INDIRECT IMPACT EVALUATION OF THE STATEWIDE ENERGY EFFICIENCY EDUCATION AND TRAINING PROGRAM

VOLUME I OF IV: FINAL REPORT

Study ID: CPU0014.01

Prepared for:

CALIFORNIA PUBLIC UTILITIES COMMISSION

ENERGY DIVISION

Prepared by:

OPINION DYNAMICS CORPORATION

Wirtshafter Associates, Inc.

Jai J. Mitchell Analytics

Summit Blue Consulting

Structure of the Report

This report is divided into four volumes. The information in this volume (Volume I) provides an overview of the program evaluation, as well as findings from the indirect impact analysis. This volume's appendices also include case studies, performance metrics and evaluability assessments. Volume II presents a detailed program description and findings by Energy Center. Volume III contains the survey instruments utilized for the analysis. Volume IV contains early feedback memos submitted to the CPUC during the evaluation process.

PROGRAMS EVALUATED

The programs covered in this report are shown below.

Utility	Program ID	Program Name
PGE	PGE2010	PG&E Education and Training Program
SCE	SCE2513	SCE Education, Training and Outreach Program
SDGE	SDGE3009	California Center for Sustainable Energy/Energy Resource Center Partnership
SCG	SCG3503	SCG Education and Training Program

ABSTRACT

This report presents the results of the indirect impact evaluation of the 2006-2008 Statewide Energy Efficiency Education and Training Programs. Opinion Dynamics was charged with assessing the success of these programs by (1) identifying changes in knowledge of energy efficiency, and (2) quantifying net energy savings for key components of the programs.

This research documents moderate to high knowledge gains among all participant types (i.e., market actors, commercial end-users and residential end-users). We also present a description of the level and type of behavioral changes in each group. As a result of these behavior changes, we estimate that the Energy Centers combined yearly gross impact was approximately 700 GWh with a net impact of 544 GWh. The Centers are responsible for annual gas savings of approximately 6 million net therms. Respectively, these electric and gas savings equate to approximately 267,000 and 30,000 metric tons of avoided carbon dioxide (CO_2) emissions. The net savings of the Energy Centers are similar in magnitude to the savings achieved by other individual IOU programs that reach similar sectors and is estimated to provide an additional 5% to the overall projected energy impact of the portfolio (that is, 5% of 10,500 net annual ex ante GWh). Notably these savings looked only at end-users and do not include any additional savings that may occur based on the training of market actors (e.g., contractors, architects, engineers) who made up more than half of all course participants.

Table of Contents

TABLE OF TABLES

TABLE OF FIGURES

1. EXECUTIVE SUMMARY

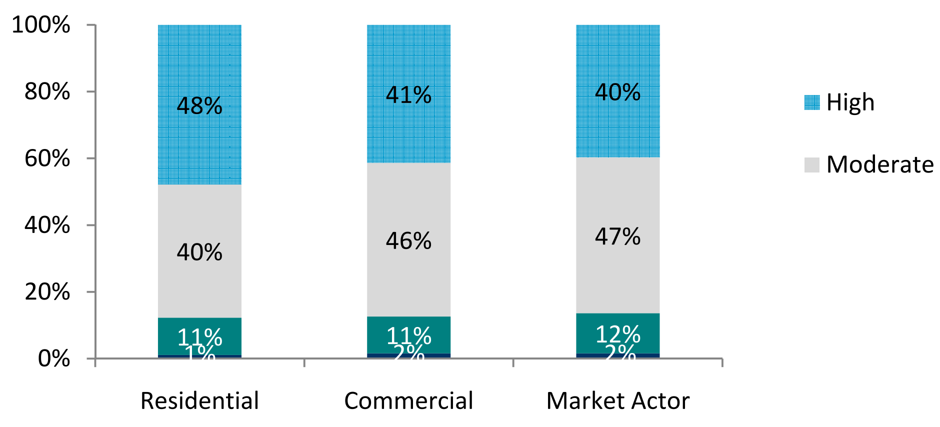
The Statewide Energy Efficiency Education and Training Program is offered in the service territories of Pacific Gas & Electric (PG&E), Southern California Edison (SCE), San Diego Gas and Electric (SDG&E), and Southern California Gas Company (SCG). The program objective is to provide utility customers with information about energy-efficient technologies and practices that will help them reduce energy usage, lower their utility bills, reduce operation and maintenance costs, and improve their productivity at both home and work. The programs also provide services to a variety of market actors (i.e., architects, designers, engineers, distributors, and contractors) who use information and tools to design more efficient buildings or processes and to conduct energy efficiency retrofits and renovations.

The overarching purpose of this evaluation was to assess the indirect energy efficiency impacts of these programs. This evaluation sought to understand the reach of the program, identify changes in knowledge of energy efficiency, understand the behaviors that resulted as an outcome of the program, and quantify net energy savings for key components of the programs. The key findings from this study include:

- Reach of the Centers: Over the three year program period (January 1, 2006 – December 31, 2008), the nine Centers offered 840 unique courses that were taken by 39,793 unique attendees. Combined, the Centers offered 547,560 hours of training. Just over half of the unique course takers across all nine Centers were market actors (55%), followed by commercial end-users (30%) and residential end-users (15%). In total, we estimate that the Centers touched nearly 20,000 market actors, 12,000 commercial end-users, and nearly 6,000 residential end-users. (See Section 6)

- Knowledge Change: Over 95% of training participants self-reported gains in knowledge that moved them closer to implementing efforts to save energy. As Figure 1 shows, most participants (over 87%) cited a moderate or large increase in knowledge across all market segments (residential, commercial and market actor).

Figure 1: Knowledge Increase by Participant Type



Notably, the courses were effective at increasing knowledge among all course participants regardless of the amount of prior knowledge they had of the course concepts. (See Section 7)

- **Behavior Change:** Almost four out of five (77%) commercial respondents took actions to save energy at their facilities; while more than two out of five (43%) residential end-users took actions to save energy in their homes as a result of the course(s). For the residential end-users who took action, the majority of changes were related to solar energy, followed by building envelope, HVAC, lighting and changes in practices such as turning off lights. Commercial end-users show similar results in terms of subject focus with changes primarily in HVAC, lighting, and building envelope. (See Section 8.1.1)

  In addition, 70% of market actors indicate that they changed or enhanced the services they provide to clients using concepts learned in the courses. The top three areas where market actors took action varied by group but tended to include building envelope, HVAC, and lighting, which is consistent with the areas in which the majority of courses were offered. Market actors also noted that the training they received through the courses helped them to make informed recommendations to clients and more effectively advocate for the installation of particular energy efficient technologies or approaches. (See Section 8.1.2)

- **Energy Savings among End-Users:** We estimate that the nine Energy Centers combined yearly gross impact was approximately 700 GWh with a net impact of 544 GWh. We estimate the Centers are responsible for annual gas savings of approximately 6 million net therms. Respectively, these electric and gas savings equate to approximately 267,000[1] and 30,000[2] metric tons of avoided carbon dioxide (CO_2) emissions. Overall, the portfolio of programs was estimated to save approximately 10,500 net annual ex ante GWh. The net savings from the Centers provides an additional 5% to the overall ex ante projected energy impact from the IOU portfolio. Notably, these net impacts are for end users who made changes as a result of the trainings through the Center. The values do not account for what are perhaps significant additional savings from market actors (described in the next bullet). (See Section 9)

- **Energy Saving Among Market-Actors:** We also found evidence of savings from Market Actors. The energy savings associated with a specific change in practice varies widely. Two of five market actors (43%) state that the changes they made because of the Energy Center course resulted in measurable energy savings for their clients, with 15% classifying the savings as "significant." In addition, we conducted in-depth analysis of the actions taken by 29 market actors as a result of the courses. We estimate that yearly gross impact of these 29 market actors is approximately 10 GWh. The average savings per market actor is 0.36 GWh, although there is significant variation as demonstrated by the median value of 0.011 GWh. While this number cannot be extrapolated to all market

---

[1] This value is calculated using EPA annual non-baseload output emission rates for the WECC California subregion of 1,083.02 lb/MWh and 2,204.6 lbs CO2/metric ton. (http://www.epa.gov/cleanenergy/documents/egridzips/eGRID2007V1_1_year05_GHGOutputRates.pdf)

[2] This value is calculated from the EPA estimate of 0.005 metric tons CO2/therm. (http://www.epa.gov/RDEE/energy-resources/refs.html)

actors, it gives some insights into the possible energy savings associated with those market actors who revised their practices as a result of their participation in an Energy Center course. (See Section 10)

The findings from this evaluation support the use of the Energy Centers as an integral part of energy efficiency knowledge transfer for the State, and demonstrate the value of the Centers for delivering energy and carbon savings. In addition, the research shows that these programs play other important functions that cannot be captured in terms of kWh or therms, including:

1. Channeling Participants into IOU Programs
2. Filling a Gap in Existing Training Offerings
3. Providing Continuing Education For Those Already In The Workforce
4. Facilitating Professional Development in New Areas
5. Providing Cutting-Edge Information Directly to Building Operators
6. Reducing Barriers to Energy Efficiency Through Customized Training
7. Catalyzing the Market Transformation of Energy Efficiency Products
8. Training-the-Trainers
9. Creating an Environment for Networking and Community Collaboration

Overall, the evaluation efforts were able to document the value of the Statewide Education and Training Program—both in terms of energy savings and additional roles in the marketplace. As such, we believe it is clear that these programs play a valuable role and that they should be continued. The results of this evaluation can also help inform and improve future program efforts. Specifically, we recommend the following for program design:

- Clearly identify program goals and performance metrics and ensure that these are acknowledged by both the utilities and the CPUC either prior to the program cycle, or as early as possible.
- Review the results and use this information to help inform future program design, such as the roles that the programs seek to fill in the marketplace, the emphasis on some technologies over others (e.g., HVAC), and the level of effort placed on channeling into rebate programs.

The 2006-2008 evaluation also provided insights on the current tracking mechanisms, and how these could be enhanced in order to allow the Centers to better identify who they are touching. Specifically, we recommend the following program tracking recommendations:

- Create a common registration form that is used across all nine Centers including participant type, profession, years in profession, and existing knowledge.
- Use consistent data entry for course and participant tracking.

- Create a shared registration system across the nine Centers, and if possible, assign each participant a unique identification number to help track individuals touched by the Centers.

Finally, we make the following recommendations to assist with future evaluation efforts:

- Ensure that future evaluation methods and techniques seek to measure more than just energy savings.
- Measure participant knowledge gain on an ongoing basis.
- Include questions on decision making and other demographic and firmographic information that can help better understand barriers to action.
- Plan to implement different research designs for end-users and market actors. Note that this would require Centers to collect information on participant types at registration as recommend above.
- Focus on the potential energy savings from market actors for future evaluation efforts, since effects are broader and less understood.

These recommendations are described in more detail in Section 12.

2. Purpose of Study

The overarching purpose of this evaluation is to assess the indirect energy efficiency impacts of the Statewide Energy Efficiency Education and Training Program (PGE2010, SCE2513, SDGE3009, and SCG3503). The evaluation period occurred from January 2006 through December 2008. Opinion Dynamics led the evaluation team with the support of Summit Blue Consulting, Wirtshafter Associates, the CADMUS Group, Jai J. Mitchell, and Lutzenhiser Associates.

The estimated cost of the indirect impact research was approximately $3.2 million across the three-year program cycle. Decision 05-04-051 (April 21, 2005) directs the following for Education and Training Programs:

> *"For schools, universities and other training programs, the performance basis should be based on: a) attitude, awareness and knowledge of students; b) reasonable impacts on energy savings or intention to act based on students' actions."*

Thus, this evaluation had two main charges: identify changes in attitudes, awareness, and knowledge of energy efficiency, and quantify net energy savings for key components of the programs.

The evaluation focused its efforts on program activities that have the highest likelihood to induce behavioral change and achieve associated energy savings. Wherever possible, we also provide a holistic assessment of the programs. However, this indirect impact evaluation serves many alternative purposes including improving these programs, providing data for future programs and informing strategic planning for energy efficiency programs in California.

Specifically, the evaluation answers the following researchable questions:[3]

1. **What is the reach of the Centers?**

   For each Energy Center, the Opinion Dynamics Team explored the overall exposure, or reach, of the program. This included the number and the roles of people (e.g., market actors, end-users, etc.) touched by the Center's efforts.

2. **What is the change in awareness of energy saving opportunities and knowledge of energy efficiency practices as a result of Center activities?**

   Our team examined changes in awareness and knowledge of energy saving opportunities among participants.

3. **What behavioral changes are encouraged by the Centers?**

---

[3] The Evaluation Team presented 12 research questions in the evaluation plan. As additional information about the Programs was gained, the Team found that slightly reframing the questions for a total of 11 questions better focused the evaluation. Each original question is still addressed in the evaluation.

Our team examined the types of behaviors encouraged by the Centers. This includes a description of the behaviors encouraged by Center courses and activities based on a content review of course materials.

4. What percentage of the people targeted and exposed to each Center changed behaviors as a result of the program?

   For most Center activities, the Team determined the percentage of program participants who changed their energy-related behaviors as a result of participating in a course or activity.

5. Among what groups and in what end-use areas are the changes occurring?

   The Evaluation Team reports on the types of participants who are most likely to change their behaviors as well as the end-use areas where change is most likely to occur.

6. What percentage of participants were channeled into resource programs, and which programs were promoted?

   The Team also examined the extent to which each Center channeled customers into resource programs. The percentage of all participants who went on to participate in another utility sponsored program is reported.

7. What indirect behaviors were taken by those people who received education or training from the Centers?

   The Evaluation Team examined the indirect behaviors attributable to the Energy Centers' activities. Examples include accessing other sources of energy efficiency information or spreading energy efficiency knowledge among one's social network.

8. What direct energy saving behaviors were taken by those who received education or training from the Centers?

   At a gross level, the evaluation indentifies the direct energy saving behaviors that were taken by those who received education or training from each Center. These behaviors will vary by program and targeted audience but may include actions such as turning off lights or installing energy efficient equipment.

9. What are the net energy-saving behaviors taken by those who receive education or training from the Centers?

   Based on self-reported data, the evaluation identifies the energy saving behaviors taken by Center participants that can be attributed to the Center. The Evaluation Team determined what behaviors were possible to be taken as detailed under Evaluation Question 3.

10. What are the net energy savings demonstrated by courses or activities at each Center?

    Based on self-reported data, the Evaluation Team reports the energy savings that are attributable to each Center. Our team determined the net energy savings attributable to each Center by estimating the savings for each behavior detailed under Evaluation Question 9.

11. What course and activity characteristics are most likely to be associated with net energy saving behavioral changes?

    The Evaluation Team collected information on the characteristics of the Center courses including subject and teaching methods. Using this information, we conducted an analysis to determine the course characteristics that are most likely to be associated with energy saving behavior changes.

3. Introduction to Education and Training Programs

The Statewide Energy Efficiency Education and Training Program is offered in the service territories of Pacific Gas & Electric (PG&E), Southern California Edison (SCE), San Diego Gas and Electric (SDG&E), and Southern California Gas Company (SCG). The program objective is to provide utility customers with information about energy-efficient technologies and practices that will help them reduce energy usage, lower their utility bills, reduce operation and maintenance costs, and improve their productivity. The programs also provide services to a variety of market actors (i.e., architects, designers, engineers, distributors, and contractors) who use information and tools to design more efficient buildings or processes and to conduct energy efficiency retrofits and renovations. An overview of the program is presented below, including a brief overview of each of the nine Energy Centers evaluated (i.e., their programmatic offerings, their target markets and participants, and end-uses.) In addition, this section provides an overview of the key objectives, goals and outcomes by Center. This section is intended to give the reader an overarching picture of the program in advance of the research method (Section 4) and findings (Sections 6-11).

3.1 Overview

Within the four Education and Training Programs (PGE2010, SCE2513, SDGE3009, and SCG3503) are nine unique Energy Centers.[4] The Centers, listed in Table 1, are the primary vehicle for the dissemination of information and the promotion of energy efficiency. Each Center has its own mission, target audience, course offerings, and goals. As such, the evaluation effort for the four programs was conducted for each of the nine Energy Centers. The total budget for the 2006-2008 program years was $72.2 million. This analysis evaluated programs that totaled $48.6 million of the total program portfolio budget.

[4] We identified eight Energy Centers in the evaluation plan. Interviews with Center directors revealed that there are actually nine distinct centers, with two, SDG&E and CCSE, occupying a single physical space. While the CCSE and SDG&E offer their courses in the same physical space, they have differing missions and key objective strategies. These two Centers schedule, market, plan and execute different activities and often operate independently of one another, including having separate administrative support staff, tracking databases, and budgets. As such, we evaluated them separately for a total of nine Centers.

Table 1: Energy Centers Location and Utility Program Information

Utility/Program	Energy Centers	Location of Physical Center	Allocated Budget
Pacific Gas and Electric (PGE2010)	Pacific Energy Center (PEC)	San Francisco	$11.2 million
	Energy Training Center (ETC)	Stockton	$3.3 million
	Food Service Technology Center (FSTC)	San Ramon	$6.1 million
Southern California Edison (SCE2513)	Agricultural Technology Application Center (AgTAC)	Tulare	$4.2 million
	Customer Technology Application Center (CTAC)	Irwindale	$8.8 million
	Technology and Test Centers (TTC)	Irwindale	$2.1 million
Southern California Gas (SCG3503)	Energy Resource Center (SCG ERC)	Downey	$6.5 million
San Diego Gas and Electric (SDGE3009)	Energy Resource Center (SDG&E)	San Diego	$1.3 million
	California Center for Sustainable Energy (CCSE)		$2.8 million
Total Portion Evaluated			**$48.6 million**[5]
Total Program Budget			**$72.2 million**[6]

Each evaluated Energy Center shares a common objective of delivering energy efficiency information and training. However, each Center has unique program offerings that are targeted to distinct markets and participants, promoting diverse behavioral changes according to end-uses. Below we outline each Center's information delivery methods, course content, and behaviors and actions promoted. This section informs the type and amount of energy savings that can be measured and attributed to each Center.

Each Center used a variety of courses and activities to promote energy efficiency. These include educational courses, workshops, seminars, as well as customer-specific trainings and consultations, lending libraries, outreach activities, information dissemination and technology testing (see Table 2).

[5] This analysis also reviewed the cross cutting Builder Operator Certification program with an in-depth case study. The total budget for the BOC program was $2.3 million.

[6] For a detailed assessment of the evaluability of the Education, Training and Outreach programs see Evaluability Appendix

Table 2: Overview of Energy Center Efforts

Energy Center	Methods of Information Dissemination					
	Classes, Seminars and Workshops	Customer-specific Trainings, Demonstrations and Consultations	Lending Libraries	Outreach Activities (facility tours, trade shows, industry events)	Information Dissemination (Displays, Exhibits, Brochures, website)	EE Technology Testing
Agricultural Technology Application Center (AgTAC)	√	√	√	√	√	
Customer Technology Application Center (CTAC)	√	√		√	√	
Technology and Test Centers (TTC)	√	√		√	√	√
Pacific Energy Center (PEC)	√	√	√	√	√	
Stockton Energy Training Center (ETC)	√	√	√	√	√	
Food Service Technology Center (FSTC)	√	√			√	√
SCG Energy Resource Center (ERC)	√	√		√	√	
SDG&E Energy Resource Center (ERC)	√	√		√	√	
CA Center for Sustainable Energy (CCSE)	√	√	√	√	√	

All of the Centers offer classes, seminars, and workshops and emphasize these as their primary program efforts. As such, courses are the primary focus of this evaluation because they are a common effort among all Energy Centers and because they serve the largest number of participants.

The Centers also engage in a number of additional activities. For example, while FSTC and TTC both offer classes, their efforts are primarily conducted in research laboratories and/or technology testing facilities. The primary aim of these efforts is to replicate end-use customer environments and demonstrate the performance and energy efficiency of technologies specific to the markets they target. Additionally, the FSTC is instrumental in creating and maintaining testing methods for commercial foodservice equipment. These methods (which undergo the ASTM International process) are instrumental in helping to determine the energy efficiency of specific products and allow for an ENERGY STAR ® standard to be created. These and other non-course specific Center activities that were determined as likely to change behavior were subject to smaller in-depth analyses and we present the results in individual case studies of each program effort in Appendix D: Case Studies.

3.1.1 Targeted Markets and Participants

In addition to utilizing a variety of methods to promote education and training around energy efficiency, each Center differs in their target audiences. Table 3 outlines the target markets and participants reached through the nine Centers' program efforts.

Table 3: Overview of Target Markets and Participants

Center	Target Markets			Target Participants	
	Commercial	Industrial	Residential	Market Actors	End Users
Pacific Energy Center (PEC)	√			√	
Energy Training Center (ETC)	√		√	√	
Food Service Technology Center (FSTC)	√			√	
Customer Technology Application Center (CTAC)	√	√	√	√	√
Agricultural Technology Application Center (AgTAC)		√		√	√
Technology and Test Centers (TTC)	√	√		√	√
SCG Energy Resource Center (ERC)	√	√	√	√	√
San Diego Energy Resource Center (ERC)	√	√		√	√
California Center for Sustainable Energy (CCSE)	√	√	√	√	√

With the exception of CCSE and ETC, all of the Centers focus primarily on the commercial market segment, often through training market actors. The CCSE disseminates information on a wide range of energy efficient topics to both residential and commercial customers through courses and other efforts targeting both market actors and end-use customers. The ETC's efforts focus almost exclusively on residential market actors, such as residential builders, contractors and design professionals, with some courses targeting small commercial contractors.

AgTAC and FSTC further distinguish themselves from the other Centers by the technologies that they address as well as their target audiences. AgTAC's efforts include seminars, workshops, displays, demonstrations, technical consultations, and on-site seminars and presentations to provide market actors and end-use customers with in-depth and objective energy efficiency information targeting agricultural end-uses. FSTC's efforts target the food service industry exclusively.

Below, we examine each Center individually, outlining the course content offered and the additional activities promoted, based on our research of course instruction and materials. Additionally, the evaluation team created Program Theory Logic Models for each Center that are presented along with a brief discussion in Volume IV of this report.

3.2 PGE2010: PG&E Education and Training Program

The PG&E Education and Training program includes three Energy Centers, the Pacific Energy Center in San Francisco, the Energy Training Center in Stockton and the Food Service Training Center in San Ramon. While all three centers provide courses aimed at increasing energy efficiency, each of the three PG&E centers also has a unique focus.

3.2.1 Pacific Energy Center

The PEC utilizes courses, consultations, tool lending and information to target the commercial building operation and new construction design markets including building owners and operators, architects, engineers, and contractors. PEC's stated objective is to break down market barriers that keep customers from taking advantage of energy efficient opportunities in their buildings. PG&E sees educational classes as one of the most important first steps in introducing customers and market actors to the benefits of energy efficiency. PEC employs seminars and workshops (both in-classroom and online), energy efficiency showcases, customer consultations, and resources (Tool Lending Library, Energy Library, etc.) to achieve the desired market effect.

Pacific Energy Center Facts: 2006-2008

- Geographic Area: San Francisco, CA – serves all of PG&E's territory
- Budget: $11.2 million
- Target Markets: Commercial Building Operation & New Construction
- Target Participants: Commercial Building Owners & Operators; Architects, Engineers & Contractors involved in new construction
- Program Activities: Seminars, Workshops, Displays, Exhibits, Showcases, Consultations, Tool Lending Library, Fact Sheets & Brochures, Off-site Seminars & Presentations

This Center also focused on increasing the overall reach (i.e., attendance) of their seminars and workshops during the 2006-2008 program period. From our in-depth interviews with Center staff we were informed that they were given direction from the CPUC, -to increase attendance to bring down the cost per student by 5 percent. As such, offering lecture style courses that appeal to large numbers of people is also a goal of this Center. The majority of the seminars and courses are primarily offered at the PEC facility in San Francisco and appeal to people willing to come to the physical Center. However, through partnerships, PEC has also started to offer courses in remote locations.[7] In January 2006, the PEC began simulcasting courses to extend the reach of the Center.

Although the reach of the Center is clearly an important objective, in recent years, the PEC has also taken steps to increase the effectiveness of their courses. Many of the PEC courses qualify for AIA accreditation and as part of this process, the course must state the learning objectives of the course. In addition, the PEC has asked instructors to incorporate more case studies and hands-on exercises to increase the energy savings potential of their interactions.

The increasing priority on energy savings is also demonstrated by offering an existing building commissioning workshop series that focuses on changes that lead to energy savings. Participants in this workshop are pre-screened to ensure that they have a building that will serve as a case study, and that they are able to commit to a series of 12 full day workshops on increasing energy efficiency in their buildings. The commissioning workshop series was the subject of a case study presented in Appendix D: Case Studies.

Our instructor survey asked instructors to indicate the percentage of course time dedicated to different content delivery methods. A breakdown of how course content is delivered to participants is shown in Table 4. On average, 77% of course time was dedicated to instructor lectures or presentations. This is consistent with PEC's objective of offering lecture style courses that appeal to large numbers of customers. Less time was devoted to methods that involved student interaction such as group discussions and hands-on exercises.

Table 4: Course Content Delivery Method: PEC

Delivery Method	Percent of Course Time
Lecture/Presentation	77%
Group Discussion	13%
Hands-On Exercises	5%
Instructor Demonstration	4%
Attendee Presentation	<1%
Video/Movie	<1%
Other	1%

Instructors were asked to classify the course's emphasis on energy efficiency. Energy efficiency is the central or only theme of nearly three-quarters (72%) of the courses taught at the PEC. Additionally, nearly half (46%) of course instructors provided detailed examples of energy efficiency in their course materials.

[7] In the third quarter of 2006, Silicon Valley Energy Watch (SVEW) held a workshop, "Title 24 Non-residential/Building Envelop Requirements," which was the first in a series hosted through Partnership. . . . . . . In the fourth quarter of 2006, SVEW held five additional trainings in Santa Clara County.

In addition to its course offerings, PEC provides a number of educational efforts that were evaluated through an in-depth case study. These case studies are presented in Appendix D: Case Studies. The PEC's consultation service provides a wide range of market actors with information and guidance on energy efficient building and technologies. In addition, the Centers provide interested residential and business customers with access to energy efficiency tools and added resources such as energy efficiency software through its tool lending library. Finally, the PEC offers a 12-session existing building commissioning workshop series designed to increase knowledge and provide hands-on experience in commissioning for operations and maintenance professionals and facility managers, as well as consultants and engineers providing commissioning services.

Finally, the PEC emphasizes the value of the physical building as a "community energy center" to bring people together to exchange ideas. Although the impact is not immediately quantifiable, people come to the Center to meet others and work together on projects. In addition, as part of the building and physical meeting space, the PEC maintains displays and exhibits, including some that are hands-on, to educate visitors to their Center.

3.2.2 Energy Training Center

The ETC's efforts focus almost exclusively on residential market actors, with some courses targeting small commercial contractors. The targets for this Center are HVAC contractors, residential builders and general contractors, mechanical engineers, energy consultants, and designers/architects. This Center also targets Home Energy Rating System (HERS) Raters, building department inspectors and plan checkers because these market actors have the potential to touch many homes. In the marketing materials for their courses, the Center clearly lays out the target audience for each upcoming course.

Energy Training Center Facts: 2006-2008

- Geographic Area: Stockton, CA – serves all of PG&E's territory
- Budget: $3.3 million
- Target Markets: Mass market residential upstream market actors, midstream residential market actors and small commercial market actors
- Target Participants: Residential and small commercial market actors
- Program Activities: Seminars, Workshops, Consultations, Tool Lending Library and Technical Support

ETC's primary objective is to eliminate gaps in skills and thus improve the quality of the installation of energy efficiency technologies. ETC identifies critical skill gaps and works with distributors, contractors, builders, designers, and city and county building departments to eliminate these gaps. The ultimate goals are to improve the quality of installation of energy efficiency measures, influence the mass market through upstream and midstream market actors, and improve compliance with Title 24 code updates.

ETC describes itself as a proactive leader in the industry—Utility-wide, Statewide and Nationwide. The Center emphasizes changes in the marketplace, serves as an important channel for providing information on utility courses, and plays a national leadership role through their involvement with organizations such as Affordable Comfort.

The ETC staff is committed to offering classes that lead to energy savings. They do this by (1) emphasizing courses that target market actors (to increase the "influencer effect"), (2) tracking key characteristics and course objectives to ensure that their courses lead to savings, and (3) conducting self-evaluations to better understand the effects of their efforts. For example, information provided by the Center on a self-evaluation of several courses offered through the Bakersfield/Kern Energy Watch Partnership shows that "the sessions resulted in a potential energy savings of 7,230,960 kWh of electricity and 1,047,168 therms of natural gas annually." In addition, the Center has created a "course cruncher" which determines a score (up to 100) for each class based on a number of characteristics including attendance, cost/student, savings potential, channeling and support of overall PG&E sustainability efforts.

As seen in Table 5, over half (59%) of course time is devoted to lectures and presentations, which is on par with other Centers. However, ETC instructors also make use of a variety of other methods such as group discussions, hands-on exercises and demonstrations.

Table 5: Course Content Delivery Method: ETC

Delivery Method	Percent of Course Time
Lecture/Presentation	59%
Group Discussion	15%
Hands-On Exercises	12%
Instructor Demonstration	11%
Attendee Presentation	1%
Video/Movie	<1%
Workplace Consultation	<1%
Other	1%

Energy efficiency is the central or only theme of 87% of the courses taught at the ETC. In addition, nearly two-thirds (63%) of course instructors provide detailed examples of energy efficiency in their course materials.

Because the Center believes they have saturated the market within 40 miles of Stockton, the Center also has portable models for whole house, insulation and systems (primarily HVAC) to allow for demonstrations at off-site locations. ETC attempts to expand the reach of the Center by partnering with distributors and distributor training facilities, which allow them to meet contractors as they procure equipment. ETC also partners with organizations such as the Builder Exchange and with Local Government Partnerships. For example, in the second quarter of 2007, the ETC conducted seven training sessions in support of the Fresno, Stockton and Redwood Coast Energy Watch programs. For all of these partnership courses, the ETC controls the course content, but the distributor markets the courses and ensures that the participants subscribe and attend the class.

In addition, the Center provides consultations and tool lending through a tool lending library (described in detail in Appendix D). The activity level for both consultations and tool lending is somewhat small relative to the numbers served through the courses. These libraries are not seen as having a large potential to induce energy savings since there are only a few types of tools, and the consultations are given primarily to assist the contractor with understanding how to use the tools.

The Center also offers contractors an opportunity for hands-on experience through its Contractor Training House, which is located on the Energy Center property. The contractor training house is a full-scale home with multiple systems and an open design to allow contractors to see different types of lighting, windows, and insulation. In addition to the House, this Energy Center has multiple rooms to demonstrate lighting in a kitchen or living room.

3.2.3 Food Service Technology Center (FTSC)

FSTC is a research lab that offers training, provides support to other program efforts, and conducts industry-based outreach efforts for the food service sector. The Center aims to increase energy efficiency in food service throughout the state of California. The Center does this through FSTC's equipment testing and equipment testing protocol development that serve to close gaps in product knowledge and allow customers to make informed purchase decisions (described in detail in a case study of FSTC in Appendix D). The Center also offers seminars and consultations to customers, with a specific focus in food service technologies. While FSTC reaches fewer participants compared to most other Centers, these efforts tend to be more targeted.

Food Service Technology Center Facts: 2006-2008

- Geographic Area: San Ramon, CA – serves all IOU territories
- Budget: $6.1 million
- Target Markets: Food Service Industry
- Target Participants: Food service equipment manufacturers and their customers including hospitals, educational facilities, restaurants and commercial cooking design consultants
- Program Activities: Research and Testing, Seminars, Workshops, Consultations, Fact Sheets, Brochures and Online Content

FSTC is responsible for the course content of a number of courses offered at other Energy Centers (both within PG&E and across the state). As such, FSTC courses include several Joint Energy Center (JEC) courses, or Statewide IOU Food Service Seminars, which are courses that are developed by FSTC but conducted at other Centers. This allows the FSTC to broaden the reach and touch to customers throughout the state. In these cases, FSTC provides the instructor and the course content while the other Center provides the facility and marketing support.

Some of the Food Service Seminars are designed for the general commercial food service audience, such as "Ten Energy Saving Tips," while others are targeted at specific customers such as "Starwood Hotel Saving Energy in the Commercial Kitchen." Many of the food service seminars are focused on universities, such as "University of California, Davis, Commercial Food Service Appliance Basics" or the "National Association of College & University Food Service Conference Purchasing Energy Efficient Equipment for Your Sustainable Kitchen." A few of these university-based courses are for students, and so the program effects are expected to be delayed until the students enter the work-force. In addition, several of FSTC's courses were aimed at internal training of sales and service people.

A breakdown of how information is delivered to participants is shown in Table 6. Seven-tenths (70%) of course time is devoted to lectures and presentations, which is slightly higher than other Centers. A number of FSTC instructors also made use of group discussions.

Table 6: Course Content Delivery Method: FSTC

Delivery Method	Percent of Course Time
Lecture/Presentation	70%
Group Discussion	23%
Video/Movie	<1%
Other	6%

Energy efficiency is the central or only theme of all of the courses taught. However, very few (4%) course instructors provide detailed examples of energy efficiency in their course materials; instead most instructors (96%) provide general energy efficiency examples.

In addition to its course offerings, as a research lab, the FSTC is a national leader in increasing energy efficiency in the food-service industry. The FSTC facility houses a test center that allows them to test food-service equipment for specific applications (e.g., fryers, pizza ovens, open refrigeration units for convenience stores). For example, a large chain store or restaurant will approach the FSTC with several options for refrigeration or cooking equipment. The FSTC tests the equipment being considered specifically for the application needed, and makes a recommendation about which equipment is the most efficient equipment for the application. In general, the equipment (and the customer that requested the test) is then eligible for a custom rebate through a resource acquisition program.

