Contract Group H

Evaluation Report:
PG&E Agricultural and Food Processing Program; Greenhouse Heat Curtain and Infrared Film Measures

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Abstract

This report presents results of an impact evaluation of the 2006-2008 PG&E Agricultural and Food Processing Program (PGE2001) and two high impact greenhouse measures: heat curtains and infrared film. Gross impacts were developed using a project-specific engineering approach for the Agricultural and Food Processing Program and a calibrated building energy simulation approach for the greenhouse measures. Net savings were developed using a customer self report method.

Statewide annual net savings for the greenhouse heat curtain measure are estimated to be 1.28 million therms (41% of the ex-ante estimate) and 0.14 GWh. Statewide annual net savings for the greenhouse infrared film measure are estimated to be 0.23 million therms (18% of the ex-ante estimate) and 0.06 GWh. Net savings for the PG&E Agricultural and Food Processing Program (excluding commercial new construction projects) are estimated to be 58.7 GWh per year (61% of the ex-ante estimate), 8.0 MW (51% of the ex-ante estimate), and 6.8 million therms per year (102% of the ex-ante estimate).

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Executive Summary

In this report we present the results of an impact evaluation conducted by the PG&E Agricultural and Food Processing contract group for the California Public Utilities Commission. This group was lead by KEMA Inc. with support from ERS, Inc., ADM Associates, California AgQuest Consulting, Robert Thomas Brown Company, and Itron, Inc. The evaluation focused on estimating gross and net kWh, kW, and therm impacts for the 2006-2008 period associated with the PG&E Agriculture and Food Processing (Ag-Food) Program (PGE2001)[1] and two high-impact measures (HIMs): [2] greenhouse heat curtains and greenhouse infrared film. These two HIMs were installed through programs run by PG&E, SDG&E, and SCG.

Evaluation Approach

The gross impact evaluation of the PG&E Ag-Food Program utilized a project-specific engineering methodology that consisted of retrofit isolation engineering models or building energy simulation models that were calibrated to site-specific data. The gross impact analysis of the two HIMs utilized a building energy simulation (eQuest), which was calibrated using detailed data collected at six sites and then used to simulate energy usage at subsequent sites using site-specific data collected for each studied site. All gross impact analyses were supported by on-site data collection activities.

Net savings were developed using a customer self-report net-to-gross (NTG) approach, with additional interviews of selected vendors, when necessary to support the analysis. A common approach was utilized across several non-residential evaluation contract groups to provide for a consistent analysis across many similar programs. The method uses a “0” to “10” scoring system for key questions used to estimate the net-to-gross ratio (NTGR). It asks respondents to jointly consider and rate the importance of the many likely events or factors that may have influenced their energy-efficiency decision-making.

Sample sizes were designed to provide relative precision of 10% at the 90% confidence level for the PG&E Ag-Food Program and 20% at the 90% confidence level for the greenhouse HIMs. A total of 38

[1] For the PG&E Ag-Food Program, all projects that were identified as commercial new construction projects were reassigned to the New Construction Codes and Standards evaluation. Thus, all Ag-Food Program results presented in this report show effects that exclude these commercial new construction projects.

[2] Subsequent to the initial allocation of programs to the evaluation contract groups, the overall focus of the CPUC evaluation activities shifted from a program evaluation to a “high impact measure” (HIM) evaluation. During this process, a list of HIMs was developed from the E3 calculators delivered by the Investor-owned utilities (IOUs) covering program savings claims through the end of the second quarter of 2008 (Q2-2008). A single Access database containing E3 measure line items, from the E3 calculator’s Input tab, was created. Each of the measures was assigned a measure name using a consistent measure-naming scheme. The savings claims for each IOU were tabulated for each named measure, and each measure’s contribution was calculated to the total IOU portfolio savings claim for kWh, kW, and therms. The list of HIMs was developed by identifying all measures that contributed more than 1% to any of the kWh, kW, or therm savings parameters and categorized by IOU.

electric projects and 30 natural gas projects received engineering analysis for the PG&E Ag-Food Program evaluation. Twenty one greenhouse heat curtain sites and 18 greenhouse infrared film sites were included in the HIM engineering analyses. Net-to-gross sample sizes came in at 29 for the Ag-Food electric projects, 15 for the Ag-Food gas projects, 53 for the greenhouse heat curtain sites and 57 for the greenhouse infrared film sites.

Results

Table 1 presents the gross impact realization rates and NTGRs estimated in this study along with their standard precision estimates. As the table indicates, realization rates range from a low of 0.39 for greenhouse infrared film therm savings to a high of 1.07 for PG&E Ag-Food Program therm savings. Relative precision estimates for the gross realization rates are higher than targeted for the greenhouse HIMs, but are lower than targeted for the PG&E Ag-Food Program. Lower than expected precision estimates for the Ag-Food realization rates are a result of worse than expected correlation between the ex-ante and ex-post project savings estimates. NTGRs range from a low of 0.46 for the greenhouse infrared film measure to a high of 0.78 for the PG&E Ag-Food Program kW savings.

Table 1: Summary of Key Evaluation Parameters and Their Associated Precision

Measure/Program	Gross Realization Rate	Relative Precision	NTGR	Relative Precision
Greenhouse Heat Curtains – Therms	0.63	9.7%	0.63	5.3%
Greenhouse Infrared Film – Therms	0.39	16.9%	0.46	10.2%
PG&E Ag-Food – kWh	0.68	16.9%	0.70	14.6%
PG&E Ag-Food – kW	0.52	30.4%	0.78	14.1%
PG&E Ag-Food – Therms	1.07	24.6%	0.69	16.1%

Table 2 presents statewide measure level impacts for the greenhouse heat curtain HIM and also compares ex-ante savings estimates with ex-post evaluation results. As the table shows, net savings for the heat curtains are 0.14 GWh and 1.28 million therms per year. Ex-post net therm savings are calculated to be about 41% of the ex-ante estimates. This is the result of a gross realization rate of 0.63 combined with a NTGR of 0.63, which is much lower that the average ex-ante NTGR of 0.95. The evaluation determined that the heat curtain HIM is generating a small amount of electric savings that are not currently being claimed by the programs.

Table 2: Greenhouse Heat Curtain Gross and Net Impacts

Savings Units	Evaluation Result	Ex Ante	Ex Post	Realization Rate
kWh	Gross Savings		227,123	-
	NTGR		0.63	
	Net Savings		142,411	-
Therms	Gross Savings	3,246,599	2,034,028	0.63
	NTGR	0.95	0.63	
	Net Savings	3,095,637	1,275,383	0.41

Table 3 presents statewide measure level impacts for the greenhouse infrared film HIM. As shown, net savings for the infrared films are 0.06 GWh and 0.23 million therms per year. Ex-post net therm savings are calculated to be only 18% of the ex-ante estimates. A low gross realization rate, combined with an NTGR that is much lower that the program assumption, contribute to this result. Similar to the heat curtain measure, the evaluation determined that the infrared films are generating a small amount of electric savings that are not currently being claimed by the programs.

Table 3: Greenhouse Infrared Film Gross and Net Impacts

Savings Units	Evaluation Result	Ex Ante	Ex Post	Realization Rate
kWh	Gross Savings		131,481	-
	NTGR		0.46	
	Net Savings		59,940	-
Therms	Gross Savings	1,290,728	500,527	0.39
	NTGR	0.96	0.46	
	Net Savings	1,239,099	228,181	0.18

Table 4 present program-level impacts for the PG&E Ag-Food Program. Ex-post net savings are calculated at 58.7 GWh, 8.0 MW, and 6.8 million therms, reflecting net realization rates of 0.61, 0.51, and 1.02, respectively. Note that gross realization rates for kWh and kW are slightly higher than those shown in Table 1, and the gross therm realization rate is slightly lower. This difference is because the realization rates shown in Table 4 reflect dual fuel impacts that were omitted from ex-ante calculations and the realization rates in Table 1 do not.

Table 4: PG&E Ag-Food Program Gross and Net Impacts

Savings Units	Evaluation Result	Ex Ante	Ex Post	Realization Rate
kWh	Gross Savings	120,778,653	84,125,757	0.70
	NTGR	0.79	0.70	
	Net Savings	95,598,936	58,719,351	0.61
kW	Gross Savings	19,504	10,262	0.53
	NTGR	0.80	0.78	
	Net Savings	15,667	7,999	0.51
Therms	Gross Savings	9,229,753	9,865,607	1.07
	NTGR	0.72	0.69	
	Net Savings	6,653,438	6,798,317	1.02

Recommendations

Key program-related recommendations include the following, which are discussed further at the end of each measure/program specific section of this report:

- For greenhouse heat curtain and infrared film measures, we recommend that the utilities make some changes to the models they use to calculate ex-ante unit savings. These changes would have the effect of lowering savings for these greenhouse measures.
- For the PG&E Ag-Food Program, we recommend a number of changes to improve the accuracy of the ex-ante estimates and to provide for more accurate evaluations of the program (see Section 5.4 of this report for more detail):
  - Provide better documentation, justification, and supporting data for the base case equipment on which savings are based
  - Compute peak demand savings on the same basis as defined by the evaluations (and in the Database for Energy Efficiency Resources) (DEER)
  - Incorporate remaining useful life calculations into early replacement projects
  - Require more pre- and post-retrofit measurement on large projects to ensure evaluators have sufficient data on which to base savings calculations

We also provide several additional recommendations that would help facilitate improved evaluation of the programs (also discussed more thoroughly in Section 5.4 of this report):

- Extend the evaluation schedule to allow for more analysis time after summer field activities are completed – particularly for programs such as the PG&E Ag-Food Program where key site activity often occurs in late summer and early fall
- Develop an electronic filing system for program project files so that data requests for these files can be expedited
- Improve program tracking data to better describe project activities for custom projects, thereby allowing evaluators to develop more efficient sample designs that could focus on specific types of custom projects

1 Introduction and Purpose of the Study

This is the evaluation report for the Pacific Gas and Electric Company (PG&E) Agriculture and Food Processing Program Contract Group. The evaluation project was led by KEMA, Inc., who was in charge of overall project planning, sample design, summarization of evaluation results, and reporting. Measurement and Verification (M&V) activities were led by ERS, Inc., with assistance from ADM Associates, California AgQuest Consulting, and Robert Thomas Brown Company. Itron, Inc. assisted in conducting and scoring net-to-gross surveys.

The evaluation focused on the PG&E Agriculture and Food Processing (Ag-Food) Program (PGE2001) and two high-impact measures (HIMs): [3] greenhouse heat curtains and greenhouse infrared film. These two HIMs were installed through five different programs: the PG&E Ag-Food Program, the PG&E Commercial Mass Markets Program, the Southern California Gas (SCG) Express Efficiency Program, the San Diego Gas and Electric Company (SDG&E) Express Efficiency Program, and the SDG&E Small Business Super Saver Program. The evaluated program period operated from January 2006 through December 2008.

The evaluation objectives were to:

1) Determine the total adjusted gross- and net-energy impacts of the greenhouse heat-curtain and infrared film measures and the PG&E Ag-Food Program for the 2006-2008 program years
2) Establish monthly and hourly performance profiles for the projects in which the program measure was implemented, based on review of records, interviews, energy modeling, and measurements, where necessary
3) Account for the energy and peak-demand effects of spillover, if applicable
4) Explain discrepancies between the results of this study and the ex-ante savings estimated by utilities
5) Inform future updates to ex-ante energy savings estimates (including the Database for Energy Efficient Resources (DEER)) for program planning purposes

[3] Subsequent to the initial allocation of programs to the evaluation contract groups, the overall focus of the CPUC evaluation activities shifted from a program evaluation to a "high impact measure" (HIM) evaluation. During this process, a preliminary list of HIMs was developed from the E3 calculators delivered by the Investor-owned utilities (IOUs) covering program savings claims through the end of the second quarter of 2008 (Q2-2008). A single Access database containing E3 measure line items, from the E3 calculator's Input tab, was created. Each of the measures was assigned a measure name using a consistent measure-naming scheme. The savings claims for each IOU were tabulated for each named measure, and each measure's contribution was calculated to the total IOU portfolio savings claim for kWh, kW, and therms. An initial list of HIMs was developed by identifying all measures that contributed more than 1% to any of the kWh, kW, or therm savings parameters and categorized by IOU.

1.1 EM&V Activities and Results Contained in this Report

This evaluation is designed to meet the following high-priority uses for the results: adjustments to gross savings claimed by utilities: net savings estimations after considering other influences that affect customers' decisions to implement efficiency measures; and allocation of energy savings to time periods. This last factor is needed to properly value reduced electricity use, whose cost and consumer price vary over different day-types and hours. Impact evaluation results are also used to support cost-effectiveness analyses, program process improvements and strategic planning, and to determine shareholder incentives. Moreover, data collected for the impact evaluation may support other program planning and evaluation functions including: estimating incremental measure costs; assessing program market effects; and estimating measures' useful lives. Because many of the above priorities are best met by producing data at the measure or end-use level, the project focused evaluation resources on detailed end-use-level field data collection and subsequent analysis.

For the gross savings evaluation, the KEMA team applied a common, basic approach. The KEMA team used measurement and verification of gross and net savings for a sample of sites and expanded those sample results to the program population via stratified ratio estimation, using tracking system savings as the ratio variable. These site evaluations were executed using the following steps.

- **Validate and adjust ex-ante savings estimates.** In evaluations of this type, the first step is to ensure that project-level energy and demand reductions estimates contained in utility tracking-system databases are correct and complete.
- **Develop Monitoring and Verification (M&V) sample.** Once tracking system savings estimates were validated, the next step was to select a sample of sites for M&V activities. The basic goal of the sample design was to meet prescribed levels of statistical precision for total kWh, kW, and therm savings. Sample sizes developed for the evaluation were:
  - PG&E Ag-Food Program: 71 projects (40 projects selected for their electric savings and 31 projects selected for natural gas savings)
  - Greenhouse heat-curtain HIM: 18 sites
  - Greenhouse infrared-film HIM: 17 sites
- **Develop M&V plans for sample sites.** Research team engineers developed a custom data collection and analysis plan (site plan) for each sampled project for the PG&E Ag-Food Program and standardized M&V plans for the more homogeneous greenhouse HIMs. The plans' objectives were to identify the key data that would be required to ascertain conditions and energy consumption for both baseline and as-built conditions so that energy savings and demand reduction could be estimated. The plans also identified how the data would be collected and processed into energy savings and demand reduction estimates to correspond to the California Public Utilities Commission's (CPUC) reporting requirements. The M&V plans took into account the level of rigor specified for the study, number and types of measures installed, the

sensitivity of energy savings to variable conditions, including: weather, occupancy, volume of production or facility utilization, customer ability to vary energy service levels, and the share of total program energy and demand savings accounted for by the site. Researchers supplemented tracking system and application file materials with direct interviews with sample facility representatives and review of billing data to support development of the site plans.

- **Collect data and estimate site-level ex-post gross energy savings**. Site data collection and analysis occurred in the following stages.
  - *Preliminary interview.* The engineer assigned to the site interviewed facility personnel to ascertain basic facts about the site's design and operation so that the site plan could be finalized for implementation.
  - *Verification of measure installation.* During the on-site visit, the field engineer verified the installation of the measures in question and checked key attributes against program records. These included the quantity, capacity, location, and efficiency ratings of the items installed.
  - *Installation of measurement instruments.* The engineer installed measure-level meters or other measuring devices, such as lighting hours-of-use loggers. For many of the measures included in this evaluation, researchers collected interval data for electric demand.
  - *Estimation of site-level gross savings.* After on-site meters were retrieved and downloaded, the site engineer combined data from numerous sources—including installation verification, facility staff (concerning facility hours of operation, seasonal use patterns, and control schemes), equipment specifications, and post-installation observations and metering—to estimate savings. The general strategy was to estimate the affected equipment's energy usage for both baseline and post-installation conditions, and then use the differences between those usage estimates to estimate energy savings and demand reductions.
- **Estimate site-level net energy savings and demand reductions**. CPUC evaluation protocols require that savings net of free-ridership be estimated. The research team estimated site-level free-ridership and participant spillover based on results of questions posed to facility staff about the programs' effect on decisions to implement program-supported measures. These questions generally attempted to define what customers would have done in the absence of the program in regard to the quantity, capacity, efficiency rating, and timing of the purchase that was supported by the program. Questionnaires measuring net program effects were administered by subject-matter analysts trained in interviewing and research. The analysts also utilized extensive information about the site to guide their questions, including application materials and on-site observations provided by the field engineers. The analysts used other data developed through the site inspection and file review to corroborate customer self-reports.
- **Analysis and reporting of program-level and HIM-level savings.** The research team expanded sample site findings across the entire population of program/HIM participants, utilizing a ratio estimation approach. In brief, this procedure applies the ratio of verified *ex-post* savings to sampled sites' tracking system-recorded ex-ante savings to total tracking system energy savings

and demand reductions to arrive at estimates of verified gross energy savings and demand reductions.

Key results presented in this report include gross and net energy and peak demand savings for the PG&E Ag-Food Program, greenhouse heat curtain and infrared film measures, and key savings parameters associated with these savings including installation rates, unit energy savings, hours of operation, realization rates, and net-to-gross ratios.

The following tables summarize key activities conducted for the evaluation and key evaluation results that are contained in this report.

High-Impact Measure Evaluations

	Verification	***Gross Savings***			***Net Savings***		
Evaluation Methods →	*Surveys, on-site Audits*	*Billing Analysis*	*Field measurement*	*Other*	*Participant Self Report*	*Discrete Choice*	*Other*
Report Section	*Parameters estimated – or evaluation outputs.*						
3. Greenhouse Heat Curtains	Installation Rate		Gross energy and peak demand savings, operating hours, UES, realization rates		Net measure savings, NTG ratio		
4. Greenhouse Infrared Film	Installation Rate		Gross energy and peak demand savings, operating hours, UES, realization rates		Net measure savings, NTG ratio		

Program-Specific Evaluations

	Verification	***Gross Savings***			***Net Savings***		
Evaluation Methods →	*Surveys, on-site Audits*	*Billing Analysis*	*Field measurement*	*Other*	*Participant Self Report*	*Discrete Choice*	*Other*
Report Section	*Parameters estimated – or evaluation outputs.*						
5. PG&E Ag – Food Processing	Installation Rate		Gross energy and peak demand savings, operating hours, UES, realization rates		Net program savings, NTG ratio		

1.2 Grouping and Rationale for Grouping Evaluation Activities

KEMA, Inc. was contracted to conduct program evaluations for six PG&E agricultural and food processing programs. These programs provided specialized technical services and financial incentives that promote installation of energy-efficiency measures in agricultural and food processing facilities. In addition to the largest PG&E Ag-Food Program (PGE2001), five smaller specialty programs operated by third-party contractors were initially included in the evaluation:

- Industrial Refrigeration Performance Plus Program – VaCom (PGE 2079)
- Industrial Cold Storage/Food Processing Efficiency – Onsite (PGE 2065)
- Wine Industry Efficiency Solutions – D&R International (PGE 2049)
- Dairy Energy Efficiency Program (DEEP) – EnSave (PGE 2045)
- Combined Approach to Solar and Efficiency (CASE) – Powerlight (PGE 2069)

These programs were grouped together for evaluation purposes, because they target a narrowly defined group of facilities. Moreover, energy and demand savings from measures supported by these programs are concentrated within a few technologies, including pumps, boilers, process heat, and production processes that are specific to the food and beverage industries.

Subsequent to the initial allocation of programs to the Ag-Food Contract Group, the overall focus of the CPUC evaluation activities shifted from a program evaluation to a HIM evaluation. During this process, a preliminary list of HIMs was developed from the E3 calculators delivered by the Investor-owned utilities (IOUs) covering program savings claims through the end of the second quarter of 2008 (Q2-2008). A single Access database containing E3 measure line items, from the E3 calculator's Input tab, was created. Each of the measures was assigned a measure name using a consistent measure-naming scheme. The savings claims for each IOU were tabulated for each named measure, and each measure's contribution was calculated to the total IOU portfolio savings claim for kWh, kW, and therms. An initial list of HIMs was developed by identifying all measures that contributed more than 1% to any of the kWh, kW, or therm savings parameters and categorized by IOU.

As part of the HIM process, the Ag-Food Contract Group was assigned two HIMs, the greenhouse heat curtain and greenhouse infrared film measures. The HIMs were assigned as such since they were focused on agricultural facilities that were similar to facilities already targeted by the Ag-Food evaluation. To free up resources for the HIM evaluations, it was necessary to remove the five smaller third-party programs from the evaluation. Each of these programs contributed less than 0.5% to PG&E's ex-ante savings for the 2006-2008 period. Ex-ante savings estimates are being accepted for these smaller programs.

1.3 Programs included in this Evaluation

The evaluation activities and results discussed in this report address measures covered by five programs:

- The PG&E Agriculture and Food Processing Program (PGE2001)
- The PG&E Commercial Mass Markets Program (PGE2080)
- The SCG Express Efficiency Program (SCG3507)
- The SDG&E Express Efficiency Program (SDGE3012)
- The SDG&E Small Business Super Saver Program (SDGE3020)

All program measures are addressed in the PG&E Ag- Food Program evaluation, while only greenhouse heat curtain and greenhouse infrared film measures are addressed in the evaluations of the other four programs.

The following table provides a brief description of the programs included in this evaluation.

Programs Included in this Evaluation

PROGRAMS INCLUDED IN THIS EVALUATION	PROGRAM DESCRIPTION	KEY PROGRAM ELEMENTS
PG&E Agriculture and Food Processing Program (PGE2001)	The Agricultural and Food Processing Program is PG&E's umbrella effort to promote energy efficiency in agriculture and the food processing industry. Its objective is "to provide the most cost-effective, comprehensive, relevant portfolio of program elements for the targeted customers…" The core program is operated by PG&E staff and provides coordinated marketing of technical services and incentives to target sub-markets including: farms, dairies, food processing facilities, wineries, and refrigerated warehouses.	The elements provided directly by PG&E include: o On-site audits of agricultural facilities and pump tests o Engineering support and design assistance for new construction and retrofit projects o Education and training in energy efficiency, demand response, and distributed generation specific to the submarket o Deemed and calculated (custom) incentives for retrofit and new construction measures specific to the submarkets Key program measures include custom process, boiler, refrigeration, HVAC, lighting, and motors measures.

PROGRAMS INCLUDED IN THIS EVALUATION	PROGRAM DESCRIPTION	KEY PROGRAM ELEMENTS
PG&E Commercial Mass Markets Program (PGE2080)	This program targets single-family and multifamily residential retrofits, commercial renters, and commercial customers who often lack information, time and resources for energy-efficiency projects. The program uses PG&E and third-party specialists and local government partnerships to deliver a portfolio of energy-efficiency, demand response, and distributed generation services. It includes statewide and other elements specially targeted to mass-market customers in PG&E's service area. Both turnkey and customized direct installation program elements are included in various partnerships.	To achieve maximum outreach and penetration into all sectors of the mass market, the program is provided through a variety of delivery channels. Local government partnerships provide outreach and marketing as well as direct installation for single-family and multifamily residences and small businesses to localized portions of the mass market. The program includes a large variety of measures that lend themselves to prescriptive rebates; however, this evaluation focuses only on greenhouse heat curtain and infrared film measures.
SCG Express Efficiency Program (SCG3507)	Express Efficiency is a statewide rebate program targeting all nonresidential customers and encourages the adoption of selected energy-efficient technologies. SCG's program focuses on replacing existing energy-efficient natural-gas equipment and encouraging customers to upgrade to higher than standard efficiency models when purchasing equipment for their business.	The 2006-2008 program expands the outreach of this rebate program to remote rural small business communities by deploying a grass-roots outreach team that offers on-site audits as well as assists customers with the rebate application process. The program includes a large variety of measures that lend themselves to prescriptive rebates; however, this evaluation focuses only on greenhouse heat curtain and infrared film measures.
SDG&E Express Efficiency Program (SDGE3012)	This statewide program is designed to assist nonresidential customers who have a monthly demand above 100 kW and/or an average monthly gas usage of 4,166 therms and above to retrofit existing equipment with high-efficiency equipment. In addition, the 500 kW monthly demand barrier between the statewide Express Efficiency Programs and statewide Standard Performance Contract Programs was removed to ensure that IOUs' nonresidential customers have a seamless approach to participate in an energy-efficient program best suiting their retrofit project needs. Rebates are intended to cover a portion of the incremental cost associated with installing higher-efficiency equipment. Financial incentives are also awarded for comprehensive projects that include more than one measure or participate in demand-response programs.	The program uses multiple marketing channels to increase awareness and participation in the program. In addition, the SDG&E Express Efficiency has a local program component specific to the needs of the customers in its territory. The program includes a large variety of measures that lend themselves to prescriptive rebates; however, this evaluation only focuses on greenhouse heat curtain and infrared film measures.

