Contract Group H

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

Volume 2: Appendices A-C

CALMAC Study ID: CPU0024.02

Prepared by:

KEMA, Inc.
ERS, Inc.
ADM Associates
California AgQuest Consulting
Robert Thomas Brown Company
Itron, Inc.

For the
California Public Utilities Commission, Energy Division

February 10, 2010

Table of Contents

A Glossary of Acronyms

ACE	The ACE Project software is used by the evaluation to store and exchange important information between evaluation team members. For example the M&V plans and reports prepared for each sampled measure are uploaded to ACE for MECT/DMQC review, CPUC approval and sharing between contract groups.
Ag-Food	Agriculture and food processing
BEEP	(Business Energy Efficiency Program)-This local non-residential program consists of four program elements that meet the diverse needs of SCG's non-residential gas customers.
BISP	(Business incentive and Services Program)-This non-residential conservation program, offered by SCE to its non-residential customers, consists of three components – Standard Performance Contract (SPC), Express Efficiency (EE) and Non-residential Audit (NRA).
CASE	Combined Approach to Solar and Efficiency
CIMIS	California Irrigation Management Information System
CPUC	(California Public Utilities Commission), the sponsor of the evaluation.
CV	Coefficient of variation
CZ	Climate zone
DEEP	Dairy Energy Efficiency Program
DEER	(Database for Energy Efficient Resources) -The California Energy Commission and California Public Utilities Commission (CPUC) sponsors this database designed to provide well-documented estimates of energy and peak demand savings values, measure costs, and effective useful life (EUL) all with one data source. DEER has been has been designated by the CPUC as its source for deemed and impact costs for program planning.
DMQC	(The Data Management and Quality Control Contractor)-A group of consultants with specialized expertise in important aspects of program impact evaluation that are technical advisors to ED staff and MECT on issues related to data management and quality control.
ED	Energy Division of the CPUC
EEGA	Energy Efficiency Groupware Application - The CPUC's central repository for utility submitted monthly, quarterly, and annual reports.
EM&V	Evaluation, Measurement, Monitoring and Verification.

ERT	(Evaluation Reporting Tool)-The database application that was created by ED to support the final estimates of program level life cycle costs and savings for the 2006-08 program cycle.
ESB	(Energy Savings Bid)-A local non-residential energy-efficiency incentive program that is designed for large commercial or industrial efficiency projects that require more flexibility than is offered by the statewide SPC program. A project may include a single customer or an aggregation of customers at multiple sites.
EUL	(Effective Useful Life)-An estimate of the median number of years that the measures installed under a program are still in place and operable.
Guidelines	*Guidelines for Estimating Net-To-Gross Ratios Using the Self-Report Approaches*
HIM	(High-Impact Measure)-A group of measures within each IOU that account for the majority of utility reported annual energy and demand savings during the 2006/2008 program cycle.
HVAC	(Heating, Ventilation and Air-Conditioning)-End-use classification of mechanical equipment that is used to condition spaces in commercial and industrial facilities.
IOU	(Investor-Owned Utilities)-They include Pacific Gas and Electric (PG&E), Southern California Edison (SCE)-San Diego Gas and Electric (SDG&E) and Southern California Gas.
IPMVP	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.
MECT	(Master Evaluation Contractor Team)-A group of consultants with specialized expertise in important aspects of program impact evaluation that are technical advisors to ED staff and assist the evaluation contractors with development and execution of the verification and evaluation plans.
M&V	Measurement and verification
NRA	(Non-residential Audits)–One of the conservation programs offered by Southern California Edison to its non-residential customers. It is offered as one of the components of the SCE2517 program. Non-residential audits are also offered as part of the SCG3503 Education and Training program.
NTG	(Net-to-Gross) Ratio–A ratio that is estimated from a free-ridership analysis and applied to gross savings to calculate net savings.
PG&E	(Pacific Gas and Electric)-One of the three investor-owner utilities that are regulated by the California Public Utilities Commission.

PGC	(Public Goods Charge)-Per Assembly Bill (AB) 1890, a universal charge applied to each electric utility customer's bill to support the provision of public goods. Public goods covered by California's electric PGC include public purpose energy efficiency programs, low-income services, renewables, and energy-related research and development.
Protocols	*California Energy Efficiency Evaluation: Protocols: Technical, Methodological, and Reporting Requirements for Evaluation Professionals*
RUL	remaining useful life
SC	shading coefficient
SCE	(Southern California Edison)-One of the three investor-owner utilities that are regulated by the California Public Utilities Commission.
SCG	(Southern California Gas)-A gas utility owned by Sempra. Sempra is one of the three investor-owner utilities that are regulated by the California Public Utilities Commission.
SCR	selective catalytic reduction
SDG&E	(San Diego Gas and Electric)-A gas and electric utility owned by Sempra. Sempra is one of the three investor-owner utilities that are regulated by the California Public Utilities Commission.
SPC	(Standard Performance Contract)-A statewide conservation program offered by the investor owned utilities to their non-residential customers. This program meets customer needs by being open to an unlimited variety of energy efficiency retrofit projects involving commercial, industrial, and agricultural facilities.
SRA	self-report approach
Title 20/24	California's 2005 Building Energy Efficiency Standards (Title 24), and Appliance Efficiency Regulations (Title 20), specify minimum energy-efficiency standards for new installations or remodels of sufficient scope to require a permit. The 2005 Title 24 regulations were in effect during the entire period covered by the Evaluation. The 2005 Title 20 standards were amended in December 2007.
TRC	(Total Resource Cost) test–A cost-effectiveness test used by the California Public Utilities Commission to assess the overall cost-effectiveness of energy-efficiency programs from a societal perspective.
VRT	(Verification Reporting Template)–The database application that was created by ED to support the first and second year verification reports.
UES	(Unit Energy Savings)-Energy savings for an efficiency measure, expressed as annual savings divided by the total equipment count.

B Net-to-Gross Analysis Detail

This appendix contains the following elements:

- Detailed methodology for the nonresidential self-report NTG analysis, including survey instruments
- Survey results for greenhouse heat curtain NTG analyses
- Survey results for greenhouse infrared film NTG analyses
- Survey results for Ag-Food NTG analyses
- Summary write-ups for Ag-Food large-project NTG analyses

Methodological Framework for Using the Self-Report Approach to Estimating Net-to-Gross Ratios for Nonresidential Customers

Prepared for the Energy Division, California Public Utilities Commission

By

The Nonresidential Net-To-Gross Ratio Working Group

Final Version

TABLE OF CONTENTS

Acknowledgments

As part of the evaluation of the 2006-08 energy efficiency programs designed and implemented by the four investor-owned utilities (Pacific Gas & Electric Company, Southern California Edison Company, Southern California Gas Company, and San Diego Gas and Electric Company) and third parties, the Energy Division of the California Public Utilities Commission (CPUC) formed a nonresidential net-to-gross ratio working group that was composed of experienced evaluation professionals. The main purpose of this group was to develop a standard methodological framework, including decision rules, for integrating in a systematic and consistent manner the findings from both quantitative and qualitative information in estimating net-to-gross ratios. The working group, listed alphabetically, was composed of the following evaluation professionals:

- Michael Baker, SBW Consulting
- Fred Coito, KEMA
- Kevin Cooney, Summit Blue Consulting
- Tim Drew, Energy Division, CPUC
- Jennifer Fagan, Itron, Inc.
- Miriam Goldberg, KEMA
- Nick Hall, TecMarket Works
- Kay Hardy, Energy Division, CPUC
- Ken Keating
- John Reed, Innovologie LLC
- Richard Ridge, Ridge & Associates
- Mike Rufo, Itron, Inc.
- Eric Swan, KEMA (formerly of RLW Analytics, Inc.)
- Christina Torok, Itron, Inc.
- Philippus Willems, PWP, Inc.

A public webinar was conducted to obtain feedback from the four investor-owned utilities and other interested stakeholders. The questionnaire was then pre-tested and, based on the pre-test results, finalized in November 2008.

1. Overview of the Large Nonresidential Free Ridership Approach

The methodology described in this section was developed to address the unique needs of Large Nonresidential customer projects developed through energy efficiency programs offered by the four California investor-owned utilities and third-parties. This method relies exclusively on the Self-Report Approach (SRA) to estimate project and program-level Net-to-Gross Ratios (NTGRs), since other available methods and research designs are generally not feasible for large nonresidential customer programs. This methodology provides a standard framework, including decision rules, for integrating findings from both quantitative and qualitative information in the calculation of the net-to-gross ratio in a systematic and consistent manner. 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 D.

This approach preserves the most important elements of the approaches previously used to estimate the NTGRs in large nonresidential customer programs[1]. However, it also incorporates several enhancements that are designed to improve upon that approach, for example:

- The method introduces a 0 to 10 scoring system for key questions used to estimate the NTGR, rather than using fixed categories that were assigned weights (as was done previously).

- The method 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 only their rating of the program's importance. This question structure more accurately reflects the complex nature of the real-world decision making and should help to ensure that all non-program influences are reflected in the NTGR assessment in addition to program influences.

It is important to note that the NTGR approach described in this document is a general framework, designed to address all large nonresidential programs. In order to implement this approach on a program-specific basis, it might need to be somewhat customized to reflect the unique nature of the individual programs.

[1] Such as, for example, the NTGR method used to evaluate NTGRs for the California Standard Performance Contracting Program.

2. BASIS FOR SRA IN SOCIAL SCIENCE LITERATURE

The social sciences literature provides strong support for use of the methods used in the SRA to assess program influence. As the *Guidelines* notes,

> More specifically, the SRA is a mixed method approach that involves asking one or more key participant decision-makers a series of structured and open-ended questions about whether they would have installed the same EE equipment in the absence of the program as well as questions that attempt to rule out rival explanations for the installation (Weiss, 1972; Scriven, 1976; Shadish, 1991; Wholey et al., 1994; Yin, 1994; Mohr, 1995). In the simplest case (e.g., residential customers), the SRA is based primarily on quantitative data while in more complex cases the SRA is strengthened by the inclusion of additional quantitative and qualitative data which can include, among others, in-depth, open-ended interviews, direct observation, and review of program records. Many evaluators believe that additional qualitative data regarding the economics of the customer's decision and the decision process itself can be very useful in supporting or modifying quantitatively-based results (Britan, 1978; Weiss and Rein, 1972; Patton, 1987; Tashakkori and Teddlie, 1998).[2]

More details regarding the philosophical and methodological underpinnings of this approach are in Ridge, Willems and Fagan (2009), Ridge, Willems, Fagan and Randazzo (2009) and Megdal, Patil, Gregoire, Meissner, and Parlin (2009). In addition to these two articles, Appendix A provides an extensive listing of references in the social sciences literature regarding the methods employed in the SRA.

3. FREE RIDERSHIP ANALYSIS BY PROJECT TYPE

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 and most complex projects (representing 10 to 20% of the total) with the greatest expected levels of gross savings[3] 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 must exercise their own discretion as to what the appropriate thresholds should be for each of these three levels.

4. SOURCES OF INFORMATION ON FREE RIDERSHIP

There are five sources of free-ridership information in this study. Each level of analysis relies on information from one or more of these sources. These sources are described below.

---

[2] *Guidelines for Estimating Net-To-Gross Ratios Using the Self-Report Approaches*, October 15, 2007, pg. 3.

[3] 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.

1. **Program Files**. As described in previous sections of this report, programs often maintain a paper file for each paid application. These can contain various pieces of information which are relevant to the analysis of free-ridership, such as letters written by the utility's customer representatives that document what the customer had planned to do in the absence of the rebate and explain the customer's motivation for implementing the efficiency measure. Information on the measure payback with and without the rebate may also be available.

2. **Decision-Maker Surveys**. When a site is recruited, one must also determine who was involved in the decision-making process which led to the implementation of measures under the program. They are asked to complete a Decision Maker survey. This survey obtains highly structured responses concerning the probability that the customer would have implemented the same measure in the absence of the program. First, participants are asked about the timing of their program awareness relative to their decision to purchase or implement the energy efficiency measure. Next, they are asked to rate the importance of the program versus non-program influences in their decision making. Third, they are asked to rate the significance of various factors and events that may have led to their decision to implement the energy efficiency measure at the time that they did. These include:

    - the age or condition of the equipment,
    - information from a feasibility study or facility audit
    - the availability of an incentive or endorsement through the program
    - a recommendation from an equipment supplier, auditor or consulting engineer
    - their previous experience with the program or measure,
    - information from a program-sponsored training course or marketing materials provided by the program
    - the measure being included as part of a major remodeling project
    - a recommendation from program staff, a program vendor, or a utility representative
    - a standard business practice
    - an internal business procedure or policy
    - stated concerns about global warming or the environment
    - a stated desire to achieve energy independence.

    In addition, the survey obtains a description of what the customer would have done in the absence of the program, beginning with whether the implementation was an early replacement action. If it was not, the decision maker is asked to provide a description of what equipment would have been implemented in the absence of the program, including both the efficiency level and quantities of these alternative measures. This is used to adjust the gross engineering savings estimate for partial free ridership, as discussed in Section 5.2.

    This survey contains a core set of questions for **Basic** NTGR sites, and several supplemental questions for both **Standard and Standard – Very Large** NTGR sites For example, if a Standard or Standard-Very Large respondent indicates that a financial calculation entered highly into their decision, they are asked additional questions about their *financial criteria* for investments and their rationale for the current project in light of them. Similarly, if they respond that a *corporate policy* was a primary consideration in their decision, they are asked a series of questions about the specific policy that led to their adoption of the installed measure. If they indicate the installation was a *standard practice*, there are supplemental questions to understand the origin and evolution of that standard practice within their organization. These questions are intended to provide a deeper understanding of the decision making process and the likely level of program influence versus these internal policies and procedures. Responses to these questions also serve as a basis for consistency checks to investigate conflicting answers regarding the relative importance of the program and other elements in influencing the decision. In addition, **Standard – Very Large** sites may receive additional detailed probing on various aspects of their installation decision based on industry- or technology-specific issues, as determined by review of other information sources. For Standard-Very Large sites all these data are used to construct an internally consistent "story" that supports the NTGR calculated based on the overall information given.

3. **Vendor Surveys**. A Vendor Survey is completed for all **Standard** and **Standard-Very Large** NTGR sites that utilized vendors, and for **Basic** NTGR sites that indicate a high level of vendor influence in the decision to implement the energy efficient measure. For those sites that indicate the vendor was very influential in decision making, the vendor survey results enter directly into the NTGR scoring. The vendor survey findings are also be used to corroborate Decision Maker findings, particularly with respect to the vendor's specific role and degree of influence on the decision to implement the energy efficient measure. Vendors are queried on the program's significance in their decision to recommend the energy efficient measures, and on their likelihood to have recommended the same measure in the absence of the program. Generally, the vendors contacted as part of this study are contractors, design engineers, distributors, and installers.

4. **Utility and Program Staff Interviews**. For the Standard and Standard-Very Large NTGR analyses, interviews with utility staff and program staff are also conducted. These interviews are designed to gather information on the historical background of the customer's decision to install the efficient equipment, the role of the utility and program staff in this decision, and the name and contact information of vendors who were involved in the specification and installation of the equipment.

5. **Other information**. For **Standard – Very Large Project** NTGR sites, secondary research of other pertinent data sources is performed. For example, this could include a review of standard and best practices through industry associations, industry experts, and information from secondary sources (such as the U.S. Department of Energy's Industrial Technologies Program, Best Practices website URL, http://www1.eere.energy.gov/industry/bestpractices/). In addition, the Standard- Very Large NTGR analysis calls for interviews with other employees at the participant's firm, sometimes in other states, and equipment vendor experts

from other states where the rebated equipment is being installed (some without rebates), to provide further input on standard practice within each company.

Table 1 below shows the data sources used in each of the three levels of free-ridership analysis. Although more than one level of analysis may share the same source, the amount of information that is utilized in the analysis may vary. For example, all three levels of analysis obtain core question data from the Decision Maker survey.

Table 1: 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 indicate a vendor influence score (N3d) greater than maximum of the other program element scores (N3b, N3c, N3g, N3h, N3l).

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

[3]Only performed if significant vendor influence reported or if secondary research indicates the installed measure may be becoming standard practice.

Appendix B provides the full battery of Decision Maker and Vendor survey questions along with notes, for each NTGR level, regarding which questions are asked (denoted by an "X"), and the intended uses of the information in the NTGR analysis. In the case of Basic sites, "TRIGGER" means that a vendor influence score greater than the maximum of other program element scores (N3b, N3c, N3g, N3h, N3l) triggers a vendor survey. In the case of Standard and Standard-Very Large NTGR sites, "TRIGGER" means that a score of 6 or greater triggers a further investigation. A copy of the complete survey forms (with lead-in text and skip patterns) are contained in *Final Large Nonresidential NTGR Survey Instruments.XLS* that is available upon request.

5. NTGR FRAMEWORK

The Self-Report-based Net-to-Gross analysis relies on responses to a series of survey questions that are designed to measure the influence of the program on the participant's decision to implement program-eligible energy efficiency measure(s). Based on these responses, a NTGR is derived based on responses to a set of “core” NTGR questions. The NTGR includes the effects of deferred free ridership (i.e., accelerated adoption).

5.1. NTGR Questions and Scoring Algorithm

A self-report NTGR is computed for all NTGR levels using the following approach. Adjustments may be made for **Standard – Very Large** NTGR sites, if the additional information that is collected is inconsistent with information provided through the Decision Maker survey.

The NTGR is 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 that reflects 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 this time. Program influence through vendor recommendations is also incorporated in this score.

2. A **Program Influence** score that captures 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 is determined by asking respondents to assign importance values to both the program and most important non-program influences so that the two total 10. The program influence score is adjusted (i.e., divided by 2) if respondents say they had already made their decision to install the specific program qualifying measure before they learned about the program.

3. A **No-Program** score that captures the likelihood of various actions the customer might have taken at this 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 are multiple questions that feed into the scoring algorithm, as is the case for both the **Timing and Selection** and **No-Program** scores, the maximum score is always used. The rationale for using the maximum value is to capture the most important element in the participant’s decision making. Thus, each score is always based on the strongest influence indicated by the respondent. However, high scores that are inconsistent with other previous responses trigger consistency checks and can lead to follow-up questions to clarify and resolve the discrepancy.

The calculation of each of the above scores is discussed below. For each score, the associated questions are presented and the computation of each score is described. For a detailed explanation of the scoring algorithm, including examples, see Appendix C.

5.1.1. Timing and Selection Score

For the Decision Maker, the questions asked are:
I'm going to ask you to rate the importance of the program as well as other factors that might influence your decision to implement [MEASURE.] Think of the degree of importance as being shown on a scale with equally spaced units from 0 to 10, where 0 means not at all important and 10 means very important, so that an importance rating of 8 shows twice as much influence as a rating of 4.

Now, using this 0 to 10 rating scale, where 0 means "Not at all important" and 10 means "Very important," please rate the importance of each of the following in your decision to implement this specific [MEASURE] at this time.

- Availability of the PROGRAM rebate
- Information provided through a recent feasibility study, energy audit or other types of technical assistance provided through PROGRAM
- Information from PROGRAM training course
- Information from other PROGRAM marketing materials
- Recommendation from a vendor/supplier (If a score of greater than 5 is given, a vendor interview is triggered)

For the Vendor, the questions asked (if the interview is triggered) are:
I'm going to ask you to rate the importance of the [PROGRAM] in influencing your decision to recommend [MEASURE] to [CUSTOMER] and other customers. Think of the degree of importance as being shown on a scale with equally spaced units from 0 to 10, where 0 means not at all important and 10 means very important, so that an importance rating of 8 shows twice as much influence as a rating of 4.

1. Using this 0 to 10 scale where 0 is 'Not at all important" and 10 is "Very Important," how important was the PROGRAM, including incentives as well as program services and information, in influencing your decision to recommend that CUSTOMER install the energy efficiency MEASURE at this time?
2. And using a 0 to 10 likelihood scale, where 0 denotes "not at all likely" and 10 denotes "very likely," if the PROGRAM, including incentives as well as program services and information, had not been available, what is the likelihood that you would have recommended this specific energy efficiency MEASURE to CUSTOMER?
3. Now, using a 0 to 100 percent scale, in what percent of sales situations did you recommend MEASURE before you learned about the [PROGRAM]?
4. And using the same 0 to 100 percent scale, in what percent of sales situations do you recommend MEASURE now that you have worked with the [PROGRAM]?

5. And, using the same 0 to 10 scale where 0 is “Not at all important” and 10 is “Very important”, how important in your recommendation were:
   a. Training seminars provided by UTILITY?
   b. Information provided by the UTILITY website?
   c. Your firm’s past participation in a rebate or audit program sponsored by UTILITY?

If the Vendor interview is triggered, a score is calculated that captures the highest degree of program influence on the vendor’s recommendation. This score (VMAX) is calculated as the MAXIMUM value of the following:

1. The response to question 1
2. 10 minus the response to question 2
3. The response to question 4 minus the response to question 3, divided by 10
4. The response to question 5a.
5. The response to question 5b.
6. The response to question 5c.

Note that vendors are asked an additional question regarding other ways that their recommendations regarding the measure might have been influenced. Their responses are not used in the direct calculation of the NTGR but are potentially useful in making adjustments to the core NTGR.

The Timing and Selection Score is calculated as:
The highest of the responses to the first four decision maker questions and, if the vendor interview has been triggered, the VMAX score multiplied by the score the decision makers assigned to the vendor recommendation.

5.1.2. Program Influence Score

The questions asked are:

1. Did you learn about PROGRAM BEFORE or AFTER you decided to implement the specific MEASURE that was eventually adopted or installed?

2. Now I'd like to ask you a last question about the importance of the program to your decision as opposed to other factors that may have influenced your decision. Again using the 0 to 10 rating scale we used earlier, where 0 means “Not at all important” and 10 means “Very important,” please rate the overall importance of PROGRAM versus the most important of the other factors we just discussed in your decision to implement the specific MEASURE that was adopted or installed. This time I would like to ask you to have the two importance ratings -- the program importance and the non-program importance -- total 10.

The Program Influence score is calculated as:
The importance of the program, on the 0 to 10 scale, to question 2. This score is reduced by half if the respondent learned about the program after the decision had been made.

5.1.3. No-Program Score

The questions asked are:

1. Regarding the installation of this equipment, if the PROGRAM had not been available, using a likelihood scale from 0 to 10, where 0 is "Not at all likely" and 10 is "Extremely likely" how likely is it that you would have installed exactly the same item/equipment, using a 0 to 10 scale, where 0 is not at all likely and 10 is extremely likely?

2. IF 1>0. You indicated that there was an "***X***" in 10 likelihood that you would have installed the same equipment if the PROGRAM had not been available. When do you think you would have installed this equipment? Please express your answer in months
   a. _____ ____ within 6 months? (Deferred NTG Value=0)
   b. _____ ____ 7 to 47 months later (Deferred NTG Value=(months-6)*.024)
   c. _____ ____ 48 or more months later (Deferred NTG Value =1)
   d. _____ ____ Never (Deferred NTG Value=1)

   Note: The value 0.024 is 1 divided by 41 (41 is calculated as 47 – 6). This assumes that the deferred NTG value is a linear function beginning in month 7 through month 47, increasing 0.024 for each month of deferred installation.

The No-Program Score is calculated as:

10 minus (the likelihood of installing the same equipment multiplied by one minus the *deferred net-to-gross value* associated with the timing of that installation).

5.1.4. The Core NTGR

The self-reported core NTGR in most cases is simply the average of the Program Influence, Timing and Selection, and No-Program Scores, divided by 10. The one exception to this is when the respondent indicates 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 is based on the average of the Program Influence and No-Program scores only.

5.2. Data Analysis and Integration

The calculation of the Core NTGR is fairly mechanical and is 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 requires 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, one will need to integrate all of this information into an internally consistent and coherent story that supports a specific NTGR.

The following data sources should be investigated and reviewed as appropriate to supplement the information collected through the decision maker interviews.

- Account Representative Interview
- Utility Program Manager/Staff Interview
- Utility Technical Contractor Interview
- Third party Program Manager Interview
- Evaluation Engineer Interview
- Gross Impact Site Plan/Analysis Review
- Corporate Green/Environmental Policy Review (if mentioned as important)
- Corporate Standard Practice Review (if mentioned as important)
- Industry Standard Practice Review (if mentioned as important)
- Corporate payback review (if mentioned as important)
- Review relevant codes and standards, including regulatory requirements
- Review industry publications, websites, reports such as the Commercial Energy Use Survey, historical purchase data of specific measures etc.

As detailed in the Self-Report NTGR Guidelines, when complementing the quantitative analysis of free-ridership with additional quantitative and qualitative data from multiple respondents and other sources, there are some basic concerns that one must keep in mind. Some of the other data – including interviews with third parties who were involved in the decision to install the energy efficient equipment – may reveal important influences on the customer's decision to install the qualifying program measure. When one chooses to incorporate other data, one should keep the following principles in mind: 1) the method chosen should be balanced. That is, the method should allow for the possibility that the other influence can either increase or decrease the NTGR calculated from the decision maker survey responses, 2) the rules for deciding which customers will be examined for potential other influences should be balanced. In the case of Standard –Very Large interviews, all customers are subject to such a review, so that the pool of customers selected for such examination will not be biased towards ones for whom the evaluator believes the external influence will have the effect of influencing the NTGR in only one direction, 3) the plan for capturing other influences should be based on a well-conceived causal framework. The onus is on the evaluator to build a compelling case using a variety of quantitative and/or qualitative data for estimating a customer's NTGR.

Establishing Rules for Data Integration

Before the analysis begins, the evaluation team should establish, to the extent feasible, rules for the integration of the quantitative and qualitative data. These rules should be as specific as possible and be strictly adhered to throughout the analysis. Such rules might include instructions regarding when the NTGR based on the quantitative data should be overridden based on qualitative data, how much qualitative data are needed to override the NTGR based on quantitative data, how to handle contradictory information provided by more than one person at a given site, how to handle situations when there is no decision-maker interview, when there is no appropriate decision-maker interview, or when there is critical missing data on the questionnaire, and how to incorporate qualitative information on deferred free-ridership.

One must recognize that it is difficult to anticipate all the situations that one may encounter during the analysis. As a result, one may refine existing rules or even develop new ones during the initial phase of the analysis. One must also recognize that it is difficult to develop algorithms that effectively integrate the quantitative and qualitative data. It is therefore necessary to use judgment in deciding how much weight to give to the quantitative versus qualitative data and how to integrate the two. The methodology and estimates, however, must contain methods to support the validity of the integration methods through preponderance of evidence or other rules/procedures as discussed above.

For the **Standard-Very Large** cases in the large Nonresidential programs, the quantitative data used in the NTGR Calculator (which calculates the "core" NTGR), together with other information collected from the decision maker regarding the installation decision, form the initial basis for the NTG "story" for each site. Note that in most cases, supplemental data such as tracking data, program application files and results of interviews with program/IOU staff and vendors, will have been completed before the decision maker is contacted and will help guide the non-quantitative questioning in the interview. In practice, this means that most potential inconsistencies between decision maker responses and other sources of information should have been resolved before the interview is complete and data are entered into the NTGR Calculator. For example, if a company has an aggressive "green" policy widely promoted on its website that is not mentioned by the decision makers, the interviewer will ask the respondent to clarify the role of that policy in the decision. Conversely, if the decision maker attributes the decision to install the equipment to a new company wide initiative rather than the program, yet there is no evidence of such an initiative reported by program staff, vendors, or the company's website, the decision maker will be asked to explain the discrepancy so that his or her responses can be changed if needed.

In some cases, however, it may be necessary to modify or override one of the scores contributing to the overall NTGR or the NTGR itself. Before this is done all quantitative and qualitative data will be systematically (and independently) analyzed by two experienced researchers who are familiar with the program, the individual site and the social science theory that underlies the decision maker survey instrument. Each will determine whether the additional information justifies modifying the previously calculated NTGR score, and will present any recommended modifications and their rationale in a well-organized manner, along with specific references to the supporting data. Again, it is important to note that the other influences can have the effect of either increasing or decreasing the NTGR calculated from the decision maker survey responses, and one should be skeptical about a consistent pattern of "corrections" in one direction or another.

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[4].

Once the individual analysts have completed their review, they meet to discuss their respective findings and present to the other the rationale for their recommended changes to the Calculator-derived NTGR. Key points of these arguments will be written down in summary form (e.g., Analyst 1 reviewed recent AQMD ruling and concluded that customer would have had to install the same measure within 2 years, not 3, thereby reducing NP score from 7.8 to 5.5) and also presented in greater detail in a workpaper so that an independent reviewer can understand and judge the data and the logic underlying each NTGR estimate. Equally important, the CPUC will have all the essential data to enable them to replicate the results, and if necessary, to derive their own estimates.

The outcome of the reconciliation by two analysts determines the final NTGR for a specific project. Again, the reasoning behind the "negotiated" final value must be thoroughly documented in a workpaper, while a more concise summary description of the rationale can be included in the NTGR Calculator workbook (e.g., Analyst 1 and Analyst 2 agreed that the NTGR score should have been higher than the calculated value of 0.45 because of extensive interaction between program technical staff and the customer, but they disagreed on whether this meant the NTGR should be .6 or .7. After discussion, they agreed on a NTGR of .65 as reflecting the extent of program influence on the decision).

In summary, it has been decided that supplemental data from non-core NTG questions collected through these surveys should be used in the following ways in the California Large Nonresidential evaluations:

- Vendor interview data will be used at times in the direct calculation of the NTGR. It will also be used to provide context and confirming/contradictory information for Standard-Very Large decision maker interviews.

- Qualitative and quantitative information from other sources (e.g., industry data, vendor estimates of sales in no-program areas, and other data as described above) may be used to alter core inputs only if contradictions are found with the core survey responses. Since judgments will have to be made in deciding which information is more compelling when there are contradictions, supplemental data are reviewed independently by two senior analysts, who then summarize their findings and recommendations and together reach a final NTGR value.

---

[4] 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.

- Responses will also be used to construct a NTGR "story" around the project; that is they will help to provide the context and rationale for the project. This is particularly valuable in helping to provide guidance to program design for future years. It may be, for example, that responses to the core questions yield a high NTGR for a project, but additional information sources strongly suggest that the program qualifying technology has since become standard practice for the firm or industry, so that free ridership rates in future years are likely to be higher if program rules are not changed.

- Findings from other non-core NTGR questions (e.g., Payback Battery, Corporate Policy Battery) are also be used to **cross-check the consistency** of responses to core NTGR questions. When an inconsistency is found, it is presented to the Decision Maker respondent who is then be asked to explain and resolve it if they can. If they are not able to do so, their responses to the core NTGR question with the inconsistency may be overridden by the findings from these supplemental probes. These situations are handled on a case-by-case basis; however consistency checks are programmed into the CATI survey instrument used for the Basic and Standard cases.

Finally, some analysis of additional information beyond the close-ended questions that are used to calculate the Core NTGR could be done for the **Standard NTGR**. For example information regarding the financial criteria used to make capital investments, corporate policy regarding the purchase of energy efficiency equipment or the influence of standard practice in the same industry as the participant could be taken into account and used to make adjustments to the Core NTGR in a manner similar what is done for the Standard – Very Large NTGR.

5.3. Accounting for Partial Free Ridership

Partial free-ridership can occur when, in the absence of the program, the participant would have installed something more efficient than the program-assumed baseline efficiency but not as efficient as the item actually installed as a result of the program.

In situations where there is partial free ridership, the assumed baseline condition is affected. Absent partial free ridership, the assumed baseline would normally be based on existing equipment (in early replacement cases), on code requirements (in normal replace on burnout cases), or on a level above current code (e.g., this could be a market average or value purposefully set above code minimum but below market average; in this case, the definition and requirement would typically be defined by a specific program's baseline rules). In some cases, there may be a "dual" baseline (more specifically, a baseline that changes over the measure's EUL) if the project involves early replacement plus partial free ridership. In such cases, the baseline basis for estimating savings is the existing equipment over the remaining useful life (RUL) of the equipment, and then a baseline of likely intermediate efficiency equipment (e.g., code or above) for the remainder of the analysis period (i.e., the period equal to the EUL-RUL). When there is partial free ridership, the baseline equipment that would have been installed absent the program is of an intermediate efficiency level (resulting in lower energy savings than that assumed by the program if the program took in situ equipment efficiency as the basis for savings over the entire EUL). A related issue with respect to determination of the appropriate baseline is whether the adjustment made, if any, from the in situ or otherwise claimed baseline in the ex ante calculation, is whether the adjustment applies to the gross or net savings calculation.

<u>Assignment of Partial Free Ridership Effects to Gross versus Net.</u> In past evaluations, partial free ridership impacts have principally been incorporated into the net-to-gross ratio. This is because most partial free ridership is induced by market conditions, rather than by non-market factors. Market conditions refer primarily to standard adoption of a technology by a particular market segment or end user as a result of competitive market forces or other end user-specific factors. The key determining principle with respect to application of the adjustment to the net-to-gross ratio is whether there is a level of efficiency, below the efficiency of the measure for which savings are paid and claimed, but above what is required by code or minimum program baseline requirements that the end user would have implemented anyway without the program. Conditions that cause this adjustment to be made to gross savings rather than the net-to-gross ratio may include factors such as

- changing baseline equipment to meet changed business circumstances (such as increased production/throughput, changes in occupancy, etc.);
- compliance with environmental regulations, indoor air quality requirements, safety requirements; or
- the need to address an operational problem.

Each project should be examined separately for partial free ridership and a determination should be made based on the unique circumstances of each installation of whether an adjustment to gross savings or the net-to-gross ratio is warranted.

Data Collection Procedures. Information is gathered on partial free ridership using the following questions asked as part of the decision maker NTGR survey.

1. Now I would like you to think one last time about what action you would have taken if the program had not been available. Supposing that you had not installed the program qualifying equipment, which of the following alternatives would you have been MOST likely to do?
    a. Install fewer units
    b. Install standard efficiency equipment or whatever required by code
    c. Install equipment more efficient than code but less efficient than what you installed through the program
    d. repair/rewind or overhaul the existing equipment
    e. do nothing (keep the existing equipment as is)
    f. something else (specify what _____________)
2. (IF FEWER UNITS) How many fewer units would you have installed? (It is okay to take an answer such as ...HALF...or 10 percent fewer ... etc.)

3. (IF MORE EFFICIENT THAN CODE) Can you tell me what model or efficiency level you were considering as an alternative? (It is okay to take an answer such as … 10 percent more efficient than code or 10 percent less efficient than the program equipment)

4. (IF REPAIR/REWIND/OVERHAUL) How long do you think the repaired/rewound/refurbished equipment would have lasted before requiring replacement?

In addition, these same partial free ridership questions should be asked during the on-site audit for a given project. This latter interview will be conducted by the project engineers. The collected information helps the gross impact and NTG analysis teams gain a more complete understanding of the true project baseline and equipment selection decision. These decision maker questions are included in the Excel version of the CATI-based Standard and Basic decision maker survey instrument as well as in the Standard-Very Large instrument.

Data Analysis and Integration Procedures. In cases where partial free ridership is found and it is determined that the adjustment should be made to the net-to-gross ratio, the following procedure should be used:

On the net side, the adjustment is based on the intermediate baseline indicated by the decision maker for the time period in which the intermediate equipment would have been installed. The calculation of energy saved under this intermediate baseline is done, and then divided by the savings calculated under the in situ baseline. The resulting ratio is then multiplied by the initial NTGR which was previously calculated using only the 'core' scoring inputs. The effect of this adjustment is to reduce the NTGR further to reflect the effects of the revealed partial free ridership.

In all cases, the Gross Impacts and NTG analysis teams will need to carefully coordinate their calculations to ensure that they are not inadvertently adjusting the savings twice for the same partial free ridership, i.e., through adjustments both to the gross savings calculation and to the NTG ratio.

6. NTGR INTERVIEW PROCESS

The NTGR surveys are conducted via telephone interviews. Highly-trained professionals with experience levels that are commensurate with the interview requirements should perform these interviews. Basic and Standard level interviews should be conducted by senior interviewers, who are highly experienced conducting telephone interviews of this type. Standard - Very Large interviews should be completed by professional consulting staff due to the complex nature of these projects and related decision making processes. More than likely, these will involve interviews of several entities involved in the project including the primary decision maker, vendor representatives, utility account executives, program staff and other decision influencers, as well as a review of market data to help establish an appropriate baseline.