FSTC also provides support to energy audits and design consultations for PG&E customers. The energy audits are typically performed by a member of the FSTC staff and the customer account representative who go on-site to a commercial facility to assess their energy efficiency practices and make recommendations on potential improvements. Similar to the energy audits, the design consultations are a one-on-one interaction between FSTC staff and customers. However, FSTC staff reported that these consultations do not lead to large energy savings.

3.3 SCE2513: SCE Education and Training Program

SCE's Education, Training and Outreach program includes three Energy Centers, the Customer Technology Application Center in Irwindale (CTAC), the Agricultural Technology Application Center in Tulare (AgTAC) and the Technology and Test Centers in Irwindale (TTC). While the Centers serve all of SCE's customers, there is an emphasis on business customers, with CTAC focusing specifically on commercial and industrial customers and AgTAC focusing on agricultural end-uses.

3.3.1 Customer Technology Application Center (CTAC)

SCE's CTAC promotes energy efficiency to virtually all of their customer market segments, primarily focusing on commercial and industrial customers, and a number of market actors. The primary focus is on providing classes, seminars and workshops. However, the Center also offers customized trainings, conducts demonstrations, provides consultations, and provides print information, facility tours, and interactive displays and exhibits. Each of these activities is aimed at breaking down customer market barriers concerning up-front first cost, performance uncertainty, and asymmetrical product information in order to influence customers to implement energy efficient measures which result in energy savings and bill reductions.

Customer Technology Application Center Facts: 2006-2008

- Geographic Area: Irwindale, CA – serves all of SCE's territory
- Budget: $8.8 million
- Target Markets: All customer market sectors – focus on commercial and industrial customers.
- Target Participants: Market actors and end-users including architects, engineers, distributors and contractors
- Program Activities: Seminars, Workshops, Displays, Demonstrations, Technical Consultations, Facility Presentations, Fact Sheets and Brochures and Off-site Seminars and Presentations

CTAC shows a strong commitment to adult education best practices, and has begun to update class, seminar and workshop content to reflect these practices; as well as offering teachers the opportunity to receive training in order to improve the quality of instruction at the Center.

As shown in Table 7, over half (54%) of course time is devoted to lectures and presentations, which is slightly less than other Centers. CTAC instructors also make relatively frequent use of other methods including group discussions, hands-on exercises and instructor demonstrations.

Table 7: Course Content Delivery Method: CTAC

Delivery Method	Percent of Course Time
Lecture/Presentation	54%
Instructor Demonstration	18%
Group Discussion	15%
Hands-On Exercises	11%
Video/Movie	<1%
Attendee Presentation	<1%
Workplace Consultation	<1%
Other	<1%

Nearly all (91%) CTAC courses emphasize energy efficiency as the central or only theme. However, only a quarter (24%) of course instructors report providing specific and actionable examples of how to implement energy efficiency practices, while the rest (76%) say they provide more general examples.

In addition to offering courses, CTAC conducts a number of other activities which support the Center's goal of promoting energy efficiency to business customers. The primary activity outside of classes, seminars and workshops are the technical consultations. Customers who have questions about specific technologies or end-uses or would like to see these technologies in action may contact the Center for a technical consultation. These consultations make use of the demonstrations and displays available at the Center as well as the expertise of Center staff.

Similar to the technical consultations, CTAC offers Center tours and demonstrations. These run from self-guided tours to guided, customized tours led by Center staff. These can be scheduled in advance or done on a walk-in basis and range from a large group to even one individual. The tours and demonstrations are informal in nature and are largely used as marketing tools that help drive participants into one (or more) of the Center's course or workshop offerings.

Like the tours and demonstrations at CTAC, the exhibits, displays and brochures that are generated by the Center are used primarily as marketing tools to draw customers into the Center and then into available classes, seminars and workshops. The exhibits and displays are also used during the classes, seminars and workshops as teaching aides and during technical consultations as demonstration aides. A limited number of the exhibits and displays are mobile and can be brought directly into the classroom as well as on the road to off-site events.

3.3.2 Agricultural Technology Application Center (AgTAC)

Similar to CTAC, AgTAC emphasizes providing courses for SCE customer market actors and end-users. However, because of its location, many of the courses and much of the Center's displays and exhibits focus on agricultural end-uses. AgTAC offers all of the standard activities that are expected of an Energy Center. AgTAC's cornerstone activity is offering classes, seminars and workshops that focus on energy management and energy efficiency solutions.

Agricultural Technology Application Center Facts: 2006-2008

- Geographic Area: Tulare, CA – serves all of SCE's territory
- Budget: $4.2 million
- Target Markets: Agriculture
- Target Participants: Agricultural Market Actors and End-Users
- Program Activities: Seminars, Workshops, Displays, Demonstrations, Technical Consultations, Facility Presentations, Fact Sheets and Brochures and Off-site seminars and presentations

Similar to CTAC, AgTAC shows a strong commitment to adult education best practices, and has begun to update class, seminar and workshop content to reflect these practices. A breakdown of how information is delivered to participants is shown in Table 8. Sixty-two percent of course time is devoted to lectures and presentations, which is on par with other Centers. AgTAC instructors also use group discussions, hands-on exercises and instructor demonstrations.

Table 8: Course Content Delivery Method: AgTAC

Delivery Method	Percent of Course Time
Lecture/Presentation	62%
Hands-On Exercises	13%
Group Discussion	12%
Instructor Demonstration	11%
Video/Movie	2%
Other	<1%

Energy efficiency is the central or only emphasis of nearly all (96%) of the courses taught at AgTAC. Furthermore, nearly two-fifths (39%) of course instructors provide detailed examples of energy efficiency in their course materials, while the rest provide general examples.

AgTAC conducts a number of additional activities that support the Center's goal of promoting energy efficiency to business customers. The primary activity outside of classes, seminars and workshops is the Tool Lending Library (discussed in detail in Appendix D). Customers who are interested in exploring an energy efficiency software tool can come to the Center and check out any number of tools.

AgTAC also offers technical consultations, demonstrations and tours to customers who have questions about specific technologies or end-uses and would like to see these technologies in action. These visits can be scheduled in advance or done on a walk-in basis and make use of the displays available at the Center as well as the expertise of Center staff. The consultations focus on one technology while the tours and demonstrations give an overview of all of the technologies available at the Center. AgTAC's tours and consultations are largely used as marketing tools that help drive participants into one or more of the Center's course offerings. AgTAC's exhibits and displays are also used during the classes, seminars and workshops as teaching aides. A limited number of the exhibits and displays are mobile and can be brought directly into the classroom as well as on the road to off-site events.

3.3.3 Technology and Test Centers (TTC)

The TTC consists of two components: the lighting test center and the refrigeration test center.[8] The Center's offerings emphasize end-uses that provide a large opportunity for energy savings, specifically process refrigeration, lighting and HVAC. A large portion of the Center's information and training is providing customer specific training and workshops for commercial and industrial market segments, including market actors and end-users. The Education and Training component of the TTC includes seminars and workshops as well as customized consultations and tours of the Center. The Center is also responsible for a handful of courses that are offered at CTAC and AgTAC.

Technology and Test Centers Facts: 2006-2008

- Geographic Area: Irwindale, CA – serves all of SCE's territory
- Budget: $2.1 million
- Target Markets: Commercial & Industrial
- Target Participants: Market Actors & End-Users
- Program Activities: Seminars, Workshops, Demonstrations, Technical Consultations

[8] TTC was created in the 2006-2008 program cycle. Previously, much of the activities included in TTC were part of the Emerging Technologies Program (ETP). TTC personnel continue to be funded by and continue to work in both the ETP and Education and Training programs. However, TTC has a broader mandate than ETP and performs work within Codes and Standards and Demand Response as well. While TTC personnel have a role within the ETP, the activities they perform for TTC are separate. Similar to ETP, TTC performs testing on equipment. However, there is no overlap between the testing that occurs under TTC and testing by ETP. The TTC testing activity is considered more of a research and development effort than what occurs in ETP. Technologies tested by the TTC may be considered under the ETP at the end of the TTC activity, but not always. This means that if technologies move from one program to the other, it is a one-way move from TTC to ETP.

A breakdown of how information is delivered to participants of the courses offered by TTC is shown in Table 9. Just under half (49%) of course time is devoted to lectures and presentations, which is slightly lower than other Centers. Group discussions are another popular content delivery method at the TTC.

Table 9: Course Content Delivery Method: TTC

Delivery Method	Percent of Course Time
Lecture/Presentation	49%
Group Discussion	37%
Hands-On Exercises	9%
Instructor Demonstration	5%

Energy efficiency is the central or only theme of a majority (86%) of the courses taught by the TTC. In addition, the same percent of instructors provide detailed examples of energy efficiency in their course materials.

As the TTC is a laboratory for technology testing, the primary activity at the TTC is the technical consultations. These can take the form of either a customized seminar or a tour of the Center. TTC uses these customized training sessions as a way to address specific needs of customers. Customers are able to bring specific questions to the TTC and make use of the demonstration centers and expertise of TTC staff in order to answer those questions. This component of the TTC is discussed in detail in Appendix D: Case Studies.

The TTC also offers internal trainings which provide energy efficiency information to utility staff. These trainings target both account executives through periodic "updates" and new hires through customized training sessions.

In addition, TTC performs outreach functions such as contributing to industry publications or presenting at industry conferences. Finally, the Center holds quarterly meetings with SCE employees (generally account representatives) to discuss energy efficiency measures.

3.4 SCG3503: SCG Education and Training Program

SCG's Education and Training program is comprised of the efforts coordinated by the Energy Resource Center.

3.4.1 SCG Energy Resource Center (ERC)

The goal of SCG's ERC is to provide SCG customers with information that will assist them in reducing their energy usage, lowering their utility bills, reducing operation and maintenance costs, and improving productivity. The SCG ERC disseminates information through training courses to a variety of market actors, including architects, designers, engineers, distributors, and contractors, to increase system wide energy savings. The SCG ERC also houses the Food Service Equipment Center, which offers seminars focused on the food service industry as well as food service equipment demonstrations.

SCG Energy Resource Center Facts: 2006-2008

- Geographic Area: Downey, CA – serves all of SCG's territory
- Budget: $6.5 million
- Target Markets: Residential and Non-Residential
- Target Participants: Market Actors and End-Users
- Program Activities: Classes, Seminars, Workshops, Demonstrations and Technical Consultations

As shown in Table 10, over half (57%) of course time is devoted to lectures and presentations, similar to the other Centers. SCG ERC instructors also make use of instructor demonstrations, group discussions and hands-on exercises.

Table 10: Course Content Delivery Method: SCG ERC

Delivery Method	Percent of Course Time
Lecture/Presentation	57%
Instructor Demonstration	24%
Group Discussion	9%
Hands-On Exercises	5%
Video/Movie	3%
Workplace Consultation	1%
Attendee Presentation	<1%
Other	1%

Energy efficiency was a focus of a majority of courses and is the central or sole theme of 70% of the courses taught. In addition, just over half (53%) of instructors indicated that they provided detailed examples of energy efficiency in the course while 40% provided general examples. The remaining 7% did not provide energy efficiency examples in their courses.

In addition to the seminars offered by the SCG ERC, the Center undertakes a number of activities including the Industrial End User Program, technical consultations and demonstrations, manufacturer training sessions, and facility tours.

The Industrial End User Program is designed to offer on-site energy efficiency workshops or seminars at selected industrial customer sites. The program provides industrial customers with energy savings analyses, consultations about rebates and incentive programs, and field observations and software modeling/simulation tools to assess existing energy use and forecast potential cost and savings. The SCG ERC also offers technical consultations and food service demonstrations that allow customers to test out different types of energy efficient equipment as well as learn how to properly use and maintain energy efficient equipment. The Industrial End-User program is discussed in detail in Appendix D.

Tours at the SCG ERC are designed to showcase the Center itself, a LEED certified building. As a LEED certified building, the SCG ERC is unique when compared to the other Centers because the building itself can be used as a tool for demonstrating energy efficient technology.

3.5 SDGE3009: California Center for Sustainable Energy/Energy Resource Center Partnership (CCRE)

The SDG&E Program consists of two distinct units, the San Diego Energy Resource Center (SDG&E) and the California Center for Sustainable Energy (CCSE), which occupy the same location. While the CCSE and SDG&E offer their courses in the same physical space, they have different missions and key objective strategies. In addition, the SDG&E and the CCSE schedule, market, plan and execute different activities funded by the SDGE3009 Program and generally operate independently of one another, including having separate administrative support staff, tracking databases, and budgets.

3.5.1 Energy Resource Center (SDG&E)

The SDG&E targets the non-residential sector with an emphasis on contractors and commercial and industrial building operators/facilities. The Center is primarily used for training courses and as a channeling mechanism for resource acquisition programs.

The Center offers courses in the form of workshops and customized trainings which are scheduled, planned, marketed and executed separately and independently from the CCSE's efforts. SDG&E uses classroom space at the CCSE to conduct the courses that they plan, however SDG&E staff plans and executes the courses out of offices at SDG&E. The Center's courses are almost entirely system-specific, focusing heavily on HVAC systems.

San Diego Energy Resource Center Facts: 2006-2008

- Geographic Area: San Diego, CA – serves all of SDG&Es territory
- Budget: $1.3 million
- Target Markets: Non-Residential
- Target Participants: Market Actors and End-Users
- Program Activities: Training Classes, Seminars, Workshops

A breakdown of how information is delivered to participants is shown in Table 11. Three-quarters (75%) of course time is devoted to lectures and presentations, slightly higher than the other Centers. Group discussions and instructor demonstrations were other popular content delivery methods.

Table 11: Course Content Delivery Method: SDG&E

Delivery Method	Percent of Course Time
Lecture/Presentation	75%
Group Discussion	12%
Instructor Demonstration	6%
Video/Movie	4%
Hands-On Exercises	2%
Other	2%

Energy efficiency is the central or only theme of nearly all (91%) of the courses taught. However, less than half (45%) of instructors provide detailed and actionable examples of energy efficiency in their course materials; with 52% providing more general examples and 3% not providing any examples of energy efficiency.

The SDG&E also offers technical assistance informally via the SDG&E account managers and workshop coordinators by speaking with participants about further resources provided by CCSE and SDG&E. SDG&E's account representatives often attend the workshops with their customers and shepherd them through the process of learning about resources and methods and ultimately implementing energy efficient practices in their business. SDG&E also encourages their course participants to take advantage of the Technical Assistance offered by the CCSE.

The Center has a demonstration area featuring energy efficiency related equipment, displays and exhibits. The area has a wall of brochures and marketing collateral divided into three sections: SDG&E Programs, CCSE Programs and Other Programs. SDG&E's only involvement in the exhibit areas is to maintain the marketing collateral designated for its programs.

3.5.2 California Center for Sustainable Energy

The CCSE has a much broader mission than the other Centers. The Center's mission is "to create a sustainable energy future," by emphasizing three areas: (1) clean and renewable distributed generation, (2) green construction and, (3) energy efficiency. The CCSE targets a larger audience of both residential and non-residential sectors through multiple activities including workshops, outreach at community events, and technical consultations. The Center also has a demonstration area that exhibits multiple energy efficient technologies, green construction materials and distributed generation. Like some of the other Centers, CCSE has an energy efficiency tool lending library. CCSE targets both non-residential and residential customers for all activities at the Center. However, the workshops focus primarily on non-residential market actors including architects, designers, builders, and some commercial and industrial building operators/facilities. The CCSE courses emphasize green building or green design specific topics, along with several lighting and daylighting courses. The CCSE also offers renewable courses on Solar Water Heating.

California Center for Sustainable Energy Facts: 2006-2008

- Geographic Area: San Diego, CA – serves all of SDG&Es territory
- Budget: $2.8 million
- Target Markets: Residential and Non-Residential
- Target Participants: Market Actors and End-Users
- Program Activities: Seminars, Workshops, Displays, Demonstrations, Exhibits, Technical Consultations, Tool Lending, Resource Lending

As shown in Table 11, just under two-thirds (65%) of course time is devoted to lectures and presentations, which is on par with other Centers. Other delivery methods include group discussions, instructor demonstrations and hands-on exercises.

Table 12: Course Content Delivery Method: CCSE

Delivery Method	Percent of Course Time
Lecture/Presentation	65%
Group Discussion	14%
Instructor Demonstration	11%
Hands-On Exercises	6%
Video/Movie	1%
Workplace Consultation	<1%
Attendee Presentation	<1%
Other	3%

Energy efficiency was a focus of most courses, being is the central or only theme of 81% of the courses taught. In addition, more than half (58%) of instructors provide detailed examples of energy efficiency in their course materials, while 39% provides general examples and 3% do not provide examples of energy efficiency.

In addition to its course offerings, the CCSE offers customized trainings to building operators who have recently retrofitted a building and need training on proper operation of the new equipment. Market actors interested in lighting, compressors, windows, energy controls for water heating, exit signs, and pathway systems can also receive customized training.

The CCSE provides Technical Assistance Sessions that coach participants through project design, equipment purchase and installation, commissioning, and ongoing operation and maintenance. The consultations primarily help with energy efficient measures such as questions related to lighting options or equipment/technology. However, the consultations also provide information about resource acquisition programs, help with a home energy audit, inquiries into CCSE tool resources, and general consultation about energy efficiency options while building a new home. Two engineers on the CCSE staff offer technical assistance. The technical assistance involves educating customers about their energy efficient options as well as financing assistance opportunities by channeling customers to incentive programs offered by the SDG&E and other third parties.

The CCSE manages and maintains The Energy Resource Library and Tool Lending Program. The library offers space where customers can browse and borrow resources on energy efficiency. SDG&E participants can also take advantage of energy efficient resources through the Tool Lending Program where customers can borrow energy efficiency tools for a specific amount of time. The Tool Lending Program is a hands-on activity that provides customers with tools and instructions on how to use the tools to estimate energy savings potential.

Finally, the CCSE creates, manages and maintains the Center's exhibit area. The area is divided into four exhibit spaces: Mechanical (compressors), Lighting (types of track lighting, indoor and outdoor, street lamps and exit signs), Renewable Energy (distributed generation and solar water heating) and Building Materials (example of an energy efficient residence using many types of building materials). The area also has a wall of brochures and marketing collateral divided into three sections: SDG&E Programs, CCSE Programs and Other Programs.

4. Study Methodology

The evaluation of the nine Energy Centers involved numerous research and data collection tasks including in-depth interviews, review of program materials, quantitative surveys with course instructors and participants, and an engineering analysis of survey results.

This section details the methods used to conduct the indirect impact evaluation of the Education and Training Program. The reporting structure for this section follows the evaluation protocols. However, we have condensed sub-sections where possible and excluded sections that were not germane to an indirect impact evaluation.

4.1 Overview of the Approach

Figure 2 outlines the flow of tasks involved in our evaluation approach. The first set of tasks (Task 1) dealt with collecting background information on Center activities and customers participating in those activities. We used this information to conduct the course participant surveys including drawing the samples and crafting the survey instruments (Task 2) for the instructor and course participant survey efforts (Task 3). Finally, we analyzed the survey results to determine the impact of the courses on participant learning, cognitive change, and energy saving actions (Task 4). Additionally, we identified non-course activities that did not lend themselves to the same type of assessment - used for the courses. We conducted case studies for these activities.

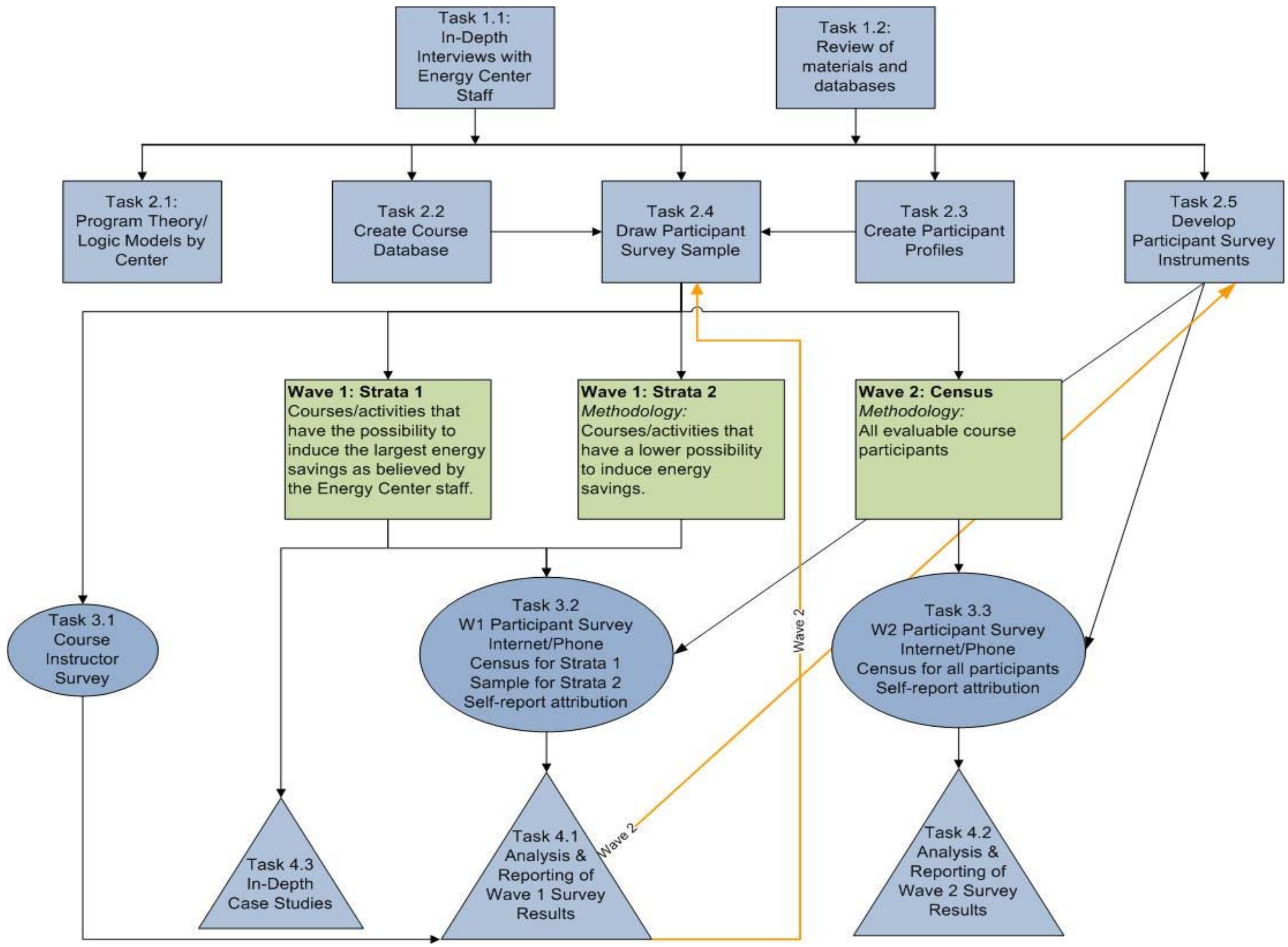
The main focus of the evaluation effort was an assessment of the 840 unique training classes provided throughout the three-year evaluation period. Based on the evaluation plan, we surveyed course participants in two waves. Wave 1 included Center activities that took place between January 2006 and June 2007 while Wave 2 activities took place between July 2007 and December 2008.

The two-wave approach had several advantages. We were tasked with presenting results at the level of the Energy Center. With nine Centers, we needed the most efficient sampling design possible. The Energy Centers conduct a large number and wide variety of courses and activities. A sample design that stratifies courses based on their likelihood to lead to behavioral change could be a more efficient design. However, it was impossible to identify *a priori* the types of activities that were most likely to lead to energy savings. Therefore, by using the Wave 1 survey, we could gain information that could be used in designing a more efficient Wave 2 sampling plan.

The two-wave approach also allowed us to refine the survey instruments based on the Wave 1 findings. Because previous evaluations of the Energy Centers did not focus on determining energy savings associated with the course trainings, there was no precedent for survey design that would capture energy savings. Though we were confident in our approach for capturing savings, we wanted the opportunity to test the approach and revise the survey instruments to improve the estimates.

Details of the four tasks and the sampling approaches are presented later in this section.

Figure 2: Evaluation Approach



4.2 Research Questions Addressed

The Opinion Dynamics Team addressed twelve researchable questions in this evaluation. As we gained additional information about the Programs, we found that slightly reframing the questions helped to better focus the evaluation while still addressing each original question. Table 13 outlines each updated researchable question, its correlated original evaluation plan number, and directs the reader to the section in the report where these questions are addressed.

Table 13. Research Questions

Updated Number	Evaluation Plan Number	Report Section	Research Question
1	1	6	What is the reach of the Centers?
2	3	7	What is the change in awareness of energy saving opportunities and knowledge of energy efficiency practices as a result of Center activities?
3	2	Appendix C	What behavioral changes are encouraged by the Centers?
4	5	8	What percentage of the people targeted and exposed to each Center changed behaviors as a result of the program?
5	6	8	Among what groups and in what end-use areas are the changes occurring?
6	7	9	What percentage of participants were channeled into resource programs, and which programs were promoted?
7	8	8	What indirect behaviors were taken by those people who received education or training from the Centers?
8	9	9 & Appendix C	What direct energy saving behaviors were taken by those who received education or training from the Centers?
9	2, 10	9 & Appendix C	What are the net energy-saving behaviors taken by those who receive education or training from the Centers?
10	11	Vol II	What are the net energy savings demonstrated by courses or activities at each Center?
11	4,12	4 & Vol IV	What course and activity characteristics are most likely to be associated with net energy saving behavioral changes?

4.3 Protocols and Rigor Levels

In the evaluation plan, the Evaluation Team indicated a standard rigor level for this evaluation but also stated that not all courses, activities or program components within each of the Centers would be evaluated up to the Standard rigor level. All assessment of courses met the standard rigor level while the case studies met the basic levels.

The protocol requirements for indirect impact evaluations have three different rigor levels for the minimum allowable methods. Below we describe the two levels of rigor utilized in this evaluation.

- Basic Level: An evaluation to estimate the program's net change on the behavior of the participants is required, i.e. the impact of the Center on participant behavior. The evaluation team analyzed select program activities with this level of rigor in in-depth case studies.
- Standard Level: A two-stage analysis is required that will produce energy and demand savings. The first stage is to conduct an evaluation to estimate the program's net changes on the behavior of the participants. The second is to link the behaviors identified to estimates of energy and demand savings either prior studies and/or engineering calculations. The evaluation team analyzed select and randomized courses with the standard level of rigor.

We have met or exceeded the CPUC's rigor level assignments for evaluation of these programs.

4.4 Description of the Study Methodology

In this section, we provide detailed descriptions of the various research efforts, including sampling methods, used in the evaluation. The presentation follows the flow diagram in Figure 2 and is organized by task.

4.4.1 Task 1: Collection of Program Background Information

In-Depth Interviews and Material Review (Tasks 1.1 and 1.2)

The first task of the evaluation was to collect background information on the activities of each Center. The team began by conducting in-person interviews with the directors and key staff of each Energy Center. These meetings were typically a half-day in length and included a discussion of the structure and primary mission of the centers and in many cases included a detailed tour of the Energy Center itself. Specifically, these interviews were used to identify the types of courses and activity tracking data that the Centers maintain and determine the organizational structure of the data. In addition, we asked Energy Center directors to identify the courses or activities they felt were most likely to lead to energy savings, which we combined with additional course information to assign each course or activity to a sampling stratum for the Wave 1 participant survey. Section 4.4.3 below provides additional information on the Wave 1 sampling design.

In conjunction with the interviews, the Team requested and received course and activity data from each Energy Center.[9] The data requested included participant information (event name and ID, event date, participant name, organization, address, telephone and email) and training event information (name and ID, time and date, location, description, instructor and

[9] The Centers offer a wide range of training programs including courses, demonstrations and consultations. Our primary evaluation effort involved surveys with participants of courses and a few select activities. For ease of presentation, we use the term "courses" when discussing the participant surveys. We evaluate most non-course activities with in-depth case studies.

attendees). This information was used to create both our course database and participant profiles which served as the foundation of our Wave 1 and Wave 2 survey samples.

4.4.2 Task 2: Synthesis of Background Information for Use in Surveys

Program Logic Models (Task 2.1)

The Evaluation Team used the in-depth interviews and a review of Center materials to create a program logic model for each Center. Each logic model outlines the intended program outcomes and goals. It is a graphic representation of the intervention that shows what occurs and provides clear steps as to what change the intervention activities are expected to bring about in the targeted population. The nine logic models are in Volume IV, Section 1.

Course Database (Task 2.2)

The first step in constructing a course database was to review and synthesize all course descriptions, schedules, and participant lists to identify the unique course offerings across the nine Energy Centers. The result is a comprehensive database of 840 unique courses over the three year evaluation period.

After identifying the unique courses across the nine Centers, the team requested the course materials associated with each course. The materials included items such as instructor presentations, handouts, and videos. We reviewed the materials to classify each course by subject matter and identify the energy efficiency measures and actions that were taught in the course. Based on this review, we assigned each course to one of 16 end-use categories.

The review of course materials also included developing a comprehensive database of the energy-saving actions detailed in the course materials. The team used this data to craft end-use specific impact assessment questionnaires. The surveys contained questions about energy-saving actions and behaviors that participants could have reasonably taken as a result of taking the course.[10]

Participant Profiles (Task 2.3)

The participant lists - received from the Energy Centers also required a significant amount of review and cleaning. The Centers provided participant list for each course. The Evaluation Team soon discovered that many participants took multiple courses, sometimes at multiple Centers. Considerable time was spent reviewing the lists to identify unique participants and their course taking histories. During this review, we also removed Energy Center employees, course instructors, and any participant who was missing course information. The end result was 39,793 unique participants, each with a course taking profile over the three-year evaluation period.

[10] For ease of reporting going forward, we use the term “action” to refer to both behavior changes and installations of equipment that was done as a result of the course. Examples of behavior changes would be a change to lighting operations whereas an installation would be a lighting retrofit.

Participant Survey Sample Design (Task 2.4)

The course database and participant profiles were used to draw the samples for the Wave 1 and 2 surveys. Because the two waves had slightly different objectives they required different sample designs.

A significant research objective of Wave 1 was to develop an understanding of the course characteristics or combination of characteristics that were most likely to induce behavioral change. Therefore, the sampling unit for Wave 1 was the course. We selected a sample of 200 Wave 1 courses, and all participants who took a sampled course were included in the Wave 1 sample. We used the results from Wave 1 to design the sampling plan for Wave 2.

The objective for Wave 2 was to estimate net indirect energy impacts at the Center level. With nine Energy Centers, we were concerned with meeting the required levels of statistical precision. We could increase the precision of our sample by either increasing the sample size, or by drawing a stratified sample. With a stratified sample, the strata are less variable which reduces the overall variability of the sample.

The Evaluation Team planned to use the Wave 1 survey results to identify course characteristics that are associated with energy saving behavior change. We could then stratify the Wave 2 sample on these characteristics and improve the precision of the sample. The analysis compared the relative influence of course characteristics such as course subject and content delivery method with participant characteristics such as number of courses taken and knowledge gained from the course. The Wave 1 analysis showed that *participant* characteristics better predict behavioral change than *course* characteristics. Stratifying the Wave 2 sample by course characteristics would not improve the precision of our sample. Unfortunately, participant characteristics are not known in advance of the survey, only course characteristics.

Increasing the sample size was the other option to increase the precision of the Wave 2 sample. Given the results of the Wave 1 survey, the Team chose this approach for Wave 2 and attempted a census of all Wave 2 course participants.

Additional information on the sampling designs can be found in Section 4.4.3 and the methods used to conduct the Wave 1 analysis in Section 4.4.4.

Participant Survey Instrument Design (Task 2.5)

The course content review produced the background material used to design the participant survey instruments. The surveys consisted of two parts: (1) a core survey that all participants received and (2) impact assessment surveys for participants who took energy saving action as a result of taking the course.

The core survey contained questions that measured the impact of the course on knowledge gain, cognitive change, and behavioral change. The survey contained a series of questions that classified respondents by their occupation or reason for taking the course. Residential participants were those who intended to apply the course information in their homes or who did not have a specific purpose in mind when taking the course. Those who intended to apply what they learned on the job were further broken into two categories: (1) commercial participants who would apply the information in facilities their company owned or rented, and (2) market actors who would apply the information in their client's facilities. Market actors were further broken down by general market actors, code officials, HERS raters, and teachers.

We tailored the survey questions by respondent type to ensure that we asked about changes in knowledge and behavior that were appropriate for the respondent. Residential and commercial respondents who took energy saving actions based on what they learned in the course were directed to one of 16 impact assessment tools that asked about the details of the actions taken. The Evaluation Team designed these questions using the course materials to ensure we asked about actions that could be reasonably taken based on what was presented in the courses. The questions needed to be quite detailed to obtain the information necessary to calculate energy savings through an engineering analysis.

Because market actors may have taken actions multiple times across many clients, we did not ask them to provide the same amount of information that was asked of end-users. Instead, we asked some general questions about the type of changes they had made and to describe in their own words how the course affected their work. We also asked the frequency with which they took the actions and to provide a rough estimate of resulting energy savings. We conducted follow-up interviews with a sample of market actors who took courses in HVAC, lighting, and building envelope, which are the most popular course subjects among market actors. We used the interviews to learn more about the details of the changes the market actors had made and how the courses had influenced their work. Using the interview transcripts as guides, we conducted an engineering analysis of the market actors' actions. We used these results to characterize the energy saved by market actors as a result of what they learned in the Energy Center courses.