PROGRAMS INCLUDED IN THIS EVALUATION	PROGRAM DESCRIPTION	KEY PROGRAM ELEMENTS
SDG&E Small Business Super Saver Program (SDGE3020)	The Small Business Super Saver program is a prescriptive rebate program targeting nonresidential customers under 100kW of monthly demand and/or under an average monthly usage of 4,166 therms. The program encourages nonresidential customers to retrofit existing equipment with high-efficiency equipment. Rebates are intended to cover a significant portion of the incremental cost associated with installing higher-efficiency equipment.	The program integrates contractor incentives, creating the potential for a no-cost approach for the very small customer and/or an incentive for comprehensive retrofits. In addition, the program offers an on-bill financing opportunity for customers who qualify and have a monthly demand of 50kW and above. The program includes a large variety of measures that lend themselves to prescriptive rebates; however, this evaluation only focuses on greenhouse heat curtain and infrared film measures.

1.4 Report Organization

The remainder of this report is organized as follows:

- Section 2 presents the gross impact and net impact evaluation methodology
- Section 3 presents and discusses the results of the greenhouse heat curtain HIM evaluation
- Section 4 presents and discusses the results of the greenhouse infrared film HIM evaluation
- Section 5 presents and discusses the results of the PG&E Ag-Food Program evaluation
- Appendix A contains a glossary of acronyms
- Appendix B contains further detail on the net-to-gross analysis conducted for this evaluation, including a detailed description of methodology, the survey forms used for the analysis, site-specific survey results, and write-ups for large-project NTG analyses
- Appendix C contains M&V reports for the greenhouse heat-curtain and infrared-film HIMs
- Appendix D contains M&V site reports for the PG&E Ag-Food Program
- Appendix E contains non-confidential responses to public comments
- Appendix F contains confidential responses to public comments.

Note that the appendices are contained in separate report volumes.

2 Methodology

In this section, the methods that were used to evaluate gross and net impacts for the greenhouse heat curtain and infrared film measures and the PG&E Ag-Food Program are described. First, the greenhouse measures are described and the measures included in the PG&E Ag-Food program are presented. Then, our approaches for estimating gross and net impacts are discussed. Each of these discussions addresses the research team's sample design, analysis approach, and summarization and expansion of site-specific results to measure/program-level results.

2.1 Measure and Program Descriptions

2.1.1 Greenhouse Heat Curtain Measure Description

The measure under evaluation is the installation of heat curtains in existing greenhouse structures. This measure is most often installed as a supplement to existing envelope systems.

Greenhouse heat curtains are thermal blankets installed in greenhouses to decrease heat loss from conduction, convection, and radiation through the building envelope. The curtains are typically deployed during nighttime hours for heat retention and during daytime hours for shading.

Properly installed, program-qualified heat curtains improve the thermal properties of a building's envelope, resulting in reduced heating, ventilation, and air conditioning (HVAC) system loads. The measure's impact was quantified as heating, cooling, and ventilation energy savings in the greenhouse.

During the 2006-2008 program period, there were 68 prescriptive projects and one customized heat curtain project. Only interior roof curtain installations in natural-gas-heated commercial greenhouses qualified for prescriptive incentives; new construction and site-wall-curtain projects were not eligible.

2.1.2 Greenhouse Infrared Film Measure Description

The measure under evaluation is the installation of infrared films in existing greenhouse structures. This measure is most often installed as the inside layer of an inflated double-polyethylene roof system.

Polyethylene materials with low-transmissivity infrared films are typically installed as replacements for existing greenhouse envelopes, most commonly in greenhouses with existing single or double polyethylene shells. Replacements of existing roof structures are most common, but full envelope replacements may also be performed.

Infrared films act to cut down radiant heat loss from the building envelope, especially during cool, clear nights when radiation from the greenhouse to the night sky can be significant. When installed as a replacement for old, leaky glass greenhouse envelopes, infrared films can also cut down on infiltration heat losses. However, because glass already has a low infrared transmissivity, use of low-transmissivity polyethylene films result in insignificant changes in heat loss via radiation. Consequently, infrared films are most commonly installed as a replacement for existing synthetic greenhouse envelopes. Once installed, infrared films cut down on long-wave infrared radiation into and out of the greenhouse envelope. The measure impact can be quantified as the savings in heating, cooling, and ventilation energy in the greenhouse.

PG&E, SDG&E, and SCG's programs all required that rebated infrared films were made of an anti-condensate polyethylene that was more than 6 mils thick.

In the 2006-2008 program period, there were 57 prescriptive infrared-film projects. Only installations of infrared films in natural-gas-heated commercial greenhouses qualified for prescriptive incentives. New construction projects were not eligible.

2.1.3 PG&E Agricultural and Food Processing Program Measures

A variety of measures were installed through the Ag-Food Program, necessitating a custom evaluation approach. Table 5 shows the various measures and associated ex-ante savings estimates, as provided in the PG&E tracking system.

Overall, a total of 1009 projects, as defined by unique application number, were included in the Ag-Food Program (PGE2001) during the 2006-2008 evaluation period. Sixty-four of these projects were identified as "commercial new construction" projects and were reassigned to the New Construction Codes and Standards Evaluation, leaving 945 projects to be assessed in this study. In Table 5, we present all the measures associated with this Ag-Food evaluation and break out, as a separate line item (at the bottom of the tables), the ex-ante savings associated with the New Construction Codes and Standards Evaluation.

Table 5: PG&E Ag-Food Program Measure Summary

Tracking System Measure Description	Ex-Ante kWh	Ex-Ante kW	Ex-Ante Therms	Rebate
ADD HIGH EFFICIENCY CHILLER	3,650,823	564.0	0	$400,378
AG PUMPS OTHER	2,044,195	219.3	0	$163,532
AIR COMPRESSER SYSTEM CHANGE/MODIFY	4,206,793	723.1	0	$325,498
CHANGE/ADD OTHER EQUIPMENT	5,485,235	523.1	0	$478,539
COOL ROOF	40,914	41.7	0	$3,273
DAYLIGHTING CONTROLS	44,071	12.3	0	$1,763
EARLY RETIREMENT, MOTORS	3,789	0.8	0	$303
FLOATING HEAD PRESSURE (AIR-COOLED)	146,416	2.1	0	$34,860
HEAT CURTAINS	0	0.0	81,146	$64,917
HIGH EFF. VSD CHILLER	410,000	28.8	0	$50,299
HIGH EFFICIENCY LIGHTING	2,240,585	132.7	-708	$106,227
HOT WATER OTHER	0	0.0	446,584	$328,898
HVAC - OTHER	5,808,247	893.1	0	$463,236
HVAC ADJUSTABLE SPEED DRIVE	34,218	1.2	0	$2,737
HVAC CONTROLS	376,648	4.8	0	$7,083
HVAC ENERGY EFFICIENT MOTOR	52,968	6.9	0	$4,163
HVAC ENERGY EFFICIENT MOTOR - PUMP	1,124	1.9	0	$90
HVAC OTHER MOTOR	2,944,413	530.5	0	$202,969
IMPROVED PROFILE COMPRESSORS & SIZING	486,988	51.7	0	$33,156
INSULATE BUILDING SHELL (CEILING, WALLS)	351,134	121.8	0	$27,110
LIGHTING - OTHER	9,615,355	1,128.6	0	$471,302
LIGHTING CONTROLS	756,848	86.0	0	$37,842
MH FIXTURES - INDOOR	873,542	104.5	0	$42,434
NON-PROCESS BOILER CHANGE/ADD	0	0.0	2,728,336	$1,950,020
NON-PROCESS BOILER CONTROLS	0	0.0	170,180	$136,144
NON-PROCESS BOILER ECONOMIZER	0	0.0	433,626	$289,458
NON-PROCESS BOILER HEAT RECOVERY	0	0.0	97,516	$78,013
NON-PROCESS BOILER OTHER	0	0.0	25,199	$20,159
OVERSIZED CONDENSERS	2,396,436	497.8	0	$270,441
PACKAGED HVAC SYSTEMS	0	0.0	0	$0
PIPE/DUCT INSULATION	732,362	154.4	0	$58,589
PROCESS (CUSTOMIZED)	35,892,605	7,938.9	690,497	$3,927,905
PROCESS ADJUSTABLE SPEED DRIVE	7,136,963	2,716.6	0	$437,216
PROCESS BOILER BURNERS	0	0.0	136,179	$108,943
PROCESS BOILER CHANGE/ADD	0	0.0	885,769	$669,621
PROCESS BOILER HEAT RECOVERY	0	0.0	565,365	$288,099
PROCESS BOILER INSULATION	0	0.0	107,900	$33,310
PROCESS BOILER OTHER	777	0.0	2,542,239	$1,757,462
PROCESS CHANGE/ADD EQUIPMENT	5,721,197	760.9	0	$643,732
PROCESS ENERGY EFFICIENT MOTOR	1,105,862	54.9	0	$62,429
PROCESS HEAT RECOVERY	0	0.0	151,621	$98,000
PROCESS OTHER	5,884,717	1,237.0	39,476	$419,396
PUMP RETROFIT - APPLICATION ASSISTANCE	75	0.0	0	$15,150
PUMP RETROFIT - ELECTRIC	17,162,927	0.0	0	$1,011,028
PUMP RETROFIT - GAS	0	0.0	0	$5,819
REFRIGERATION CHANGE/ADD	807,131	149.6	0	$94,507
REFRIGERATION CONTROLS	264,015	0.0	0	$19,680
REFRIGERATION HEAT RECOVERY	277,815	53.1	0	$22,225
REFRIGERATION OTHER	1,949,679	380.2	0	$193,999
WHOLE BUILDING (NRNC) - PROCESS	1,871,785	381.0	100,685	$298,237
Subtotal - Included in Ag-Food Evaluation	120,778,653	19,503.5	9,201,610	$16,160,192
New Construction Codes and Standards Evaluation	24,980,570	5,323.4	62,703	$2,415,124
Ag-Food Program (PGE2001) Totals	145,759,223	24,826.9	9,264,313	$18,575,316

2.2 Gross-Impact Analysis

2.2.1 Gross Impact Sample Design

For the greenhouse heat-curtain and infrared-film measure evaluations, a project site was defined as a group of tracking-system greenhouse measure line items associated with a single address, each for the 2006-2007 and 2008 periods. (For example, program heat curtains installed at a single address in 2006, 2007, and 2008 would be counted as two sites, one for the 2006-2007 period and one for the 2008 period.) This split between the 2006-2007 and 2008 program periods was necessary to allow for initial planning for the 2006-2007 measurement and verification (M&V) analyses prior to the identification of the 2008 sites. Table 6 summarizes ex-ante savings reported for the greenhouse heat curtain measure during the 2006-2008 program period, and Table 7 summarizes ex-ante savings for the greenhouse infrared film measure.

Table 6: Greenhouse Heat-Curtain Measure Summary

Utility	Sites	Square Feet Installed	Ex-Ante Gross Therm Savings	Rebates
PG&E	23	2,351,860	998,371	$532,868
SCG	39	6,087,836	1,948,108	$1,184,767
SDG&E	7	913,025	300,120	$193,966
Total	69	9,352,721	3,246,599	$1,911,601

Table 7: Greenhouse Infrared-Film Measure Summary

Utility	Sites	Square Feet Installed	Ex-Ante Gross Therm Savings	Rebates
PG&E	10	1,476,300	84,149	$44,289
SCG	34	4,808,141	817,384	$144,244
SDG&E	13	2,393,928	389,195	$83,801
Total	57	8,678,369	1,290,728	$272,335

For the PG&E Ag-Food Program evaluation, a project was defined as a group of measures associated with a single PG&E program application. Table 8 summarizes, at the project level, ex-ante savings reported for the PG&E Ag-Food Program during the 2006-2008 program period, excluding the commercial new construction projects.

Table 8: PG&E Ag-Food Program Summary

Project Type	Projects	Ex-Ante kWh	Ex-Ante kW	Ex-Ante Therms	Rebate
Projects with Electric Savings	667	120,778,653	19,503.5	3,864,144	$12,603,295
Projects with Gas Savings	93	4,051,887	608.5	9,229,753	$6,764,515
Projects with No Savings*	202	0	0	0	$27,377
Overall	945	120,778,653	19,503.5	9,229,753	$16,166,972

All but two of the projects with zero savings were identified as line items in which PG&E paid incentives for "pump retrofit application assistance."

A stratified ratio estimation approach was used for both greenhouse measure sample designs, because savings are based on the amount of measure installed in each greenhouse (measured in square feet). Similarly, a stratified ratio estimate approach was used for the PG&E Ag-Food Program because customized savings were developed for each project. In each case, a stratified ratio estimation approach was expected to provide higher precision, with fewer sample points, than a simple random sample.

Using the standard formula to determine sample size (provided in The California Evaluation Framework[4]), the research team arrived at sample sizes of 18 sites for greenhouse heat curtain measure and 17 sites for the greenhouse infrared film measure, which were expected to each be sufficient to provide ±20% relative precision at the 90% confidence level. The California Energy Efficiency Protocols[5] recommend a ±10% relative precision at the 90% confidence level, but the evaluation team determined that targeting a somewhat lower precision level would be appropriate, given evaluation resources. The sample size, based on The California Evaluation Framework, was determined using the following two equations:

$$n_0 = \left(\frac{1.645\,er}{D}\right)^2 \quad and \quad n = \frac{n_0}{1 + n_0 / N}$$

Where n_0 is the initial sample size, n is the population-adjusted sample size, er is the estimated error ratio[6] for the study, D is the targeted precision level (20% or 0.20), and N is the population count. An error ratio of 0.60 was utilized for this study, based on a review of past error ratios (0.35 for the 2004-2005 Standard Performance Contractor - SPC - program), and a judgment-based adjustment to account for the fact that ex-ante impacts at the greenhouse measure sites were estimated using a prescriptive methodology, which will tend to be less precise than a customized site-specific methodology.

Application of the sample size equations yields a sample size of 18 for the greenhouse heat curtains:

[4] The California Evaluation Framework (June 2004) is available at http://www.calmac.org/publications/California_Evaluation_Framework_June_2004.pdf.

[5] Available at http://www.calmac.org/events/EvaluatorsProtocols_Final_AdoptedviaRuling_06-19-2006.pdf.

[6] See the California Evaluation Framework for a discussion of the error ratio.

$$n_0 = \left(\frac{1.645 \times 0.60}{0.20}\right)^2 = 24.4 \; and \;\; n = \frac{24.4}{1 + 24.4/69} = 18$$

Application of the sample size equations yields a sample size of 17 for the greenhouse infrared films:

$$n_0 = \left(\frac{1.645 \times 0.60}{0.20}\right)^2 = 24.4 \; and \;\; n = \frac{24.4}{1 + 24.4/57} = 17$$

To implement the sample design, three strata were developed for each measure using the guidelines set out in The California Evaluation Framework. Table 9 summarizes the sample design for the greenhouse heat curtains, and Table 10 summarizes the sample design for the greenhouse infrared films.

Table 9: Greenhouse Heat-Curtain Gross Impact Sample Design (Ex-Ante Data)

Stratum	N	Maximum Therms	Average Therms	Total Therms	Sample Size
1	42	40,464	20,692	869,049	6
2	17	87,500	66,582	1,131,888	6
3	10	276,164	124,566	1,245,662	6
Total	69		47,052	3,246,599	18

Table 10: Greenhouse Infrared-Film Gross Impact Sample Design (Ex-Ante Data)

Stratum	N	Maximum Therms	Average Therms	Total Therms	Sample Size
1	36	23,945	10,240	368,632	5
2	13	38,485	29,432	382,612	6
3	8	142,775	67,436	539,485	6
Total	57		22,644	1,290,728	17

For the PG&E Ag-Food Program, we used the same approach to determine sample sizes that would be sufficient to provide ±10% relative precision at the 90% confidence level for both electric and natural gas projects. An error ratio of 0.40 was utilized for this study, based on a review of past error ratios (0.35 for the 2004-2005 SPC program) and a slight upward adjustment to provide for a somewhat more conservative estimate of the number of sampled sites it would take to reach targeted precision levels.

Application of the sample size equations yields sample sizes of 41 for the electric projects and 30 for the natural-gas projects:

Electric sample: $$n_0 = \left(\frac{1.645 \times 0.40}{0.10}\right)^2 = 43.3 \; and \;\; n = \frac{43.3}{1 + 43.3/667} = 41$$

Natural gas sample: $$n_0 = \left(\frac{1.645 \times 0.40}{0.10}\right)^2 = 43.3 \; and \;\; n = \frac{43.3}{1 + 43.3/93} = 30$$

To implement the sample design for the PG&E Ag-Food Program, four strata were developed for each fuel type using the guidelines set out in the California Evaluation Framework. Table 11 and Table 12 summarize the sample design.

Table 11: PG&E Ag-Food Program Electric Sample Design

Stratum	N	Maximum kWh	Average kWh	Total kWh	Sample Size
1	467	137,790	44,397	20,733,504	11
2	122	365,304	219,616	26,793,157	10
3	56	935,851	575,650	32,236,422	10
4	22	5,504,884	1,864,344	41,015,571	10
Total	667			120,778,653	41

Table 12: PG&E Ag-Food Program Natural-Gas Sample Design

Stratum	N	Maximum Therms	Average Therms	Total Therms	Sample Size
1	62	87,938	24,819	1,538,762	9
2	18	165,161	128,919	2,320,547	9
3	10	328,510	223,934	2,239,341	9
4	3	1,697,071	1,043,701	3,131,104	3
Total	93			9,229,753	30

2.2.2 Gross Impact Analysis Approach

This subsection describes the M&V analysis approaches that were used in the study. These approaches are further described in Appendix C (greenhouse heat curtain and infrared film measures) and Appendix D (which contains the individual PG&E Ag-Food site reports).

2.2.2.1 Greenhouse Heat Curtains

The greenhouse heat-curtain measure was designated as a high-impact measure (HIM) by the CPUC evaluation team, and therefore it was evaluated at an enhanced rigor level.

The most appropriate analysis approach that complied with an enhanced rigor level for this measure involved building simulation modeling, calibrated to customer's pre-retrofit or post-retrofit energy bills (IPMVP Option D[7]). However, calibration was not always possible, since many of the evaluated projects were partial-site retrofits (e.g., two of twelve greenhouses were retrofit) or multiple measures were implemented (e.g., steam-trap repair). There were also other issues that prevented using calibration to pre- or post-retrofit billing data. Therefore, the overall HIM approach had two stages of analysis.

[7] IPMVP is the International Performance Measurement and Verification Protocol that specifies alternative measurement and analysis methods that can be used to estimate gross energy savings from a measure installed under a program being evaluated. Option D refers to the use of calibrated simulation models to estimate savings.

The first stage included modeling with reconciliation to metered data. (This stage of the analysis is referred to as method validation, the process that was used to validate the method that was eventually used to estimate site savings.) Evaluators applied this approach to six greenhouses at four sites, where metering was performed over a 4-week period. Field staff collected comprehensive building envelope, heating system, and schedule data for these sites and also logged key parameters, including air temperature at multiple heights within the greenhouse and parameters needed to calculate heating load. Heating load was measured by either:

a) Logging greenhouse supply and return hot-water temperatures and flow rates (spot measurement only if constant flow) for boiler-based systems (3 houses)
b) Measuring unit heater cycle times and recording rated capacity and efficiency to then calculate heat load (2 houses)
c) Collecting monthly gas-bill data for the one pilot site that had a dedicated meter for the retrofitted greenhouse

One of the pilot greenhouses was a pre-retrofit house; that is, it had no heat curtain but was otherwise identical in construction, systems, and schedule to another on-site greenhouse that received heat curtains. Facilities' staff at a second house allowed evaluators to measure heat load and temperatures for two weeks with heat curtain control and two weeks without the curtains. These two houses provided limited pilot modeling of both baseline and post-retrofit conditions.

Pilot sites used an eQuest-based greenhouse-specific modeling tool, with input parameters known to calibrate measured loads for six houses, both with and without heat curtains. This modeling tool was applied for the second stage of analysis—modeling the remaining sites without reconciliation against metered data—once evaluators gained confidence in the tool's structure and inputs.

2.2.2.1.1 Evaluation Method

The adopted method to evaluate the ex-post impact of the heat-curtain measure was as follows:

1) Reviewed available data from project applications and utility bills for each site
2) Performed site surveys to quantify pre- and post-measure greenhouse operating characteristics. These characteristics included geometry, envelope materials, heating and cooling system types, heating and cooling temperature setpoints and schedules, plant-growth schedules, and heat-curtain data and operating characteristics.
3) Input collected data into computer models. Computer simulation of hourly energy consumption in each greenhouse was performed with the eQuest v3.63b building energy-simulation software. Where inputs were not available through site surveys and data collection, the research team reviewed previous studies, such as the greenhouse work performed for DEER, and applied engineering judgment where necessary.

3a) Reconciliation with metered data. If a pilot site, the model was reconciled with measured heating load using local CIMIS weather station data or in one case, an evaluator-installed weather station.

4) Evaluate measure impacts. Impacts for each site were evaluated by modeling each site with the eQuest building energy simulation. Each site was modeled twice: once to calculate the energy consumption before measure installation and another time to calculate the energy consumption after measure installation. All other simulation variables were held fixed, aside from those directly affecting the measure impact, during these two simulations. Measure impacts were evaluated with California Climate Zone (CZ) typical weather year data for the climate zone in which each site was located. Measure impacts were evaluated for all sites. All model variables were held fixed during the pre- and post-measure implementation simulations, except in the following scenarios:

   - In greenhouses with unit heater systems, the number of (temperature) degrees offset by temperature stratification was calculated according to the following equation:

     Temperature offset =

     0.32°F/ft x (average height between greenhouse thermostat and greenhouse roof)

     This temperature offset number was added to the heating setpoint in the greenhouse model to account for the effects of temperature stratification, which led to higher temperatures near the greenhouse roof and therefore higher heat transfer via this surface. In greenhouses with heat curtains, the "greenhouse roof height" was defined as the height to the bottom of the heat curtain, not the height to the greenhouse roof. No temperature stratification was modeled in greenhouses with underbench heating systems.

   - Maximum solar radiation, minimum solar radiation, maximum temperature, and minimum temperature controls were modeled in greenhouses with heat curtains to simulate the heat curtain operation. Typically, these parameters are measured by automated heat-curtain control systems to determine whether the curtains should be drawn, retracted, or partially retracted.

