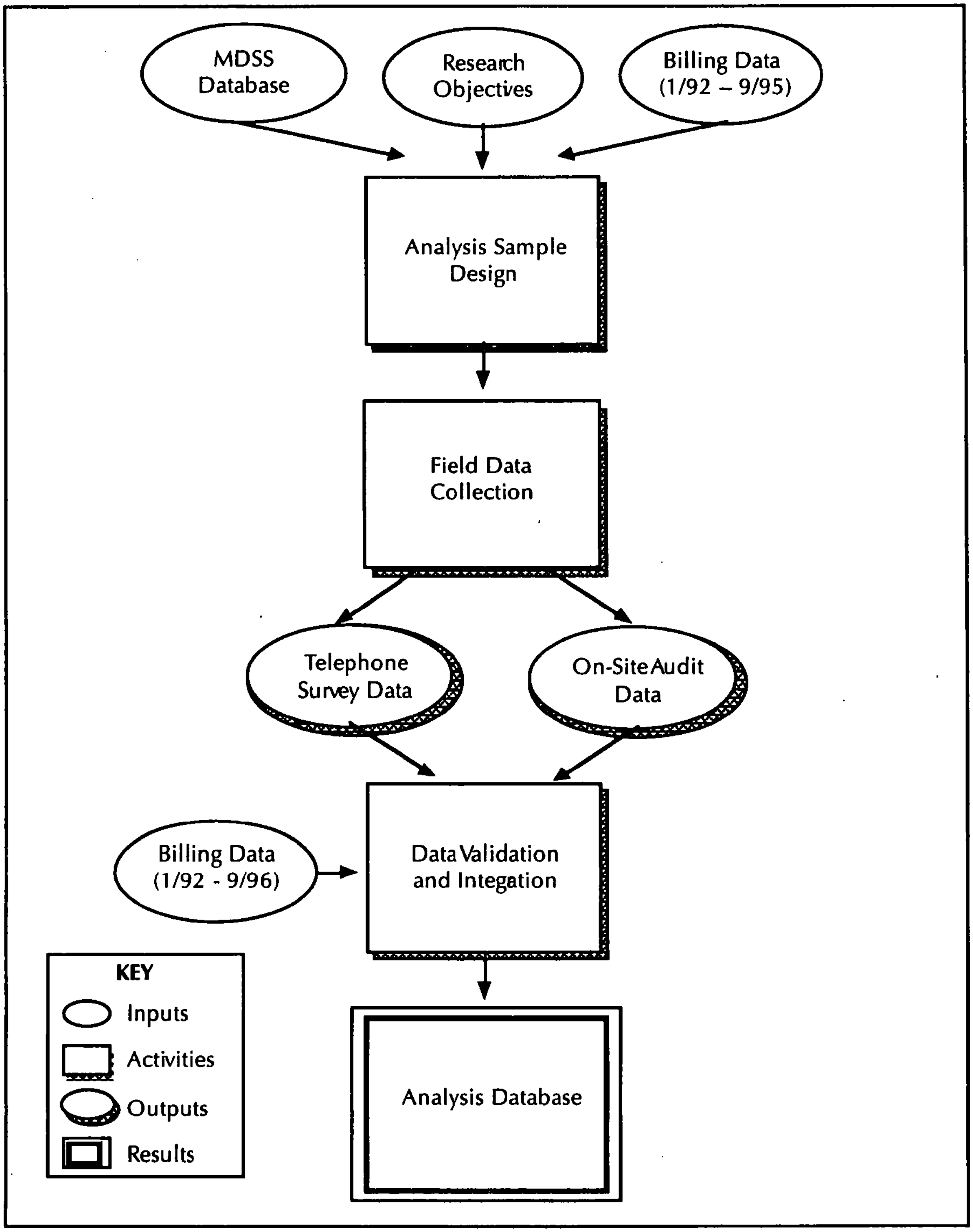
Throughout the course of sample design and creation, survey data collection, and data analysis, several data quality assurance procedures were in place to insure that all energy usage data used in analysis and all telephone survey data collected was of high quality and would prove useful in later analysis. The stages of data validation undertaken and the methods employed are detailed below:

Pre-Survey Usage and Account Characteristic Data Validation. The goal of this stage of data validation was to screen out customers who had unreasonable or unreliable usage data, or who had changes in key elements of their billing data over the 1992 to 1995 period. Accounts for which changes were observed in account numbers, service addresses, SIC codes, electric rate schedules, electric meter numbers, or corporation and premise identification variables, were excluded from sample eligibility. Usage data reliability screening first eliminated from sample accounts which experienced service interruptions, exhibited inconsistent read dates, or for which bills were estimated. Additionally, based on comparisons of account usage between years, and between different months in the same year, customers with unusual usage patterns such as unusually high variation in monthly or yearly usage were given special attention and, in some cases, excluded from the sample frame.