4.4.3 Task 3: Instructor and Participant Surveys

We conducted three main surveys as part of this evaluation: (1) a survey of Wave 1 course instructors, (2) the Wave 1 participant survey that covered courses taken from January 2006 through June 2007, and (3) the Wave 2 participant survey that covered courses taken from July 2007 through December 2008.[11]

Instructor Survey (Task 3.1)

Between March and April 2008 we conducted a survey with Wave 1 course instructors. The survey contained questions regarding course content delivery methods, target audience and emphasis on energy efficiency behavioral changes. The purpose of the survey was to gather information to determine whether course characteristics were associated with participant behavioral change. These results were a key objective of Wave 1 and were needed to determine the sampling plan for Wave 2. Therefore, without a completed survey we were unable to evaluate the course in Wave 1. To get the maximum response rate, we fielded the survey via the internet and then followed up by telephone with instructors who did not

[11] We also conducted participant surveys of the Tool Lending Libraries at the PEC, ETC, AgTAC, and CCSE, and consultations at the PEC and the Building Operator Certification program. These were smaller efforts, the details of which are described in Appendix C where the case studies are reported.

complete the online survey. Out of 204 instructors, 163 completed the survey. Many instructors taught more than one course and therefore completed more than one survey. Overall, we received completed surveys for 83% of the unique Wave 1 courses. The specific rates for each Center are presented in Table 14.

Table 14: Percent of Courses with a Completed Instructor Survey

Energy Center	Instructor Survey Response Rate (% of courses)
PG&E Energy Training Center	94%
PG&E Pacific Energy Center	68%
PG&E Food Service Training Center	98%
SCE Agricultural Technology Application Center	95%
SCE Customer Technology Application Center	84%
SCE Technology and Test Centers12	26%
SCG Energy Resource Center	81%
SDG&E Energy Resource Center	86%
California Center for Sustainable Energy	94%
Overall	83%

Wave 1 Participant Survey (Task 3.2)

The Wave 1 participant survey was a multi-mode survey conducted from October 2008 to March 2009. The survey covered courses taken between January 2006 and June 2007. The sampling unit for the survey was the unique course. Course participants entered the sample by taking a Wave 1 sample course. The team evaluated 200 of the 539 unique Wave 1 courses and activities.

In the evaluation plan, the team proposed dividing the 539 unique courses and activities into three strata from which to draw the sample. The three strata were:

Tier 1: a census of high-impact courses identified with the help of Center directors

Tier 2: a random draw stratum of all remaining courses and activities deemed to have a good likelihood of inducing behavioral change based on course characteristics

Tier 3: a low-impact stratum of activities deemed less likely to lead to behavioral change.

Based on the information received from the Centers, we found that the courses and activities that were expected to fall into the low-impact stratum did not have associated participant lists (e.g. Center tours). Furthermore, the overall number of unique courses was far lower than anticipated. Therefore, we split the sample into two strata: the high-impact

[12] The majority of TTC courses are taught by one of two SCE employees. We worked closely with each of these instructors to determine the best possible way to get the Instructor Survey completed for each of the Center's courses. However, the time commitment on the part of the instructors was still significant. Therefore, we prioritized the courses which were selected for the "Tier 1" evaluation. SCE employees completed all surveys requested of them.

stratum (Tier 1) and a random draw stratum (Tier 2) that included all unique courses with a valid Instructor Survey and participant data list.

The Tier 1 stratum was designed to include the five to nine courses and activities per Center that would have the highest potential for energy savings. During interviews with Energy Center directors in early 2008 and again in a data request in May 2008, we asked each Center to provide us with a list of at least five courses or activities which they believed had the best potential for creating energy saving behavioral change among participants. These courses and activities made up the bulk of the Census Stratum. It should be noted that three of the Centers did not provide us with a list of at least five courses or activities, therefore the evaluation team rounded out the list of courses and activities by selecting courses and activities with similar characteristics as those already selected by the Centers.

The census stratum contained 63 courses and activities, which are shown by Center in Table 15. All of the courses and one activity were part of the Wave 1 participant survey effort. Due to the varied nature of the other nine activities, we determined they were better suited to a case study approach in which we conducted an in-depth analysis of the impact of the activity rather than inclusion in our participant survey. More information on the case studies is presented in Appendix D.

Table 15: Census Stratum Courses and Activities by Center

Center	High Impact Courses	Activities	Total
ETC	9	1	10
PEC	7	2	9
FSTC	4*	2	6
AgTAC	8	1	9
CTAC	4	1	5
TTC	5	-	5
SCG ERC	6**	2	8
SDG&E ERC	5**	-	5
CCSE	5	1**	6
Total	**53**	**10**	**63**

*2 of the 4 courses were added by the evaluation team due to incomplete list of courses and activities from Center.
** Added by the evaluation team due to incomplete list of courses and activities from Center

The random draw stratum contained the remaining 137 courses to achieve the Wave 1 total of 200 courses. The remaining 137 courses were drawn from a randomly generated list of unique courses at the Center level. The Centers offered different numbers of unique courses. To avoid “over” sampling courses from a Center with a small number of courses, such as TTC, we stratified the remaining unique courses by Center and randomly drew courses in proportion to each Center’s percentage of the total number of valid courses. We present our random draw sample in Table 16 below.

Table 16: Random Draw Sampling Exercise

Center	Valid Courses	Percentage of Total	Sample Size
PGE ETC	87	19%	26
PGE PEC	91	20%	28
PGE FSTC	24	5%	7
SCE AgTAC	47	10%	14
SCE CTAC	51	11%	15
SCE TTC	6	1%	2
SCG ERC	77	17%	22
SDG&E ERC	46	10%	14
SDG&E CCSE	28	6%	9
Total	457*	100%	137

*Note that in order to keep the evaluation process moving forward it was necessary to generate the random lists prior to the conclusion of the Instructor Survey effort. Therefore the number of valid courses (unique courses minus Tier 1 courses and activities) is based on our understanding of the unique courses at the time we generated the random lists.

As we continued with the evaluation efforts, including the conclusion of the Instructor Survey, it was determined that we needed to drop some of the courses in the initial draw due to insufficient or missing participant data, an incomplete instructor survey, or because it was a duplicate course that was already included in our sample. In these cases we replaced the course with the next course on the randomized list for that Center.

We completed the survey over the internet with participants who had valid email addresses. For those who did not respond and those who did not provide an email address, the survey was completed over the telephone.

The creation of the participant profiles revealed that many participants had taken multiple courses within an end-use area. We believed that these participants would not be able to attribute their actions to a single course so they were asked to evaluate all of the courses they took in that area. For example, if a participant took three lighting courses, this participant would answer the questions based on the combined effects of all three courses.

To minimize respondent burden, we also limited the number of survey requests a single participant would receive. If a participant took courses across multiple end use areas, we limited the number of survey requests to three. Of the 2,657 participants who completed surveys, 93% completed one survey, 6% completed two surveys, and 1% completed three surveys. Overall, this resulted in 2,864 completed Wave 1 surveys.

Wave 2 Participant Survey (Task 3.3)

The Wave 2 participant survey was a multi-mode survey conducted from August to October 2009. The survey covers courses taken between July 2007 and December 2008. The primary objective of this effort was to calculate the most precise energy savings estimates possible for all Centers combined as well as for each of the Energy Centers.

The Wave 2 sampling approach was developed based on findings from the Wave 1 survey effort. The results of the Wave 1 analysis did not support stratifying by course characteristics. Because our analysis of Wave 1 data showed that individual participant characteristics are more predictive of behavior change than course characteristics, a simple random sample was deemed an appropriate sample selection method for Wave 2.

However, in order to produce reliable results for Centers that had fewer course participants, the approach would require a very large sample. Fortunately, with our multi-modal approach the team had the capabilities to survey a large population. By conducting the survey via the Internet and telephone, we could survey participants who provided either an email address or a telephone number. This approach also provided two opportunities to reach participants who provided both forms of contact information. During the Wave 2 time period, 21,103 individuals took courses across the nine Energy Centers. Based on the Wave 1 results, and because our analysis was attempting to determine results at the Center level, we attempted to complete interviews with each participant who took an Energy Center course between July 2007 and December 2008, our Wave 2 time period.

The evaluation team made several key methodological changes to the Wave 2 survey as a result of the Wave 1 survey effort. One of the driving reasons for these changes was to reduce participant burden. The issues encountered and decisions made follow below:

- *Issue:* Nearly one-quarter of the Wave 2 participants (23%) took courses in more than one end-use area.
  - In Wave 1, if a participant took courses across multiple end use areas, we asked participants to complete up to three surveys. Respondents were often confused by receiving more than one e-mail request, and most did not complete more than one survey.
  - Because of this outcome, for Wave 2, we limited our survey requests to one end-use area, which was selected as the area that participants obtained the most courses based on hours of training. Despite the benefits of obtaining information about all courses from all participants, this approach was the least burdensome while still providing information about end-uses in which participants focused their course taking.

Issue: One in ten Wave 2 participants took courses at more than one Center, making attributing these participants' results by Energy Center -challenging.

- This analysis reports the results from survey questions for each Center at which participants took courses. For example, if a participant took courses at both the PEC and ETC, that participant's results would be included in each Center's results.
- To avoid double-counting energy savings, we report energy savings by apportioning savings to each Center based on the hours of courses the participant took at each Center. So if one participant took 10 hours of total HVAC training, with 7 at PEC and 3 at ETC, we credit 70 percent of the savings to PEC and 30 percent to ETC.

Issue: Many participants took courses in both time periods and some had even completed a survey for Wave 1. There were 2,642 unique participants who appeared in both our Wave 1 and Wave 2 samples.

- To help respondents consider only the effects of the courses they took in the Wave 2 time period, our survey instrument provided the specific date for all single course participants and provided the time range to respondents who took multiple courses in an end-use.

- For participants who took multiple courses and had already completed a survey in Wave 1 for the end-use assigned, the survey instrument asked about an end use for which they had not already completed a survey.

As with the Wave 1 survey, we first attempted to complete surveys via the internet with participants for whom we had valid email addresses. For those participants who did not respond or did not provide an email address, we conducted telephone interviews.

4.4.4 Task 4: Analysis and Reporting

The research objectives of the two participant survey waves differed slightly. The primary objective for Wave 1 was to identify the characteristics of the courses that were most likely to induce behavioral change. This analysis drew on data collected from both the instructor and Wave 1 participant surveys. Our team used this information to design the Wave 2 sampling plan to ensure that our sample of courses was representative of each Center and could be used to characterize savings for each Center. In addition, we used the Wave 1 participant survey results to fine tune the survey instruments and analytic methods for Wave 2.

The primary objective of the Wave 2 participant survey was to provide reliable overall results and for each Energy Center. The analysis assessed the indirect impact of the Energy Center courses on behavioral change and the gross and net energy saved as a result.

Additionally, we identified seven non-course activities that did not lend themselves to the same type of assessment that we used for the courses. We conducted case studies for these activities.

Throughout the evaluation, the evaluation team wrote several memos to update the CPUC on our progress and share preliminary results. These memos are in Volume IV of this report.

Instructor Survey and Wave 1 Participant Survey (Task 4.1)

CART Analysis

As discussed above, we used results from the Wave 1 participant survey to design the Wave 2 sample. We used a technique called Classification and Regression Tree (CART) to conduct this analysis. Our objective was to identify course characteristics such as course subject or content delivery method that best predict behavioral change. We could then select a stratified sample for Wave 2 based on these course characteristics and improve the precision of our Wave 2 sample.

One major finding from the CART analysis was that there are no strong relationships between course characteristics and behavior change. When we used CART to determine whether course attributes predicted behaviors, even the best fit model was not able to predict behavior change well. When we ran a second model that included both course *and* participant attributes we found that taking action is driven less by the course attributes than other factors. The strongest predictors in this model included the type of respondent (i.e.

market actor, end-user), the respondent's business type, and knowledge gained from the course.

Based on these two models, we learned that *participant* characteristics better predict behavioral change than *course* characteristics. Stratifying the Wave 2 sample by course characteristics would not improve the precision of our sample. Unfortunately, we do not know participant characteristics in advance of the survey, only course characteristics. The results of the analysis indicated that a simple random sample of Wave 2 participants would be an efficient sample design.

Overall, the CART analysis proved useful for understanding the best way to sample for future evaluation efforts, and for supporting the need to ask about self-reported knowledge gain in future evaluation efforts. Additional details on the CART analysis and results can be found in Volume IV, Section 4.

Engineering Analysis

A major element of the Wave 1 survey results was testing the engineering analysis that would be used to estimate the amount of energy saved due to the courses. The end-users who said they had made energy saving changes in the core survey were directed to one of 16 impact modules where they were asked about details of the changes they had made. The impact module results were then analyzed to estimate gross energy (kWh and therm) and demand (coincident peak kW) savings. Savings methods leveraged core California-based secondary resources (e.g., DEER, CEUS, reports on CALMAC.org) and models (eQUEST) wherever possible. When data from these sources was not adequate, not reflective of the range of participant conditions, or was internally inconsistent, we utilized additional secondary sources and engineering calculations. This analysis highlighted areas where the survey instruments could be improved. Between Waves 1 and 2, the Evaluation Team modified nearly every impact module to some degree.

The Wave 1 survey results also identified changes that the Team could make to improve the impact results for the market actors who took Energy Center courses. The Wave 1 survey revealed that approximately half of the course participants were market actors and that a large percentage said they had made changes to their practices that could result in sizable energy savings. The Wave 1 questions about the types of changes made were fairly general. The Wave 2 questions are more precise and allow us to better characterize the types of actions taken.

Wave 2 Participant Survey (Task 4.2)

The attempted Census of all Wave 2 course participants allowed the evaluation team to provide results for each Energy Center in addition to all Centers combined. We present statewide results in Sections 7 through 11. Center level results are presented in Volume II. The analysis examines changes in attitudes, awareness, and knowledge of energy efficiency from our core survey. The engineering analysis of the impact surveys generates an estimate of gross energy savings for residential and commercial end-users.

Net Energy Savings

In more typical resource acquisition programs, participation is defined as using program support to install a particular measure or take a specific action. When we measure net effects for these type programs, a net-to-gross ratio is applied to gross energy impacts to *screen out* free-riders, that is, program participants "who would have implemented the program measure or practice in the absence of the program."[13]

For non-rebate programs such as information, education and training, we are forced to consider a different approach for determining net savings. We cannot assume that participation equates with taking energy saving action. The default assumption for each person touched is that they learned something that would change future energy saving actions. As such, we must adjust the standard concept of net-to-gross (screening out savings) for information, education and training programs.

During our evaluation planning, we proposed constructing a cognitive change index (CCI) as a method to estimate net behavior change. The cognitive change index (CCI) contains three specific concepts: 1) newness of the information learned in the courses, 2) determination of cognitive change due to information learned in the courses, and 3) a direct influence assessment. This method was agreed upon in discussions with the CPUC and MECT in August 2008. The CCI is the result of a series of questions asked in the core survey. Net savings are estimated by applying the CCI to gross savings. Appendix E contains detailed information on the questions comprising the index and its calculation.

Engineering Analysis

We conducted an engineering analysis of the Wave 2 survey results as was done with the Wave 1 results. End-users who said they took energy saving action as a result of what they learned in the course were asked a series of detailed questions about their actions. We analyzed the results to estimate gross energy (kWh and therm) and demand (coincident peak kW) savings. Savings methods leveraged core California-based secondary resources (e.g., DEER, CEUS, reports on CALMAC.org) and models (eQUEST) whenever possible. When data from these sources was not adequate, not reflective of the range of participant conditions, or was internally inconsistent, we utilized additional secondary sources and engineering calculations.

Appendix F contains detailed information on the methods we used to calculate savings for each end-use area.

Market Actor Analysis

For market actors, we conducted follow-up in-depth interviews with a sample of market actors who took the lighting, HVAC and building envelope surveys.[14] The interviews collected detailed information about how their practices have changed. This information was also

[13] California Energy Efficiency Evaluation Protocols: Technical, Methodological and reporting Requirements for Evaluation Professionals. April 2006. TecMarket Works Team, p 226.

[14] We selected the end-uses that had the most participants. Section 5 will provide more information on participation rates by end-use.

subjected to an engineering analysis that characterized the savings that a market actor could achieve as a result of the Energy Center courses.

In-Depth Case Studies (Task 4.3)

In the review of program materials, we identified non-course activities that were significant activities for the Centers but did not lend themselves to the same type of assessment as used for the courses. We conducted case studies for these activities. We list the activities, the involved Centers, and time period of the activity in Table 17. We selected the activities when we drew our Wave 1 participant survey sample and, in most cases, completed some of the case studies at the same time we conducted our Wave 1 survey. These case studies only include people who participated from January 2006 through June 2007. The other case studies include the full evaluation period and include participants from January 2006 through December 2008.

Table 17: Energy Center Activities Included in Case Studies

Case Study	Centers	Time Frame
FSTC Testing	PG&E FSTC	Approximately 16 years (1992-2008)
Consultations	PG&E PEC	Wave 1
Tool Lending Library	SCE AgTAC, PG&E PEC, PG&E ETC, SDG&E CCSE	Wave 1
Customer Specific Consultations	SCE TTC	Waves 1 and 2
Industrial End Use Program	SCG ERC	Waves 1 and 2
Retro-Commissioning Workshop Series	PG&E PEC	Waves 1 and 2
Building Operator Certification	All IOUs	Waves 1 and 2

We used different research methods for each case study depending on the activity being studied. The methods included review of program materials, interviews with program managers, participant surveys, and in-depth interviews with program participants. More detail on the methods used in each can be found in case study reports in Appendix D.

4.5 Expected Precision or Power Analysis Results

As stated in the protocols, power is the probability that you will detect an "effect" that exists in the true population under study. It is used for a variety of analyses, but most typically for regression analyses. Power analysis can be used to determine the minimum sample size needed to detect an effect at a given level of confidence. When a census is used, power analysis is unnecessary.

Though there are many potential sources of survey error, the most well-known is sampling error. Because we attempted a census and did not draw a sample of participants for the calculation of energy savings, the concept of sampling error does not apply to our energy saving estimates. Therefore, we cannot provide error bounds for the estimates of energy savings.

Other sources of survey error include measurement error, coverage error and non-response bias. We attempted to minimize all sources of error. For example, we conducted the surveys over the telephone and via the internet to reduce non-response bias. We also sent up to three email reminders and placed numerous callbacks to participants who did not respond to our initial survey request. Despite our best attempts, we acknowledge that there is still the potential for non-response bias in the results as we did not complete a survey with every participant.

In Section 5, we present results from the participant surveys that provide insight into the potential impact on non-response bias and other sources of error in the evaluation.

4.6 Sample Descriptions

In this section, we provide additional information on the construction of our participant survey samples, how they compare to the overall population, and survey completion rates.

4.6.1 Participant Population Contact Information

After combining the participant lists received from the nine Centers and eliminating duplicate names, we had a total of 107,492 participants across the three-year evaluation period. From this list, we removed utility and Energy Center employees, course instructors, and records that the Centers had indicated should be removed. We also removed a few participants who were lacking a contact name. As shown in Table 18, we were left with 97,997 course participants to include in our evaluation.

Table 18: Removal of Course Participants

Category	Wave 1	Wave 2	Total
Total participants received from Energy Centers	55,235	52,257	107,492
Utility/Energy Center employee	3,323	4,246	7,569
Participant in course that lacked content information (W1 only)	938	n/a	938
Course Instructor	419	432	851
No contact name	71	3	74
Record marked as Duplicate/Deceased/Do not use	48	15	63
Total Participants Included in Evaluation	50,436	47,561	97,997

We had both email addresses and phone numbers for approximately three-quarters of the sample participants. We had only email addresses for another 3 to 10% depending on the survey wave (see Table 19). We first attempted to complete interviews via the internet with participants who had provided email addresses. We followed up by telephone with those who did not respond and participants who lacked an email address.

Table 19: Percentage of Participants by Contact Information

Category	Wave 1 (n=11,310)	Wave 2 (n=20,705)
Both Email and Phone	74%	78%
Phone Number Only	16%	19%
Email Address Only	10%	3%

As Table 20 shows, we completed a majority of surveys via the internet for both the Wave 1 and 2 participant surveys. We completed slightly more via the Internet in Wave 2.

Table 20: Percentage of Interviews Completed by Survey Mode

Category	Wave 1 (n=2,864)	Wave2 (n=4,907)
Took Survey on the Internet	60%	68%
Took Survey on the Phone	40%	32%

4.6.2 Response Rates

Table 21 and 22 show the dispositions for the Wave 1 and 2 participant surveys. Each participant was assigned two dispositions, one for the outcome of the internet survey and another for the telephone survey. We reviewed each one to determine a final disposition for each participant. The dispositions are grouped into four categories: completed interviews, eligible participants with no completed interview, unknown eligibility with no completed interview, and ineligible participants.

The response rates for the Wave 1 and 2 surveys were similar, 31% and 29% respectively using the standard definitions established by the American Association for Public Opinion Research (AAPOR). We used AAPOR Response Rate 4 (RR4) for our calculations.[15] In essence, the response rate is calculated by dividing completed interviews by the total number of eligible participants. We had to estimate eligibility for participants that we were unable to contact. Approximately 9% of the population we did contact were ineligible because they worked for an IOU utility, did not end up taking the course, or did not recall taking the course.

Our cooperation rate was 79% for both waves using AAPOR's Cooperation Rate 4 (CC4). The cooperation rate is the percentage of participants who completed interviews out of all

[15] For more information on AAPOR standard definitions and response rates see: http://www.aapor.org/AM/Template.cfm?Section=Standard_Definitions&Template=/CM/ContentDisplay.cfm&ContentID=1819.

eligible participants with whom we made contact. Approximately 4 of every 5 participants agreed to participate once we made contact.

Table 21: Wave 1 Participant Survey Dispositions

Result Description	Count
Interview	
Completed interview	2,864
Partial	260
Total	*3,124*
Eligible Non-Interview	
Refusal	1,598
Asked to be emailed survey but did not complete	553
Call back	604
Claimed already completed interview	92
Total	*2,847*
Unknown Eligibility Non-Interview	
No longer employed at company	1,712
No good contact information	454
No email response; no answer/machine/busy/blocked	908
No email response; Disconnected phone; wrong number	2,068
Unsampled end-use (took courses in 4+ end-use areas)	1,563
No email response; No phone number	621
Language Problems	157
Total	*7,483*
Not Eligible	
Works for utility or energy center	604
Registered for the course but did not attend	154
Does not recall taking course	774
Don't know to screeners; Can't Classify	10
Total	*1,542*
Total Participants	**14,996**

Table 22: Wave 2 Participant Survey Dispositions

Result Description	Count
Interview	
Completed interview	4,553
Partial Interview	687
Total	*5,240*

Result Description	Count
Eligible Non-Interview	
Refusal	890
Mid-interview terminate	90
Asked to be emailed survey but did not complete	1,101
Call back	1,373
Claimed already completed interview	88
Total	*3,942*
Unknown Eligibility Non-Interview	
No longer employed at company	1,507
No good contact information	143
No email response; no answer/machine/busy/blocked	5,089
No email response; Disconnected/wrong number/computer tone	2,451
No email response; No phone number	367
Language Problems	126
Total	*9,683*
Not Eligible	
Works for utility or energy center/course instructor	782
Registered for the course but did not attend	237
Does not recall taking course	781
Don't know to screeners; Can't Classify	40
Total	*1,840*
Total Participants	20,705

4.6.3 Course Taking Behavior of Participant and Sample Populations

As we mentioned earlier in this section, we discovered that many participants took multiple courses. The 97,997 participants ended up being 39,793 unique participants once we took into account all of the courses a single individual took during the evaluation period. Just over one-third of both Wave 1 and 2 course takers took more than one course. Most took just a few courses but a few took a great number of courses. We present more detailed information on people who took a larger than average number of courses in Section 11.

Table 23 shows that for Wave 1, our survey respondents took more courses than the overall Wave 1 participant population. For Wave 2, the opposite was the case. We completed slightly more interviews with people who took just one course compared to the Wave 2 participant population. We attempted to complete up to three interviews with people who had taken courses in three end-uses areas in Wave 1 but only attempted to complete one interview in Wave 2, which might account for these differences.

Table 23: Number of Courses Taken: Population and Survey Sample

	Wave 1		Wave 2	
Courses	Population (n=22,096)	Sample (n=2,864)	Population (n=22,178)	Sample (n=4,970)
1	62%	46%	64%	72%
2 – 4	28%	41%	27%	24%
5 – 9	7%	10%	7%	3%
10 +	3%	3%	2%	1%

Participants also took course in more than one end-use area. As Table 24 shows, 22% of participants in both waves took courses on more than one subject. Our survey respondents for both waves reflect the overall participant populations quite well.

Table 24: Number of Course End-Uses Taken: Population and Survey Sample

	Wave 1		Wave 2	
Survey Modules	Population (n=22,096)	Sample (n=2,864)	Population (n=22,178)	Sample (n=4,970)
1	78%	71%	78%	71%
2 – 3	19%	27%	20%	26%
4+	3%	1%	2%	3%

5. Reliability Assessment of Study Findings

The Evaluation Team carefully designed the research methods and instruments used in this evaluation to minimize error and avoid bias. In this section, we detail the techniques we used to design our survey instruments, conduct the surveys, and analyze the data that enhance the validity and reliability of our findings.

5.1 Construct Validity

A concern with the self-report method is ensuring that participants' reports of their actions and program influence reflect reality. In essence, do the participant self-reports measure what they claim to measure?

Threats to the construct validity of self-reported evaluation data come from a number of sources. The most basic is poorly written survey questions. The team relied on its years of experience in survey design to create questions that, at face value, appear to measure the idea or construct that they are intended to measure. The questions were also reviewed to assure that double-barreled questions (i.e., questions that ask about two subjects, but with only one response) and "loaded" questions (i.e., questions that are slanted one way or the other) were not asked.

Though we followed best practices in survey design, we still had reason to worry about measurement error. Many questions in the core survey required self-assessments of knowledge gain and course influence on behavior change. It is well-known that people have difficulty articulating why they took an action. These difficulties can be due to problems remembering the specifics of an event, but more likely due to how people store and later recall information.

To address these concerns, we used multiple questions to measure a single construct. This increases reliability but can also confirm the validity of the items when numerous measures produce the same result. We constructed scales of some items and performed statistical tests such as Cronbach's alpha, to measure how well a set of items (or variables) measures a single unidimensional latent construct, such as the attitudes and awareness.[16]

Respondents who reported taking energy saving action in the core survey were directed to impact assessment questionnaires for each end-use area. These surveys mainly contained factual questions about the types of actions taken and the details of these actions (e.g. type of insulation installed, location of installation, amount installed, etc.) With factual questions, participants can forget details or misremember actions they took. To try to discourage

---

[16] Cronbach's alpha can be written as a function of the number of test items and the average inter-correlation among the items. Below, for expository purposes, we show the formula for the standardized Cronbach's alpha:

$$\partial = \frac{N \times \bar{r}}{1 + (N-1) \times \bar{r}}$$

Here N is equal to the number of items and r-bar is the average inter-item correlation among the items.

participants from making up information, we allowed them to discontinue the survey if they felt they did not have technical knowledge of the project. We also did not require a response to every question and allowed participants to say they did not know the answer.

Our two wave research design also allowed us to adjust our survey instruments between Waves 1 and 2 based on our Wave 1 results. We changed several questions in the core survey when the Wave 1 results showed some problems with measurement error.[17] The team's survey designers and engineers worked in tandem to make changes to the impact assessment questionnaires as well to ensure we were collecting the necessary information for our estimates of energy savings.

5.2 External Validity

The evaluation team selected sample designs and data collection methods that would ensure the *external validity* of our results. These included a two-wave data collection strategy, a census of course participants, and a multi-mode survey design.

We used our Wave 1 participant survey results to adjust our Wave 2 sample design. For Wave 1, we sampled courses and attempted to complete interviews with all participants of those courses. The result was 2,864 completed interviews and a 28% response rate. To report energy savings at the Center level and ensure that our Wave 2 results were reflective of the larger participant population, we needed to interview more respondents. As a result, we attempted a census of participants for Wave 2. We completed 4,907 interviews with a 25% response rate.

As we had hoped, the census was successful at increasing the number of completed surveys. However, whether we drew a sample of participants or attempted a census, our response rates were roughly the same.[18] Because we have data on approximately one-quarter of the participant population, we need to be concerned about non-response bias, which could impede our ability to extrapolate our survey results to the larger participant population. Non-response bias occurs when people who do not complete the survey are different from those who do in a way that is correlated with the variables of interest in the study. It can be reduced by taking extra effort to complete interviews with people who are difficult to reach or are less inclined to participate.

---

[17] An example is the changes we made to our market actor impact questions. In both waves, we asked market actors who changed their practices several follow up questions about the types of changes they had made. In Wave 1, nearly three-quarters of market actors indicated making each type of change. We felt there should be more variation among these responses given the variety of actions in question. For Wave 2, we fine tuned the question wording but also allowed respondents to say the question did not apply as their work did not involve the activity in question. We also asked market actors to describe the change in their own words. The result was more variation in responses and a richer understanding of the changes made.

[18] This is to be expected since we used the same data collection strategies for Waves 1 and 2. There are a number of potential sources of survey error that apply to sample surveys as well as those conducted through a census. Sampling error is the most commonly discussed source of survey error and can be quantified. Non-response error is another and cannot be quantified in the same way as sampling error. We need to be concerned with both sampling and non-response error for the Wave 1 survey results. Because Wave 2 was a census attempt, sampling error is not a concern. However, since not every participant completed a Wave 2 survey, non-response error could still be a problem.

To ensure as high of a response rate as possible and reduce non-response bias, we conducted the participant survey on-line and via the telephone. For participants who provided an email address (82%), we first sent them an email requesting they fill out an on-line survey. If they did not complete the survey, we followed up by telephone. We sent two email reminders before attempting to contact a participant by telephone. We also attempted telephone surveys with participants who only provided a telephone number (18%) or if their email survey request came back as undeliverable (21% of participants with email address). We called each participant numerous times at different times a day and called participants back at a later time if it is was more convenient.

These extra efforts not only increased our overall response rate, but likely helped us to complete surveys with participants who were more difficult to reach. We have no prior information on whether or how participants who are difficult to reach might be different from those who are more likely to complete a survey. Since we used the telephone survey to follow up with participants who did not reply to the internet survey request, a comparison of the surveys' results could provide an indication of whether such differences exist and if multi-mode survey design enhanced the external validity of the results.

Tables 23 through 26 compare internet and telephone respondents on several survey questions. We reached similar types of participants via the internet and the telephone. Market actors comprised 56% of the internet respondents compared to 53% of telephone respondents, but overall, the two surveys methods reached similar participant types.

Table 25: Type of Participant by Mode of Survey Administration

Type of Participant	Internet (n=3,317)	Telephone (n=1,580)
Market Actors	56%	53%
End Users		
Residential	15%	17%
Commercial	30%	30%

More telephone survey respondents report having "a lot" of knowledge of the course material prior to taking the course than internet respondents. But as Table 25Table 26 shows, more telephone respondents also report having little or no prior knowledge.

Table 26: Prior Knowledge of Course Material by Mode of Survey Administration

Prior Knowledge	Internet (n=3,317)	Telephone (n=1,580)
A lot	23%	30%
Some	58%	44%
Very Little	17%	21%
None	3%	5%

Slightly more internet respondents report a high level of knowledge gain than telephone respondents, more of whom report moderate knowledge gains (see Table 27).

Table 27: Knowledge Gain by Mode of Survey Administration

Knowledge Increase	Internet (n=3,317)	Telephone (n=1,580)
High	43%	39%
Moderate	44%	48%
Low	12%	12%
None	1%	2%

Overall, internet respondents are slightly more likely to report taking energy saving action as a result of the course. However, as Table 28 shows, this is only true of end-users. Market actors who completed a telephone survey are more likely to report taking action than market actors who completed an internet survey.

Table 28: Took Energy Saving Action by Mode of Survey Administration

	Internet (n=3,317)	Telephone (n=1,580)
Overall	69%	66%
Residential End-Users	46%	37%
Commercial End-Users	79%	71%
Market Actors	69%	73%

Overall, the telephone survey respondents are only slightly different from the internet survey respondents. Since telephone respondents are more difficult to reach, they are likely similar to participants who did not complete a survey. Given the small differences between the internet and telephone survey results, we have increased confidence that the survey respondents are representative of the larger participant population and that non-response bias is minimized.

The external validity of our results is also enhanced through our use of surveys that included participants who took a wide variety of courses and, as a result, a wide range of energy saving actions. Across 12 different end-uses, our surveys included questions about 204 possible actions that could have been reasonably taken based on our review of course materials. In the end, participants took 104 of these actions. (Appendix C lists the unique actions buy end-use and the number of participants taking each one.)

With a traditional M&V approach, it would not have been cost-effective to do on-site work that included as many participants who took such a variety of actions. Our survey based approach provides a more comprehensive understanding of the variety of actions taken and the resulting energy savings. The trade-off is that we must rely on self-reported data to cover such a wide range of actions. However, we are confident that this method provided results that are representative of the overall population of participants and the impact of the Energy Centers.

5.3 Internal Validity

The internal validity of the evaluation is enhanced through the wording of the survey questions and method the Evaluation Team used to assess net energy savings.

The causal relationship underlying the evaluation is that course attendance causes changes in cognition that bring about behavior change. We applied the Cognitive Change Index as the value representing the influence of the program (and as such, the causal factor in the savings provided). A brief discussion of the approach can be found in Section 4. A more detailed discussion is available in Appendix E

Additionally, to help reduce temporal ambiguity (i.e., the timing of when information was learned) and ensure that the reported behavior changes were taken as a result of what participants learned in the course and not some other reason, we carefully worded the survey questions to focus respondents only on changes that were because of the course.