   - Roof U-value improvements were modeled in greenhouses with heat curtains by applying a U-value multiplier to the greenhouse roof-glazing U-value, as per the following equation:

     Roof U-value w/Heat Curtain = Roof U-value x Heat Curtain U-value Multiplier

     The heat curtain U-value multipliers were derived from data provided by manufacturers.

   - Roof shading coefficient (SC) improvements were modeled in greenhouses with heat curtains by applying a shading coefficient multiplier to the greenhouse roof-glazing shading coefficient, as per the following equation:

     Roof SC w/Heat Curtain = Roof SC x Heat Curtain SC Multiplier

The heat-curtain shading coefficient multipliers were derived from manufacturer-provided data.

The ex-ante impacts for the heat-curtain measure were quantified in therms of gas/ft^2/year of measure installed. The expected therms/ft^2/year of savings for this measure were also calculated using the eQuest building energy-simulation software (eQuest v3.63b). These per unit estimates were then applied to the square feet covered in each greenhouse for each participating greenhouse in the program. Key advantages to ex-post modeling efforts over the ex-ante estimates include customization to site-specific parameters, more advanced heat-curtain control options, and the identification of key inputs through the method validation procedure that was performed at several sites.

2.2.2.1.2 Data Collection

Data collection activities included follow-up telephone surveys for sites that had already been visited as part of the small commercial program verification work. For sites that were not included in the small commercial program verification work, on-site data collection, phone conversations, project applications, manufacturer's literature, and review of pre- and post-installation utility billing information were performed. This approach minimized both cost and customer inconvenience. Follow-up calls were conducted by the initial site surveyor and modeling engineer team.

Data collected under the small commercial program verification work includes:

- Greenhouse location (climate zone, city, address, etc.)
- Type of plants grown in greenhouse (trees, shrubs, cut flowers, vegetables, etc.)
- Greenhouse dimensions and existing envelope materials
- Measure description and area of rebated installation
- Implementation schedule for heat curtains
- Greenhouse operating hours (seasonal and daily)
- HVAC system runtime
- Make and model of heaters (boilers, furnaces, etc.)
- Space temperature setpoints and control type

Additional data were collected for the impact evaluation, including:

- Greenhouse orientation
- Installed lighting power density and lighting schedules
- Cooling and ventilation details (schedules, unit size, runtime schedules, etc.)
- Pump and fan motor details. including size and expected runtime
- Heating equipment runtimes
- Floor area, envelope, and HVAC characteristics of the other greenhouses on site
- Percent of greenhouses on site with heat curtains and descriptions of these heat curtains

Gas and electric utility billing information were made available for all evaluation sites.

Project applications were procured, which included cut sheets, manufacturers, and model numbers for each installed heat curtain measure.

California climate zone (CZ) typical weather year data were provided by the CPUC Weather Working Group (composed of ED staff and its consultants and evaluation contractors) for this evaluation.

Pilot site data collection included all of the discussed items above as well as the following additional elements, which were logged for four weeks (though not all parameters existed at every site):

- Temperature at plant height, thermostat height, below heat curtain, and above heat curtain
- Heat-curtain motor amps
- Temperature in front of unit heater to measure heater cycle time
- Hot-water supply and return temperature
- Hot-water flow rate, if variable
- Outdoor dry-bulb and wet-bulb temperature and solar insolation

2.2.2.2 Greenhouse Infrared Film

The greenhouse infrared-film measure was designated as a high impact measure (HIM), and therefore it was evaluated at an enhanced rigor level.

The most appropriate analysis approach that complied with an enhanced rigor level for this measure involved building simulation modeling, calibrated to pre-retrofit or post-retrofit bills (IPMVP Option D). However, the calibration element was not always possible, as many of the evaluated projects were partial site retrofits (e.g. two of twelve greenhouses were retrofit), or multiple measures were implemented (e.g. steam trap repair), or there were other issues that interfered with calibration to billing data before or after the retrofit. Therefore, the overall HIM approach had two stages of analysis.

The first stage included modeling with reconciliation to metered data (Method Validation). Evaluators applied this approach to six greenhouses at four sites, at which metering was performed over a 4-week period. Field staff collected comprehensive building envelope, heating system and schedule data for these sites and also logged key parameters including air temperature at multiple heights in the greenhouse and parameters needed to calculate heating load. Heating load was measured by either:

a) Logging the greenhouse supply and return hot water temperatures and flow rates (spot measurement-only if constant flow) for boiler-based systems (3 houses).
b) Measuring unit heater cycle times and recording rated capacity and efficiency to then calculate heat load (2 houses).
c) Collecting monthly gas bill data, for the one pilot site that had a dedicated meter for the retrofitted greenhouse.

The product of the pilot was an eQuest-based greenhouse-specific modeling tool with input parameters known to calibrate to measured loads for six houses, both with and without infrared films.

Once evaluators developed and gained confidence in this modeling tool's structure and inputs, it was applied for the second stage of analysis: Modeling the remaining sites without reconciliation against metered data.

2.2.2.2.1 Evaluation Method

The method that was adopted to evaluate the ex-post impact of the infrared film measure was as follows:

1) Reviewed available data from project applications and utility bills for each site
2) Performed site surveys to quantify pre- and post-measure greenhouse operating characteristics. These characteristics included geometry, envelope materials, heating and cooling system types, heating and cooling temperature setpoints and schedules, plant-growth schedules, and heat-curtain data and operating characteristics.
3) Input collected data into computer models. Computer simulation of hourly energy consumption in each greenhouse was performed with the eQuest v3.63b building energy-simulation software. Where inputs were not available through site surveys and data collection, previous studies were referenced, and engineering judgment was employed.

3a) Reconciliation with metered data. If a pilot site, the model was reconciled with measured heating load using local CIMIS weather station data or in one case, an evaluator-installed weather station.

4) Evaluate measure impacts. Impacts for each site were evaluated by modeling each site with the eQuest building energy simulation. Each site was modeled twice: once to calculate the energy consumption before measure installation and once to calculate the energy consumption after measure installation. During these two simulations all other simulation variables were held fixed aside from those directly affecting the measure impact. Measure impacts were evaluated with California Climate Zone (CZ) typical weather year data for the climate zone in which each site was located. Measure impacts were evaluated for all sites. All model variables were held fixed during the pre- and post-measure implementation simulations, except those indicated in Table 13.

Table 13: Inputs for Modeling Infrared Film Measure Impact

	Variable	Pre-Implementation (no infrared film)	Post-Implementation (with infrared film)
Single layer polyethylene	U-value of the greenhouse roof	1.1 Btuh/ft^{2}°F	1 Btuh/ft^{2}°F
	Shading coefficient of the greenhouse roof	0.26	0.22
Double layer polyethylene	U-value of the greenhouse roof	0.7 Btuh/ft^{2}°F	0.5 Btuh/ft^{2}°F
	Shading coefficient of the greenhouse roof	0.24	0.20

The ex-ante impacts for the infrared film measure were quantified in therms of gas/ft^2/year of measure installed. The expected therms/ft^2/year of savings for this measure were also calculated using the eQuest building energy simulation software (eQuest v3.63b). These per unit estimates were then applied to the square feet covered in each greenhouse that participated in the program. The key advantages to ex-post modeling efforts over the ex-ante estimates were customization to site-specific parameters, more advanced infrared film control options, and the identification of key inputs through the method validation procedure that was performed at several sites.

2.2.2.2.2 Data Collection

Data collection activities included follow-up telephone surveys for sites that had already been visited as part of the Small Commercial Verification work. For sites that were not included in the Small Commercial Verification work, on-site data collection, phone conversations, project applications, manufacturer's literature, and review of pre- and post- installation utility billing information were performed. This approach minimized both cost and customer inconvenience. Follow-up calls were conducted by a team of the initial site surveyor and the modeling engineer.

Data collected as a part of the Small Commercial verification work included:

- Greenhouse location (climate zone, city, address, etc.)
- Type of plants grown in greenhouse (trees, shrubs, cut flowers, vegetables, etc.)
- Greenhouse dimensions and existing envelope materials
- Measure description and area of rebated installation
- Schedule of implementation for infrared films
- Greenhouse operating hours (seasonal and daily)
- HVAC system runtime
- Make and model of heaters (boilers, furnaces, etc.)
- Space temperature setpoints and control type

Additional data were collected for the evaluation, including:

- Greenhouse orientation
- Installed lighting power density and lighting schedules
- Cooling and ventilation details (schedules, unit size, runtime schedules, etc.)
- Pump and fan motor details including size and expected runtime
- Heating equipment runtimes
- Floor area, envelope, and HVAC characteristics of the other greenhouses on site
- Percent of greenhouses on site with infrared films and descriptions of these infrared films

Gas and electric utility billing information were made available for all evaluation sites.

Project applications were procured which included cut sheets, manufacturers, and model numbers for each installed infrared film measure.

California climate zone (CZ) typical weather year data were provided by the California Public Utility Commission (CPUC) Weather Working Group for this evaluation.

The pilot site data collection included the all of the above plus the following additional elements logged for four weeks (not all parameters at every site):

- Temperature at plant height, thermostat height, below infrared film, and above infrared film
- Infrared-film motor amps
- Temperature in front of unit heater to measure heater cycle time
- Hot water supply and return temperature
- Hot water flow rate, if variable
- Outdoor dry bulb and wet bulb temperature and solar insolation

2.2.2.3 PG&E Agricultural and Food Processing Program

Gross energy-impact assessments for most projects assessed under the PG&E Ag-Food Program were guided by the specifications for the enhanced rigor level of the Gross Energy Impact Protocol. The enhanced rigor assessments were based on site specific engineering analyses utilizing one of the two relevant methods prescribed by the protocols:

- Retrofit Isolation engineering models (IPMVP Option B), or
- Building energy simulation models (IPMVP Option D).

The choice of method depended on the project and measures being analyzed and was discussed in the site evaluation plans that were prepared for each project. In addition, a few sites were evaluated at the *basic* and *verify* rigor levels. The selection of basic or verify rigor levels took into account project size, complexity, and suitability of enhanced rigor methods.

The general evaluation approach was to estimate, on a project-specific basis, energy usage associated with the post installation equipment and energy usage for the baseline equipment, and then calculate savings as the difference between baseline energy use and post-installation energy use. Estimates were developed by time of use in order to allow for the projection of savings to 8,760 hours per year.

The basic steps involved in the project-specific evaluation for each sampled site were:

1) **Request project specific files and utility billing data**. For the sampled projects, we requested from PG&E all relevant project files. These included hardcopy project files and electronic data and analysis files, when available. We also collected extracts of billing data from 2005 to present.

2) **Conduct initial file review and assign projects to M&V engineers**. Once project files were delivered, the KEMA team lead engineer conducted an initial review of the information in order to gain an initial understanding of the type, size, and complexity of the project. Based on the initial file reviews, the lead engineer assigned projects to the appropriate team engineer, based on project attributes and appropriate engineering skill sets.

3) **Recruit selected project into the study sample**. The assigned M&V engineer then made various contacts to recruit the project into the study. The first step in the recruitment process was to notify PG&E that the project had been selected for an evaluation. Next, the M&V engineer contacted the customer to recruit it into the study. At that time, clarifying questions about the project were explored, as necessary, to help in M&V plan development. If customers were not initially willing to participate in the evaluation, the M&V engineer worked with PG&E to gain customer cooperation.

4) **Conduct detailed file review and develop site M&V plans**. The assigned M&V engineer reviewed all project-related data provided by PG&E. The project technical files and support documentation provided information on the measure scope, equipment efficiency assumptions, operation conditions, and base-case assumptions. This information was usually sufficient to develop an initial measurement plan without a customer site visit.

   The M&V engineers used this data to prepare site-specific M&V plans based on the project evaluation strategy and level of resources available for the project. The strategy included overall analytical approach, data collection activities, and, where necessary, a proposed monitoring plan.

   Site M&V plans included lists of site-specific information required and proposed monitoring instrumentation to be installed. Customer limitations with respect to on-site personnel support, staff time, and scheduling were also taken into account.

5) **Review site M&V plans**. Plans were reviewed internally by the lead engineer. After the initial review, all plans were provided to the CPUC for additional review.

6) **Schedule site visit and conduct field data collection activities**. Once plans were approved, project engineers scheduled their own site visits with the appropriate site contact person. While in discussion with the contact, they gathered additional information that could be used to adjust plans, identified potential spillover by conducting a short spillover survey, and developed a preliminary understanding of data availability and access for monitoring equipment. The project engineer then conducted on-site surveys, performed measurements, and installed monitoring equipment as necessary.

7) **Conduct follow-up data collection activities**. If necessary, an engineer returned to the site to remove monitoring equipment. At that time, follow-up activities were conducted, as necessary. These activities included activities such as working with the customer to collect trend-log data and conducting subsequent discussions with equipment vendors to better understand measure performance.

8) **Prepare analysis and site report**. Using the data collected on site and elsewhere, the project engineer performed the analysis to estimate project savings and prepared a site report documenting savings. The report explained any significant differences between ex-ante and ex-post savings estimates. Spillover projects were evaluated separately. Individual site results included the site report and supporting data and analysis, usually in the form of an Excel "Workbook."

9) **Review of site reports**. Similar to site plans, site reports were reviewed by the lead engineer and other senior engineering team members. After completion of internal review, site reports were forwarded to the CPUC for additional review. Adjustments to the analysis and reports were made, as necessary, in response to comments.

Table 14 below summarizes the PG&E Ag-Food Program projects that were included in the evaluation, rigor levels assigned to the project, and the evaluation approach utilized for each project.

Table 14: Project Descriptions and M&V Approach for Evaluated Projects

ID	Project Description	M&V Rigor Level	M&V Approach
120	Installed two new hot water heaters to replace old steam-to-hot water system	Verify	Spot measurements & site staff interviews were conducted
121	Installed VFDs on milk pumps, installed milk pre-cooler & efficient lighting fixtures	Enhanced	Obtained 24-hour use profiles from logged data and used that in savings analysis.
122	Insulated wine storage tanks & installed efficient lighting for outside catwalk	Enhanced	Used SPC software with appropriate verified input values.
123	Tortilla Oven Retrofit	Verify	Confirm operation schedule and production rates with facility staff.
124	Facility retrofitted dehydration tunnels with curved air guides and improved air recirculation, allowing them to install smaller sheaves to reduce motor speed for motors serving the fans providing hot air for dehydration.	Enhanced	Take one-time power readings of a sample of motors, log motor runtime, and confirm pre- and post-retrofit sheave sizes. Used fan law to calculate baseline kW
125	Boiler Stack Economizer	Enhanced	Measure flow rate and delta T across economizer

Table 14: Project Descriptions and M&V Approach for Evaluated Projects

ID	Project Description	M&V Rigor Level	M&V Approach
126	Insulate Four Wine Tanks	Enhanced	Calculate heat transfer through insulated and uninsulated tanks using TMY weather data with a COP modified by DOE-2 chiller curves
127	Installed dual thermosyphone deodorizer, heat exchanger to preheat make-up water to boiler & insulated deodorizer & a pipe.	Basic	Conducted spot measurements & used EMS data for deodorizer measures & used 3EPlus software with appropriate verified input values for insulation measure
128	Insulated storage tanks	Basic	Used 3EPlus software with appropriate verified input values
129	Insulated pipes carrying condensate, processed oil and steam	Basic	Used 3EPlus software with appropriate verified input values
130	The facility installed an oxygen trim, parallel positioning controls, and a boiler fan VFD on Boiler #3	Enhanced	Monitor boiler steam & feedwater temperature, test combustion efficiency, and monitor boiler fan power
131	Facility installed one boiler economizer, recovering lost stack heat.	Enhanced	Monitor temperature entering and exiting the heat exchanger and flow rate through the heat exchanger. Test boiler efficiency with a combustion efficiency probe, and use to calculate therms recovered
132	Facility installed a VFD on a 10 HP Glycol Pump	Verify	Confirm operation schedule with staff. Spot-measure motor power, and confirm pre-retrofit method of control for the pump.
133	Motor Retrofit	Verify	Inspect to verify installation and nameplate efficiency. Recalculate savings based on stipulated load factor.
134	High Pressure Condensate Pump	Enhanced	Bill analysis with install and remove dates form participant. (measure remained in place for only 19 months of predicted 7 year measure life)
135	Facility installed a new cool roof on a 27,000ft^2 refrigerated warehouse.	Enhanced	Collect data on refrigeration equipment, reflectivity of cool roof, and building thermal characteristics and then calibrate a DOE-2 simulation to billing data.
136	Replace 1968 B&W 150K pph boiler with a new 50K pph B&W boiler with flue gas condenser to preheat makeup water.	Enhanced	We studied the 2007, 2008, and 2009 operating profiles of boilers #2 and #3. We estimated their efficiency based on their steam production and we estimated the measure energy impact by comparing the pre-retrofit and the post-retrofit boilers operation.
137	Facility installed 1.5" of insulation on 1,779 ft. of ammonia line, ranging from 1.25" - 6" in diameter.	Basic	Spot check temperature setpoints and confirm operation schedule with staff. Calculate heat transfer through insulated and uninsulated pipe using TMY data and COP modified by DOE-2 chiller curves.
138	Efficient Filtration Membrane	Enhanced	Measure removed prior to evaluation, Savings are based on IOU algorithm with actual production data for period measure was in place.
139	Enhanced HVAC equipment and control	Enhanced	Analysis based on overall facility consumption and production records.
140	Installation of direct water heaters for sanitary hot water, reduced boiler load.	Enhanced	Logged flow and delta T for water heaters, adjusted baseline to reflect logged flow values.
143	Condenser Replacement	Enhanced	Computer simulation Model (eQuest 3.61R) used to model savings based on existing and baseline conditions. Used post-retrofit metered kW data for calibration.
144	Refrigerant Pipe Replacement	Enhanced	Pre and Post Measurements, evaluated for weather influence, and calculated.
145	Facility retrofitted dehydration tunnels with curved air guides and improved air recirculation, allowing them to install smaller sheaves to reduce motor speed for motors serving the fans providing hot air for dehydration.	Enhanced	Take one-time power readings of a sample of motors, log motor runtime, and confirm pre- and post-retrofit sheave sizes. Used fan law to calculate baseline kW
146	High Efficiency Pumps	Basic	Measured pump load to determine shaft power then used difference in baseline and installed power curves to determine delta. Operating hours were tracked by facility
147	Replace pump components in a 150-hp agricultural deep well pump to increase efficiency	Enhanced	12+ months of pre-/post-bill data analysis of a utility meter dedicated to the pump. Re-pump test to adjust calculations. Interviews & weather data analysis to adjust two-year performance for long-term operation.

Table 14: Project Descriptions and M&V Approach for Evaluated Projects

ID	Project Description	M&V Rigor Level	M&V Approach
148	This project includes the installation of double acrylic roof, double polycarbonate walls, underbench steam heating, and moveable benches in greenhouse E-1.	Enhanced	Measure impacts were calculated with pre- and post-measure implementation whole building simulations of the affected greenhouse. Site-specific data for the greenhouse was collected via site visits and phone surveys.
149	This project includes the installation of double acrylic roof, double polycarbonate walls, underbench steam heating, heat curtains, and moveable benches in greenhouse E-2.	Enhanced	Measure impacts were calculated with pre- and post-measure implementation whole building simulations of the affected greenhouse. Site-specific data for the greenhouse was collected via site visits and phone surveys.
150	Customer added a 98,000 ft^2 free-stall barn, and they installed lighting and fans that exceed the values provided in the "Dairy Baseline Study" from 2002 as well as California Title 24 standards.	Enhanced	Lighting savings were calculated by comparison of W/ft^2 of baseline and as-built lighting, with monitoring data used to establish hours of use, and spot metering to establish kW. Fan savings compared as-built fan kW, established through spot metering, and baseline kW, which was calculated for equivalent air flow. Runtime was determined through monitoring and was annualized using TMY weather data.
151	Replaced existing refrigeration system with efficient refrigeration system	Verify	Spot measurements & site staff interviews were conducted
152	Installation of a new high efficiency centrifugal chiller with a VFD and the installation of a new cooling tower with VFD fan controls	Verify	Spot measurements & site staff interviews were conducted
153	Implemented floating head pressure & suction pressure strategies for refrigeration compressors, installed VFD on glycol pump, and decommissioned motors	Enhanced	Computer simulation Model (eQuest 3.61R) used to model savings based on existing and baseline conditions. Used EMS data to generate hourly parameter profiles for calibration.
154	This was a new construction project for installation of efficient equipment used in the water bottling process: blow molders, injection molders, chilled water, compressed air, lighting, and controls.	Enhanced	ERS logged equipment for a period of three weeks. This included power and current logging on molding machines, compressors, chiller, and lighting circuits. ERS normalized to production when necessary to extrapolate full-year consumption.
155	Phase 2 of a new construction project for installation of efficient equipment used in the water bottling process: blow molders, injection molders, chilled water, and compressed air.	Enhanced	ERS logged equipment for a period of three weeks. This included power and current logging on molding machines, compressors, chiller, and lighting circuits. ERS normalized to production when necessary to extrapolate full-year consumption.
156	Installation of two heat exchangers used to preheat Gatorade prior to the pasteurization process. This resulted in lower gas consumption for the boiler plant.	Enhanced	ERS logged two temperature points and Gatorade flow for each heat exchanger. Up-to-date boiler efficiency data was also obtained from the site contact. In this manner, avoided gas consumption was determined.
158	Facility installed a new, more efficient 4-stage deep well vertical turbine pump, leaving the old motor in place.	Enhanced	Commission an independent pump test to determine post-retrofit kWh-MG. Compare to pre-retrofit tested kWh-MG, and use pre-retrofit annual kWh to calculate total production (post-retrofit annual kWh unavailable). Collect facility runtime reports for the week containing the peak days in order to calculate peak kW reduction, as development of 8,760 profile not feasible for this measure.
159	The facility installed automatic steam flow controls on their shell cookers. Previously they had used manual steam controls, and had used excess steam in order to guarantee full pasteurization.	Enhanced	Use pre- and post-retrofit monitored steam use data along with monitored temperature of boiler feedwater and steam and combustion efficiency in order to calculate pre- and post-retrofit therms consumed.
160	The facility installed oxygen trims and fully metered burner controls on Boiler #4 and new burners on Boiler #3 and #5	Enhanced	Measure post-retrofit combustion efficiency on affected boilers. Collect feedwater and steam temperature, as well as boiler loading, from facility daily boiler reports. Use this data and the change in efficiency to calculate annual therms savings
161	Facility installed a preheat tank that collects peeler wastewater from four peelers and uses it to preheat tomatoes entering Peeler #1, reducing the Therms consumed by the one peeler.	Enhanced	Measure temperature of water entering and exiting the preheat tank, and combustion efficiency of boilers providing steam to the peelers. Use this along with facility recorded flow rate to calculate therms recovered by the preheat tank using peeler wastewater.