Exhibit A
Analysis Database Development



Real Time Survey Data Validation. Survey data collection was performed using QC's 24 station Computer Aided Telephone Interviewing (CATI) center. Data entry applications, programmed using SAS/AF software, employed logical branching routines and real-time data validation procedures to insure that survey questions were appropriate for each customer's situation and that recorded responses were reasonable and logical. Data entry applications also performed real time range checks and field protection for out of range values during the data collection process thereby affording an additional means of ongoing data validation. Finally, because SAS/AF was used to program the data collection software, the survey data was on-line in the form of a SAS dataset continuously throughout the course of data collection. This allowed for the generation of frequency distributions and cross-tabs on data at regular stages throughout the survey fielding to facilitate QC's internal early detection and correction of data entry errors.

Final Survey Data Validation. Following the completion of survey data collection, all data was subjected to a final stage of validation and cleaning during which illogical responses were identified and corrected or flagged, and corrections were made to any mis-coding of data not detected in earlier stages of cleaning and validation. All activities undertaken in the course of survey were documented in accordance with QC's Enumerated Quality Assurance Logs and Standards (EQUALS) survey data collection documentation protocols.

5. Unused Data Elements

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

C. SAMPLING

1. Sampling Procedures and Protocols

The sampling plan for the Ag Evaluation was developed based upon program avoided cost for each of the program measures paid in 1995 and in recognition of the limited size of the participant population. As explained in *Section 6, Request for Retroactive Waiver*, the limited participant population necessitated an attempted census of participants who were expected to contribute data to the statistical analysis. The number of completed participant surveys discussed above reflects such an attempted census.

For nonparticipants, the number of completed surveys discussed in the data sources section above meets the protocol requirements for the lighting nonparticipants (in terms of matching the size of the participant population.) The final sampling survey sample therefore both complied with the protocols and met the program evaluation objectives described in *Section 2* of this report. Nonparticipants were selected from a random sample of PG&E's agricultural customers. Nonparticipants that were likely to have a lighting end use on their account were selected to act as the control group for the lighting end use. This was done on the basis of SIC code. It was found that ornamental nurseries (SIC code 181) were the primary facility type which participated in the lighting end use. Therefore, nonparticipants with SIC code 181 were oversampled, and were considered to be a likely candidate for having lighting on their account.

The MDSS database program application information is used to extrapolate 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.

2. Survey Information

Telephone survey instruments are presented in the *Volume II of the Appendix, Appendix F* (for participants) and *Appendix G* (for comparison group customers). Participant and comparison group customer's survey response frequencies are presented in *Appendix M and N,* respectively.

On-site audit instruments are presented in *Appendix H.*

3. *Statistical Descriptions*

As mentioned above, a complete set of participant and comparison group customer's responses frequencies are presented in *Appendix M and N*. In addition, statistics on usage and engineering impact variables that were used in the attempted billing data regression models are also presented in *Section 3.3* and *Appendix C*.

D. DATA SCREENING AND ANALYSIS

A detailed discussion of the billing data regression data analysis is presented in *Section 3.3*. Specific procedures and modeling issues are discussed below.

1. *Outliers, Missing Data and Weather Adjustment*

As described in more detail in *Section 3.3*, of the customer control identifiers, 155 qualified as indoor lighting customers (74 participants with engineering estimates of energy change and 81 nonparticipants with indoor lighting end uses). Of these, 140 observations were used in the final model (70 participants and 70 nonparticipants). The other observations, 4 participants and 11 nonparticipants, were censored because their 1994 or 1996 energy consumption exceeded 1,000,000 kWh.

2. *Background Variables*

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

3. *Data Screen Process*

Section 3.3 of the report and Section 1 above describe all of the data screening criteria.

4. *Regression Statistics*

A variety of regressions were run with different combinations of variables, intercepts, and screening criteria. In addition, the robustness of the models was examined by identifying outliers and rerunning the models with outliers excluded. None of the models yielded results that were statistically significant.

The most significant model results of the regression are shown in Exhibit B. The coefficient for the gross program impacts was 0.08 and was statistically insignificant. The coefficient for other program impacts was -1.47. This coefficient was significant.

Exhibit 3-11
Indoor Lighting
SAE Model Results

Parameter Description	Regression Coefficient	t-statistic
1994 total billing	0.99	44.862
Indoor Lighting Eng. Est. of Gross Impact	0.08	0.677
Other Program Measure MDSS Impacts	-1.47	-3.133
Number of Observations	140	
Adjusted R-square	0.94	

5. Model Specification

The model specifications are presented in *Section 3.3*. Although no billing regression result was applied, some specific model specification issues are still discussed below:

Cross-sectional Variation. The final model specification recognizes the potential heterogeneity problem in the model and uses the following procedures to eliminate the impacts of the cross-sectional variation: (1) observations with highest usage values were removed in the model to reduce the overall variance of the sample in terms of usage and size; and (2) independent variables were all intercepted with the pre-installation usage to ensure that change of independent variable will be proportional to the usage value.

Time Series Variation. The key factors to control for the time series variation in the final model are: (1) use of the comparison group to define the relationship of the energy consumption between two different time periods and (2) eliminate the multiple time period interactions by only one yearly pre-installation period and one yearly post-installation period for each stage.