All but the Standard -Very Large interviews should be conducted using computer-aided telephone interview (CATI) software. Use of a CATI approach has several advantages: (1) the surveys can be customized to reflect the unique characteristics of each program, and associated program descriptions, response categories, and skip patterns; (2) it drastically reduces inaccuracies associated with the more traditional paper and pencil method; and (3) the process of checking for inconsistent answers can be automated, with follow up prompts triggered when inconsistencies are found.

7. Compliance with Self-Report Guidelines

The proposed NTGR framework fully complies with all of the CPUC/ED and the MECT's Guidelines for Estimating Net-to-Gross Ratios Using the Self-Report Approach, as demonstrated in Appendix D.

Appendix A

References

Blalock, H. (1970). Estimating measurement error using multiple indicators and several points in time," *American Sociological Review*, 35, pp. 101-111.

Bogdan, Robert and Steven J. Taylor. (1975). *Introduction to qualitative research methods*. New York: John Wiley & Sons.

Britan, G. M. (1978). Experimental and contextual models of program evaluation. *Evaluation and Program Planning,* 1: 229-234.

Cochran, William G. (1977). *Sampling techniques*. New York: John Wiley & Sons.

Crocker, L. and J. Algina. (1986). *Introduction to classical and modern test theory*. New York: Holt, Rinehart & Winston.

Cronbach L.J. (1951). Coefficient alpha and the internal structure of tests. *Psychometrika*, 16, 297-334.

DeVellis, R.F. (1991). *Scale development: Theory and applications*. Newbury Park, CA: Sage Publications, Inc.

Duncan, O.D. (1984). *Notes on social measurement: Historical and critical*. New York: Russell Sage.

Guba, E. G. (1978). Toward a methodology of naturalistic inquiry in educational evaluation. *CSE Monographic Series in Evaluation No. 8*. Los Angeles: Center for the Study of Evaluation.

Hall, Nick, Johna Roth, Carmen Best, Sharyn Barata, Pete Jacobs, Ken Keating, Ph.D., Steve Kromer, Lori Megdal, Ph.D., Jane Peters, Ph.D., Richard Ridge, Ph.D., Francis Trottier, and Ed Vine, Ph.D. (2007). *California Energy Efficiency Evaluation: Protocols: Technical, Methodological, and Reporting Requirements for Evaluation Professionals*. Prepared for the California Public Utilities Commission.

Lyberg, Lars, Paul Biemer, Martin Collins, Edith De Leeuw, Cathryn Dippo, Norbert Schwarz, and Dennis Trewin. (1997). *Survey measurement and process quality*. New York, NY: John Wiley & Sons.

Madow, William G., Harold Nisselson, Ingram Olkin. (1983). *Incomplete data in sample surveys*. New York: Academic Press.

Maxwell, Joseph A. (2004). Using Qualitative Methods for Causal Explanations. *Field Methods*, *Vol. 16, No. 3*, 243-264.

Megdal, Lori, Yogesh Patil, Cherie Gregoire, Jennifer Meissner, and Kathryn Parlin (2009). Feasting at the Ultimate Enhanced Free-Ridership Salad Bar. *Proceedings of the International Energy Program Evaluation Conference*.

Mohr, Lawrence B. (1995). *Impact analysis for program evaluation*. Thousand Oaks, CA: Sage Publications, Inc.

Netemeyer, Richard G., William O. Bearden, and Subhash Sharma. (2003). *Scaling procedures: Issues and applications*. Thousand Oaks, CA: SAGE Publications.

Patton, Michael Quinn. (1987). *How to use qualitative methods in evaluation*. Newbury Park, California: SAGE Publications.

Ridge, Richard, Philippus Willems, and Jennifer Fagan. (2009). Self-Report Methods for Estimating Net-to-Gross Ratios in California: Honest! *Proceedings from the 19th National Energy Services Conference*.

Ridge, Richard, Philippus Willems, Jennifer Fagan and Katherine Randazzo. (2009). The Origins of the Misunderstood and Occasionally Maligned Self-Report Approach to Estimating the Net-To-Gross Ratio. *Proceedings of the International Energy Program Evaluation Conference*.

Rogers, Patricia J., Timothy A. Hacsi, Anthony Petrosino, and Tracy A. Huebner (Eds.) (2000). *Program theory in evaluation: Challenges and opportunities*. San Francisco, CA: Jossey-Bass Publishers.

Rossi, Peter and Howard E. Freeman. (1989). *Evaluation: A systematic approach.* Newbury Park, California: SAGE Publications.

Sayer, Andrew. (1992). *Method in social science: A Realist Approach*. New York: Routledge.

Sax, Gilbert. (1974). *Principles of educational measurement and evaluation*. Belomont, CA: Wadsworth Publishing Company, Inc.

Schumacker, Randall E. and Richard G. Lomax. (1996). *A beginner's guide to structural equation modeling*. Mahwah, New Jersey: Lawrence Erlbaum Associates.

Scriven, Michael. (1976). Maximizing the power of causal explanations: The modus operandi method. In G.V. Glass (Ed.), *Evaluation Studies Review Annual, Vol. 1*, pp.101-118). Bevery Hills, CA: Sage Publications.

Shadish, Jr., William R. and Thomas D. Cook, and Laura C. Leviton. (1991). *Foundations of program evaluation*. Newbury Park, CA: Sage Publications, Inc.

Stone, Arthur A., Jaylan S. Turkkan, Christine A. Bachrach, Jared B. Jobe, Howard S. Kurtzman, and Virginia S. Cain. (2000). *The science of the self-report: Implications for research and practice*. Mahwah, New Jersey: Lawrence Erlbaum Associates.

Tashakkori, Abbas and Charles Teddlie. (1998). *Mixed methodology: Combining qualitative and quantitative approaches*. Thousand Oaks, CA: SAGE Publications.

TecMarket Works, Megdal & Associates, Architectural Energy Corporation, RLW Analytics, Resource Insight, B & B Resources, Ken Keating and Associates, Ed Vine and Associates, American Council for an Energy Efficient Economy, Ralph Prahl and Associates, and Innovologie. (2004). *The California evaluation framework.* Prepared for the California Public Utilities Commission and the Project Advisory Group.

Velleman, P. F., and Wilkinson, L. (1993), Nominal, ordinal, interval and ratio typologies are misleading. *American Statistician, 47(1)*, 65-72.

Weiss, Carol H. (1998). *Evaluation*. Upper Saddle River, New Jersey: Prentice Hall.

Weiss, R. S. and M.Rein. (1972). The Evaluation of broad-aim programs: Difficulties in experimental design and an alternative. In C. H. Weiss (ed.) *Evaluating action programs: Readings in social action and education*. Boston: Allyn and Bacon.

Wholey, Joseph S., Harry P. Hatry and Kathryn E. Newcomer. (1994). *Handbook of practical program evaluation*. San Francisco, CA: Jossey-Bass, Inc.

Yin, Robert K. (1994). *Case study research: Design and methods*. Newbury Park, California: SAGE Publications.

Appendix B

Net-to-Gross Questions and Uses of Data by Level of NTGR Analysis

Note: A more detailed version of this survey, with skip patterns and complete response categories, is available in Excel format from the NTG Working Group or at http://www.energydataweb.com/cpuc/default.aspx

DECISION MAKER SURVEY

	Question Text	Basic	Standard and Standard – Very Large
	Introduction Hello, my name is ______ from COMPANY NAME and I am calling about your recent participation in PROGRAM NAME. Are you the person who was most involved with the decision to participate in the PROGRAM NAME? [IF YES, CONTINUE]. We are interviewing firms that participated in the PROGRAM NAME in 2006 and 2007 to discuss the factors that may have influenced your decision to participate in the program. The interview will take about 20 minutes. The questions on this survey pertain to work completed by your company at this current address, excluding other locations.		
	WARM-UP QUESTIONS		
A1	First, according to our records, you participated in PROGRAM NAME on (approximate date). [READ: Program Description. PROGRAM NAME promotes energy efficiency improvements in commercial/industrial facilities. The program offers (choose all that apply): energy audits to help identify applicable measures, feasibility studies to analyze the energy and cost savings of recommended measures, incentives to help cover a portion of the cost of implementing energy efficient measures, etc. Is that correct?	X	X
	Yes, No, DK, Refused		
A2	Next, I'd like to confirm the following information regarding the measures you implemented through the program: (READ: PROJECT DETAILS INCLUDING SERVICES RECEIVED, MEASURES INSTALLED, KEY DATES, PARTICIPATING VENDORS, ETC.) Does that sound right?	X	X
	Yes, No, DK, Refused		
A3	Why did you decide to implement MEASURE NAME? Were there any other reasons?	X	X
	a. Record VERBATIM		
	b. DK/Refused		
	NET-TO-GROSS BATTERY		
N1	When did you first learn about PROGRAM? Was it BEFORE or AFTER you first began to **think about implementing MEASURE**?	X	X
	a. Before (Skip to N3)		
	b. After		
	c. DK/Refused		

N2	Did you learn about PROGRAM BEFORE or AFTER you **decided to implement** the specific MEASURE that was eventually adopted or installed?	X	X
	a. Before		
	b. After		
	c. DK/Refused		
	READ: Program Description: *As I mentioned earlier, [PROGRAM NAME] promotes energy efficiency improvements in commercial/industrial facilities. The program offers (choose all that apply): energy audits to help identify applicable measures, feasibility studies to analyze the energy and cost savings of recommended measures, incentives to help cover a portion of the cost of implementing energy efficient measures, etc. I'm going to ask you to rate the importance of the program as well as other factors that might influence your decision to implement [MEASURE.) Think of the degree of importance as being shown on a scale with equally spaced units from 0 to 10, where 0 means not at all important and 10 means very important, so that an importance rating of 8 shows twice as much influence as a rating of 4.*		
N3	Now, using this 0 to 10 rating scale, where 0 means "Not at all important" and 10 means "Very important," please rate the importance of each of the following in your decision to implement this specific [MEASURE] at this time. [CUSTOMIZE LIST OF FACTORS FOR PROGRAM BEFORE ASKING THEM TO SCORE THE FULL LIST. ROTATE PRESENTATION OF ITEMS. FOLLOW UP WITH "And is there anything else that I may have missed?" RECORD AS p. Other (SPECIFY)]		
	a. The age or condition of the old equipment	X	X
	b. Availability of the PROGRAM rebate	X	X
	c. Information provided through a recent feasibility study, energy audit or other types of technical assistance provided through the PROGRAM (probe on when and by whom?)	X	X
	d. Recommendation from a vendor/supplier (If >5, Vendor interview may be triggered)	TRIGGER	TRIGGER
	e. Previous experience with PROGRAM?	X	X
	f. Previous experience with this MEASURE?	X	X
	g. Information from PROGRAM training course?	X	X
	h. Information from other PROGRAM marketing materials?	X	X
	i. A recommendation from an auditor or consulting engineer	X	X
	j. Standard practice in our business/industry (IF >5, ask standard practice battery)	X	TRIGGER
	k. Endorsement or recommendation by PROGRAM staff, PROGRAM vendor, or UTILITY representative	X	X
	l. Corporate policy or guidelines (If >5 ask Policy questions)	X	TRIGGER
	m. Payback on the investment (If >5 ask payback battery)	X	TRIGGER
	n. General concerns about the environment	X	X
	o. Specific concerns about global warming	X	X
	p. Specific concerns about achieving energy independence	X	X
	q. Other (SPECIFY)______________________________	X	X
N4	Now I'd like to ask you a last question about the importance of the program to your decision. Again using the 0 to 10 rating scale we used earlier, where 0 means "Not at all important" and 10 means "Very important," please rate	X	X

	the overall importance of PROGRAM versus the other factors we just discussed in your decision to implement the specific MEASURE. I'd like you to give me a 0 to 10 score for the PROGRAM's influence and a 0 to 10 score for the influence of the most important other factor so that the two scores total 10.		
	a. ________rating of the importance of PROGRAM NAME	X	X
	b. ________rating of the importance of Other Factors	X	X
	Now I would like you to think about the action you would have taken with regard to the installation of this equipment PROGRAM had not been available.		
N5	Regarding the installation of this equipment if the PROGRAM had not been available, how likely is it that you would have installed exactly the same item/equipment, using a 0 to 10 likelihood scale, where 0 is not at all likely and 10 is extremely likely?	X	X
N6	*IF N5>0.* You indicated in your previous responses that there was a X in 10 likelihood that you would have installed the same equipment if the PROGRAM had not been available.	X	X
	When do you think you would have installed this equipment? (Please answer in months)________		
	a. _____ ____ ..within 6 months? NTGR = 0		
	b. _____ ____.. 6 – 47 months later (NTGR=(months-6)*.024)		
	c. _____ ____ ..4 or more years later (NTGR=1)		
	g. _____ ____ ..Never (NTGR=1)		
	PARTIAL FREE RIDERSHIP BATTERY	**GROSS IMPACT**	**GROSS IMPACT**
P1	Now I would like you to think one last time about what action you would have taken if the program had not been available. Supposing that you had not installed the program qualifying equipment, which of the following alternatives would you have been MOST likely to do?: a. Install fewer high efficiency units (e.g., controls, VFDs, lights) b. Install standard efficiency equipment or whatever required by code c. Install equipment more efficient than code, but less efficient than we installed through the program d. Repair/rewind/refurbish the existing equipment e. do nothing (keep the existing equipment as is) f. Something else (specify)		
P4	If P1=a: How many units would you have installed? Record number of units or percentage of units actually installed		
P5			
P6	If P1=c: Can you tell me what model or efficiency level you were considering as an alternative? (It is okay to take an answer such as … 10 percent more efficient than code or 10 percent less efficient than the program equipment)		
P7	If P1=d: How long do you think the repaired/rewound/refurbished equipment would have lasted before requiring replacement?		
P8			
P9			
	Additional Decision Maker Questions		

	PAYBACK BATTERY (If payback importance >5)		
N10	What financial calculations does your company make before proceeding with installation of a MEASURE like this one?		X
N11	What is the cut-off point your company uses before deciding to proceed with the investment?		X
N12	What was the result of the calculation for MEASURE: a) with the rebate? b) without the rebate?		X
	INVESTIGATE INCONSISTENT RESPONSE		
N13	What competing investments, if any, were considered for the funds that were allocated to the adoption of MEASURE?		X
N14	Why was MEASURE chosen over these other investments		X
	CORPORATE POLICY BATTERY (If corporate policy importance >5)		
N15	Does your organization have a corporate environmental policy to reduce environmental emissions or energy use? Some examples would be to "buy green" or use sustainable approaches to business investments.		X
N16	What specific corporate policy influenced your decision to adopt or install MEASURE?		X
N17	Had that policy caused you to adopt the MEASURE at this facility before participating in this program?		X
N18	Had that policy caused you to adopt the MEASURE at other facilities before participating in this program? When and where?		X
N19	Did you receive an incentive for a previous [MEASURE]? If so, please describe.		X
	STANDARD PRACTICE BATTERY (If standard practice importance >5)		
N20	How long has MEASURE been standard practice in your industry?		X
N21	Does your company ever deviate from the standard practice? If yes, under what conditions?		X
N22	How did this standard practice influence your decision to install the energy efficiency equipment		X
N23	What industry group or trade organization do you look to establish standard practice for your industry?		X
N24	How do you and other firms/facilities receive information on updates in standard practice?		X
	OTHER INFLUENCES BATTERY		
N25	Who provided the most assistance in the design or specification of MEASURE? Designer or Consultant, Equipment Distributor or Mfr Rep, Installer, Utility rep, or Internal staff	X	X
N26	Please describe the type of assistance that they provided.	X	X
N27	Please state, in your own words, any other factors that influenced your decision to go ahead on this energy efficient equipment/project.	X	X

VENDOR SURVEY

	Question Text	Basic	Standard and Standard Very Large
	Warm Up		
A1	The CUSTOMER indicates that you recommended the installation of [EFFICIENT MEASURE] at their facility at [CUSTOMER LOCATION] on [DATE]. Do you recall making this recommendation?	X	X
	a .Yes		
	b. No		
	c. DK (-8)		
	d. Refused (-9)		
	I'm going to ask you to rate the importance of the [PROGRAM] in influencing your decision to recommend [MEASURE] to [CUSTOMER] and other customers. Think of the degree of importance as being shown on a scale with equally spaced units from 0 to 10, where 0 means not at all important and 10 means very important, so that an importance rating of 8 shows twice as much influence as a rating of 4.		
V1	Using this 0 to 10 scale where 0 is 'Not at all important" and 10 is "Very Important" , how important was PROGRAM, including incentives as well as program services and information, in influencing your decision to recommend that CUSTOMER install the energy efficiency MEASURE at this time?	X	X
V2	And using a 0 to 10 likelihood scale, where 0 denotes "not at all likely" and 10 denotes "very likely," if the PROGRAM, including incentives as well as program services and information, had not been available, what is the likelihood that you would have recommended this specific energy efficiency MEASURE to CUSTOMER?	X	X
V3	Now, using a 0 to 100 percent scale, in what percent of sales situations did you recommend MEASURE before you learned about the [PROGRAM]?	X	X
V4	And using the same 0 to 100 percent scale, in what percent of sales situations do you recommend MEASURE now that you have worked with the [PROGRAM]?	X	X
V4a	In what other ways have your recommendations regarding MEASURE been influenced? [For each mention, ask: And using the same 0 to 10 scale, where 0 is "Not at all important" and 10 is "Very important", how important in influencing your recommendations. . . (INSERT FIRST MENTION, INSERT SECOND MENTION ETC.)]	X	X
V5	And, using the same 0 to 10 scale where 0 is "Not at all important" and 10 is "Very important", how important in your recommendation were		
	a. Training seminars provided by UTILITY?	X	X
	b. Information provided by the UTILITY website?	X	X
	c. Your firm's past participation in a rebate or audit program sponsored by UTILITY?	X	X

	Optional:		
V6	Approximately what percentage of your sales of MEASURE in UTILITY'S service territory are energy efficient models that qualify for incentives from the UTILITY program.	X	X
V7	On a 0 percent to 100 percent scale, in what percent of sales situations do you encourage your customers in UTILITY territory to purchase program qualifying [MEASURES]?	X	X
V8.	(IF LESS THAN 100) In what situations do you NOT encourage your customers to purchase energy efficient models if they qualify for a rebate? Why is that?	X	X
V9	Of those installations of EQUIPMENT in UTILITY service territory that qualify for incentives, approximately what percentage do not receive the incentive?	X	X
V10	Why do they not receive the incentive (open end?)	X	X
V11	Do you also sell MEASURE in areas where customers do not have access to incentives for energy efficient models?	X	X
V12	About what percent of your sales of MEASURE are represented by these areas where incentives are not available?	X	X
V12a	IF AT LEAST 10%: And approximately what percentage of your sales of MEASURE in these areas are the energy efficient models that would qualify for incentives in UTILITY'S service territory?	X	X
V13	Have you changed your stocking practices as a result of the UTILITY program? If yes, how?	X	X
V14	Do you promote energy efficient models equally in areas with and without incentives?	X	X

Appendix C

NTGR Scoring Algorithm and Example

The calculation of the self-report-based core NTGR is described below. The NTGR is calculated as an average of three scores representing responses to one or more questions about the decision to install a program measure.

1. A ***Timing and Selection*** score that captures the influence of the most important of various program and program-elated elements in influencing the customer to select the specific program measure at this time. Program influence through vendor recommendations is also captured in this score.

2. An overall ***Program Influence*** score that captures the perceived importance of the program (whether rebate, recommendation, or other information) in the decision to implement the specific measure that that was eventually adopted or installed. The overall program influence score is reduced by half if the respondent says they learned about the program only after they decided to install the program qualifying measure.

3. A ***No-Program*** score that captures the likelihood of various actions the customer might have taken at this time and in the future if the program had not been available. This score accounts for deferred free ridership by capturing the likelihood that the customer would have installed program qualifying measures at a later date if the program had not been available.

Calculation of each of the above scores is discussed below. For each score, the questions contributing to the calculation are presented, the calculation is described, and an example is provided.

Timing and Selection Score

For the decision maker, the questions asked are:

Using a 0 to 10 rating scale, where 0 means not at all important and 10 means very important, please rate the importance of each of the following in your decision to implement this specific measure at this time:

- Availability of the PROGRAM rebate
- Information provided through a recent feasibility study, energy audit or other types of technical assistance provided through the PROGRAM
- Information from PROGRAM training course
- Information from other PROGRAM marketing materials
- Recommendation from a vendor/supplier (If >5, a vendor interview is triggered)

For the vendor, the questions asked if the interview is triggered are:

1. On a 0 to 10 scale where 0 is Not at all important" and 10 is "Very important", how important was PROGRAM, including incentives as well as program services and information, in influencing your decision to recommend that CUSTOMER install the energy efficiency MEASURE at this time?
2. And using a 0 to 10 likelihood scale, where 0 denotes "Not at all likely" and 10 denotes "Extremely Likely," if the PROGRAM, including incentives as well as program services and information, had not been available, what is the likelihood that you would have recommended this specific energy efficiency MEASURE to CUSTOMER?
3. Now, using a 0 to 100 percent scale, in what percent of sales situations did you recommend this MEASURE before you learned about the PROGRAM?
4. And using the same 0 to 100 percent scale, in what percent of sales situations do you recommend this MEASURE now that you have worked with the PROGRAM?
5. And, using the same 0 to 10 scale where 0 is "Not at all important" and 10 is "Extremely Important", how important in your recommendation were:
   a. Training seminars provided by UTILITY?
   b. Information provided by the UTILITY website?
   c. Your firm's past participation in a rebate or audit program sponsored by UTILITY?

If the vendor interview is triggered, a score is calculated that captures the highest degree of program influence on the vendor's recommendation. This score (VMAX) is calculated as the MAXIMUM value of the following:

1. The response to question 1
2. 10 minus the response to question 2
3. The response to question 4 minus the response to question 3, divided by 10
4. The response to question 5 a.
5. The response to question 5b.
6. The response to question 5c.

The Timing and Selection Score is calculated as:
The highest of the responses to the first four decision maker questions and, if the vendor interview has been triggered, the VMAX score multiplied by the score the decision makers assigned to the vendor recommendation..

Example:
The decision maker provides responses of 5 for the importance of the rebate, 6 for an audit or feasibility study, 3 for training, 2 for other marketing materials, and 7 for the vendor recommendation, which means a vendor interview is triggered.

The vendor responses are 8 for the significance of the program, 5 for the likelihood of recommending the measure in the absence of the program, 40% for how often the measure was recommended before program awareness and 60% for how often it is recommended after program awareness, 3 for the importance of training, 2 for the importance of the website and 5 for the importance of previous participation. The VMAX score is the greatest of 8, (10-5), (60-40)/10, 3, 2 and 5. So VMAX is 8. This score is multiplied by the importance of the vendor recommendation, to which the decision maker assigned a 7, so the vendor score is 5.6.

The timing and selection score is the maximum of the four decision maker responses (5, 6, 3, and 2) and the vendor score (5.6). Even though the vendor interview was triggered, the vendor score is not as high as the 6 assigned to the importance of the audit or feasibility study, so the timing and selection score is 6.

Program Influence Score

The questions asked are:

1. Did you learn about PROGRAM BEFORE or AFTER you decided to implement the specific MEASURE that was eventually adopted or installed?

2. Again using the 0 to 10 rating scale we used earlier, where 0 means "Not at all important" and 10 means "Very important," please rate the overall importance of PROGRAM versus the most important of the other factors we just discussed in your decision to implement the specific MEASURE that was adopted or installed. This time I would like to ask you to have the two importance ratings -- the program importance and the non-program importance -- total 10.

The program influence score is calculated as:
The program importance response, on the 0 to 10 scale, to question 2. This score is reduced by half if the respondent became aware of the program only after having decided to adopt the program qualifying measure.

Example:
The decision maker says they became aware of the program before deciding to implement the measure, and provides a response of 7 to question 2, which becomes the program influence score.

No-Program Score

The questions asked are:

1. Regarding the installation of this equipment if the PROGRAM had not been available, how likely is it that you would have installed exactly the same item/equipment, using a 0 to 10 likelihood scale, where 0 is not at all likely and 10 is extremely likely?

2. IF 1>0. You indicated in your previous responses that there was an ***"X"*** in 10 likelihood that you would have installed the same equipment if the PROGRAM had not been available. When do you think you would have installed this equipment? Please express your answer in months
   a. _____ ____ Within 6 months? (Deferred NTG Value=0)
   b. _____ ____ 7 to 47 months later (Deferred NTG Value=(months-6)*.024)

c. _____ ____ 48 or more months later (Deferred NTG Value =1)
d. _____ ____ Never (Deferred NTG Value=1)

Note: The value 0.024 is 1 divided by 41 (41 is calculated as 47 – 6). This assumes that the deferred NTG value is a linear function beginning in month 7 through month 47, increasing 0.024 for each month of deferred installation.

The No-Program Score is calculated as:

10 minus (the likelihood of installing the same equipment multiplied by one minus the deferred net-to-gross value associated with the timing of that installation).

Example

The respondent says there is a 4 in 10 likelihood that they would have installed the same equipment. In response to question 5, the decision maker says they would have installed the qualifying equipment 18 months later, which has a NTGR value of (18-6)*.024, or .29 associated with it.

The No-Program score is 10 minus (4*(1-.29)), which is 10 minus 4*.71 or 7.16.

Core NTG Ratio

The self-reported core NTGR in most cases is simply the average of the Program Influence, Timing and Selection, and No-Program Scores, divided by 10. The one exception to this is when the respondent indicates 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 is based on the average of the Program Influence and No-Program scores only.

Example (Core NTGR)

The NTGR is the average of 6, 8 and 7.2, or 7.1 divided by 10 = .71. This figure is then applied to adjusted gross savings to yield net savings.

Appendix D

Demonstration of Compliance with the CPUC/ED and MEC's Guidelines for Estimating Net-to-Gross Ratios Using the Self-Report Approach

1. Timing of the interview

To minimize problems of recall, every effort should be made to conduct the NTGR interview as close to project completion as possible.

2. Identifying the correct respondent

The survey form includes some initial probing on the respondent's role in the completed project, to confirm their involvement in the decision to implement the energy efficiency measures. In addition, both the utility or third party representative and any trade allies involved should be asked to confirm they are the correct contact. If multiple decision makers are identified, each one should be interviewed and the results pooled.

In the unfortunate circumstance where the key decision maker has left the company, that sample point should be discarded and replaced with a respondent from within the same stratum in the backup sample.

3. Set-up questions

The survey includes a series of warm-up questions that serve to remind the respondent about the circumstances and motivations surrounding the project, the project scope (including installed measures), incentives paid, and the project schedule. This information also helps to build the "story" to substantiate the NTGR responses given.

4. Use of multiple questions

The NTGR scoring algorithm relies on responses from several questions to determine the final NTGR score. The scoring is a function of:

- The timing of their program awareness relative to their decision to implement the installed measure
- The importance of program versus non-program influences in their decision making
- The importance of specific influences in the participant's general decision to implement the measure and that led them to implement the specific measure at the time they did rather than an alternative
- Without the program, the probability of alternative actions to implementing the selected measure

5. Validity and reliability

The proposed NTGR method is designed to produce valid and reliable NTGR results, based on the use of:

- *"Tried and true" question wording.* Many of the core questions used in NTGR scoring are substantially the same as those that have been used extensively in previous large C&I program evaluations, such as the last several rounds of evaluation for the California Standard Performance Contracting Program. While the question construct is somewhat different from in the past, the wording used is essentially the same as has been used previously.

- *Information from supplemental questions and multiple data sources to corroborate and triangulate on the NTGR "story".* In addition to self-reported information, the NTGR findings for Standard and Standard – Very Large NTGR sites include responses to a number of supplemental questions surrounding the project (e.g., corporate policy, standard industry practice and payback), and the results from an interview with the vendor(s) involved in the project. These findings will be used to converge on a plausible estimate of the NTGR and to help tell the "story" behind the project and its context.
- *Multiple reviewers. Standard - Very Large customer projects are reviewed by two experienced analysts.* The two reviewers seek to develop a NTGR consensus on the project, and resolve any differences of opinion.
- *Identification and explicit consideration of alternate hypotheses.* Respondents are asked about the relative influence of a variety of program and non-program factors.

During the pre-test of the NTGR survey instrument, reliability tests should be conducted using the CATI software. Any problem areas detected should be corrected.

6. Consistency checks

Questions within the NTGR battery that are more likely to produce inconsistent responses have been flagged. These include questions regarding the program's reported importance in the decision to implement the specified measure, alternative actions in the program's absence, questions reporting the motivations for doing the project, as well as any closely related supplemental questions. The CATI software should be specifically programmed to flag any inconsistencies, and include follow-up prompts when they are found. Interviewers should be instructed how to administer these follow-up questions to resolve these inconsistencies. Interviewers should make every effort to resolve any inconsistencies before concluding the interview. Examples of the procedures for checking consistency of responses are provided in Section 3.

7. Making the Questions Measure-Specific

In general, most projects involve one type or class of measure. However, there are a few instances where the project consists of multiple types of measures, but usually, one measure predominates. In such cases, the interview should be conducted around the dominant measure with the greatest share of savings. If there are projects with multiple types of measures and no one measure class predominates, the NTGR sequence should be repeated for each significant measure class (e.g., once for lighting and once for process measures). At the beginning of each interview, there is a prompt with a description of the measure class that the questions pertain to so that it is clear in the minds of the respondent which measures they are being asked about.

8. Partial free-ridership

Questions P1-P9 are designed to collect the information necessary to adjust for any partial free-ridership. *However, this adjustment is be made to the **gross savings** estimates and not to the NTGR.*

9. Deferred free-ridership

Question N6 addresses deferred free ridership, and provides specific adjustment factors for each response category. The NTGR algorithm (See Section 5 and Appendix C) text fully explains the specifics of this adjustment.

10. Scoring algorithms

The methodology includes a specific algorithm for developing a NTGR based on responses received. The results of the 0 to 10 scoring are used to develop specific values for each question used to score the NTGR. A description of the scoring algorithm is provided in Section 5 and in Appendix C.

11. Handling unit and item non-response

Every effort should be made to discourage non-responses (i.e., refusals and terminates). For example, in California, the interviewer points out that the energy efficiency program requires the project to be evaluated as a condition of participation. Absent such a requirement, interviewers should stress such things as the importance of evaluation in improving program design and delivery. In some cases, incentives can be offered to respondents. In the event various strategies are not successful, the non-responding customer should be replaced by another customer within the same stratum. While efforts to minimize item non-response ("don't knows" and "refusals") should be made using a variety of available techniques, one should recognize that forcing a response can distort the respondent's answer and introduce bias.

12. Weighting the NTGR

The mean NTGR for a given measure, end use or program should be weighted to take into account the size of the ex post gross impacts.

13. Ruling out rival hypotheses

The core NTGR questions, particularly question 4 of the Decision Maker survey, have been carefully constructed to try to rule out rival hypotheses. The method 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 only their rating of the program's importance. This question structure more accurately reflects the complex nature of the real-world decision making and should help to ensure that all non-program influences are reflected in the NTGR assessment in addition to program influences.

14. Precision of the NTGR

The calculation of the achieved relative precision of the NTGRs (for program-related measures and practices and non-program measures and practices) is expected to be straightforward. However, the inclusion of more complicated situations involving multiple participant and vendor interviews as well as the inclusion of additional qualitative information means that the NTGR standard errors may underestimate the uncertainty surrounding the NTGR estimate.

15. Pre-testing the questionnaire

The NTGR survey should be carefully and extensively pre-tested and adjusted in response to pre-test findings before it is fielded.

16. Incorporation of additional qualitative and quantitative data in estimating the NTGR (data collection, rules for data integration, analysis)

Specific rules have been established for data integration and these are described in Section 3.

17. Qualified interviewers

The NTGR surveys should be fielded by highly experienced interviewers. High level professional interviewers should be used for the largest and most complex projects, while less experienced professional interviewers should be used for smaller, simpler projects. A CATI approach should be used for all but the very largest and most complex projects.