Table 14: Project Descriptions and M&V Approach for Evaluated Projects

ID	Project Description	M&V Rigor Level	M&V Approach
162	Installation of 218 VFDs with humidity controls on dryer line fan motors, resulting in electric savings at part load.	Enhanced	ERS logged a sample of eight motors for current and one for real power. Average part-load profile was extrapolated for the entirety of the drying season (mid-August through mid-September) for both 25 and 30 hp motors. Electric utility bills were also obtained through the site contact. Pre and post-install production data was obtained to normalize kWh for production variance.
163	Installation of 218 VFDs with humidity control on dryer line fan motors, resulting in a decrease in outside air intake. Lower air intake translates to a decrease in gas heating.	Enhanced	ERS logged a sample of eight motors for current and one for real power. Logged data was used to confirm the reliability of gas bills obtained from the site contact. Pre and post-install production data was obtained to normalize gas consumption for production variance.
164	Installed VFD air-compressor	Enhanced	Obtained 24-hour use profiles from logged data and used that in savings analysis.
165	Drip Tape Irrigation	Basic	Since the pumps are individually metered, we collected IOU billing history for several years to determine a pre and post delta.
166	Installed 202 T8 fixtures in place of 250W HPS fixtures at one address and 18 T5HO fixtures in place of 250W HPS fixtures at another address.	Enhanced	On-off light loggers and rated nameplate fixture power ratings. Circuit monitoring was in the original plan but practical challenges discovered on site prevented execution of this approach.
167	Convert two 2-effect evaporators to 3-effect evaporators. This increased the efficiency of the evaporators, decreasing the steam used per pound of product processed in these lines.	Enhanced	For a period of three weeks, we trended various parameters of two Rossi evaporators. Based on the trended data, we estimated the energy use of the post-installation system. Based on the existing production and brix values, we estimated the energy use of the pre-retrofit system. We estimated the measure energy impact by comparing the post-retrofit and pre-retrofit system operation.
168	Installed 90 four-lamp linear fluorescent T5HO high-bay fixtures with manual controls in the warehouse in place of 1000-watt high-bay high pressure sodium (HPS) fixtures.	Enhanced	On-off light loggers and rated nameplate fixture power ratings. Circuit monitoring was in the original plan but practical challenges discovered on site prevented execution of this approach.
231	Customer added a barrel storage room, and installed a night cooling system instead of a chiller.	Enhanced	Monitor night cooling fans and chiller system. Collect building thermal characteristics and calibrate DOE-2 simulation to post-retrofit billing data, then replace measures with industry standard practice equipment to calculate baseline kW/kWh
234	Replace pump components in a 150-hp agricultural deep well pump to increase efficiency	Enhanced	12+ months of pre-/post-bill data analysis of a utility meter dedicated to the pump. Re-pump test to adjust calculations. Interviews & weather data analysis to adjust two-year performance for long-term operation.
235	Facility installed a new, more efficient 4-stage deep well vertical turbine pump, leaving the old motor in place.	Enhanced	Commission an independent pump test to determine post-retrofit kWh-MG. Compare to pre-retrofit tested kWh-MG, and use pre-retrofit annual kWh to calculate total production (post-retrofit annual kWh unavailable). Collect facility runtime reports for the week containing the peak days in order to calculate peak kW reduction, as development of 8,760 profile not feasible for this measure.
237	Installed 200 HP steam turbine in place of electric motor and replaced 60 HP turbine with electric motor.	Enhanced	Logged electric energy consumption, natural gas impact based on stipulated steam flow rates and thermodynamic calculations.
238	Facility installed an oversized cooling tower that uses two VFD fans. Facility also installed a large chiller and removed two small chillers, but they were inappropriately given credit for this measure as it was not part of their application.	Enhanced	Monitor affected chillers and cooling tower, and use data to calibrate a DOE-2 simulation, with baseline being a correct-sized cooling tower for the two chillers in the central plant.
239	As part of a capacity expansion, the facility installed R-19 insulation on 35 wine tanks. Savings were initially calculated using uninsulated tanks as the baseline, but per CPUC guidelines for large wineries the baseline was revised to a lower grade of insulation.	Enhanced	Collect data on operation schedule and wine content from facility staff. Monitor affected chiller, and calibrate DOE-2 simulation to post-retrofit billing data.

Table 14: Project Descriptions and M&V Approach for Evaluated Projects

ID	Project Description	M&V Rigor Level	M&V Approach
240	Replace pump components in a 150-hp agricultural deep well pump to increase efficiency	Verify	12+ months of pre-/post-bill data analysis of a utility meter dedicated to the pump. Re-pump test to adjust calculations. Interviews & weather data analysis to adjust two-year performance for long-term operation. Level later switched to back to verify because pump had been moved.
241	Oversized Evaporative Condensers with Floating Head Pressure	Enhanced	Computer simulation Model (eQuest 3.61R) used to model savings based on existing and baseline conditions. The model was calibrated using logged consumption values.
242	Condenser Replacement	Enhanced	Computer simulation Model (eQuest 3.61R) used to model savings based on existing and baseline conditions. Used post-retrofit metered kW data for calibration.
243	Installed VFDs to control evaporator and condenser fans	Enhanced	Obtained 24-hour use profiles from logged data and used that in savings analysis.
244	This project includes the installation of double polycarbonate roof in range W7 at the site.	Enhanced	Measure impacts were calculated with pre- and post-measure implementation whole building simulations of the affected greenhouse. Site-specific data for the greenhouse was collected via site visits and phone surveys.
245	Modification to Drying Ovens	Enhanced	Logged fan data fro electric energy consumption, reviewed gas utility bill to determine gas savings
246	Facility installed two boiler economizers, recovering lost stack heat.	Enhanced	Collect facility metered data on temperature entering and exiting heat exchangers, and of flow rate entering heat exchanger. Test combustion efficiency of the two boilers and use to calculate therms recovered by the economizers.
247	Facility installed a caustic lye peeler in a production expansion on this line from 26 ton/hr to 60 ton/hr. This technology is more efficient per ton than the standard practice scalding peeler technology.	Enhanced	Monitor steam and condensate temperature and motor power. Collect steam-use data from facility records. Test combustion efficiency of boilers supplying steam to peeler. Use monitored data along with baseline hourly production level to recalculate baseline kWh/ton and therms/ton. Normalize savings to post-retrofit production levels.
248	VFD installation, pipe insulation, boiler staging, and thermal energy recovery	Enhanced	Boiler was determined ineligible because the just shut one off. Blower fan was logged for real power draw. Flow rate and temperature measurements were taken to determine heat recovery savings. Pipe insulation was modeled using 3E-Plus.
249	Replacement of a greenhouse steam boiler heating system with a hot water boiler with root-zone heating system.	Enhanced	Heating energy savings were calculated with through regression of monthly pre- and post-measure implementation metered gas data vs. outdoor conditions for the greenhouses affected by the measure.
250	Spiral Tunnel Drey	Enhanced	Log data to determine Nat Gas and Electric consumption of Installed and baseline equipment. (Baseline equipment remains, just used less.)
251	Replace 60,000-lb/hr boiler with a new 13,800-lb/hr equipped with two economizers. Replace the 60-hp combustion air fan motor with a 20-hp motor and the 40-hp feed water pump motor with a 10-hp motor.	Enhanced	We studied the 2006 operating profile of the pre-retrofit boiler and 2008 operating profile of the post-retrofit boiler. We estimated the measure energy impact by comparing the pre-retrofit and the post-retrofit boilers operation.
252	New Pasteurizer for packing Line 40	Enhanced	Logged data to calculate existing Nat gas and electric consumption, deducted these values from IOU verified baseline levels of consumption.
253	New process effluent treatment process that produces Biogas, offsetting natural gas consumption.	Enhanced	Savings based on logged electric energy consumption and metered steam consumption biogas production (from facility meters) minus baseline consumption predicated by the IOU analysis.
254	VFD on Brine Pump	Enhanced	Logged consumption data, baseline adjusted to reflect logged operating hours

Table 14: Project Descriptions and M&V Approach for Evaluated Projects

ID	Project Description	M&V Rigor Level	M&V Approach
255	Replacement of the condenser serving the ammonia based refrigeration system with a larger capacity unit, allowing for a reduced condensing temperature, and associated compressor energy savings.	Enhanced	Logged compressor and condenser fan power. Collected data on variations in production rates/process tons from interviews, wet bulb weather data from NCDC, and compressor performance specifications from manufacturer. Calculated theoretical savings, adjusted theoretical estimates with logged data, and then used adjustment factors to extrapolate to long-term average performance.

2.2.3 Gross Impact Summarization and Expansion to the Population

The following steps were performed to summarize and expand site-specific M&V results to the measure and program populations (as outlined in The California Evaluation Framework):

- Calculate the case weights
- Calculate the ratio estimator
- Calculate the standard error of the ratio estimator
- Calculate the error ratio
- Estimate gross savings for the measure

Case weights were calculated for each stratum as the ratio of the number of sites in the population to the number of sites in the final sample. Except for the PG&E Ag-Food gas sample, the final sample sizes differed from the initial sample sizes because of field logistics, and therefore we were required to adjust our final case weights. Results are shown in Table 15 and Table 16 for the greenhouse measures and in Table 17 and Table 18 for the PG&E Ag-Food Program.

Table 15: Calculation of Case Weights for Greenhouse Heat Curtains

Stratum	N	Initial Sample Size	Initial Case Weight	Final Sample Size	Final Case Weight
1	42	6	7.0	7	6.0
2	17	6	2.8	8	2.1
3	10	6	1.7	6	1.7
Total	69	18		21	

Table 16: Calculation of Case Weights for Greenhouse Infrared Film

Stratum	N	Initial Sample Size	Initial Case Weight	Final Sample Size	Final Case Weight
1	36	5	7.2	6	6.0
2	13	6	2.2	6	2.2
3	8	6	1.3	6	1.3
Total	57	17		18	

Table 17: Calculation of Ag- Food Program Electric Case Weights

Stratum	N	Initial Sample Size	Initial Case Weight	Final Sample Size	Final Case Weight
1	467	11	42.5	12	38.9
2	122	10	12.2	8	15.3
3	56	10	5.6	8	7.0
4	22	10	2.2	10	2.2
Total	667	41		38	

Table 18: Calculation of Ag- Food Program Gas Case Weights

Stratum	N	Sample Size	Case Weight
1	62	9	6.9
2	18	9	2.0
3	10	9	1.1
4	3	3	1.0
Total	93	30	

The gross realization rates were calculated using the following equation:

$$\hat{B} = \frac{\sum_{1}^{n} w_i y_i}{\sum_{1}^{n} w_i x_i}$$

Where w_i is the case weight for sampled site i, y_i is the ex-post gross savings estimate for site i, and x_i is the ex-ante savings estimate for site i.

The standard error of each realization rate was calculated using the following equation:

$$se(\hat{B}) = \frac{\sqrt{\sum_{1}^{n} w_i (w_i - 1) e_i^2}}{\sum_{1}^{n} w_i x_i}$$

Where w_i and x_i are as described above, and $e_i = y_i - \hat{B} x_i$.

To estimate the error ratio, which may be used to inform future evaluation sample designs, the following equation was used:

$$\hat{e}r = \frac{\sqrt{\left(\sum_{1}^{n} w_i\, e_i^2 / x_i^{\gamma}\right)\left(\sum_{1}^{n} w_i\, x_i^{\gamma}\right)}}{\sum_{1}^{n} w_i x_i}$$

Where γ is assumed to be 0.80 based on the analysis of many prior evaluation studies (as referenced in the California Evaluation Framework, page 377).

In order to estimate the gross savings for the greenhouse measures and the PG&E Ag-Food Program, the gross realization rate, $\hat{B}$, is multiplied by total ex-ante gross savings estimate for the measure/program.

Note, for dual fuel projects/sites where the evaluation calculated impacts for a fuel that was omitted by the program and no ex-ante impacts were available, it was not possible to use a ratio estimation approach to determine program/measure-level savings. For these cases, a simple mean expansion approach was utilized, using the same strata that were developed for the ratio estimates.

2.3 Net Impact Analysis

2.3.1 Net Impact Sample Design

The initial sample design for the greenhouse measure net-to-gross (NTG) analysis was set to be the same as for the gross savings analysis (18 sites for heat curtains and 17 sites for infrared film). However, per internal review with the CPUC, it was decided that the sample size should be increased to 50 projects for each measure, in order to increase precision in the net-to-gross ratio (NTGR) estimates. Table 19 shows the NTG sample design for heat curtains, and Table 20 shows the NTG sample design for infrared film. We did not achieve our desired sample sizes for the NTG surveys because of implementation logistics, mostly related to customers not responding to repeated calls. In addition to the targeted sample sizes, the following tables also show the numbers of completed surveys

Table 19: Greenhouse Heat Curtain NTG Sample Design

Stratum	N	Gross Savings Sample Size	NTG Sample Size	Completed NTG Surveys
1	42	6	26	28
2	17	6	14	14
3	10	6	10	9
Total	69	18	50	51

Table 20: Greenhouse Infrared Film NTG Sample Design

Stratum	N	Gross Savings Sample Size	NTG Sample Size	Completed NTG Surveys
1	36	5	31	24
2	13	6	11	7
3	8	6	8	4
Total	57	17	50	35

The PG&E Ag-Food Program sample design for the gross savings analysis was also used for the net-to-gross analysis. Table 21 and Table 22 summarize the sample design and the completed number of surveys.

Table 21: PG&E Ag- Food Program Electric NTG Sample Design

Stratum	N	Gross Savings Sample Size	NTG Sample Size	Completed NTG Surveys
1	467	11	11	8
2	122	10	10	7
3	56	10	10	9
4	22	10	10	5
Total	667	41	41	29

Table 22: PG&E Ag- Food Program Gas NTG Sample Design

Stratum	N	Gross Savings Sample Size	NTG Sample Size	Completed NTG Surveys
1	62	9	9	6
2	18	9	9	3
3	10	9	9	3
4	3	3	3	3
Total	93	30	30	15

2.3.2 Net Impact Analysis Approach

The CPUC's Energy Division formed a nonresidential net-to-gross ratio working group that was composed of experienced evaluation professionals, as part of the evaluation of the 2006-2008 energy-efficiency programs designed and implemented by the four IOUs and third parties. The main purpose of this group was to develop a standard methodological framework, including decision rules for integrating the findings from both quantitative and qualitative information to estimate net-to-gross ratios in a systematic, consistent manner.

The methodology developed, and described in this section, addresses the unique needs of the evaluation of large nonresidential customer projects supported by energy-efficiency programs offered by the four

California IOUs and third parties. This method relies exclusively on the Self-Report Approach (SRA) to estimate project- and domain-level NTGRs, since other available methods and research designs are not feasible for large nonresidential customer programs. This approach is designed to fully comply with the *California Energy Efficiency Evaluation: Protocols: Technical, Methodological, and Reporting Requirements for Evaluation Professionals* (Protocols) and the *Guidelines for Estimating Net-To-Gross Ratios Using the Self-Report Approaches* (Guidelines) as demonstrated in Appendix B.[8]

The method uses a “0” to “10” scoring system for key questions used to estimate the NTGR rather than using fixed categories that are assigned weights. It asks respondents to jointly consider and rate the importance of the many likely events or factors that may have influenced their energy-efficiency decision-making, rather than focusing narrowly on their rating of the program’s importance only. This question structure reflects more accurately the complex nature of real-world decision-making and helps ensure that all non-program influences are considered when assessing the program’s unique contribution as reflected in the NTGR.

There are three levels of free-ridership analysis. The most detailed level of analysis, the Standard – Very Large Project NTGR, is applied to the largest, most complex projects (representing 10% to 20% of total projects) with the greatest expected gross savings’ levels.[9] The Standard NTGR, involving a somewhat less-detailed level of analysis, is applied to projects with moderately high levels of gross savings. The least detailed analysis, the Basic NTGR, is applied to all remaining projects. Evaluators exercised their own discretion as to what the appropriate thresholds should be for each of these three levels.

A standard level of NTG analysis was targeted for all the greenhouse heat-curtain and infrared-film projects included in the study. Table 23 identifies the projects included in the PG&E Ag-Food Program NTG analysis and the associated rigor level used for each project.

[8] Appendix B contains the detailed Methodological Framework for Using the Self-Report Approach to Estimating Net-to-Gross Ratios for Nonresidential Customers, which includes a demonstration of how this methodology complies with the California Energy Efficiency Evaluation: Protocols: Technical, Methodological, and Reporting Requirements for Evaluation Professionals (Protocols) and the Guidelines for Estimating Net-To-Gross Ratios Using the Self-Report Approaches (Guidelines).

[9] Note that we do not refer to an Enhanced level of analysis, since this is defined by the Protocols to involve the application of two separate analysis approaches, such as billing analysis or discrete choice modeling.

Table 23: NTG Rigor Level for Studied PG&E Ag- Food Program Projects

ID	NTG Rigor	ID	NTG Rigor
120	Basic	158	No NTG
121	Basic	159	Standard
122	No NTG	160	Standard
123	No NTG	161	Basic
124	Basic	162	Standard
125	Basic	163	Standard
126	Basic	164	Basic
127	No NTG	165	Standard
128	No NTG	166	Basic
129	No NTG	167	Std - Very Large
130	No NTG	168	Basic
131	No NTG	231	Basic
132	Basic	234	Basic
133	No NTG	235	No NTG
134	No NTG	236	Standard
135	Basic	237	Basic
136	Std - Very Large	238	No NTG
137	Basic	239	No NTG
138	Basic	240	Basic
139	Standard	241	Std - Very Large
140	Standard	242	Std - Very Large
143	Std - Very Large	243	No NTG
144	Std - Very Large	244	Basic
145	Basic	245	Basic
146	Basic	246	Standard
147	No NTG	247	No NTG
148	No NTG	248	No NTG
149	No NTG	249	No NTG
150	Basic	250	No NTG
151	No NTG	251	No NTG
152	Basic	252	Std - Very Large
153	Standard	253	Std - Very Large
154	Std - Very Large	254	Basic
155	Std - Very Large	255	No NTG
156	No NTG		

Data Sources. There were five sources from which free-ridership information was derived in this study. Each analysis level relied on information from one or more of these sources.

Table 24 below shows the data sources that were used for each of the three levels of free-ridership analysis. Although more than one level of analysis might share the same source, the amount of information that was utilized in the analysis might vary. For example, all three levels of analysis obtained core question data from the Decision Maker survey.

Table 24: Information Sources for Three Levels of NTGR Analysis

	Program File	Decision Maker Survey Core Question	Vendor Surveys	Decision Maker Survey Supplemental Questions	Utility & Program Staff Interviews	Other Research Findings
Basic NTGR	✓	✓	✓[1]		✓[2]	
Standard NTGR	✓	✓	✓[1]	✓	✓	
Standard NTGR - Very Large Projects	✓	✓	✓[3]	✓	✓	✓

[1]Only performed for sites that indicated a vendor influence score (N3d) greater than the maximum of the other program element scores (N3b, N3c, N3g, N3h, N3l).

[2]Only performed for sites that had a utility account representative

[3]Only performed if significant vendor influence was reported or if secondary research indicated that the installed measure might be becoming standard practice.

NTGR Questions and Scoring Algorithm. The NTGR was calculated as an average of three scores. Each of these scores represents the highest response or the average of several responses given to one or more questions about the decision to install a program measure.

1. A **Timing and Selection** score reflected the influence of the **most important** of various program and program-related elements in the customer's decision to select the specific program measure at that time. Program influence through vendor recommendations was also incorporated in this score if a vendor interview was triggered.
2. A **Program Influence** score captured the perceived importance of the program (whether rebate, recommendation, training, or other program intervention) relative to non-program factors in the decision to implement the specific measure that was eventually adopted or installed. This score was determined by asking respondents to assign importance values to both the program and most important non-program influences so that the two totaled 10. The program influence score was adjusted (i.e., divided by 2) if respondents said they had already made their decision to install the specific program-qualifying measure before they learned about the program.
3. A **No-Program** score captured the likelihood of various actions the customer may have taken at that time and in the future if the program had not been available (the counterfactual). This score also accounts for deferred free-ridership by incorporating the likelihood that the customer would have installed program-qualifying measures at a later date if the program had not been available.

When there were multiple questions that fed into the scoring algorithm, as was the case for both the **Timing and Selection** and **No-Program** scores, the maximum score was always used. The rationale for using the maximum value was to capture the most important program element in the participant's decision making. Thus, each score was always based on the strongest influence indicated by the respondent. However, high scores that were inconsistent with other previous responses triggered consistency checks and could lead to follow-up questions to clarify and resolve the discrepancy.

When there were missing data or 'don't knows' to critical elements of each score, one of two options was used. The missing element might be backfilled with a value that represents the average of the lowest and highest extreme values. Alternatively, if it was one of several other elements that were considered in the algorithm, the missing element might simply be excluded from consideration.

The self-reported core NTGR in most cases was simply the average of the Program Influence, Timing and Selection, and No-Program Scores, divided by 10. The one exception to this was when the respondent indicated a 10 in 10 probability of installing the same equipment at the same time in the absence of the program, in which case, the NTGR was based on the average of the Program Influence and No-Program scores only.

Data Analysis and Integration. The calculation of the Core NTGR was fairly mechanical and based on the answers to the closed-ended questions. However, the reliance of the Standard NTGR – Very Large on more information from so many different sources required more of a case study level of effort. The SRA Guidelines point out that a case study is one method of assessing both quantitative and qualitative data in estimating a NTGR. A case study is an organized presentation of all these data available about a particular customer site with respect to all relevant aspects of the decision to install the efficient equipment. In such cases where multiple interviews are conducted eliciting both quantitative and qualitative data and a variety of program documentation has been collected, all of this information is integrated into an internally consistent and coherent story that supports a specific NTGR.

Sometimes, *all* the quantitative and qualitative data will clearly point in the same direction while, in others, the *preponderance* of the data will point in the same direction. Other cases will be more ambiguous. In all cases, in order to maximize reliability, it is essential that more than one person be involved in analyzing the data. Each person must analyze the data separately and then compare and discuss the results. Important insights can emerge from the different ways in which two analysts look at the same set of data. Ultimately, differences must be resolved and a case made for a particular NTGR. Careful training of analysts in the systematic use of rules is essential to insure inter-rater reliability[10].

Once the individual analysts completed their review, they discussed their respective findings and presented their respective rationales for any recommended changes to the Calculator-derived NTGR. The outcome of this discussion was the final NTGR for a specific project.

2.3.3 Net Impact Summarization and Expansion to the Population

After development of site/project-specific NTGRs, statistical analysis was required to expand these results to the measure/program population. The first step in developing measure/program-level savings was to calculate savings-weighted mean NTGRs for each stratum in each sample (greenhouse heat

[10] Inter-rater reliability is the extent to which two or more individuals (coders or raters) agree. Inter-rater reliability addresses the consistency of the implementation of a rating system.

curtains, greenhouse infrared films, and the PG&E Ag-Food Program). For the PG&E Ag-Food Program, separate savings-weighted mean NTGRS were required for kWh, kW, and therms. These stratum-level NTGRs were calculated as:

$$\overline{NTGR_h} = \sum_{i=1}^{n_h} w_i NTGR_i$$

Where:

$\overline{NTGR_h}$ = the weighted mean net to gross ratio for stratum *h*

$NTGR_i$ = the net-to-gross ratio for site *i*

n_h = the sample size for stratum *h*

$w_i = \frac{x_i}{\sum_{i=1}^{n_h} x_i}$ which is the energy weight for site *i*

and x_i is the ex-ante energy savings (kWh, kW, or therms) for site *i*.

The associated variance of the stratum-level NTGR, s_h^2, is calculated as:

$$s_h^2 = \frac{\sum_{i=1}^{n_h} w_i (NTGR_i - \overline{NTGR_h})^2}{1 - \sum_{i=1}^{n_h} w_i^2}$$

Once stratum-level NTGRs were calculated, the measure/program-level NTGR is calculated as:

$$\overline{NTGR} = \sum_{h=1}^{L} W_h \overline{NTGR_h}$$

Where:

$W_h = \frac{X_h}{X}$ which is the stratum weight for stratum *h*

X_h = the ex-ante energy savings for stratum *h*

X = the ex-ante energy savings for the population

L = the number of strata in the sample

The associated measure-level variance is calculated as:

$$s^2(\overline{NTGR}) = \sum_{h=1}^{L} W_h^2 s_h^2 - \sum_{h=1}^{L} \frac{W_h^2 s_h^2}{N}$$

The second term in the above equation represents the finite population correction. The standard error of the mean NTGR is then calculated as:

$$se(\overline{NTGR}) = \frac{s}{\sqrt{n}}$$

Once measure/program-level mean NTGRs and their associated standard errors were calculated, they were applied to gross savings estimates to determine net measure/program savings and their associated relative precision estimates and confidence intervals.