Examples include:

10. Using a scale of 1 to 7 where 1 is no more knowledgeable and 7 is significantly more knowledgeable, *as a result of your participation in this course*, to what degree did your knowledge of how to accomplish the course concepts increase?
11. *As a result of taking the course*, I recommend energy efficient technologies or practices to my management more often.
12. *Since your participation in the [COURSE NAME] course*, have you made any efforts to save energy at the facility(ies) your business occupies or manages *where you applied the concepts taught in the course*?
13. *Since your participation in the [COURSE]*, have you changed or enhanced the service you provide to your [clients/students] *where you applied the concepts taught in the course?*

Full survey instruments can be found in Volume III.

6. PROGRAM REACH

This section presents our findings on program participation and the reach of the Energy Centers. First we present course participation information. Second we present program reach data both by market segment and end use.

6.1 Program Participation

Over the three year evaluation period (January 1, 2006 – December 31, 2008), the nine Centers offered 840 unique courses that 39,793 unique people attended. Many people took more than one course so that the total number of course attendees was 97,997 across the three years.[19]

The courses varied in length and structure from one hour lunch-time talks to multi-day seminars. The average length of a course was 5.7 hours. By summing the length of each of the 97,997 course attendances, we find that the Centers combined to offer 547,560 hours of training, which is the equivalent of approximately 350 four-year college educations.

Program Participation Facts: 2006-2008

- Number of Course Attendees: 97,997
- Percent Taking More Than One Course: 39%
- Number of Unique Course Takers: 39,793
- Number of Courses with Unique Content: 840
- Average Course Length: 5.7 hours
- Total Hours of Training: 552,913 (~ 350 4 year college educations)

The breakdown of participants by Energy Center is shown in Table 29. This table also shows the number of unique courses offered by each Energy Center. The number of unique participants in Table 29 (44,729) is greater than the overall number of unique participants (39,793) because some participants took courses at more than one Center and therefore are counted in each Center's total.

[19] Each Center provided the Evaluation Team with a list of participants for each course. These lists were combined and cleaned to create a participant profile for each unique participant. We removed IOU employees, course instructors, participants who resided outside the U.S. and participants who lacked course information. The participant totals presented in this section are the number of "evaluable" participants. The methods section contains more information on how we created the participant profiles.

Table 29: Overall Participation by Center

Center	Total Participants	Unique Participants	Unique Courses
PEC	16,541	8,196	159
ETC	16,745	9,650	141
FSTC	1,902	1,515	22
AgTAC	3,686	1,838	105
CTAC	16,850	7,291	116
TTC	979	864	8
SCG ERC	28,763	10,244	119
SDG&E ERC	9,518	3,252	100
CCSE	3,013	1,899	70
Total	**97,997**	**44,729**	**840**

Table 30 provides a number of different measures of frequency of course offerings by end-use. These include the number of courses with unique content, the number of training sessions in which a unique course is offered more than once, the number of unique participants, the total number of participants, and finally the total hours of training.

HVAC is the leader across all of these categories. Regardless of which measure we use, the Centers offered more courses that were taken by more people for more hours on HVAC than any other end-use. One quarter of the Energy Center training hours were devoted to HVAC related topics. Courses on green building, lighting and renewables were also popular.

The Centers offer a number of courses on general energy efficiency topics that could address a variety of end-use areas. Examples include AgTAC's "Managing Your Residential Energy Costs" or CTAC's "Introduction to Life Cycle Costing". Courses on "other" topics that were not offered enough to warrant a dedicated end-use impact module include CTAC's "Industrial Maintenance" course or ETC's "Dairy Energy Management course.

Table 30: Course Offerings and Participation Levels by End-Use:
Nine IOU Energy Centers, 2006-2008

End-Use	Unique Courses	Training Sessions	Unique Participants	Total Participants	Hours of Training
HVAC	149	663	9,990	30,311	143,815
Green Building/Envelope	100	224	7,290	11,027	81,814
General/Other	141	323	8,342	11,312	62,774
Renewables	27	211	6,087	8,134	47,203
Lighting	120	310	6,262	10,032	44,444
Boilers/Furnaces/Water Heating	43	119	3,090	4,790	39,909
Commissioning	26	74	1,117	1,972	32,886
Title 24	50	187	4,204	5,995	29,567

End-Use	Unique Courses	Training Sessions	Unique Participants	Total Participants	Hours of Training
Motors/Pumps	38	97	2,165	2,822	19,991
Commercial Cooking/Foodservice/ Refrigeration	58	127	3,585	4,951	15,928
Controls/EMS	34	74	1,483	1,841	11,081
Financial Incentives	26	101	2,237	2,448	7,061
Compressed Air	11	31	897	990	6,637
Water Management	8	11	603	742	6,073
CHP/Gas Engines	5	5	297	363	2,194
Pools	4	24	254	267	1,538
Overall	**840**	**2,581**	**39,793**[20]	**97,997**	**552,913**

6.2 Program Reach

Here we present the reach of the Energy Centers both by market segment (market actor, commercial end-user and residential end-user) and by the subject matter or end-use of the course.

Reach by Market Segment

Our analysis provided a review of the segments that were reached through the Centers programs. In the course participant surveys, we asked a series of questions that were used to classify respondents by their occupation or reason for taking the course. We identified three main types of participants:

Market actors who took the course to learn something they could apply in their client's facilities.

Commercial end-users who took the course to learn something they could apply in their company's own facility or one they manage.

Residential end-users who took the course to learn something they could apply in their homes or who did not have a specific purpose in mind.

As shown in Table 31, just over half of the unique course takers across all nine Centers were market actors (55%), followed by commercial end-users (30%) and residential end-users (15%). By multiplying these percentages by the total number of unique course participants from 2006 through 2008, we also provide an estimate of the number of course participants in each category.

[20] The number of unique participants is the number of unique individuals in each end-use. Because some people attended courses in multiple end-uses, the sum of the unique participants by end-use would greater than the total number of unique participants overall. The overall number represents the actual number of unique participants across all end-uses and not the sum of unique participants by end-use.

Table 31: Course Participant Type

Participant Type	Percentage	Participants
Market Actors[21]	55%	19,941
Commercial End-Users	30%	10,877
Residential End-Users	15%	5,439
Total	**100%**	**36,257[22]**

The remainder of this section presents specific information on the reach of the Centers among each course participant type.

In all, the Centers have reached nearly 20,000 market actors across the state. Table 32 shows the breakdown of industry areas among market actors.

[21] This includes Code officials (<1%), HERS raters (<1%) and teachers (2%).

[22] In Table 31, we show that there were 39,793 participants. However, though our survey efforts, we learned that approximately 9% were ineligible to be included in our evaluation for a variety of reasons. Some were course instructors or energy center employees. Others registered for the course but were unable to attend. The adjusted number of unique participants is 36,257 and is the basis for our population estimates going forward.

Table 32: Industry Area of Market Actors

	Percent (n=2,695)
Engineering or Architectural Design	36%
Construction	25%
Lighting	23%
HVAC	19%
Energy Technology Research/Consulting	15%
Renewables	14%
Facility Operations or Maintenance	9%
Government Agency/Regulatory/Inspector	9%
Boilers/Water Heating Sales	9%
Refrigeration	7%
Motors	7%
Pumping/Hydraulic Equipment	6%
Energy Conservation Services/Energy Audits	1%
Other	8%
Don't Know/Refused	6%

Note: Market actors could select more than one industry area so the percentages sum to more than 100%.

Using the self-reported industry areas in Table 32 and the total number of market actors reached by the Centers, we calculated an estimated number of market actors reached in each industry area. We compared these numbers to the number of market actors statewide[23] to get a sense of the reach of the Centers across different industries. Table 33 presents the estimated proportion of market actors reached by the Centers during the evaluation period by market actor type. Our analysis indicates that the Centers are having particular success in reaching the HVAC/Refrigeration industry area as well as Engineering/Architectural Design.

It should be noted that the employment categories used to estimate the number of statewide market actors do not map directly to the industry areas listed in Table 32. Many categories include several types of workers, only a portion of which would be a direct target of the Energy Center courses. As a result, the number of statewide market actors is often an overestimate. Thus, our estimate of the percent of market actors reached by the Centers is conservative in many cases. In addition, the market actor figures are based on statewide employment numbers while the Centers only target the portion of California served by the four IOUs.

[23] The California Employment Development Department provides estimates of statewide employment for each of the employment categories in the US Bureau of Labor Statistics' Standard Occupation Classification Codes (SOC Codes). In some cases, our estimates are an aggregate of several SOC employment categories.

Table 33: Market Actors Reached by Industry Area

	Market Actors (Statewide)[24]	Estimated Reach by Centers	Percent Reached (Statewide)
HVAC & Refrigeration[25]	19,700	9,427	44%
Government Agency/Regulatory/Inspector	12,500	3,263	26%
Engineering/Architectural Design	58,200	13,053	22%
Lighting	68,300	8,339	12%
Construction	161,200	9,064	6%
Boilers/Water Heating Sales	56,000	3,263	6%
Other	55,800	2,901	5%
Motors	49,400	2,538	5%
Facility Operations or Maintenance	163,000	3,263	2%
Energy Technology Research/Consulting	N/A	5,801	N/A
Pumping/Hydraulic Equipment	N/A	2,175	N/A
Renewables	N/A	5,076	N/A
Don't Know/Refused	N/A	2,175	N/A

Because market actors have the ability to affect change in a larger number of buildings than a single commercial or residential end-user, the Centers efforts could potentially impact a larger segment of the market through the market actors who attend the courses.

In addition to market actors, the Centers reached nearly 12,000 commercial customers. This level of participation compares favorably to the Standard Performance Contract (SPC) program, which is a nonresidential retrofit program run by PG&E, SCE and SDG&E. In comparison, during PY2004-2005, SPC reached 1,499 businesses.[26]

Survey respondents were asked to categorize their business, Table 34 presents the range of business types identified. In general, the Centers are reaching a diverse group of businesses; however close to half of businesses categorize themselves in one of three business types: office, industrial process/manufacturing/assembly, or government.

---

[24] Source: California Employment Development Department: http://www.edd.ca.gov/. In some cases, these are an aggregate of several SOC employment categories.

[25] HVAC and Refrigeration are combined here in order to compare to employment statistics.

[26] 2004-2005 Statewide Nonresidential Standard Performance Contract Program Measurement and Evaluation Study: Impact, Process and Market Evaluation Final Report. Itron, October 2008.

Table 34: Type of Business

Category	Percent (n=1,241)
Government	17%
Industrial Process/Manufacturing/Assembly	15%
Office	11%
College/University	7%
Health Care/Hospital	5%
School	5%
Contractor	4%
Community Service/Church/Temple/Municipality	3%
Engineering	3%
Retail (Non-food)	3%
Restaurant	2%
Condo Association/Apartment Management	2%
Personal Service	2%
Research/Laboratory	2%
Warehouse	2%
Construction/Building Design	2%
Agriculture	2%
Transportation	2%
Hotel/Motel	1%
Water Related Industry	1%
Grocery Store	1%
Technology/IT/Computers	1%
Food Industry	1%
Entertainment/Recreation	1%
Other	4%
Don’t Know/Refused	1%

Table 35 presents additional demographic information about the businesses that are taking courses across the nine Energy Centers. Generally, the businesses are medium to large, have ten or fewer locations and own their facilities. These are the commercial end-users most likely to have the resources and authority to implement energy savings actions in their facilities.

Table 35: Demographic Data:
Commercial End-Users (n=1,241)

Size of Business	
Small	24%
Medium	28%
Large	38%
Don't know/Refused	10%
Number of Locations	
1	34%
2 to 4	18%
5 to 10	12%
11 to 25	8%
Over 25	19%
Don't Know/Refused	9%
Own or Lease Facility	
Own	69%
Lease	23%
Both own and lease	4%
Other	1%
Don't Know/Refused	3%

Note: Respondents self-classified the size of their business. They were asked to compare it to others in their industry.

Finally, the Centers reached close to 6,000 residential end-users. Compared to other residential education efforts, such as the HEES survey which reached close to 75,000 customers during PY 2006-08, the reach of the Education and Training programs are clearly smaller.[27] However, this is consistent with the Centers' primary focus of educating commercial customers and market actors.

As shown in Table 36, the residential end-users reached by the program are a well-educated, affluent population, a majority of who are over the age of 35 and live in single-family, detached dwellings. These residential customers are the ones most likely to take energy saving actions in their homes.

[27] Source: Process Evaluation of the SCE 2006-08 Home Energy Efficiency Survey (HEES) Program, August 4, 2009. ECONorthwest.

Table 36: Demographic Data:
Residential End-Users (n=713)

Home Type	
Detached Single Family	76%
Multi-Family	12%
Attached Single Family	8%
Mobile Home	2%
Other	1%
Age	
18-34	9%
35-44	17%
45-54	28%
55-64	28%
65+	15%
Refused	3%
Education Level	
Less than HS	1%
HS Graduate	4%
Trade School or Some College	19%
College Graduate	31%
Post-Grad	42%
Refused	3%
Income Level	
Less than $20,000	4%
$20,000 - $49,999	12%
$50,000 - $74,999	15%
$75,000 - $99,999	16%
$100,000 - $199,999	25%
$200,000+	5%
Don't Know/Refused	24%

Reach By End Use

The courses offered by the Centers covered 16 different end-use categories. The number and variety of end-uses is similar to those covered by IOU resource acquisition programs. In fact, many of the trainings sought to channel participants into the utilities' resource acquisition programs.

The Centers are likely having the greatest impact on the HVAC, lighting, green building and renewable markets. As shown in Table 37, the Centers offered more unique courses on HVAC than any other end-use. Lighting and building envelope were also popular course subjects. In addition to specific end-uses, a number of courses covered energy saving topics of general interest and were classified as "general/other". Examples include courses on the impact of climate change on businesses or advice on how to implement energy efficiency projects. Others covered a wide range of end-uses such as the "Technology Update," which gave participants information on the latest energy efficiency technology in HVAC, lighting, motors and a number of additional areas.

Table 37: Unique Course Offerings by End-Use

End-Use	Unique Courses
HVAC	149
General/Other	141
Green Building/Envelope	100
Lighting	120
Renewables	27
Title 24	50
Commercial Cooking/Foodservice/Refrigeration	58
Boilers/Furnaces/Water Heating	43
Motors/Pumps	38
Financial Incentives	26
Commissioning	26
Controls/EMS	34
Compressed Air	11
Water Management	8
CHP/Gas Engines	5
Pools	4
Total	**840**

When considering market segment and subject matter, the broadest reach was clearly within HVAC: HVAC courses were the most popular courses among both market actors and commercial end-users. However, renewable courses, which were mainly on solar technology, were the courses most frequently attended by residential end-users. (Note that this is consistent with where we see changes in Section 8)

Table 38: Percent of Unique Participants by Type and End-Use

End-Use	Market Actors (n=2,695)	Commercial End-Users (n=1,459)	Residential End-Users (n=753)
Renewables	15%	9%	53%
General	12%	18%	11%
Building Envelope	19%	10%	11%
HVAC	12%	15%	7%
Lighting	13%	11%	6%
Title 24	11%	4%	2%
Boilers/Hot Water	4%	7%	3%
Commercial Cooking/Refrigeration	4%	6%	3%
Financial Incentives	3%	3%	1%

End-Use	Market Actors (n=2,695)	Commercial End-Users (n=1,459)	Residential End-Users (n=753)
Motors/Pumps	1%	6%	<1%
Controls/EMS	1%	3%	1%
Commissioning	2%	2%	<1%
Compressed Air	1%	3%	<1%
Water Management	<1%	2%	1%
Combined Heat & Power/Gas Engines	1%	1%	<1%
Pools	1%	<1%	<1%

This breakdown also provides insights into the type of information learned by course participants, described further in Section 8.

7. Knowledge Change

Decision 05-04-051 (April 21, 2005), for Education and Training Programs states that "*For schools, universities and other training programs, the performance basis should be based on: attitude, awareness, and knowledge of students*" as well as on energy savings from behavior changes. As such, throughout this chapter, we present findings of key changes in knowledge and attitudes, followed by behaviors in the next section. We present overall findings in this section. Center-by-Center data is available in Volume II.

7.1 Knowledge Gain

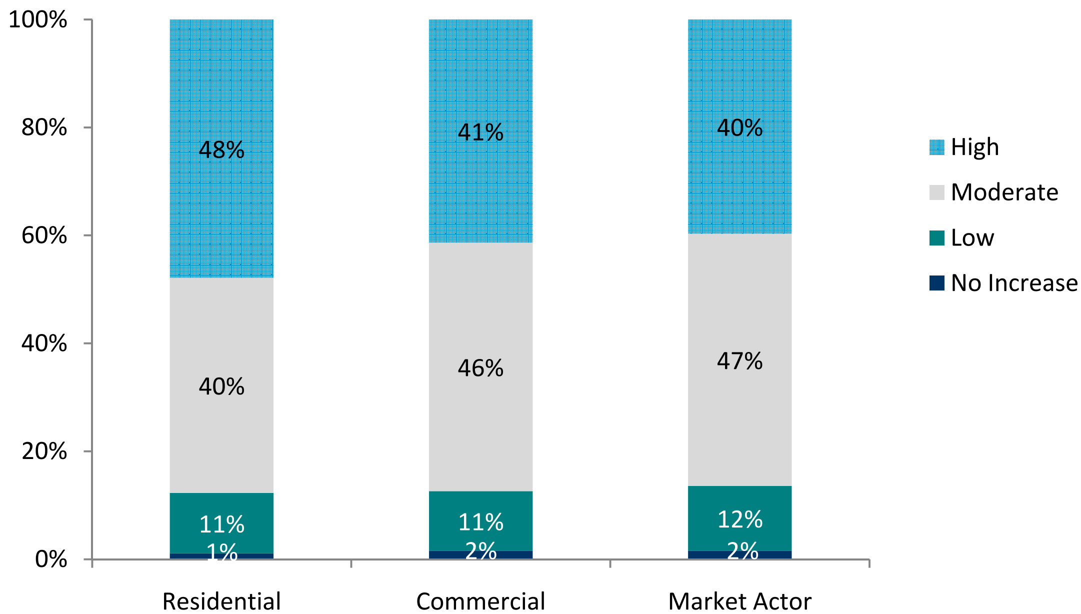
We asked course participants whether the courses provided them with new information. Nearly all said they did (95%). Two percent of respondents, who stated that they did not learn anything new, thought their participation moved them closer to implementing efforts to save energy that they were already considering.

When we explored the depth of the knowledge increase, results were split between a moderate and large increase in knowledge: 40% of market actors, 41% of commercial end-users, and 48% of residential end-users reported that they became significantly more knowledgeable about how to achieve course concepts; an additional 40% to 47% of all segments reported a moderate increase in knowledge. (See Figure 3.)[28] The split between moderate and large increases in knowledge was relatively consistent across the three types of participants: residential end-users, commercial end-users, and market actors.

---

[28] Our findings regarding self-reported awareness of energy efficiency (as opposed to knowledge) were almost identical to knowledge, so we focus on knowledge in this chapter.

Figure 3: Knowledge Increase by Participant Type



Note: Participants were asked to rate the impact of the course on their knowledge of how to achieve course concepts using a 7-point scale in which 1 represented "no more knowledgeable" and 7 "significantly more knowledgeable". High includes responses of 6 and 7; Moderate includes 4 and 5; Low includes 2 and 3; and No Increase includes responses of 1.

Our analysis showed that self-reported knowledge change was relatively consistent across the various end-uses (e.g., HVAC, lighting, building envelope, etc.).

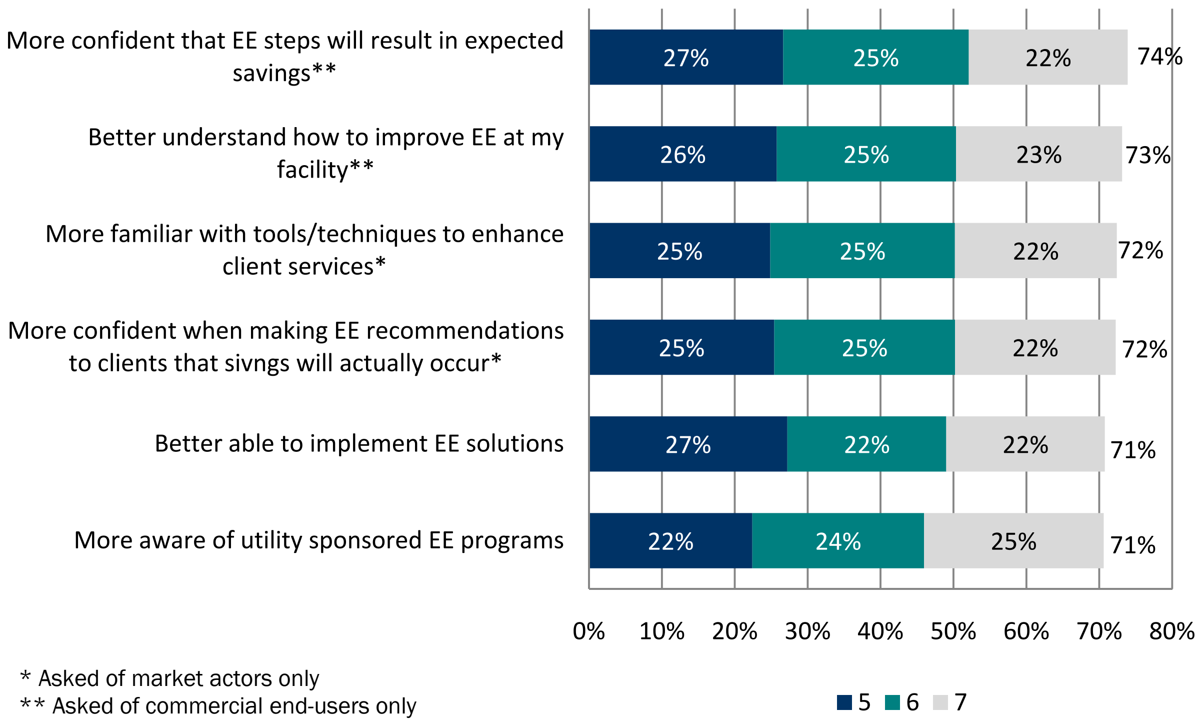
As Figure 4 shows, the courses were effective at increasing knowledge among all course participants regardless of the amount of prior knowledge they had of the course concepts.

Figure 4: Mean Knowledge Increase by Prior Level of Knowledge

To further investigate the impact of the courses on participants' knowledge of energy efficiency topics, we asked respondents about several areas that had the potential to be impacted by the courses. The questions covered subjects such as tools and techniques used in their work or implementing energy efficient solutions. We used a 7-point scale in which 1 indicated "strongly disagree" and 7, "strongly agree." Across all areas, at least 70% of respondents rated their agreement as a 5 or higher, indicating that the course had a positive effect on their knowledge. Figure 3 displays the frequency distribution of respondents who agreed that their knowledge had increased and shows the responses to be fairly evenly distributed among the top three categories.

In addition to reporting an increased understanding of how to implement energy efficiency opportunities, 71% of participants agreed that they were also more aware of utility-sponsored energy efficiency programs as a result of taking the course. We provide details regarding channeling participants into utility-sponsored rebate programs in Section 9.

Figure 5: Percentage of Respondents that Agreed
That the Course Impacted Specific Areas of Knowledge



Note: Participants rated their agreement with each statement using a scale of 1 to 7 where 1 is "strongly disagree" and 7 is "strongly agree" – 5 through 7 all indicate agreement.

7.2 Detailed Results by Subject Area

To more fully understand what participants learned in Energy Center courses, we conducted in-depth interviews with market actors who took courses in HVAC, lighting, and building envelope, which were the most popular course subjects among market actors. Participant comments provide a more nuanced image of how the courses have influenced their work. Among different end uses, participants of HVAC courses were more likely in most cases to report gains in knowledge than other participants. We describe these findings below.

HVAC

Market actors who took the HVAC course(s) report that they have improved the quality of their work as a result of using different diagnostic tools, through the availability of new data and the refinement of their skills. In addition, they acquired new information that has allowed them to adopt new planning, design and installation practices.

- *"We are using an entirely different set of diagnostic tools to determine what needs [to be] done in order to improve efficiency of units."*
- *"I'm doing more calculations of peak loads. I'm sealing ducts better. I'm choosing high efficiency equipment, and I've learned about the whole house in general -- you*

know, from infiltration, insulation in windows and that sort of thing. The classes totally upgraded my skills."

- *"We were looking at actually using a lot of the technology that was in the class to help in evaluating the data centers and showing up the change of control strategy.*
- *"It gave us some ideas on how to evaluate different AC techniques for cooling."*

Knowledge gained in the courses also changed the sales pitches delivered by some market actors. Others are changing their sizing practices to size down equipment. Some are doing much more work in certain areas than before. One participant noted, "I'm doing a lot more [duct optimization] now. I'm doing 50% more let's say than I did before." In some cases, market actors were trained in how to evaluate different optimization techniques, conduct troubleshooting or better plan their HVAC duct work.

Lighting

Market actors who took lighting courses report that the courses have enabled them to educate their customers, provided them with a better understanding of differentiation between products, as well as different installation, stocking, and inventory practices. The following quotes from participants illustrate what the Energy Center courses teach lighting market actors:

- *"I have learned what the cost savings is and I've shared that with them [my clients] to help them in deciding, based on what the cost of the fixture is and forth, what the payback is."*
- *"Because we specify the product, I think just learning about products that were available made us understand a little bit better what's new, what's you know – a good product."*
- *"Well it was more of an education as far as knowing the differences in the products. It wasn't product specific, but I learned more about the actual product that we sell."*
- *"It just you know, keeps me informed and you know gives me a little bit wider range of arguments I can make to my clients. So maybe you can just say that you know it gives me better tools for working with my clients."*
- *"Just in regards to the LEDs, a little more knowledgeable about how they work and how they last and the pluses and minuses."*

Beyond changes in the equipment installed or the diagnostic tools used to assess energy efficiency, market actors also changed the way they interact with clients. As a result of the courses, they report having additional arguments to use in supporting their recommendations, as well as recommending different products than they would have previously.

Building Envelope

Based on interviews with market actors who took building envelope courses, it is clear that the courses had an important impact on their work by providing them with an improved understanding of home performance, as well as assistance in making recommendations and offering advice to clients, and also in changing their installation practices. Individual respondents remarked as follows:

- *"I think the overall benefit in taking these courses has been picking up knowledge that was presented at these classes on numerous topics. All aspects of home performance and a house's system… I would say it's just much deeper level of understanding about how to be more aware of a lot of the details on all the subsystems that provide performance and energy at home."*
- *"I better understand the relationship between green building and building performance than I did prior to taking those classes so I could talk to clients and answer their questions that are about why building performance is so improving a carbon footprint in a house and so forth."*
- *"I think the most important information we learned was on ventilation and a very good explanation of the new Title 24 requirements and heat recovery ventilators and how they should be used."*
- *"As a matter of fact, before the class I really didn't understand the significance of solar heat gain coefficient. And after having attended the class, I'm more concerned with solar heat gain coefficient and, as a matter of fact, can talk to the home owner about the importance of [it]."*

In addition, participants in the building envelope courses report that they provide greater value to their customers by making more informed recommendations and also by employing the tools and techniques covered in their courses to more accurately measure, test or calculate building performance. As one participant noted, they are also able to disseminate their knowledge to the market more generally through their relationships with other designers and contractors.

- *"Now I can go in there [to a client] and explain in more detail about every type of insulation that is available to them. Whereas before I couldn't do that, and I think that resulted in more insulation being installed."*
- *"What I can do now is I can advise people; I can advise [the] installer or I advise sales teams or advise clients even directly which materials to choose and I can explain a little bit more about the different types of materials."*
- *"We're doing more upfront analysis; we're analyzing early design schemes in terms of their impact…so we're able to give them a more efficient building you know by extending options and incorporating changes earlier."*
- *"I felt that overall it was a huge shift in our ability to do the work by taking the classes and more clearly understanding the details of overall home performance."*

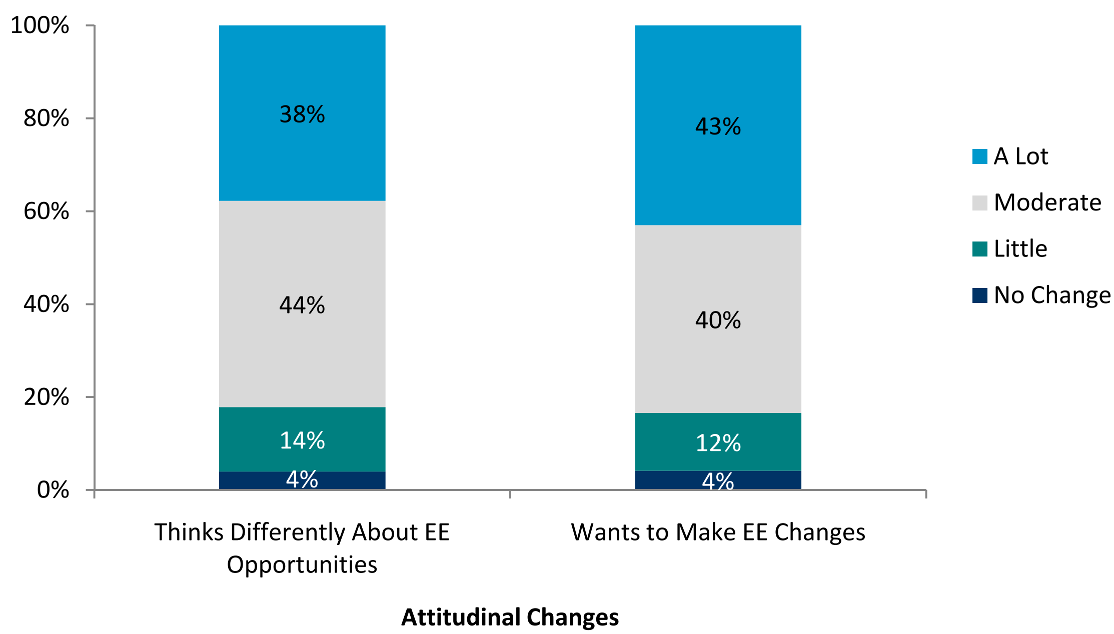
- *"We're spending a lot more time talking with our designers and our contractors about better methods and better techniques to give themselves a tighter envelope, to redesign their ductwork so that it actually is more functional."*

The courses that respondents took at the Energy Centers had an important influence on their decision to make these types of changes in their professional practice. Several participants stated that they don't think they would have made the changes they did without the course(s). Additionally, participation in the courses and the changes made as a result generally illustrate market actor interest in and commitment to improving the quality of their work. Given economic conditions, not all respondents reported growth in their businesses over the evaluation period, but the majority of interview participants feel they are better at their jobs as a direct result of attending a course.

7.3 Attitudinal Change

The courses also changed how participants think and feel about energy efficiency opportunities. As a result of taking the courses, the large majority of participants report thinking differently about energy efficiency opportunities and wanting to make energy efficiency changes. Over 80% of respondents noted that they think differently as a result of their coursework. Slightly under half said that their attitudes changed a lot (43%) while two of five noted that there was a moderate change (44% to 41%).

Figure 6: Course Impact on Attitudinal Change



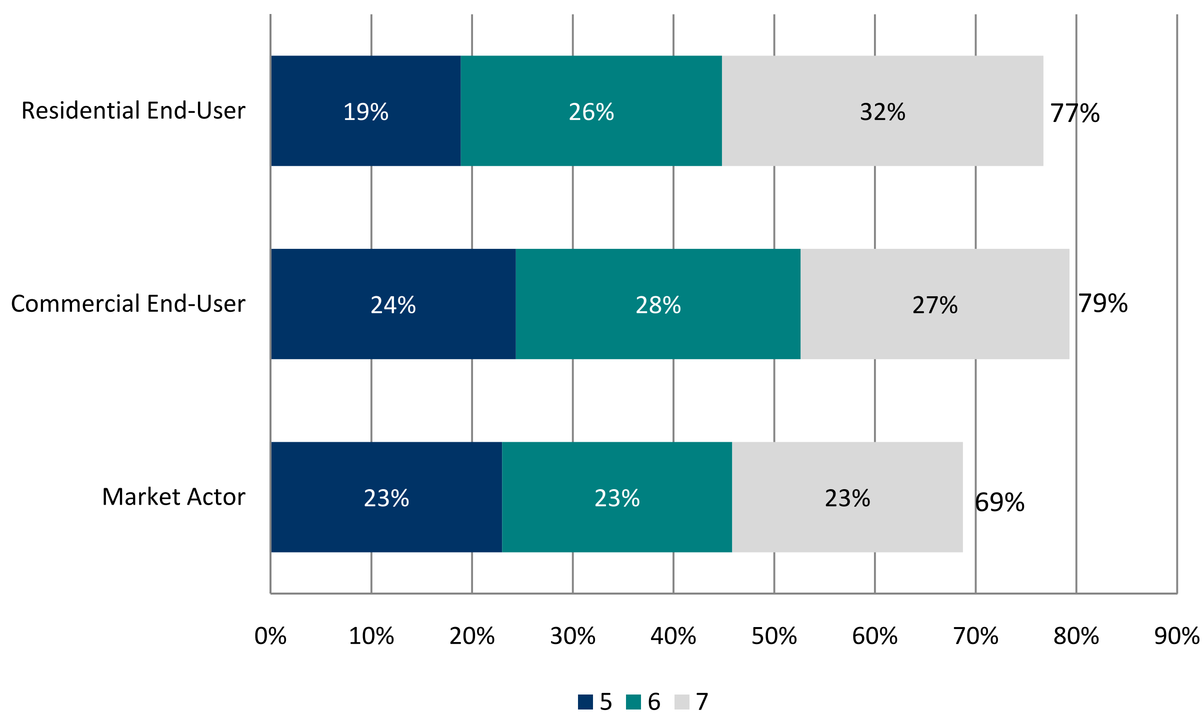
Note: Using a 7-point scale where 1 represented "not at all" and 7 "a great deal, participants were asked to rate the impact that the courses had on their thinking about energy efficiency opportunities. The wording for each participant type was slightly different, but the concepts remained the same A Lot includes responses of 6 and 7; Moderate includes 4 and 5; Little includes 2 and 3; and No Change includes responses of 1 on a scale of 1-7.