Survey Results for Greenhouse Heat Curtain NTG Analyses

Heat Curtain Decision Maker NTG Survey Results

Interview Type	STD1	STD3	STD1	STD1	STD3	STD1	STD2	STD2	STD3
Site ID	PGE1	PGE1a	PGE2	PGE2a	PGE3	PGE4	PGE8	PGE9	PGE9a
Timing and Selection Score	**8**	**8**	**8**	**8**	**8**	**10**	**9**	**9**	**9**
Please rate the importance of each of the following in your decision to implement this specific [MEASURE] at this time.									
The age or condition of the old equipment	9	8	5	5	8	N/A	8	7	6
Availability of the program rebate	8	8	8	8	8	10	9	9	9
Information provided through study, audit or other technical assistance provided through the program	0	0	0	0	0	0	0	0	0
Recommendation from a vendor	6	6	10	10	8	5	7	7	7
VENDOR VMAX Score times Vendor Rec. score if Vendor Rec.>5									
Previous experience with MEASURE	8	8	10	10	8	10	9	9	9
Previous experience with PROGRAM	8	8	8	8	6	9	9	9	9
Information from UTILITY or program training course	0	0	0	0	0	0	0	0	0
Information from UTILITY or program marketing materials	5	4	8	8	6	9	5	5	5
A recommendation from a design or consulting engineer	N/A	N/A	5	5	N/A	N/A	6	6	N/A
Standard practice in your industry	7	6	10	10	N/A	10	8	7	7
Recommendation from PROGRAM staff	4	5	8	8	N/A	0	5	5	5
Endorsement or recommendation by UTILITY Account Rep	0	0	0	0	0	0	0	0	0
Corporate policy or guidelines	5	5	5	5	N/A	9	1	1	1
Payback on the investment	9	9	8	8	10	10	9	9	9
Other, such as non-energy benefits	No	No	No	No	No	No	No	No	No
Importance of other factor	0	0	0	0	0	0	0	0	0
Program Influence Score (reduced by half if learned after decision)	**7**	**8**	**5**	**5**	**3**	**6**	**3**	**3**	**3**
Did you first learn about &PROGRAM BEFORE or AFTER you first began to think	Before	Before	Before	Before	Before	DK	Before	Before	Before
Did you learn about the program BEFORE or AFTER you decided to implement this measure?	0	0	0	0	0	Before	0	0	0
Please rate the overall importance of the Program versus the most important of the non-program factors we just discussed in your decision to implement the measure, so that the two importance ratings total 100									
Please rate the overall importance of PROGRAM in your decision to implement MEASURE?	7	8	5	5	3	6	3	3	3
Please rate the overall importance of other factors in your decision to implement MEASURE?	3	2	5	5	7	4	7	7	7
No-Program Score	**8.86**	**8.57**	**0.00**	**0.00**	**0.00**	**4.00**	**10.00**	**10.00**	**10.00**
If the &PROGRAM had not been available, what is the likelihood that you would have installed exactly the same item/equipment	4	5	10	10	10	7	5	4	5
When do you think you would have done this?	36	36	6	6	3	12	Never	Never	Never
Number of months	36	36	6	6	3	12	666	666	666
NTG Score	**0.80**	**0.82**	**0.25**	**0.25**	**0.15**	**0.67**	**0.73**	**0.73**	**0.73**

Heat Curtain Decision Maker NTG Survey Results

Interview Type	STD2	STD3	STD2	STD1	STD3
Site ID	PGE10	PGE11	PGE12	PGE21	PGE23
Timing and Selection Score	**10**	**10**	**6**	**8**	**9**
Please rate the importance of each of the following in your decision to implement this specific [MEASURE] at this time.					
The age or condition of the old equipment	8	10	8	5	7
Availability of the program rebate	10	10	6	8	9
Information provided through study, audit or other technical assistance provided through the program	0	0	0	0	0
Recommendation from a vendor	5	8	5	10	7
VENDOR VMAX Score times Vendor Rec. score if Vendor Rec.>5					
Previous experience with MEASURE	8	N/A	6	10	9
Previous experience with PROGRAM	8	N/A	6	8	9
Information from UTILITY or program training course	0	0	0	0	0
Information from UTILITY or program marketing materials	8	8	3	8	5
A recommendation from a design or consulting engineer	9	8	N/A	5	N/A
Standard practice in your industry	8	DK	3	10	7
Recommendation from PROGRAM staff	8	8	N/A	8	5
Endorsement or recommendation by UTILITY Account Rep	0	0	0	0	0
Corporate policy or guidelines	10	4	3	5	1
Payback on the investment	10	8	8	8	9
Other, such as non-energy benefits	No	No	The nice thing about is it let us think about doing a more efficiant roof before we wouldn't because it costs more and to find out what it meant it let us do something different otherwise we would do the same thing we would always do	No	No
Importance of other factor	0	0	8	0	0
Program Influence Score (reduced by half if learned after decision)	**6**	**7**	**3**	**5**	**3**
Did you first learn about &PROGRAM BEFORE or AFTER you first began to think	Before	After	Before	Before	Before
Did you learn about the program BEFORE or AFTER you decided to implement this measure?	0	DK	0	0	0
Please rate the overall importance of the Program versus the most important of the non-program factors we just discussed in your decision to implement the measure, so that the two importance ratings total 100					
Please rate the overall importance of PROGRAM in your decision to implement MEASURE?	6	7	3	5	3
Please rate the overall importance of other factors in your decision to implement MEASURE?	4	3	7	5	7
No-Program Score	**5.24**	**10.00**	**10.00**	**0.00**	**10.00**
If the &PROGRAM had not been available, what is the likelihood that you would have installed exactly the same item/equipment	5	0	2	10	5
When do you think you would have done this?	8	0	Never	6	Never
Number of months	8	0	666	6	666
NTG Score	**0.71**	**0.90**	**0.63**	**0.25**	**0.73**

Heat Curtain Decision Maker NTG Survey Results

Interview Type	STD2	STD2	STD2	STD2	STD1	STD1	STD2	STD3
Site ID	PGE25	PGE26	SCG1	SCG2	SCG4	SCG4a	SCG5	SCG6
Timing and Selection Score	**9**	**9**	**10**	**9**	**8**	**8**	**8**	**8**
Please rate the importance of each of the following in your decision to implement this specific [MEASURE] at this time.								
The age or condition of the old equipment	N/A	7	8	8	2	2	8	4
Availability of the program rebate	9	9	10	9	8	8	8	8
Information provided through study, audit or other technical assistance provided through the program	0	0	0	0	0	0	0	0
Recommendation from a vendor	10	5	8	N/A	7	7	8	5
VENDOR VMAX Score times Vendor Rec. score if Vendor Rec.>5								
Previous experience with MEASURE	10	5	10	7	8	8	8	8
Previous experience with PROGRAM	10	N/A	10	7	7	7	8	8
Information from UTILITY or program training course	0	0	0	0	0	0	0	0
Information from UTILITY or program marketing materials	8	9	10	5	5	5	3	8
A recommendation from a design or consulting engineer	10	N/A	0	0	N/A	N/A	3	N/A
Standard practice in your industry	N/A	8	10	6	10	10	8	8
Recommendation from PROGRAM staff	N/A	8	N/A	0	7	7	8	N/A
Endorsement or recommendation by UTILITY Account Rep	0	0	0	9	0	0	0	0
Corporate policy or guidelines	DK	8	N/A	5	8	8	3	5
Payback on the investment	10	10	10	9	10	10	10	4
Other, such as non-energy benefits	No	No	No	No	No	No	No	No
Importance of other factor	0	0	0	0	0	0	0	0
Program Influence Score (reduced by half if learned after decision)	**5**	**3.5**	**6**	**6**	**5**	**5**	**5**	**5**
Did you first learn about &PROGRAM BEFORE or AFTER you first began to think	After	After	Before	DK	After	After	Before	Before
Did you learn about the program BEFORE or AFTER you decided to implement this measure?	Before	After	0	Before	Before	Before	0	0
Please rate the overall importance of the Program versus the most important of the non-program factors we just discussed in your decision to implement the measure, so that the two importance ratings total 100								
Please rate the overall importance of PROGRAM in your decision to implement MEASURE?	5	7	6	6	5	5	5	5
Please rate the overall importance of other factors in your decision to implement MEASURE?	5	3	4	4	5	5	5	5
No-Program Score	**9.14**	**8.29**	**3.00**	**9.14**	**10.00**	**10.00**	**8.29**	**2.19**
If the &PROGRAM had not been available, what is the likelihood that you would have installed exactly the same item/equipment	3	3	7	3	3	3	3	8
When do you think you would have done this?	36	24	6	36	120	120	24	7
Number of months	36	24	6	36	120	120	24	7
NTG Score	**0.77**	**0.69**	**0.63**	**0.80**	**0.77**	**0.77**	**0.71**	**0.51**

Heat Curtain Decision Maker NTG Survey Results								
Interview Type	STD2	STD2	STD2	STD1	STD1	STD1	STD2	STD2
Site ID	SCG7	SCG8	SCG10	SCG12	SCG13	SCG14	SCG15	SCG16
Timing and Selection Score	**8**	**10**	**8**	**9**	**9**	**10**	**10**	**10**
Please rate the importance of each of the following in your decision to implement this specific [MEASURE] at this time.								
The age or condition of the old equipment	8	10	10	0	9	10	10	10
Availability of the program rebate	8	10	8	9	9	10	10	7
Information provided through study, audit or other technical assistance provided through the program	0	0	0	0	0	0	0	0
Recommendation from a vendor	8	7	8	0	4	2	5	10
VENDOR VMAX Score times Vendor Rec. score if Vendor Rec.>5								
Previous experience with MEASURE	8	8	10	9	9	0	10	5
Previous experience with PROGRAM	8	0	10	9	9	10	10	N/A
Information from UTILITY or program training course	0	0	0	0	0	0	0	0
Information from UTILITY or program marketing materials	3	2	8	1	5	8	10	5
A recommendation from a design or consulting engineer	N/A	0	5	0	N/A	N/A	8	8
Standard practice in your industry	3	10	10	8	9	8	5	10
Recommendation from PROGRAM staff	0	0	8	0	N/A	5	8	10
Endorsement or recommendation by UTILITY Account Rep	0	N/A	0	0	0	0	0	0
Corporate policy or guidelines	0	5	8	8	4	0	0	10
Payback on the investment	10	10	10	9	9	10	10	10
Other, such as non-energy benefits	The type of crop that you are growing in your greenhouses.	No	High energy costs.	No	Cost.	No	No	No
Importance of other factor	10	0	10	0	9	0	0	0
Program Influence Score (reduced by half if learned after decision)	**5**	**5**	**5**	**7**	**7**	**8**	**6**	**10**
Did you first learn about &PROGRAM BEFORE or AFTER you first began to think	Before	Before	Before	Before	Before	DK	Before	Before
Did you learn about the program BEFORE or AFTER you decided to implement this measure?	0	0	0	0	0	Before	0	0
Please rate the overall importance of the Program versus the most important of the non-program factors we just discussed in your decision to implement the measure, so that the two importance ratings total 100								
Please rate the overall importance of PROGRAM in your decision to implement MEASURE?	5	5	5	7	7	8	6	10
Please rate the overall importance of other factors in your decision to implement MEASURE?	5	5	5	3	3	2	4	0
No-Program Score	**8.00**	**8.86**	**1.43**	**10.00**	**7.14**	**10.00**	**4.00**	**0.00**
If the &PROGRAM had not been available, what is the likelihood that you would have installed exactly the same item/equipment	2	2	10	0	5	5	7	10
When do you think you would have done this?	6	24	12	0	24	60	12	6
Number of months	6	24	12	0	24	60	12	6
NTG Score	**0.70**	**0.80**	**0.32**	**0.87**	**0.77**	**0.93**	**0.67**	**0.50**

Heat Curtain Decision Maker NTG Survey Results

Interview Type	STD2	STD1	STD1	STD1	STD1	STD1	STD1	STD3
Site ID	SCG17	SCG20	SCG20a	SCG21	SCG22	SCG23	SCG23a	SCG24
Timing and Selection Score	**9**	**10**	**10**	**8**	**10**	**8**	**8**	**9**
Please rate the importance of each of the following in your decision to implement this specific [MEASURE] at this time.								
The age or condition of the old equipment	9	N/A	N/A	2	N/A	2	2	9
Availability of the program rebate	9	10	10	8	10	8	8	9
Information provided through study, audit or other technical assistance provided through the program	0	0	0	0	0	0	0	0
Recommendation from a vendor	4	8	8	7	8	7	7	5
VENDOR VMAX Score times Vendor Rec. score if Vendor Rec.>5								
Previous experience with MEASURE	7	N/A	N/A	8	N/A	8	8	5
Previous experience with PROGRAM	N/A	N/A	N/A	7	N/A	7	7	4
Information from UTILITY or program training course	0	0	0	0	0	0	0	0
Information from UTILITY or program marketing materials	1	10	10	5	10	5	5	4
A recommendation from a design or consulting engineer	0	N/A	N/A	N/A	N/A	N/A	N/A	2
Standard practice in your industry	8	10	10	10	10	10	10	8
Recommendation from PROGRAM staff	0	N/A	N/A	7	N/A	7	7	5
Endorsement or recommendation by UTILITY Account Rep	0	0	0	0	0	0	0	0
Corporate policy or guidelines	1	10	10	8	10	8	8	5
Payback on the investment	6	10	10	10	10	10	10	9
Other, such as non-energy benefits	The sempra representative	No	No	No	No	No	No	No
Importance of other factor	9	0	0	0	0	0	0	0
Program Influence Score (reduced by half if learned after decision)	**6**	**4**	**4**	**5**	**4**	**5**	**5**	**5**
Did you first learn about &PROGRAM BEFORE or AFTER you first began to think	Before	Before	Before	After	Before	After	After	Before
Did you learn about the program BEFORE or AFTER you decided to implement this measure?	0	0	0	Before	0	Before	Before	0
Please rate the overall importance of the Program versus the most important of the non-program factors we just discussed in your decision to implement the measure, so that the two importance ratings total 100								
Please rate the overall importance of PROGRAM in your decision to implement MEASURE?	6	4	4	5	4	5	5	5
Please rate the overall importance of other factors in your decision to implement MEASURE?	4	6	6	5	6	5	5	5
No-Program Score	**4.86**	**10.00**	**10.00**	**10.00**	**10.00**	**10.00**	**10.00**	**8.57**
If the &PROGRAM had not been available, what is the likelihood that you would have installed exactly the same item/equipment	6	5	5	3	5	3	3	2
When do you think you would have done this?	12	48	48	120	48	120	120	18
Number of months	12	48	48	120	48	120	120	18
NTG Score	**0.66**	**0.80**	**0.80**	**0.77**	**0.80**	**0.77**	**0.77**	**0.75**

Heat Curtain Decision Maker NTG Survey Results								
Interview Type	STD2	STD3	STD1	STD1	STD2	STD3	STD2	STD1
Site ID	SCG25	SCG42	SCG43	SCG44	SCG45	SCG47	SCG48	SDG1
Timing and Selection Score	**9**	**9**	**8**	**0**	**9**	**8**	**9**	**7**
Please rate the importance of each of the following in your decision to implement this specific [MEASURE] at this time.								
The age or condition of the old equipment	10	6	2	8	7	9	N/A	4
Availability of the program rebate	9	9	8	0	9	8	9	7
Information provided through study, audit or other technical assistance provided through the program	0	0	0	0	0	0	0	0
Recommendation from a vendor	10	7	7	6	N/A	6	3	0
VENDOR VMAX Score times Vendor Rec. score if Vendor Rec.>5								
Previous experience with MEASURE	9	9	8	8	8	8	8	8
Previous experience with PROGRAM	8	9	7	6	8	9	5	6
Information from UTILITY or program training course	0	0	0	0	0	0	0	0
Information from UTILITY or program marketing materials	8	5	5	0	4	8	8	4
A recommendation from a design or consulting engineer	8	N/A	N/A	7	N/A	0	1	2
Standard practice in your industry	8	7	10	7	6	6	7	8
Recommendation from PROGRAM staff	7	5	7	0	0	0	2	3
Endorsement or recommendation by UTILITY Account Rep	0	0	0	0	0	0	0	0
Corporate policy or guidelines	9	1	8	6	5	8	1	5
Payback on the investment	10	9	10	8	5	10	8	9
Other, such as non-energy benefits	No	No	No	We also installed because we wanted to block the lights	Cost savings.	Being able to have a better growing environment	No	No
Importance of other factor	0	0	0	8	7	8	0	0
Program Influence Score (reduced by half if learned after decision)	**5**	**3**	**5**	**2**	**7**	**6**	**5**	**4**
Did you first learn about &PROGRAM BEFORE or AFTER you first began to think	Before	Before	After	After	Before	Before	Before	Before
Did you learn about the program BEFORE or AFTER you decided to implement this measure?	0	0	Before	After	0	0	0	0
Please rate the overall importance of the Program versus the most important of the non-program factors we just discussed in your decision to implement the measure, so that the two importance ratings total 100								
Please rate the overall importance of PROGRAM in your decision to implement MEASURE?	5	3	5	4	7	6	5	4
Please rate the overall importance of other factors in your decision to implement MEASURE?	5	7	5	6	3	4	5	6
No-Program Score	**5.43**	**10.00**	**10.00**	**0.00**	**2.29**	**6.00**	**10.00**	**8.86**
If the &PROGRAM had not been available, what is the likelihood that you would have installed exactly the same item/equipment	8	5	3	10	9	7	6	4
When do you think you would have done this?	24	Never	120	6	12	24	48	36
Number of months	24	666	120	6	12	24	48	36
NTG Score	**0.65**	**0.73**	**0.77**	**0.10**	**0.61**	**0.67**	**0.80**	**0.66**

Heat Curtain Decision Maker NTG Survey Results

Interview Type	STD2	STD3	STD3	STD3	STD3
Site ID	SDG3	SDG4	SDG4a	SDG13	SDG14
Timing and Selection Score	**6**	**8**	**8**	**8**	**8**
Please rate the importance of each of the following in your decision to implement this specific [MEASURE] at this time.					
The age or condition of the old equipment	4	10	10	10	2
Availability of the program rebate	4	8	8	8	7
Information provided through study, audit or other technical assistance provided through the program	0	0	0	0	0
Recommendation from a vendor	3	10	10	10	2
VENDOR VMAX Score times Vendor Rec. score if Vendor Rec.>5					
Previous experience with MEASURE	10	10	10	10	8
Previous experience with PROGRAM	8	10	10	10	7
Information from UTILITY or program training course	0	0	0	0	0
Information from UTILITY or program marketing materials	6	3	3	3	5
A recommendation from a design or consulting engineer	3	N/A	N/A	N/A	N/A
Standard practice in your industry	8	9	9	9	6
Recommendation from PROGRAM staff	6	5	5	5	8
Endorsement or recommendation by UTILITY Account Rep	0	0	0	0	0
Corporate policy or guidelines	5	10	10	10	4
Payback on the investment	10	10	10	10	9
Other, such as non-energy benefits	Plants i grow need shade systems	No	No	No	No
Importance of other factor	8	0	0	0	0
Program Influence Score (reduced by half if learned after decision)	**2**	**5**	**5**	**5**	**3**
Did you first learn about &PROGRAM BEFORE or AFTER you first began to think	After	Before	Before	Before	Before
Did you learn about the program BEFORE or AFTER you decided to implement this measure?	After	0	0	0	0
Please rate the overall importance of the Program versus the most important of the non-program factors we just discussed in your decision to implement the measure, so that the two importance ratings total 100					
Please rate the overall importance of PROGRAM in your decision to implement MEASURE?	4	5	5	5	3
Please rate the overall importance of other factors in your decision to implement MEASURE?	6	5	5	5	7
No-Program Score	**0.00**	**1.43**	**1.43**	**1.43**	**8.00**
If the &PROGRAM had not been available, what is the likelihood that you would have installed exactly the same item/equipment	10	10	10	10	7
When do you think you would have done this?	6	12	12	12	36
Number of months	6	12	12	12	36
NTG Score	**0.10**	**0.32**	**0.32**	**0.32**	**0.63**

Survey Results for Greenhouse Infrared Film NTG Analyses

Infrared Film Decision Maker NTG Survey Results

Interview Type	STD2	STD1	STD2	STD2	STD3	STD2	STD2	STD2
Site ID	PGE13	PGE14	PGE14a	PGE15	PGE16	PGE28	PGE29	PGE31
Timing and Selection Score	**4**	**8**	**8**	**8**	**10**	**10**	**8**	**8**
Please rate the importance of each of the following in your decision to implement this specific [MEASURE] at this time.								
The age or condition of the old equipment	10	0	0	7	10	8	8	6
Availability of the program rebate	4	8	8	8	10	8	8	8
Information provided through study, audit or other technical assistance provided through the program	0	0	0	0	0	0	0	0
Recommendation from a vendor	8	2	N/A	4	10	7	5	7
VENDOR VMAX Score times Vendor Rec. score if Vendor Rec.>5								
Previous experience with MEASURE	10	5	8	N/A	10	5	0	6
Previous experience with PROGRAM	4	5	5	N/A	10	8	8	6
Information from UTILITY or program training course	0	0	0	0	0	0	0	0
Information from UTILITY or program marketing materials	4	6	5	5	10	10	0	7
A recommendation from a design or consulting engineer	N/A	0	N/A	N/A	0	10	0	7
Standard practice in your industry	8	5	6	5	8	10	0	7
Recommendation from PROGRAM staff	N/A	4	6	5	5	10	5	6
Endorsement or recommendation by UTILITY Account Rep	0	0	0	0	0	0	0	0
Corporate policy or guidelines	7	5	5	6	5	3	0	7
Payback on the investment	7	6	8	7	10	10	8	8
Other, such as non-energy benefits	No	No	No	No	No	Rebate allowed us to lower cost and purchase the better product	No	No
Importance of other factor	0	0	0	0	0	10	0	0
Program Influence Score (reduced by half if learned after decision)	**2**	**6**	**6**	**6**	**3**	**10**	**8**	**5**
Did you first learn about &PROGRAM BEFORE or AFTER you first began to think about implementing this measure?	DK	Before	Before	Before	Before	DK	Before	Before
Did you learn about the program BEFORE or AFTER you decided to implement this measure?	Before	0	0	0	0	Before	0	0
Please rate the overall importance of the Program versus the most important of the non-program factors we just discussed in your decision to implement the measure, so that the two importance ratings total 100								
Please rate the overall importance of PROGRAM in your decision to implement MEASURE?	2	6	6	6	3	10	8	5
Please rate the overall importance of other factors in your decision to implement MEASURE?	8	4	4	4	7	0	2	5
No-Program Score	**0.00**	**10.00**	**10.00**	**5.00**	**4.86**	**5.71**	**6.00**	**7.21**
If the &PROGRAM had not been available, what is the likelihood that you would have installed exactly the same item/equipment	10	2	2	5	6	6	4	3
When do you think you would have done this?	6	Never	Never	6	12	18	0	9
Number of months	6	666	666	6	12	18	0	9
NTG Score	**0.10**	**0.80**	**0.80**	**0.63**	**0.60**	**0.86**	**0.73**	**0.67**

Infrared Film Decision Maker NTG Survey Results

Interview Type	STD2	STD2	STD1	STD2	STD3	STD1
Site ID	PGE33	SCG28	SCG29	SCG29a	SCG30	SCG31
Timing and Selection Score	**10**	**8**	**8**	**8**	**10**	**9**
Please rate the importance of each of the following in your decision to implement this specific [MEASURE] at this time.						
The age or condition of the old equipment	10	8	9	9	10	6
Availability of the program rebate	10	7	7	7	10	9
Information provided through study, audit or other technical assistance provided through the program	0	0	0	0	0	0
Recommendation from a vendor	N/A	7	3	3	8	8
VENDOR VMAX Score times Vendor Rec. score if Vendor Rec.>5						
Previous experience with MEASURE	10	N/A	7	7	10	N/A
Previous experience with PROGRAM	10	7	6	6	10	N/A
Information from UTILITY or program training course	0	0	0	0	0	0
Information from UTILITY or program marketing materials	10	5	8	8	10	7
A recommendation from a design or consulting engineer	N/A	N/A	N/A	N/A	10	0
Standard practice in your industry	10	8	8	8	N/A	0
Recommendation from PROGRAM staff	N/A	8	7	7	8	0
Endorsement or recommendation by UTILITY Account Rep	0	Without that info we would not have done much	0	0	0	0
Corporate policy or guidelines	10	N/A	8	8	10	N/A
Payback on the investment	10	10	8	8	10	8
Other, such as non-energy benefits	No	No	No	No	No	Sounded like material would be better
Importance of other factor	0	0	0	0	0	8
Program Influence Score (reduced by half if learned after decision)	**3**	**2.5**	**3**	**3**	**8**	**8**
Did you first learn about &PROGRAM BEFORE or AFTER you first began to think about implementing this measure?	After	After	Before	Before	Before	Before
Did you learn about the program BEFORE or AFTER you decided to implement this measure?	After	After	0	0	0	0
Please rate the overall importance of the Program versus the most important of the non-program factors we just discussed in your decision to implement the measure, so that the two importance ratings total 100						
Please rate the overall importance of PROGRAM in your decision to implement MEASURE?	6	5	3	3	8	8
Please rate the overall importance of other factors in your decision to implement MEASURE?	4	5	7	7	2	2
No-Program Score	**4.00**	**0.00**	**1.00**	**1.00**	**7.14**	**10.00**
If the &PROGRAM had not been available, what is the likelihood that you would have installed exactly the same item/equipment	6	10	9	9	5	0
When do you think you would have done this?	6	2	6	6	DK	0
Number of months	6	2	6	6	24	0
NTG Score	**0.57**	**0.13**	**0.20**	**0.20**	**0.84**	**0.90**

Infrared Film Decision Maker NTG Survey Results

Interview Type	STD1	STD2	STD1	STD2	STD1	STD1
Site ID	SCG33	SCG34	SCG36	SCG37	SCG40	SCG52
Timing and Selection Score	**5**	**2**	**10**	**8**	**7**	**10**
Please rate the importance of each of the following in your decision to implement this specific [MEASURE] at this time.						
The age or condition of the old equipment	0	10	7	10	8	7
Availability of the program rebate	5	2	10	6	5	10
Information provided through study, audit or other technical assistance provided through the program	0	0	0	0	0	0
Recommendation from a vendor	N/A	1	8	8	2	8
VENDOR VMAX Score times Vendor Rec. score if Vendor Rec.>5						
Previous experience with MEASURE	N/A	2	5	10	10	5
Previous experience with PROGRAM	N/A	2	8	7	8	8
Information from UTILITY or program training course	0	0	0	0	0	0
Information from UTILITY or program marketing materials	5	1	6	8	7	6
A recommendation from a design or consulting engineer	N/A	0	N/A	6	N/A	N/A
Standard practice in your industry	5	5	3	7	6	3
Recommendation from PROGRAM staff	2	1	6	6	N/A	6
Endorsement or recommendation by UTILITY Account Rep	0	0	0	They were very helpful and communicated the diff things avail to us with the program	0	0
Corporate policy or guidelines	0	0	5	5	5	5
Payback on the investment	5	3	4	7	7	4
Other, such as non-energy benefits	No	No	No	No	No	No
Importance of other factor	0	0	0	0	0	0
Program Influence Score (reduced by half if learned after decision)	**5**	**1**	**6**	**10**	**5**	**6**
Did you first learn about &PROGRAM BEFORE or AFTER you first began to think about implementing this measure?	Before	After	Before	After	Before	Before
Did you learn about the program BEFORE or AFTER you decided to implement this measure?	0	After	0	Before	0	0
Please rate the overall importance of the Program versus the most important of the non-program factors we just discussed in your decision to implement the measure, so that the two importance ratings total 100						
Please rate the overall importance of PROGRAM in your decision to implement MEASURE?	5	2	6	10	5	6
Please rate the overall importance of other factors in your decision to implement MEASURE?	5	8	4	0	5	4
No-Program Score	**5.00**	**0.00**	**7.14**	**6.57**	**4.86**	**7.14**
If the &PROGRAM had not been available, what is the likelihood that you would have installed exactly the same item/equipment	5	10	5	4	9	5
When do you think you would have done this?	6	6	24	12	DK	24
Number of months	6	6	24	12	24	24
NTG Score	**0.50**	**0.05**	**0.77**	**0.82**	**0.56**	**0.77**

Infrared Film Decision Maker NTG Survey Results

Interview Type	STD1	STD2	STD2	STD2	STD2	STD2
Site ID	**SCG53**	**SCG55**	**SCG56**	**SCG58**	**SCG59**	**SCG61**
Timing and Selection Score	**10**	**10**	**10**	**8**	**10**	**10**
Please rate the importance of each of the following in your decision to implement this specific [MEASURE] at this time.						
The age or condition of the old equipment	8	DK	10	8	10	10
Availability of the program rebate	10	10	10	8	10	10
Information provided through study, audit or other technical assistance provided through the program	0	0	0	0	0	0
Recommendation from a vendor	0	10	10	8	8	8
VENDOR VMAX Score times Vendor Rec. score if Vendor Rec.>5						
Previous experience with MEASURE	10	10	10	8	10	10
Previous experience with PROGRAM	10	10	10	8	10	10
Information from UTILITY or program training course	0	0	0	0	0	0
Information from UTILITY or program marketing materials	2	5	N/A	8	10	8
A recommendation from a design or consulting engineer	0	N/A	N/A	5	5	10
Standard practice in your industry	10	DK	10	8	10	N/A
Recommendation from PROGRAM staff	0	10	N/A	8	5	10
Endorsement or recommendation by UTILITY Account Rep	0	0	0	0	0	Its tremendous this program is huge the cost savings is amazing
Corporate policy or guidelines	0	8	0	8	5	N/A
Payback on the investment	8	10	10	8	10	10
Other, such as non-energy benefits	No	No	No	No	No	Quality of growing and cost
Importance of other factor	0	0	0	0	0	10
Program Influence Score (reduced by half if learned after decision)	**5**	**5**	**5**	**5**	**5**	**8**
Did you first learn about &PROGRAM BEFORE or AFTER you first began to think about implementing this measure?	Before	Before	After	Before	Before	Before
Did you learn about the program BEFORE or AFTER you decided to implement this measure?	0	0	Before	0	0	0
Please rate the overall importance of the Program versus the most important of the non-program factors we just discussed in your decision to implement the measure, so that the two importance ratings total 100						
Please rate the overall importance of PROGRAM in your decision to implement MEASURE?	5	5	5	5	5	8
Please rate the overall importance of other factors in your decision to implement MEASURE?	5	5	5	5	5	2
No-Program Score	**0.00**	**10.00**	**0.00**	**1.43**	**3.14**	**0.00**
If the &PROGRAM had not been available, what is the likelihood that you would have installed exactly the same item/equipment	10	0	10	10	8	10
When do you think you would have done this?	6	0	6	12	12	6
Number of months	6	0	6	12	12	6
NTG Score	**0.25**	**0.83**	**0.25**	**0.32**	**0.60**	**0.40**

Infrared Film Decision Maker NTG Survey Results

Interview Type	STD3	STD2	STD1	STD1	STD1
Site ID	SCG62	SCG63	SDG5	SDG8	SDG8a
Timing and Selection Score	**10**	**9**	**5**	**0**	**0**
Please rate the importance of each of the following in your decision to implement this specific [MEASURE] at this time.					
The age or condition of the old equipment	8	10	**9**	10	10
Availability of the program rebate	10	8	**5**	0	0
Information provided through study, audit or other technical assistance provided through the program	0	0	**0**	0	0
Recommendation from a vendor	8	9	**3**	0	0
VENDOR VMAX Score times Vendor Rec. score if Vendor Rec.>5					
Previous experience with MEASURE	8	9	**7**	10	10
Previous experience with PROGRAM	8	N/A	**5**	5	5
Information from UTILITY or program training course	0	0	**0**	0	0
Information from UTILITY or program marketing materials	8	9	**5**	0	0
A recommendation from a design or consulting engineer	6	N/A	**3**	N/A	N/A
Standard practice in your industry	N/A	9	**7**	5	5
Recommendation from PROGRAM staff	N/A	9	**5**	0	0
Endorsement or recommendation by UTILITY Account Rep	0	Because people in my industry we all talk and share ideas	**0**	0	0
Corporate policy or guidelines	N/A	8	**5**	10	10
Payback on the investment	10	9	**8**	10	10
Other, such as non-energy benefits	No	No	**No**	Ability to run higher light without getting too hot	Ability to run higher light without getting too hot
Importance of other factor	0	0	**0**	10	10
Program Influence Score (reduced by half if learned after decision)	**6**	**4**	**5**	**2**	**2**
Did you first learn about &PROGRAM BEFORE or AFTER you first began to think about implementing this measure?	Before	Before	**Before**	Before	Before
Did you learn about the program BEFORE or AFTER you decided to implement this measure?	0	0	**0**	0	0
Please rate the overall importance of the Program versus the most important of the non-program factors we just discussed in your decision to implement the measure, so that the two importance ratings total 100					
Please rate the overall importance of PROGRAM in your decision to implement MEASURE?	6	4	**5**	2	2
Please rate the overall importance of other factors in your decision to implement MEASURE?	4	6	**5**	8	8
No-Program Score	**6.00**	**1.43**	**7.14**	**0.00**	**0.00**
If the &PROGRAM had not been available, what is the likelihood that you would have installed exactly the same item/equipment	7	10	**5**	10	10
When do you think you would have done this?	24	12	**24**	6	6
Number of months	24	12	**24**	6	6
NTG Score	**0.73**	**0.27**	**0.57**	**0.10**	**0.10**

Infrared Film Decision Maker NTG Survey Results

Interview Type	STD1	STD1	STD1	STD1
Site ID	SDG11	SDG12	SDG12a	SDG16
Timing and Selection Score	**0**	**5**	**5**	**0**
Please rate the importance of each of the following in your decision to implement this specific [MEASURE] at this time.				
The age or condition of the old equipment	10	**9**	**9**	10
Availability of the program rebate	0	**5**	**5**	0
Information provided through study, audit or other technical assistance provided through the program	0	**0**	**0**	0
Recommendation from a vendor	0	**3**	**3**	0
VENDOR VMAX Score times Vendor Rec. score if Vendor Rec.>5				
Previous experience with MEASURE	10	**7**	**7**	10
Previous experience with PROGRAM	5	**5**	**5**	5
Information from UTILITY or program training course	0	**0**	**0**	0
Information from UTILITY or program marketing materials	0	**5**	**5**	0
A recommendation from a design or consulting engineer	N/A	**3**	**3**	N/A
Standard practice in your industry	5	**7**	**7**	5
Recommendation from PROGRAM staff	0	**5**	**5**	0
Endorsement or recommendation by UTILITY Account Rep	0	**0**	**0**	0
Corporate policy or guidelines	10	**5**	**5**	10
Payback on the investment	10	**8**	**8**	10
Other, such as non-energy benefits	Ability to run higher light without getting too hot	**No**	**No**	Ability to run higher light without getting too hot
Importance of other factor	10	**0**	**0**	10
Program Influence Score (reduced by half if learned after decision)	**2**	**5**	**5**	**2**
Did you first learn about &PROGRAM BEFORE or AFTER you first began to think about implementing this measure?	Before	**Before**	**Before**	Before
Did you learn about the program BEFORE or AFTER you decided to implement this measure?	0	**0**	**0**	0
Please rate the overall importance of the Program versus the most important of the non-program factors we just discussed in your decision to implement the measure, so that the two importance ratings total 100				
Please rate the overall importance of PROGRAM in your decision to implement MEASURE?	2	**5**	**5**	2
Please rate the overall importance of other factors in your decision to implement MEASURE?	8	**5**	**5**	8
No-Program Score	**0.00**	**7.14**	**7.14**	**0.00**
If the &PROGRAM had not been available, what is the likelihood that you would have installed exactly the same item/equipment	10	**5**	**5**	10
When do you think you would have done this?	6	**24**	**24**	6
Number of months	6	**24**	**24**	6
NTG Score	**0.10**	**0.57**	**0.57**	**0.10**

Survey Results for Ag-Food NTG Analyses

Ag-Food Decision-Maker NTG Survey Results

Interview Type	BASIC	BASIC	BASIC	BASIC	BASIC	BASIC	BASIC
Site ID	120	121	124	125	126	132	135
Timing and Selection Score	**10**	**9**	**10**	**8**	**7**	**6**	**9**
Please rate the importance of each of the following in your decision to implement this specific [MEASURE] at this time.							
The age or condition of the old equipment	8	4	DK	7	0	N/A	8
Availability of the program rebate	10	9	10	5	7	6	6
Information provided through study, audit or other technical assistance provided through the program	0	0	0	0	0	0	0
Recommendation from a vendor	8	7	10	8	6	5	8
VENDOR VMAX Score times Vendor Rec. score if Vendor Rec.>5							
Previous experience with MEASURE	8	8	N/A	4	6	DK	0
Previous experience with PROGRAM	8	8	10	4	0	5	9
Information from UTILITY or program training course	0	0	0	0	0	0	0
Information from UTILITY or program marketing materials	9	9	N/A	5	0	4	9
A recommendation from a design or consulting engineer	8	7	10	9	0	5	5
Standard practice in your industry	8	8	10	9	6	7	7
Recommendation from PROGRAM staff	8	8	DK	8	0	2	4
Endorsement or recommendation by UTILITY Account Rep	9	5	10	1	0	N/A	5
Corporate policy or guidelines	8	5	DK	10	0	5	3
Payback on the investment	9	9	10	8	7	7	10
Other, such as non-energy benefits	No	Number one reason is to help the cows stay cool in hot weather	No	No	No	No	No
Importance of other factor	0	10	0	0	0	0	0
Program Influence Score (reduced by half if learned after decision)	**5**	**5**	**5**	**3**	**2.5**	**7**	**3**
Did you first learn about &PROGRAM BEFORE or AFTER you first began to think about implementing this measure?	Before	Before	Before	Before	After	Before	Before
Did you learn about the program BEFORE or AFTER you decided to implement this measure?	0	0	0	0	After	0	0
Please rate the overall importance of the Program versus the most important of the non-program factors we just discussed in your decision to implement the measure, so that the two importance ratings total 100							
Please rate the overall importance of PROGRAM in your decision to implement MEASURE?	5	5	5	3	5	7	3
Please rate the overall importance of other factors in your decision to implement MEASURE?	5	5	5	7	5	3	7
No-Program Score	**4.86**	**5.00**	**7.14**	**1.43**	**6.00**	**7.71**	**3.14**
If the &PROGRAM had not been available, what is the likelihood that you would have installed exactly the same item/equipment	6	5	5	10	4	4	8
When do you think you would have done this?	12	6	DK	12	3	24	12
Number of months	12	6	24	12	3	24	12
NTG Score	**0.66**	**0.63**	**0.74**	**0.22**	**0.52**	**0.69**	**0.50**

Ag-Food Decision-Maker NTG Survey Results

Interview Type	STD LRG	BASIC	BASIC	STD	STD	STD LRG
Site ID	136	137	138	139	140	143
Timing and Selection Score	**9**	**10**	**8**	**8**	**10**	**10**
Please rate the importance of each of the following in your decision to implement this specific [MEASURE] at this time.						
The age or condition of the old equipment	0	10	2	4	4	7
Availability of the program rebate	8	10	8	1	10	10
Information provided through study, audit or other technical assistance provided through the program	8	0	0	0	0	7
Recommendation from a vendor	10	0	10	8	6	6
VENDOR VMAX Score times Vendor Rec. score if Vendor Rec.>5	0					0
Previous experience with MEASURE	5	10	N/A	N/A	N/A	6
Previous experience with PROGRAM	0	10	8	8	8	8
Information from UTILITY or program training course	8	0	0	0	0	6
Information from UTILITY or program marketing materials	N/A	0	6	N/A	6	5
A recommendation from a design or consulting engineer	9	0	10	N/A	6	5
Standard practice in your industry	1	10	4	DK	7	5
Recommendation from PROGRAM staff	9	0	N/A	8	3	8
Endorsement or recommendation by UTILITY Account Rep	1	N/A	8	DK	8	8
Corporate policy or guidelines	4	0	4	8	6	8
Payback on the investment	6	10	8	8	10	10
Other, such as non-energy benefits	Meeting NOx pollution requirements	No	No	No	No	Before contact's time at company. Typically many reasons.
Importance of other factor	8	0	0	0	0	8
Program Influence Score (reduced by half if learned after decision)	**5**	**10**	**5**	**4**	**5**	**5**
Did you first learn about &PROGRAM BEFORE or AFTER you first began to think about implementing this measure?	After	Before	Before	Before	After	Before
Did you learn about the program BEFORE or AFTER you decided to implement this measure?	Before	0	0	0	DK	0
Please rate the overall importance of the Program versus the most important of the non-program factors we just discussed in your decision to implement the measure, so that the two importance ratings total 100						
Please rate the overall importance of PROGRAM in your decision to implement MEASURE?	5	10	5	4	5	5
Please rate the overall importance of other factors in your decision to implement MEASURE?	5	0	5	6	5	5
No-Program Score	**1.00**	**10.00**	**6.57**	**0.00**	**7.71**	**10.00**
If the &PROGRAM had not been available, what is the likelihood that you would have installed exactly the same item/equipment	9	0	4	10	4	3
When do you think you would have done this?	0	0	12	6	24	120
Number of months	0	0	12	6	24	120
NTG Score	**0.30**	**1.00**	**0.65**	**0.20**	**0.76**	**0.83**