3 Greenhouse Heat-Curtain Evaluation Results

In this section, we present findings from the impact evaluation of the greenhouse heat-curtain HIM. Detailed, site-specific results are presented first; validity and reliability of the results are discussed next; and finally, statewide measure-level results and their associated precision are presented.

3.1 Detailed Findings for the Greenhouse Heat-Curtain Evaluation

In this subsection, we present our gross and net impact results on an unweighted basis (i.e. not reflecting sample-design expansion weights) for each site included in the analysis. The gross impact analysis addressed a total of 21 sites, and the net-to-gross analysis covered 51 sites.

3.1.1 Site-specific Gross Impacts

Site-specific savings for the sampled greenhouse heat-curtain sites are presented in Table 25. This table shows ex-ante therm savings, ex-post therm and kWh savings, and therm realization rates. While only gas impacts were reported for the programs, the evaluation determined that electric savings were present for all sites. For sites without mechanical cooling, the electricity savings result from reduced cycling of the unit heater fans, reduced use of horizontal airflow fans, or less load on boiler hot-water pumps. Energy use of heat-curtain drive motors was logged at one pilot site and found to be inconsequential. Peak-demand impacts were not evaluated, although model outputs showed the installation of heat curtains did result in a slight reduction in the peak cooling load in some greenhouses with mechanical cooling systems.

Table 25: Summary of Greenhouse Heat Curtain Ex-Ante and Ex-Post Savings

	Ex-Ante Savings		Ex-Post Savings		Realization Rate	
Site ID	kWh	Therms	kWh	Therms	kWh	Therms
PGE1	0	16,493	670	10,612	-	0.64
PGE11	0	80,667	4,704	70,332	-	0.87
PGE2	0	276,164	9,730	89,376	-	0.32
PGE21	0	58,391	6,192	43,675	-	0.75
PGE2a	0	40,464	4,753	29,984	-	0.74
PGE4	0	21,753	1,119	8,219	-	0.38
PGE5	0	26,274	2,180	14,800	-	0.56
SCG12	0	98,964	5,155	88,134	-	0.89
SCG13	0	115,204	2,470	81,000	-	0.70
SCG14	0	154,688	4,003	74,593	-	0.48
SCG20	0	116,909	7,880	87,600	-	0.75
SCG20a	0	54,374	4,013	40,735	-	0.75
SCG23	0	64,189	1,782	60,198	-	0.94
SCG23a	0	65,388	1,892	59,012	-	0.90
SCG4	0	68,513	1,803	33,775	-	0.49
SCG44	0	90,092	4,650	64,898	-	0.72
SCG4a	0	31,511	1,203	17,046	-	0.54
SCG9	0	65,202	2,260	33,674	-	0.52
SDG1	0	81,021	6,138	22,338	-	0.28
SDG4	0	26,646	6,171	22,915	-	0.86
SDG4a	0	10,783	2,497	9,273	-	0.86
Total	0	1,563,690	81,265	962,189	-	0.62

Figure 1 provides a graphical comparison of ex-ante and ex-post therm savings. The diagonal line in the figure shows points where ex-ante and ex-post results would be equal. Points below the line represent sites where ex-post results are lower than ex-ante results. As this figure shows, ex-post impacts were determined to be lower than ex-ante impacts in all cases. The two largest sites show ex-post impacts that are considerably lower than ex-ante impacts.

Figure 1: Comparison of Greenhouse Heat-Curtain Ex-Ante and Ex-Post Savings

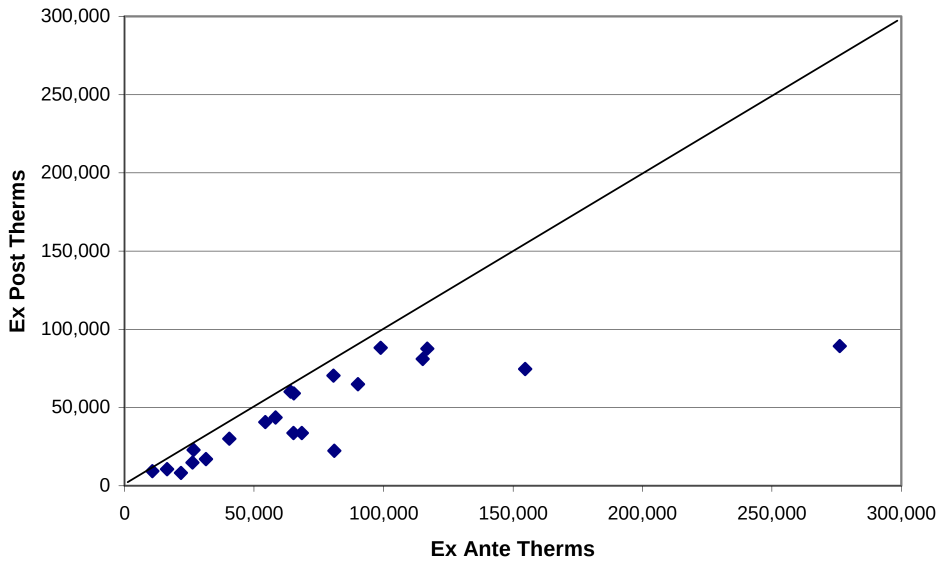


Table 26 shows the normalized ex-ante and ex-post savings as a function of the floor area of the greenhouses where the measure was installed. Note that there are two ex-ante savings values presented in this table. The ex-ante therm/ft^2 impact was used by the utilities to calculate the measure impact for each project. The adjusted ex-ante impact was calculated during this evaluation and accounts for divergences between the utility-rebated-measure square footage and the installed-measure square footage. The adjusted ex-ante impacts differ from the deemed ex-ante impacts, because at several of the sites, the rebated-measure square footage was overstated. Overall, the adjusted ex-ante impacts are very close to the deemed ex-ante impacts. The two sites (PGE4, PGE21), where adjusted ex-ante impacts are more than 80% greater than the deemed ex-ante impacts, are sites where at least one of the greenhouses included in the rebate application was rebated for a two-layer heat-curtain system.

Table 26: Summary of Greenhouse Heat Curtain Ex-Ante and Ex-Post Savings per Square Foot

Site ID	Installed Ft^2	Therm per Ft^2 Savings: Deemed Ex Ante	Therm per Ft^2 Savings: Adjusted Ex Ante**	Therm per Ft^2 Savings: Ex Post	Realization Rate**	kWh per Ft^2 Savings Ex Post
PGE1	42,000	0.39	0.39	0.25	0.65	0.02
PGE11	164,160	0.39	0.49	0.43	1.10	0.03
PGE2	367,000	0.39	0.75	0.24	0.62	0.03
PGE21	149,720	0.39	0.39	0.29	0.75	0.04
PGE2a	96,141	0.39	0.42	0.31	0.80	0.05
PGE4	27,888	0.39	0.78	0.29	0.76	0.04
PGE5	67,316	0.39	0.39	0.22	0.56	0.03
SCG12	309,261	0.32	0.32	0.28	0.89	0.02
SCG13	317,520	0.32	0.36	0.26	0.80	0.01
SCG14	483,291	0.32	0.32	0.15	0.48	0.01
SCG20	345,576	0.32	0.34	0.25	0.79	0.02
SCG20a	169,920	0.32	0.32	0.24	0.75	0.02
SCG23	200,592	0.32	0.32	0.30	0.94	0.01
SCG23a	197,856	0.32	0.33	0.30	0.93	0.01
SCG4	213,840	0.32	0.32	0.16	0.49	0.01
SCG44	281,539	0.32	0.32	0.23	0.72	0.02
SCG4a	98,472	0.32	0.32	0.17	0.54	0.01
SCG9	205,556	0.32	0.32	0.16	0.51	0.01
SDG1	253,190	0.32	0.32	0.09	0.28	0.02
SDG4	83,268	0.32	0.32	0.28	0.86	0.07
SDG4a	33,696	0.32	0.32	0.28	0.86	0.07

* The square feet in the denominator of the Deemed Ex Ante savings is the square feet of rebated curtain. The square feet in the denominator of the Adjusted Ex Ante is the horizontal greenhouse floor space covered by the curtain. Differences between the two are due to the incentive being paid for either (a) slightly more curtain than actually was installed; (b) the curtain being installed at an angle; or (c) two layers of curtain being installed over the same space.

*Calculated as ex post divided by the deemed ex-ante therm/ft^2 impacts

Table 27 shows estimated percent savings for the greenhouse heat curtains at each site. The heating energy savings range from 22% to 43%. There is a high degree of variation in the percent electric savings with heat curtains (4% to 34%).

Table 27: Estimated Percent Savings Greenhouse Heat Curtains

Site ID	Modeled Therms per Year		Percent	Modeled kWh per Year		Percent
	Pre-retrofit Use	Savings	Savings	Pre-retrofit Use	Savings	Savings
PGE1	43,372	10,612	24%	9,620	670	7%
PGE4	35,158	8,219	23%	7,045	1,119	16%
PGE5	55,200	14,800	27%	32,650	2,180	7%
SDG4	58,232	22,915	39%	22,029	6,171	28%
PGE2a	82,853	29,984	36%	42,258	4,753	11%
SDG4a	23,565	9,273	39%	8,914	2,497	28%
SCG4a	62,768	17,046	27%	18,339	1,203	7%
SCG23	152,212	60,198	40%	5,271	1,782	34%
SCG9	88,464	33,674	38%	23,030	2,260	10%
SCG4	95,946	33,775	35%	37,816	1,803	5%
SDG1	52,339	22,338	43%	25,885	6,138	24%
SCG20a	181,454	40,735	22%	29,265	4,013	14%
SCG23a	148,746	59,012	40%	5,846	1,892	32%
PGE21	116,665	43,675	37%	23,313	6,192	27%
PGE11	258,144	70,332	27%	17,599	4,704	27%
SCG13	303,400	81,000	27%	25,640	2,470	10%
PGE2	337,059	89,376	27%	46,107	9,730	21%
SCG12	338,153	88,134	26%	28,329	5,155	18%
SCG20	383,300	87,600	23%	51,840	7,880	15%
SCG44	252,390	64,898	26%	121,175	4,650	4%
SCG14	212,843	74,593	35%	59,909	4,003	7%

3.1.2 Site-Specific Net-to-Gross Results

Table 28 provides a summary of the net-to-gross results for the survey greenhouse heat-curtain sites. As discussed in the methodology section, the estimated NTGR is an average of three scores: a timing and selection score that reflects the influence of the most important of the program elements in the customer's decision to select the program measure; a program influence score that captures the perceived influence of the program relative to non-program factors in the decision to implement the measure; and a no-program score that captures the likelihood of various actions the customer might have taken in the absence of the program.

As the table shows, NTGRs range from a low of 0.10 to a high of 0.93. The unweighted average NTGR for the heat-curtain measure is 0.63.

Table 28: **Summary of Site-Specific Greenhouse Heat-Curtain Net-to-Gross Results**

Site ID	Timing and Selection Score	Program Influence Score	No-Program Score	NTGR
PGE1	8	7	8.9	0.80
PGE10	10	6	5.2	0.71
PGE11	10	7	10.0	0.90
PGE12	6	3	10.0	0.63
PGE1a	8	8	8.6	0.82
PGE2	8	5	0.0	0.25
PGE21	8	5	0.0	0.25
PGE23	9	3	10.0	0.73
PGE25	9	5	9.1	0.77
PGE26	9	3.5	8.3	0.69
PGE2a	8	5	0.0	0.25
PGE3	8	3	0.0	0.15
PGE4	10	6	4.0	0.67
PGE8	9	3	10.0	0.73
PGE9	9	3	10.0	0.73
PGE9a	9	3	10.0	0.73
SCG1	10	6	3.0	0.63
SCG10	8	5	1.4	0.32
SCG12	9	7	10.0	0.87
SCG13	9	7	7.1	0.77
SCG14	10	8	10.0	0.93
SCG15	10	6	4.0	0.67
SCG16	10	10	0.0	0.50
SCG17	9	6	4.9	0.66
SCG2	9	6	9.1	0.80
SCG20	10	4	10.0	0.80
SCG20a	10	4	10.0	0.80
SCG21	8	5	10.0	0.77
SCG22	10	4	10.0	0.80
SCG23	8	5	10.0	0.77
SCG23a	8	5	10.0	0.77
SCG24	9	5	8.6	0.75
SCG25	9	5	5.4	0.65
SCG4	8	5	10.0	0.77
SCG42	9	3	10.0	0.73
SCG43	8	5	10.0	0.77
SCG44	0	2	0.0	0.10
SCG45	9	7	2.3	0.61
SCG47	8	6	6.0	0.67
SCG48	9	5	10.0	0.80
SCG4a	8	5	10.0	0.77
SCG5	8	5	8.3	0.71
SCG6	8	5	2.2	0.51
SCG7	8	5	8.0	0.70
SCG8	10	5	8.9	0.80
SDG1	7	4	8.9	0.66
SDG13	8	5	1.4	0.32
SDG14	8	3	8.0	0.63
SDG3	6	2	0.0	0.10
SDG4	8	5	1.4	0.32
SDG4a	8	5	1.4	0.32

3.2 Validity and Reliability for the Greenhouse Heat-Curtain Evaluation

3.2.1 Method Validation

Prior to developing eQuest models of all evaluation sites, the modeling procedure was benchmarked against pre- and post-installation metered data for five pilot projects, which included six greenhouses on four different sites and included sites that were rebated for both heat curtains and infrared films during the 2006-2008 program years. The intention of this investigation was (1) to determine whether the heating energy impact of implementing energy curtains and infrared films in greenhouses in California could be accurately modeled with the eQuest energy-simulation software and (2) what variables were most significant to generating accurate greenhouse energy simulations in eQuest. This validation required that the simulated model for each sample site be calibrated against metered data. Models were considered calibrated when the energy-consumption output by the simulation program showed a good (based on engineering judgment) visual and statistical match with the greenhouse's hourly and daily metered energy-use information.

Data logging was performed for a minimum of four weeks during March and April of 2009 for each of the sample greenhouses that was modeled during the Method Validation. eQuest models were generated for each greenhouse, and a comparison was made between the daily and hourly heating energy use at each pilot greenhouse.

Statistically, the coefficient of variation (CV) was calculated to assess how well the daily logged and modeled energy use for each greenhouse matched. The coefficient of variation was calculated as the standard deviation between the daily modeled and logged energy use divided by the mean of the daily logged energy use. Literature reviews indicated that CV values between 15%-30% were desirable for calibrated models. All of the models had CV values within 19%-64%, which were on the high end of the range recommended in literature for considering models to be calibrated. However, given the relatively short period of data available for calibration and the assumptions necessary to model greenhouses in eQuest, in conjunction with the good fit between the hourly logged and modeled data in the figures above, the high CV values were considered acceptable for these models, and the procedure was deemed to be valid and reliable for evaluating the remaining evaluation projects.

This work resulted in modifications to several of the modeling assumptions that were included in previous eQuest models of greenhouses:

- Temperature stratification was accounted for by assuming a 0.32°F/ft temperature gradient in greenhouses with unit heaters and no temperature gradient in greenhouses with underbench heat. This was consistent with current DEER assumptions, but was lower than the ~0.7°F/ft that appeared to be used to model the ex-ante impacts. The 0.32°F/ft temperature gradient was established from logging done at a pilot site, identified as SDG8a (with unit heaters), DEER values, and a review of published literature.

- Manufacturer's glazing shading coefficients were reduced, on average, by 75% to account for solar energy that enters the greenhouse but is not gained as heat. This energy is instead used for photosynthesis and is lost through evapotranspiration. Previous models reduced the shading coefficient of the greenhouse glazing by ~60% although the source of this reduction was not clear.
- Greenhouse thermal mass was set with the *floor-weight* input and assigned as 10 lbs/ft^2. DEER models had used a *floor-weight* of 5 lbs/ft^2, though it was unclear what the *floor-weight* was in the ex-ante impact calculation models. Coupled with the higher shading coefficient reduction noted above, the models with 10 lbs/ft^2 of thermal mass showed a better fit between the hourly logged and modeled heating energy usage than the models with only 5 lbs/ft^2 of thermal mass.

This work also resulted in the identification of 5-10 important variables, to which special attention was paid when collecting data for the remaining evaluation sites. These variables are listed below:

- Heating temperature setpoints and schedules
- Cooling temperature setpoints and schedules
- Heat-curtain control setpoints
- Heat-curtain manufacturer and model number
- Greenhouse envelope materials, manufacturer, and model number
- Greenhouse heating-system size, efficiency, manufacturer, and model number
- Greenhouse heating-system type and specifications

3.2.2 Quality Assurance Procedures

All method validation site models were reconciled against logged gas use or measured heat load data. All evaluation modeling was supervised and reviewed by the lead engineer. Energy Division technical consultants reviewed the analysis effort at various stages and provided feedback on all aspects of the modeling effort.

3.2.3 Uncertainties

The principal uncertainties relate to simplifications required to model a greenhouse in eQuest. Based on initial experimentation, we observed several key variables in the eQuest greenhouse model. Of these variables, the most influential variables in the calculation of the measure impact are the U-value multiplier of the heat curtain, the shading coefficient multiplier of the heat curtains, the degree of temperature stratification in greenhouses with unit heaters, and the heat-curtain control setpoints. Data were collected from multiple sources to define the pre- and post-implementation heat-curtain U-values and shading coefficient multipliers, the degree of temperature stratification, and the heat control setpoints in each greenhouse. Of these variables, the heat curtain U-value multiplier and degree of temperature stratification had the most uncertain input definitions. Therefore, a sensitivity analysis was run to assess the uncertainty of the heat-curtain measure impacts given the uncertainty associated with these two input variables. The average and standard deviation of the heat-curtain U-value multipliers and the degree of temperature stratification are shown in Table 29 for the three projects that received heat-curtain rebates and were included in the method validation study:

Table 29: Heat Curtain Uncertainty Analysis: Input Variables

Input Uncertainty	PGE 4		PGE 11		SDG 1	
	Average	Uncertainty	Average	Uncertainty	Average	Uncertainty
Post-implementation (U-Value Multipler)	0.47	0.07	0.59	0.08	0.47	0.07
Pre-implementation (°F of temperature stratification)	HW boiler w/underbench heating. Stratification equals 0°F.		1.92	0.75	HW boiler w/underbench heating. Stratification equals 0°F.	
Post-implementation (°F of temperature stratification)			0.64	0.25		

Three eQuest runs were performed to calculate the (1) average measure impacts, (2) the maximum measure impacts, and (3) the minimum measure impacts. These values are presented in Table 30 along with their percent variation from the average and the estimated standard deviation of the measure impact.

Table 30: Heat Curtain Uncertainty Analysis: Output

Uncertainty Output	PGE 4		PGE 11		SDG 1	
Gas Impact	Therms	% change	Therms	% change	Therms	% change
Average Savings	8,219	-	70,332	-	22,338	-
Max Savings	9,458	15%	98,100	39%	27,137	21%
Min Savings	6,947	-15%	39,636	-44%	17,984	-19%
Stdev	1,256	-	29,244	-	4,578	-
Uncertainty Output	**PGE 4**		**PGE 11**		**SDG 1**	
Electric Impact	kWh	% change	kWh	% change	kWh	% change
Average Savings	1,119	-	4,704	-	6,138	-
Max Savings	1,181	6%	6,570	40%	8,015	31%
Min Savings	1,037	-7%	2,647	-44%	4,457	-27%
Stdev	72	-	1,962	-	1,780	-

3.3 Measure-Level Results for the Greenhouse Heat-Curtain Evaluation

Site-specific results were weighted and expanded to measure-level results using the approaches described above in the methodology section. This subsection reports on these measure-level results for the greenhouse heat curtains.

3.3.1 Gross Greenhouse Heat-Curtain Measure Savings

Table 31 presents the statewide measure-level gross realization rate for the greenhouse heat-curtain measure and associated precision estimates. As shown, the estimated realization rate for the heat curtains is 0.63 with a relative precision of ± 9.7% at the 90% confidence level. This relative precision exceeded the targeted precision of ± 20%. In designing the heat-curtain gross impact sample, an error ratio of 0.60 was assumed. The calculated error ratio for this measure was 0.34, which is considerably lower than the estimate the sample design was based on.

Table 31: **Greenhouse Heat-Curtain Natural Gas Realization Rate and Precision Estimates**

Result	Estimate
Realization Rate	0.63
Standard Error	0.037
Error Bound - 90% Confidence Level	0.061
Relative Precision	9.7%
Error Ratio	0.34

Table 32 presents the mean electric savings calculated for the greenhouse heat curtains. The curtains provide an average savings of 3,292 kWh per site, with a relative precision of ± 24%.

Table 32: **Greenhouse Heat-Curtain Electric Savings and Precision Estimates**

Result	Estimate
Mean kWh	3,292
Standard Error	480
Error Bound - 90% Confidence Level	790
Relative Precision	24.0%

The overall statewide measure savings for the greenhouse heat curtain measure are calculated by applying the estimated realization rate and the mean kWh savings to program tracking data. Table 33 summarizes the results. Overall, the greenhouse heat curtains installed during the 2006-2008 period have estimated first-year savings of 2.03 million therms, with a 90% confidence interval of 1.84 million therms to 2.23 million therms. Estimated electric savings are 0.227 GWh, with a 90% confidence interval of 0.173 GWh to 0.282 GWh.

Table 33: Greenhouse Heat-Curtain Statewide Measure-Level Gross Impacts

Fuel	Result	Estimate
Gas	Ex-Ante Savings - Therms	3,246,599
	Realization Rate	0.63
	Ex-Post Savings - Therms	2,034,028
	Relative Precision	9.7%
	Lower Bound, 90% Confidence Interval - Therms	1,836,404
	Upper Bound, 90% Confidence Interval - Therms	2,231,653
Electricity	Number of project Sites	69
	Mean kWh	3,292
	Ex-Post Savings - kWh	227,123
	Relative Precision	24.0%
	Lower Bound, 90% Confidence Interval - kWh	172,595
	Upper Bound, 90% Confidence Interval - kWh	281,651

3.3.2 Net Greenhouse Heat-Curtain Measure Savings

Table 34 presents the overall weighted NTGR for the greenhouse heat-curtain measure and its associated precision estimates. As shown, the estimated NTGR is 0.62 with a relative precision of 5.4%.

Table 34: Greenhouse Heat Curtain Net to Gross Ratio and Precision Estimates

Result	Estimate
Net-to-Gross Ratio	0.63
Standard Error	0.020
Error Bound - 90% Confidence Level	0.033
Relative Precision	5.3%

Combining the NTGR results with the gross savings results provide estimates of statewide net savings for the greenhouse heat-curtain measure. Table 35 shows the results. Overall, the net savings for the greenhouse heat-curtain measure are estimated at 1.28 million therms and 0.142 GWh per year.