Self-selection. Self-selection is not treated explicitly in the billing regression analysis. The reasons for excluding such a correction is based on the following considerations: (1) the objective of the billing regression analysis is to estimate the program gross energy impacts. The self-selection bias, even exists, has very limited impacts on the outputs of such estimation when both cross-sectional and time series data are used and (2) the existing self-selection correction procedures all have serious flaws in their underlying assumptions.

Collinearity. Various statistical tests (such as COLLIN and VIF options in SAS) were used to check multiple collinearity problem among independent variables in the model.

Net Impact. No net billing model was implemented because no statistically significant results could be obtained from the gross model.

6. Measurement Errors

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

Measurement errors are a combination of random and non-random error components that plague all survey data. The non-random error frequently takes the form of systematic bias, which includes, but is not limited to, ill-formed or misleading questions and mis-coded study variables. In this project, we have implemented several controls to reduce the systematic bias in the data. These steps included (1) thorough auditor/coder training; (2) instrument pretest; and (3) cross-validation between on-site audit data and telephone survey responses.

The random measurement error, such as data entry error, has no impact on estimating mean values because the errors are typically unbiased. For the measures that were modeled in the billing regression analysis, the impact of random unbiased measurement errors was accounted for as part of the overall standard variance in the parameter estimate.

7. *Autocorrelation*

The autocorrelation problem exists if the residuals in one time period are correlated with the residuals in the previous time period. Since the final model is based on a yearly pre- and post-installation period comparison with only one year in each period, the autocorrelation problem was unlikely to occur under this scenario, as was confirmed by examining the Durbin-Watson statistic for these models.

8. *Heteroskdasticity*

The final model specification recognizes the potential heterogeneity problem in the model and uses the following procedures to eliminate the impacts of the cross-sectional variation: (1) observations with highest usage values were removed in the model to reduce the overall variance of the sample in terms of usage and size; and (2) independent variables were all intercepted with the pre-installation usage to ensure that change of independent variable will be proportional to the usage value.

9. *Collinearity*

Various statistical tests (such as COLLIN and VIF options in SAS) were used to check multiple collinearity problem among independent variables in the model. No problems with collinearity were identified.

10. *Influential Data Points*

Various SAS diagnostics were used to test for influential data points, such as COOKD, theCook's D influence statistic, the DFFITS standard influence of observation on predicted values, and the RSTUDENT studentized residual test. In addition, the observations with highest usage values were removed, which tended to have significant influence over the model.

11. *Missing Data*

Any data that were omitted are described in *Section D, Data Screening and Analysis*.

12. *Precision*

Relative precision's for net estimates were calculated using the following procedure:

- First, NTG ratios, N_i, were computed for all technology groups that were represented in the telephone survey.

- Then, the program level NTG and program level standard error for the NTG were calculated using the classic stratified sample techniques. The program level NTG was a weighted average of technology level NTG values with adjusted gross impacts per technology group providing the weights.[3] The functional relation can be best described in the following equations:

$$\overline{N} = \Sigma_i w_i * \overline{N}_i \text{ with } w_i = MWh_i$$

$$StdErr_{NTG} = \sqrt{\Sigma_i\left((w_i)^2 * StdErr_i^2\right)}$$

where

N = Net-to-Gross Value

i = Technology Group

w = Weight

- Then, the relative precision[4] for the program NTG value for energy was calculated and combined with the relative precision of the gross energy impact to yield an overall relative precision for the net energy impacts:

$$RP_{NTG\_Energy} = \frac{t_{\alpha=10} * StdErr}{NetMWH}$$

$$RP_{NetEnergy} = \sqrt{RP^2{}_{NTG\_Energy} + RP^2{}_{GrossEnergy}}$$

- Finally, the relative precision net demand impacts was calculated using a scaled version of the relative precision for the net energy impact. The sample sizes of the on-site audits and telephone surveys served as the scalars:

$$RP_{NetDemand} = RP_{NetEnergy} * \sqrt{\frac{N_{OnSite}}{N_{Telephone}}}$$

- Per-unit NTG relative precision's appearing in Table 6 (Items 1-5) were calculated in a similar fashion.

E. DATA INTERPRETATION AND APPLICATION

The program net-to-gross analysis was conducted based on a survey self-report analysis. For a detailed NTG analysis discussion, see *Section 3.4*.

The self-report method used to score free-ridership uses participant responses to survey questions regarding the timing of and reasons for equipment replacement actions. As described in *Section*

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[3] Technology groups with no standard errors were excluded from this calculation.

[4] The example shown is for the 90 percent confidence level. Relative precision was also calculated at the 80 percent confidence level.

3.4, a series of questions was posed to program participants. If the customer indicated that he had not been shopping for new equipment before becoming aware of the program, he was scored initially as a net participant. A customer was then classified as a free-rider if he (1) stated that he would have installed high-efficiency equipment within the year and had already selected the equipment; and (2) stated that he would have purchased high-efficiency equipment if the program had not existed.

The net-to-gross ratio using the self-report method relied only on free ridership and did not include any estimate of spillover.