Ag-Food Decision-Maker NTG Survey Results

Interview Type	STD LRG	BASIC	BASIC	BASIC	BASIC	STD	STD LRG
Site ID	144	145	146	150	152	153	154
Timing and Selection Score	**10**	**8**	**10**	**10**	**5**	**10**	**9**
Please rate the importance of each of the following in your decision to implement this specific [MEASURE] at this time.							
The age or condition of the old equipment	6	8	10	8	8	4	0
Availability of the program rebate	10	8	10	8	5	9	9
Information provided through study, audit or other technical assistance provided through the program	7	0	0	0	0	0	8
Recommendation from a vendor	6	5	10	10	0	0	7
VENDOR VMAX Score times Vendor Rec. score if Vendor Rec.>5	0						0
Previous experience with MEASURE	6	0	0	8	8	9	7
Previous experience with PROGRAM	8	0	5	N/A	8	4	8
Information from UTILITY or program training course	6	0	0	0	0	0	6
Information from UTILITY or program marketing materials	5	2	5	10	4	4	7
A recommendation from a design or consulting engineer	5	5	2	N/A	6	10	8
Standard practice in your industry	5	5	5	10	10	9	3
Recommendation from PROGRAM staff	8	6	5	10	0	10	7
Endorsement or recommendation by UTILITY Account Rep	8	5	5	10	N/A	N/A	7
Corporate policy or guidelines	8	5	5	10	9	10	3
Payback on the investment	10	7	10	10	6	10	9
Other, such as non-energy benefits	Before contact's time at company. Typically many reasons.	No	No	No	No	Easier for maint and repairs were to be reduced	New plant operations
Importance of other factor	8	0	0	0	0	6	0
Program Influence Score (reduced by half if learned after decision)	**5**	**8**	**3**	**5**	**4**	**5**	**8**
Did you first learn about &PROGRAM BEFORE or AFTER you first began to think about implementing this measure?	Before	Before	DK	Before	Before	Before	Before
Did you learn about the program BEFORE or AFTER you decided to implement this measure?	0	0	Before	0	0	0	0
Please rate the overall importance of the Program versus the most important of the non-program factors we just discussed in your decision to implement the measure, so that the two importance ratings total 100							
Please rate the overall importance of PROGRAM in your decision to implement MEASURE?	5	8	3	5	4	5	8
Please rate the overall importance of other factors in your decision to implement MEASURE?	5	2	7	5	6	5	2
No-Program Score	**10.00**	**10.00**	**10.00**	**0.00**	**4.00**	**10.00**	**10.00**
If the &PROGRAM had not been available, what is the likelihood that you would have installed exactly the same item/equipment	3	0	0	10	6	0	2
When do you think you would have done this?	120	0	0	6	6	0	120
Number of months	120	0	0	6	6	0	120
NTG Score	**0.83**	**0.87**	**0.77**	**0.25**	**0.43**	**0.83**	**0.90**

Ag-Food Decision-Maker NTG Survey Results

*

Interview Type	STD LRG	STD	STD	BASIC	STD	BASIC	STD
Site ID	155	159	160	161	163	164	165
Timing and Selection Score	**9**	**10**	**10**	**10**	**8**	**10**	**9**
Please rate the importance of each of the following in your decision to implement this specific [MEASURE] at this time.							
The age or condition of the old equipment	0	3	3	0	8	5	2
Availability of the program rebate	9	10	10	10	8	8	9
Information provided through study, audit or other technical assistance provided through the program	8	0	0	0	0	0	0
Recommendation from a vendor	7	0	0	N/A	5	10	7
VENDOR VMAX Score times Vendor Rec. score if Vendor Rec.>5	0						
Previous experience with MEASURE	7	6	6	0	9	8	8
Previous experience with PROGRAM	8	5	5	6	8	10	N/A
Information from UTILITY or program training course	6	0	0	0	0	0	0
Information from UTILITY or program marketing materials	7	0	0	0	5	8	8
A recommendation from a design or consulting engineer	8	0	0	0	N/A	10	5
Standard practice in your industry	3	6	6	10	0	8	7
Recommendation from PROGRAM staff	7	0	0	0	6	10	7
Endorsement or recommendation by UTILITY Account Rep	7	0	0	0	5	N/A	N/A
Corporate policy or guidelines	3	7	7	7	2	5	1
Payback on the investment	9	10	10	10	10	8	8
Other, such as non-energy benefits	New plant operations	No	No	No	No	No	No
Importance of other factor	0	0	0	0	0	0	0
Program Influence Score (reduced by half if learned after decision)	**8**	**6**	**6**	**7**	**6**	**3**	**8**
Did you first learn about &PROGRAM BEFORE or AFTER you first began to think about implementing this measure?	Before	Before	Before	Before	After	Before	After
Did you learn about the program BEFORE or AFTER you decided to implement this measure?	0	0	0	0	Before	0	Before
Please rate the overall importance of the Program versus the most important of the non-program factors we just discussed in your decision to implement the measure, so that the two importance ratings total 100							
Please rate the overall importance of PROGRAM in your decision to implement MEASURE?	8	6	6	7	6	3	8
Please rate the overall importance of other factors in your decision to implement MEASURE?	2	4	4	3	4	7	2
No-Program Score	**10.00**	**10.00**	**10.00**	**10.00**	**10.00**	**0.00**	**6.57**
If the &PROGRAM had not been available, what is the likelihood that you would have installed exactly the same item/equipment	2	0	0	0	1	10	6
When do you think you would have done this?	120	0	0	0	96	6	24
Number of months	120	0	0	0	96	6	24
NTG Score	**0.90**	**0.87**	**0.87**	**0.90**	**0.80**	**0.15**	**0.79**

Ag-Food Decision-Maker NTG Survey Results

Interview Type	BASIC	STD LRG	BASIC	BASIC
Site ID	166	167	168	231
Timing and Selection Score	**10**	**10**	**10**	**8**
Please rate the importance of each of the following in your decision to implement this specific [MEASURE] at this time.				
The age or condition of the old equipment	6	N/A	10	N/A
Availability of the program rebate	10	10	10	8
Information provided through study, audit or other technical assistance provided through the program	0	10	0	0
Recommendation from a vendor	8	10	6	8
VENDOR VMAX Score times Vendor Rec. score if Vendor Rec.>5		0		
Previous experience with MEASURE	4	10	2	N/A
Previous experience with PROGRAM	8	10	8	6
Information from UTILITY or program training course	0	6	0	0
Information from UTILITY or program marketing materials	10	10	5	7
A recommendation from a design or consulting engineer	N/A	10	1	10
Standard practice in your industry	10	8	4	10
Recommendation from PROGRAM staff	8	10	0	8
Endorsement or recommendation by UTILITY Account Rep	10	10	6	0
Corporate policy or guidelines	10	6	7	8
Payback on the investment	10	10	10	8
Other, such as non-energy benefits	Installed a 1 meg solar power station and the lighting was part of that whole package		Old lights were old and replacing would be expensive and made sense to put in effic lights	Putting in new tech that willl help environment and the co
Importance of other factor	10	0	5	10
Program Influence Score (reduced by half if learned after decision)	**10**	**Refused**	**5**	**10**
Did you first learn about &PROGRAM BEFORE or AFTER you first began to think about implementing this measure?	Before	Before	After	DK
Did you learn about the program BEFORE or AFTER you decided to implement this measure?	0	0	Before	Before
Please rate the overall importance of the Program versus the most important of the non-program factors we just discussed in your decision to implement the measure, so that the two importance ratings total 100				
Please rate the overall importance of PROGRAM in your decision to implement MEASURE?	10	Refused	5	10
Please rate the overall importance of other factors in your decision to implement MEASURE?	0	Refused	5	0
No-Program Score	**6.57**	**10.00**	**5.00**	**3.00**
If the &PROGRAM had not been available, what is the likelihood that you would have installed exactly the same item/equipment	4	0	5	7
When do you think you would have done this?	12	240	6	6
Number of months	12	240	6	6
NTG Score	**0.89**	**1.00**	**0.67**	**0.70**

Ag-Food Decision-Maker NTG Survey Results

Interview Type	BASIC	STD	BASIC	BASIC	STD LRG	STD LRG	BASIC
Site ID	234	236	237	240	241	242	244
Timing and Selection Score	**4**	**10**	**10**	**8**	**8**	**10**	**5**
Please rate the importance of each of the following in your decision to implement this specific [MEASURE] at this time.							
The age or condition of the old equipment	4	6	7	6	7	7	10
Availability of the program rebate	4	10	10	4	6	10	5
Information provided through study, audit or other technical assistance provided through the program	0	0	0	0	8	7	0
Recommendation from a vendor	1	7	N/A	6	2	6	3
VENDOR VMAX Score times Vendor Rec. score if Vendor Rec.>5					0	0	
Previous experience with MEASURE	7	7	10	10	5	5	5
Previous experience with PROGRAM	8	10	10	10	N/A	8	5
Information from UTILITY or program training course	0	0	0	0	N/A	6	0
Information from UTILITY or program marketing materials	2	10	10	8	0	5	0
A recommendation from a design or consulting engineer	2	7	N/A	N/A	8	5	0
Standard practice in your industry	8	7	10	10	2	5	5
Recommendation from PROGRAM staff	1	6	N/A	6	3	8	3
Endorsement or recommendation by UTILITY Account Rep	0	0	0	0	8	8	0
Corporate policy or guidelines	2	6	8	DK	6	8	0
Payback on the investment	8	8	10	8	9	10	8
Other, such as non-energy benefits	No	No	Get more reliable equipment	No	Increase in summer month productivity	Before contact's time at company. Typically many reasons.	No
Importance of other factor	0	0	10	0	9	8	0
Program Influence Score (reduced by half if learned after decision)	**2**	**8**	**6**	**8**	**3**	**5**	**2**
Did you first learn about &PROGRAM BEFORE or AFTER you first began to think about implementing this measure?	DK	DK	Before	After	Before	Before	Before
Did you learn about the program BEFORE or AFTER you decided to implement this measure?	Before	Before	0	Before	0	0	0
Please rate the overall importance of the Program versus the most important of the non-program factors we just discussed in your decision to implement the measure, so that the two importance ratings total 100							
Please rate the overall importance of PROGRAM in your decision to implement MEASURE?	2	8	6	8	3	5	2
Please rate the overall importance of other factors in your decision to implement MEASURE?	8	2	4	2	7	5	8
No-Program Score	**2.00**	**10.00**	**7.14**	**0.00**	**1.00**	**10.00**	**4.00**
If the &PROGRAM had not been available, what is the likelihood that you would have installed exactly the same item/equipment	8	5	5	10	9	3	7
When do you think you would have done this?	1	60	DK	6	0	120	12
Number of months	1	60	24	6	0	120	12
NTG Score	**0.27**	**0.93**	**0.77**	**0.40**	**0.20**	**0.83**	**0.37**

Ag-Food Decision-Maker NTG Survey Results

Interview Type	BASIC	STD	STD LRG	STD LRG	BASIC
Site ID	245	246	252	253	254
Timing and Selection Score	**10**	**9**	**4**	**10**	**10**
Please rate the importance of each of the following in your decision to implement this specific [MEASURE] at this time.					
The age or condition of the old equipment	2	10	7	0	5
Availability of the program rebate	10	7	0	10	10
Information provided through study, audit or other technical assistance provided through the program	0	0	0	0	0
Recommendation from a vendor	N/A	8	10	10	6
VENDOR VMAX Score times Vendor Rec. score if Vendor Rec.>5			0	0	
Previous experience with MEASURE	9	8	10	10	10
Previous experience with PROGRAM	8	9	4	8	10
Information from UTILITY or program training course	0	0	0	0	0
Information from UTILITY or program marketing materials	2	6	0	0	6
A recommendation from a design or consulting engineer	N/A	8	0	0	0
Standard practice in your industry	DK	8	5	5	10
Recommendation from PROGRAM staff	N/A	9	0	0	0
Endorsement or recommendation by UTILITY Account Rep	0	0	4	8	0
Corporate policy or guidelines	0	8	10	10	10
Payback on the investment	10	10	4	10	10
Other, such as non-energy benefits	Account rep from the utility pgande supported the measure with the client	No	Production requirements	Position as a enviromentally responsible company	No
Importance of other factor	8	0	9	8	0
Program Influence Score (reduced by half if learned after decision)	**4**	**2**	**0**	**4**	**5**
Did you first learn about &PROGRAM BEFORE or AFTER you first began to think about implementing this measure?	Before	Before	Before	Before	Before
Did you learn about the program BEFORE or AFTER you decided to implement this measure?	0	0	0	0	0
Please rate the overall importance of the Program versus the most important of the non-program factors we just discussed in your decision to implement the measure, so that the two importance ratings total 100					
Please rate the overall importance of PROGRAM in your decision to implement MEASURE?	4	2	0	4	5
Please rate the overall importance of other factors in your decision to implement MEASURE?	6	8	10	6	5
No-Program Score	**9.14**	**8.00**	**0.00**	**10.00**	**3.00**
If the &PROGRAM had not been available, what is the likelihood that you would have installed exactly the same item/equipment	3	7	10	3	7
When do you think you would have done this?	36	36	0	Never	6
Number of months	36	36	0	666	6
NTG Score	**0.77**	**0.63**	**0.00**	**0.80**	**0.60**

Summary Write-ups for Ag-Food Large-Project NTG Analyses

Site ID: 136

Measure Description: Replace 1968 B&W 150K pph boiler with a new 50K pph B&W boiler with flue gas condenser to preheat makeup water.

	The replacement of the boiler was prompted by the impending nitrogen oxides (NOx) requirements. The company was required to reduce their emissions by December 2008. Emission requirements limit NOx levels to 5 parts-per-million (pph) although at the time of the replacement, limits were set at 9 ppm. The new equipment used for processing steam operates at 95% fuel efficiency and is currently operating at 0.3ppm NOx due to the selective catalytic reduction system which controls the emissions. The existing boiler was in excellent condition but operating characteristics had changed and the efficiency levels were at only 58% at low fire. The low level of efficiency was due to converting the plant from one type of produce processing to a different type of produce processing facility and as a result the boiler is much larger than required for off season production. The dialog with PG&E began due to the emission requirements coupled with the opportunity to improve efficiency. If the emission levels were the only factor they may have retrofitted the existing equipment to meet emission standards. The boiler design concept had never been done before and PG&E was instrumental by lending credibility to the design concept, and helping to improve the return on investment (ROI). Due to the unique design a significant amount of research was required. Recommendations from the equipment vendor (10), design consultant (9), and PG&E program staff (9) were rated as the most significant factors to the implementation of the measure. The project as designed met the customer's ROI criterion of less than 5 years, and the customer indicated that they would have proceeded with the project without (9 out of 10 likelihood). However, since utility support was key to the design of the measure, the project was affected by the utility's program.
	NTG ratio - .30

Site ID: 143

Measure Description: Condenser Replacement

	Company corporate policy encourages engineers to find projects to reduce energy and save money. Projects are prioritized on a simple payback basis. At this facility, the customer stores fresh vegetables, requiring refrigeration. This measure, replacement of old, undersized compressors with new condensers that operate more efficiently, is consistent with the company approach to energy efficiency. Other factors noted were information received from utility seminars, engineering studies, and trade associations like Pacific Produce and the California League of Food Processors. The availability of the program rebate (10) and payback on the investment with rebate (10) were the most significant factors for this measure. Although the respondent was not with the company at the time of the measure installation, he indicated it was unlikely the project would have met the corporate payback criterion of less than 4 years without the program rebate. Other key factors were the experience with utility programs (8), recommendations by program staff and account reps (8), and corporate policy (8).		
	NTG ratio - .83		

Site ID: 144

Measure Description: Refrigerant Pipe Replacement

	The corporate policy at this company encourages engineering staff to seek opportunities to reduce energy at their facilities, prioritizing projects by simple payback. Equipment operators and other internal staff are also encouraged to develop projects to save energy and money. Additionally, the project would likely improve operations. At this facility, the customer uses liquid ammonia piping for their refrigeration system. The availability of the program rebate (10) and payback on the investment with rebate (10) were the most significant factors. Although the contact was not with the company at the time of the measure installation, he indicated it was unlikely the project would have met the corporate payback criterion of less than 4 years without the program rebate. Other key factors were the experience with utility programs (8), recommendations by program staff and account reps (8), corporate policy (8), and other factors, such as operational improvement.		
	NTG ratio - .83		

Site ID: 154 and 155

Measure Description: Phase I and Phase II of 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.

	The customer chose to locate the bottling plant in California based on the rebates available under utility programs. The respondent stated that the plant would have been built in a different state absent the utility program. Two high speed bottling lines were installed as Phase I and Phase II of the project. Prior to developing these measures, the company considered only the minimum cost to install. As a result of experiences with energy efficiency projects in southern California, the company began hunting for more efficient equipment. The ideas for the project were developed with in-house engineering and upper management support. The availability of the program rebate (9) and payback on the investment with rebate (9) were the most significant factors. Other key factors were information provided by technical assistance through the utility program (8), the experience with utility programs (8), recommendations by program staff, vendors, and account reps (7), and vendor recommendations (7). The company performs life-cycle analysis to evaluate which equipment to install. The designer and consultants on the project influenced the decisions, by providing all the machines capable of providing service and helping to weigh the costs with respect to the operations.		
	NTG ratio - .90 and .90		

Site ID: 167

Measure Description: 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.

	Corporate policy to improve efficiency of equipment coupled with rising electrical costs and a common practice in the industry was the motivation behind the customer's decision to examine the replacement of their 2-effect evaporator with a 3- effect evaporator. According to the respondent the 2-effect evaporator has been widely used the last 20 years while the 3-Effect for the last 10 years. At the plant where the 3-effect evaporator was installed there are two additional 2-effect evaporators that have yet to be replaced; however there are no current plans to replace them. The customer assessed the feasibility of the project and took into account factors such as replacement cost, operational savings and PG&E's incentive to determine the return on investment (ROI) which is less than 2 years. In the initial talks with PG&E, the program incentive cap was limited to $350,000. The incentive at this level did not meet their ROI threshold of two years and as a result the project was considered a financial burden and dropped. It wasn't until PG&E proposed to lift the incentive cap and based the rebate on the projected energy savings did the project become cost-effective. According to the respondent, the additional incentive just barely met minimum requirement at 2.4 years. The respondent felt the likelihood the equipment would have been installed absent the incentive was 0 out of 10 and that it may have taken as long as 20 years before without the rebate.		
	NTG ratio - 1.0		

Site ID: 241

Measure Description: Oversized Evaporative Condensers with Floating Head Pressure

Limitations in the production lines and safe operating conditions were the motivations to improve the company's equipment. The facility was in reasonably good condition except when system operating parameters were too high during summer months which required them to shut down production lines. PG&E had sent a firm to do an energy audit and identified discharging pressure and condensing capacity problems. Upgrades to the condensers would solve the problem, increase production, and improve system performance. A thorough analysis and feasibility study was conducted by an outside consulting firm. Meanwhile the company began talks with PG&E to qualify for an incentive.

The payback on the investment (9) was the most important aspect as it met their criterion of less than 3 years even without a rebate. Absent the rebate, the customer indicated they might not have added automation controls or variable speed capabilities. The selection of automated controls not only impacted efficiency but it also improved system operations. Significant energy savings, improvements in production, and safety concerns were other benefits (8) that influenced the decision. The availability of the rebate (6), while important, was less significant than the program support provided by the PG&E audit and recommendations (8) and the endorsement by the account rep (8).

NTG ratio - .20

Site ID: 242

Measure Description: Condenser Replacement

This customer employs an energy manager to reduce energy at their facilities, and they look for energy efficiency projects. Projects are prioritized on a simple payback basis. At this facility, the customer requires refrigeration to prepare, pack and store fresh vegetables. The measure to replace old, undersized compressors with new condensers that operate more efficiently was developed internally by plant staff as one of their ongoing energy efficiency projects.

The availability of the program rebate (10) and payback on the investment with rebate (10) were the most significant factors. Although the contact was not with the company at the time of the measure installation, he indicated it was unlikely the project would have met the corporate payback criterion of less than 4 years without the program rebate. Other key factors were the experience with utility programs (8), recommendations by program staff and account reps (8), and corporate policy (8).

NTG ratio - .83

Site ID: 252

Measure Description: New Pasteurizer

The company installed a new pasteurizer that allowed additional production flexibility. The previous unit could handle one size of cans only, but the new unit could handle additional sizes. The new pasteurizer was also more energy efficient than the previous unit. The ROI for this project met the corporate requirements without the rebate.

The program rebate was identified as having no effect on whether this project went forward (score of 0); the project would have been done without changes and at the same time without the rebate. Instead, key factors were the recommendation from equipment venders, the age or condition of the old equipment (7), previous experience with this type of project (10) and corporate policy (10). The low score reflects the unimportance of the program rebate for this measure.

NTG ratio - .00

Site ID: 253

Measure Description: New process effluent treatment process that produces Biogas, offsetting natural gas consumption.

The company put in the bio energy recovery system (BERS) to reduce steam usage and harvest digester gas. The BERS processes waste products, generating a biogas as a byproduct of anaerobic digestion that is used in the plant boilers. The BERS process replaced a steam aided evaporator and distillation unit. The installation of the BERS also follows their corporate policy to reduce emissions, fuel use and impact on the environment.

The availability of the program rebate, previous experience with similar projects, recommendation from an equipment vendor, corporate policy and the payback on the investment with rebate were all scored at 10, the highest level. The customer indicated that the project would never have been completed without the rebate. The company required defined estimates with capital, operating and return on investment calculations. The ROI for this project was 6 or 7 years without the rebate, but met the corporate requirements of 5.5 years payback.

NTG ratio - .80

C Greenhouse High-Impact Measure M&V Reports

This appendix contains the following elements:

- M&V report for the greenhouse heat-curtain measure
- M&V report for the greenhouse infrared-film measure
- Greenhouse M&V survey instrument

HIGH IMPACT MEASURE SITE MEASUREMENT AND VERIFICATION REPORT

GREENHOUSE HEAT CURTAINS

November 6th, 2009

PROJECT

Program Being Evaluated	PG&E, SDG&E, SCG greenhouse heat curtain rebates from the 2006-2008 program years
Project ID	High Impact Measures – Greenhouse Heat Curtains
Customer Name	
Site Name	
Site Address	
Site Type	Greenhouses
Customer Business/Product	

PRINCIPAL SITE CONTACT

Name		**Telephone**	
E-mail		**Title**	

IOU REPRESENTATIVE

Name		**Telephone**	
E-mail			

THIRD-PARTY SPONSOR OR IMPLEMENTER

Name		**Telephone**	
E-mail		**Company**	

ASSIGNED LEAD ENGINEER

Name	

AUTHOR

Name	

1. EVALUATION OBJECTIVES

1.1. Evaluation Objectives

This Measurement and Verification (M&V) Plan is part of the impact evaluation of Pacific Gas and Electric (PG&E), San Diego Gas and Electric (SDG&E), and Southern California Gas's (SCG) greenhouse heat curtain energy efficiency rebate programs. The primary goal of the impact evaluation is to assess the net energy impacts for the programs in these groups.

The objectives of the impact evaluation are to:

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

2. METHODS USED: IOU AND EVALUATION ALGORITHMS

2.1. Measures Included in the Evaluation

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 typically are deployed during nighttime hours for heat retention and during daytime hours for shading. Photograph 1 shows a furled heat curtain.

Photograph 1: Furled Greenhouse Heat Curtain

Heat curtains work by reducing infiltration, radiation, convection, and conduction through the greenhouse envelope. Metals with high reflectivity and low emissivity may be woven into the fabric of heat curtains to reflect radiant heat back into the greenhouse or excess solar energy out of the greenhouse. Additionally, heat curtains act to create a barrier between the air near the greenhouse plants and the air near the greenhouse roof. In doing so, heat curtains reduce convective and conductive heat loss through the greenhouse envelope and prevent temperature stratification from occurring. In older glass roof greenhouses with leaky envelopes, heat curtains may cut down on infiltration losses by reducing the total leakage area of the greenhouse envelope.

Heat curtains are intended to reduce heat loss at night, but may also be drawn during the day to cut down on excess solar gains. Heat curtains are put into place manually or with electronic motors and controls. More sophisticated heat curtain systems are automated, while much simpler systems are hand drawn.

PG&E, SDG&E, and SCG's programs all required that rebated heat curtains have an energy savings rating of more than 40%. This energy savings is achieved by cutting down on heat loss during the heating season and heat gain during the cooling season through the four heat transfer mechanisms described above.

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

In the 2006-2008 program period there were 69 prescriptive projects and one customized heat curtain project. Each project may include one or more greenhouses that were rebated under a single application at a site. Only installations of interior curtains in natural gas heated commercial greenhouses qualified for the prescriptive incentives. New construction projects were not eligible.

2.2. Impact Type

This measure is a *direct impact* measure.

2.3. Baseline Type

Heat curtains rebated through SDG&E and SCG programs were *early* replacement measures, while those rebated through PG&E programs were either *early* or *normal* replacement. Coversations during site visits indicated that the heat curtain installations at all of the sites included in the evaluation sample were normal replacement.

The following guidelines were followed to define the measure baseline for each site:

1) When as-built conditions indicated no heat curtains were installed prior to measure installation, then the measure baseline was no heat curtain. In the sample 13 projects fit this category.

2) When as-built conditions indicated two-layers of heat curtains were installed simultaneously, and at least one of the layers was rebated through the programs, then the measure baseline was no heat curtain and the evaluated measure was two layers of heat curtains. In the sample 5 projects fit this category.

3) When as-built conditions indicated two-layers of heat curtains and conversations with site staff indicated that the second heat curtain was installed after the first, and only the first heat curtain was rebated through the programs, the baseline was no heat curtain, the second curtain was not modeled, and the second curtain was identified as a potential spillover measure. In the sample 2 projects fit this category.

4) When as-built conditions in the greenhouse indicated two-layers of heat curtains and only one layer was included in the application and conversations with site staff indicated that the second heat curtain was installed before the rebated heat curtain, the baseline was one heat curtain.

According to program rules such an application should not have been approved. In the sample 1 project fit this category[1].

2.4. Sample Type

These projects were selected from a *post-only* sample. These projects were completed when the projects were sampled.

2.5. Pre-installation Equipment and Operation

The following conditions were present in all greenhouses prior to measure installation and, unless otherwise indicated in collected data, were assumed to be held constant after measure installation.

The greenhouses under evaluation were designed with polyethylene, glass, fiberglass, polycarbonate, or acrylic roofs and walls. The floors of the greenhouses were either concrete or bare soil. The majority of greenhouses were operated from 7 AM to 5 PM Monday through Friday, plus or minus 1-2 hours from site to site, and with abbreviated schedules on weekends.

A number of greenhouses had both mechanical heating systems and mechanical cooling systems. The most common mechanical cooling systems were fan and pad (direct evaporative) cooling systems. Where mechanical cooling systems were not installed, either natural or forced ventilation systems were present. This was true of greenhouses located in all the climate zones in California.

The mechanical heating systems in the greenhouses were forced air, steam, or hot water. At the majority of sites, individual greenhouses were either served by their own heating systems, or the space temperature was controlled by a greenhouse-specific thermostat connected to a steam or hot water loop. This allowed for the precise temperature control needed to ensure healthy plant growth. On a number of larger sites, boilers were centrally located to provide heating to multiple greenhouses.

The plants grown in each greenhouse varied from site to site and included vegetables, cut flowers, potted flowers, and tropical plants. This was documented through site visits and interviews at each site. It was assumed that the plants cultivated in each greenhouse remained the same during the pre- and post-installation period.

All pre-installation conditions were verified with site visits and interviews with facility staff. Unless otherwise indicated in collected data, no heat curtains were present prior to measure installation.

2.6. As-Built Equipment and Operation

Heat curtains were installed in the evaluated greenhouses in a variety of configurations with either manual or automated controls. Heat curtains were commonly installed beneath greenhouse roofs and this is the only positioning eligible for incentives. Several sites also had heat curtains installed on greenhouse walls.

[1] The project that fits this category is PGE2a, which covers multiple greenhouses, some of which had baseline #4 and others that had baseline #1.

Collected data confirmed the location, area, and control mechanism of the heat curtains installed as a part of the program.

2.7. Seasonable Variability in Schedule and Production

All of the evaluated greenhouses were occupied year-round. The evaluated greenhouses generally were located in mild climates. They were likely to demand either heating or cooling at varying times of day and throughout the year, with high heating demands at night and possible cooling demands during the day. This was verified through interviews with site staff and computer simulations of each of greenhouse.

2.8. Energy Savings Methods Used by IOUs

The measure savings is deemed. Table 1 shows the deemed values.

Table 1: IOU Measure Impacts

Program	*Ex ante* Impact	Algorithm
SDG&E	0.32 therms/sq.ft.	therms/sq.ft. of heat curtain
SGC	0.32 therms/sq.ft.	therms/sq.ft. of heat curtain
PG&E	0.39 therms/sq.ft.	therms/sq.ft. of heat curtain

The *ex ante* impacts for the heat curtain measure were quantified in therms of gas/sq.ft./year of measure installed. The expected therms/sq.ft./year of savings for this measure were calculated with the eQuest v3.5 building energy simulation software.[2] This software was used to calculate the expected impact in therms/sq.ft. of installed heat curtain in a typical greenhouse in California. These simulations were based on collected data and surveys of greenhouses throughout California. The measure impact for all three utilities was capped at the floor area of the greenhouse where the measure was installed. [3]

2.9. Level of Rigor in Evaluation

The level of rigor for this project is enhanced.

2.10. Energy Savings Algorithms Used in the Evaluation

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).

[2] Deemed savings were established from project applications and PG&E, SCG, and SDG&E template applications from the 2006-2008 program years. The method for estimating these savings was based on Green Building Studio's 2005 report for PG&E titled "Greenhouse Baseline Study Final Report".

[3] Not all heat curtains open parallel to the floor; some are tilted to align with the roof or structural trusses. The square foot basis used by the utility companies for incentives and used throughout this evaluation report is the covered horizontal floorspace, not the curtain area.

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.

One of the pilot greenhouses was a pre-retrofit house, that is, it had no heat curtain but otherwise was identical in construction, systems and schedule to another greenhouse on-site 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 using the curtains. These two houses allowed limited pilot modeling of both baseline and post-retrofit conditions.

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 heat curtains.

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.

In preparation for evaluation of this measure, ERS examined using four different modeling tools:

1. eQuest v3.63b—standard
2. eQuest v3.63—custom-modified by John Hill for J. J. Hirsh & Associates
3. eQuest v3.5—original John Hill model modified by Green Building Studio (GBS) Custom spreadsheet model
4. USDA Virtual Grower greenhouse simulator

After considering the available data, number of models to simulate, measures being evaluated, accuracy for modeling greenhouses, and testing the five options, Options 2 and 3 quickly stood out as the best options. A modified Option 3 was selected that incorporated the John Hill and GBS customization into eQuest v3.63b. The GBS tool has the same underlying analysis engine as the Hill version and was more accommodating for parametric modeling regarding temperature stratification and dimensional inputs. However, some of the strengths of Mr. Hill's latest version, such as temperature stratification assumptions, more advanced heat curtain controls, and an upgrade to eQuest v3.63b, were incorporated into the GBS tool for this evaluation.

The key advantages to *ex post* modeling over the *ex ante* estimates described in the IOU algorithm were 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.

Evaluation Method

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

1) **Review** of data available from project applications and utility bills for each site.

2) **Site surveys** were performed 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 NOAA NCDC 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 for the following:

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

     Temperature offset =

     0.32°F/ft x (average height between greenhouse thermostat and greenhouse roof)[4]

     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

[4] This value was established through a combination of metering at pilot sites and literature reviews. This is discussed in later sections of this report.

greenhouse roof, and therefore higher heat transfer via this surface. In greenhouses without heat curtains the “greenhouse roof height” was taken to be the average between the peak roof height and gutter height. In greenhouses with heat curtains, the “greenhouse roof height” was taken to be 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 operation of the heat curtains. These parameters are typically measured by automated heat curtain control systems to determine whether the curtains should be drawn, retracted, or partially retracted.
- The improvement in the roof U-value in greenhouses with heat curtains was modeled 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 and are shown in Table 2 for single heat curtain systems and in Table 3 for double heat curtain systems.
- The improvement in the roof shading coefficient (SC) in greenhouses with heat curtains was modeled 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 data provided by manufacturers and are shown in Table 2 for single heat curtain systems and in Table 3 for double heat curtain systems.

Table 2: Single Curtain System Roof U-Value and Shading Coefficient Multipliers[5]

Description	Base Material	Permeable?	% energy savings	U-value Multiplier	Shading multiplier	Example Curtains
Translucent Plastic Curtain	Translucent Plastic	No	45%	0.62	0.76	LS XLS 10, Novavert SHS Series
Blackout Curtain	Blackout	No	75%	0.36	0.08	LS XLS Obscura, Novavert NOVAthermal Black
Fabric Knit Curtain	Fabric Knit	Yes	48%	0.59	0.55	Novavert Trevira CS, Novavert Modacryl, LS SLS 10 , HS930
Translucent plastic weave w/30% aluminum	Translucent Plastic	No	49%	0.60	0.62	LS XLS 13 Firebreak or Revolux, Novavert HS880
Translucent plastic weave w/40% aluminum	Translucent Plastic	No	53%	0.57	0.54	LS XLS 14 Firebreak
Translucent plastic weave w/50% aluminum	Translucent Plastic	No	56%	0.54	0.46	Novavert HS885, LS XLS 15 Firebreak, LS ILS 15 Revolux, LF ILS 15 Ultra
Translucent plastic weave w/60% aluminum	Translucent Plastic	No	60%	0.51	0.38	LS XLS 16 Revolux, LS XLS 16 Firebreak, LS ILS 60 Revolux, Novavert HS887
Translucent plastic weave w/70% aluminum	Translucent Plastic	No	63%	0.47	0.30	LS XLS 17 Revolux, LS XLS 17 Firebreak, LS, ILS 60 Ultra, LS ILS 70 Ultra, Novavert HS888
Open weave w/30% aluminum	None	Yes	20%	0.88	0.62	LS XLS 13 F Firebreak, Novavert HS890
Open weave w/40% aluminum	None	Yes	22%	0.86	0.54	LS XLS 14 F Revolux & Firebreak
Open weave w/50% aluminum	None	Yes	24%	0.84	0.46	LS XLS 15 F Revolux & Firebreak, Novavert HS895
Open weave w/60% aluminum	None	Yes	26%	0.83	0.38	LS XLS 16 F Revolux & Firebreak
Open weave w/70%aluminum	None	Yes	28%	0.81	0.30	LS XLS 17 F Revolux & Firebreak

Table 3: Double Curtain System Roof U-Value and Shading Coefficient Multipliers

Recommendations for modeling double curtain systems (to be used when no energy savings data is available)			
Estimating the U-value multiplier for a curtain combination:			
Adding a	**to a**	**reduces the U-value multiplier of the**	**by approximately**
impermeable heat curtain (fabric or plastic without aluminum)	impermeable heat curtain (fabric or plastic with or without aluminum)	impermeable heat curtain (fabric or plastic with or without aluminum)	20%
permeable heat curtain with aluminum	impermeable heat curtain (fabric or plastic with or without aluminum)	impermeable heat curtain (fabric or plastic with or without aluminum)	20%
impermeable heat curtain with aluminum	impermeable heat curtain (fabric or plastic with or without aluminum)	impermeable heat curtain (fabric or plastic with or without aluminum)	30%
impermeable heat curtain (fabric or plastic without aluminum)	permeable aluminum heat curtain	permeable aluminum heat curtain	50%
permeable heat curtain with aluminum	permeable aluminum heat curtain	permeable aluminum heat curtain	20%
impermeable heat curtain with aluminum	permeable aluminum heat curtain	permeable aluminum heat curtain	60%
Estimating the shading coefficient for a curtain combination:			
In all cases the shading coefficient for the curtain combination is equal to the product of the shading coefficients for each of the individual curtains			

Contrary to the IOU measure impact algorithm described above, each site was modeled with mechanical systems, operating schedules, temperature setpoints, greenhouse envelope, and internal gains and losses

[5] The data contained in Tables 2 and 3 were developed from a report performed by a third party research group for heat curtain manufacturer Ludvig Svensson. This report contained information on how different curtain configurations changed the rate of heat transfer across the greenhouse roof in two test greenhouses – one with a inflated double polyethylene roof with low emissivity infrared films and one with a glass roof. The output from this report was a table of measured roof U-values with and without curtains in place. These U-values each curtain configurations influence on the conduction, convection, radiation, and infiltration across the greenhouse roof. This report was written in 2002 by Sonneveld, P.J, Loeffen, H., Mohammadkhani, V., and Campen, J.B. and was titled “Insulation Values of Thermal Screens”. This report is not yet available for public distribution.

specific to the greenhouse under evaluation, including its location, design, and the plants being cultivated. These inputs were held constant during the energy impact evaluation. Site interviews were performed to verify the pre- and post-measure implementation conditions in each greenhouse. In greenhouses where additional changes were made in conjunction with the measures under evaluation, these changes were accounted for in the measure evaluation.