Table 35: Greenhouse Heat-Curtain Measure-Level Net Savings Estimates

Result	Therms	kWh
Gross Measure Savings	2,034,028	227,123
Net-to-Gross Ratio	0.63	0.63
Net Measure Savings	1,275,383	142,411
Lower Bound, 90% Confidence Interval	1,133,968	107,370
Upper Bound, 90% Confidence Interval	1,416,797	177,453

Table 36 compares the ex-ante and ex-post estimates of net savings for the greenhouse heat-curtain measure. The overall net realization rate is estimated at 0.41, indicating the measures are savings 41% of the ex-ante net estimate.`

Table 36: **Greenhouse Heat-Curtain Comparison of Net Measure-Level Ex-Ante and Ex-Post Results**

Result	Ex Ante	Ex Post
Gross Measure Savings - Therms	3,246,599	2,034,028
Net-to-Gross Ratio	0.95	0.63
Net Measure Savings - Therms	3,095,637	1,275,383
Net Realization Rate		0.41

3.4 Discussion of Findings for the Greenhouse Heat-Curtain Evaluation

Installing heat curtains in greenhouses in California during the 2006-2008 program years resulted in reductions in gas usage across the state. However, the magnitude of these savings depended on numerous factors, including the site location, greenhouse construction, temperature setpoints and schedules, heat-curtain type, and heat-curtain control scheme.

We recommend, when next updating the generic greenhouse template that is used by the utilities to estimate measure savings, making the following adjustments to reflect the typical participant population characteristics, as opposed to the general greenhouse population characteristics:

- Change the template's presumed heating system type from unit heater to radiant underbench. This will reduce the average temperature, annual energy use, and savings. Underbench steam and hot-water heating systems were more common than unit heaters at the sample sites that received rebates for installing heat curtains during the 2006-2008 program years. This observation was contrary to previously established baselines, which assumed unit heaters were the predominant heat source in these greenhouses. Unit heaters are more common for the general greenhouse population, but they appear to be less common for the typical participant.
- Modify the envelope-material shading coefficients to account for solar energy that enters the greenhouse but is not gained as heat. In this work, the shading coefficient was reduced on average by 75% to account for this energy. Further research into shading coefficient modifiers is warranted, as this can have a strong influence on the energy use of the greenhouse model.
- Define the thermal mass of the models to be 10 lbs/ft^2 and eliminate the greenhouse floor from all models. In this work, 10 lbs/ft^2 of thermal mass showed good results when combined with the shading coefficient reduction noted above.

Also consider these additional model input adjustments:

- Model temperature stratification in greenhouses with unit heaters, but not in greenhouses with underbench heating systems. Calculating the offset temperature with a temperature gradient of 0.32°F/ft rather than 0.7°F/ft was shown to provide reasonable results in this work. This is consistent with the assumptions used in current DEER models.

Overall, evaluators believe that the deemed-savings values currently being used are higher than actual savings and should be reduced. We recommend making the changes to the generic greenhouse template suggested above to adjust these deemed-savings values. Furthermore, we recommend considering adding more deemed-savings categories to reflect the site-to-site variation in savings that consistently appear in the models. We recommend considering the following changes to the deemed-savings structure:

- Offer a bonus incentive for customers that install two-layer curtain systems, as they deliver 20%-25% more savings than single-layer curtain systems and are more expensive than single-layer curtain systems.
- Offer a bonus incentive for customers with unit heaters, as these sites generally deliver greater energy savings with heat curtains than sites with boilers with underbench heating systems.
- Use climate zone rather than utility service territory to calculate deemed savings. The climates located within a utility service territory can be extremely different (i.e., coastal vs. inland), which was shown in this work to significantly affect measure impacts.

Implementing the model change recommendations should result in similar energy use and savings compared to what we modeled in our evaluations.

Areas for Future Research. Over the course of this evaluation, several areas were identified where further research could help to more accurately capture the heat-curtain measure impacts. These areas are as follows:

Long-term metering - A number of the sites that were included in this evaluation would be well-suited for long-term metering. Such metering would provide long-term data against which to benchmark future eQuest models and to assess measure impacts.

Benchmarking – Many greenhouses are located within the confines of large nurseries that are made up of many greenhouses. Observations made during site visits indicated that for any given site, many of the greenhouses had similar constructions and similar plants grown in them. This would appear to indicate that greenhouses are good candidates for energy benchmarking. Future research could focus on collecting information from greenhouse sites throughout California that would allow the annual therm/ft^2 of greenhouse floor area to be characterized for each site. This would be useful in identifying differences in heating energy use between nurseries (1) in different climate zones, (2) with different plant types, and (3) with different constructions. Further, characterizing the heating energy use at a greenhouse site on a therm/ft^2 of greenhouse-floor-area basis helps to establish a upper bound for the energy savings that could be expected when installing heat curtains at the site.

4 Greenhouse Infrared Film Evaluation Results

In this section we present findings from the impact evaluation of the greenhouse infrared-film HIM. Detailed site-specific results are presented first; validity and reliability of the results are discussed next; and finally, statewide measure-level results and their associated precision are presented.

4.1 Detailed Findings for the Greenhouse Infrared-Film Evaluation

In this subsection we present our gross and net impact results on an unweighted basis (i.e. not reflecting sample-design expansion weights) for each site included in the analysis. The gross impact analysis addressed a total of 18 sites and the net-to-gross analysis covered 35 sites.

4.1.1 Site-Specific Gross Impacts

Site-specific savings for the sampled greenhouse infrared-film sites are presented in Table 37. This table shows ex-ante therm savings, ex-post therm and kWh savings, and therm realization rates. While only gas impacts were reported for the programs, the evaluation determined that electric impacts were present for all sites, although impacts at some sites were negligible. For sites without mechanical cooling, the electricity savings result from reduced cycling of the unit heater fans, reduced use of horizontal airflow fans, or less load on boiler hot-water pumps. Energy use of heat-curtain drive motors was logged at one pilot site and found to be inconsequential. Peak demand impacts were not evaluated, although model outputs showed the installation of heat curtains did result in a slight reduction in the peak cooling load in some greenhouses with mechanical cooling systems.

Table 37: Summary of Greenhouse Infrared-Film Ex-Ante and Ex-Post Savings

	Ex-Ante Savings		Ex-Post Savings		Realization Rate	
Site ID	kWh	Therms	kWh	Therms	kWh	Therms
PGE14	0	44,475	3,049	17,337	-	0.39
SCG29	0	30,303	468	15,783	-	0.52
SCG31	0	12,648	1,915	4,596	-	0.36
SCG33	0	142,775	1,100	108,942	-	0.76
SCG35	0	33,023	1,580	9,222	-	0.28
SCG40	0	8,976	1,224	3,346	-	0.37
SCG52	0	40,576	205	3,473	-	0.09
SCG53	0	1,170	277	1,091	-	0.93
SCG57	0	23,945	-221	1,353	-	0.06
SCG64	0	72,420	1,504	16,878	-	0.23
SCG65	0	49,646	1,211	4,377	-	0.09
SDG10	0	5,127	896	3,240	-	0.63
SDG11	0	26,671	10,000	16,181	-	0.61
SDG16	0	27,118	10,130	15,647	-	0.58
SDG5	0	86,808	5,298	23,451	-	0.27
SDG6	0	24,650	-65	9,700	-	0.39
SDG8	0	50,956	11,304	20,720	-	0.41
SDG8a	0	26,622	6,106	12,801	-	0.48
Total	0	707,908	55,980	288,137	-	0.41

Figure 2 provides a graphical comparison of ex-ante and ex-post therm savings. The diagonal line in the figure shows points where ex-ante and ex-post results would be equal. Points below the line represent sites where ex-post results are lower than ex-ante results. As this figure shows, ex-post impacts were determined to be lower than ex-ante estimates in all cases.

Figure 2: Comparison of Greenhouse Infrared-Film Ex-Ante and Ex-Post Savings

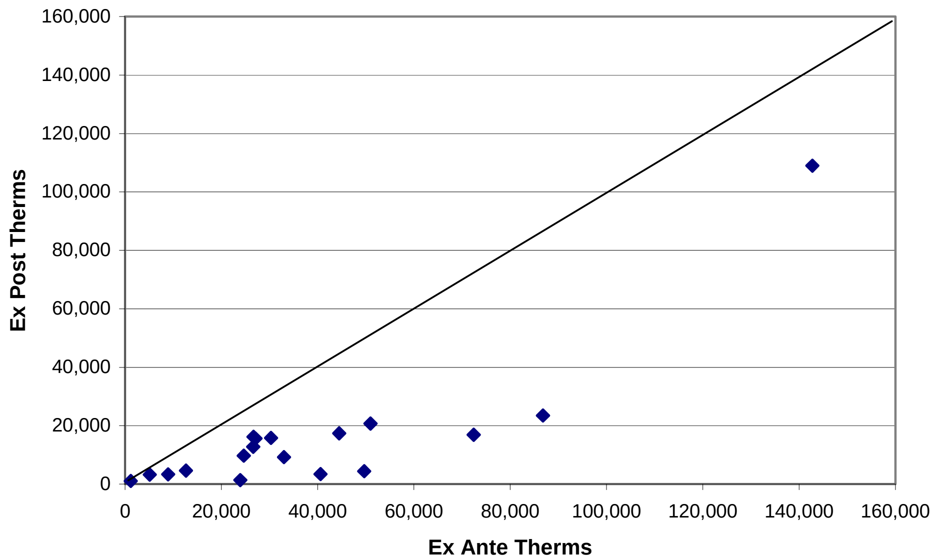


Table 38 shows the normalized ex-ante and ex-post savings as a function of the floor area of the greenhouses where the measure was installed.

Table 38: Summary of Greenhouse Infrared-Film Ex-Ante and Ex-Post Savings per Square Foot

Site ID	Installed Ft^2	Therm per Ft^2 Savings: Deemed Ex Ante	Therm per Ft^2 Savings: Ex Post	Realization Rate*	kWh per Ft^2 Savings Ex Post
PGE14	261,620	0.17	0.07	0.39	0.01
SCG29	178,250	0.17	0.09	0.52	0.00
SCG31	74,400	0.17	0.06	0.36	0.03
SCG33	839,850	0.17	0.13	0.76	0.00
SCG35	194,250	0.17	0.05	0.28	0.01
SCG40	52,800	0.17	0.06	0.37	0.02
SCG52	238,680	0.17	0.01	0.09	0.00
SCG53	6,880	0.17	0.16	0.93	0.04
SCG57	140,851	0.17	0.01	0.06	0.00
SCG64	426,000	0.17	0.04	0.23	0.00
SCG65	292,036	0.17	0.01	0.09	0.00
SDG10	30,160	0.17	0.11	0.63	0.03
SDG11	156,888	0.17	0.10	0.61	0.06
SDG16	159,520	0.17	0.10	0.58	0.06
SDG5	510,637	0.17	0.05	0.27	0.01
SDG6	145,000	0.17	0.07	0.39	0.00
SDG8	299,740	0.17	0.07	0.41	0.04
SDG8a	156,600	0.17	0.08	0.48	0.04

*Calculated as ex post divided by the deemed ex-ante therm/ft^2 impacts

Table 39 shows estimated percent savings for the greenhouse infrared films at each site. The heating energy savings range from 3% to 24%. There is also a high degree of variation in the percent electric savings with infrared films (-1% to 28%).

Table 39: Estimated Percent Savings for Greenhouse Infrared Films

Site ID	Modeled Therms per Year		Percent	Modeled kWh per Year		Percent
	Pre-retrofit	Savings	Savings	Pre-retrofit	Savings	Savings
PGE14	81,383	17,337	21%	43,425	3,049	7%
SCG29	90,345	15,783	17%	28,919	468	2%
SCG31	19,499	4,596	24%	27,211	1,915	7%
SCG33	625,218	108,942	17%	105,239	1,100	1%
SCG35	38,446	9,222	24%	15,685	1,580	10%
SCG40	19,706	3,346	17%	19,321	1,224	6%
SCG52	61,190	3,473	6%	34,332	205	1%
SCG53	7,476	1,091	15%	2,568	277	11%
SCG57	44,674	1,353	3%	18,320	-221	-1%
SCG64	262,445	16,878	6%	35,807	1,504	4%
SCG65	170,185	4,377	3%	79,006	1,211	2%
SDG10	16,550	3,240	20%	4,769	896	19%
SDG11	76,445	16,181	21%	37,060	10,000	27%
SDG16	72,233	15,647	22%	36,125	10,130	28%
SDG5	87,173	23,451	27%	40,239	5,298	13%
SDG6	66,289	9,700	15%	33,623	-65	0%
SDG8	111,960	20,720	19%	62,598	11,304	18%
SDG8a	73,017	12,801	18%	29,483	6,106	21%

4.1.2 Site-specific Net-to-Gross Results

Table 40 provides a summary of the net-to-gross results for the surveyed greenhouse infrared-film sites. As discussed in the methodology section, the estimated NTGR is an average of three scores: a timing and selection score that reflects the influence of the most important of the program elements in the customer's decision to select the program measure; a program influence score that captures the perceived influence of the program relative to non-program factors in the decision to implement the measure; and a no-program score that captures the likelihood of various actions the customer might have taken in the absence of the program.

As the table shows, NTGRs range from a low of 0.05 to a high of 0.90. The unweighted average NTGR for the infrared-film measure is 0.49.

Table 40: Summary of Site-Specific Greenhouse Infrared-Film Net-to-Gross Results

Site ID	Timing and Selection Score	Program Influence Score	No-Program Score	NTGR
PGE13	4	2	0.0	0.10
PGE14	8	6	10.0	0.80
PGE14a	8	6	10.0	0.80
PGE15	8	6	5.0	0.63
PGE16	10	3	4.9	0.60
PGE28	10	10	5.7	0.86
PGE29	8	8	6.0	0.73
PGE31	8	5	7.2	0.67
PGE33	10	3	4.0	0.57
SCG28	8	2.5	0.0	0.13
SCG29	8	3	1.0	0.20
SCG29a	8	3	1.0	0.20
SCG30	10	8	7.1	0.84
SCG31	9	8	10.0	0.90
SCG33	5	5	5.0	0.50
SCG34	2	1	0.0	0.05
SCG36	10	6	7.1	0.77
SCG37	8	10	6.6	0.82
SCG40	7	5	4.9	0.56
SCG52	10	6	7.1	0.77
SCG53	10	5	0.0	0.25
SCG55	10	5	10.0	0.83
SCG56	10	5	0.0	0.25
SCG58	8	5	1.4	0.32
SCG59	10	5	3.1	0.60
SCG61	10	8	0.0	0.40
SCG62	10	6	6.0	0.73
SCG63	9	4	1.4	0.27
SDG11	0	2	0.0	0.10
SDG12	5	5	7.1	0.57
SDG12a	5	5	7.1	0.57
SDG16	0	2	0.0	0.10
SDG5	5	5	7.1	0.57
SDG8	0	2	0.0	0.10
SDG8a	0	2	0.0	0.10

4.2 Validity and Reliability for the Greenhouse Infrared-Film Evaluation

4.2.1 Method Validation

See Section 3.2.1 for a discussion of method validation for the greenhouse heat-curtain and infrared-film measures.

4.2.2 Quality Assurance Procedures

All method validation site models were reconciled against logged gas use or measured heat load data. All evaluation modeling was supervised and reviewed by the lead engineer. The Energy Division technical consultants reviewed the analysis effort at various stages and provided feedback on all aspects of the modeling effort.

4.2.3 Uncertainties

The principal uncertainties relate to simplifications required to model a greenhouse in eQuest. Based on initial experimentation, it appears that there are several key variables in the eQuest greenhouse model. Of these variables, the most influential variables in the calculation of the measure impact are the U-value of the roof, the shading coefficient of the roof, the degree of temperature stratification in greenhouses with unit heaters, and the heat-curtain properties and controls setpoints in greenhouses with heat curtains. Data were collected from multiple sources to define the pre- and post-implementation roof U-values and shading coefficients, the degree of temperature stratification, and the heat-curtain control setpoints in each greenhouse. Of these variables, the roof U-value was the most uncertain input and the most pertinent to calculating the infrared-film measure impact. Therefore, a sensitivity analysis was run to assess the uncertainty of the infrared-film measure impacts given the uncertainty associated with this input variable. The average and standard deviations of the roof U-value are shown in Table 41 for the two projects that received infrared-film rebates and that were included in the method validation study.

Table 41: Infrared-Film Uncertainty Analysis: Input Variables

Input Uncertainty	SDG 8a		SDG 5	
	Average	Uncertainty	Average	Uncertainty
Pre-implementation (Roof U-value)	0.70	0.02	0.70	0.02
Post-implementation (Roof U-value)	0.50	0.06	0.50	0.06

Three eQuest runs were performed to calculate the (1) average measure impacts, (2) the maximum measure impacts, and (3) the minimum measure impacts. These values are presented in Table 42 along with their percent variation from the average and the estimated standard deviation of the measure impact.

Table 42: Infrared-Film Uncertainty Analysis: Output

Uncertainty Output Gas Impact	SDG 8a		SDG 5	
	Therms	% change	Therms	% change
Average Savings	12,801	-	23,451	-
Max Savings	20,326	59%	34,547	47%
Min Savings	5,858	-54%	13,245	-44%
Stdev	7,236	-	10,654	-
Uncertainty Output Electric Impact	SDG 8a		SDG 5	
	kWh	% change	kWh	% change
Average Savings	6,106	-	5,298	-
Max Savings	7,187	18%	8,060	52%
Min Savings	5,272	-14%	2,869	-46%
Stdev	960	-	2,597	-

4.3 Measure-Level Results for the Greenhouse Infrared-Film Evaluation

Site-specific results were weighted and expanded to measure-level results using the approaches described above in the methodology section. This subsection reports on these measure-level results for the greenhouse infrared films.

4.3.1 Gross Greenhouse Infrared-Film Measure Savings

Table 43 presents the statewide measure-level gross realization rate for the greenhouse infrared-film measure and associated precision estimates. As shown, the estimated realization rate for the infrared films is 0.39 with a relative precision of ± 16.9% at the 90% confidence level. This relative precision exceeded the targeted precision of ± 20%. In designing the infrared-film gross impact sample, an error ratio of 0.60 was assumed. The calculated error ratio for this measure was 0.57, which is close to the estimate the sample design was based on.

Table 43: Greenhouse Infrared-Film Realization Rate and Precision Estimates

Result	Estimate
Realization Rate	0.39
Standard Error	0.040
Error Bound - 90% Confidence Level	0.066
Relative Precision	16.9%
Error Ratio	0.57

Table 44 presents the mean electric savings calculated for the greenhouse infrared films. The films provide an average savings of 2,307 kWh per site, with a relative precision of ± 31%.

Table 44: Greenhouse Infrared-Film Mean kWh Savings and Precision Estimates

Result	Estimate
Mean kWh	2,307
Standard Error	440
Error Bound - 90% Confidence Level	724
Relative Precision	31.4%

The overall statewide measure savings for the greenhouse infrared film measure are calculated by applying the estimated realization rate and the mean kWh savings to program tracking data. Table 45 summarizes the results. Overall, the greenhouse infrared films installed during the 2006-2008 period have estimated first-year savings of 0.50 million therms, with a 90% confidence interval of 0.42 million therms to 0.59 million therms. Estimated electric savings are 0.131 GWh, with a 90% confidence interval of 0.090 GWh to 0.173 GWh.

Table 45: Greenhouse Infrared-Film Statewide Measure-Level Gross Impacts

Fuel	Result	Estimate
Gas	Ex-Ante Savings - Therms	1,290,728
	Realization Rate	0.39
	Ex-Post Savings - Therms	500,527
	Relative Precision	16.9%
	Lower Bound, 90% Confidence Interval - Therms	415,916
	Upper Bound, 90% Confidence Interval - Therms	585,138
Electricity	Number of project Sites	57
	Mean kWh	2,307
	Ex-Post Savings - kWh	131,481
	Relative Precision	31.4%
	Lower Bound, 90% Confidence Interval - kWh	90,207
	Upper Bound, 90% Confidence Interval - kWh	172,755

4.3.2 Net Greenhouse Infrared-Film Measure Savings

Table 46 presents the overall weighted NTGR for the greenhouse infrared-film measure and its associated precision estimates. As shown, the estimated NTGR is 0.46 with a relative precision of 10.2%.

Table 46: Greenhouse Infrared-Film Net-to-Gross Ratio and Precision Estimates

Result	Estimate
Net-to-Gross Ratio	0.46
Standard Error	0.028
Error Bound - 90% Confidence Level	0.046
Relative Precision	10.2%

Combining the NTGR results with the gross savings results provide estimates of statewide net savings for the greenhouse infrared-film measure. Table 47 shows the results. Overall, the net savings for the greenhouse infrared-film measure are estimated at 1.25 million therms and 0.140 GWh per year.

Table 47: Greenhouse Infrared-Film Measure-Level Net Savings Estimates

Result	Therms	kWh
Gross Measure Savings	500,527	131,481
Net-to-Gross Ratio	0.46	0.46
Net Measure Savings	228,181	59,940
Lower Bound, 90% Confidence Interval	183,105	38,482
Upper Bound, 90% Confidence Interval	273,257	81,398

Table 48 compares the ex-ante and ex-post estimates of net savings for the greenhouse infrared-film measure. The overall net realization rate is estimated at 0.18, indicating that the infrared-film measure is saving about 18% of the ex-ante net estimate.

Table 48: Greenhouse Infrared-Film Comparison of Net Measure-Level Ex-Ante and Ex-Post Results

Result	Ex Ante	Ex Post
Gross Measure Savings - Therms	1,290,728	500,527
Net-to-Gross Ratio	0.96	0.46
Net Measure Savings - Therms	1,239,099	228,181
Net Realization Rate		0.18

4.4 Discussion of Findings for the Greenhouse Infrared-Film Evaluation

Installing infrared films in greenhouses in California during the 2006-2008 program years resulted in reductions in gas usage across the state. However, the magnitude of these savings depended on numerous factors, including the site location, greenhouse construction, temperature setpoints and schedules, and heat-curtain usage (in addition to the infrared films).

We recommend, when next updating the generic greenhouse template, making the following adjustments to reflect the typical participant population characteristics, as opposed to the general greenhouse population characteristics:

- Change the template’s presumed heating system type from unit heater to radiant underbench. This will reduce the average temperature, annual energy use, and savings. Underbench steam and hot-water heating systems were more common than unit heaters at the sample sites that received rebates for installing infrared-films during the 2006-2008 program years. This observation was contrary to previously established baselines, which assumed unit heaters were the predominant heat source in these greenhouses. Unit heaters are more common for the general greenhouse population, but they appear to be less common for the typical participant.

- Modify the envelope material shading coefficients to account for solar energy that enters the greenhouse but is not gained as heat. In this work, the shading coefficient was reduced, on average, by 75% to account for this energy. Further research into shading coefficient modifiers is warranted, as this can have a strong influence on the energy use of the greenhouse model.
- Define the thermal mass of the models to be 10 lbs/ft^2 and eliminate the greenhouse floor from all models. In this work, 10 lbs/ ft^2 of thermal mass showed good results when combined with the shading coefficient reduction noted above.

Also consider these additional model input adjustments:

- Model temperature stratification in greenhouses with unit heaters, but not in greenhouses with underbench heating systems. Calculating the offset temperature with a temperature gradient of 0.32°F/ft rather than 0.7°F/ft was shown to provide reasonable results in this work. This is consistent with the assumptions used in current DEER models.