Residential, commercial and market actor participants showed similar levels of attitude change.

7.4 Overall Perceptions of the Value of the Courses

To understand participants' opinions regarding the value of the course we asked participants to rate their agreement with the statement that the course was a good way to explain the importance of taking advantage of energy efficiency opportunities. A majority of both end-users (77%-79%) and market actors (69%) agreed with this statement (see Figure 7). Almost one-third of residential participants strongly agreed (rated 7) (32%) with commercial end-users following at 27% and market actors at 23%.

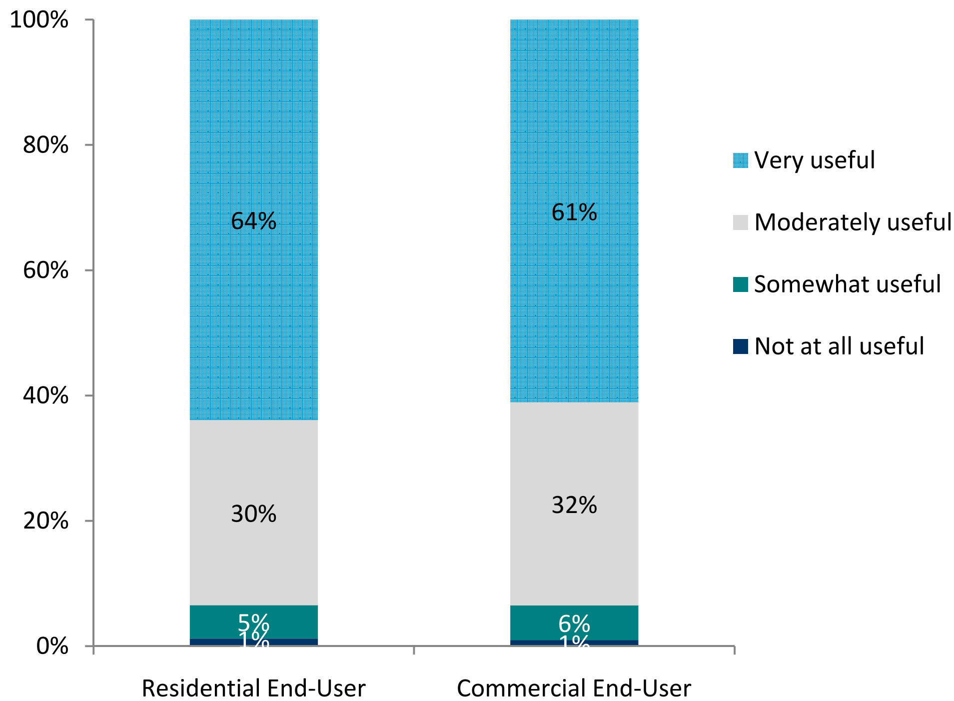
Figure 7: Agreed the Course Was a Good Way to Explain the Importance of Taking Advantage of Energy Efficiency Opportunities (Rated Top Three)



Note: Participants rated their agreement with each statement using a scale of 1 to 7 where 1 is "strongly disagree" and 7 is "strongly agree" – 5 through 7 all indicate agreement.

End-users also found the courses to be useful. When asked how useful the information presented in the course was, just under two-thirds of all end-users reported the information was very useful (rated 6 or 7). Residential and commercial end-users show similar results, with only one percent of both considering the course as not at all useful (See Figure 8).

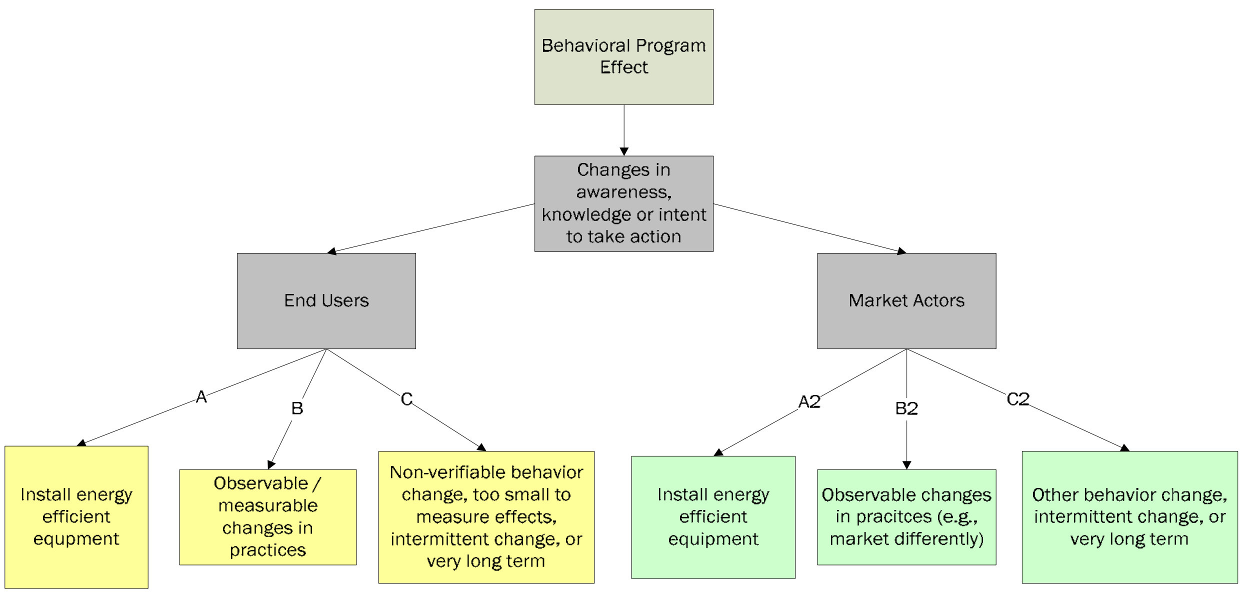
Figure 8: Usefulness of Course Information by End-User



8. BEHAVIOR CHANGE

In addition to changes in knowledge and attitudes, we examined behavior changes among end-users and market actors. Based on the protocols for evaluation of programs that are designed to change behaviors, we investigate three types of behavior changes. Figure 9 is a diagram of the behavioral program effects outlined in California Energy Efficiency Evaluation Protocols and serves as a guide for the types of behavior changes we evaluate: A) installations of energy efficient measures (such as the installation of new lighting), B) changes in practices that directly lead to energy savings (such as changes to operation and maintenance), and C) other behavior changes that are too small to measure, or could have delayed effects (such as sharing information with others, or seeking out additional information).

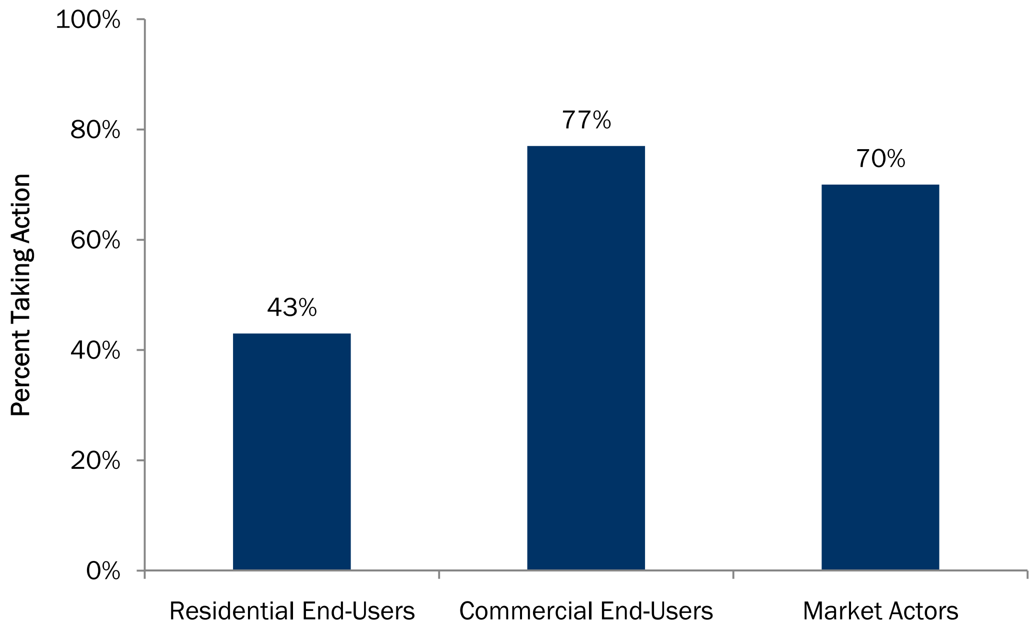
Figure 9: Behavioral Program Effect



8.1 End-User and Market Actor Changes

We asked course participants whether they had made any efforts to save energy based on what they learned in the course. Among residential respondents, approximately two out of five (43%) took actions to save energy in their homes whereas almost four out of five commercial respondents (77%) took energy saving actions at their facility as a result of the course. Market actors most closely resembled commercial users in the percentages that took action, although the extent of the market actor changes are much broader since they have the potential to influence numerous end-users. Some 70% of market actors indicated that they changed or enhanced the services they provide to clients using concepts learned in the courses they took.

Figure 10: Course Impact on Energy Saving Behaviors



In total, based on our review of course content, the courses provided participants with information about 204 possible actions: 126 types of energy efficient equipment that could have been installed and 78 energy saving practices or behaviors that did not require the installation of equipment.

Below we explore the types of changes made by end-users, followed by changes made by market actors.

8.1.1 End-User Changes

As shown in Figure 10, 43% of residential end-users took some sort of action. For residential end-users who took action, the majority were changes in Renewables, followed Building Envelope, HVAC and Lighting. (Note that the table uses the base of all respondents within the group who took action.)

Commercial end-users reveal different trends with actions taken primarily in HVAC, Lighting, and Building Envelope. Again, a larger percentage of commercial end-users (77%) took action following the course.

The numbers shown in the table below reflect the number and types of changes made, not the energy savings associated with those changes. (We present Energy Savings in Section 9).

Table 39: Percent Taking Actions in End Use of Total Who Took Action

End Use	Percent of Residential End-Users Who Took Action (n=318)	Percent of Commercial End-Users Who Took Action (n=1,080)
Renewables	33%	5%
General	19%	21%
Building Envelope	16%	9%
HVAC	9%	17%
Lighting	9%	13%
Boilers	4%	7%
Title 24	4%	4%
Refrigeration/Commercial Cooking	3%	6%
Controls	1%	3%
Water Management	1%	2%
Compressed Air	--	3%
Motors and Pumps	--	6%
Commissioning	--	3%
CHP	--	1%
Total	100%	100%

Additional End-User Actions That May Lead to Savings Over the Longer Term

In addition to installations and behavior changes, we asked residential and commercial participants whether they had taken any other actions that could lead to energy-saving behavior in the future either by themselves or by others (See Table 40). A majority of end-users shared course information with someone else, while a sizable number were motivated to search for additional information related to the course concepts. An equally large number of commercial participants took an advocacy role after taking the course by helping convince others in their organization that additional energy saving actions were needed. While the changes shown in the table below cannot immediately be traced to direct energy savings, they may have an even greater effect on saving energy over the long term.

Table 40: Course Impact on Behavioral Change Among End-Users

Changes in behavior…	Residential (n=753)	Commercial (n=1,459)
Total Percent Who Made Behavioral Changes	92%	96%
Shared course information with friend/family/colleague	86%	90%
Searched for additional information related to course concepts	72%	72%
Helped convince others in organization that energy saving actions are needed	--	79%
Helped convince others outside organization that certain types of actions help save energy	--	68%

8.1.2 Market Actor Changes

Market actors also made changes as a result of the courses. Overall, 70% of market actors changed their practices as a result of the course.

Of those market actors that indicated they took action, the greatest percent made changes in Building Envelope, followed by Lighting, Renewables, and HVAC changes.

Table 41: Percent Taking Actions in End Use of Total Market Actors Who Took Action

End-Use	Percent of Market Actors Who Took Action (n=1,823)
Building Envelope	21%
Lighting	14%
Renewables	14%
HVAC	14%
General	12%
Title 24	10%
Commercial Cooking/Refrigeration	4%
Boilers	4%
Controls	1%
Motors and Pumps	1%
Compressed Air	1%
Pools	1%
Water Management	1%
CHP	0%
Commissioning	2%
Total	**100%**

We asked market actors a series of general behavior questions to gather a broader sense of the energy saving actions they took as a result of the course. Almost half of market actors (47%) revealed that they recommend different energy efficient equipment or recommend energy efficient equipment more frequently as a result of the course. Changing their approach for sizing equipment (28%) and designing buildings differently (27%) were the next most frequently mentioned changes. If these types of changes become a standard practice, there is the potential for a continued and long-lasting influence on energy savings.

Table 42: Changes in Market Actor Behaviors

	Market Actors (n=2,556)
Recommend different EE equipment or more frequently	47%
Changed approach for specifying size of equipment*	28%
Use different design approaches for buildings, systems, building shells*	27%
Use new or different diagnostic tools*	16%
Changed maintenance practices*	12%

Note: HERS Raters and Code Officials were not asked this series. *Not asked of Teachers.

Our participant classification questions identified some sub-categories of market actors, one of which is code officials. Due to the nature of code officials' responsibilities, the list of potential energy saving behaviors is different from that of general market actors. Slightly over half of code officials (56%) indicate that they conduct more thorough examinations as a result of the course, and 39% enforce energy efficiency codes that were unfamiliar to them before they took the course. Similar to the larger category of market actors, code officials have the potential to reach a large number of end-users and influence a great deal of projects. Changes among this group will lead to continued savings over the long-term.

Table 43: Changes in Code Official Practices

	Code Officials (n=36)
Conduct a more thorough examination	56%
Enforce EE codes that they were previously unfamiliar with	39%
Use new methods to enforce codes they were familiar with	19%

Additional Market Actor Actions That May Lead to Savings Over the Longer Term

While we did not explore additional actions in depth, there are several behavioral changes that market actors made which could result in long-term energy savings. An overwhelming majority (87%) of market actors have shared the information they learned in the course with a colleague which could motivate the colleague to take energy saving action. In addition, 77% of market actors report searching for additional information related to the course. Market actors also indicated in our qualitative interviews that the networking at the course itself also has a positive effect. For example, as one market actor mentioned, *"You know, there's interface that goes on among my peers at these things. I pick up a lot there too."*

Table 44: Course Impact on Behavioral Change Among Market Actors

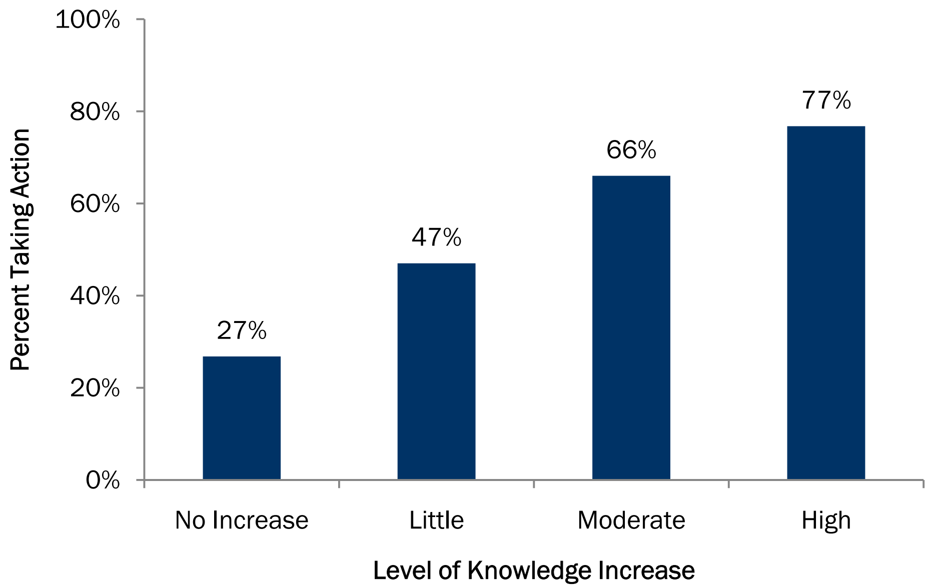
Changes in behavior…	Market Actors (n=2,573)
Total Percent Who Made Behavioral Changes	95%
Shared information you learned in the course with a colleague?	87%
Searched for additional information related to the concepts taught in the course?	77%
Changed your approach to selling your clients on the benefits of energy saving actions they could take?	62%

Note: HERS Raters and Code Officials were not asked.

8.2 Relationship Between Knowledge Gain and Action

Our results demonstrate a strong link between course learning and taking energy saving actions. Participants who learned more were more likely to act. Figure 11 shows that a majority of those who gained a moderate or high degree of knowledge from the course were the most likely to take action. Two out of three who gained a moderate amount of knowledge took energy saving actions (66%), while three out of four who gained a high degree of knowledge took action (77%). Those who gained little knowledge were less likely to act.

Figure 11: Impact of Knowledge Increase on Actions Taken



Note: High includes responses of 6 and 7; Moderate includes 4 and 5; Low includes 2 and 3; and No Increase includes responses of 1.

8.3 Effectiveness of the Courses

We also looked at each course type to explore whether some types of courses were more likely to result in actions (i.e., conversion rates from participation to action). When we explored the actions taken by end use or type of course, many of the course types resemble the overall results; a few, however, stood out. The percentage of course participants who reported taking action in water management courses were among the highest, followed by compressed air, commissioning, and HVAC. The least likely courses to result in changes in actions were courses on renewables and combined heat and power. This may be due to the significant upfront investment necessary to make changes in these areas. Yet, even though upfront costs and barriers to entry are high for actions such as renewables, almost half of those respondents (44%) report taking some kind of action or making some change as a result of the course.

Table 45: Percent of Participants who took Energy Saving Behaviors by End Use (i.e., Course "Conversion to Action" Overall and By Participant Type)

End Use	% Taking Action	Residential	Commercial	Market Actors
Water Management	90%	40%	26 of 27	10 of 10
Compressed Air	81%	0 of 1	92%	19 of 28
Commissioning	80%	1 of 1	91%	71%
HVAC	79%	60%	84%	78%
Lighting	78%	64%	88%	75%
Controls and EMS	77%	2 of 4	80%	76%
Commercial Cooking/Refrigeration	74%	10 of 22	80%	76%
General	73%	72%	85%	65%
Building Envelope	72%	60%	68%	75%
Motors and Pumps	71%	1 of 3	77%	60%
Boilers, Furnaces, And Water Heating	70%	14 of 25	73%	71%
Title 24	65%	13 of 18	73%	63%
Pools	64%	1 of 3	2 of 5	11 of 14
Combined Heat & Power/Gas Engines	44%	0 of 0	6 of 18	9 of 16
Renewables	44%	26%	39%	62%

*Note: Bases vary by end use and participant type. Bases less than 30 are indicated as numbers not percentages.

The percentages shown in the table demonstrate how effective each course type is in moving participants to action, but it does not reflect the overall actions taken by the population (described above) nor the resulting energy savings. In Section 9, we describe the energy savings from the actions discussed above.

8.4 Reasons for Not Taking Action

We asked course participants who had not taken action based on the course what their reasons were for not making any changes. The most common reason given by commercial end-users was that there have not been any appropriate situations to apply the course concepts (41%). Another common reason included that they were already applying the concepts from the course (17%). Relatively few, only 13%, stated that the course did not provide sufficient information—in general, the information presented in the courses is of high value.

Reasons from residential participants were more varied. An equal percentage of residential respondents indicate that they did not make changes because they do not have the money to make changes or that there have not been any appropriate situations to apply the concepts. Table 8 provides the details.

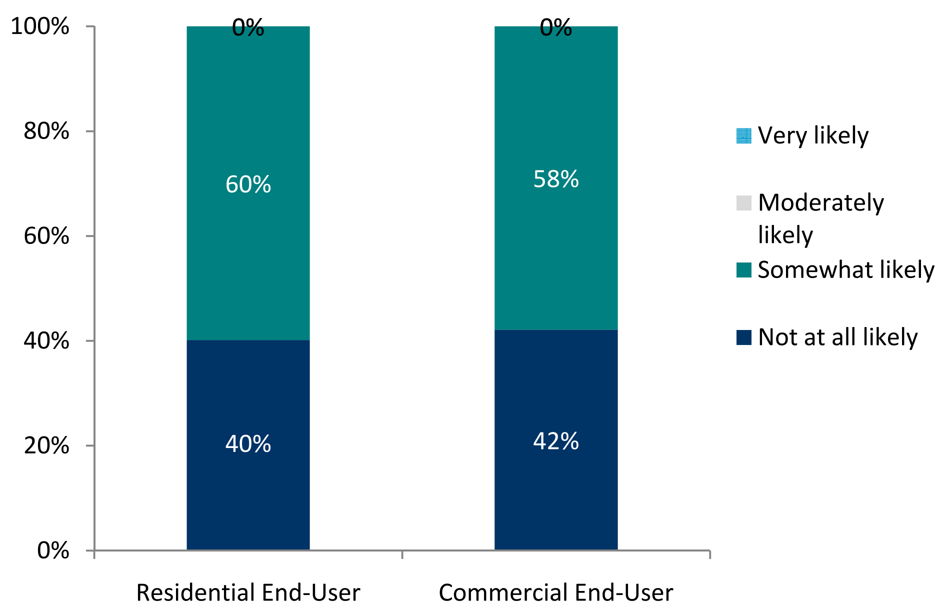
Table 46: Reasons for Not Taking Action by End-User

Reasons*...	Residential End-Users (n=137)	Commercial End-Users (n=121)
There have been no appropriate situations to apply the concepts	20%	41%
I was already applying the concepts	15%	17%
The course did not give sufficient information	6%	13%
Do not have the money at this time	20%	3%

Note: Base includes those who answered that they did not take any action as the result of this course and those who gave a reason for not taking action. *Multiple Responses allowed.

End-users who did not take action do not appear likely to do so in the next 12 months. (See Figure 12) For many of these end-users, the reasons they provided may continue to hold true in the coming months making it unlikely that they would take action. Furthermore, a number of their reasons such as the fact that the course did not give sufficient information may create a stumbling block for future action.

Figure 12: Likelihood to Make an Effort to Save Energy in the Next 12 Months Among Those End-Users Who Did Not Take Action



Note: Using a 7-point scale where 1 represented "not at all likely" and 7 "very likely," participants were asked to rate the likelihood they would make an effort to save energy in the next 12 months. Very likely includes responses of 6 and 7; Moderately likely includes 4 and 5; Somewhat likely includes 2 and 3; and Not at all likely includes responses of 1 on a scale of 1-7.

Among market actors, the reasons for not taking action are more straightforward. The main reason market actors did not take action as a result of the course was because they were already applying the course concepts. In addition, market actors indicated that there have not been any appropriate situations for applying the concepts (33%). Relatively few market actors state that the course did not provide specific information (10%). The Centers may want to consider offering more advanced courses to market actors, or at least think more about how the course offerings are being offered to ensure that participants attend the right course for their level of knowledge.

Table 47: Reasons for Not Taking Action

Reason given…	Market Actors (n=764)
I was already applying the concepts	40%
There have been no appropriate situations to apply the concepts	33%
The course did not give sufficient information	10%
Clients do not have the money at this time	1%

Note: Base includes those who answered that they did not take any action as the result of this course and those who gave a reason for not taking action.

9. Energy Saving Estimates: End-Users

Our research on Education and Training includes many different components, one of which is determining the energy savings associated with this effort. In this section, we present estimated energy savings for end-users (market actor energy saving information follows in the next section). We provide many caveats to our energy savings information. However, we strongly believe that it is possible to determine the magnitude of energy savings associated with these types of programs, and we believe the savings numbers in this report are representative of the effectiveness of energy center training activities. In the recommendations section, we provide some ideas to ensure future evaluation provides the most accurate results possible.

In the previous sections, we showed that the Energy Center courses increased participants' knowledge of energy efficiency, which is associated with behavior change. Ultimately, a majority of both end-users and market actors took actions that have saved either themselves or their client's energy. In this section, we present additional information on the types of actions taken and estimates of the resulting energy saved.

As we noted earlier, slightly over half of the course participants during the three year evaluation period were market actors (55%) while the rest were commercial (30%) and residential (15%) end-users. We used different methods to characterize savings for end-users and market actors due to differences in the nature of their work. End-users are likely to have applied their course knowledge to a limited number of sites, whereas market actors can make changes to everyday -, and thus each market actor could influence many different energy saving choices and many more sites than end users. These differences required different survey instruments and analytic methods. This section focuses on end-users; the next section, focuses market actors.

9.1 Actions Taken

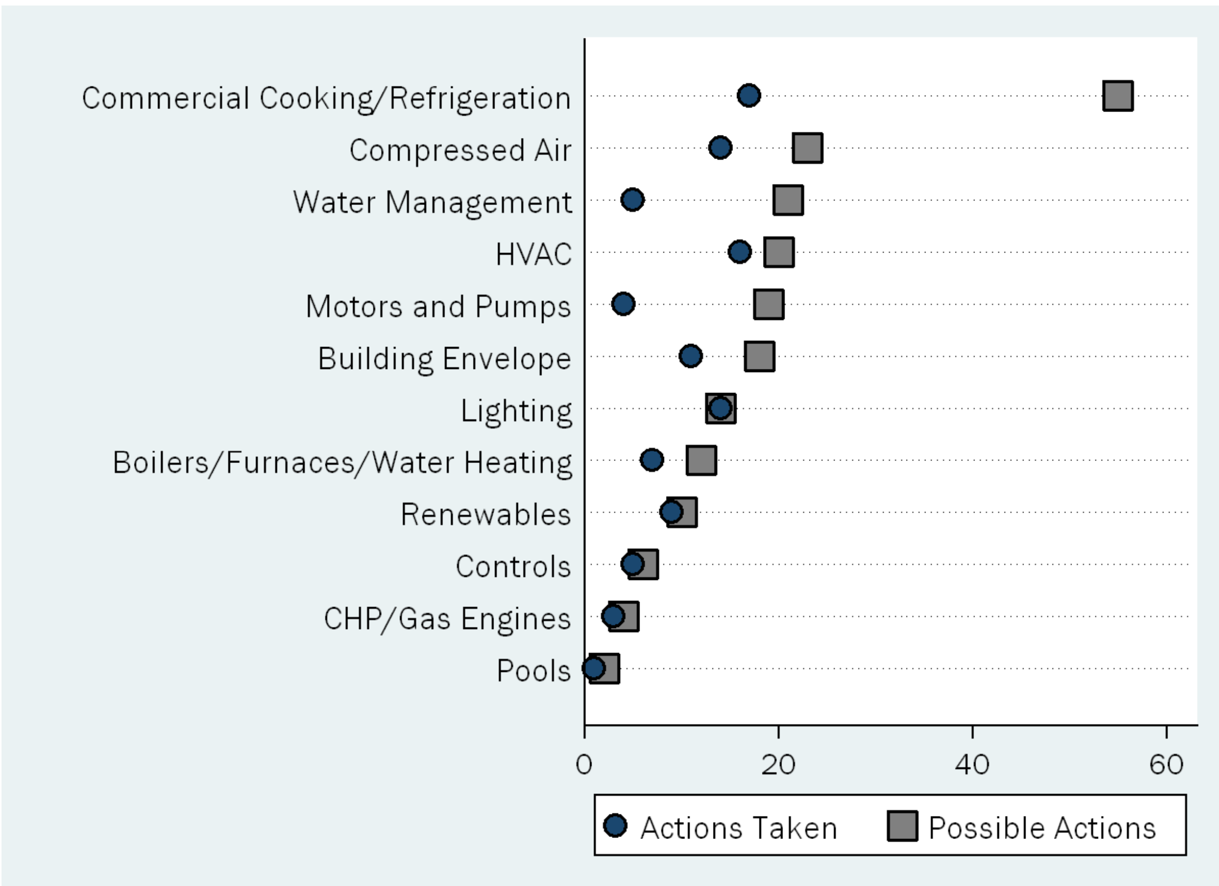
For commercial and residential end-users who said they made efforts to save energy, we asked a series of follow-up questions that were used to estimate energy savings. Through the course content review, we identified 204 unique actions that course participants could have reasonably taken. For each one, survey questions were developed to measure the energy saved by a participant who took the action. Across 12 end-uses, we asked about 204 specific actions.[29] Examples of an action include installing lighting controls following a lighting course or energy efficient windows following a building envelope course. Actions also include changes in behavior such as turning lights off when leaving a room or changing HVAC maintenance practices.

In some cases, no course participants performed an action that we identified--overall, they performed 103 unique actions (about half of the possible actions). The number of actions taken varied across end-uses with the most being taken in commercial cooking, HVAC,

[29] We also gave respondents the opportunity to tell us about actions they took that fell outside our predefined categories. When we examined these open-ended responses most either fit into our preexisting categories or were actions that were outside the course end-use (e.g. installing LEDs after having taking a boilers course).

lighting and compressed air. However, the number of possible actions also varies across end-use. We asked about 14 different lighting actions and course participants took all 14. There were 55 possible commercial cooking actions and 17 were taken. However, these differences should not be interpreted as meaning that courses in certain end-uses were more successful at inducing behavior change than others. The differences between possible and actual actions taken are likely due, in part, to the nature of the end-use and how the surveys were constructed-. For example, for ease of survey administration, we included courses on refrigeration with courses on other commercial cooking equipment so that these survey modules included a large number of varied actions. The courses also covered more types of refrigeration equipment than types of lighting, which is due to differences in the nature of the end-uses. Appendix C contains a table for each end-use that lists the specific actions taken within each end-use.

Figure 13: Number of Possible Unique Actions by End Use



Note: Total Possible Actions = 204, Total Actions Taken = 103

9.2 The Path to Energy Savings

In this section, we detail the process for getting from survey response to energy savings. Figure 14 diagrams the path to energy savings for end-users and will guide the presentation of results.

In Section 8, we showed that 77% of commercial and 43% of residential end-users took action to save energy based on what they learned in the course. Combined, 63% of end-users took energy saving action, which amounts to 29% of all unique participants who took an Energy Center course. When we multiply this survey estimate by the total number of unique participants during the three year evaluation period, we estimate that 10,330 end-users took energy saving action.[30] (See Figure 14)

Having determined who took action based on the courses, our next step was to identify the participants whose actions could be credited to the Energy Centers. The Centers can only take credit for savings that result from actions taken in IOU territory and that did not receive financial assistance through an IOU resource acquisition program. Out of all course participants, 3% were end-users who took action but did so outside IOU territory. We removed these participants from our analysis of energy savings.

We also could not credit the Centers with savings if the course participant received support from a resource acquisition program for taking that action—as these savings were already credited through other evaluation efforts. We found that the Energy Centers channel participants into rebate programs through two types of courses. The first type focuses exclusively on explaining the programs that are available to IOU customers. Over the three year evaluation period, the Centers offered 26 such courses that were attended by 2,237 people. In the second type of course, instructors on other subjects mention existing utility programs when applicable to the course content.

Of the end-users who did take action in IOU territory, approximately one-third, or 7% of the entire sample, utilized an IOU rebate program when taking action. Although we did not credit the Energy Centers with the savings from these efforts, the end-users took action in part because of what they learned in the Center courses. A large majority of these end-users (75%) said they learned about the rebate program through an Energy Center course. This amounts to 5% of the entire sample, or approximately 1,833 end-users. As with those outside of the IOU service territory, we removed these participants from our analysis of energy savings.

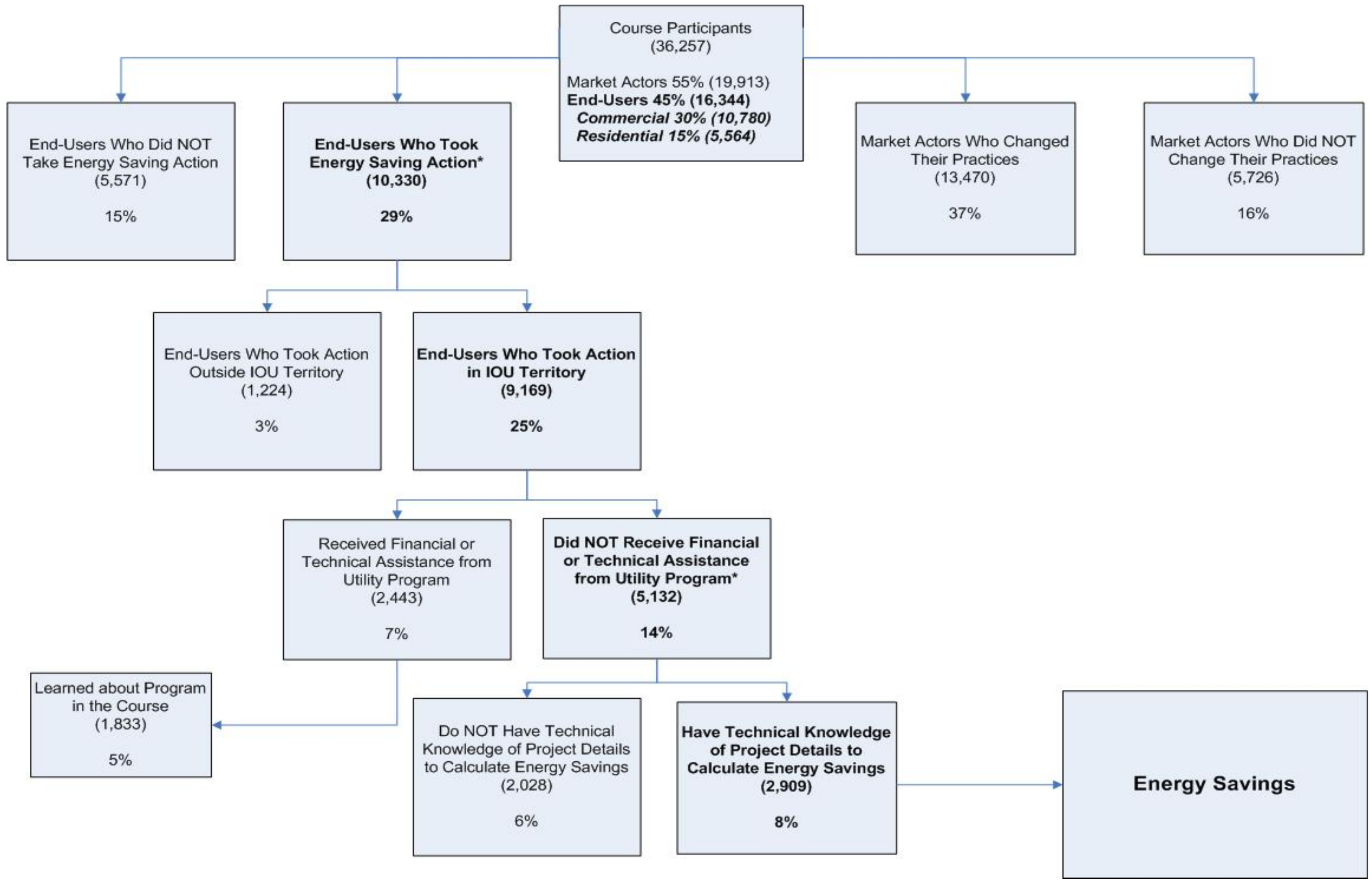
After we account for participation in resource acquisition programs, we are left with 14% of survey participants who are end-users and whose actions can be attributed to the Energy Centers (n=630). When extrapolated over the three year evaluation period, this amounts to 5,132 unique course participants.