Method Validation (applicable to the pilot sites)

Prior to developing eQuest models of all evaluation sites, the procedure described was benchmarked against pre- and post- installation measured heat load or utility data for 5 sample projects, which were located on 4 different sites and required modeling of 6 different greenhouses. This validation required that the simulated models for each sample project be calibrated to match metered data. Models were considered calibrated when the energy consumption output by the simulation program showed a good visual and statistical match against the site's hourly and daily metered energy use information.

Data logging was performed for a minimum of four weeks during March and April for each of the sample sites that was modeled during the Method Validation.

After validation was performed for the sample projects, evaluators used the adjusted model for the remainder of the evaluation sites.

2.11. Peak Demand Algorithms Used in the Evaluation

Electricity savings represented less than 0.5% of the total site energy savings. Peak demand impacts were not evaluated, although model outputs showed that the installation of heat curtains did result in a slight reduction in the peak cooling load in greenhouses, which corresponded with a reduction in the peak kW demand in greenhouses with mechanical cooling systems.

2.12. Energy Savings Data Collection & Data Collection Method

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[6]:

- 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

[6] See appendix for copy of data collection form.

- Measure description and area of rebated installation
- Schedule of implementation 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, 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 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 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

Table 4 summarizes the key characteristics of each site under evaluation.

Table 4: Summary of Heat Curtain Evaluation Site Characteristics

Utility ID	Climate Zone	Installed Measure Area (sq.ft.)	Baseline	Heat Curtain Type	Plant Type	Greenhouse Shape	Envelope Materials	Heat Curtain?	Heating System Type	Cooling System Type	Heating Temperature Schedules
PGE1	CZ03	42,290	No Heat Curtain	HS930	Vegetables	Gabled roof; ridge N-S	Roof: Glass Wall: Glass	1 layer for shade and heat retention	HW boiler w/ underbench forced air distribution	Natural ventilation	Winter and Summer: 65°F
PGE4	CZ03	55,776	No Heat Curtain	HS930	Orchids	Round roof, ridge E-W	Roof: 2-PE w/IR Wall: 2-PC	2 layers, for shade and heat retention	HW boiler w/underbench	Natural ventilation	Winter and Summer: 67°F
PGE5	CZ04	67,370	No Heat Curtain	Modeled with XLS 15 Firebreak	Perennials and ornamental flowers	Round roof, ridge E-W	Roof: 1-PE Wall: 1-PC	1 layer for shade and heat retention	HW boiler w/underbench	Natural ventilation	Winter: 55-65°F Summer: Heat Off
SDG4	CZ10	83,268	No Heat Curtain	XLS14 Revolux	Tropical Foliage Plants	Round roof; ridge N-S	Roof: 2-PE w/IR Wall: 3" Polystyrene	2 layers, for shade and heat retention	Unit Heaters	Evaporative cooling	Winter and Summer: 70F
PGE2a	CZ03	103,755	No Heat Curtain	XLS14 Revolux	Orchids	Mix of gabled and round roofs, ridge E-W and NE-SW	Roof: 2-PC Wall: 2-PC	2 layers, for shade and heat retention	Steam boiler w/underbench	Natural ventilation & evaporative	Winter: 64-67°F Summer: 64-67°F
SDG4a	CZ10	33,696	No Heat Curtain	XLS 16 Firebreak, Novavert 630, XLS16 Firebreak	Tropical Foliage Plants	Round roof; ridge N-S	Roof: 2-PE w/IR Wall: 3" Polystyrene	2 layers, for shade and heat retention	Unit Heaters	Evaporative cooling	Winter and Summer: 70F
SCG4a	CZ06	98,472	No Heat Curtain	XLS 15 Firebreak	Chrysanthemums and Lilies	Round roof, ridge N-S	Roof: 1-PE w/IR Wall: 1-PC	1 layer for shade and heat retention	HW boiler w/underbench	Natural ventilation	Winter: 55-65°F Summer: Heat Off
SCG23	CZ06	200,592	No Heat Curtain	XLS15 Firebreak and Obscura	Chrysanthemums	Round and gabled roofs; ridge N-S	Roof: Glass Wall: Fiberglass	1 layer for shade and heat retention	Steam boiler w/underbench	Natural ventilation	Winter: 60-65°F Summer: Heat Off
SCG9	CZ06	203,756	No Heat Curtain	Obscura and XLS 15 Firebreak	Roses	Gabled roof; ridge N-S	Roof and Walls: 1-PC	1-layer for shade and heat retention	HW boiler w/underbench	Natural ventilation	Winter and Summer: 60F
SCG4	CZ06	214,104	No Heat Curtain	XLS 15 Firebreak	Chrysanthemums and Lilies	Round roof, ridge N-S	Roof: 1-PE w/IR Wall: 1-PC	1 layer for shade and heat retention	HW boiler w/underbench	Natural ventilation	Winter: 55-65°F Summer: Heat Off
SDG1	CZ07	253,190	No Heat Curtain	SLS 10 UltraPlus	Cut flowers	Gabled roof; ridge N-S	Roof: 2-PE w/IR Wall: 1-PE	1 layer for shade and heat retention	HW boiler w/underbench	Natural ventilation	Winter and Summer: 58-62F
SCG20a	CZ06	169,920	No Heat Curtain	Obscura	Gerber Daisies	Gabled roof; ridge NE-SW	Roof and Walls: 1-PC	1 layers, for shade and heat retention	HW boiler w/underbench	Natural ventilation	Winter and Summer: 68F
SCG23a	CZ06	204,336	No Heat Curtain	Obscura	Chrysanthemums	Round and gabled roofs; ridge N-S	Roof: Glass Wall: Fiberglass	1 layer for shade and heat retention	Steam boiler w/underbench	Natural ventilation	Winter: 60-65°F Summer: Heat Off
PGE21	CZ03	149,720	No Heat Curtain	XLS 16 Firebreak	Orchids	Mix of gabled and round roof, ridge E-W and NE-SW	Roof: 2-PC Wall: 2-PC	2-layers for shade and heat retention	Steam boiler w/underbench	Evaporative cooling	Winter: 64-67°F Summer: 64-67°F
PGE11	CZ03	206,838	No Heat Curtain	HS 930	Impatiens	Gabled roof; ridge N-S	Roof: 1-Glass Wall: 1-Glass w/1-PE	1-layer for shade and heat retention	Unit Heaters	Natural Ventilation	Winter: 65-70F Summer: 55
SCG13	CZ06	360,012	No Heat Curtain	XLS 15 Firebreak	Ornamental Lillies	Round roof: ridge E-W	Roof and Walls: 1-PC	1 layer for shade and heat retention	Steam boiler w/HX to HW and underbench	Natural ventilation	Winter: 70F Summer: Off
PGE2	CZ03	708,113	4 houses with No Heat Curtain and 2 houses with One Heat Curtain	HS930, XLS16 Firebeak, XLS 17 Firebreak	Orchids	Mix of gabled and round roof, ridge E-W and NE-SW	Roof: 2-PC Wall: 2-PC	2 layers, for shade and heat retention	Steam boiler w/underbench	Natural ventilation & evaporative	Winter: 64-67°F Summer: 64-67°F
SCG12	CZ06	309,261	No Heat Curtain	PH1, Obscura	Cut flowers	Gabled roof; ridge N-S	Roof: 1-PC Wall: 1-PC	1 layer, for heat retention and blackout	Steam boiler w/underbench	Natural Ventilation	Winter and Summer: 68F
SCG20	CZ06	365,341	No Heat Curtain	SLS 10 UltraPlus	Gerber Daisies	Gabled roof; ridge NE-SW	Roof and Walls: 1-PC	1 layers, for shade and heat retention	HW boiler w/underbench	Natural ventilation	Winter and Summer: 68F
SCG44	CZ06	281,539	No Heat Curtain	Novavert HS Acrylic, Svennson XLS 18 Revolux	Vegetables (lettuce and arugila)	Round roof; ridge NE-SW	Roof and walls: Mix of 1 - PC & 1-PE	1 layer for shade and heat retention	HW boiler w/underbench	Natural ventilation	Winter: 68F Summer: Off
SCG14	CZ06	309,065	No Heat Curtain	XLS 15 Firebreak	Lillies	Pitched Roof, ridge N-S	Roof: 2-PE Wall: 1-PE	1 layer for shade and heat retention	HW boiler w/underbench	Natural Ventilation	Winter: 65°F Summer: 60°F

3. CONFIDENCE AND PRECISION OF KEY FINDINGS

3.1. Engineering Accuracy

Metering accuracy was limited to the proxy on-off measurements and the assumption that the systems run at rated input and output when on. Additionally, data accuracy was limited by the quality of the data collected from site contacts during site visits and follow-up phone calls. At several sites, similar measures had been installed in multiple greenhouses, not all of which were covered by the project under evaluation. This led to potential inaccuracies in accounting for the installed measure location and square footage. For those sites included in the Method Validation pilot study the building simulation model accuracy was +/-15% compared to daily logged data.

Issues associated with engineering uncertainty are discussed in the next section.

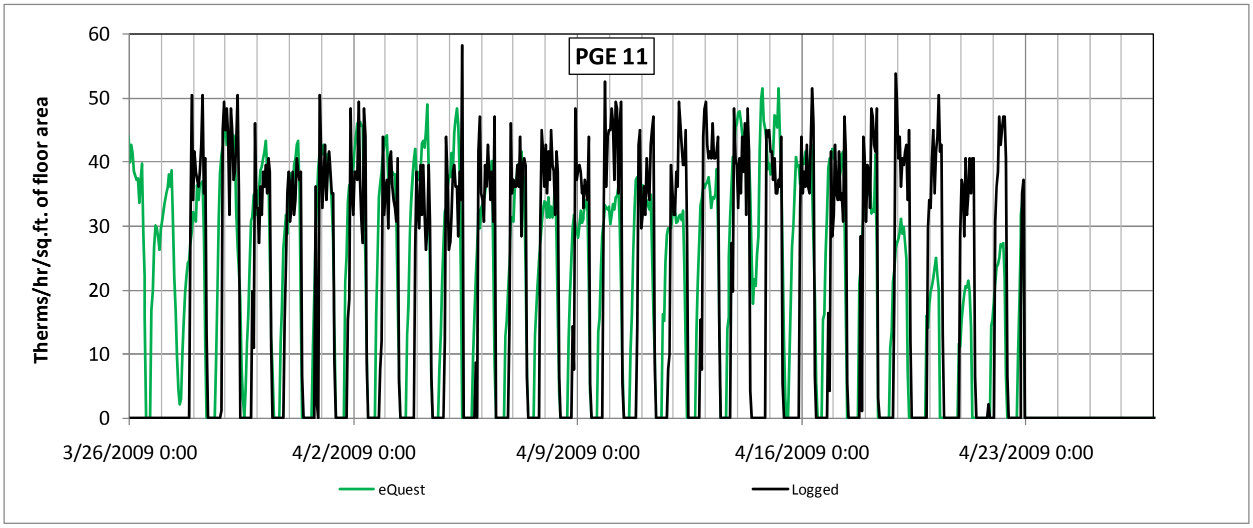
4. VALIDITY AND RELIABILITY

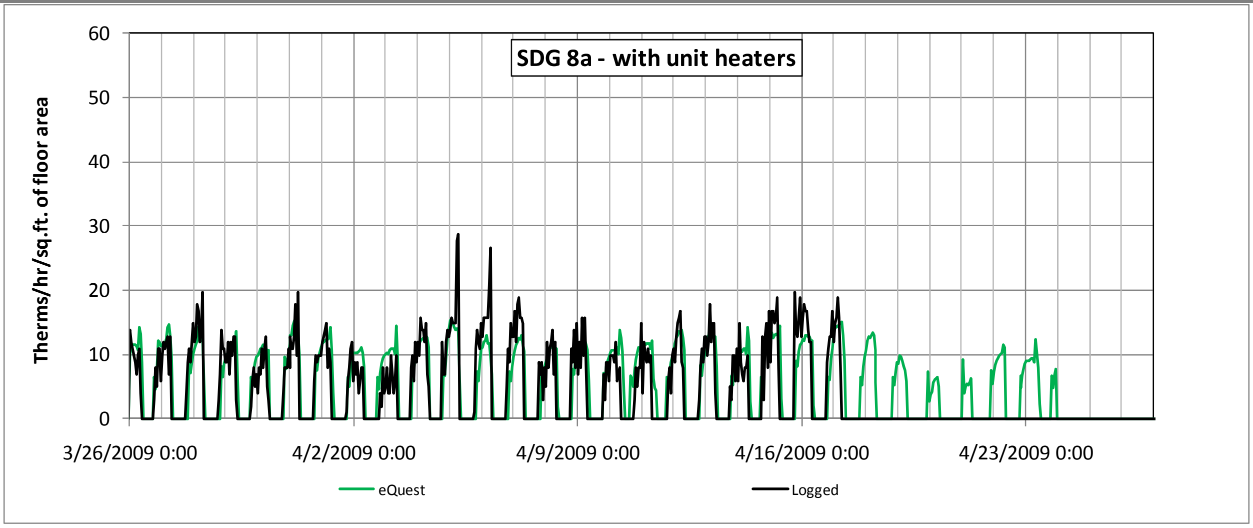
4.1. Method Validation

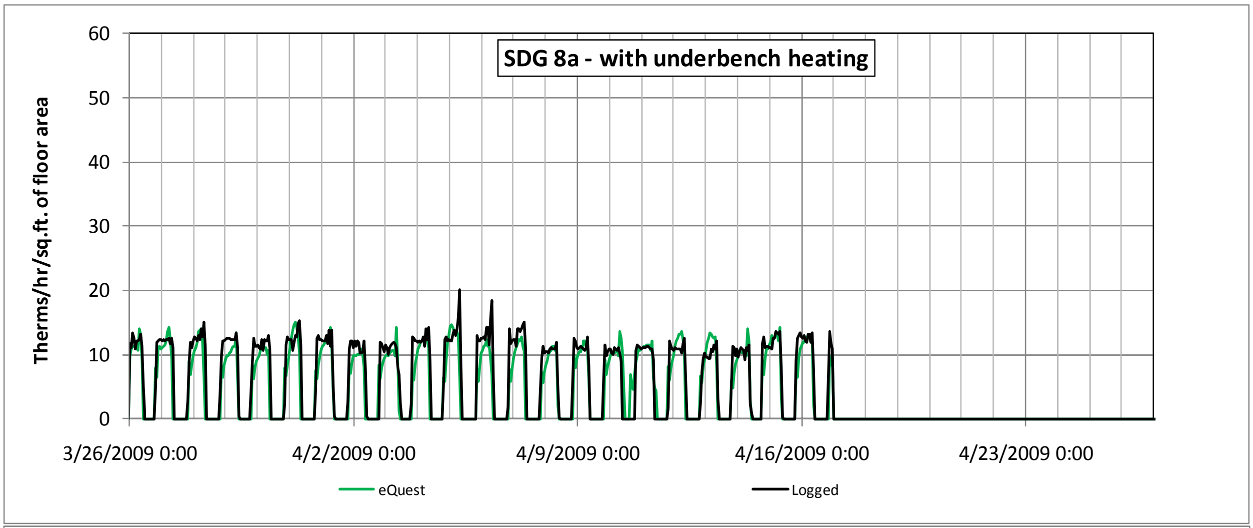
Prior to developing eQuest models of all evaluation sites, the procedure was benchmarked against pre- and post- installation metered data for 5 pilot projects, which included 6 greenhouses on 4 different sites and included sites that were rebated for both heat curtains and infrared films in the 2006-2008 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 visual and statistical match with the greenhouse's hourly and daily metered energy use information.

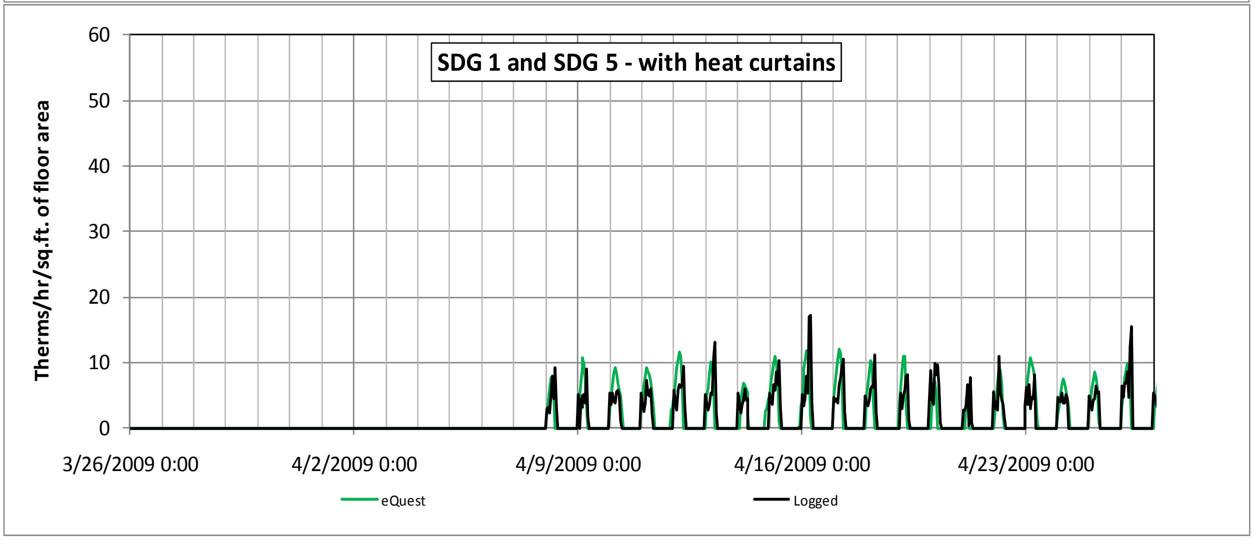
Data logging was performed for a minimum of four weeks during March and April for each of the sample greenhouses that was modeled during the Method Validation. eQuest models were generated for each greenhouse and a comparison was made between the daily and hourly heating energy use at each pilot greenhouse. Figures 1 through 5 show the hourly modeled and logged heating energy consumption (per sq.ft. of greenhouse floor area) for five of the six greenhouses included in the pilot projects. Site PGE 4 is not included in these figures because inaccurate metering led to inexact logged data.

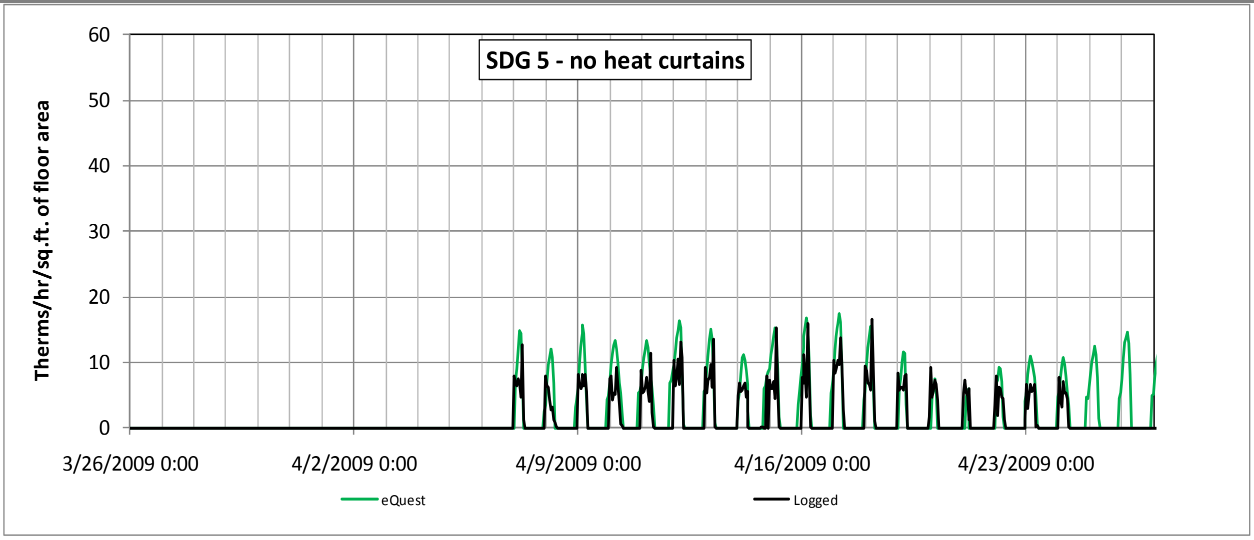
Figure 1 through 5: Modeled and Metered Impacts: Greenhouse Heat Load Over Time




SDG 8a - with unit heaters
Therms/hr/sq.ft. of floor area
60
50
40
30
20
10
0
3/26/2009 0:00
4/2/2009 0:00
4/9/2009 0:00
4/16/2009 0:00
4/23/2009 0:00
eQuest
Logged


SDG 8a - with underbench heating
Therms/hr/sq.ft. of floor area
60
50
40
30
20
10
0
3/26/2009 0:00
4/2/2009 0:00
4/9/2009 0:00
4/16/2009 0:00
4/23/2009 0:00
eQuest
Logged


SDG 1 and SDG 5 - with heat curtains
Therms/hr/sq.ft. of floor area
60
50
40
30
20
10
0
3/26/2009 0:00
4/2/2009 0:00
4/9/2009 0:00
4/16/2009 0:00
4/23/2009 0:00
eQuest
Logged



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[7]. 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 assumption 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 under-bench 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 pilot site SDG8a (with unit heaters), DEER values, and a review of published literature[8].

[7] See ASHRAE Guideline 14-2001 "Measurement of Energy and Demand Savings" for information on CV values for calibrated models. In general, this guideline recommends that models be considered calibrated when the hourly CV is less than 30% or the monthly CV is less than 15% for models calibrated against one full year of data.

[8] Winspear, K.W. 1978. "Vertical Temperature Gradients and Greenhouse Energy Economy" Acta Hort. (ISHS) 76:97-104; Martinez, P.F. and Miranda, J. 1974. "Study on Temperature Gradients and Profiles in Greenhouses". Acta Hort. (ISHS) 42:103-112; Teitel, M. and Tanny, J. 1996. "Energy Saving in Heated Enclosures". Acta Hort. (ISHS) 417:139-146; Green Building Studio's 2005 report for PG&E "Greenhouse Baseline Study".

- Manufacturer's glazing shading coefficients were reduced, on average, by 75%[9] 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/sq.ft. DEER models had used a "Floor-Weight" of 5 lbs/sq.ft., while 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/sq.ft. of thermal mass showed a better fit between the hourly logged and modeled heating energy than the models with only 5 lbs/sq.ft. 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

4.2. 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.

4.3. 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

[9] 25% of the solar energy entering a greenhouse is used for photosynthesis or reflected back outdoors, while 50% of the solar energy in a full greenhouse is absorbed by the plants and subsequently released as moisture via evapotranspiration. This moisture is removed from the greenhouse via natural ventilation. In total, only about 25% of the solar energy transmitted into the greenhouse is gained as sensible heat. See pages 63 through 68 of NRAES-33: Greenhouse Engineering, 3rd Revision, 1994, published by the Natural Resource, Agriculture, and Engineering Service (NRAES) Cooperative Extension and page 10.15 in the chapter on "Environmental Control for Animals and Plants" in the 2005 ASHRAE Handbook of Fundamentals for more details.

multiplier of the heat curtain, the shading coefficient multiplier of the heat curtains, the degree of temperature stratification in greenhouse with unit heaters, and the heat curtain control setpoints. Data was collected from multiple sources to define the pre- and post-implementation heat curtain U-value 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 5 for the three projects that received heat curtain rebates and that were included in the Method Validation study:

Table 5: 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 6 along with their percent variation from the average and the estimated standard deviation of the measure impact.

Table 6: 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	-

5. DETAILED FINDINGS

5.1. Annual Measure Savings

Heat curtains were the only energy efficiency measure included in this evaluation. Depending on the site, this measure yielded gas or electric savings, or both. Only gas savings were reported to the programs. Tables 7, 8, 9, and 10 present the *ex ante* and *ex post* impact for all evaluation sites. Pilot sites are highlighted in gray. Monthly pre- and post-implementation energy as well as measure impacts are presented in Appendix A.

Table 7: Gross *Ex ante* and *Ex post* Measure Impacts – Therms and kWh per Year

		Annual Gas Impact (Therms)			Annual Electric Impact (kWh)
Utility ID	Installed Measure Area (sq.ft.)	Ex Ante	Ex Post	Realization Rate	Ex Post
PGE1	42,000	16,493	10,612	0.64	670
PGE4	27,888	21,753	8,219	0.38	1,119
PGE5	67,316	26,274	14,800	0.56	2,180
SDG4	83,268	26,646	22,915	0.86	6,171
PGE2a	96,141	40,464	29,984	0.74	4,753
SDG4a	33,696	10,783	9,273	0.86	2,497
SCG4a	98,472	31,511	17,046	0.54	1,203
SCG23	200,592	64,189	60,198	0.94	1,782
SCG9	205,556	65,202	33,674	0.52	2,260
SCG4	213,840	68,513	33,775	0.49	1,803
SDG1	253,190	81,021	22,338	0.28	6,138
SCG20a	169,920	54,374	40,735	0.75	4,013
SCG23a	197,856	65,388	59,012	0.90	1,892
PGE21	149,720	58,391	43,675	0.75	6,192
PGE11	164,160	80,667	70,332	0.87	4,704
SCG13	317,520	115,204	81,000	0.70	2,470
PGE2	367,000	276,164	89,376	0.32	9,730
SCG12	309,261	98,964	88,134	0.89	5,155
SCG20	345,576	116,909	87,600	0.75	7,880
SCG44	281,539	90,092	64,898	0.72	4,650
SCG14	483,291	154,688	74,593	0.48	4,003

For sites without mechanical cooling the electricity savings derives from reduced cycling of the unit heater fans, reduced use of horizontal airflow fans, or less load on the boiler hot water pumps. Energy use of heat curtain drive motors was logged at one pilot site and found to be inconsequential.

Table 8 presents the normalized *ex ante* and *ex post* savings as a function of the floor are of the greenhouse(s) where the measure was installed. Note that there are two *ex ante* savings values presented in this table. The *ex ante* therm/sq.ft. impact (also shown in Table 1) 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.

Table 8: Gross *Ex ante* and *Ex post* Measure Impacts – Therms/sq.ft. and kWh/sq.ft. per Year

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

*Calculated as ex post divided by the deemed ex ante therm/sq.ft. impacts
**Adjusted for the floor area of the greenhouse where the measure was installed rather than the rebated measure quantity

The sites with evaporative cooling (SDG4, PGE2a, SDG4a) have higher electric impacts, due largely to the fan energy that is saved during the summer when the heat curtains are drawn for shading.

The lowest therm/sq.ft. *ex post* savings occur at site SDG1, which is located in a coastal climate zone (climate zone CZ07). These relatively low savings are due to the site location and the low heating temperature setpoints (58°F) in the modeled greenhouse at this site. This was tested with additional runs of the eQuest models for this site, which showed that increasing the heating temperature setpoint resulted in a significant increase the heat curtain measure impacts.

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 application were rebated for a two-layer heat curtain system.

The average of the gross realization rates shown in Table 8 is 0.72, which is higher than the 0.66 average of the gross realization rates shown in Table 7. This is because the deemed *ex ante* therm/sq.ft. savings in Table 8 are independent of the over-rebated measure quantities that were included in the *ex ante* savings values in Table 7.

Table 9: Gross *Ex post* Measure Impacts - Total Btus per Year

		Ex Post Total Annual Impacts (Btus/year)				
Utility ID	Installed Measure Area (sq.ft.)	Gas	Electric	Total	% Gas	% Electric
PGE1	42,000	1,061,200,000	2,286,040	1,063,486,040	100%	0.2%
PGE4	27,888	821,865,981	3,816,837	825,682,818	100%	0.5%
PGE5	67,316	1,480,000,000	7,438,160	1,487,438,160	99%	0.5%
SDG4	83,268	2,291,536,264	21,054,852	2,312,591,116	99%	0.9%
PGE2a	96,141	2,998,440,000	16,216,554	3,014,656,554	99%	0.5%
SDG4a	33,696	927,314,286	8,520,251	935,834,537	99%	0.9%
SCG4a	98,472	1,704,569,892	4,105,406	1,708,675,299	100%	0.2%
SCG23	200,592	6,019,829,412	6,080,646	6,025,910,057	100%	0.1%
SCG9	205,556	3,367,438,231	7,711,342	3,375,149,573	100%	0.2%
SCG4	213,840	3,377,500,000	6,151,349	3,383,651,349	100%	0.2%
SDG1	253,190	2,233,838,561	20,941,257	2,254,779,818	99%	0.9%
SCG20a	169,920	4,073,452,078	13,693,725	4,087,145,803	100%	0.3%
SCG23a	197,856	5,901,170,588	6,456,748	5,907,627,337	100%	0.1%
PGE21	149,720	4,367,456,543	21,127,840	4,388,584,384	100%	0.5%
PGE11	164,160	7,033,200,000	16,050,048	7,049,250,048	100%	0.2%
SCG13	317,520	8,100,000,000	8,427,640	8,108,427,640	100%	0.1%
PGE2	367,000	8,937,600,000	33,197,395	8,970,797,395	100%	0.4%
SCG12	309,261	8,813,427,436	17,589,920	8,831,017,356	100%	0.2%
SCG20	345,576	8,760,000,000	26,886,560	8,786,886,560	100%	0.3%
SCG44	281,539	6,489,766,863	15,865,249	6,505,632,112	100%	0.2%
SCG14	483,291	7,459,279,273	13,658,292	7,472,937,565	99.8%	0.2%

Electric energy accounts for less than 2% of the total *ex post* impacts for this measure. The *ex ante* impacts did not include electric energy. The highest *ex post* electric impacts (on a kWh/sq.ft. basis) tended to be at sites with fan and pad cooling systems.

Table 10: Gross *Ex post* Measure Impacts – % Annual Energy

		Modeled Gas Energy (therms/yr)		Modeled Gas Energy (therms/sq.ft./yr)		% Savings	Modeled Electric Energy (kWh/yr)		Modeled Electric Energy (kWh/sq.ft./yr)		% Savings
Utility ID	Installed Measure Area (sq.ft.)	Pre- retrofit	Savings	Pre-retrofit	Savings		Pre-retrofit	Savings	Pre-retrofit	Savings	
PGE1	42,000	43,372	10,612	1.03	0.25	24%	9,620	670	0.23	0.02	7%
PGE4	27,888	35,158	8,219	1.26	0.29	23%	7,045	1,119	0.25	0.04	16%
PGE5	67,316	55,200	14,800	0.82	0.22	27%	32,650	2,180	0.49	0.03	7%
SDG4	83,268	58,232	22,915	0.70	0.28	39%	22,029	6,171	0.26	0.07	28%
PGE2a	96,141	82,853	29,984	0.86	0.31	36%	42,258	4,753	0.44	0.05	11%
SDG4a	33,696	23,565	9,273	0.70	0.28	39%	8,914	2,497	0.26	0.07	28%
SCG4a	98,472	62,768	17,046	0.64	0.17	27%	18,339	1,203	0.19	0.01	7%
SCG23	200,592	152,212	60,198	0.76	0.30	40%	5,271	1,782	0.03	0.01	34%
SCG9	205,556	88,464	33,674	0.43	0.16	38%	23,030	2,260	0.11	0.01	10%
SCG4	213,840	95,946	33,775	0.45	0.16	35%	37,816	1,803	0.18	0.01	5%
SDG1	253,190	52,339	22,338	0.21	0.09	43%	25,885	6,138	0.10	0.02	24%
SCG20a	169,920	181,454	40,735	1.07	0.24	22%	29,265	4,013	0.17	0.02	14%
SCG23a	197,856	148,746	59,012	0.75	0.30	40%	5,846	1,892	0.03	0.01	32%
PGE21	149,720	116,665	43,675	0.78	0.29	37%	23,313	6,192	0.16	0.04	27%
PGE11	164,160	258,144	70,332	1.57	0.43	27%	17,599	4,704	0.11	0.03	27%
SCG13	317,520	303,400	81,000	0.96	0.26	27%	25,640	2,470	0.08	0.01	10%
PGE2	367,000	337,059	89,376	0.92	0.24	27%	46,107	9,730	0.13	0.03	21%
SCG12	309,261	338,153	88,134	1.09	0.28	26%	28,329	5,155	0.09	0.02	18%
SCG20	345,576	383,300	87,600	1.11	0.25	23%	51,840	7,880	0.15	0.02	15%
SCG44	281,539	252,390	64,898	0.90	0.23	26%	121,175	4,650	0.43	0.02	4%
SCG14	483,291	212,843	74,593	0.44	0.15	35%	59,909	4,003	0.12	0.01	7%

The heating energy savings range from 22% to 43%, with the highest percent savings in those greenhouses with the lowest baseline energy consumption, and the highest percent savings in those greenhouses with the highest baseline energy consumption. There is a high degree of variation in the percent electric savings with heat curtains (4% to 34%).

5.2. Discussion of Results

Climate Zone

Table 11 presents the average *ex ante* and *ex post* savings for each climate zone represented in the measure sample. Note the higher *ex post* impacts in climate zone 3 and 10, both of which are inland climates with cool winters and warm summers. Climate zones 4, 6, and 7 are all coastal climates with moderate annual outdoor temperatures, which is reflected in the lower *ex post* impacts in these climates.

Table 11: Gross Measure Savings – Heat Curtain Sites

		Annual Measure Impact	
Climate Zone	# of Sites	Ex Ante Impact (therms/sq.ft.)	Ex Post Impact (therms/sq.ft.)
CZ03	6	0.39	0.30
CZ04	1	0.39	0.22
CZ06	11	0.32	0.23
CZ07	1	0.32	0.09
CZ10	2	0.32	0.28
Average	21	0.34	0.24

All sites in CZ03 and CZ04 were in PG&E territory, while those in CZ04 were in SCG territory, and those in CZ07 and CZ10 were in SDG&E territory. The greenhouses located in coastal climates CZ04, CZ06, and CZ07 all have lower measure impacts than the greenhouses located in inland climates CZ03 and CZ10, which appears to show that climate zone is a better indicator of measure impact level than utility territory.