Overall, evaluators believe that the deemed-savings values currently being used are higher than actual savings and should be reduced. We recommend making the changes to the generic greenhouse template suggested above to adjust these deemed-savings values. Furthermore, we recommend considering adding more deemed-savings categories to reflect the site-to-site variation in savings that consistently appear in the models. We recommend considering the following changes to the deemed-savings structure:

- Reduce the incentive for customers that install infrared films at sites with heat curtains, as they deliver 20%-25% less savings than infrared films installed at sites without heat curtains.
- Eliminate incentives to customers that install infrared films at sites with single-layer inflated polyethylene roof systems, as these roof systems deliver only a fraction of the savings of double-layer polyethylene roof systems.
- With a change to underbench heating in the baseline model, a bonus incentive should be offered for customers with unit heaters, as these sites generally deliver 40% more energy savings with infrared films than sites with boilers and underbench heating systems.
- Use climate zone rather than utility service territory to calculate deemed savings. The climates located within a utility service territory can be extremely different (i.e., coastal vs. inland), which was shown in this work to significantly affect measure impacts.

Areas for Future Research. Over the course of this evaluation, several areas were identified where further research could help to more accurately capture the heat-curtain measure impacts. These areas are as follows:

Long-term metering - A number of the sites that were included in this evaluation would be well-suited for long-term metering. Such metering would provide long-term data against which to benchmark future eQuest models and to assess measure impacts.

Benchmarking – Many greenhouses are located within the confines of large nurseries that are made up of many greenhouses. Observations made during site visits indicated that for any given site, many of the greenhouses had similar constructions and similar plants grown in them. This would appear to indicate that greenhouses are good candidates for energy benchmarking. Future research could focus on collecting information from greenhouse sites throughout California that would allow the annual therm/ft^2 of greenhouse floor area to be characterized for each site. This would be useful in identifying differences in heating energy use between nurseries (1) in different climate zones, (2) with different plant types, and (3) with different constructions. Further, characterizing the heating energy use at a greenhouse site on a therm/ft^2 of greenhouse-floor-area basis helps to establish an upper bound for the energy savings that could be expected when installing infrared films at the site.

5 PG&E Agricultural and Food Processing Program Evaluation Results

In this section, we present findings of the impact evaluation of the PG&E Ag-Food Program. Detailed, site-specific results are presented first; validity and reliability of the results are discussed next; and finally, statewide measure-level results and their associated precision are presented.

5.1 Detailed Findings for the PG&E Agricultural and Food Processing Program Evaluation

In this subsection, we present our gross and net impact results on an unweighted basis (i.e. not reflecting sample-design expansion weights) for each site included in the analysis. The gross impact analysis addressed a total of 68 sites and the net-to-gross analysis covered 44 sites.

5.1.1 Site-specific Gross Impacts

Site-specific savings for the sampled PG&E Ag-Food Program projects are presented in Table 49. This table shows ex-ante savings, ex-post savings, and realization rates for kWh, kW, and therms. For a number of projects, the evaluation determined impacts for fuels whose savings were omitted by the program. The table also shows which fuel each project was sampled by.

Table 49: Summary of PG&E Ag-Food Program Ex-Ante and Ex-Post Savings

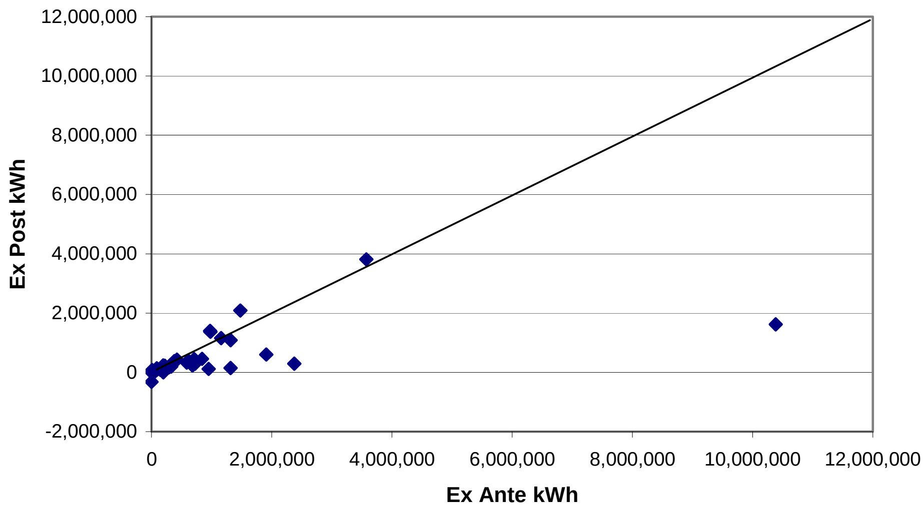
	Fuel	Ex-Ante Savings			Ex-Post Savings			Realization Rate		
Site ID	Sampled	kWh	kW	Therms	kWh	kW	Therms	kWh	kW	Therms
121	Electric	722,188	102.0	0	288,020	13.2	0	0.40	0.13	-
122	Electric	837,616	310.9	0	455,304	182.8	0	0.54	0.59	-
126	Electric	33,060	14.4	0	23,675	11.7	0	0.72	0.81	-
132	Electric	34,523	0.0	0	34,523	0.0	0	1.00	-	-
133	Electric	52,968	6.9	0	16,319	2.4	0	0.31	0.35	-
135	Electric	195,676	0.0	0	151,584	28.2	0	0.77	-	-
137	Electric	48,848	16.3	0	51,793	22.8	0	1.06	1.40	-
138	Electric	189,567	0.0	0	114,838	-21.4	0	0.61	-	-
139	Electric	707,919	0.0	0	445,766	1.0	0	0.63	-	-
143	Electric	2,372,656	270.9	0	292,095	30.9	0	0.12	0.11	-
144	Electric	3,571,308	407.7	0	3,808,514	543.0	0	1.07	1.33	-
145	Electric	211,084	150.8	0	144,148	0.0	0	0.68	0.00	-
146	Electric	8,678	3.0	0	44,925	5.1	0	5.18	1.71	-
147	Electric	87,203	0.0	0	131,663	1.5	0	1.51	-	-
150	Electric	59,814	6.8	0	66,622	9.3	0	1.11	1.37	-
151	Electric	67,727	8.7	0	67,272	8.7	0	0.99	1.00	-
152	Electric	220,725	22.0	0	220,725	25.7	0	1.00	1.17	-
153	Electric	972,290	110.7	0	1,399,829	128.0	0	1.44	1.16	-
154-155	Electric	10,381,986	1,387.0	0	1,615,657	300.0	0	0.16	0.22	-
158	Electric	88,048	0.0	0	118,984	7.3	0	1.35	-	-
163	Electric	1,316,390	1,995.0	0	146,181	198.1	0	0.11	0.10	-
164	Electric	614,555	86.0	0	381,846	29.7	0	0.62	0.35	-
165	Electric	951,696	0.0	0	116,753	13.3	0	0.12	-	-
166	Electric	193,297	29.6	0	232,745	29.1	0	1.20	0.98	-
168	Electric	294,613	77.9	0	168,972	48.1	0	0.57	0.62	-
231	Electric	87,523	4.0	0	84,495	17.9	0	0.97	4.47	-

Table 49: Summary of PG&E Ag-Food Program Ex-Ante and Ex-Post Savings

	Fuel	Ex-Ante Savings			Ex-Post Savings			Realization Rate		
Site ID	Sampled	kWh	kW	Therms	kWh	kW	Therms	kWh	kW	Therms
234	Electric	325,452	0.0	0	193,716	22.7	0	0.60	-	-
235	Electric	200,805	0.0	0	92,698	0.6	0	0.46	-	-
237	Electric	423,991	108.7	0	427,743	76.5	-4,584	1.01	0.70	-
238	Electric	679,956	149.4	0	228,499	34.5	0	0.34	0.23	-
239	Electric	586,585	279.0	0	327,238	129.0	0	0.56	0.46	-
240	Electric	66,887	0.0	0	64,880	0.0	0	0.97	-	-
241	Electric	1,478,184	211.9	0	2,087,323	356.4	0	1.41	1.68	-
242	Electric	1,910,119	299.5	0	601,833	56.4	0	0.32	0.19	-
243	Electric	1,156,626	0.0	0	1,156,626	11.4	0	1.00	-	-
254	Electric	11,243	5.8	0	78,373	13.1	0	6.97	2.28	-
255	Electric	380,590	55.7	0	376,264	42.5	0	0.99	0.76	-
120	Gas	0	0.0	69,375	0	0.0	63,323	-	-	0.91
123	Gas	0	0.0	85,282	0	0.0	85,282	-	-	1.00
124	Gas	0	0.0	60,433	199,946	0.0	63,931	-	-	1.06
125	Gas	0	0.0	8,656	0	0.0	4,639	-	-	0.54
127	Gas	0	0.0	44,616	0	0.0	180,526	-	-	4.05
128	Gas	0	0.0	201,450	0	0.0	56,743	-	-	0.28
129	Gas	0	0.0	159,055	0	0.0	208,975	-	-	1.31
130	Gas	0	0.0	17,384	139,968	19.3	7,259	-	-	0.42
131	Gas	0	0.0	165,161	0	0.0	108,680	-	-	0.66
134	Gas	0	0.0	146,923	0	0.0	154,194	-	-	1.05
136	Gas	0	0.0	328,510	-10,530	-1.2	293,656	-	-	0.89
140	Gas	0	0.0	178,213	30,519	15.0	210,827	-	-	1.18
148	Gas	31,284	10.0	104,585	7,699	0.0	36,403	0.25	0.00	0.35
149	Gas	32,144	11.0	100,685	13,771	0.0	85,032	0.43	0.00	0.84
156	Gas	0	0.0	186,671	0	0.0	127,301	-	-	0.68
159	Gas	0	0.0	291,748	0	0.0	341,721	-	-	1.17
160	Gas	0	0.0	118,233	0	0.0	147,267	-	-	1.25
161	Gas	0	0.0	30,336	0	0.0	16,345	-	-	0.54
162	Gas	0	0.0	130,545	0	0.0	48,027	-	-	0.37
167	Gas	0	0.0	795,029	0	0.0	571,997	-	-	0.72
244	Gas	777	0.0	1,520	1,412	0.0	8,284	1.82	-	5.45
245	Gas	321,984	61.9	8,358	256,560	71.6	219,535	0.80	1.16	26.27
246	Gas	0	0.0	156,472	0	0.0	115,635	-	-	0.74
247	Gas	51,040	4.6	106,720	52,483	18.8	66,995	1.03	4.09	0.63
248	Gas	146,223	68.5	262,542	84,558	0.0	187,520	0.58	0.00	0.71
249	Gas	0	0.0	195,793	0	0.0	187,399	-	-	0.96
250	Gas	1,597	0.0	245,354	-320,036	-29.4	229,338	-200.37	-	0.93
251	Gas	196,054	35.4	178,880	0	0.0	40,615	0.00	0.00	0.23
252	Gas	1,315,925	219.9	639,004	1,083,596	271.7	330,348	0.82	1.24	0.52
253	Gas	978,805	169.9	1,697,071	1,369,409	226.2	1,601,270	1.40	1.33	0.94
Total		34,618,229	6,701.8	6,714,604	19,167,795	2,949.0	5,794,483	0.55	0.44	0.86

Figure 3 provides a graphical comparison of ex-ante and ex-post kWh savings. The diagonal line in the figure shows points where ex-ante and ex-post results would be equal. Points below the line represent sites where ex-post results are lower than ex-ante results. As this figure shows, the project with the largest ex-ante savings had relatively low ex-post savings (site 154-155).

Figure 3: Comparison of PG&E Ag-Food Program Ex-Ante and Ex-Post Electric Savings



In order to better distinguish the smaller projects, a similar comparison is shown in Figure 4, but excludes these two large projects. This figure demonstrates that a majority of projects have ex-post savings that fall below ex-ante savings. However, there are a number of medium- to large-sized projects with ex-post savings that are greater than ex-ante savings. A few of the projects are associated with negative savings.

Figure 4: Comparison of PG&E Ag-Food Program Ex-Ante and Ex-Post Electric Savings, Excluding Two Large Projects

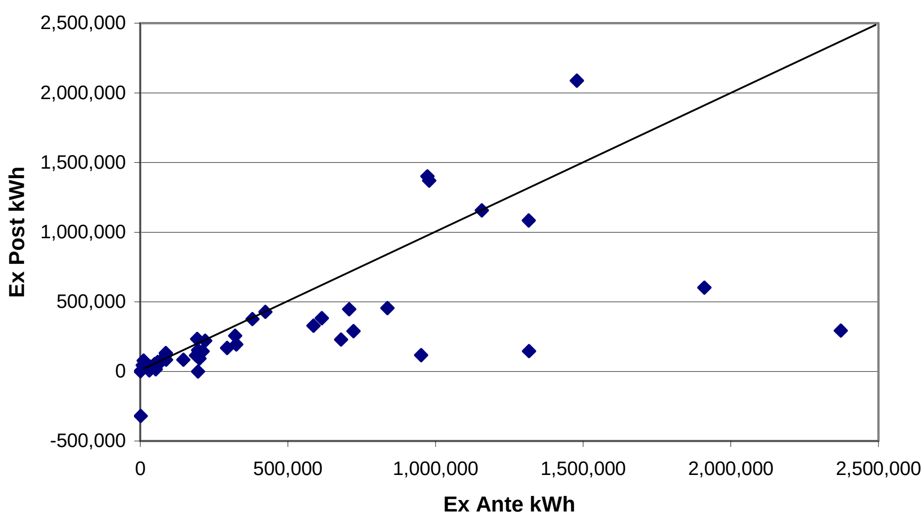


Figure 5 shows similar results to the previous figures for electric kW impacts. Similar to the kWh results, two particularly large projects show much lower savings than expected in the ex-ante estimates. Figure 6 shows the ex-ante/ex-post comparison after removing these two projects. The pattern is similar to the kWh charts. A number of projects were determined to have zero peak-demand impacts.

Figure 5: Comparison of PG&E Ag-Food Program Ex-Ante and Ex-Post Electric Peak Savings

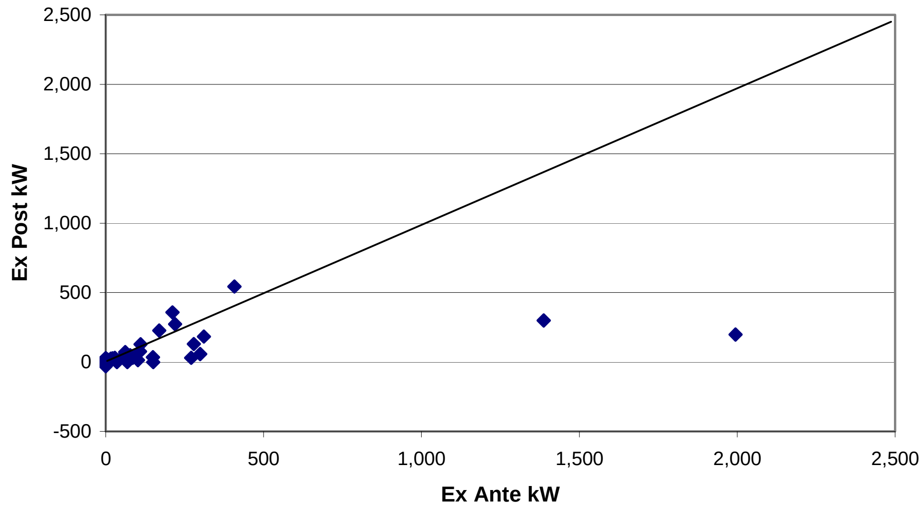
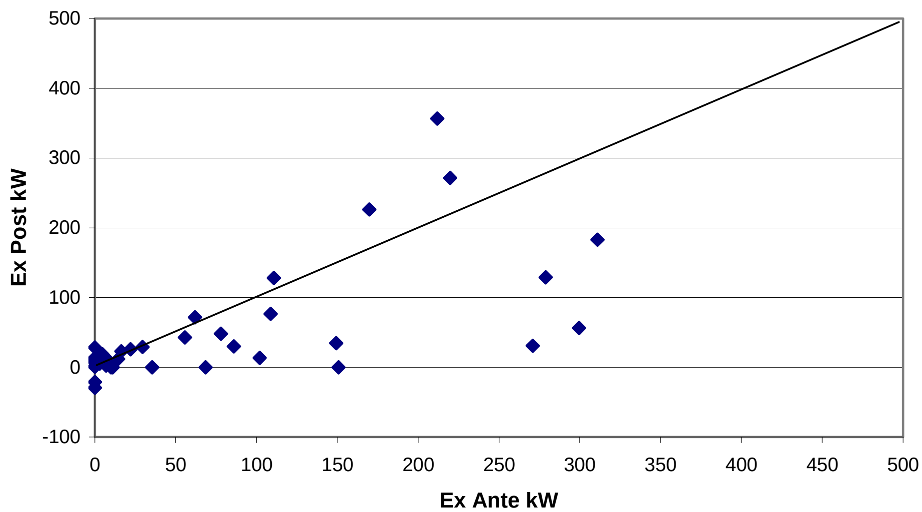


Figure 6: Comparison of PG&E Ag-Food Program Ex-Ante and Ex-Post Electric Peak Savings, Excluding Two Large Projects



Ex-ante and ex-post gas impact estimates are compared in Figure 7. Figure 8 shows the same comparison, excluding the three largest projects. As can be seen in the second gas figure, a majority of the projects have ex-post impacts that are lower than ex-ante impacts. However, a few of projects show ex-post impacts that are significantly higher than ex-ante predictions.

Figure 7: Comparison of PG&E Ag-Food Program Ex-Ante and Ex-Post Gas Savings

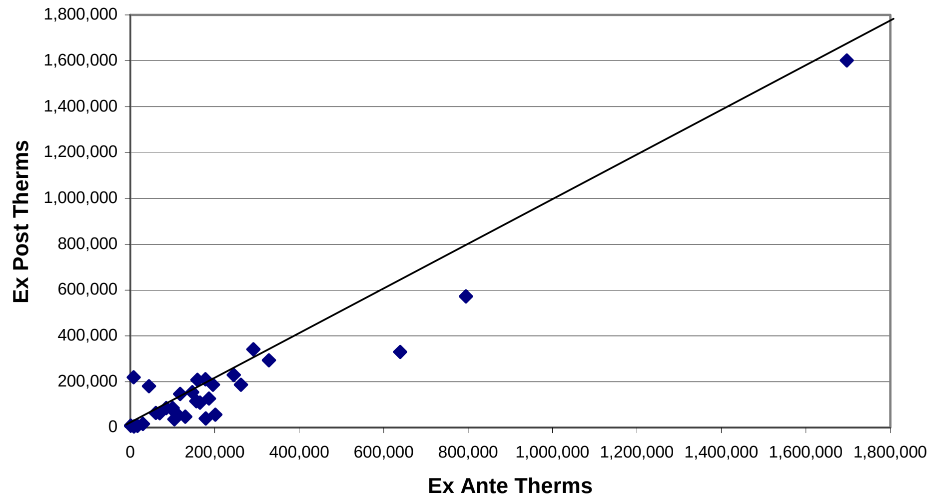
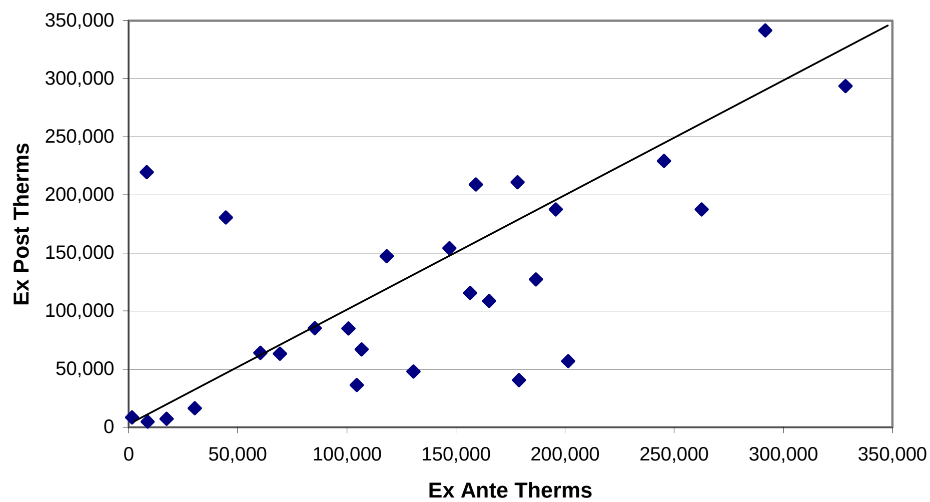


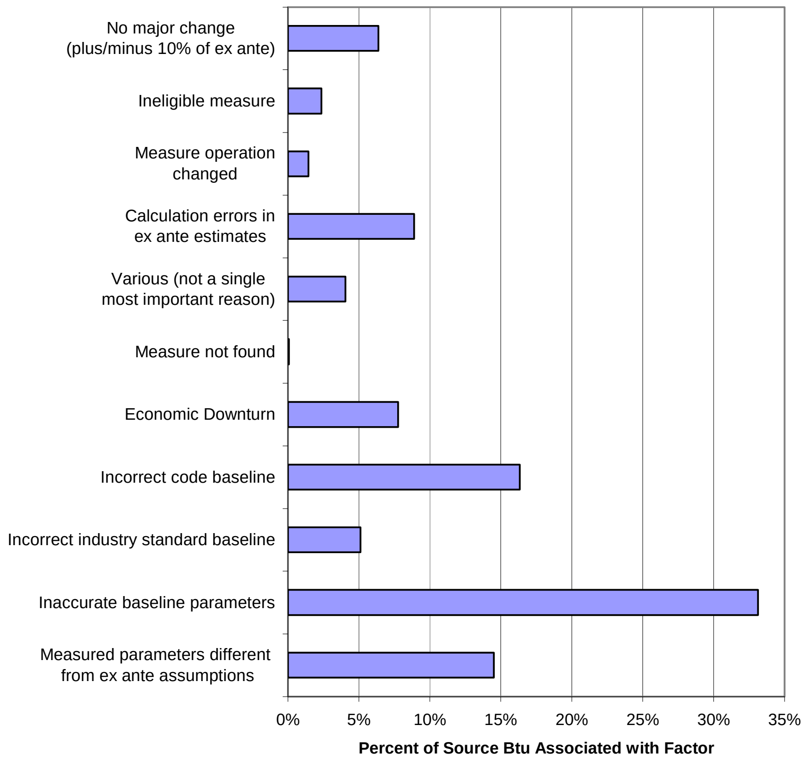
Figure 8: Comparison of PG&E Ag-Food Program Ex-Ante and Ex-Post Gas Savings, Excluding Three Large Projects



5.1.1.1 Factors causing Discrepancies between Ex-Ante and Ex-Post Impacts

Site engineers were asked to provide the key factors causing discrepancies between ex-ante and ex-post impacts. Figure 9 shows which discrepancy factors were determined to be most important in explaining differences between the ex-post evaluation calculations and the ex-ante impact estimates. As the figure shows, baseline-related factors account for many of the discrepancies (as over 50% of the discrepancies, weighted by source Btu, are associated with baseline factors). Other important discrepancy factors include calculation errors in the ex-ante analysis and measure parameters performing differently than expected from the ex-ante assumptions.

Figure 9: Discrepancy Factors for PG&E Ag-Food Program



5.1.2 Site-Specific Net-to-Gross Results

Table 50 provides a summary of the net-to-gross results for the surveyed PG&E Ag-Food Program projects. As discussed in the methodology section, the estimated NTGR is an average of three scores: a timing and selection score that reflects the influence of the most important of the program elements in the customer's decision to select the program measure; a program influence score that captures the perceived influence of the program relative to non-program factors in the decision to implement the measure; and a no-program score that captures the likelihood of various actions the customer might have taken in the absence of the program.

As the table shows, NTGRs range from a low of 0.00 to a high of 1.00. The unweighted average NTGR for the PG&E Ag-Food Program is 0.65.