---

[30] In Section 4, we noted that there were 39,793 unique participants after cleaning the participant files we received from the Energy Centers. However, though our survey efforts, we learned that approximately 9% were ineligible to be included in the assessment of energy savings for a variety of reasons. Some were course instructors or energy center employees. Others registered for the course but were unable to attend. The adjusted number of unique participants is 36,257, of which 16,344 were end users.

To calculate energy savings due to an equipment installation or behavior change, we asked a number of detailed questions. When designing the survey instruments, we realized that not all course participants would have knowledge of these details, perhaps because they did not perform the work themselves. To not frustrate these respondents by asking a lot of questions they could not answer, s we started with the technical part of the survey and then allowed respondents to opt out if they could not provide this information. Approximately 40% did not have the necessary information. We were able to calculate savings for the remaining 377 respondents who were able to provide details of their actions.

Figure 14: The Path to End-User Energy Savings



*We lose 4% of the sample participants at this stage because some participants failed to complete the entire survey and we kept them in the sample. We kept participants who completed the core survey questions even if they did not complete the entire impact module. The break between the core survey and the impact module comes after the question about actions taken in IOU territory. See Section 3 for more information on the participant survey response rates and disposition codes.

9.3 Energy Savings: Surveyed End-Users

The actions attributed to the Energy Centers were concentrated in HVAC, lighting and building envelope. Out of 630 participants who took action, 121 (19%) were in HVAC while 183 (29%) were in lighting. However, HVAC participants took more actions than lighting participants so there were more total HVAC actions taken than lighting or any other end-use area. In total, the surveyed course participants took 1,427 energy saving actions that can be attributed to the Energy Centers.

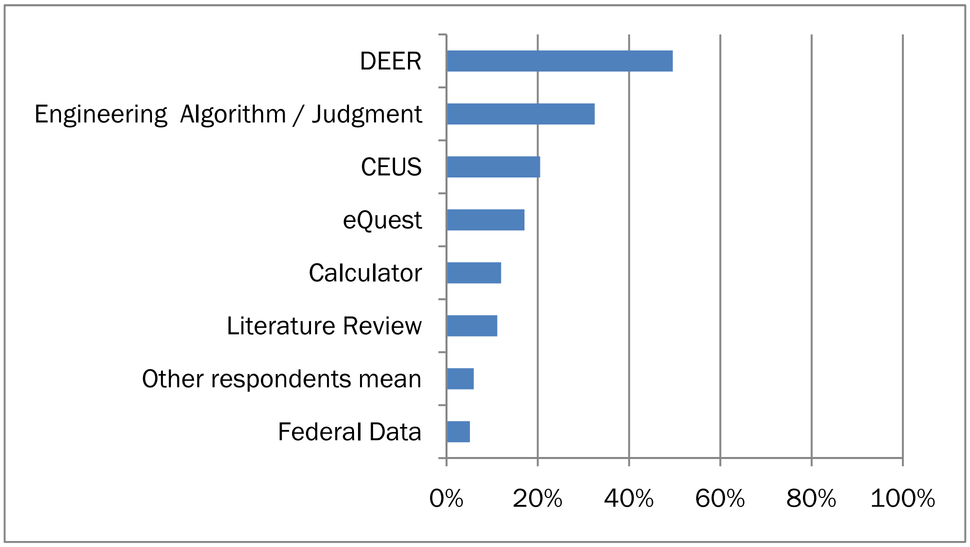
Table 48: Number of Participants Taking Action and Number of Actions Taken

End-Use	Participants Taking Action	Total Actions Taken
HVAC	121	352
Lighting	183	333
Building Envelope	94	222
Boilers/Furnaces/Water Heating	46	145
Motors and Pumps	31	101
Commercial Cooking/Refrigeration	37	98
Compressed Air	17	68
Renewables	73	56
Controls	17	36
Water Management	8	14
CHP/Gas Engines	3	3
Pools	2	2
Total	630	1427

9.3.1 Gross Savings

For the 377 participants who were able to provide us with details of their actions, we analyzed their survey responses to estimate gross energy (kWh and therms) and demand (coincident peak kW) savings. Through this engineering approach, we utilized core California-based secondary resources (e.g., DEER, CEUS, reports on CALMAC.org) and models (eQUEST) wherever possible. Where data from these sources was not adequate, not reflective of the range of participant conditions, or was internally inconsistent, additional secondary sources and engineering calculations were used. Approximately one third of the measures (37%) used multiple data sources to obtain a savings value. The most frequently used source was DEER. (See Figure 15)

Figure 15: Sources of Gross Impacts



Additional details on the methods used to produce the engineering estimates of energy savings in Appendix F.

Table 49 displays estimates of gross energy saved by end-use for the survey respondents only. We extrapolate this to the larger population in the next section.

Combined, we estimate that the 377 surveyed end-users saved approximately 51 GWh a year using what they learned in the Energy Center courses. The mean savings per participant is approximately 137,000 kWh, but the distribution of savings is highly skewed with a number of a big savers; the median participant saved just over 2,000 kWh.

HVAC participants saved the most at 15.4 GWh followed by lighting at 14.6 GWh. Renewables participants saved half as much as lighting but were the next highest savers by end-use. The savings of water management participants illustrates the case of a big saver having a large amount on overall savings. Only four participants took calculable energy savings, but the total savings for the end-use were the fifth highest. Nearly all of the savings in this end use were due to one participant who took multiple actions at multiple sites.

Very little of the overall savings are due to actions taken by residential end-users. Commercial end-users represent slightly under two-thirds (62%) of the participants for whom we were able to calculate savings, but they account for nearly all of the savings (99%). (See Table 50) As would be expected, residential end-users took actions that resulted in smaller savings, such as installing CFLs, insulation, and windows. They also took these actions in their homes compared to the much larger facilities of many commercial end-users.

Should energy savings continue to be a major success factor for the Energy Centers, then reducing or eliminating course marketing and content away from residential end users may be prudent.

Table 49: Gross Energy Savings: Surveyed End-Users

		Annual kWh			Peak kW			Therms		
End-Use	Participants	Total	Mean	Median	Total	Mean	Median	Total	Mean	Median
HVAC	70	15,388,152	219,831	15,993	10,417	149	7	355,123	5,073	382
Lighting	114	14,584,882	127,938	1,883	1,680	15	0	-142,375	-1,249	-5
Renewables	51	6,880,028	134,903	6,735	3,664	72	4	8,120	159	0
Compressed Air	12	5,400,041	450,003	284,106	1,095	91	35	14	1	0
Water Management	4	5,098,139	1,274,535	27,224	497	124	31	0	0	0
Boilers/Water Heating	30	2,642,552	88,085	0	527	18	0	270,309	9,010	1,106
Controls/EMS	12	567,034	47,253	15,259	77	6	1	214	18	0
Motors/Pumps	8	421,478	52,685	5,372	101	13	3	0	0	0
Green Building/Envelope	69	385,803	5,591	307	201	3	0	5,770	84	2
Comm Cooking/Refrigeration	6	373,626	62,271	23,878	58	10	3	4,546	758	471
Pools	1	1,400	1,400	1,400	5	5	5	4,557	4,557	4,557
Totals	**377**	**51,743,135**	**137,250**	**2,288**	**18,323**	**505**	**1**	**506,278**	**18,411**	**0**

Note: These values do not have any error bounds as there was no sample error in our method of data collection (i.e., we did not use a sample). See the methodology section for a more detailed discussion about precision in our analysis.

Table 50: Gross Energy Savings by End-User Type

		Annual kWh			Peak kW			Therms		
	Participants	Total	Mean	Median	Total	Mean	Median	Total	Mean	Median
Commercial	233	51,436,707	220,758	12,420	18,181	78	3	497,019	2,133	0
Residential	144	306,429	2,128	426	141	1	0	9,259	64	0
Totals	**377**	**51,743,135**	**137,250**	**2,288**	**18,323**	**49**	**1**	**506,278**	**1,343**	**0**

9.3.2 Net Savings

As an indirect impact evaluation, our charge was to obtain net behaviors and to estimate energy savings using secondary research. We describe the approach used to assess the influence of the program on participant behaviors (i.e. net behaviors) in Section 4. The method involved creating a cognitive change index (CCI) that measures the net influence of the course on participants' energy saving actions. The CCI shows that the Centers had a high degree of influence on the actions that course participants took. The CCI value is unique for each participant. The mean value for all participants with energy savings is .78, which indicates that on average the participants found value in the information the courses provided, and that the knowledge they gained influenced how they thought about energy efficiency and their subsequent behaviors.[31]

While not conceptually identical to the net-to-gross ratio (NTGR) used in the assessment of resource acquisition programs, the application of the CCI to the gross energy impacts serves a similar purpose. By multiplying gross savings by the CCI, we obtain an estimate of net energy savings for respondents who took energy saving action due to the influence of the Centers. Additional information on the CCI is available in Section 4 and Appendix E.

Table 51 displays overall net energy savings as well as by end-use for surveyed participants for whom we were able to calculate savings. These 377 participants combined, on a net basis, to save approximately 40 annual GWh by making changes based on what they learned in the Energy Center courses.

[31] We applied each respondent's CCI value to his or her estimated annual kWh, peak kW, and therms savings. For participants with estimable savings, actions varied and many did not have savings in each category. For example, we calculated HVAC savings for 70 respondents but only some had kWh savings, some therms, while some had both. .As a result, comparing the ratios of net to gross savings for annual kWh to therms will give the impression that a different CCI was used. In reality, the savings are based on different respondents who took different actions and have different individual CCIs.

Table 51: Net Energy Savings: Surveyed End-Users

		Annual kWh			Peak kW			Therms		
End-Use	Participants	Total	Mean	Median	Total	Mean	Median	Total	Mean	Median
HVAC	70	13,239,315	189,133	13,568	9,150	131	6	303,499	4,336	275
Lighting	114	10,362,233	90,897	1,322	1,157	10	0	-98,205	-861	-3
Renewables	4	5,004,109	102,125	4,990	2,665	54	3	6,095	122	0
Compressed Air	51	4,132,457	344,371	239,678	816	68	30	12	1	0
Water Management	12	3,866,596	966,649	20,898	374	93	22	0	0	0
Boilers/Water Heating	30	1,767,958	58,932	0	353	12	0	219,006	7,300	641
Controls/EMS	6	413,282	34,440	12,700	54	4	1	355	30	0
Motors/Pumps	8	344,001	43,000	4,211	84	10	2	0	0	0
Comm Cooking/Refrigeration	12	343,987	57,331	20,943	56	9	3	3,982	664	336
Green Building/Envelope	69	306,051	4,501	290	152	2	0	4,387	65	1
Pools	1	1,068	1,068	1,068	4	4	4	3,475	3,475	3,475
Totals	377	39,781,057	106,366	1,779	14,865	40	0	442,606	1,180	0

Note: These values do not have any error bounds as there was no sample error in our method of data collection (i.e., we attempted a census of participants). See the methodology section for a more detailed discussion about precision in our analysis

9.4 Energy Savings: All End-Users

The gross and net savings presented in Table 49, Table 50, and Table 51 are based on the 377 surveyed Wave 2 participants whose actions could be credited to the Energy Centers and who could provide the sufficient detail on their actions to calculate savings. These savings estimates under represent program savings attributable to end-user participants because they do not include Wave 1 participants, participants who did not have technical knowledge of their actions to answer the detailed questions needed to calculate savings, and participants who did not participate in the survey. To get an estimate of the larger program impact, we needed to extrapolate savings from the surveyed participants to the larger participant population whose actions could be attributed to the Energy Centers.

In Section 9.2, we estimate that 14% of course participants were end-users whose actions could be credited to the Centers. Table 16 summarizes the path to energy savings across all Centers. It gives the relevant survey responses and associated survey sample sizes. When we multiply the survey response percentage by the overall participant population (36,257), we get an estimate of the number of overall participants that fall into each category, which is the fourth column. The bolded line (Did Not Receive a Rebate) indicates the participants whose energy savings can be attributed to the Energy Centers, but not every one of these participants could provide the information we needed to calculate savings. The italicized line (Had Technical Knowledge) indicates the participants for whom we were able to calculate energy savings. It is these savings that are the basis for our extrapolation to the larger population of course participants (5,132).

Table 16: Extrapolation of Energy Savings from Sample to Population

	W2 Survey Response	Sample Cases	Participant Population
All Participants	100%	4,907	36,257
.All End-Users	45%	2,212	16,344
..Who Took Action	28%	1,398	10,330
...In IOU Territory	25%	1,241	9,169
....Did Not Receive a Rebate	**14%**	**658**	**5,132**
.....Had Technical Knowledge	*8%*	*377*	*2,909*

To extrapolate savings we estimated the number of participants whose actions can be attributed to the Centers for each end-use. We multiplied the number of participants by the average savings for each end-use (annual kWh, peak kW and therms). We produced estimates for both gross and net savings. As Table 17 shows, we estimate that the Energy Centers combined yearly gross impact was approximately 700 GWh with a net impact of 544 GWh. The Centers are also responsible for annual gas savings of approximately 6 million net therms. Respectively, these electric and gas savings equate to approximately 267,000[32] and 30,000[33] metric tons of avoided carbon dioxide (CO_2) emissions.

[32] This value is calculated using EPA annual non-baseload output emission rates for the WECC California subregion of 1,083.02 lb/MWh and 2,204.6 lbs CO2/metric ton. (http://www.epa.gov/cleanenergy/documents/egridzips/eGRID2007V1_1_year05_GHGOutputRates.pdf)

[33] This value is calculated from the EPA estimate of 0.005 metric tons CO2/therm. (http://www.epa.gov/RDEE/energy-resources/refs.html)

Table 17: Gross and Net Energy Savings: All End-Users

		Annual GWh		Peak kW		Annual Therms	
End-Use	Participants	Gross	Net	Gross	Net	Gross	Net
HVAC	978	215	185	145,588	127,879	4,963,106	4,241,613
Lighting	1,483	190	135	21,867	15,054	-1,852,735	-1,277,947
Water Management	64	82	62	7,963	5,993	0	0
Renewables	553	75	57	39,747	30,097	88,095	67,450
Compressed Air	136	61	47	12,435	9,267	159	135
Boilers/Water Heating	377	33	22	6,621	4,435	3,395,856	2,751,349
Comm Cooking/Refrigeration	313	19	18	3,042	2,897	236,928	207,556
Motors/Pumps	249	13	11	3,145	2,610	0	0
Controls/EMS	136	6	5	874	610	2,436	4,038
Green Building/Envelope	778	4	4	2,269	1,744	65,046	50,179
Pools	8	0	0	43	33	36,541	27,862
Totals	5,076	699	544	243,594	200,619	6,935,432	6,072,235

Note: These values do not have any error bounds as there was no sample error in our method of data collection (i.e., we attempted a census of participants). See the methodology section for a more detailed discussion about precision in our analysis

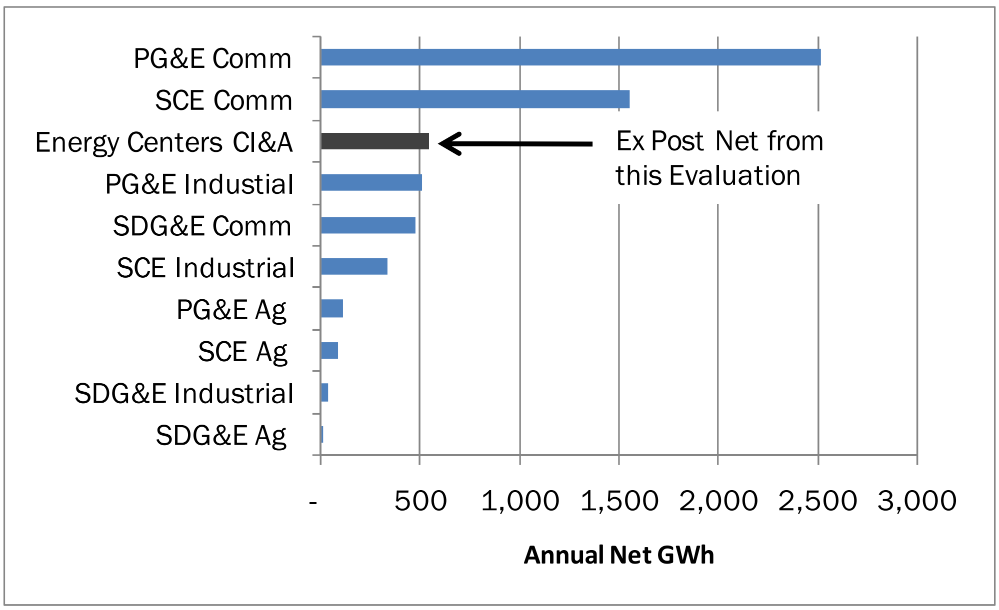
9.5 Energy Center Savings Compared to Resource Acquisition Programs

To provide some context for the Energy Center savings estimates, we compared them to the savings estimates for all of the IOU's resource acquisition programs.[34] Overall, the portfolio of programs was estimated to save approximately 10,500 net annual ex ante GWh. The net savings from the Centers provides an additional 5% to the overall energy impact.

Because this part of the analysis focuses solely on end-users (as opposed to market actors), we wanted to narrow our comparison to program's with a similar constituency. Since nearly all of the end-user savings could be traced to nonresidential end-users, we compared the Energy Center savings with those from IOU nonresidential programs. While not exact, the end-users who take courses at the Centers are providing an additional 10% of energy savings over the net ex ante savings from programs designated by the IOUs as commercial, industrial or agricultural.

Next, we compared the Energy Centers' net GWh value to resource acquisition savings by utility by sector. As Figure 18 highlights, the net savings of the Energy Centers are similar in magnitude to the savings achieved by IOU programs that reach similar sectors.

Figure 18: Energy Center Energy Impacts and Other Sector Impacts



Note: the IOU values are ex ante values while the Energy Center value is Ex Post

The California Strategic Plan includes Workforce, Education and Training programs as a policy tool for market transformation. Our findings from this evaluation support the use of the Energy Centers as an integral part of energy efficiency knowledge transfer for the State. The net impacts for end users are measurable and comparable to other resource acquisition

[34] The data used for this comparison were from the last monthly reports from the IOUs for 2008. The downloaded Excel files were named: PGE.MR.200812.4; SCE.MR.200812.4; SDGE.MR.200812.2; SCG.MR.200812.2

sectors. Additionally, the values do not account for what are perhaps significant additional savings from a more educated participant group of market actors.

10. ENERGY SAVINGS ESTIMATES: MARKET-ACTORS

Energy Centers provide training to a broad range of market actors with significant variability in the types of services they provide, the projects they complete, and the size and type of clients they serve. As such, the evaluation team faced unique challenges in assessing the impacts of Energy Center courses on market actors. In response to these challenges, we developed and implemented a mixed method approach to analyze the activities of market actors participating in Energy Center activities. This approach utilized market actor responses to the course participant survey to identify the different kind of market actors that took action as a result of taking a course, and to inform the development of in-depth interview guides designed to refine our understanding of the specific actions taken by market actors. We then conducted case studies of a limited sample of market actors to develop a more complete understanding of the influence of course participation, the manner in which market actors' work with clients, and the magnitude of the energy savings associated with those changes.

We found that most of the market actors that made changes to their services as a result of taking the class were lighting, HVAC and building envelope providers. In-depth interviews with a sample of these market actors helped to identify the types of changes made and specific actions taken and are outlined in Table 52. These are specific examples of course impacts on market actor practices are representative of a limited sample of respondents and therefore cannot be extrapolated to the entire market actor population. However, they do provide an indication of the manner in which Energy Center training is influencing market actor behavior.

Table 52: Examples of Course Impact on Market Actors

Market Actor Focus	Actions Taken
Lighting	Install energy efficient lighting Optimize lighting levels Improve lighting and building design Install lighting controls Use diagnostic tools Improve maintenance practices
HVAC	Install high efficiency furnaces Install high efficiency AC Correctly size HVAC Economizers Duct optimization Improve installation and diagnostics
Building Envelope	Install insulation Install windows Install cool roofs and green roofs Conduct air sealing (weatherization) Minimize thermal bypassing Use advanced framing techniques

There is a multiplier effect with market actors a energy-saving changes that become standard practice for market actors for this group have the greatest potential to provide significant energy savings throughout California, given their ability to affect numerous design projects, equipment installations, and otherwise influence customer decisions and practices in the course of conducting their business. Over half of market actors (59%) specified that the changes they made as a result of participating in an Energy Center course have become standard practice for them.

The energy savings associated with a specific change in practice varies widely. Two of five market actors responding (43%) to our survey estimate that their changes resulted in measurable energy savings for their clients, with 15% classifying the savings associated with the changes as “significant.”

Table 53: Magnitude of Market Actor Changes (Self-Reported)

	Market Actors (n=2,598)
Made changes that became standard practice	59%
Made changes resulting in measurable energy savings for clients	43%
Made changes resulting in "significant" savings	15%

Overall, the case study approach with the follow-up in-depth interviews allowed us to further explore the actions taken by 29 market actors as a result of the courses and estimate the energy savings associated with those actions. As illustrated in Table 54, we estimate that over 10 GWh of savings are attributable to the 29 market actors with whom we spoke. This group of market actors “touched” anywhere from 1 to 400 projects a year, averaging 55 projects per year and a median of 10 projects per year. Combined with making the information learned in the course standard practice and the estimated energy savings from just these few case studies, the possible multiplier effect seems real and large.

While this savings number should not be extrapolated to all market actors, it does give some insights of possible energy savings gained from market actors who revised their practices as a result of taking an Energy Center course.

Table 54: Gross Annual Savings from Interviewed Market Actors (n=29)

Gross Savings per Year of Projects	Total Savings			
	Lighting (n=9)	HVAC (n=10)	Building Envelope (n=10)	Total
Gross Annual MWh Savings	7,869	2,319	327	10,515
Gross Peak kW Savings	584	465	138	1,187
Gross Annual Therms Savings	(48,024)	16,809	32,914	1,699

10.1 Approach

As part of the Wave 1 research effort, market actors received only the core survey. Given that market actors may have taken actions multiple times across many clients or taken multiple different actions for different types of clients, the evaluation team determined that it was not possible to gather reliable information regarding each specific application of course information using the impact survey module approach employed for end-users. We also determined that gathering information about a "typical" or representative application of the information learned would not provide accurate data that could be used to estimate energy savings. As such, we did not ask market actors to provide comparable information as part of the core survey effort. Instead, market actors provided information about the frequency with which they take actions and the magnitude of the energy savings associated with those actions.

This information was then used as the basis for follow-up interviews with a sample of market actors taking courses related to lighting, HVAC and building envelope as these are the most popular course subjects among market actors. The evaluation team conducted 29 interviews in total and used them to better understand the types of changes market actors made as a result of participation in the courses, as well as to characterize the likely energy savings associated with those changes.

The evaluation team used these interviews to learn more about the details of the changes the market actors had made and how the courses had influenced their work. Using the interview transcripts as guides, we conducted an engineering analysis of the market actors' actions. These results were used to characterize the energy saved by market actors as a result of the Energy Center courses. This approach yielded energy impact estimates associated with the specific practice changes made by this sample of market actors.

We selected participants using a purposeful sampling approach with the goal of identifying market actors that reported making a range of practice changes and that differed with respect to the number of jobs completed annually. The evaluation team also reviewed market actor open-ended responses from the quantitative survey to understand the type of activities generally performed by this group.

To confirm that the market actors selected for these follow-up interviews were similar to the overall sample, we compared them on a few key characteristics. Market actors selected for the follow-up interviews made more changes to their practices (mean of 3.2 changes) than the larger sample of market actors (mean of 2.3 changes). However, the two groups complete ad similar average number of jobs a year in which they apply what they learned in the course. The market actors selected for depth interviews completed 39.5 compared 35.2 for the larger sample of market actors.

10.2 Detailed Results by Subject Area

10.2.1 Lighting

Participant Characteristics

The evaluation team attempted to contact nine lighting market actors, and ultimately spoke with eight individuals who completed lighting courses at the Energy Centers that resulted in energy saving actions. Just over half of these course takers are electrical contractors, distributors or installers (63%) while architects (25%) and a lighting designer (13%) compose the remaining portion of this group. The firms represented by these individuals range in size from those who complete as few as two projects per year to 150 and 400 for the electrical contractors.

Table 55: Lighting Market Actor Profile

Respondent	Occupation	Sector	Num. Projects per Year
1	Lighting Architect	Residential	15
2	Architect	Residential	3
3	Electrical Installer	Both	24
4	Account Manager	Both	10
5	Electrical Distributor	Both	25
6	Electrical Contractor	Both	150
7	Electrical Contractor	Both	400
8	Architect	Commercial	2

The market actors participating in the in-depth interviews took courses on a variety of levels ranging from introductory courses to more advanced topics. These market actors took courses focusing on the technical specification of lighting products, daylighting and daylight modeling, lighting fundamentals, design and retrofits, fixture maintenance, ballast and lamp basics, and LED technology. In general, those interviewed took one or two courses, although one individual took 12 courses.

Actions Taken and Energy Savings

Based upon responses to the quantitative participant survey, the evaluation team developed a specific lighting interview guide to further explore the type of actions taken by lighting market actors and the impact of those actions on energy savings. When asked how they changed the services they provide to their clients, market actors gave a wide range of answers that show the scale of changes possible among enrollees. We categorized the changes into six different types of lighting practices highlighted in Table 56. The most common actions taken as a result of attending a course are the installation of energy efficient lighting and the optimization of lighting levels.

Table 56: Energy Saving Actions Taken by Lighting Interviewees

Type of Action	Number of Respondents Implementing (n=8)
Install energy efficient lighting	7
Optimize lighting levels	6
Install lighting controls	2
Improve lighting and building design	2
Use diagnostic tools	1
Improve maintenance practices	1

The in-depth interviews provided specific examples of these actions including one participant who said his company now reduces the number of fixtures and uses high efficiency and high performance ballasted lamps on all their projects. Other changes include the greater use of diagnostic tools like savings calculators and cost analysis, as well as increased recommendations to customers regarding and installations of LEDs. Additional comments include:

- *"I have changed my supplies from non-energy efficient to efficient only. Now I'm …focusing on efficient lighting supplies only."*
- *"The number [one] thing was specifying 800 series T8 lamps as opposed to 700 series and the advantages of taking it a step further and using T5 lamps as opposed to HID for warehouse lighting."*
- *"I don't design very often and so the most common application is the warehouse lighting and stemming from what I learned in that class, I'm definitely steering people towards T5 florescent as opposed to HID [lighting]."*

Based on the actions taken by each of the participants with whom we spoke, we developed estimates of gross annual energy savings. For further information regarding energy savings, please refer to Appendix F. In developing these estimates, we also considered the amount of time that had elapsed between our interview (October 2009) and when the participant enrolled in their first course. Among this group of lighting market actors, the elapsed time ranged from 1.1 to 2 years with an average of 1.6 years.

Of the eight participants with whom the evaluation team completed interviews, two reported that that the course(s) did not have an influence on their installation or design practices. Actions from the remaining five yielded a total annual savings of 7.8 million kWh. This figure increases to almost 9,000,000 kWh when accumulated savings from the date of participants' first courses is considered.

We selected a purposeful sample of market actors for these interviews to ensure we included market actors that differed both in terms of the type of work they do and the number of jobs they complete per year. As illustrated in Table 57, these differences can heavily influence savings. Most of the estimated energy savings are associated with the installation of energy efficient lighting by one particular market actor. Among market actors it is typical to see some that completed many projects with significant estimated savings and others completed fewer projects or with lower savings estimates.

Table 57: Savings (kWh) by Lighting Respondent and Action

Respondent	Num. Projects per Year	Install Energy Efficient Lighting	Optimize Lighting Levels	Install Lighting Controls	Improve Lighting & Building Design	Use Diagnostic Tools*	Improve Maintenance Practices
1	15	19,685	X	-	-	-	-
2	3	-	-	-	-	-	-
3	24	16,371	-	-	-	-	-
4	10	9,160	-	-	-	-	-
5	25	37,482	-	-	-	-	-
6	150	7,394,761	X	-	-	7,764,499	X
7	400	-	-	-	-	-	-
8	2	-	X	21,380	-	-	-
Total	**629**	**7,477,469**	-	**21,380**		**7,764,499**	

*Note: In cases where diagnostic tools are used, their impact is applied after the initial savings are calculated. As a result, numbers in this column include those listed under "Install energy efficient lighting". Cells marked with an X indicate that the savings for this action was developed in conjunction with another action taken by that participant and is already accounted for in the table.

It is possible that some energy savings associated with course-inspired practice changes made my market actors have been accounted for in the impact assessments of the resource acquisition programs offered by California IOUs. Participant survey data indicates that five of the nine market actors we contacted said their projects receive rebates or financial assistance. Two of the interviewees noted that only a small percentage of their projects received such assistance while the remaining three had customers that participated in a "PG&E lighting program," "PG&E T5 program," or general lighting program.

Overall, it is evident that market actors specializing in lighting are taking many different energy saving actions as a result of their participation in Energy Center courses, although not all of these actions can be captured using traditional methodologies. Changes in the type of lighting installed are widespread among this group, while other actions related to lighting levels, controls, and design are minimal. Interviews do suggest, however, that changes are broadly applied across customers and are to be likely persistent over time.

10.2.2 Building Envelope

Participant Characteristics

We spoke with 10 market actors that completed course work related to building envelope and indicated they took action as a result of their participation. Interviewees come from diverse professional backgrounds, with only four of ten individuals sharing the same title, consultant. As seen among lighting specialists, the companies where the interviewees work range dramatically in size from 2 to 250 projects per year, although consultants have a greater capacity to take on larger numbers of projects.

Table 58: Building Envelope Market Actor Profile

Respondent	Occupation	Sector	Num. Projects per Year
1	Consulting	Residential	250
2	Municipal EE Coordinator	Commercial	3
3	Consultant & Teacher	Com & Small Industrial	2
4	Consultant	Both	10
5	Developer-Builder	Residential	5
6	Architect	Commercial	6
7	Contractor	Residential	50
8	Consultant	Both	7
9	Contractor & Auditor	Residential	15
10	Green Building Professional	Both	175

Building envelope market actors enroll in a range of courses covering how to perform specific actions such as specific types of installations and energy audits, as well as how to use certain analytic tools like energy modeling for LEED and software such as Energypro. In addition, market actors participate in introductory classes on new technologies like photovoltaics, courses on retrofits, maintenance practices, HVAC systems, and classes outlining state and utility energy initiatives and programs. In total, these courses form a broad curriculum focused on home performance and green building practices.

Actions Taken and Energy Savings

We asked market actors the ways they had changed the services they provided to their clients as a result of having this new knowledge. We categorized their responses into six different types of building envelope related practices highlighted in Table 59. The most common actions taken as a result of course completion are the installation of insulation and windows, as well as weatherization.

Table 59: Energy Saving Actions Taken by Building Envelope Interviewees

Type of Action	Number of Respondents Implementing (n=10)
Install insulation	9
Install windows	6
Conduct air sealing (weatherization)	6
Install cool & green roofs	3
Minimize thermal bypassing/insulate electrical boxes	1
Use advanced framing techniques	1

Market actor comments and descriptions regarding the work they have done since the courses provides more specific examples of the types of projects performed by this group:

- *"Absolutely more insulation is installed because if I'm able to better advocate for it, if I can explain what it is in more detail, then I can have a better picture of what needs to be done [and] then I can sell the idea and more of it will get installed."*
- *"We've also talked [with designers and contractors] even more about using better framing techniques trying to reduce their use of lumber and get a better product in the end."*
- *When discussing ceiling insulation, one market actor noted that "prior we were bringing [the R value] up to R38 and now we're doing a lot more R44."*

Based on the actions taken and information provided in the interviews, the evaluation team estimated gross annual energy savings for each participant. In developing these estimates, we considered the amount of time elapsed since the participant enrolled in their first course. Among building envelope market actors, the elapsed time from course participation to our interview ranged from 0.9 years to 1.9 years with an average of 1.4 years since their first course. Calculations for the entire group yielded a total annual kWh savings of 327,133 kWh. When accounting for the time elapsed since the date of the participants' initial course, the total gross savings to date is 493,186 kWh.