Heat Curtain Thermal Properties

The thermal properties of heat curtains can vary significantly from one material to another. Table 12 presents the average *ex ante* and *ex post* measure gas impacts with respect to the heat curtain material that was installed at each site. Note the higher impacts with blackout curtains and curtains with an aluminum weave, than with a fabric curtain. While the heat curtain properties vary considerably the effect of the variations on savings is only moderate, due largely to the variances in other key variables like climate zone and temperature setpoints in the greenhouses with each heat curtain type.

Table 12: Gross Measure Savings – Heat Curtain Sites

Heat Curtain Description*	# sites	Ex Post Impact therms/sq.ft.
Knit Fabric	5	0.26
Transparent Aluminum Weave	5	0.19
Blackout Curtian	1	0.27
*Only includes those sites with one heat curtain		

When properly deployed, two-layer curtain systems provide additional energy savings over similar single-layer curtain system. Table 13 bins the average *ex ante* and *ex post* measure gas impacts with respect to the number of layers of heat curtain material that was installed at each site. Note the higher *ex post* impacts at sites where 2-layer heat curtain systems were installed.

Table 13: Gross Measure Savings – Heat Curtain Sites

Heat Curtain Description*	# sites	Ex Post Impact therms/sq.ft.
1-layer of curtain, no curtain as baseline	15	0.23
2-layers of curtians, no curtain as baseline	5	0.29

*Site PGE2 is excluded because the baseline conditions include a mix of greenhouses no heat curtain and one existing heat curtain

Temperature Setpoints

Greenhouses that maintain higher temperature setpoints have a greater potential for energy savings than greenhouses that maintain lower temperature setpoints. Figure 6 shows the annual impact in therms/sq.ft. of gas use versus the average heating temperature setpoint during the heating season (October – April) for each of the 21 heat curtain sites that were evaluated. The lines at 0.39 therms/sq.ft. and 0.32 therms/sq.ft. represent the deemed savings for 2006-2008 PG&E and SDG&E/SCG projects, respectively.

Figure 6: *Ex ante* and *Ex post* Impacts - Annual Energy vs. Heating Setpoint

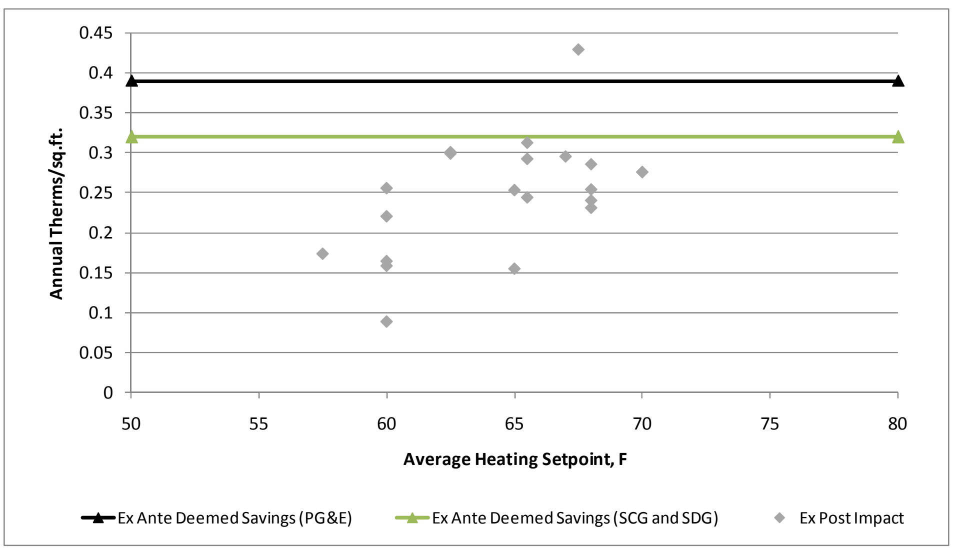


Figure 6 indicates a trend toward lower *ex post* measure impacts at lower heating setpoints. The high degree of scatter in the *ex post* data is due to differences in the envelope materials, heat curtain types, and seasonal temperature schedules at each site.

Heating System Type

Greenhouses with unit heaters tend to be more susceptible to increased heat loss due to temperature stratification, and therefore have a greater potential for energy savings with heat curtains. Table 14 shows the annual therms/sq.ft. of gas use for the three predominant greenhouse heating systems identified in this evaluation. Note the higher impacts at sites where unit heater systems were installed.

Table 14: Gross Measure Savings – Heat Curtain Sites

Heating System Description	# sites	Ex Post Impact therms/sq.ft.
Hot water boiler with underbench distribution	11	0.20
Steam heat with underbench distribution	7	0.28
Unit heaters	3	0.33

The *ex ante* impacts for greenhouses with steam heating systems were higher than those with hot water boilers because these greenhouses tended to be located in cooler climate zones (3 of 7 were in CZ03) and had higher heating temperature setpoints than the greenhouses with hot water boilers. The higher impacts in greenhouses with unit heaters are largely attributable to changes in temperature stratification with and without heat curtains in place.

5.3. Differences between *Ex ante* vs. *Ex Post* Impact Estimates

The gross realization rate for the 21 sites had mean of 0.66, ranged from 0.28 to 0.94, and had a standard deviation of 0.20. The *ex ante* impacts were calculated using properties for generic greenhouses in California, while the *ex post* measure impacts were calculated with properties and operating characteristics specific to each project. This led to the range of gross realization rates. In addition, the use of the newer eQuest model and modified template input assumptions influenced the average gross realization rates, but not the variance in gross realization rates.

The reduction from the *ex ante* to the *ex post* measure impact is likely due to two factors: (1) the *ex ante* greenhouse baseline energy use per square foot was higher than the *ex post* models and (2) the percentage savings in the *ex post* impact calculations was lower than the *ex ante* impact calculations. While evaluators do not have access to the models that were used to develop the *ex ante* savings values, we do have access to the report on which the greenhouse baseline definition was based[10] and the modeling tool[11] that was more likely used to establish the *ex ante* savings estimates. Based on this information, several likely *ex ante* calculation assumptions were indentified that, when compared to the *ex post* assumptions, contributed to (1) decreasing the *ex post* baseline energy use and/or (2) reducing the percent savings in the *ex post* calculations.

[10] Green Building Studio's 2005 report for PG&E titled "Greenhouse Baseline Study Final Report"

[11] Green Building Studio's eQuest greenhouse simulation tool.

Temperature Stratification

It appears that the degree of temperature stratification with unit heaters varied between the *ex ante* and *ex post* models. *Ex post* impact evaluation algorithms assumed ~0.32°F/ft of temperature stratification in greenhouses with unit heaters, while *ex ante* models appeared to assume ~0.7°F/ft. This led to higher baseline and percent savings estimates in the *ex ante* calculations compared to the *ex post* calculations.

Heating System Type

It appeared that the *ex ante* calculations included unit heaters as the default heat source for all greenhouses. This type of system may be the most common statewide, but this study found it is not predominant in the population of program participants. In *ex post* models, all sites were modeled with the heating system that was found at that site, which varied between underbench heating systems and unit heaters. Greenhouses with unit heaters tend to use more energy. Because unit heaters were assumed to be the baseline for all *ex ante* impact models, and because temperature stratification was included with the unit heater model, both the baseline and percent savings in the *ex ante* calculations were greater than in the *ex post* calculations, especially in greenhouses with underbench heating systems.

Temperature Setpoints

Ex post measure savings were modeled with temperature setpoints and schedules specific to the sites where the measures were installed. Although it isn't clear what temperature setpoints and schedules were used to calculated the *ex ante* measure savings, it likely differed from the site-specific temperature setpoints and schedules applied in the *ex post* calculations. The more site-specific approach in the *ex post* impact analysis included shutting down heating systems at several sites during the summer and modeling temperature setpoints between 58°F and 70°F in the various greenhouses under evaluation. Although it was not clear what the temperature setpoints were in the *ex ante* impact calculation, in those greenhouses with low temperature setpoints (58-62°F) and no summer heating, the *ex post* measure impacts tended to be lower than the *ex ante* impacts.

Climate Zone

It appeared that the *ex ante* impact calculations only accounted for differences between weather conditions at PGE sites and SCG/SDG&E sites. No differences in weather conditions from site-to-site were accounted for. The *ex post* impact results appeared to show that climate zone played a large part in the estimated measure impacts, and contributed to increasing the site-to-site variance in the calculated measure impacts. Sites in coastal climates tended to have lower impacts than those in inland climates, and a large number of the sites included in this evaluation were located in coastal climates which resulted in a lower average *ex post* impact than *ex ante* impact for this measure.

Rebated vs. Installed Measure Square Footage

The *ex ante* impacts were calculated by multiplying 0.32 (SCG/SDG&E) or 0.39 (PG&E) therms/sq.ft. by the rebated measure area. However, at several sites, the rebated measure area exceeded the floor area of the greenhouse(s) where the measure was installed, which was the 2006-2008 program defined maximum measure area for calculating rebates. Therefore, the measure impacts tended to be overstated in greenhouses where one of the following conditions applied:

(1) More than one layer of heat curtain was installed and rebated in a greenhouse

(2) The installed heat curtain configuration followed the shape of the greenhouse roof rather than paralleling the floor and the site was rebated for the total heat curtain area rather than the greenhouse floor area

(3) The site was rebated for the total purchased heat curtain square footage, which exceeded the square footage of the greenhouse floor where the heat curtains was installed.

These conditions applied to several of the sites included in the evaluation sample, and led to *ex ante* measure impacts that were higher than the *ex post* impacts calculated for these sites.

6. PROGRAM RESULTS

The following tables present the *ex ante* and *ex post* heat curtain measure impacts by utility.

Table 15: Program Impact – Gas Usage

Summary of Results - Gas		# sites	Ex Ante		Ex Post		Average Realization Rate
			Therms	Therms/ sq.ft.	Therms	Therms/ sq.ft.	
Heat Curtain	PG&E	7	520,206	0.39	266,998	0.29	0.61
	SCG	11	925,035	0.32	640,664	0.23	0.70
	SDG&E	3	118,449	0.32	54,527	0.21	0.67
	Total	**21**	**1,563,690**	**-**	**962,189**	**-**	**-**

Table 16: Program Impact – Electric Usage

Summary of Results - Electric		# sites	Ex Ante		Ex Post		Realization Rate
			kWh/yr	kWh/ sq.ft.	kWh/yr	kWh/ sq.ft.	
Heat Curtain	PG&E	7	n/a	n/a	29,347	0.03	n/a
	SCG	11	n/a	n/a	37,112	0.01	n/a
	SDG&E	3	n/a	n/a	14,805	0.06	n/a
	Total	**21**	**n/a**	**n/a**	**81,265**	**-**	**n/a**

Overall, higher *ex post* measure impacts were calculated for sites in PG&E's territory than SDG&E's and SCG's territories. This is likely due to the fact that most of the evaluated sites in PG&E's territory were located in California climate zone 3, which is relatively cool, especially during the fall, winter, and spring months when heating demands are greatest. The higher *ex post* electric impacts in SDG&E's territory are the result of increased mechanical cooling savings in houses with fan and pad cooling systems.

7. DISCUSS FINDINGS AND RECOMMENDATIONS

7.1. Conclusions & Recommendations

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 that, when next updating the generic greenhouse template, make 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 under bench. 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/sq.ft. and eliminate the greenhouse floor from all models. In this work, 10 lbs/sq.ft. 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 the 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 abonus incentive for customers that install two-layer curtain systems, as they deliver 20-25% more savings (see Table 13) than single 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 (see Table 14) 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.

7.2. 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/sq.ft. 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/sq.ft. 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.

Utility ID	Pre-Implementation Monthly Gas Use (Therms/month)											
	January	February	March	April	May	June	July	August	September	October	November	December
PGE1	6,475	4,619	4,176	3,604	2,979	2,090	1,817	1,968	1,934	2,804	4,412	6,494
PGE4	4,240	3,164	3,033	2,674	2,870	2,413	2,316	2,413	2,348	2,413	3,098	4,175
PGE5	10,500	7,700	6,700	5,300	3,000	0	0	0	0	3,800	7,900	10,300
SDG4	7,727	7,099	6,352	4,567	3,395	2,338	1,785	1,816	2,648	4,625	6,803	9,078
PGE2a	12,441	8,825	7,940	6,824	5,752	4,053	3,596	3,871	3,799	5,427	8,198	12,128
SDG4a	3,127	2,873	2,570	1,848	1,374	946	722	735	1,071	1,871	2,753	3,674
SCG4a	10,829	8,322	9,225	6,818	0	0	0	0	2,406	4,813	8,322	12,032
SCG23	26,225	20,225	22,355	16,601	0	0	0	0	6,008	11,763	20,166	28,869
SCG9	13,675	10,612	11,696	8,224	5,807	1,722	1,280	1,140	2,262	5,526	10,334	16,185
SCG4	17,036	13,339	14,464	9,964	0	0	0	0	2,411	6,107	12,375	20,250
SDG1	9,773	7,694	6,676	4,534	2,716	1,013	320	236	318	2,911	6,168	9,981
SCG20a	24,020	18,516	20,617	16,014	13,111	9,308	8,107	7,106	7,606	12,110	19,016	25,922
SCG23a	25,630	19,789	21,866	16,235	0	0	0	0	5,849	11,480	19,696	28,201
PGE21	17,250	12,763	11,666	9,174	7,479	5,484	4,587	5,185	5,484	8,177	12,464	16,951
PGE11	36,660	27,012	33,996	29,004	26,040	2,820	2,208	2,544	14,232	19,308	25,932	38,388
SCG13	51,700	39,400	43,700	34,000	0	0	0	0	10,400	26,800	41,600	55,800
PGE2	47,994	36,051	33,694	27,544	23,489	18,293	15,201	16,582	16,620	23,164	32,861	45,566
SCG12	47,587	35,691	39,706	30,216	23,554	15,849	13,588	10,883	12,454	21,641	36,393	50,591
SCG20	50,800	39,100	43,500	33,800	27,700	19,500	17,100	15,000	16,000	25,700	40,200	54,900
SCG44	43,398	32,899	35,899	27,399	0	0	0	0	12,000	20,499	33,599	46,698
SCG14	31,829	24,604	26,752	20,113	15,231	3,710	2,538	2,734	8,201	15,036	25,385	36,711

Utility ID	Pre-Implementation Monthly Electric Energy (kWh/month)											
	January	February	March	April	May	June	July	August	September	October	November	December
PGE1	1,200	910	890	730	700	570	540	590	590	760	950	1,190
PGE4	594	538	594	571	603	587	607	607	587	590	574	594
PGE5	4,700	3,970	4,130	3,790	3,520	0	0	0	10	3,660	4,220	4,650
SDG4	1,822	1,624	1,850	1,807	1,709	1,836	2,358	1,977	1,765	1,638	1,737	1,906
PGE2a	1,369	1,593	2,339	4,014	5,149	5,840	6,185	5,527	4,545	3,008	1,436	1,253
SDG4a	737	657	749	731	691	743	954	800	714	663	703	771
SCG4a	2,577	2,226	2,457	2,226	0	0	0	0	1,775	2,106	2,336	2,637
SCG23	873	701	763	598	0	0	0	0	248	441	703	944
SCG9	3,100	2,546	2,652	2,231	1,939	672	606	527	1,071	1,887	2,566	3,233
SCG4	5,095	4,500	4,982	4,596	0	0	0	0	4,146	4,500	4,725	5,271
SDG1	4,005	3,491	3,281	2,491	1,780	876	345	203	353	1,829	3,140	4,090
SCG20a	3,573	2,852	3,083	2,572	2,232	1,691	1,521	1,391	1,491	2,152	2,983	3,723
SCG23a	961	778	845	670	0	0	0	0	283	496	779	1,034
PGE21	3,031	2,403	2,283	1,815	1,615	1,256	1,087	1,207	1,276	1,815	2,523	3,001
PGE11	2,490	1,838	2,306	1,966	1,768	202	161	184	980	1,325	1,772	2,608
SCG13	3,950	3,250	3,540	3,110	0	0	0	0	1,320	2,930	3,470	4,070
PGE2	6,050	4,723	4,520	3,681	3,283	2,635	2,280	2,477	2,527	3,441	4,631	5,858
SCG12	3,778	2,929	3,179	2,557	2,058	1,445	1,270	1,043	1,187	1,941	3,025	3,917
SCG20	6,400	5,100	5,530	4,600	3,950	2,940	2,640	2,380	2,540	3,770	5,330	6,660
SCG44	16,309	14,289	15,779	14,739	0	0	0	20	13,629	14,669	15,199	16,539
SCG14	7,557	6,053	6,346	5,468	5,018	2,304	1,953	1,816	3,964	5,214	6,463	7,752

Utility ID	Post-Implementation Monthly Gas Use (Therms/month)											
	January	February	March	April	May	June	July	August	September	October	November	December
PGE1	5,078	3,535	3,172	2,661	2,177	1,487	1,271	1,376	1,405	2,090	3,409	5,099
PGE4	3,196	2,381	2,283	1,989	2,250	1,957	1,892	1,957	1,892	1,826	2,250	3,066
PGE5	7,700	5,700	4,900	3,800	2,100	0	0	0	0	2,700	5,800	7,700
SDG4	4,896	4,462	3,896	2,717	1,892	1,214	946	959	1,491	2,776	4,315	5,751
PGE2a	8,490	5,807	5,194	4,241	3,578	2,447	2,096	2,307	2,289	3,349	5,087	7,984
SDG4a	1,981	1,806	1,577	1,099	766	491	383	388	603	1,123	1,746	2,327
SCG4a	8,022	6,016	6,718	4,813	0	0	0	0	1,705	3,509	6,016	8,924
SCG23	16,108	12,023	13,605	9,958	0	0	0	0	3,648	6,934	12,101	17,637
SCG9	8,599	6,579	7,243	4,968	3,396	1,235	922	988	1,228	3,182	6,307	10,144
SCG4	11,182	8,632	9,375	6,243	0	0	0	0	1,425	3,914	8,050	13,350
SDG1	5,912	4,556	3,832	2,877	1,295	343	63	48	88	1,406	3,534	6,046
SCG20a	18,516	14,212	15,713	12,310	10,109	7,306	6,506	5,805	6,105	9,408	14,712	20,017
SCG23a	15,728	11,735	13,294	9,707	0	0	0	0	3,526	6,750	11,787	17,207
PGE21	10,370	7,578	7,279	5,883	4,986	3,989	3,291	3,789	3,989	5,185	6,980	9,672
PGE11	27,624	19,896	25,680	21,444	19,212	1,224	744	1,020	9,684	13,512	18,852	28,920
SCG13	38,200	28,700	32,100	24,800	0	0	0	0	7,700	19,500	30,300	41,100
PGE2	34,322	25,680	24,728	21,114	18,719	15,121	12,266	13,364	12,806	16,368	21,913	31,282
SCG12	31,989	23,544	27,893	22,352	17,914	12,635	13,814	12,702	12,909	16,204	24,794	33,270
SCG20	38,900	30,000	33,100	25,900	21,200	15,200	13,700	12,100	12,800	19,800	30,900	42,100
SCG44	32,899	24,399	26,599	19,999	0	0	0	0	8,300	14,899	25,099	35,299
SCG14	21,480	16,207	17,769	13,083	9,568	1,562	976	1,367	5,468	9,373	16,598	24,799

Utility ID	Post-Implementation Monthly Electric Energy (kWh/month)											
	January	February	March	April	May	June	July	August	September	October	November	December
PGE1	1,180	870	840	680	650	500	450	500	520	680	910	1,170
PGE4	502	453	499	470	512	496	512	512	496	486	486	502
PGE5	4,320	3,680	3,850	3,560	3,370	0	0	0	10	3,470	3,900	4,310
SDG4	1,440	1,356	1,483	1,299	1,186	1,186	1,511	1,285	1,101	1,101	1,299	1,610
PGE2a	1,080	1,377	2,164	3,745	4,667	5,220	5,608	4,948	3,872	2,691	1,199	933
SDG4a	583	549	600	526	480	480	611	520	446	446	526	651
SCG4a	2,396	2,066	2,286	2,056	0	0	0	0	1,695	1,975	2,176	2,487
SCG23	592	454	509	383	0	0	0	0	168	280	456	648
SCG9	2,890	2,353	2,462	2,004	1,619	606	541	527	817	1,577	2,317	3,056
SCG4	4,803	4,253	4,703	4,377	0	0	0	0	4,086	4,373	4,484	4,935
SDG1	3,316	2,832	2,550	2,012	1,231	452	89	69	161	1,231	2,417	3,387
SCG20a	3,113	2,442	2,652	2,192	1,872	1,441	1,331	1,231	1,301	1,822	2,562	3,293
SCG23a	666	514	577	435	0	0	0	0	194	321	516	729
PGE21	2,343	1,755	1,705	1,386	1,197	957	798	907	957	1,246	1,645	2,224
PGE11	1,890	1,364	1,753	1,464	1,314	90	55	74	674	937	1,301	1,978
SCG13	3,570	2,950	3,230	2,850	0	0	0	0	1,170	2,610	3,130	3,660
PGE2	4,830	3,655	3,580	3,031	2,718	2,228	1,879	2,054	2,025	2,556	3,311	4,509
SCG12	2,913	2,165	2,540	2,071	1,680	1,223	1,308	1,211	1,241	1,546	2,270	3,006
SCG20	5,510	4,310	4,710	3,840	3,240	2,440	2,230	2,040	2,160	3,110	4,520	5,850
SCG44	15,569	13,679	15,119	14,189	0	0	0	20	13,349	14,269	14,579	15,749
SCG14	7,303	5,780	6,092	5,272	4,706	1,836	1,328	1,308	3,710	4,862	6,073	7,635

Utility ID	Monthly Gas Impacts (Therms/month)											
	January	February	March	April	May	June	July	August	September	October	November	December
PGE1	1,397	1,084	1,004	943	802	603	546	592	529	714	1,003	1,395
PGE4	1,044	783	750	685	620	457	424	457	457	587	848	1,109
PGE5	2,800	2,000	1,800	1,500	900	0	0	0	0	1,100	2,100	2,600
SDG4	2,831	2,636	2,456	1,850	1,502	1,124	839	857	1,157	1,848	2,488	3,327
PGE2a	3,951	3,017	2,745	2,584	2,174	1,606	1,500	1,564	1,510	2,078	3,111	4,144
SDG4a	1,146	1,067	994	749	608	455	339	347	468	748	1,007	1,346
SCG4a	2,808	2,306	2,507	2,005	0	0	0	0	702	1,303	2,306	3,108
SCG23	10,117	8,202	8,750	6,643	0	0	0	0	2,360	4,829	8,065	11,231
SCG9	5,076	4,033	4,453	3,257	2,411	487	359	153	1,034	2,344	4,027	6,041
SCG4	5,854	4,707	5,089	3,721	0	0	0	0	986	2,193	4,325	6,900
SDG1	3,862	3,137	2,845	1,657	1,420	669	257	188	230	1,505	2,634	3,934
SCG20a	5,505	4,304	4,904	3,703	3,003	2,002	1,601	1,301	1,501	2,702	4,304	5,905
SCG23a	9,902	8,054	8,572	6,528	0	0	0	0	2,323	4,730	7,909	10,995
PGE21	6,880	5,185	4,387	3,291	2,493	1,496	1,296	1,396	1,496	2,991	5,484	7,279
PGE11	9,036	7,116	8,316	7,560	6,828	1,596	1,464	1,524	4,548	5,796	7,080	9,468
SCG13	13,500	10,700	11,600	9,200	0	0	0	0	2,700	7,300	11,300	14,700
PGE2	13,672	10,371	8,966	6,430	4,770	3,172	2,935	3,218	3,814	6,796	10,948	14,284
SCG12	15,599	12,148	11,812	7,865	5,640	3,214	-225	-1,819	-455	5,437	11,599	17,321
SCG20	11,900	9,100	10,400	7,900	6,500	4,300	3,400	2,900	3,200	5,900	9,300	12,800
SCG44	10,500	8,500	9,300	7,400	0	0	0	0	3,700	5,600	8,500	11,400
SCG14	10,349	8,397	8,982	7,030	5,663	2,148	1,562	1,367	2,734	5,663	8,787	11,911

Utility ID	Monthly Electric Impact (kWh/month)											
	January	February	March	April	May	June	July	August	September	October	November	December
PGE1	20	40	50	50	50	70	90	90	70	80	40	20
PGE4	91	85	95	101	91	91	95	95	91	104	88	91
PGE5	380	290	280	230	150	0	0	0	0	190	320	340
SDG4	381	268	367	508	522	650	847	692	664	537	438	297
PGE2a	288	216	175	268	482	620	577	579	673	317	237	320
SDG4a	154	109	149	206	211	263	343	280	269	217	177	120
SCG4a	180	160	170	170	0	0	0	0	80	130	160	150
SCG23	281	247	254	216	0	0	0	0	80	161	247	296
SCG9	210	193	190	226	320	66	66	0	253	310	250	177
SCG4	292	248	280	219	0	0	0	0	60	127	241	336
SDG1	689	659	730	479	549	424	256	134	192	597	724	703
SCG20a	460	410	430	380	360	250	190	160	190	330	420	430
SCG23a	295	264	268	235	0	0	0	0	89	175	263	304
PGE21	688	648	578	429	419	299	289	299	319	568	877	778
PGE11	600	474	553	502	454	112	106	109	306	388	472	630
SCG13	380	300	310	260	0	0	0	0	150	320	340	410
PGE2	1,220	1,068	940	650	565	407	401	423	502	886	1,320	1,349
SCG12	865	765	639	487	378	222	-38	-169	-54	395	755	910
SCG20	890	790	820	760	710	500	410	340	380	660	810	810
SCG44	740	610	660	550	0	0	0	0	280	400	620	790
SCG14	254	273	254	195	312	469	625	508	254	351	391	117

HIGH IMPACT MEASURE SITE MEASUREMENT AND VERIFICATION REPORT

GREENHOUSE INFRARED FILMS

November 6th, 2009

PROJECT

Program Being Evaluated	PG&E, SDG&E, and SCG greenhouse infrared film rebates from the 2006-2008 program years
Project ID	High Impact Measures – Infrared Film
Customer Name	
Site Name	
Site Address	
Site Type	Greenhouses
Customer Business/Product	

PRINCIPAL SITE CONTACT

Name		**Telephone**	
E-mail		**Title**	

IOU REPRESENTATIVE

Name		**Telephone**	
E-mail			

THIRD-PARTY SPONSOR OR IMPLEMENTER

Name		**Telephone**	
E-mail		**Company**	

ASSIGNED LEAD ENGINEER

Name	

AUTHOR

Name	

1. EVALUATION OBJECTIVES

1.1. Evaluation Objectives

This Measurement and Verification (M&V) Plan is part of the impact evaluation of Pacific Gas and Electric (PG&E), San Diego Gas and Electric (SDG&E), and Southern California Gas's (SCG) greenhouse infrared film energy efficiency rebate programs. The primary goal of the impact evaluation is to assess the net energy impacts for the programs in these groups.

The objectives of the impact evaluation are to:

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

2. METHODS USED: IOU AND EVALUATION ALGORITHMS

2.1. Measures Included in the Evaluation

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 a replacement 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 on 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, 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.

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. Qualified infrared films cut down on greenhouse heat loss, especially at night.

Properly installed and program qualified infrared films improve the thermal properties of the building envelope, resulting in reduced HVAC systems loads. The measure impact can be quantified as the savings in heating, cooling, and ventilation energy in the greenhouse.

In the 2006-2008 program period there were 65 prescriptive infrared film projects. Only installations of infrared films in natural gas heated commercial greenhouses qualified for the prescriptive incentives. New construction projects were not eligible.

2.2. Impact Type

This measure is a *direct impact* measure.

2.3. Baseline Type

Infrared films rebated through PG&E, SDG&E, and SCG programs were either *early* or *normal* replacement measures. In the baseline, it was assumed that no infrared films were installed in each evaluated greenhouse. Conversations during site visits indicated that the infrared films installed at all of the sites included in the evaluation sample were normal replacement.

2.4. Sample Type

These projects were selected from a *post-only* sample. These projects were completed when the projects were sampled.

2.5. Pre-installation Equipment and Operation

The following conditions were present in all greenhouses prior to measure installation and, unless otherwise indicated in collected data, were assumed to be held constant after measure installation.

The greenhouses under evaluation were designed with polyethylene roofs and polyethylene, glass, fiberglass, polycarbonate, or acrylic walls. The floors of the greenhouses were either concrete or bare soil. The majority of greenhouses were operated from 7 AM to 5 PM Monday through Friday, plus or minus 1-2 hours from site to site, and with abbreviated schedules on weekends.

A number of greenhouses had both mechanical heating systems and mechanical cooling systems. The most common mechanical cooling systems were fan and pad (direct evaporative) cooling systems. Where mechanical cooling systems were not installed, either natural or forced ventilation systems were present. This was true of greenhouses located in all the climate zones in California.

The mechanical heating systems in the greenhouses were forced air, steam, or hot water. At the majority of sites, individual greenhouses were either served by their own heating systems, or the space temperature was controlled by a greenhouse-specific thermostat connected to a steam or hot water loop. This allowed for the precise temperature control needed to ensure healthy plant growth. On a number of larger sites, boilers were centrally located to provide heating to multiple greenhouses.

The plants grown in each greenhouse varied from site to site (between 60-72°F) and included vegetables, cut flowers, potted flowers, and tropical plants. This was documented through site visits and interviews at each site. It was assumed that the plants cultivated in each greenhouse remained the same during the pre- and post- installation period.

All pre-installation conditions were verified with site visits and interviews with facility staff.

2.6. As-Built Equipment and Operation

At 14 of the 18 sites in the evaluation sample infrared films were installed as the interior layer of a 2-layer inflated polyethylene roof. At 4 of the evaluated sites the infrared film was installed as the only layer of a single polyethylene roof.

2.7. Seasonable Variability in Schedule and Production

All of the evaluated greenhouses were occupied year-round. The evaluated greenhouses generally were located in mild climates. They were likely to demand either heating or cooling at varying times of day and throughout the year, with high heating demands at night and possible cooling demands during the day. This was verified through interviews with site staff and computer simulations of each of greenhouse.

2.8. Energy Savings Methods Used by IOUs

The measure savings is deemed. Table 1 shows the deemed values.

Table 1: IOU Measure Impacts

Program	*Ex ante* Impact	Algorithm
SDG&E	0.17 therms/sq.ft.	therms/sq.ft. of infrared film
SGC	0.17 therms/sq.ft.	therms/sq.ft. of infrared film
PG&E	0.17 therms/sq.ft.	therms/sq.ft. of infrared film

The *ex ante* impacts for the infrared film measure were quantified in therms of gas/sq.ft./year of measure installed. The expected therms/sq.ft./year of savings for this measure were calculated with the eQuest v3.5 building energy simulation software.[1] This software was used to calculate the expected impact in therms/sq.ft. of infrared film installed in a typical greenhouse in California. These simulations were based on collected data and surveys of greenhouses throughout California.

2.9. Level of Rigor in Evaluation

The level of rigor for this project is enhanced.

2.10. Energy Savings Algorithms Used in the Evaluation

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).

[1] Deemed savings were established from project applications and PG&E, SCG, and SDG&E template applications from the 2006-2008 program years. The method for estimating these savings was based on Green Building Studio's 2005 report for PG&E titled "Greenhouse Baseline Study Final Report".

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 heat curtains.

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.

In preparation for evaluation of this measure, ERS examined using four different modeling tools:

1. eQuest v3.63b—standard
2. eQuest v3.63—custom-modified by John Hill for J. J. Hirsh & Associates
3. eQuest v3.5—original John Hill model modified by Green Building Studio (GBS) Custom spreadsheet model
4. USDA Virtual Grower greenhouse simulator

After considering the available data, number of models to simulate, measures being evaluated, accuracy for modeling greenhouses, and testing the five options, Options 2 and 3 quickly stood out as the best options. A modified Option 3 was selected that incorporated the John Hill and GBS customization into eQuest v3.63b. The GBS tool has the same underlying analysis engine as the Hill version and was more accommodating for parametric modeling regarding temperature stratification and dimensional inputs. However, some of the strengths of Mr. Hill's latest version, such as temperature stratification assumptions, more advanced heat curtain controls, and an upgrade to eQuest v3.63b, were incorporated into the GBS tool for this evaluation.

The key advantages to *ex post* modeling over the *ex ante* estimates described in the IOU algorithm were 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.

Evaluation Method

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

1) **Review** of data available from project applications and utility bills for each site.
2) **Site surveys** were performed 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 2.

Table 2: Inputs for Modeling Infrared Film Measure Impact[2]

	Variable[3]	Pre-Implementation (no infrared film)	Post-Implementation (with infrared film)
Single layer polyethylene	U-value of the greenhouse roof	1.1 Btuh/ft$^{2\circ}$F	1 Btuh/ft$^{2\circ}$F
	Shading coefficient of the greenhouse roof	0.26	0.22
Double layer polyethylene	U-value of the greenhouse roof	0.7 Btuh/ft$^{2\circ}$F	0.5 Btuh/ft$^{2\circ}$F
	Shading coefficient of the greenhouse roof	0.24	0.20

Contrary to the IOU measure impact algorithm described above, each site was modeled with mechanical systems, operating schedules, temperature setpoints, greenhouse envelope, and internal gains and losses specific to the greenhouse under evaluation, including its location, design, and the plants being cultivated. These inputs were held constant during the energy impact evaluation. Site interviews were performed to verify the pre- and post-measure implementation conditions in each greenhouse. In greenhouses where

[2] Material U-values and shading coefficients taken from Green Building Studio's 2005 report for PG&E "Greenhouse Baseline Study Final Report", NRAES-3: "Energy Conservation for Commercial Greenhouses", and NRAES-33: "Greenhouse Engineering", the latter two of which were published by the Natural Resource, Agriculture, and Engineering Service (NRAES) Cooperative Extension.

[3] Shading coefficient values include a 75% reduction from manufacturer values to account for solar energy that enters the greenhouse but it not gained as heat. In a typical greenhouse, 25% of the solar energy entering a greenhouse is used for photosynthesis or reflected back outdoors, while 50% of the solar energy in a full greenhouse is absorbed by the plants and subsequently released as moisture via evapotranspiration. This moisture is removed from the greenhouse via natural ventilation. In total, only about 25% of the solar energy transmitted into the greenhouse is gained as sensible heat. See: NRAES-33: Greenhouse Engineering, 3rd Revision, 1994, published by the Natural Resource, Agriculture, and Engineering Service (NRAES) Cooperative Extension and 2005 ASHRAE Handbook of Fundamentals for more details.

additional changes were made in conjunction with the measure under evaluation, these changes were accounted for in the measure evaluation.

Method Validation (applicable to the pilot sites)

Prior to developing eQuest models of all evaluation sites, the procedure described was benchmarked against pre- and post- installation measured heat load or utility data for 5 sample projects, which were located on 4 different sites and required modeling of 6 different greenhouses. This validation required that the simulated models for each sample project be calibrated to match metered data. Models were considered calibrated when the energy consumption output by the simulation program showed a good visual and statistical match against the site's hourly and daily metered energy use information.

Data logging was performed for a minimum of four weeks during March and April for each of the sample sites that was modeled during the Method Validation.

After validation was performed for the sample projects, evaluators used the adjusted model for the remainder of the evaluation sites.

2.11. Peak Demand Algorithms Used in the Evaluation

Electricity savings represented less than 2% of the total site energy savings. Peak demand impacts were not evaluated, although model outputs showed that the installation of infrared films did result in a slight reduction in the peak cooling load in greenhouses, which corresponded with a reduction in the peak kW demand in greenhouses with mechanical cooling systems.

2.12. Energy Savings Data Collection & Data Collection Method

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[4]:

- 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 heat curtains

[4] See appendix for copy of data collection form.

- 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, 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 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 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

Table 3 summarizes the key characteristics of each site under evaluation.