Table 50: Summary of Project-Specific PG&E Ag-Food Program Net-to-Gross Results

Site ID	Timing and Selection Score	Program Influence Score	No-Program Score	NTGR
120	10	5	4.9	0.66
121	9	5	5.0	0.63
124	10	5	7.1	0.74
125	8	3	1.4	0.22
126	7	2.5	6.0	0.52
132	6	7	7.7	0.69
135	9	3	3.1	0.50
136	9	5	1.0	0.30
137	10	10	10.0	1.00
138	8	5	6.6	0.65
139	8	4	0.0	0.20
140	10	5	7.7	0.76
143	10	5	10.0	0.83
144	10	5	10.0	0.83
145	8	8	10.0	0.87
146	10	3	10.0	0.77
150	10	5	0.0	0.25
152	5	4	4.0	0.43
153	10	5	10.0	0.83
154	9	8	10.0	0.90
155	9	8	10.0	0.90
159	10	6	10.0	0.87
160	10	6	10.0	0.87
161	10	7	10.0	0.90
162	8	6	10.0	0.80
163	8	6	10.0	0.80
164	10	3	0.0	0.15
165	9	8	6.6	0.79
166	10	10	6.6	0.89
167	10	-	10.0	1.00
168	10	5	5.0	0.67
231	8	10	3.0	0.70
234	4	2	2.0	0.27
236	10	8	10.0	0.93
237	10	6	7.1	0.77
240	8	8	0.0	0.40
241	8	3	1.0	0.20
242	10	5	10.0	0.83
244	5	2	4.0	0.37
245	10	4	9.1	0.77
246	9	2	8.0	0.63
252	4	0	0.0	0.00
253	10	4	10.0	0.80
254	10	5	3.0	0.60

5.2 Validity and Reliability for the PG&E Agricultural and Food Processing Program Evaluation

The primary factors affecting the validity and reliability of the PG&E Ag-Food Program evaluation are:

- Executing the appropriate engineering analysis

- Developing the appropriate base case to calculate savings from
- Accurately measuring equipment performance
- Assessing impacts at the appropriate production levels
- Extrapolating short-term results to a full year.

Below, we address each of these factors and discuss steps that were taken to minimize uncertainty in impact estimates resulting from these factors.

Execution of the analysis. Choosing an appropriate analysis approach that makes the best use of the available data and correctly executing the analysis approach are key factors in any engineering analysis. For this study, there were two rounds of review for every analyzed project. First, site plans were developed and extensively reviewed. Then, evaluation reports were prepared under guidance of senior engineers, and these reports also received considerable review. In each case, the plans and reports were reviewed internally by senior engineers on the KEMA team, and subsequently the plans and reports were reviewed by the ED staff and their technical consultants, who provided an additional level of review to ensure that each project analysis approach was given appropriate attention in order to minimize errors.

Developing the base case. Since the evaluation relied solely on ex-post site inspections, it was usually not possible to observe pre-retrofit equipment and conditions. In many, but not all, cases, project files contained adequate documentation to support the estimation of base-case energy use. Project engineers relied on a number of approaches to support the base-case analysis, including discussions with customers about the pre-retrofit equipment and operations; observation of other, similar equipment located on site; research into industry standard practices; and review of environmental factors that could affect the choice of base-case equipment. Improved utility project documentation, including pre-retrofit metering and collection of pre-retrofit production data, could greatly reduce base-case-related uncertainty.

Measuring equipment performance. For many sites, metering, monitoring, or extraction of customer performance data could be used to measure equipment performance. In a number of cases (e.g., gas boilers), assessing equipment performance was not as straightforward. In these cases, site engineers relied on project documentation, equipment specifications, discussions with customers, and indirect measurements to assess equipment performance. Pre- and post-retrofit billing data were also utilized, when appropriate and were adequately linked to the equipment in question, to assess performance.

Determining appropriate production levels. Many projects involved sites where production was likely to vary, from season-to-season and year-to-year, due to the variable nature of the agricultural industry, which is weather and crop dependent. Complicating matters is the fact that many customers do not maintain (or are not willing to share) adequate production records. When production records were not available, project engineers used a variety of approaches to determine correct production levels from which to base energy savings. These approaches included observation of current operations, discussions with customers, review of utility bills, and observation of equipment capacities.

Annualization. Because field measurements usually occurred over a two- to four-week period, extrapolation of short-term results to a full year and beyond was a significant source of uncertainty in the estimation of savings. The annualization task was particularly difficult for this evaluation due to the variable nature of the agricultural industry. A number of approaches were used to increase the reliability of the annualization process: review of production records when available, discussions with customers about how annual operations related to the operations observed during the measurement period, review of utility bills, simple correlations of measured parameters to weather data, and modeling of the relationships between energy use and weather with programs, such as eQuest.

Project engineers used judgment and the site planning and review process to select appropriate evaluation approaches in order to address and minimize key sources of uncertainty for each project. Overall, judgment-based estimates of uncertainty ranged from about 5% to 20% across sites. However, there were a few sites where engineering precision levels exceeded 20%.

5.3 Program Specific Results for the PG&E Agricultural and Food Processing Program Evaluation

Project-specific results were weighted and expanded to program-level results using the approaches described above in the methodology section. This subsection reports on these measure-level results for the PG&E Ag-Food Program.

5.3.1 PG&E Agricultural and Food Processing Program-Level Gross Savings

Table 51 presents the program-level gross realization rate for the PG&E Ag-Food Program and associated precision estimates. As shown, the estimated realization rates for kWh, kW, and therms are 0.68, 0.52, and 1.07, respectively, with respective relative precisions of ±17%, ±30%, and ±25% at the 90% confidence level. These relative precisions are below the targeted precision of ± 10%. In designing the PG&E Ag-Food Program gross impact sample, an error ratio of 0.40 was assumed. The calculated error ratios for this program were 0.78, 0.99, and 1.40 for kWh, kW, and therms, respectively. This indicates that there was more variability in the relationship between ex-ante and ex-post impacts than was initially expected. Given this finding, it would make sense to increase sample sizes for similar evaluations if ± 10% precision at the 90% confidence level is desired.

One should also note that the gas error ratio was strongly influenced by an outlier site. If one particular site with a very large realization rate is removed from the sample, the gas error ratio declines to 0.59 and the relative precision improves to 16%. The gas realization rate also declines to 0.93.

Table 51: PG&E Ag-Food Program Realization Rate and Precision Estimates

Result	kWh	kW	Therms
Realization Rate	0.68	0.52	1.07
Standard Error	0.070	0.096	0.160
Error Bound - 90% Confidence Level	0.115	0.158	0.264
Relative Precision	16.9%	30.4%	24.6%
Error Ratio	0.78	0.99	1.40

Table 52 presents the mean savings calculated for dual-fuel impact sites where the program omitted savings for one of the fuels. These results are necessary to calculate total program impacts, since a ratio estimation approach is not viable when there are zero ex-ante savings. Overall, mean-per-project impacts are relatively modest, especially for gas, where omitted gas savings were determined at only one sampled project. Given the limited number of projects where omitted savings occur (four electric and one gas), relative precision is not very good, at over 100% for each for kWh, kW, and therms.

Table 52: PG&E Ag-Food Program Mean Savings and Precision Estimates for Omitted Impacts

Result	kWh	kW	Therms
Mean	25,418	1.6	-48
Standard Error	16,989	1.4	48
Error Bound - 90% Confidence Level	27,947	2.4	79
Relative Precision	110%	149%	-165%

The overall PG&E Ag-Food Program savings (excluding the commercial new construction projects) are calculated by applying the estimated realization rates and the mean energy savings to program tracking data. Table 53 summarizes the results, which are broken out by included impacts (those covered in the program tracking data), omitted impacts, and combined impacts. Overall, the measures installed through the PG&E Ag-Food Program during the 2006-2008 period have estimated first-year savings of 84 GWh, 10.3 MW, and 9.9 million therms. The respective 90% confidence intervals are estimated to be 68 to 100 GWh, 7.0 to 13.5 MW, and 7.4 to 12.4 million therms.

Table 53: PG&E Ag-Food Program-Level Gross Impacts

Impact Type	Result	kWh	kW	Therms
Included Impacts	Ex-Ante Savings	120,778,653	19,504	9,229,753
	Realization Rate	0.68	0.52	1.07
	Ex-Post Savings	82,194,017	10,141	9,896,878
	Relative Precision	16.9%	30.4%	24.6%
	Lower Bound, 90% Confidence Interval	68,331,455	7,058	7,461,866
	Upper Bound, 90% Confidence Interval	96,056,579	13,225	12,331,889
Omitted Impacts	Number of Projects	76	76	650
	Mean Use	25,418	2	-48
	Ex-Post Savings	1,931,740	121	-31,270
	Relative Precision	110.0%	148.7%	-164.5%
	Lower Bound, 90% Confidence Interval	-192,226	-59	-82,710
	Upper Bound, 90% Confidence Interval	4,055,705	301	20,169
Combined Impacts	Ex-Post Savings	84,125,757	10,262	9,865,607
	Relative Precision	19.0%	31.8%	25.2%
	Lower Bound, 90% Confidence Interval	68,139,230	6,999	7,379,157
	Upper Bound, 90% Confidence Interval	100,112,284	13,526	12,352,058

5.3.2 PG&E Agricultural and Food Processing Program-Level Net Savings

Table 54 presents the overall, energy-weighted NTGRs and the associated precision estimates for the PG&E Ag-Food Program. As shown, the estimated NTGRs are 0.70 for kWh, 0.78 for kW, and 0.69 for therms, with respective relative precisions of ±14.6%, ±14.1%, and ±16.1% at the 90% confidence level. The inability to complete all NTG surveys in the sample was a major reason the relative precisions were below the targeted ±10% precision level. We were only able to complete 29 out of 41 electric NTG surveys and only 15 out of 30 gas NTG surveys.

Table 54: PG&E Ag-Food Program Net-to-Gross Ratios and Precision Estimates

Result	kWh	kW	Therms
Net-to-Gross Ratio	0.70	0.78	0.69
Standard Error	0.062	0.067	0.067
Error Bound - 90% Confidence Level	0.102	0.110	0.111
Relative Precision	14.6%	14.1%	16.1%

Combining the NTGR results with the gross savings results provide estimates of net savings for the PG&E Ag-Food Program (again, excluding the commercial new construction projects). Table 55 shows the results. Overall, the net savings for the PG&E Ag-Food Program are estimated at 59 GWh, 8.0 MW, and 6.8 million therms.

Table 55: PG&E Ag-Food Program-Level Net Savings Estimates

Impact Type	Result	kWh	kW	Therms
Included Impacts	Ex-Post Gross Measure Savings	82,194,017	10,141	9,896,878
	Net-to-Gross Ratio	0.70	0.78	0.69
	Net Measure Savings	57,388,148	7,916	6,820,150
	Lower Bound, 90% Confidence Interval	44,566,739	5,254	4,809,694
	Upper Bound, 90% Confidence Interval	70,209,557	10,577	8,830,606
Omitted Impacts	Ex-Post Gross Measure Savings	1,931,740	121	-31,270
	Net-to-Gross Ratio	0.69	0.69	0.70
	Net Measure Savings	1,331,203	83	-21,833
	Lower Bound, 90% Confidence Interval	-154,878	-42	-58,029
	Upper Bound, 90% Confidence Interval	2,817,284	209	14,363
Combined Impacts	Ex-Post Gross Measure Savings	84,125,757	10,262	9,865,607
	Net-to-Gross Ratio	0.70	0.78	0.69
	Net Measure Savings	**58,719,351**	**7,999**	**6,798,317**
	Lower Bound, 90% Confidence Interval	44,411,861	5,212	4,751,665
	Upper Bound, 90% Confidence Interval	73,026,841	10,786	8,844,969

Table 56 compares the ex-ante and ex-post estimates of net savings for the PG&E Ag-Food Program. The overall net realization rates are estimated to be 0.61 for kWh, 0.51 for kW, and 1.02 for therms, indicating that the program is saving about 61% of the ex-ante net kWh estimate, 51% of the kW estimate, and 102% of the natural gas estimate.

Table 56: PG&E Ag-Food Program Comparison of Net Program-Level Ex-Ante and Ex-Post Results

	kWh		kW		Therms	
Result	Ex Ante	Ex Post	Ex Ante	Ex Post	Ex Ante	Ex Post
Gross Measure Savings	120,778,653	84,125,757	19,504	10,262	9,229,753	9,865,607
Net-to-Gross Ratio	0.79	0.70	0.80	0.78	0.72	0.69
Net Measure Savings	95,598,936	58,719,351	15,667	7,999	6,653,438	6,798,317
Net Realization Rate		0.61		0.51		1.02

5.4 Discussion of Findings for the PG&E Agricultural and Food Processing Program Evaluation

In this subsection, we discuss findings and recommendations gleaned during the evaluation of the PG&E Ag-Food Program. We divide our discussion into two topic areas: findings and recommendations directed toward the PG&E Ag-Food Program and findings and recommendations directed to the evaluation of this program.

5.4.1 Program-Related Findings and Recommendations

Following are the key program-related findings and recommendations:

Baseline. Baseline definitions affected realization rates more than any other factor. It was both the most common "primary" reason (32% of evaluated projects) for ex-post impacts to deviate from ex-ante impacts by more than 10% and also was commonly cited in projects with low realization rates. For example, the simple average electric-energy realization rate was 35% for the seven projects that used an inappropriate industry-standard baseline definition in the ex-ante savings calculations. The simple average gas realization rate for the 15 projects that used inappropriate baseline parameters was 29%.

Most often, the discrepancy was due to the IOU program administrators having used or allowed use of existing conditions to define the baseline when the evaluators used other project-specific circumstances at the time of decision-making to define baseline. Examples of projects with differing baseline definitions included:

- Boiler replacement. Engineers evaluated multiple projects associated with boiler replacement. Some of them turned out to be driven by the need to comply with increasingly stringent California emissions standards. In one case, while the pre-existing boiler theoretically could have been retrofitted through installation of a new low NO_x burner or a selective catalytic reduction (SCR) device, evaluators concluded that circumstances at the site—boiler age, alternative retrofit cost, other related projects happening at the same time—meant that retrofit was not a viable economic alternative for the customer. It was improbable that the pre-existing boiler would have been retained. Thus evaluators used the characteristics of an industry-standard new boiler instead of the less efficient pre-existing boiler as the baseline.
- Wine-tank insulation. The IOU used no insulation as the baseline for a new tank installed at a large winery. Evaluators cited an IOU-funded report that concluded that one inch of insulation was standard practice for large winery tanks and was particularly common for outside tanks. The measure was for installation of two inches of insulation. The change in baseline from no insulation to one inch of insulation reduced measure savings by over 90%.
- Air compressor controls. In a project where the applicant bought an oil-free compressor controlled with a variable speed drive, the IOU defined the baseline compressor as an otherwise identical one controlled with less efficient throttle modulation. Evaluators researched the market and found that no such equipment exists in the oil-free market at this size and pressure class and, in fact, could not find any compressor with less efficient part load cfm/kW than the one purchased, thus all savings were negated.

Peak Demand Definition. Evaluators did not review a single project in which the applicant computed demand savings on the same basis as that defined by the evaluation protocols. Unsurprisingly, the peak demand realization rates varied tremendously. The unweighted coefficient of variation for demand savings realization rate was 115%. We recommend that program staff be educated regarding the definition upon which their projects will be evaluated and that custom projects have demand savings calculated using a basis that reflects this definition, or something that reflects the same effect.

Remaining Useful Life Definition. Evaluators judged 10% of the projects as early retirements. These seven projects are likely to realize a higher level of savings during an early period and lesser savings in later years. To our knowledge, none of the IOU projects claimed savings on this two-tiered basis; all reported the first-year savings for the duration of the measure life. This methodological discrepancy regarding the remaining useful life (RUL) systematically inflates the IOU savings estimates compared to evaluators' judgment and depresses the evaluated lifetime savings realization rate. The evaluation team recommends that the IOUs incorporate RUL into custom-project savings calculations in order to be able to properly assess lifetime savings for incentives and reporting.

Three-prong test integration into SPC software. Ag-Food's sample included two fuel switching projects that do not appear to have been subjected to the requisite "three-prong" test to ensure that the measures resulted in net energy savings, net emissions reduction, and passed cost-effectiveness tests. The IOUs may want to consider integrating such an assessment into the Standard Performance Contract (SPC) software.

Third-party review team independence. Many evaluated projects had been subject to prior review and/or management by IOU-funded third-party contractors. There was evidence in program materials of relationships that may have been allowed to get too familier. For example, one controls developer asked that a particular third-party review firm to work with them on a project due to prior satisfactory experience. That firm's subsequent reviews largely affirmed the adequacy of the developer's approach and projections rather than independently developing their own. Evaluators found that particular set of calculations to markedly overestimate savings.

In another project associated with a centrifugal air compressor, pre-implementation approval was appropriately based on a more efficient compressor than the theoretical baseline and thus the compressor was to be eligible for incentive. However, the post-implementation site visit by the IOU-funded third-party consultant found a different, less-efficient compressor installed. Due to a sequence of events untraceable by evaluation staff, the post-implementation verification savings calculations changed in a fashion favorable to the applicant without apparent change in baseline equipment, presumed circumstances, or computational method. Evaluators found the initial pre-implementation estimates to be much closer to the evaluated savings, and the IOU suffered in this evaluation by having a low realization rate for the sampled project applied to both that project and others it represented in the population. We recommend that the IOU redouble its efforts to keep third parties vigorously and independently scrutinizing projects, especially in instances where there is deviation in the installed and proposed equipment.

Demand more measurement on large projects. There were several projects with very large savings and large incentives under consideration for which there also was great uncertainty in savings projections due to their almost entirely theoretical basis. The basis may have included a few spot measurements but little logging of performance over time. This was more likely to happen with gas savings projects. The evaluation team was able to substantially improve on estimates with equipment measurement. It would seem that more measurements would be warranted in these multi-million dollar projects and be beneficial to the customers paying for them for the IOU to insist on more logging to substantiate savings projections.

Custom pump-retrofit projects. The agricultural pump-retrofit program basis of estimating incentives and savings generally appears to work very well, particularly for pumping applications that deliver water to a static situation (permanent crop, same acreage, and no other water sources). Applications that involve other irrigation water sources and loads that vary (i.e., availability of surface water from an irrigation district, annual changes in cropping, or winter rainfall) result in much more complex evaluations, and the levels of uncertainty increase significantly. While the IOU may not deem it worthwhile to complicate the incentive determination process, it is worth considering custom savings' analysis for the purpose of energy-savings reporting to the CPUC. Specifically, evaluation of long-term energy savings would benefit by not simply accepting the prior twelve months' electricity usage as representative of long-term future flow requirements and instead rigorously interview on prospects, use 24- or 36-month histories, or both.

Good methodology. While there were exceptions as noted above, overall the engineering evaluation team found the computational approaches used by the IOU, their third party contractors, and applicants to be both appropriate and defensible. Differences in savings estimates tended to be due to baseline issues or different input values due to measurement, judgment, or changes in production. The underlying methodologies were sound and executed calculations were relatively error-free.

5.4.2 Evaluation-Related Findings and Recommendations

The following findings and recommendations are directed at the evaluation process, including utility integration with the evaluation process:

Expand the field work calendar time period. The evaluation schedule resulted in virtually all of the large commercial, industrial, and agricultural site work and analysis to occur over a five-month period. The consolidated schedule meant that evaluation teams had to use more, different engineers to perform the evaluations than if the same amount of technical work had occurred over a longer period. The larger teams, and predominantly coincident work, meant more individuals needed training and management oversight. While perhaps healthy for the long-term development of the energy evaluation profession, ED technical consultants and evaluation team quality-control staff had to correct some of the same project-analysis problems repeatedly with different individuals rather than correct them for fewer individuals and then enjoy the benefits of having lessons learned on the first few projects applied to subsequent ones. To illustrate: the Ag-Food team assigned 14 different lead engineers to ensure we could meet schedule requirements, an average of less than five projects per lead. A longer schedule could have allowed an increase to the number of projects per lead, a reduction in training and quality-control costs per site, and increased quality. A more extended M&V period also would have allowed for better data collection on certain seasonal measures.

The evaluation plan process is worthwhile but needs to be streamlined. Overall, the team found the rigorous evaluation-plan review process worthwhile but unduly time consuming. One approach for streamlining the planning process would be to build more flexibility into the plans. Instead of planning for a specific analysis approach for a project, the plan might need to identify several of the most likely analysis approaches and build more data collection flexibility into the field work. This flexibility might require more site data collection in order to support several analyses options (versus one narrow option), but the collection of more data in a single site visit may be preferable to having to revisit a site to collect data required by a change in analysis approach.

The IOUs should collect and provide more pre-retrofit measured data. This contract group conducted a post-retrofit-only evaluation. The greatest evaluation uncertainties were in estimating baseline conditions and pre-retrofit production rates. In general, the IOUs and their applicants did an excellent job of performing appropriate spot measurements, such as combustion efficiency tests. More periodic measurements would have helped greatly. In at least one case, the manufacturer's process control system collected exactly the data evaluators desired, but only stored it for six months, and valuable pre-retrofit data was unutilized. We sympathize with developer's sense of urgency in selling projects, not wanting to wait for data collection, and the logical challenges that pre-retrofit data collection involves. Nonetheless, it would be to the IOUs' benefit to selectively insist on pre-retrofit logged data collection to better support their savings claims.

In addition to pre-retrofit equipment measurements, we also recommend that the IOUs better document pre-retrofit operating levels and production levels. For some projects investigated by the Ag-Food team, it was difficult to normalize pre-retrofit and post-retrofit equipment operation, because there was no way to clearly distinguish between changes in efficiency and changes in operation levels.

Project application materials. An initial step in conducting a project-specific evaluation, such as the one conducted for the PG&E Ag-Food Program, is performing a detailed review of the IOU-supplied project files. For the 2006-2008 program period, PG&E stored many of the project application files in hardcopy format, and in some cases at remote storage facilities. PG&E's ability to provide project files in a timely manner was severely limited. In one case, it took PG&E about 2 months to provide project files for a set of projects requested by the Ag-Food team. We recommend that in the future PG&E store its project files electronically – ideally in their native format (Excel workbooks, Word documents, etc.), but at least in PDF format (through the scanning of hardcopy documents). With electronic filing of project documents, retrieval would be much quicker and would allow for more efficient evaluation of PG&E programs.

In addition to electronic document storage, we recommend that PG&E does a better job organizing project files. It would save the evaluators time and improve their understanding of the project if they were to receive only the last email in strings rather than the initial one, then the response plus the initial one, then the response to the response plus the initial one, etc. In some cases, the materials included three or four copies of the same document. It took time to affirm they were in fact replications and not later iterations.

Program tracking data. While PG&E's program tracking system structure itself seems more than adequate to support impact evaluations, we recommend that PG&E do a better job of populating the fields associated with custom projects. In particular, the "Project Description" field should be more consistently and completely populated with a clear description of the custom projects such that a third party, with no inside understanding of the projects, can gain a sense of the end uses affected and measures installed as part of a project. Some examples of 2006-2008 project descriptions include:

- "Customer X Rendering Building"
- "Customer Y / air compressor"
- "Customer Z / Gas project"

These types of descriptions make it very difficult to understand the populations of projects in a program and leads the evaluator down one of two paths: (1) develop an evaluation design that avoids the need for project-specific information for the population, leading to less efficient and less precise evaluation results; or (2) request that PG&E provides detailed project files for all projects in the program, and not just a sample, leading to extra work for PG&E to extract all these files and extra work for the evaluator to review and categorize all these files.