Table 60 provides information on the actions taken by each interviewee and the corresponding energy savings associated with those actions. Cells containing "None" represent two possible outcomes. First, in some instances while the participant stated that they took actions in that area as part of the quantitative participant survey, when asked to further explain what they did differently before and after the training they revealed that in fact there was no difference. Second, for a given action, the participant may simply not have achieved any kWh savings.

Table 60: Savings (kWh) by Respondent and Action

Respondent	Num. Projects per Year	Install Insulation	Install Windows	Install Cool & Green Roofs	Conduct Air Sealing	Min. Thermal Bypassing	Use Advanced Framing
1	250	32,290	36,793	-	None	None	-
2	3	71	89	None	None	-	-
3	2	-	-	3,710	-	-	-
4	10	None	-	-	None	-	-
5	5	566	-	15	None	-	2,265
6	6	164,923	1,683	-	-	-	-
7	50	91	None	-	-	-	-
8	7	264	-	-	None	-	-
9	15	106	None	-	None	-	-
10	175	849	None	-	-	-	-
Total	**523**	**199,160**	**38,565**	**3,725**	**0**	**0**	**2,265**

*Note: cells containing "none" indicate that while the participant took actions in that area, the actions and/or savings could not be quantified.

Among interviewed participants, energy savings as a result of building envelope course attendance can range from 0 to 199,160 kWh per year. The greatest portion of savings came from the installation of insulation by one particular market actor. As seen among lighting participants, it is also possible that some of the savings generated by market actors are captured in the evaluation of utility energy efficiency programs. Half of interview participants said their clients receive financial or other support for their projects, while three said their clients did not receive rebates or other assistance, and two did not know. When these market actors were asked to estimate the percentage of their customers who participate in rebate programs, the numbers range from 5% to 100%. One program mentioned by name was the California Solar Initiative.

Overall, it is clear that market actors involved in building envelope projects have made a number of changes to their services, particularly related to how they install insulation and windows that can result in energy savings that could not be examined traditionally. It is also worth noting that market actor changes related to weatherization or air sealing did not produce energy savings estimates because they consisted mainly of changes to how and what the market actors recommend to customers in this area.

10.2.3 HVAC

Participant Characteristics

The evaluation team interviewed ten market actors that completed course work related to HVAC and indicated they took action as a result of their participation. Half of the interviewees have hands-on experience installing and servicing HVAC equipment as contractors or technicians (50%) to a large extent in both the residential and commercial sectors. The other half of the participants are involved at a higher level as consultants, engineers and in more general management functions within their companies (50%). This segment of interview participants also worked in both the residential and commercial sectors, although one participant had some experience with the industrial sector as well. Similar to other fields, Table 61 indicates that consultants typically complete many more projects per year than contractors and engineers.

Table 61: HVAC Market Actor Profile

Respondent	Occupation	Sector	Num. Projects per Year
1	Air systems-Construction	Commercial	4
2	Resource Efficiency Manager	Com & Industrial	5
3	HVAC Contractor	Both	24
4	HVAC Contractor	Both	3
5	HVAC Contractor	Residential	10
6	Mechanical Contractor	Both	100
7	Service Technician	Commercial	50
8	Energy Consultant	Both	200
9	Systems Engineer	Both	1
10	HVAC Professional	Both	10

The HVAC courses taken by interviewees cover a myriad of topics including standards, design, equipment sizing, selection and installation, testing, and maintenance. Many of the courses are also co-sponsored by the Institute of Heating and Air Conditioning Industries (IHACI), an association of firms active in the industry.

Actions Taken and Energy Savings

At the macro level, there are a number of ways in which these market actors may have applied what they learned to change the services they provide to their clients. Table 62 captures the six different types of HVAC-related practices referenced by HVAC market actor course participants. Duct optimization, sizing practices, and the installation of high efficiency air conditioners are the most common actions taken as a result of course completion.

Table 62: Energy Saving Actions Taken by HVAC Interviewees

Type of Action	Number of Respondents Implementing (n=10)
Perform duct optimization	6
Size HVAC equip. correctly/optimally	5
Install high efficiency air conditioners	4
Improve HVAC diagnostics and optimization techniques	3
Install or repair commercial economizers	2
Install high efficiency furnaces	2

As part of the depth interview process, one market actor stated that he now installs central air conditioning units with a SEER rating of 17 as opposed to 13 prior to the courses, although he acknowledged that "the advent of federal tax credit has changed the industry [by instituting] a min of 16 SEER." Other market actors also report increases in the SEER and AFUE levels of the air conditioning units they install. Comments were also made about HVAC size reductions of up to 20%.

Based on the actions taken by each of the participants, the evaluation team established estimates of gross annual energy savings (see Table 63). The estimate for this group of participants is 2,318,833 kWh per year of projects. As with the other types of market actors, we also considered the amount of time that had elapsed since the participant enrolled in their first course. For those active in the HVAC market, the elapsed time from course participation to interview completion ranged from 0.9 years to 2 years with an average of 1.4 years since their first course. When accounting for this elapsed time, the total accumulated gross savings to date is 2,366,820 kWh.

Table 63: Savings (kWh) by Respondent and Action

Respondent	Num. Projects per Year	High Efficiency Furnaces	High Efficiency Air Conditioners	Correct Sizing HVAC	Economizers	Duct Optimization	Improved Installation & Diagnostics
1	4	-	-	34,634	1,469,972	-	-
2	5	-	-	-	37,885	-	-
3	24	-	43,117	99,966	-	999	3,595
4	3	None	-	None	-	-	-
5	10	None	730	2,543	-	327	-
6	100	-	346,310	-	-	10,301	35,030
7	50	-	-	-	-	-	29,862
8	200	-	-	-	-	182,765	-
9	1	-	-	10,767	-	299	-
10	10	-	9,229	-	-	502	-
Total	407	0	399,386	147,910	1,507,857	195,193	68,487

*Note: Cells containing "None" indicate that while the participant took actions in that area, the actions and/or savings could not be quantified.

At the participant level, savings range dramatically. While some participants noted making changes to the services they provide to clients as part of the quantitative survey effort, some of those changes did not result in energy savings. One participant, however, exhibited estimated savings close to 1.5 million kWh as the result of an economizer project. As a result of this individual's projects, the greatest areas of HVAC savings are related to the installation of commercial economizers, and high efficiency air conditioners produced the second-most savings at 399,386 kWh.

As in other end-use areas, some of the energy savings documented here could be accounted for by other utility programs. For example, half of the HVAC market actors interviewed believe their customers receive financial assistance from a utility program (50%). For some market actors only a small percentage of their customers participate, while for others it is almost all of their customers.

As this section indicates, overall, market actors specializing in HVAC perform a wide range of activities that have the potential to generate energy savings. Among this group of individuals, duct optimization, installation of high efficiency AC units, and HVAC sizing practices are the most prevalent, but could not have been adequately assessed or quantified using the quantitative participant survey alone.

11. Role of Statewide Education and Training

In addition to impacts from energy savings, our findings demonstrate that the Statewide Energy Efficiency Education and Training programs perform a range of functions that help Californian's reduce their energy consumption and move the market towards the goal of "market transformation". Based on the quantitative surveys of respondents who attended trainings across the Energy Centers, as well as an in-depth look (via case studies) at seven unique information and education efforts (for more information see Appendix D), we determined that these programs play at least nine important roles. While each of the programs differs in terms of their scope and offerings, collectively the initiatives attempt to create an environment conducive to market change by:

- Channeling Participants into IOU Programs
- Filling a Gap in Existing Offerings
- Providing Continuing Education
- Facilitating Professional Development in New Areas
- Providing Cutting-Edge Information Directly to Building Operators
- Reducing Barriers to Energy Efficiency Through Ad Hoc and Customized Training
- Catalyzing the Movement of Energy Efficiency Products Into the Market
- Training-the-Trainers
- Creating an Environment for Networking and Community Collaboration

In this section, we describe how the Statewide Energy Efficiency Education and Training Programs carry out these important roles. We also explain the value that these efforts have to both the State of California and the IOUs.

11.1 Channeling Participants to IOU Programs

Our research found that there is a deliberate attempt to highlight energy efficiency programs for course participants in nearly half of all courses. Out of the 449 unique courses for which there is a complete instructor survey, 42% discussed the availability and benefits of utility and third party energy efficiency programs as a discrete course topic. The level of the discussion varied. Sixteen percent (16%) of all courses integrated the discussion of these programs into the course whereas 28% of instructors included a more general and brief discussion of program options and benefits.

Based on our findings, 15% of all end-users (and 27% of all end-users who took action in an IOU territory) received a rebate. Of these, 75% learned about it in a course offered by an

Energy Center. We estimate that this helped to influence over 1,800 participants to participate in the IOU rebate programs.

The experience of market actors that take Energy Center courses also suggests they have a role to play to encouraging customer participation in utility rebate programs. For example, market actors that implemented the changes they made to their services on more than one job in 2008 report that on average 27% of their clients received financial support or technical assistance through a utility program. In contrast, when asked what they would expect if they had not taken the course, market actors felt than on average 20% of the clients would have received similar assistance (n=1348). As a result, it is evident that a subtle link exists between market actor knowledge of programs and their customer's participation in them.

Overall, these findings demonstrate that the majority of Energy Center courses serve as a promotional opportunity for the utilities. They provide a line of communication to an audience that is interested in taking action to improve energy efficiency in any number of venues and also provide information to market actors that can reiterate and reinforce the message among their clients.

11.2 Filling a Gap in Existing Training Offerings

We also found that the Energy Centers are an integral part of the marketplace for energy efficiency specific training. Specifically, the Energy Centers offer a breadth and depth of energy-efficiency-focused trainings. They play a much needed role in providing no cost, convenient, accessible, current and in-depth training that would not otherwise be available.

To gain some additional insight into the Energy Centers role in the marketplace for workforce education and training, we gathered information related to three main questions: 1) aside from the Energy Centers, where else might individuals receive training on energy efficiency?; 2) what are the characteristics of the training alternatives?; and 3) how do the Energy Centers compare to these alternatives? Our goal was not to perform an exhaustive, quantitative study of the market, but rather to create a preliminary framework in which to view the Energy Centers.[35] Participant comments regarding other venues at which they sought training served as the foundation for this assessment. In particular, when we asked course participants about the other places they had received training, they cited a range of organizations, professional associations, and programs. A general summary of some training locations identified through this research is provided in Table 64.

[35] Our main method of exploration and data collection was an extensive internet search, which also helped to provide us with a sense of the experience facing those seeking out educational opportunities online. We also asked about this information in our in-depth interviews. One notable limitation of this approach, however, was the inherent difficulty in accessing information about the educational opportunities available through labor unions and informal peer networks. In terms of labor unions, limited access is afforded to non-members and for informal networks information is often available only by word of mouth or through other means that cannot be tracked online.

Table 64: Additional Training Providers

California Home Energy Rating Service	Community Alliance for Career Training and Utility Solutions
Air Conditioning Contractors of America	North American Technician Excellence
The Affordable Comfort Institute	The American Institute of Architects
The Building Performance Institute	The Tile Roof Institute
Leadership in Energy and Environmental Design (LEED)	Air Conditioning and Refrigeration Institute
Sheet Metal and Air Conditioning Contractors' National Association	

A review of these entities and additional searches for information revealed that the Energy Center trainings offer a stronger focus on energy efficiency than the other options available. For example, our research on the trainings mentioned by participants, including an Internet search[36], identified at least two HVAC courses offered in the state, but neither had an explicit energy efficient focus. While there is some indication that market actors completing North American Technician Excellence (NATE) preparatory courses have significantly higher field efficiencies than those who do not, the curriculum is not focused on this area of study.[37]

In addition, when we looked for lighting courses, we found no alternative courses in California for those wishing to concentrate on energy efficient lighting. However, a number of organizations do promote energy efficiency in various ways and Table 65 presents some of these alternative courses.

Table 65: Alternative Courses

Sponsor	Description
Affordable Comfort, Inc. (ACI)	ACI is a non-profit organization training building and housing professionals to make homes energy efficient, using building science, testing and diagnostics-- a systems approach.
Building Performance Institute (BPI)	BPI is a national non-profit that accredits and certifies home performance market actors. It teams with other organizations to educate market actors using a whole house-systems curriculum created by NYSERDA
Leadership in Energy and Environmental Design (LEED)	Developed by the U.S. Green Building Council (USGBC), LEED provides building owners and operators a concise framework for identifying and implementing practical and measurable green building design, construction, operations and maintenance solutions.
Community Alliance for Career Training and Utility Solutions (CACTUS)	This appears to be a non-profit that offers many kinds of energy efficient classes including Residential Energy Services Network (RESNET) classes, weatherization classes, solar, ducts, and HERS throughout the state

[36] Again, we note that our review of offerings was not extensive. A more extensive review is being conducted for the CPUC-ED under the Workforce Education and Training efforts.

[37] Source: http://www.californiaenergyefficiency.com/docs/hvac/HVAC%20Draft%201-5-08.pdf

The Energy Centers provided more depth and breadth in their course offerings than other organizations. For example, while the Energy Centers serve as a one-stop shop for training on a wide range of end-uses, as well as customized trainings, most of the organizations we researched focused solely on one end-use or on a particular type of professional training. In addition, even within these organizations' areas of specialization, the number of courses offered appeared limited and certainly did not compare to the extensive course offerings at the various Energy Centers.

The scope of training opportunities offered at the Energy Centers is important --many of the Energy Center course participants take a large number of courses thereby demonstrating a demand for a range of topics. In fact, most of the participants who take more than one course also focus on more than one area: 39% took multiple courses in only one area with the remaining participants taking trainings across a wider variety of areas (or end uses such as HVAC, lighting, etc.).

Table 66: Number of End-uses (or Areas) in Which Participants Taking More Than One Class Took Courses

Number of End-uses	Participants Who Took More than One Course (n=15,730)
1	39%
2-3	49%
4-5	9%
6 or more	3%

When we asked Energy Center course takers who also took other trainings how the other training they received compared with the Energy Centers, some consistent themes emerged. In general, course participants favored the Energy Centers because they provide the right level of information at no cost and are viewed as a trusted source of energy efficiency information. A number of participants also praised the level of the Center courses and the fact that they are not too lengthy, which can pose a barrier to attendance.

Participant comments also indicate that they favored the Energy Center classes based on their current curriculum and in-depth approach. Those who did not attend courses taught by other organizations echoed these comments and felt the Energy Centers offer everything they need – no cost, convenience and good quality.

The Energy Center trainings were also more easily accessible than some of the other trainings mentioned. In conducting an Internet search, Energy Centers appear much more frequently, and provided all of the information required for attendance (e.g., cost, content, length, location, timing). Participants who reported attending non-Energy Center trainings reiterated this sentiment, indicating that it was difficult to find user-friendly information. We researched the organizations participants mentioned, looking specifically for offerings in California and for energy efficiency content. We found that for half the organizations, it was very difficult to determine when and where any courses would be offered and what they might cover.[38]

The value of the Energy Center courses within the overall market for training is apparent from the course participant feedback. According to some of the market actors interviewed:

- *"If they didn't exist it's possible I wouldn't have even gotten [the training] because any of the other courses or classes were a little bit more intensive [in terms of the amount of time required in the classroom]."*
- *"I would be very affected…I couldn't afford to take it [the training] if it wasn't for the Energy Centers."*
- *"I've been trying to become a better lighting designer and I would have probably done it from some combination of you know manufacturers information and you know I might have hired consultants more."*
- *Noting the fact that the course allows a service technician to offer greater value to his customers, one participant remarked: "Yeah, my work would be affected. [The] quality of the service technician that provides the service to the user or the consumer is of less value without that course."*

Overall, we determined that the Energy Centers offer training that would not otherwise be available.

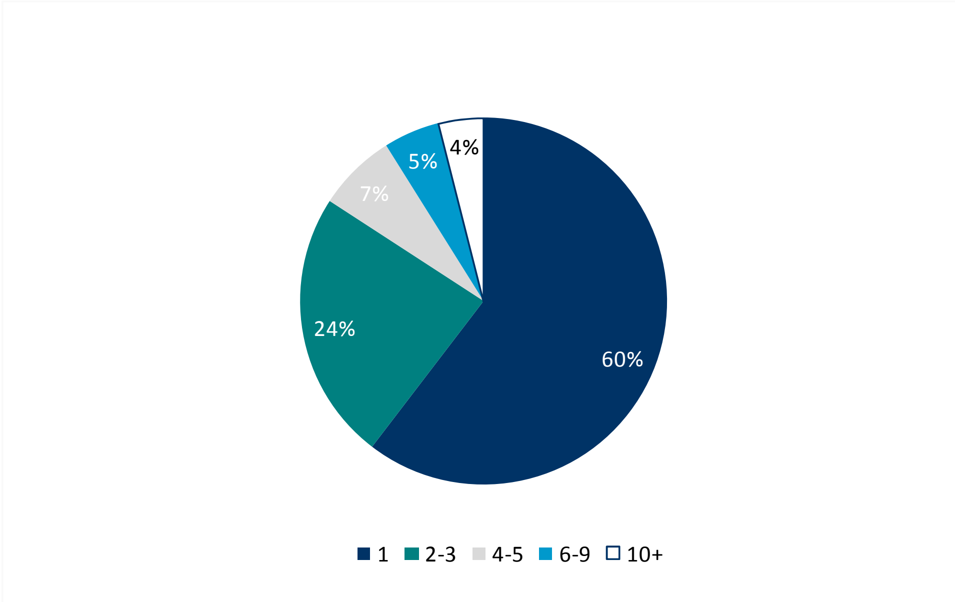
11.3 Providing Continuing Education for Those Already In The Workforce

Our research demonstrates that there is clear demand for ongoing education. Given that 40% of participants took multiple courses (Figure 19)[39], the evaluation team decided to explore why participants took multiple courses and focused in on participants who took five or more courses during the three year evaluation period. In particular, we wanted to know about the individuals' motivations to attend the Energy Center courses and whether the Centers training would advance their careers.

[38] We did not try to contact any of the organizations directly.

[39] Overall, participants took an average of 2.5 courses. However, a few took a large number of courses with one person completing 124 courses. In addition, 25 people took 50 or more courses over the three year study period though they represent less than 1/10 of a percent of the total number of participants.

Figure 19: Number of Courses Taken by All Participants (n=39,793)



We conducted 36 in-depth interviews with frequent course takers to better understand their motivation and decision-making in regard to their educational choices. [40] Among this group, the most common reason to take courses was to stay up-to-date on the practices in their field. Two of these respondents also noted the need to get continuing education credits to receive their architecture license. As described by the participants themselves:

- *"I'm constantly trying to find as many classes as possible to continue my education and deepen the level of detail about the whole building performance science. So yeah, it's an ongoing educational process and I really enjoy it."*
- *"They tend to have current information to help keep me updated."*
- *"The first reason [I took the classes] would be for my education credits for the American Institute of Architects primarily. And then also just to keep up with what is happening and I do inspections and I've helped in acquiring properties, so it is good to know that information."*
- *Course taking "has usually been for a specific purpose. I'm a HERS rater in California so I work a lot with all the energy code compliance for builders and contractors and so a lot of these things – you know, a lot of its update courses for my work."*

[40] The evaluation team conducted interviews with individuals that took courses in a number of end-uses, as well as those who took courses in a relatively small number of modules, such as market actors with defined areas of specialty.

The combination of subject areas taken by frequent course takers further suggests a deliberate approach to course selection and highlights the subjects in greatest demand. The magnitude of courses taken in the HVAC module along with the focus on other courses that collectively provide information related to building performance and envelope indicates that frequent course takers are creating their own interdisciplinary yet holistic curricula for professional development.

Table 67: Most Popular Modules among Frequent Course Takers

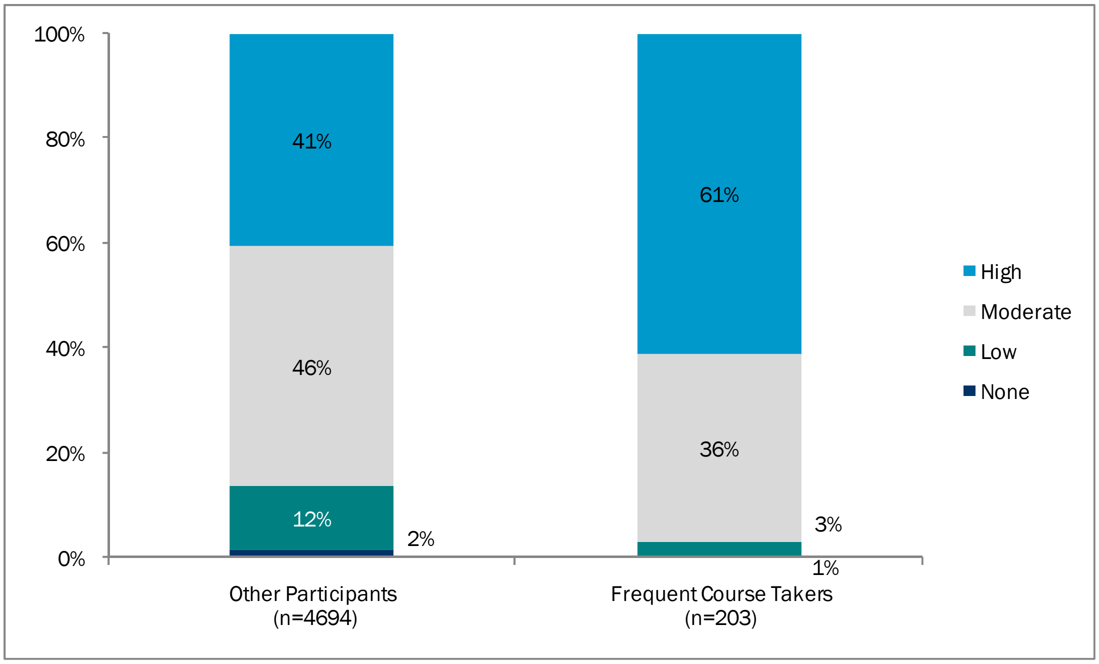
Module Type	Number of Courses Taken
HVAC	22,227
Lighting	5,106
General	4,929
Green Building	4,876

When asked about the benefit of taking a series of courses, participants spoke about being better able to perform certain professional duties such as providing informed recommendations to their clients, as well as receive training on the use of energy analysis tools.

- *"I think it just helps me make better selections for my clients and a little bit more knowledgeable about the pluses and the minuses of various systems for their specific applications"*
- *"[I took the courses] just to keep myself going and learning what's new out there, what's available to the public, and what we could do to save energy."*
- *"I try to incorporate what I can into my work."*

From the perspective of expanding energy efficiency knowledge, it is important to note that those who take more courses exhibit higher levels of learning than those who took fewer courses. For example, the majority of frequent course takers (62%) report large increases in their knowledge of the subjects covered in the course(s). In fact, the average knowledge gain among frequent course takers is greater than among those that took fewer courses regardless of the existing knowledge of each participant. This indicates that the increase in course taking is linked to increases knowledge.

Figure 20. Knowledge Gain by Type of Course Taker



The continuing education provided by the Energy Centers also has an impact on energy saving behaviors. Eighty eight percent (88%) of frequent course takers report taking energy saving actions as a result of what they learned in the course(s) compared to 67% among other course takers. As a result, it is clear that course participants utilize the Energy Centers as both a source of continuing education and mechanism for expanding both their energy efficiency knowledge and actions.

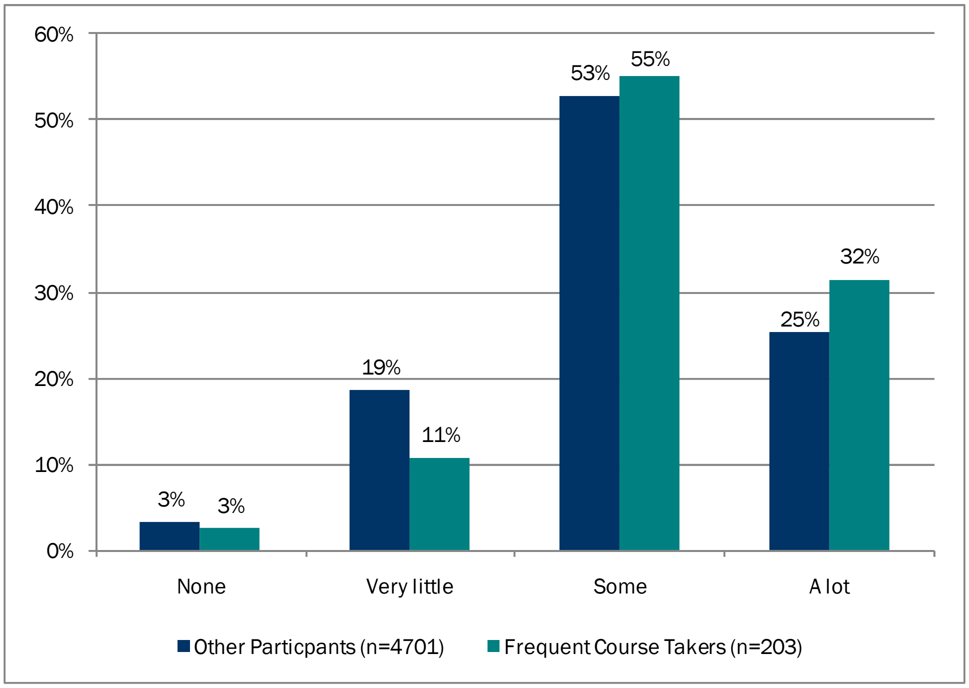
11.4 Facilitating Professional Development in New Areas

The experience of the most frequent course takers illustrates the ability of Energy Center courses to help individuals transition into new areas of work or take on new professional responsibilities. While the majority of these participants report wanting or needing to learn about energy efficiency to continue in their current profession, about one third made the decision to take courses to develop a new area of expertise or knowledge:

- *"I started out as the utility coordinator, which was a new position a little over a year ago, and even before that I had started taking classes to prepare - better prepare me for the position when I applied for it."*
- *"I think I took some in 2005 from SDG&E and I've always taken one or two a year probably, but yeah, in 2006, the last manufacturing plant I was working at shut down, and at that time, I made a decision I was going to turn my career towards energy efficiency…I want to be able to go into any kind of building and develop energy projects, energy audits that are based on current methods, and you know, can really give people value."*

Although frequent course takers took courses to make the transition into new areas of work, very few appear completely new to their industry suggesting that the Centers do not play the same role as colleges or vocational schools where individuals with no prior knowledge might go to begin professional training. For example, frequent course takers generally come to their courses with slightly more knowledge than those who take a smaller number of courses as illustrated in Figure 21 below.

Figure 21: Prior Knowledge among Frequent Course Takers



11.5 Providing Cutting-Edge Information Directly to Building Operators

Through both our analysis of course offerings, as well as some of the Energy Center's other key activities, we found that various programs offer intensive and specialized professional training opportunities directly to building operators. Specifically, the courses and activities foster skills development and provide cutting-edge technical and best practice information to building operators and facility managers. The Building Operator Certification (BOC) program and Existing Building Retro-commissioning Workshop Series (EBRCx) are two examples that allow the IOUs to indirectly influence the operation of buildings within their territories and maintain continued contact with this group of professionals over time. Examples of these two efforts are described briefly below, and covered in more detail through Case Studies in Appendix D.

The Building Operator Certification Program: Funded by the IOUs and administered by the Northwest Energy Efficiency Council (NEEC), BOC provides in-depth and hands-on experience to professionals in the building operations and maintenance field. The program provides two levels of training and certification both of which are designed to improve job skills and lead to improved comfort and energy efficiency at the participant's facility or facilities.

PG&E Existing Building Retro-commissioning Workshop Series: EBRCx is designed to increase knowledge of commissioning and provide practical experience to building professionals. The workshop series is holistic in nature and exposes participants to the entire commissioning process while ensuring relevant practice at one's own facility.

In terms of providing valuable information to professionals within or associated with the building operations field, all EBRCx participants felt they gained valuable information about commissioning, as well as practice with the process regardless of their prior experience. More generally, the workshop series' courses were seen as enabling participants to ask the right questions about retro-commissioning, to identify and include retro-commissioning measures in projects, and to communicate why retro-commissioning is valuable to plant managers.

Building operators had a similar experience. For example, when asked the degree to which their knowledge improved across the spectrum of BOC training topics, these individuals report a moderate increase in knowledge regardless of the course level. For all participants in the training, the mean improvement in knowledge was 4.8 based on a 7 point scale where 1 is "not at all" and 7 is "significantly" improved. The information provided through participation in the BOC training course also fosters greater information exchange and information seeking behavior. For example, almost all participants (97%) shared the information they learned through the BOC training with colleagues while 61% shared information with people outside their organization.

Again, additional details are available in the Case Studies, Appendix D.

11.6 Reducing Barriers to Energy Efficiency through Customized Training

The Statewide Energy Efficiency Education and Training programs also offer tailored support through ad hoc and customized training programs that can help market actors and end-users expand their competency in the area of energy efficiency. By providing a resource for individuals and organizations to draw upon when they identify gaps in knowledge, the Energy Centers improve access to information and reduce cost barriers otherwise associated with getting professional assistance. Several examples of this are described below, and examined in more detail through Case Studies described in Appendix D.

The Technology and Testing Centers Customized Trainings: TTC works collaboratively with customers to create specialized training sessions that address specific questions or gaps in knowledge among a particular company's staff.

PG&E Pacific Energy Center Consultations: PEC consultations are interactive and often hands-on. Sessions typically consist of one-on-one meetings between an individual or group of individuals and a PEC technical staff member. Areas covered include architecture, fenestration, daylighting design and modeling, building systems and retro-commissioning, measurement tools and data analysis.

Tool Lending Libraries: Each Tool Lending Library provides borrowers with no cost access to a select inventory of tools, as well as staff guidance on the function and appropriate application of those tools. The goal of the tool lending program is to enable borrowers to gain concrete experience with energy efficiency tools, learn about energy efficiency practices and identify energy efficiency project opportunities by using the tools.

SCG Industrial End-User program: The IEU program is a free service that helps large industrial customers make their operations more energy efficient, and reduce greenhouse gas emissions. The program consists of site visits and analyses related to saving energy, consultations about rebate and incentive programs, field observations and software modeling tools to assess the site's existing energy use and forecast potential costs and savings.

In particular, the often smaller size of these efforts also makes it easier for Energy Center staff to explain how a given IOU program or programs might apply to an individual's own facility or home. This level of customer attention can reduce information seeking barriers further by sharing customized information and in many cases, guidance on how to take the next step and implement a project. For example, participants in the Industrial End User Program receive an assessment carried out by a team consisting of account representatives (IEU specialists), engineers and service technicians. Customers then receive an energy report and tip sheet to help them make decisions on the purchase of energy-efficient equipment and process changes free of charge.

Tool loans also help reduce barriers to energy efficiency by providing all market segments with actionable information about the energy use of currently owned equipment, as well as the feasibility of implementing more energy efficient measures at various facilities or residences. This information then allows individuals to make decisions about specific energy saving projects, and also to better understand how they can assess energy efficient options in their work. Similarly, PEC consultations allow participants to engage with energy efficiency experts one-on-one and use sophisticated equipment such as the Heliodon to assess their projects.

11.7 Catalyzing the Movement of Energy Efficient Products into the Market

Energy Center efforts also play a role in helping to advance the manufacturing of more energy efficient equipment models and the willingness of the market to accept these products. For example, the Food Service and Technology Center's test method development and equipment testing closes gaps in product knowledge among manufacturers, utility and government policy-makers, and end-users. FSTC test data, as well as the test methods themselves, are highly valuable in utility energy efficiency program planning and ENERGY STAR labeling.

.

As those involved in the IOU and ENERGY STAR Commercial Food Service programs stated in interviews with the evaluation team, the FSTC has been invaluable and essential to the evolution of energy efficiency in this sector. Since the Center first opened in 1992, it has developed 37 test methods, all of which have been ratified by ASTM International. Further, manufacturers often use the FSTC to test the efficiency levels of their equipment as part of the research and development process. Having more accurate data about the efficiency of their products has moved manufacturers towards developing more and more efficient equipment over time.

Businesses and individuals that purchase commercial food service equipment are also affected by FSTC test methods given that the methods are used by the utilities to determine energy efficiency and therefore those products they want to incentivize. The inclusion of specific pieces of food service equipment in the portfolio can make these products more affordable and increase sales. In sum, given that the FSTC is the only entity in the United States that develops test methods for food service equipment, it is singularly important in providing this type of product information. The activities of the FSTC are explored further in a Case Study in Appendix D.