Table 3: Summary of Infrared Film Evaluation Site Characteristics

Utility ID	Climate Zone	Installed Measure Area (sq.ft.)	Baseline	IR Film Type	Plant Type	Greenhouse Shape	Envelope Materials	Heat Curtain?	Heating System Type	Cooling System Type	Heating Temperature Schedules
SDG10	CZ07	30,160	2-PE w/No IR	Durafilm Thermax	House plants	Gable roof; ridge N-S	Roof: 2-PE w/IR Wall: 1-Fiberglass	None	Unit Heater	Natural Ventilation	Winter: 65°F Summer: Off
PGE14	CZ03	261,620	2-PE w/No IR	HiTec TUV 3954 AC	Cut Roses	Gabled roof; ridge NW-SE	Roof: 2-PE w/IR Wall: 1-PE	1-layer for shade and heat retention	Steam boiler w/underbench	Evaporative cooling	Winter and Summer: 60F
SCG31	CZ10	74,400	2-PE w/No IR	Durafilm Thermax	Poinsettias and cut flowers	Round roof; Ridge N-S	Roof: 2-PE w/IR Wall: 1-Fiberglas	None	Unit Heater	Evaporative cooling	Winter: 60F Summer: Off
SCG40	CZ09	52,800	2-PE w/No IR	Durafilm Thermax	Tomatoes	Round roof; ridge NE-SW	Roof: 2-PE w/IR Wall: 1-PE	None	HW boiler w/underbench	Evaporative cooling	Winter and Summer: 62F
SCG53	CZ05	6,880	2-PE w/No IR	Gingar IR AF 303	Ferns and House Plants	Round roof; ridge N-S	Roof: 2-PE w/IR Wall: 1-PC	None	Unit heater	Evaporative cooling	Winter and Summer: 65F
SCG57	CZ06	140,851	1-PE w/No IR	Gingar IR AD Diffused	Orchids	Gabled roof; ridge N-S	Roof: 1-PE Wall: 1-PC	2-layers for shade and heat retention	HW boiler w/underbench	Natural Ventilation	Winter and Summer: 64F
SCG29	CZ05	178,250	2-PE w/No IR	Gingar IR AD 303	Indoor Tropical Foliage	Round roof; ridge N-S	Roof: 2-PE w/IR Wall: 1-PE	1-layer for shade and heat retention	HW boiler w/underbench	Natural Ventilation	Winter and Summer: 60F (Day)-66F (Night)
SCG35	CZ06	194,250	2-PE w/No IR	Durafilm Thermax	Chrysanthemums	Round roof; N-S	Roof: 2-PE w/IR, Wall: 2-PE	1 layer for shade	HW boilers w/underbench	Natural Ventilation	Winter and Summer: 62F
SDG11	CZ10	156,888	2-PE w/No IR	Kool Lite 380	Tropical Foliage Plants	Round roof; ridge N-S	Roof: 2-PE w/IR Wall: 3" Polystyrene	2 layers, for shade and heat retention	Unit Heaters	Evaporative cooling	Winter and Summer: 70F
SDG6	CZ10	145,000	2-PE w/No IR	Kool Lite 380	Bromelaids	Gabled roof; ridge NW-SE	Roof: 2-PE w/IR Wall: 1-PC	1 layer for shade and heat retention	HW boiler w/underbench	Natural Ventilation	Winter and Summer: 68F
SDG8a	CZ10	156,600	2-PE w/No IR	Kool Lite 380	Orchids and Anthiriums	Round roof, ridge E-W	Roof: 2-PE w/IR Wall: Rigid Foam	2 layers, for shade and heat retention	HW boiler w/underbench	Evaporative cooling	Winter and Summer: 72°F
SDG16	CZ10	159,520	2-PE w/No IR	Kool Lite 380 & IRAC	Tropical Foliage Plants	Round roof; ridge N-S	Roof: 2-PE w/IR Wall: 3" Polystyrene	2 layers, for shade and heat retention	Unit Heaters	Evaporative cooling	Winter and Summer: 70F
SDG8	CZ10	299,740	2-PE w/No IR	Kool Lite 380	Tropical Foliage Plants	Round roof; ridge N-S	Roof: 2-PE w/IR Wall: 3" Polystyrene	2 layers, for shade and heat retention	Unit Heaters	Evaporative cooling	Winter and Summer: 70F
SCG33	CZ05	839,850	2-PE w/No IR	Gingar AD IR	Roses	Gabled roof: ridge N-S	Roof: 2-PE w/IIR Wall: 1-White Canvas	None	HW boilers w/underbench	Natural ventilation	Winter and Summer: 62F
SDG5	CZ07	510,637	2-PE w/No IR	Klerks K50-IRAC	Cut flowers	Gabled roof; ridge N-S	Roof: 2-PE w/IR Wall: 1-PE	Mix of houses w/ and w/o curtains	HW boiler w/underbench	Natural ventilation	Winter and Summer: 58-62F
SCG52	CZ06	238,680	1-PE w/No IR	Durafilm Thermax	Chrysanthemums and Lilies	Round roof, ridge N-S	Roof: 1-PE w/IR Wall: 1-PC	1 layer for shade and heat retention	HW boiler w/underbench	Natural ventilation	Winter: 55-65°F Summer: Heat Off
SCG64	CZ05	426,000	1-PE w/No IR	Klerks K50-IRAC	Cut Roses	Round roof; ridge N-S	Roof: 1-PE w/IR Wall: 1-PC	1-layer for shade and heat retention	HW boiler w/underbench	Natural ventilation	Winter and Summer: 61F
SCG65	CZ06	292,036	1-PE w/No IR	Durafilm Thermax	Lilies, roses, hydrangas	Gabled roof; ridge N-S	Roof: 1-PE w/IR Wall: 1-PE	Mix of houses w/ and w/o curtains	Steam boiler w/underbench	Natural Ventilation	Winter & Summer: 62-68F

3. CONFIDENCE AND PRECISION OF KEY FINDINGS

3.1. Engineering Accuracy

Metering accuracy was limited to the proxy on-off measurements and the assumption that the systems run at rated input and output when on. Additionally, data accuracy was limited by the quality of the data collected from site contacts during site visits and follow-up phone calls. At several sites, similar measures had been installed in multiple greenhouses, not all of which were covered by the project under evaluation. This led to potential inaccuracies in accounting for the installed measure location and square footage. For those sites included in the Method Validation pilot study the building simulation model accuracy was +/-15% compared to daily logged data.

Issues associated with engineering uncertainty are discussed in the next section.

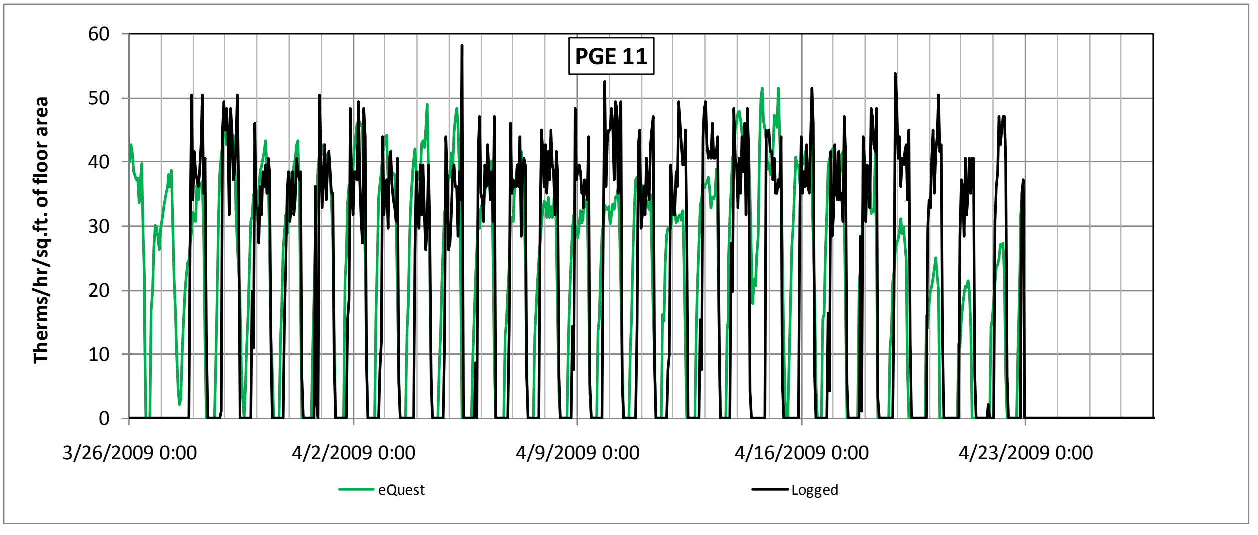
4. VALIDITY AND RELIABILITY

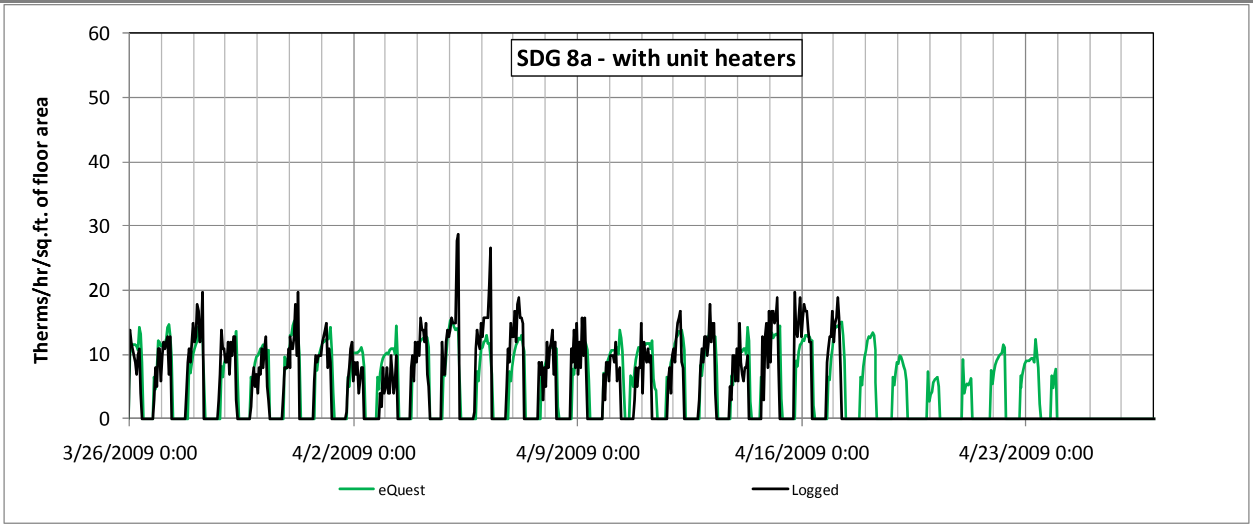
4.1. Method Validation

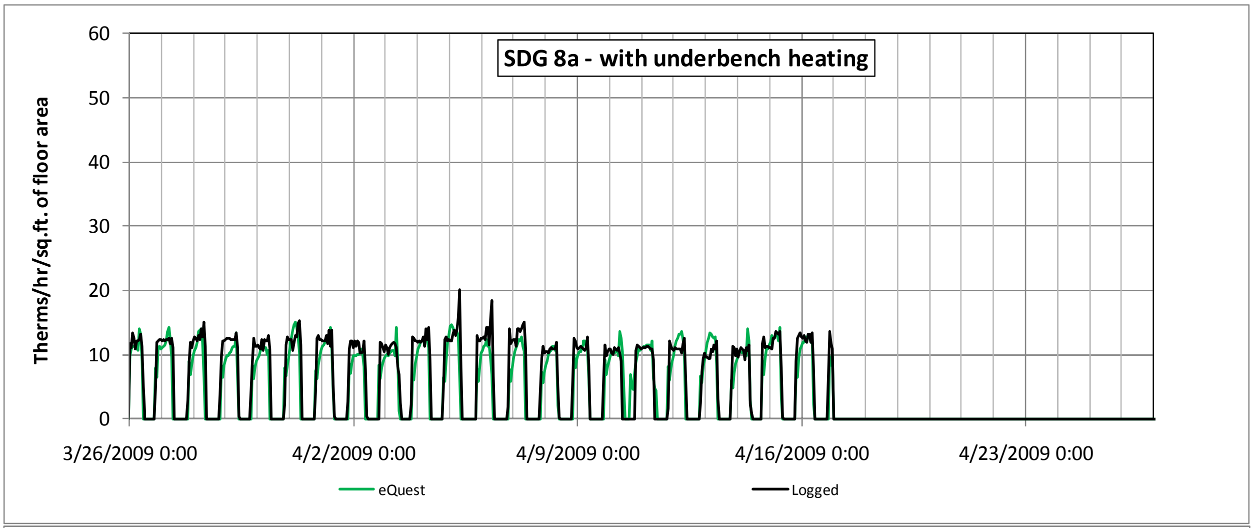
Prior to developing eQuest models of all evaluation sites, the procedure was benchmarked against pre- and post- installation metered data for 5 pilot projects, which included 6 greenhouses on 4 different sites and included sites that were rebated for both heat curtains and infrared films in the 2006-2008 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 visual and statistical match with the greenhouse's hourly and daily metered energy use information.

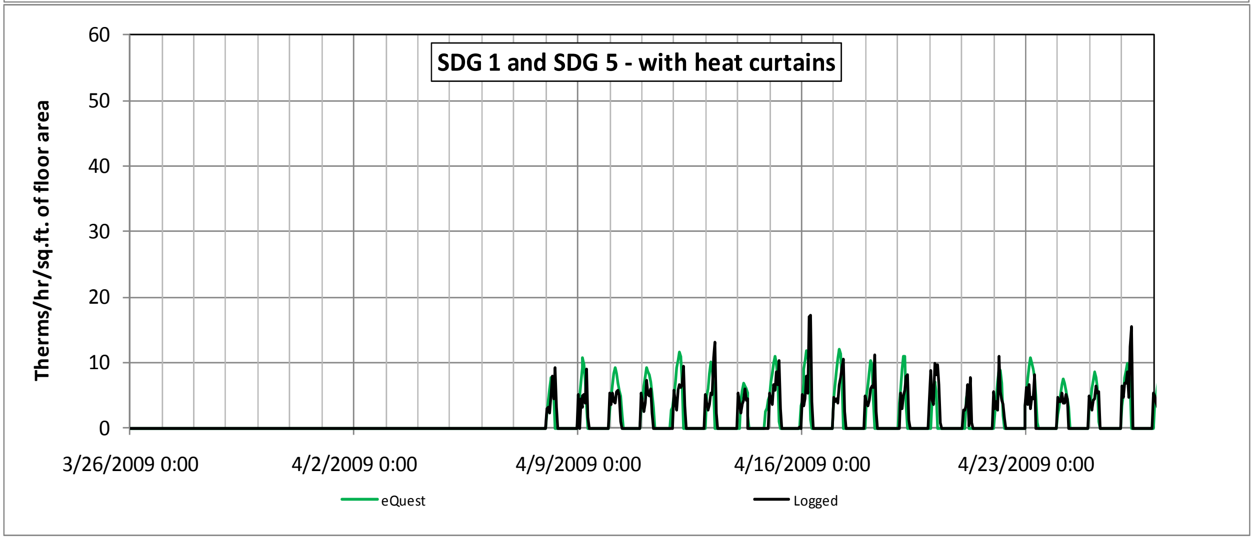
Data logging was performed for a minimum of four weeks during March and April for each of the sample greenhouses that was modeled during the Method Validation. eQuest models were generated for each greenhouse and a comparison was made between the daily and hourly heating energy use at each pilot greenhouse. Figures 1 through 5 show the hourly modeled and logged heating energy consumption (per sq.ft. of greenhouse floor area) for five of the six greenhouses included in the pilot projects. Site PGE 4 is not included in these figures because inaccurate metering led to inexact logged data.

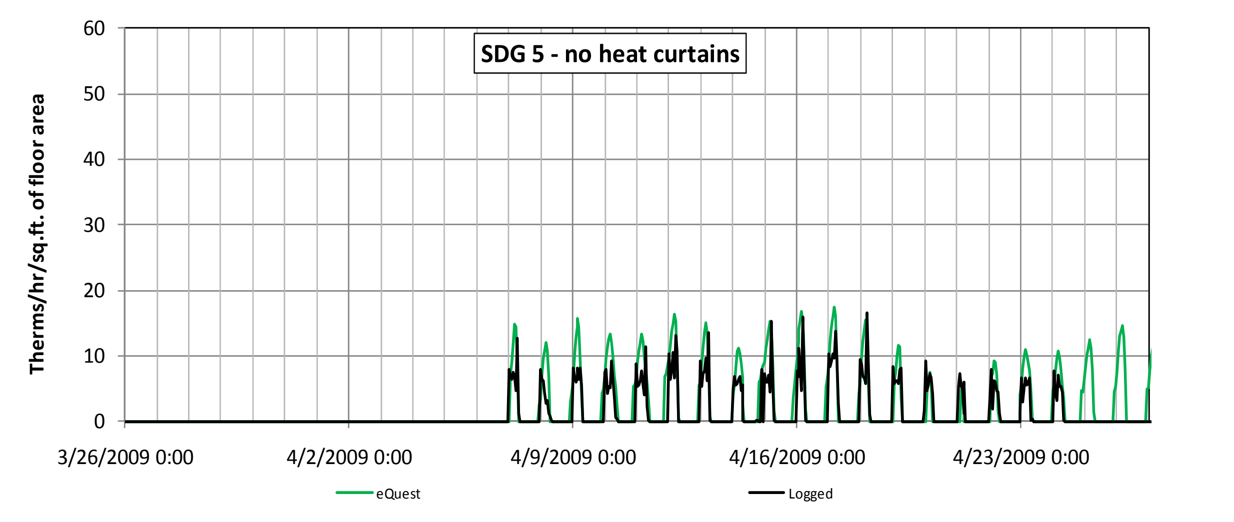
Figure 1 through 5: Modeled and Metered Impacts: Greenhouse Heat Load Over Time




SDG 8a - with unit heaters
Therms/hr/sq.ft. of floor area
60
50
40
30
20
10
0
3/26/2009 0:00
4/2/2009 0:00
4/9/2009 0:00
4/16/2009 0:00
4/23/2009 0:00
eQuest
Logged


SDG 8a - with underbench heating
Therms/hr/sq.ft. of floor area
60
50
40
30
20
10
0
3/26/2009 0:00
4/2/2009 0:00
4/9/2009 0:00
4/16/2009 0:00
4/23/2009 0:00
eQuest
Logged


SDG 1 and SDG 5 - with heat curtains
Therms/hr/sq.ft. of floor area
60
50
40
30
20
10
0
3/26/2009 0:00
4/2/2009 0:00
4/9/2009 0:00
4/16/2009 0:00
4/23/2009 0:00
eQuest
Logged



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[5]. 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 assumption 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 under-bench 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 pilot site SDG8a (with unit heaters), DEER values, and a review of published literature[6].

[5] See ASHRAE Guideline 14-2001 "Measurement of Energy and Demand Savings" for information on CV values for calibrated models. In general, this guideline recommends that models be considered calibrated when the hourly CV is less than 30% or the monthly CV is less than 15% for models calibrated against one full year of data.

[6] Winspear, K.W. 1978. "Vertical Temperature Gradients and Greenhouse Energy Economy" Acta Hort. (ISHS) 76:97-104; Martinez, P.F. and Miranda, J. 1974. "Study on Temperature Gradients and Profiles in Greenhouses". Acta Hort. (ISHS) 42:103-112; Teitel, M. and Tanny, J. 1996. "Energy Saving in Heated Enclosures". Acta Hort. (ISHS) 417:139-146; Green Building Studio's 2005 report for PG&E "Greenhouse Baseline Study".

- Manufacturer's glazing shading coefficients were reduced, on average, by 75%[7] 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/sq.ft. DEER models had used a "Floor-Weight" of 5 lbs/sq.ft., while 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/sq.ft. of thermal mass showed a better fit between the hourly logged and modeled heating energy than the models with only 5 lbs/sq.ft. 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

4.2. 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.

4.3. 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

[7] 25% of the solar energy entering a greenhouse is used for photosynthesis or reflected back outdoors, while 50% of the solar energy in a full greenhouse is absorbed by the plants and subsequently released as moisture via evapotranspiration. This moisture is removed from the greenhouse via natural ventilation. In total, only about 25% of the solar energy transmitted into the greenhouse is gained as sensible heat. See pages 63 through 68 of NRAES-33: Greenhouse Engineering, 3rd Revision, 1994, published by the Natural Resource, Agriculture, and Engineering Service (NRAES) Cooperative Extension and page 10.15 in the chapter on "Environmental Control for Animals and Plants" in the 2005 ASHRAE Handbook of Fundamentals for more details.

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 was collected from multiple sources to define the pre- and post-implementation roof U-value 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 deviation of the roof U-value is shown in Table 5 for the two projects that received infrared film rebates and that were included in the Method Validation study:

Table 5: 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 6 along with their percent variation from the average and the estimated standard deviation of the measure impact:

Table 6: Uncertainty Analysis: Output

Output Uncertainty (Therms)	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	-
Output Uncertainty (kWh)	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	-

Uncertainties associated with the roof shading coefficients, the degree of temperature stratification, and the heat curtain control setpoints in each greenhouse are estimated to contribute an additional 15-20% uncertainty to the calculated measure impact.

5. DETAILED FINDINGS

5.1. Annual Measure Savings

Infrared films were the only energy efficiency measure included in this evaluation. Depending on the site, this measure yielded gas or electric savings, or both. Only gas savings were reported to the programs. Tables 7, 8, 9, and 10 present the *ex ante* and *ex post* impact for all evaluation sites. Pilot sites are highlighted in gray. Monthly pre- and post-implementation energy as well as measure impacts are presented in Appendix A.

Table 7: Gross *Ex ante* and *Ex post* Measure Impacts – Therms and kWh per Year

		Annual Gas Impact (Therms)			Annual Energy Electricity (kWh)
Utility ID	Installed Measure Area (sq.ft.)	Ex Ante	Ex Post	Realization Rate	Ex Post
SDG10	30,160	5,127	3,240	0.63	896
PGE14	261,620	44,475	17,337	0.39	3,049
SCG31	74,400	12,648	4,596	0.36	1,915
SCG40	52,800	8,976	3,346	0.37	1,224
SCG53	6,880	1,170	1,091	0.93	277
SCG57	140,851	23,945	1,353	0.06	-221
SCG29	178,250	30,303	15,783	0.52	468
SCG35	194,250	33,023	9,222	0.28	1,580
SDG11	156,888	26,671	16,181	0.61	10,000
SDG6	145,000	24,650	9,700	0.39	-65
SDG8a	156,600	26,622	12,801	0.48	6,106
SDG16	159,520	27,118	15,647	0.58	10,130
SDG8	299,740	50,956	20,720	0.41	11,304
SCG33	839,850	142,775	108,942	0.76	1,100
SDG5	510,637	86,808	23,451	0.27	5,298
SCG52	238,680	40,576	3,473	0.09	205
SCG64	426,000	72,420	16,878	0.23	1,504
SCG65	292,036	49,646	4,377	0.09	1,211

For sites without mechanical cooling the electricity savings derives from reduced cycling of the unit heater fans, reduced use of horizontal airflow fans, or less load on the boiler hot water pumps.

Table 8: Gross *Ex ante* and *Ex post* Measure Impacts – Therms/sq.ft. and kWh/sq.ft. per Year

		Annual Gas Impact (Therms/sq.ft.)			Annual Electric Impact (kWh/sq.ft.)
Utility ID	Installed Measure Area (sq.ft.)	Ex Ante	Ex Post	Realization Rate	Ex Post
SDG10	30,160	0.17	0.11	0.63	0.03
PGE14	261,620	0.17	0.07	0.39	0.01
SCG31	74,400	0.17	0.06	0.36	0.03
SCG40	52,800	0.17	0.06	0.37	0.02
SCG53	6,880	0.17	0.16	0.93	0.04
SCG57	140,851	0.17	0.01	0.06	0.00
SCG29	178,250	0.17	0.09	0.52	0.00
SCG35	194,250	0.17	0.05	0.28	0.01
SDG11	156,888	0.17	0.10	0.61	0.06
SDG6	145,000	0.17	0.07	0.39	0.00
SDG8a	156,600	0.17	0.08	0.48	0.04
SDG16	159,520	0.17	0.10	0.58	0.06
SDG8	299,740	0.17	0.07	0.41	0.04
SCG33	839,850	0.17	0.13	0.76	0.00
SDG5	510,637	0.17	0.05	0.27	0.01
SCG52	238,680	0.17	0.01	0.09	0.00
SCG64	426,000	0.17	0.04	0.23	0.00
SCG65	292,036	0.17	0.01	0.09	0.00

The sites with evaporative cooling (PGE14, SCG31, SCG40, SCG53, SDG11, SDG8a, SDG16, SDG8) have higher electric impacts, due largely to the fan energy that is saved during the summer.

Table 9: Gross *Ex post* Measure Impacts - Total Btus per Year

		Ex Post Total Annual Impacts (Btus/year)				
Utility ID	Installed Measure Area (sq.ft.)	Gas	Electric	Total	% Gas	% Electric
SDG10	30,160	512,720,000	3,057,080	515,777,080	99%	0.6%
PGE14	261,620	4,447,540,000	10,407,304	4,457,947,304	100%	0.2%
SCG31	74,400	1,264,800,000	6,536,887	1,271,336,887	99%	0.5%
SCG40	52,800	897,600,000	4,177,874	901,777,874	100%	0.5%
SCG53	6,880	116,960,000	946,188	117,906,188	99%	0.8%
SCG57	140,851	2,394,467,000	-752,660	2,393,714,340	100%	0.0%
SCG29	178,250	3,030,250,000	1,596,428	3,031,846,428	100%	0.1%
SCG35	194,250	3,302,250,000	5,391,147	3,307,641,147	100%	0.2%
SDG11	156,888	2,667,096,000	34,129,623	2,701,225,623	99%	1.3%
SDG6	145,000	2,465,000,000	-221,962	2,464,778,038	100%	0.0%
SDG8a	156,600	2,662,200,000	20,841,104	2,683,041,104	99%	0.8%
SDG16	159,520	2,711,840,000	34,573,452	2,746,413,452	99%	1.3%
SDG8	299,740	5,095,580,000	38,579,367	5,134,159,367	99%	0.8%
SCG33	839,850	14,277,450,000	3,752,713	14,281,202,713	100%	0.0%
SDG5	510,637	8,680,829,000	18,082,261	8,698,911,261	100%	0.2%
SCG52	238,680	4,057,560,000	698,012	4,058,258,012	100%	0.0%
SCG64	426,000	7,242,000,000	5,131,600	7,247,131,600	100%	0.1%
SCG65	292,036	4,964,612,000	4,133,988	4,968,745,988	100%	0.1%

Electric energy accounts for less than 2% of the total *ex post* impacts for this measure. The *ex ante* impacts did not include electric energy. The highest *ex post* electric impacts (on a kWh/sq.ft. basis) tended to be at sites with fan and pad cooling systems.

Table 10: Gross *Ex post* Measure Impacts – % Annual Energy

Utility ID	Installed Measure Area (sq.ft.)	Modeled Gas Energy (therms/yr)		Modeled Gas Energy (therms/sq.ft./yr)		% Savings	Modeled Electric Energy (kWh/yr)		Modeled Electric Energy (kWh/sq.ft./yr)		% Savings
		Pre- retrofit	Savings	Pre-retrofit	Savings		Pre-retrofit	Savings	Pre-retrofit	Savings	
SDG10	30,160	16,550	3,240	0.55	0.11	20%	4,769	896	0.16	0.03	19%
PGE14	261,620	81,383	17,337	0.31	0.07	21%	43,425	3,049	0.17	0.01	7%
SCG31	74,400	19,499	4,596	0.26	0.06	24%	27,211	1,915	0.37	0.03	7%
SCG40	52,800	19,706	3,346	0.37	0.06	17%	19,321	1,224	0.37	0.02	6%
SCG53	6,880	7,476	1,091	1.09	0.16	15%	2,568	277	0.37	0.04	11%
SCG57	140,851	44,674	1,353	0.32	0.01	3%	18,320	-221	0.13	0.00	-1%
SCG29	178,250	90,345	15,783	0.51	0.09	17%	28,919	468	0.16	0.00	2%
SCG35	194,250	38,446	9,222	0.20	0.05	24%	15,685	1,580	0.08	0.01	10%
SDG11	156,888	76,445	16,181	0.49	0.10	21%	37,060	10,000	0.24	0.06	27%
SDG6	145,000	66,289	9,700	0.46	0.07	15%	33,623	-65	0.23	0.00	0%
SDG8a	156,600	73,017	12,801	0.47	0.08	18%	29,483	6,106	0.19	0.04	21%
SDG16	159,520	72,233	15,647	0.45	0.10	22%	36,125	10,130	0.23	0.06	28%
SDG8	299,740	111,960	20,720	0.37	0.07	19%	62,598	11,304	0.21	0.04	18%
SCG33	839,850	625,218	108,942	0.74	0.13	17%	105,239	1,100	0.13	0.00	1%
SDG5	510,637	87,173	23,451	0.17	0.05	27%	40,239	5,298	0.08	0.01	13%
SCG52	238,680	61,190	3,473	0.26	0.01	6%	34,332	205	0.14	0.00	1%
SCG64	426,000	262,445	16,878	0.62	0.04	6%	35,807	1,504	0.08	0.00	4%
SCG65	292,036	170,185	4,377	0.58	0.01	3%	79,006	1,211	0.27	0.00	2%

The heating energy savings range from 3% to 24%, with the highest percent savings in those greenhouses with the lowest baseline energy consumption.

5.2. Discussion of Results

Climate Zone

Table 11 presents the average *ex ante* and *ex post* savings for each climate zone represented in the measure sample.

Table 11: Gross Measure Savings – Infrared Film Sites

		Annual Measure Impact	
Climate Zone	# of Sites	Ex Ante Impact (therms/sq.ft.)	Ex Post Impact (therms/sq.ft.)
CZ03	1	0.17	0.07
CZ05	4	0.17	0.10
CZ06	4	0.17	0.02
CZ07	2	0.17	0.08
CZ09	1	0.17	0.06
CZ10	6	0.17	0.08
Average	18	0.17	0.07

Note the higher *ex post* impacts in climate zones 3, 5, 7, 9, and 10, nearly all of which (all except CZ07) are inland climates with cool winters and warm summers. Climate zone 6 is a coastal climate with moderate annual outdoor temperatures, which results in lower *ex post* impact. Climate zone 7 is also a coastal climate, although the average *ex post* impact for this climate zone is higher than climate zone 6, due largely to the high impacts in SDG10.[8] All sites in CZ03 were in PG&E territory, while those in CZ05, CZ06, and CZ09 were in SCG territory, and those in CZ07 and CZ10 were in SDG&E territory.

Number of Layers of Polyethylene Film

Infrared films are typically installed as the interior layer of a 2-layer inflated polyethylene (PE) roof system or as the only layer in a 1-layer PE roof system. Table 12 presents the *ex post* measure impacts, binned by the type of roof system where the measure was installed. Note the high impacts in greenhouses where 2-layers of PE were installed.

Table 12: Gross Measure Savings – Infrared Film Sites

Infrared Film Description	# sites	Ex Post Impact (Therms/sq.ft.)
One layer PE	4	0.02
Two layer PE	14	0.08

Heat Curtain Installations

When properly deployed, greenhouses with heat curtain systems have lower energy use than similar greenhouses without curtain systems. Table 13 bins the average *ex ante* and *ex post* measure gas impacts with respect to the whether or not heat curtains were installed at each site. Note the higher *ex post* impacts at sites where no curtain systems were installed.

[8] SDG10 is a greenhouse with no heat curtains and a double layer polyethylene roof film. The heating temperature setpoint is 65°F year-round. The lack of heat curtains leads to a greater potential for energy savings, which is reflected in the higher measure impact at this site.

Table 13: Gross Measure Savings – Heat Curtain Sites

Heat Curtain Description	# sites	Ex Post Impact (Therms/sq.ft.)
No Heat Curtain	7	0.08
With Heat Curtain	11	0.06

Temperature Setpoints

Greenhouses that maintain higher temperature setpoints have a greater potential for energy savings than greenhouses that maintain lower temperature setpoints. Figure 6 shows the annual therms/sq.ft. of gas use versus the average heating temperature setpoint during the heating season (October – April) for each of the 18 infrared film sites that were evaluated. The triangles at 0.17 therms/sq.ft. represent the deemed savings for 2006-2008 PG&E, SDG&E, and SCG projects, respectively.

Figure 6: *Ex ante* and *Ex post* Impacts - Annual Energy vs. Heating Setpoint

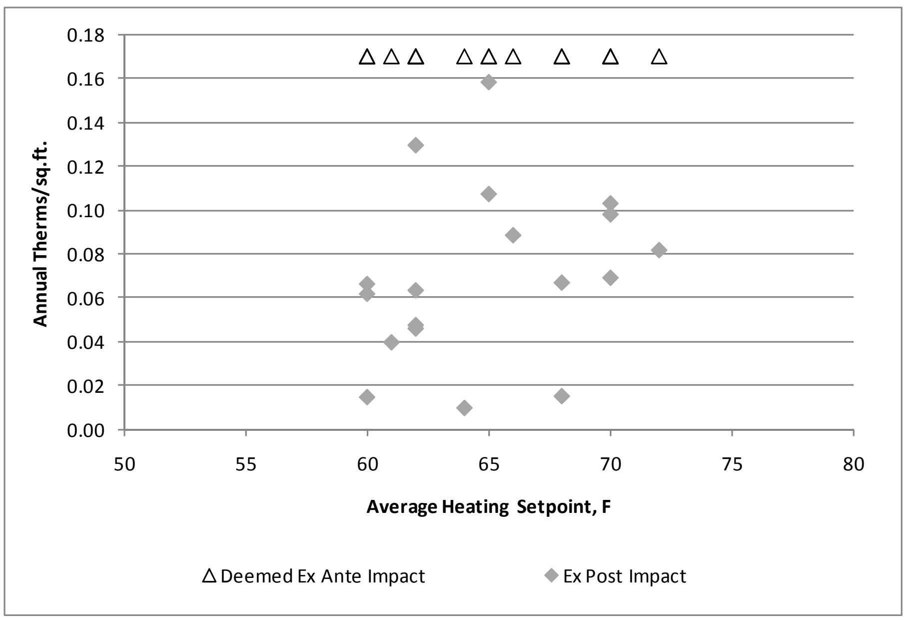


Figure 6 indicates a trend toward lower *ex post* measure impacts at lower heating setpoints. The high degree of scatter in the *ex post* data is due to differences in the envelope materials, heat curtain types, and seasonal temperature schedules at each site.

Heating System Type

Greenhouses with unit heaters tend to be more susceptible to increased heat loss due to temperature stratification, and therefore have a greater potential for energy savings with infrared films. Table 14 shows the annual therms/sq.ft. of gas use for the three predominant greenhouse heating systems identified in this evaluation. Note the higher impacts at sites where unit heater systems were installed.

Table 14: Gross Measure Savings – Infrared Film Sites

Heating System Description	# sites	Ex Post Impact therms/sq.ft.
Hot water boiler with underbench distribution	10	0.06
Steam heat with underbench distribution	2	0.04
Unit heaters	6	0.10

5.3. Differences between *Ex ante* vs. *Ex post* Impact Estimates

The gross realization rate for the 18 sites had a mean of 0.41, ranged from 0.06 to 0.93, and had a standard deviation of 0.23. The *ex ante* impacts were calculated using properties for generic greenhouses in California, while the *ex post* measure impacts were calculated with properties and operating characteristics specific to each project. This led to the range of gross realization rates. In addition, the use of the newer eQuest model and modified template input assumptions influenced the average gross realization rates, but not the variance in gross realization rates.

The reduction from the *ex ante* to the *ex post* measure impact is likely due to the *ex ante* greenhouse baseline energy use per square foot being higher than the *ex post* baseline energy use per square foot, as opposed to the percentage savings due to the IR film being lower. While evaluators do not have access to the models that were used to develop the *ex ante* savings values, we do have access to the report on which the greenhouse baseline definition was based[9] and the modeling tool[10] that was used to establish the *ex ante* savings estimates. Based on this information, several likely *ex ante* calculation assumptions were indentified that, when compared to the *ex post* assumptions, contributed to (1) decreasing the *ex post* baseline energy use.

Temperature Stratification

It appears that the degree of temperature stratification with unit heaters varied between the *ex ante* and *ex post* models. *Ex post* impact evaluation algorithms assumed ~0.32°F/ft of temperature stratification in greenhouses with unit heaters, while *ex ante* models appeared to assume ~0.7°F/ft. This led to higher baseline energy use estimates, and subsequently, to greater measure impacts in the *ex ante* calculations compared to the *ex post* calculations.

Heating System Type

It appeared that the *ex ante* calculations included unit heaters as the default heat source for all greenhouses. This type of system may be the most common statewide, but this study found it is not predominant (33% of sites sampled had unit heaters while 66% had underbench heat) in the population of program participants. In *ex post* models, all sites were modeled with the heating system that was found at

[9] Green Building Studio's 2005 report for PG&E titled "Greenhouse Baseline Study Final Report"

[10] Green Building Studio's eQuest greenhouse simulation tool.

that site, which varied between underbench heating systems and unit heaters. Greenhouses with unit heaters tend to use more energy. Because unit heaters were assumed to be the baseline for all *ex ante* impact models, and because temperature stratification was included with the unit heater model, the baseline energy use in the *ex ante* calculations was greater than in the *ex post* calculations, especially in greenhouses with underbench heating systems.

Heat Curtains

It appeared that the *ex ante* impact calculations did not include heat curtains. The *ex post* impact results showed that measure impacts were 20-30% lower at sites where heat curtains were installed. Because greenhouses without heat curtains were assumed to be the baseline for all *ex ante* impact models, the baseline energy use in the *ex ante* calculations was greater than in the *ex post* calculations, especially in greenhouses where heat curtains were installed.

Temperature Setpoints

Ex post measure savings were modeled with temperature setpoints and schedules specific to the sites where the measures were installed. *Ex ante* measure savings assumed a constant temperature setpoint and temperature schedule for all greenhouses. The more site-specific approach in the *ex post* impact analysis included shutting down heating systems at several sites during the summer and modeling temperature setpoints between 55°F and 70°F in the various greenhouses under evaluation. Although it was not clear what the temperature setpoints were in the *ex ante* impact calculation, in those greenhouses with low temperature setpoints (55-62°F) and no summer heating, the *ex post* measure impacts tended to be lower than the *ex ante* impacts.

Climate Zone

It appeared that the *ex ante* impact calculations only accounted for differences between weather conditions at PGE sites and SCG/SDG&E sites. No differences in weather conditions from site-to-site were accounted for. The *ex post* impact results appeared to show that climate zone played a large part in the estimated measure impacts, and contributed to increasing the site-to-site variance in the calculated measure impacts. Sites in coastal climates tended to have lower impacts than those in inland climates, and a large number of the sites included in this evaluation were located in coastal climates which resulted in a lower average *ex post* impact than *ex ante* impact for this measure.

6. PROGRAM RESULTS

The following tables present the *ex ante* and *ex post* heat curtain measure impacts by utility.

Table 15: Program Impact – Gas Usage

Summary of Results - Gas		# sites	**Ex Ante**		**Ex Post**		Realization Rate
			Therms	Therms/ sq.ft.	Therms	Therms/ sq.ft.	
Heat Curtain	PG&E	1	44,475	0.17	17,337	0.07	0.39
	SCG	10	415,479	0.17	169,060	0.06	0.41
	SDG&E	7	247,953	0.17	101,739	0.08	0.41
	Total	**18**	**707,908**	**-**	**288,137**	**-**	**-**

Table 16: Program Impact – Electric Usage

Summary of Results - Electric		# sites	**Ex Ante**		**Ex Post**		Realization Rate
			kWh/yr	kWh/ sq.ft.	kWh/yr	kWh/ sq.ft.	
Heat Curtain	PG&E	1	n/a	n/a	3,049	0.01	n/a
	SCG	10	n/a	n/a	9,262	0.01	n/a
	SDG&E	7	n/a	n/a	43,669	0.03	n/a
	Total	**18**	**n/a**	**n/a**	**55,980**	**-**	**-**

Overall, similar *ex post* measure impacts were calculated for sites in PG&E's, SDG&E's, and SCG's territories.

7. DISCUSS FINDINGS AND RECOMMENDATIONS

7.1. Conclusions & Recommendations

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.

We recommend that, when next updating the generic greenhouse template, make 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 under bench. 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/sq.ft. and eliminate the greenhouse floor from all models. In this work, 10 lbs/sq.ft. 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 the 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 (see Table 13) than infrared films installed at sites without heat curtains.
- Eliminate incentives to customers that install infrared films at sites with 1-layer inflated polyethylene roof systems, as these roof systems deliver only a fraction of the savings (see Table 12) of double polyethylene roof systems.
- With 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 (see Table 14) 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.

7.2. 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/sq.ft. 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/sq.ft. of greenhouse floor area basis helps to establish a upper bound for the energy savings that could be expected when installing infrared films at the site.

Utility ID	Pre-Implementation Monthly Gas Use (Therms/month)											
	January	February	March	April	May	June	July	August	September	October	November	December
SDG10	2,950	2,295	2,415	1,779	0	0	0	0	3	1,439	2,396	3,273
PGE14	16,725	10,810	9,179	7,241	5,405	0	0	0	0	5,303	10,198	16,521
SCG31	1,936	1,522	1,100	467	114	18	582	505	953	2,254	4,113	5,936
SCG40	3,683	2,920	3,053	2,098	0	0	0	0	0	825	3,039	4,088
SCG53	944	758	769	611	516	452	364	372	366	527	843	953
SCG57	7,055	5,236	5,666	3,995	2,519	1,440	1,011	799	1,109	2,635	5,211	7,999
SCG29	12,597	9,916	10,205	7,421	5,981	5,129	2,809	3,171	3,138	5,963	11,145	12,871
SCG35	6,462	4,901	5,296	3,570	2,331	0	0	0	1,079	2,455	4,845	7,506
SDG11	10,210	9,390	8,306	5,887	4,224	2,899	2,405	2,429	3,506	6,099	9,152	11,940
SDG6	9,490	7,629	7,526	5,834	4,624	3,141	2,253	2,099	2,207	4,632	7,187	9,666
SDG8a	8,986	8,677	7,784	5,823	4,570	3,345	2,969	2,964	3,868	5,716	7,977	10,336
SDG16	9,854	9,019	7,928	5,535	3,857	2,572	2,100	2,102	3,157	5,709	8,805	11,594
SDG8	15,323	13,936	11,826	8,364	5,462	3,791	3,605	3,685	5,221	9,138	13,860	17,749
SCG33	78,863	63,444	66,225	52,955	43,855	38,294	29,195	30,079	28,183	43,223	71,027	79,874
SDG5	16,147	12,698	11,035	7,985	4,501	1,750	547	395	605	4,871	10,192	16,446
SCG52	11,018	8,401	9,246	6,171	0	0	0	0	1,314	3,860	8,014	13,166
SCG64	35,716	28,124	27,290	20,709	16,656	13,715	10,776	12,234	11,808	19,226	29,953	36,239
SCG65	34,505	26,261	29,518	0	0	0	0	0	102	16,286	26,668	36,846

Utility ID	Pre-Implementation Monthly Electric Energy (kWh/month)											
	January	February	March	April	May	June	July	August	September	October	November	December
SDG10	849	660	699	519	0	0	0	0	0	424	691	927
PGE14	377	1,285	2,631	4,763	5,874	6,201	6,711	6,027	4,875	3,457	948	275
SCG31	1,436	1,212	1,701	1,844	1,987	2,720	4,248	3,576	2,883	2,160	1,742	1,701
SCG40	1,481	1,340	1,481	2,481	1,174	1,629	2,200	1,696	1,447	1,481	1,431	1,481
SCG53	201	178	196	215	228	251	276	243	208	184	185	203
SCG57	2,473	1,922	2,016	1,622	1,276	914	803	630	788	1,355	1,953	2,568
SCG29	3,152	2,603	2,847	2,298	2,318	2,054	1,749	1,871	1,708	2,359	2,827	3,132
SCG35	2,401	1,927	1,990	1,595	1,248	0	0	0	758	1,327	1,911	2,527
SDG11	2,867	2,795	3,422	3,205	3,084	3,157	3,952	3,398	2,892	2,651	2,699	2,940
SDG6	3,764	3,162	3,341	2,853	2,618	2,187	1,927	1,967	1,959	2,715	3,276	3,853
SDG8a	1,918	1,851	1,916	2,175	2,148	2,929	3,970	3,537	2,781	2,235	1,918	2,104
SDG16	2,784	2,738	3,349	3,114	2,991	3,065	3,890	3,325	2,794	2,549	2,612	2,914
SDG8	6,507	6,247	6,154	4,983	4,406	3,960	4,239	3,997	4,146	4,890	6,005	7,065
SCG33	11,122	9,289	9,908	8,253	8,215	7,229	7,204	7,381	7,077	8,379	9,959	11,223
SDG5	6,288	5,437	5,018	3,891	2,716	1,399	482	337	551	2,920	4,828	6,372
SCG52	4,586	4,050	4,486	4,164	0	0	0	0	3,886	4,163	4,279	4,717
SCG64	4,492	3,602	3,602	2,797	2,458	2,076	1,780	1,992	1,865	2,754	3,856	4,534
SCG65	15,838	12,286	13,690	0	0	0	0	0	31	7,878	12,581	16,703

Utility ID	Post-Implementation Monthly Gas Use (Therms/month)											
	January	February	March	April	May	June	July	August	September	October	November	December
SDG10	2,415	1,850	1,909	1,373	0	0	0	0	3	1,121	1,937	2,701
PGE14	13,666	8,567	7,241	5,507	4,079	0	0	0	0	3,875	7,853	13,258
SCG31	1,494	1,128	772	303	66	4	376	325	671	1,729	3,303	4,733
SCG40	3,076	2,419	2,533	1,736	0	0	0	0	0	654	2,526	3,417
SCG53	812	653	659	521	440	384	306	313	309	446	724	820
SCG57	6,827	5,082	5,526	3,908	2,492	1,415	984	767	1,059	2,534	5,003	7,725
SCG29	10,459	8,253	8,550	6,166	4,924	4,277	2,162	2,512	2,410	4,804	9,347	10,699
SCG35	5,115	3,846	4,083	2,605	1,678	0	0	0	477	1,791	3,769	5,860
SDG11	8,354	7,614	6,648	4,636	3,229	2,072	1,614	1,636	2,545	4,737	7,364	9,814
SDG6	8,111	6,510	6,477	5,043	3,988	2,717	1,888	1,754	1,846	3,874	6,120	8,260
SDG8a	7,461	7,326	6,549	4,860	3,788	2,707	2,319	2,328	3,096	4,675	6,530	8,576
SDG16	8,058	7,282	6,315	4,321	2,899	1,782	1,353	1,360	2,242	4,388	7,073	9,513
SDG8	12,653	11,729	9,887	6,897	4,386	2,917	2,651	2,685	4,042	7,349	11,287	14,756
SCG33	64,835	52,449	54,724	43,855	36,398	31,469	24,392	24,898	23,507	35,514	58,642	65,593
SDG5	12,195	9,506	8,130	5,786	3,054	998	274	201	310	3,293	7,511	12,465
SCG52	10,397	8,014	8,706	5,784	0	0	0	0	1,314	3,625	7,474	12,403
SCG64	33,817	26,599	25,593	19,293	15,535	12,724	9,573	11,157	10,968	17,798	28,211	34,298
SCG65	33,793	25,548	28,704	0	0	0	0	0	0	15,879	25,854	36,032

Utility ID	Post-Implementation Monthly Electric Energy (kWh/month)											
	January	February	March	April	May	June	July	August	September	October	November	December
SDG10	699	542	558	401	0	0	0	0	0	330	566	778
PGE14	357	1,142	2,386	4,426	5,507	5,813	6,272	5,650	4,538	3,182	836	265
SCG31	1,406	1,182	1,518	1,722	1,905	2,567	3,882	3,270	2,628	1,966	1,620	1,630
SCG40	1,481	1,332	1,481	2,299	968	1,390	1,878	1,447	1,439	1,481	1,431	1,472
SCG53	191	168	181	191	198	214	233	205	179	162	175	194
SCG57	2,489	1,953	2,048	1,654	1,292	929	803	646	772	1,370	1,969	2,615
SCG29	3,132	2,583	2,806	2,257	2,257	1,993	1,688	1,830	1,647	2,318	2,827	3,112
SCG35	2,211	1,801	1,848	1,437	1,058	0	0	0	458	1,137	1,785	2,369
SDG11	2,458	2,313	2,530	2,217	2,024	2,024	2,578	2,193	1,879	1,879	2,217	2,747
SDG6	3,805	3,170	3,341	2,853	2,658	2,195	1,910	1,927	1,959	2,683	3,260	3,926
SDG8a	1,700	1,618	1,553	1,646	1,592	2,170	2,995	2,665	2,147	1,798	1,635	1,858
SDG16	2,380	2,233	2,440	2,120	1,924	1,924	2,503	2,110	1,776	1,762	2,134	2,689
SDG8	5,187	5,187	5,113	4,146	3,625	3,309	3,588	3,309	3,384	3,941	4,797	5,708
SCG33	11,122	9,188	9,833	8,265	8,139	7,077	7,052	7,229	6,913	8,253	9,908	11,160
SDG5	5,658	4,876	4,474	3,472	2,282	974	293	192	374	2,311	4,256	5,779
SCG52	4,548	4,028	4,455	4,149	0	0	0	0	3,879	4,148	4,249	4,671
SCG64	4,322	3,475	3,475	2,670	2,331	1,992	1,653	1,865	1,802	2,627	3,729	4,365
SCG65	15,706	12,062	13,487	0	0	0	0	0	20	7,654	12,265	16,601

Utility ID	Monthly Gas Impacts (Therms/month)											
	January	February	March	April	May	June	July	August	September	October	November	December
SDG10	536	445	505	405	0	0	0	0	0	318	459	571
PGE14	3,060	2,244	1,938	1,734	1,326	0	0	0	0	1,428	2,346	3,263
SCG31	442	394	328	164	48	14	206	180	281	525	810	1,203
SCG40	607	501	520	362	0	0	0	0	0	170	513	672
SCG53	132	106	110	91	76	69	58	59	57	80	119	134
SCG57	228	154	140	87	27	25	27	32	50	101	208	274
SCG29	2,137	1,664	1,655	1,255	1,058	852	647	659	728	1,159	1,798	2,172
SCG35	1,347	1,055	1,213	965	654	0	0	0	602	663	1,076	1,646
SDG11	1,855	1,776	1,658	1,251	995	826	790	793	961	1,361	1,788	2,125
SDG6	1,379	1,119	1,049	791	636	424	365	345	361	758	1,067	1,406
SDG8a	1,526	1,351	1,234	963	782	638	650	637	772	1,041	1,447	1,760
SDG16	1,797	1,737	1,613	1,214	959	789	747	742	916	1,321	1,732	2,080
SDG8	2,670	2,207	1,939	1,467	1,076	874	954	1,000	1,179	1,789	2,573	2,993
SCG33	14,029	10,995	11,501	9,100	7,457	6,825	4,803	5,182	4,676	7,709	12,386	14,281
SDG5	3,953	3,193	2,904	2,199	1,448	752	273	194	295	1,577	2,681	3,982
SCG52	621	387	540	387	0	0	0	0	0	234	540	763
SCG64	1,898	1,526	1,697	1,415	1,121	991	1,203	1,077	840	1,428	1,742	1,941
SCG65	712	712	814	0	0	0	0	0	102	407	814	814

Utility ID	Monthly Electric Impact (kWh/month)											
	January	February	March	April	May	June	July	August	September	October	November	December
SDG10	149	118	141	118	0	0	0	0	0	94	126	149
PGE14	20	143	245	337	367	388	439	377	337	275	112	10
SCG31	31	31	183	122	82	153	367	306	255	194	122	71
SCG40	0	8	0	182	207	240	323	248	8	0	0	8
SCG53	9	10	15	24	30	37	43	38	30	22	10	9
SCG57	-16	-32	-32	-32	-16	-16	0	-16	16	-16	-16	-47
SCG29	20	20	41	41	61	61	61	41	61	41	0	20
SCG35	190	126	142	158	190	0	0	0	300	190	126	158
SDG11	410	482	892	988	1,060	1,133	1,373	1,205	1,012	771	482	193
SDG6	-41	-8	0	0	-41	-8	16	41	0	33	16	-73
SDG8a	218	233	363	529	556	759	976	873	634	437	283	246
SDG16	404	506	909	994	1,067	1,141	1,387	1,215	1,018	787	477	225
SDG8	1,320	1,060	1,041	837	781	651	651	688	762	948	1,208	1,357
SCG33	0	101	76	-13	76	152	152	152	164	126	51	63
SDG5	630	561	544	419	434	426	189	145	176	609	572	593
SCG52	38	22	31	15	0	0	0	0	7	15	31	46
SCG64	170	127	127	127	127	85	127	127	63	127	127	170
SCG65	132	224	204	0	0	0	0	0	10	224	316	102

CPUC 0608 Greenhouse Energy Curtain and IR Film Measure Evaluation On-Site Survey Form (Rev: 7/27/2009)

NOTE: Fields that will be populated with data from the CATI phone survey or the IOU tracking databases are shaded.

General Site Information (from phone survey & IOU tracking database)

SiteID	
Sample Strata	

Corporate (Multi-Site) Name			
Business Name (Tracking Data)			
Business Name (Actual/Storefront)			
Service Address			
City		Zip Code	
CEC Standards Climate Zone (from City/Zip, used for DEER measures)			
CORRECTIONS TO SITE INFORMATION			
Revised Corporate (Multi-Site) Name			
Revised Business Name			
Revised Service Address			
Revised City		Rev. Zip	

Evaluation Analysis Identifiers

Survey Tracking Information

Survey Company (Itron, KEMA, RTB):	
Assigned Surveyor's Initials:	
Survey Travel Mileage:	_____________ miles
Survey Duration (24 hr clock)	Start: _________ End: __________
Total Time (Onsite+QC+Travel)	_____________ hrs

	Date:	Initials
Scheduled date of onsite survey:	__ __ / __ __ / __ __	__ __ __
Field survey completed:	__ __ / __ __ / __ __	__ __ __
Survey received from surveyor:	__ __ / __ __ / __ __	__ __ __
Initial QC check completed:	__ __ / __ __ / __ __	__ __ __
Survey received at Itron:	__ __ / __ __ / __ __	__ __ __
Itron QC completed:	__ __ / __ __ / __ __	__ __ __
Returned to Survey Company:	__ __ / __ __ / __ __	__ __ __
Data entry completed:	__ __ / __ __ / __ __	__ __ __

IOU Tracking Data Measure Summary Sheet

This is a summary of all of the measures implemented at this site as extracted from the IOU tracking database. All of the measures listed here should also be found on the measure-level verification forms.

Measure Category	IOU Measure Name	Measure Description Unit Basis	Unit Basis	kWh Savings	Therms Savings

Basic site information

What type of measure? Heat curtain? IR film?

What greenhouses were measures installed in?

When was measure installed?

What type of heating system?

Site Contact Information

Phone Survey (PS) Completion Date:

Phone Survey Respondent:

	Contact Name	Phone Number	Alternate Phone	Email Address	Survey Contact
OS Primary					☐
OS Back-up					☐
OS Other					☐

Note: Use the "Survey Contact" check box to indicate the actual contact(s) for the site visit.

Scheduling Notes/Special Instructions for On-site Visit: ____________________

Site & Business Characteristics

Fields in this table will be populated as much as possible with data from the phone survey. However, any fields that are blank should be completed during the on-site verification. Any fields that are incorrect should also be corrected.

Electric Utility	PGE SCE SDGE SMUD LADWP OT ________
Gas Utility	PGE SCG SDGE AllElec/None Propane LBGO SWG OT ________
Phone Survey Building Type	
How manygas & electric utility meters serve this site?	
What year was this business established at this location?	
What year (or decade) was the majority of the facility built?	
Total Heated/Cooled Floor Area (or range)	
Total Floor Area of Greenhouses at site, sq ft (on-site measurement/estimate)	
Cooling Type: 1=No A/C 2=Split-System 3=PkgRooftop 4=PTAC/PTHP 5=EvapCool 6=Chiller 7=IndivAC/HP 8=WLHP OT=Other	
Heating Fuel Type: 1=Electric 2=Gas 3=Both 4=Propane 5=None OT=Other	
Heat Unit Type: 1 = Central Steam Boiler , 2 = Central HW Boiler, 3 = Single Greenhouse Steam Boiler, 4 = Single Greenhouse HW Boiler, 3 = Unit Heaters, 4 = Other	
Heating Distribution Type: 1 = Underbench, 2 = Unit Heaters, 3 = Perimeter Radiation, 4 = Other	
Number of heating loops or unit heaters in greenhouse:	

Primary Product/Service (do not leave blank)**:** Give a brief description about the type of work and/or primary product/service. What is the primary activity(ies) that occur here and what makes this premise unique from other businesses of this type?
____
____
____
____
____
____

Are hydroponics used?

Are movable benches installed?

Plant	Temperature Setpoint (F)	Humidity Setpoint	Supplemental Lighting Demands	Special Processes	Other Information

Description of Geometries:

Also indicate dimensions on site sketch below.

Config ID	**HC Config Type**	**Floor Type Code**	**# of Similar GHs**	**# of bays**	**Roof Height** (top of roof ridge)	**Gable Height**	**Width** (per bay)	**Length**	**Area**	**Description**
	G T									
	G T									
	G T									
	G T									
	G T									
	G T									

Comments:____
____
____
____

Site-Plan Sketch

This sketch sheet must be used for the lighting logger installation plan and can also be used to indicate where the rebated measures are located. Activity Areas used for subsampling and counting should also be noted on this sketch, using the appropriate Activity Area code from Form ACTAREAS. Also indicate the orientation of the building and the primary entry/exit. Include overall site plan including the location of greenhouses not included in this evaluation. Indicate location of heat curtain in greenhouse. Provide approximate dimensions for evaluation greenhouse and greenhouse orientation (North to South, East to West, etc.).

Site-Plan sketch comments (no data entry):

Site-Plan Sketch (additional)

Use this sheet if an additional sketch is required.

Site-Plan sketch comments (no data entry):

Temperature Setpoint Schedules & HVAC System Availability

Interview questions

Heating

During which months is your heating system available?

What temperatures do you maintain?

Do the setpoints vary by time of day or month of the year?

Do you use the same schedule for all the greenhouses that received curtains/film last year?

If a boiler system, what kind of heat distribution system do you have?

If a boiler system, what kind of material is your pipe made out of?

Where in the greenhouse is your thermostat located?

Cooling

Does your greenhouse have mechanical cooling?

During which months do you cool the greenhouse?

What temperatures do you maintain?

Do the setpoints vary by time of day or month of the year?

Form to complete after interview

Define setpoints (°F) for all hours for all months of a complete year. Complete multiple schedules if different greenhouses that received incentives follow different schedules.

Heating Temperature Setpoints ☐ N/A

Hour	0-12	0-1	1-2	2-3	3-4	4-5	5-6	6-7	7-8	8-9	9-10	10-11	11-12
Hour	12-24	12-13	13-14	14-15	15-16	16-17	17-18	18-19	19-20	20-21	21-22	22-23	23-24
Applicable DayTypes		Indicate "OFF" (regardless of temperature) or Temperature Setpoint °F											
	0-12												
Months:	12-24												
	0-12												
Months:	12-24												
	0-12												
Months:	12-24												

Heat Curtain Control Schedules

Interview questions

Heat Curtain Data

If the rebate was for IR film: Does the greenhouse use heat curtains?

If the rebate was for IR film: If so, do you know the make and model of the curtains? Are they woven white fabric? Woven with metal?

Are the heat curtains used for shading and heat retention?

Is there a single curtain or two layers?

How are they controlled?

If two curtains, does the top curtain follow a different schedule than the bottom curtain?

What are the control setpoints?

Do the control instructions or setpoints vary by time of year?

Were there any curtains installed in the greenhouse before the rebated measure was installed? What was the baseline condition of the greenhouse?

Additional Envelope Information:

In what direction is the greenhouse orientated (the roof ridge runs…)?

How leaky is the building envelope? Are there large holes in the wall and roof? Or are these surfaces tightly sealed?

Form to complete after interview

Heat curtain control type (circle all that apply):

Circle control type: manual automated
Circle control variable: Inside temperature outside temperature transmitted radiation incident radiation other
Circle units: W/sq.ft W/sq.m. lux fc °F other

If other or manual: Please explain:

____
____
__

If curtain control is by both light and temperature: How do they interact? Or, which control gets priority?

____
_

Is heat curtain use seasonal? If yes, then explain:

____
____
__

Are single or double heat curtains installed (circle one): single double

If double curtain: Does the upper curtain follow a different open/close rules than the lower curtain? If so please explain:

____
____

Heat curtain opening and closing setpoints (Temperature) ☐ **N/A**

Indicate temperatures (inside or outside) when heat curtains are closed. If high and low temperatures are used to open and close the heat curtains, indicate what these temperature are and the periods during which they apply. If curtains are always closed at night, then indicate opening and closing times. If a double curtain system is installed, then indicate control setpoints for each curtain.

	0-12	0-1	1-2	2-3	3-4	4-5	5-6	6-7	7-8	8-9	9-10	10-11	11-12
	12-24	12-13	13-14	14-15	15-16	16-17	17-18	18-19	19-20	20-21	21-22	22-23	23-24
Low Temp													
	0-12												
Months:	12-24												
	0-12												
Months:	12-24												
High Temp													
	0-12												
Months:	12-24												
	0-12												
Months:	12-24												

Heat curtain opening and closing setpoints (Light) ☐ **N/A**

If curtains are opened and closed based on light levels (inside or outside the greenhouse), then indicate desired light levels at each hour. If curtains are opened and closed based on high (for shading) and low (for heat retention) light levels, then indicate both of these values. If values vary seasonally, indicate this in the schedules. If a double curtain system is installed, then indicate control setpoints for each curtain. If curtains are always closed at night, then indicate opening and closing times.

	0-12	0-1	1-2	2-3	3-4	4-5	5-6	6-7	7-8	8-9	9-10	10-11	11-12
	12-24	12-13	13-14	14-15	15-16	16-17	17-18	18-19	19-20	20-21	21-22	22-23	23-24
Low Solar													
M T W T F S S	0-12												
Months:	12-24												
M T W T F S S	0-12												
Months:	12-24												
High Solar													
M T W T F S S	0-12												
Months:	12-24												
M T W T F S S	0-12												
Months:	12-24												

Lighting Schedules

Interview questions

Is supplemental lighting installed?

If yes is lighting used to increase plant growth?

Lamp type & number of fixtures:

Installed lighting (W or W/sq.ft.):

When are lights turned on?

Is lighting use seasonal?

Plant Growth Schedules

Interview questions

What type of plants are grown in the greenhouse?

Is plant growth seasonal?

If yes, what are the seasonal plant schedules?

Form to complete after interview/site visit:

Plant Growth Schedules ☐ N/A

If seasonal plants are grown, then specify the monthly periods to which the seasonal schedule applies. Provide a brief description of the period (e.g. "spring break", "winter break", "summer break", "extended holiday hours"), and list the beginning/ending months (1-12) and approximate days for up to three time periods.

TIME PERIOD 1 (name:___________________)			**TIME PERIOD 2 (name:___________________)**		
Daytime setpoints____________________________			Daytime setpoints____________________________		
Hours during which daytime setpoints apply:			Hours during which daytime setpoints apply:		
Nighttime setpoints___________________________			Nighttime setpoints___________________________		
Hours during which nighttime setpoints apply:			Hours during which nighttime setpoints apply:		
Begin Month/Day			Begin Month/Day		
End Month/Day			End Month/Day		
TIME PERIOD 3 (name:___________________)			**TIME PERIOD 4 (name:___________________)**		
Daytime setpoints____________________________			Daytime setpoints____________________________		
Hours during which daytime setpoints apply:			Hours during which daytime setpoints apply:		
Nighttime setpoints___________________________			Nighttime setpoints___________________________		
Hours during which nighttime setpoints apply:			Hours during which nighttime setpoints apply:		
Begin Month/Day			Begin Month/Day		
End Month/Day			End Month/Day		

Comments:____
____
____
____
____
____
____
____
____
____
____
____
____

Greenhouse Measures

Envelope	
Heat Curtain or Infrared Film Measure	**HC IR**
Total Number of Treated Greenhouses	
Year the Treated Greenhouses were Constructed (YYYY)	
Roof Shape: Q=Quonset/hoop GO=Gothic Arch GA=Gable/Truss	**Q GO GA**
Roof Material Type and Insulation (G = glass, A = Acrylic, 1-PE = 1-layer Polyethylene, 2-PE = 2-layer polyethylene, PC = Polycarbonate, IR = PE w/IR film) Also indicate # layers:	
If IR film is installed on a double roof, is it on the interior or exterior of the roof?	
Describe Condition of Roof (i.e. dirty, clean, tinted, clear, etc.)	
Wall Material Type and Insulation:	
Describe Condition of Walls (i.e. dirty, clean, tinted, clear, etc.)	
Floor Material Type and Insulation (S-soil, G-gravel, C-concrete):	
Describe leakiness of greenhouse envelope (tight, average, loose, etc.)	
Are there any openings in the envelope? If so, provide dimensions and indicate location on sketchs:	
Does the greenhouse have a computer management system & contact information (name and phone #)?	
If yes, make and model of computer management sytem:	
Are other greenhouses on site similar?	
If not, describe conditions in other greenhouses (heating system type, plants grown, envelope type, heat curtains, etc.):	
Heating System	
Heating System Type Code:	
# of greenhouses served by heating system:	
Make/Manufacturer	
Model #	
Heating unit capacity and efficiency (per unit):	
Night-time Indoor Setpoint Temperature, ºF	
Daytime temperature setpoint,ºF	
Seasonal temperature setpoint,ºF	
Temperature Control Type	**TH TI ST CE MA OT**
Humidity Control and Setpoints:	
Thermostat location in greenhouse (indicate on plan drawing):	
Are all heaters controlled by the same thermostat?	
Heat system distribution type and location (underbench, unit heaters, perimeter radiation, other):	
Heating loop control (2-way valve, 3 way valve, etc.):	
Heater temperature setpoint:	
Boiler loop pipe nominal or outside diameter (indicate which):	
Boiler loop pipe material type and schedule:	
Pipe spacing:	

HEAT CURTAIN Verification Data & Counts		
Location of Heat Curtain System: I=Interior E=Exterior		**I E**
Heat Curtain Config.: G=Gutter-to-gutter (width), T=Truss-to-truss (length)		**G T**
Operation of Heat Curtain: MA=Manual/By-hand MT=Motor-driven		**MA MT**
Heat curtain control type (S = solar, T = temperature, M = manual, ST = Solar and temperature, O = Other):		**S T M ST O**
If automated control, then what are the setpoints for when the curtains are deployed?		
Are heat curtains used for shading as well as heat retention at night:		
Is heat curtain use seasonal? If so, please describe:		
Heat Curtain Mat'l: **P**=Poly. Film **K**=Knitted white poly. **C**=CompositeFabric **OT**=Other		**P K C OT**
HC Condition Code: **N**=New **G**=Good **F**=Fair **R**=Ragged/Cut **M**=Missing/None		**N G F R M**
Material Make/Manufacturer		
Description/Item#/Other Identifier		
Total sq ft of Heat Curtain Installed on Active Greenhouses		
-- *Was subsampling or estimation used?*		**Y N**
Observed versus Rebated sq ft of HC: E=Equal M=More L=Less OT (describe)		**E M L OT**
If Total # of units is MORE than Rebated # of units:		
# that were rebated by other programs/projects		
# that were obtained from other means (explain in comments)		
If Total # of units is LESS than Rebated # of units:		
# of rebated units, site contact explanation (describe in comments)		
# of rebated units, unaccounted for		
INFRARED (IR) FILM Verification Data & Counts		
IR Film Condition Code: **N**=New **G**=Good **F**=Fair **R**=Ragged/Cut **M**=Missing/None		**N G F R M**
IR film used on: **R**=Roof **W**=Wall **A**=All		**R W A**
What was installed in greenhouse before IR film?		
Material Make/Manufacturer		
Description/Item#/Other Identifier		
Total sq ft of IR Film Installed on Active Greenhouses		
-- Was subsampling or estimation used?		**Y N**
Observed versus Rebated sq ft of IRF: E=Equal M=More L=Less OT (describe)		**E M L OT**
If Total # of units is MORE than Rebated # of units:		
# that were rebated by other programs/projects		
# that were obtained from other means (explain in comments)		
If Total # of units is LESS than Rebated # of units:		
# of rebated units, site contact explanation (describe in comments)		
# of rebated units, unaccounted for		

Lighting	
Is artificial light used to enhance crop production?	
If so, what type of lighting is used (I – Incandescent, F – Florescent, MH – Metal Halide, HPS – High Pressure Sodium, LPS – Low Pressure Sodium, O – Other)	
How is lighting controlled?	
What are setpoints (fc, W/sq.ft., etc.)	
Indicate lighting schedules in “hourly schedules” section.	
Is other lighting installed in the greenhouse?	
If so, for what purpose, and what type of lighting is it (I – Incandescent, F – Florescent, MH – Metal Halide, HPS – High Pressure Sodium, LPS – Low Pressure Sodium, O – Other)	
How is lighting controlled?	
What are setpoints (fc, W/sq.ft., etc.)	
Cooling System	
System type (natural ventilation, chilled water, packaged DX, split, etc.):	
# of units per greenhouse:	
Cooling capacity per unit:	
Unit manufacturer and model number, and efficiency:	
Equipment location (roof, ground, etc.)	
Describe associated pumps and fans, i.e. size, operation schedule and type (constant volume, variable volume, etc), efficiency, manufacturer and model number:	
Fan and Pump Details	
Number of fans in greenhouse:	
Number of pumps serving greenhouse:	
Are pumps or fans on VFDs (one-speed, two-speed, variable speed)?	
How are pumps and fans operated? Controlled?	
Pump/fan sizes:	
Fan/Pump efficiencies (standard, high, premium):	
Fan/Pump flow (cfm or gpm):	
Pre-Retrofit Conditions and Measure Life:	
Predominant Operation Schedule #	
# of months of complete shut-down	
Pre-Retrofit Roof Material Type	
Pre-Retrofit Wall Material Type	
How often is roof material typically replaced (years)?	
How often is wall material typically replaced (years)?	
Is IR film standard practice? (explain if needed)	**Y N**
Are Heat Curtain Systems standard practice? (explain if needed)	**Y N**

Greenhouse Details Worksheet

Greenhouse Measure Codes

Heat Curtain Material Type Codes	Roof/Wall Material Type Codes	Temperature Control Type Codes
P = Polyethylene Film **K** = Knitted white polyester **C** = Composite fabrics **OT** = Other (describe in comments)	**1G** = Single Pane Glass **2G** = Double-pane glass **1PE** = 1-layer Polyethylene (PE) **PIN** = 2-layer Inflated PE (No IR Film) **PIR** = 2-layer Inflated PE (**With IR Film**) **1F** = 1-layer Fiberglass **1PC** = 1-layer Polycarbonate (clear) **2PC** = 2-layer Polycarbonate (8 mm) **OT** = Other (describe in comments)	**TH** = Thermostat **TI** = Timers **ST** = Step Controls **CE** = Computer environment controls **MA** = Manual on/off **OT** = Other (describe in comments)

Floor Type Codes	Heating System Type Codes	
U = Un-insulated, Bare Soil **B** = Brick **C** = Concrete **S** = Styrofoam **OT** = Other (describe in comments)	**UH** = Unit Space Heater **HW** = Hot Water System **ST** = Steam Heating System **UR** = Unit Radiant Heaters	**SR** = Solar Radiant Systems **PT** = Poly-Tube Systems **OT** = Other (describe in comments)

General Comments

Item #	Form Name	Comments

Site Photo Log

Record site photo information here including the PhotoID (i.e. digital file name) and a brief description of the photo where needed. Site Photos should include the site entrance and entire building, rebated measures, and close-up photos of nameplates, lamp codes, and other make/model identification. Refer to the training manual for more on what photos to take. Photo/file naming conventions is SiteID_Item# (e.g. PGE056789_1.jpg).

Item #	**Description/Comments/Measure Code *(no data entry)***
1	
2	
3	
4	
5	
6	
7	
8	
9	
10	
11	
12	
13	
14	
15	
16	
17	
18	
19	
20	
21	
22	
23	
24	
25	
26	
27	
28	
29	
30	