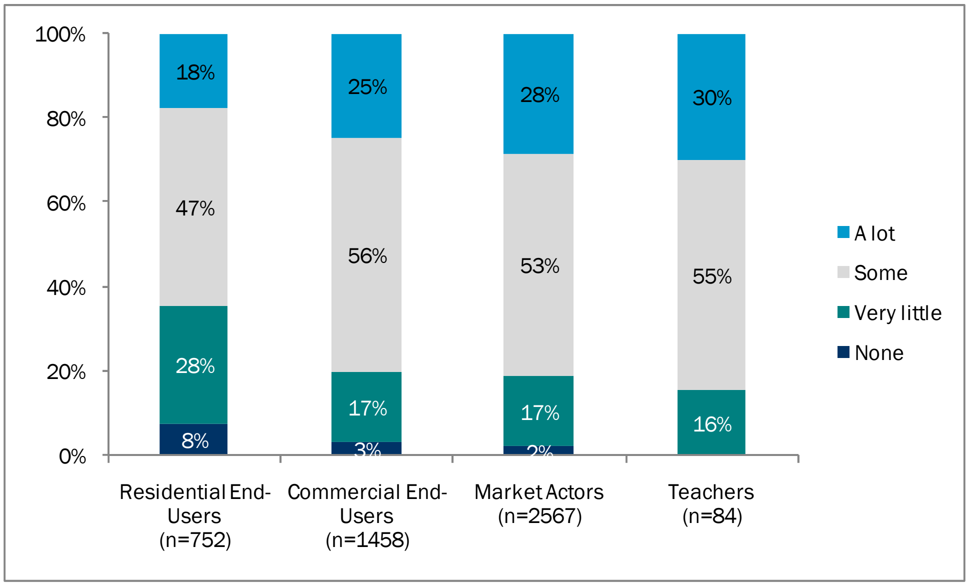
11.8 Training-the-Trainers

In addition to training market actors, building operators, and interacting with manufacturers, the Energy Center programs also touch educators who can help to expand the reach of the centers. Although the group of teachers that participated in our survey effort (n=84) is small in size, these participants are particularly well positioned to disseminate information provided by the Energy Centers, as well as train others on these topics.

The educators that took courses at the Energy Centers come from a variety of educational institutions such as school districts (12%), high schools (4%), and university systems (24%) such as the University of California, and Sacramento, Los Angeles and San Diego City Colleges. Other participants that hold a teaching role come from private companies, city departments or programs, other research and training centers, and unions. They also took a wide range of courses, with the largest number being in renewables, general energy efficiency, HVAC, green building and cooking as opposed to other topics.

Compared with participants from other professional backgrounds, educators consistently come to their courses with some existing understanding of how to accomplish the concepts presented the course. Encouragingly, despite their existing knowledge base, almost all teachers also agree that the courses provided them with at least a little new information (99%) suggesting that even for those individuals that start at a more advanced level, the courses offer a curriculum suitable for learners at all levels.

Figure 22: Prior Knowledge of How to Accomplish Course Concepts



In fact, most teachers learn a significant amount from the courses they take. For example, when asked how their knowledge had changed as a result of the courses, half of the teachers reported that their increase in knowledge was high (50%) while 45% reported a moderate increase. Strikingly, teachers that have the greatest familiarity with the course concepts prior to enrollment appear to benefit most in terms of knowledge gain as a result of the course.

As a result of taking the courses and gaining this energy efficiency knowledge, almost half of teachers (46%) strongly agree that they are more likely to recommend energy efficient equipment, designs or practices to their students. Based on a scale of 1 to 7 where 1 is "strongly disagree" and 7 is "strongly agree", the mean rating among teachers was 5.9. In addition, beyond making recommendations, educators frequently share what they learned with their colleagues (89%), and also seek out additional information related to what they studied (77%), both activities closely related to general practices within their professional field.

Further, many teachers re-evaluate the way that they perform their jobs and make changes using the information they have gained through course taking. In fact, over three quarters of the teachers who took Energy Center classes (76%) state that they applied what they learned to change the services they provide to their students. In some instances, this change includes new or different types of recommendations. Almost two-thirds (64%) of the teachers that made changes describe them in this manner and elaborate on the type of equipment they recommend. Examples cited include ENERGY STAR rated equipment, variable frequency drives, solar fans and panels, and cooking or food service equipment.

Teachers also integrate what they learned in the Energy Center courses into their class curriculum. As one participant noted, "[I am] using ideas from the courses to update class discussions" while another said they "enhanced [the] technical content of consumer workshops." A number of teachers also provide information to their own students about utility energy efficiency programs, direct them to the utilities' websites for additional information and one participant takes students to the Energy Resource Center twice a term.

Overall, the Energy Center courses had a moderately high impact on teachers' decisions to make these types of changes. On a scale from 1 to 7 where 1 is "not at all influential" and 7 is "very influential", the average rating provided by teachers who took action is 5.3. The fact that these new or enhanced practices also became standard practice for 87% of the teachers further expands the Centers' reach as information is continually passed on to new groups of students.

11.9 Creating an Environment for Networking and Community Collaboration

Beyond providing education and training, the Energy Centers provide a physical location for colleagues and professionals from related fields to interact, network and learn from one each others' experiences. As one market actor described it, "…there's interface that goes on among my peers at these things. I pick up at lot there too." In addition, our observations from courses such as Building Operator Certification demonstrate that there is often a mix of course participants in terms of their years in the industry, which allows for an informal exchange of information during breaks, as well as over the course of a multi-session program such as this one.

The Energy Centers also play an important role within the communities where they are located in part by opening their facilities to different professional organizations and entities involved in energy efficiency. As the one Pacific Energy Center staff member noted, "this is a very valuable institution because it brings all the…[or] most of the building players together" including vendors, architects, building operators and engineers. The ability of these institutions to create a community of individuals interested and engaged in energy efficiency is of significant value to the State of California based on the diffusion of energy efficiency information taking place.

12. RECOMMENDATIONS

In this section, we present program recommendations based on our research efforts. The recommendations are intended to provide the Energy Centers and IOUs with information they could use in program design and internal program monitoring and assessment. We also provide recommendations for future evaluations of the Statewide Education and Training Program.

Program Design Recommendations

The evaluation efforts were able to document the value of the Statewide Education and Training Program—both in terms of energy savings and additional roles in the marketplace. As such, it is clear that these programs play a valuable role and should be continued. The results of this evaluation, however, can also help inform and improve future program efforts. Specifically, we recommend the following:

- **Clearly identify program goals and performance metrics and ensure that these are acknowledged by both the utilities and the CPUC either prior to the program cycle, or as early as possible.**
  - The 2006-2008 program goals (as documented in the quarterly reports) focused primarily on the number of trainings and/or participants. The CPUC, however, indicated in their April 2005 decision that the performance basis should be on awareness, attitudes, knowledge, and energy savings. For the future, it is important to commonly acknowledge program goals prior to implementation in order to ensure that the programs are working toward the specific goals that the Centers are envisioned to play within California's Energy Efficiency Strategic Plan (e.g., goals for workforce education and trainings, etc.).
- **Review the results and use this information to help inform future program design, such as the roles that they seek to play in the marketplace, the emphasis on some technologies over others (e.g., HVAC), and the level of effort placed on channeling into rebate programs.**
  - While not a process evaluation, the findings from our indirect impact evaluation can help inform future efforts by the Statewide Education and Training programs. If used in conjunction with the process evaluation efforts, the information gathered through our research can provide insights that can help align actual efforts with the goals. Specifically, our findings show the focus of the courses in terms of technologies, types of participants attending, and level of effort placed on channeling into rebate programs. This information could be reviewed against the goals for the 2010-2012 programs to help confirm that the courses offered through the Centers align with the current goals and/or re-direct efforts, if necessary.

Participant Tracking Recommendations

The 2006-2008 evaluation also provided insights on the current tracking mechanisms, and how these could be enhanced in order to allow the Centers to better identify who they are touching, which would then allow future program efforts to target populations that are not currently being touched. In addition, tracking certain info can help provide additional metrics on the reach of these Centers, as well as inform whether (and how) the Centers are helping to meet the Workforce Education and Training goals identified in California's Strategic Plan. Specifically, based on our research efforts, we recommend the following:

- Create a common registration form that is used across all nine Centers. Add questions to collect:
  - *Participant Type* (e.g., end-users versus market actors, teachers, students, code officials, etc.). This information would provide Centers with another measure of program reach that they could use to monitor whether they are reaching their target markets. Evaluators could also use this information in their sample and research designs.
  - *Profession and/or Field of Participant.* This information would also provide another measure of program reach.
  - *Years in Profession*. This information will help Centers determine the role they are playing in workforce, education, and training. Specifically, this will allow the Centers to determine if they are reaching people who are new to the industry or more established professionals. As such, the Centers can use this information monitor the success of their marketing efforts.
  - *Existing Knowledge of Course Topic*. Based on this evaluation, we also suggest that the registration form include a pre-course measure of participant knowledge, which when coupled with a post-course measure, would allow more accurate and timely tracking of course impact on knowledge that the Centers could use to monitor course impact. (This is also discussed below.)
- Use consistent data entry for course and participant tracking.
  - Track complete participant information including full name, company, address, phone number and e-mail address for all education and training activities. Tool loan libraries should also track the specific tool borrowed.
  - Data that repeats over time (e.g. course name, participant name) should be entered the same way into the tracking database. Use of participant IDs would facilitate this.
- Create a shared registration system across the nine Centers, and if possible, assign each participant a unique identification number to help track individuals touched by the Centers.
  - The Team discovered that that approximately one in three participants took more than one course and one in ten took courses at more than one Center.

- o A shared registration system and participant database would allow the Centers to more easily identify unique participants giving the Centers multiple measures of Center reach. The Centers currently only have one measure: the overall number of participants. By tracking unique participants, the Centers will gain insight on how people are using the Centers to for career development as well as the role the Centers play in the workforce, education and training in California.
- o This will also help ensure that their participation “history” can easily be tracked.

Evaluation Recommendations

Finally, we present recommendations for future evaluation. Future evaluation efforts should be based on the program goals, but frequent evaluation activities can help adjust course curriculums more often to have the greatest impact. To assist with future evaluation efforts, we recommend:

- ➢ Ensure that future evaluation methods and techniques seek to measure more than just energy savings.
  - o We have shown that energy savings can be measured, however, we do not believe energy savings should be the only metric used to evaluate the Centers.
  - o Future program metrics could include energy savings and other indicators such as program reach (i.e., number of participants), percent of market reached, knowledge gain, awareness of energy saving opportunities, whether changes made have become standard practice and/or specific roles that the Centers seek to play depending upon the program goals.
- ➢ Measure participant knowledge gain on an ongoing basis. Ideally, participants would be asked to assess their existing knowledge of the course topic when registering for the course and then again shortly after taking the course.
  - o We see indications that a gain in knowledge is associated with taking energy saving action. Monitoring knowledge gain and the courses that most likely to lead to knowledge gain would allow the Centers to adjust their curriculums on a more frequent basis to have the greatest impact.
  - o By measuring knowledge gain more immediately after the course, evaluators would also have a measure of knowledge gain that is independent of and measured prior to taking action. Participants who take energy saving action may be more inclined to later self-report a higher degree of knowledge gain than those who do not end up taking action—this approach would eliminate that issue.
- ➢ Include questions on decision making and other demographic and firmographic information that can help better understand barriers to action.
  - o Our evaluation found that 7% of end-users were not decision makers.
  - o It would be useful to have more information on participants’ position within their companies and the company climate for making energy saving changes. This information could be used to adjust course curriculum to address barriers to participation.

- **Plan to implement different research designs for end-users and market actors. This would require Centers to collect information on participant types at registration as recommend above.**
  - The Centers reach both market actors and end-users, and the research approach, and effects for these populations vary. Possible research designs for consideration include:
    - For end-users: Conduct participant surveys with either a census or sample of end-users, depending on the Center. Use the existing end-user survey instruments to estimate energy savings. Focus on commercial participants since they account for 99% of savings.
    - For market actors: Use a nested sample design for market actors. The first stage would involve participant surveys with a sample of market actors. The second stage would be to conduct more in-depth research with a sample of the first stage respondents to estimate energy savings. Suggestions are below.
- **Focus on market actors for future evaluation efforts, since effects are broader and less understood.**
  - This evaluation showed that a large percentage of market actors who take Energy Center courses are changing their practices in ways that likely result in energy savings. However, quantifying energy savings (or any effects) for market actors is a challenge due to the frequency and variety of jobs they perform.
  - This evaluation included case studies with a sample of market actors, which provided insight into the types of actions being taken and the scale of savings that could result. Future efforts should take this work further. Possibilities include:
    - Conducting a larger number of case studies with a sample of market actors that could be extrapolated to the larger population.
    - Conducting field work with a sample of market actors to estimate savings.
  - Future evaluators should also consider exploring the interactions with other utility program efforts that reach the same market actors. The utilities offer multiple programs that work towards transforming the market—each of which is currently evaluated on an individual basis. For example, market actors are trained through the Centers, and as a result, they are more effective at selling energy efficient technologies to their clients who take advantage of rebate programs, which stimulates demand. Market and standard practices gradually change, which is recognized by policymakers who implement revised codes and standards. Future evaluation could connect market actors who receive training at the Energy Centers with their clients who are rebate program participants. Many market actors receive training at the Energy Centers that enables to them to do work that qualifies for a rebate. For market actors whose clients participate in IOU rebate programs, evaluators could identify the clients and collect information on the savings documented through the program. Follow this with additional research

with clients to determine the influence of the market actors on their program participation. Exploring this interaction may provide the utilities and CPUC with additional insights on the value of the Centers, and the synergies between program efforts.

Appendices

APPENDIX A: PERFORMANCE METRICS

As required by the Protocols, this appendix addresses the Education and Training Programs performance metrics. For the majority of Education and Training Programs, performance metrics were stated in terms of numbers of activities offered, which are primarily courses. However, additional metrics include outreach events, technical consultations, tool loans as well as others according to the program implementation plans. Because training sessions or courses were the most frequent program offering with the largest number of participants, the table below measures performance by training sessions offered. The goals of each Center measured against whether the Center met program goals, provides an indication of each Center's performance.

The vast majority of programs exceeded their program goals of offering a certain number of training sessions or courses. Table 68 displays the performance metrics for training sessions offered from 2006 through 2008. Note that these numbers were derived through the evaluation effort.

Table 68: Center Performance Metrics: Training Sessions Offered PY2006-2008

Energy Center	Achievement Status	Course Goals	Courses Held
PEC	✔	375	425
ETC	✔	360	773
FSTC		150	59[41]
CTAC	✔	534*	500
AgTAC	✔		222
TTC	✔	NR	37
SCG ERC	✔	307	358
SDG&E ERC	✔	25	34
CCSE	✔	50	84

*Note that AgTac and CTAC have joint goals according to their program implementation plan.

Based on our evaluation, FSTC fell short of expected goals. The FSTC's stated goal was 150 courses, while it only held 59 courses during the evaluation period. In addition, according to SCE's 2008 quarterly report, the TTC is on target; however, it does not reveal its stated goals for training sessions therefore we are unable to evaluate it.

In the following tables we present the self-reported metrics provided by the utilities in the quarterly reports for program years 2006-2008, however these metrics are not verified and the quarterly reports contained inconsistencies.[42] These data are included to facilitate the

[41] Note that according to PG&E's Quarterly Reports for 2006, 2007 and 2008, the Center held 227 training sessions over the program years. However, our evaluation found that the FSTC held only 59 courses. This is because the FSTC counts a number of activities as training sessions that were not considered training sessions for the purposes of our survey.

[42] Note that some utilities do not provide consistent quantifiable metrics for program performance or goals for each year.

review of each Center's performance metrics and to assist with determining feasibility of metrics for future evaluation efforts. Our review found that Centers defines training sessions differently. Because definitions of what constitutes training sessions varies across Centers, an evaluation of performance metrics could benefit from inclusion of alternative performance measures (such as attendance), in concert with our evaluated indicators, as a means to assess program success. Note that the information presented in the following tables was not verified by the evaluation team.

Table 69: PG&E 2006-2008 Performance Metrics

Pacific Energy Center	Achievement Status	Goal	Achievement
Training Sessions	✔	365	520
Outreach Events	✔	107	156
Technical Consultations	✔	205	259
Tool Loans	✔	893	1102
Energy Training Center	Achievement Status	Goal	Achievement
Training Sessions	✔	370	451
Outreach Events	✔	166	222
Technical Consultations	✔	290	359
Tool Loans	✔	1663	1905
Food Service Training Center	Achievement Status	Goal	Achievement
Training Sessions	✔	110	227
Outreach Events	✔	11	54
Technical Consultations	✔	21	47
Audits	✔	227	133

Note that for FSTC, PY2006 tracked additional performance metrics.

Table 70: SCE 2006-2008 Performance Metrics

Customer Technology Application Center	Achievement Status	Goal	Achievement
Training Sessions		534	511
Outreach Events	✔	300	504
Technical Consultations	NR	--	783
Agricultural Technology Application Center	Achievement Status	Goal	Achievement
Training Sessions		534	211
Technical Consultations	NR	--	126
Technology and Testing Centers	Achievement Status	Goal	Achievement
Technical Reports and Testing	NR	--	7

Note that CTAC and AgTAC goals are presented in the Program Implementation Plan. These goals may have been subsequently revised. Note that the TTC primarily provides essential energy efficiency information through application testing.

Table 71: SCG 2006-2008 Performance Metrics

SCG Energy Resource Center	Achievement Status	Goal	Achievement
Seminars	✔	307	423
Industrial End User Workshops	✔	23*	29
NATE Certification	✔	9	9

FSEC CAD Kitchen Designs		24	3
Building Operator Certification (BOC) Level I	✔	2	3
Building Operator Certification (BOC) Level II	✔	2	2
Equipment Demonstrations	✔	700	763
MFG Assisted Training Workshops		150	123

*Note that the Industrial End User Goal for 2008 was not provided, but stated that the goal was achieved. Because 8 was the number of workshops offered for that year, we used 8 as the program goal.

Table 72: SDG&E 2006-2008 Performance Metrics

SDG&E California Center for Sustainably Energy & Energy Resource Center Partnership	Achievement Status	Goal	Achievement
CCSE Onsite Workshops	✔	50	84
CCSE Outreach Events	✔	50	95
SDG&E Onsite Workshops	✔	25	34
SDG&E Offsite		0	11
CCSE Tool Lending Library		0	530
CCSE Resource Library		0	418
CCSE Technical Assistance	✔	45	425

APPENDIX B: SUCCESS AND TIMING OF DATA REQUESTS

This Appendix presents our assessment of the data provided by the Energy Centers during the evaluation period. Our assessment includes our evaluation of data availability and completeness as well as data quality. In addition, we present any additional issues we encountered with the data or necessary information, and finally we present a list of the data requests made in support of our evaluation including date of request and date of receipt.

B.1 Data Availability and Completeness

Assessment

Overall, we received the information we needed to evaluate the Energy Center programs. The Centers had the most complete information for course and seminar participants. Participant information was not collected as consistently for other types of programs such as tool lending libraries, consultations, tours, etc. This was generally true across the Centers.

Impact on Evaluation

For some activities we could only attempt to contact a portion of the participants. The impact on our results is unclear, but there could be some response bias if the collection of participant contact information is not done for certain classes or types of participants, thus excluding them from the evaluation.

Recommendation

The IOU's should ensure that Centers are tracking complete participant information. Specifically, participant information including full name, company, address, phone number and e-mail address should be tracked for all education and training activities. Tool loan libraries should also track the specific tool borrowed.

Any summary information should be tracked as well. This includes but is not limited to course descriptions, intended use of tool loans, tool loan types, consultation type, project type, etc.

B.2 Data Quality

Assessment

The data we received appeared to be complete and accurate. The IOUs generally noted areas where this was not the case. However, the data was not kept in a consistent manner across centers in the same IOU and within the same Center across time. For example, the names of courses would change over time even if the content did not. Participant data such as name spellings and contact information was also kept inconsistently.

Impact on Evaluation

We had to spend a large amount of time cleaning the data to make sure we identified unique courses and participants. We found that many individuals took more than one course but a unique individual's name could be entered with different spellings for different courses. Therefore, we were required to do a lot of detective work to create a participant profile for each unique individual to accurately characterize the activity levels of the Centers.

Recommendations

Create a new activity registration system that makes use of unique participant identification codes. Each person touched by any education and training activities should be given a unique id so that their participation "history" can easily be identified. This also allows evaluators to more easily track participants who have already been contacted by previous evaluation efforts.

Use consistent data entry for course and participant tracking. Data that repeats over time (e.g. course name, participant name) should be consistently entered into the tracking database. It can be very time consuming to attempt to identify all possible occurrences of a particular course if the course title is not consistently entered across time.

Use a database format for storing course, instructor and participant data. Data should be stored in a database format (as opposed to word or pdf) so that it can easily be incorporated into evaluation efforts.

B.3 Other Issues with Data or Necessary Information

Assessment

The data were always provided in a usable format. However, over half of the data requests (16 of 27) were delivered after the due date had passed (see Table 73). The data were between 1 and 23 days late. This was true of all IOUs.

In general, some aspects of the data request process made it difficult to communicate with IOU staff. The EEGA contacts are often not familiar with the actual data and are at least one or two steps removed from the Centers. The IOU staff providing the data generally did not contact us directly with questions about the request when they could have likely been cleared up relatively quickly. In addition, we were unable to follow-up on misunderstood data or missing data without submitting another formal request, which is time consuming when you have a simple clarification question.

Impact on Evaluation

Given that we needed a large amount of information from the Centers and that many tracked this information in a variety of ways, it is understandable that there were some delays in meeting our requests. However, the somewhat rigid nature of the data request process made it difficult to communicate with the Centers directly and move our requests ahead when there were simple questions or misunderstandings. As a result, we spent a lot of time going back and forth on data requests, which ultimately delayed our evaluation.

Recommendation

We understand the need for a formal data request process so the IOUs are not inundated with endless requests for information. However, a means of more easily communicating with the IOUs on the details of the requests when questions arise should be established.

Table 73: Education & Training Program Data Request History

IOU/Program(s)	Date Issued	Date Due[43]	Date Submitted	On-Time?
PG&E – All Centers	02/21/2008	03/14/2008	03/07/2008	Y
SCE – All Centers	02/21/2008	03/07/2008	03/10/2008	N
SCG – ERC	02/21/2008	03/20/2008	03/21/2008	N
SD&E – All Centers	02/21/2008	03/20/2008	03/27/2008	N
SCE – CTAC	05/20/2008	06/04/2008	05/29/2008	Y
SCG – ERC	05/20/2008	06/04/2008	06/13/2008	N
SCE – AgTAC	05/20/2008	06/04/2008	06/03/2008	Y
SDG&E – All Centers	05/20/2008	06/04/2008	06/20/2008	N
PG&E – All Centers	10/10/2008	10/25/2008	10/29/2008	N
PG&E – BOC Program	12/08/2008	12/22/2008	12/23/2008	N
SCE – BOC Program	12/08/2008	12/22/2008	12/17/2008	Y
SCG – BOC Program	12/08/2008	12/22/2008	12/18/2008	Y
SDG&E – BOC Program	12/08/2008	12/22/2008	12/18/2008	Y
PG&E – All Centers	01/27/2009	02/10/2009	02/18/2009	N
SCE – All Centers	01/27/2009	02/10/2009	02/09/2009	Y
SCG – ERC	01/27/2009	02/10/2009	02/09/2009	Y
SDG&E – All Centers	01/27/2009	02/10/2009	02/09/2009	Y
SCE – All Centers	03/03/2009	03/17/2009	03/12/2009	Y
PG&E – All Centers	04/13/2009	04/27/2009	05/01/2009	N
SCE – All Centers	04/13/2009	04/27/2009	05/01/2009	N
SCG – ERC	04/13/2009	04/27/2009	05/20/2009	N
SDG&E – All Centers	04/13/2009	04/27/2009	05/01/2009	N
PG&E – All Centers	05/20/2009	06/03/2009	06/11/2009	N
SCE – All Centers	05/20/2009	06/03/2009	06/05/2009	N
SCG – ERC	05/20/2009	06/03/2009	06/16/2009	N
SDG&E – All Centers	05/20/2009	06/03/2009	06/15/2009	N
SCE – All Centers	05/29/2009	06/12/2009	06/10/2009	Y

[43] The default due date is two weeks from the date of issue, however extensions may be requested.

APPENDIX C: ENERGY SAVING ACTIONS

The Evaluation Team identified the energy saving actions that course participants could reasonably take based on the information presented in the course. The tables below list the actions by end-use with the number of respondents who reported taking each action.

The total number of unique participants in each table is the number who took actions that could be credited to the Energy Center and for whom the Team was able to calculate energy savings. Respondents could take more than one action so the sum of respondents taking individual actions is greater than the total of unique participants.

Table 74: Lighting Actions

Lighting	
Installations	
Replaced existing incandescent light bulbs with CFL's	51
Installed occupancy sensors, daylighting, or combination of controls	31
Changed linear fluorescent tube lights	23
Changed Incandescent lighting	18
Changed exit signs	13
Replaced existing hard wired light fixtures with CFL fixtures	8
Changed High Bay lighting	7
Installed other lighting controls	2
Changed other types of lighting	1
Behaviors	
Reduced the number of hours you use the lights in your home	35
Changed lighting repair and maintenance practices	6
Changed the number of hours the lighting equipment is in use	4
Changed the time of day of lighting equipment	1
Made other changes to the operations of lighting equipment	1
Total unique respondents	114

Table 75: Green Building Actions

Green Building	
Installations	
Installed new energy efficient windows	16
Installed weather stripping and/or caulking	13
Installed cool roof	10
Installed window shading	6
Installed floor insulation	5
Installed wall insulation	5
Installed roof/ceiling insulation	4
Installed high R-value roof framing	3
Installed reflective window film	3
Installed radiant barrier	2
Installed standard window film, residential only	1
Installed other type of roof framing	0
Installed other type of temperature barrier	0
Installed other window film	0
Installed spectrally selective window film	0
Installed window framing	0
Performed a cost benefit analysis	0
Went through process of NFRC Site-Built Certification	0
Total unique respondents	69

Table 76: HVAC Actions

HVAC	
Installations	
Installed new Controls/Set points	10
Replaced Packaged units	9
Installed new Air Handling Components	8
Replaced Gas Furnaces	6
Replaced an old fan or fan system	5
Installed Chillers	4
Replaced Boilers	4
Replaced Chillers	4
Installed new Heating/Cooling equipment	3
Installed a new fan or fan system	2
Installed Heat pump	2
Replaced Heat pump	2
Installed Gas Furnaces	1
Installed Boilers	0
Installed Packaged units	0
Behaviors	
Made Changes to Maintenance Practices	23
Optimized Controls	17
Optimized Air handling equipment	12
Optimized other parts of HVAC	0
Made Changes to the Operation of an Existing Fan System	0
Total unique respondents	70

Table 77: Renewables Actions

Renewables	
Installations	
Installed a PV system to generate electricity	28
Installed Solar hot water heating system	6
Made changes to a solar hot water heating system	6
Made changes to a PV system to generate electricity	3
Installed a solar pool heating system	2
Installed other solar energy system	2
Installed solar hot water system for a radiant floor system	2
Made changes to a solar radiant floor heating system	2
Made changes to a solar pool heating system	1
Made changes to other solar energy system	0
Total unique respondents	51

Table 78: Boilers Actions

Boilers	
Installations	
Insulated piping	14
Installed low flow showerheads or showerhead aerators	7
Installed low-flow faucets or faucet aerators	5
Installed new or replaced high efficiency boilers	5
Installed new or replacement storage tank	5
Installed new or replacement tank less water heater	5
Installed structured plumbing	4
Installed a condensing boiler, cogeneration, or other heat recovery approaches	3
Increased hot water storage	0
Other hot water distribution changes	0
Behaviors	
Performed repair or maintenance measures	13
Installed or updated control strategy or made operational changes	12
Total unique respondents	30

Table 79: Controls Actions

Controls	
Installations	
Installed or modified controls to a lighting system	4
Made changes to air-side equipment and controls on HVAC	4
Installed or modified a new or replacement EMS	2
Made changes to system-wide controls on HVAC	1
Made changes to water-side equipment and controls on HVAC	1
Installed or modified a combined CHP or controls for CHP system	0
Total unique respondents	12

Table 80: Motor and Pump Actions

Motor and Pumps	
Installations	
Replaced motor	8
Redesigned or replaced piping to improve flow	4
Replaced pump	4
Installed a VFD on an existing motor	1
Changed the sizing or flow rate of a pump	0
Installed ASD or VSD drive on existing motor	0
Installed new motor	0
Installed new pump	0
Installed other speed or sizing controls	0
Redesigned a motor or pump system	0
Behaviors	
Check for shaft alignment or damage	0
Eliminate distribution system losses	0
Energy efficient rewinds	0
Implemented a demand reduction program involving pumps or motors	0
Increase power factor	0
Install energy efficient belts	0
Maintain voltage levels	0
Other motor maintenance	0
Other pump maintenance	0
Total unique respondents	8

Table 81: Pool Actions

Pools	
Installations	
Installed solar pool heating system	1
Installed VSD motor on pool pump	1
Installed pool pump	0
Behavior	
Made Changes to the Operation of Pool Pump	0
Total unique respondents	1

Table 82: Water Management Actions

Water Management	
Installations	
Changed the sizing or flow rate of a pump	0
Installed ASD or VSD drive on existing motor	0
Installed a VFD on an existing motor	1
Installed new motor	0
Installed new pump	0
Installed other speed or sizing controls	0
Redesigned a motor or pump system	0
Redesigned or replaced piping to improve flow	0
Replaced motor	1
Replaced pump	0
Behaviors	
Changes to water supply processes that did not involve motors/pumps	2
Changes to waste treatment processes that did not involve motors/pumps	1
Check for shaft alignment or damage	0
Eliminate distribution system losses	0
Energy efficient rewinds	0
Implemented a demand reduction program involving pumps or motors	0
Increase power factor	0
Install energy efficient belts	0
Maintain voltage levels	0
Other motor maintenance	0
Other pump maintenance	0
Total unique respondents	4

Table 83: Compressed Air Actions

Compressed Air	
Installations	
Installed or replaced auxiliary equipment	3
Installed or replaced VFDs	1
Replaced existing compressor	1
Installed an additional compressor	0
Installed new heat recovery equipment	0
Installed or replaced other components	0
Behaviors	
Fixed system leaks	10
Changed air filters or upgraded filters	9
Performed preventative maintenance on compressors	9
Performed preventative maintenance on components	6
Eliminated or reduced unnecessary compressed air uses	5
Reduced overall system pressure	4
Sequenced compressors	3
Reduced overall system run time	2
Adjusted manual staging of compressors	1
Changed use of existing storage capacity	1
Replaced end use equipment with equip. that operates at lower pressure	1
Changed source of air from room air to outside air	0
Installed individual or multiple compressor controls	0
Made changes to the design of an existing compressed air system	0
Made other changes to repair and maintenance practices	0
Other changes to operation of system	0
Replaced end use equipment with equip. that uses another source of energy	0
Total unique respondents	12

Table 84: Commercial Cooking Actions

Commercial Cooking	
Installations	
Installed an Efficient Motor	0
Installed an efficient Pump	0
Installed Hood Side Panels	1
Installed Insulation on the Storage Tank	0
Installed or Replaced Cooking Equipment	3
Installed or Replaced Hot Water Heaters	2
Installed or Replaced Ventilation System	0
Installed or Replaced Refrigeration Equipment	1
Installed or Replaced Ware Washers	0
Installed Specialty Hoods	0
Made Changes to Compressors	1
Made Changes to Condensers	0
Made Changes to Evaporators	0
Made Changes to Insulation	0
Made Changes to Lighting	0
Made Changes to the Defrost	0
Made Changes to the Pre-Rinse Spray Valve	0
Made Other Changes to Existing Hot Water Heaters	0
Made Other Changes to Existing Refrigeration Equipment	1
Made Other Changes to Existing Ventilation System	0
Made Other Changes to the Ware Washers	0
Moved Back Kitchen Equipment	0
Moved the Placement of Appliances	0
Reset Static Pressure	0
Used Bigger Hoods	0
Used Thermal Energy Storage	0
Used Variable Speed Drives	0
Behaviors	
Activated the Automatic Flue Damper	0
Adjusted Rinse Water Temperature	0
Calibrated Rinse Pressure	0
Calibrated Supply Water Temperature	0

Checked the Cleanliness of Condenser Coils	0
Checked the Cleanliness of Evaporator Coils	0
Cleaned Ware Washer Fixtures	1
Fixed all Leaks, Damaged Racks, Wash Curtains	1
Fully Load Dish Racks	1
Implemented Evaporator Pressure Resets	0
Implemented floating Condenser Head Pressure	0
Implemented Heat Reclaim	0
Implemented Microprocessor-based Control System	0
Implemented Static Pressure Reset	0
Implemented Sub cooling	0
Installed Refrigeration Timers	0
Lowered Condensing Temperatures	0
Made Operational Changes to Cooking Equipment	1
Made Other Operational Changes to Hot Water Heaters	0
Made other Operational Changes to Refrigeration Equipment	1
Made Other Operational Changes to Ventilation System	0
Made Other Operational Changes to Ware Washers	0
Performed Commissioning	0
Ran Ware Washer Only in Evening	0
Reduced Temperature Lift and/or Lowered Approach Temperatures	0
Turned off Dish machine	0
Turned off the Exhaust Hood	1
Turned off the Hot Water Heater Tank	0
Used Evaporator Fan Controller	0
Total unique respondents	**6**

APPENDIX D: CASE STUDIES

D.1 Building Operator Certification

The Building Operator Certification (BOC) Program, funded by the California Investor Owned Utilities (IOUs) and administered by the Northwest Energy Efficiency Council (NEEC), provides in-depth and hands-on experience to professionals in the building operations and maintenance (O&M) field. The program provides two levels of training and certification both of which are designed to improve job skills and lead to improved comfort and energy efficiency at the participant's facility or facilities. The Level I course series focuses on expanding knowledge of building systems and equipment while Level II students gain experience in equipment maintenance and troubleshooting.

BOC Level I training consists of seven courses and covers topics related to energy transfer, air movement, heating systems and maintenance, motors, cooling, ventilation and control systems, lighting, electrical safety, environmental health, and safety and indoor air quality. One course is held per month and each is structured to allow for lecture, work in small groups, the completion of tests and assignments, and the performance of work at one's own facility.

Course observation suggests that assignments and examinations are key factors in encouraging student engagement and active participation during the course sessions. Participants in the observed session paid close attention to the material presented, took notes and asked questions of the instructor, an indication of interest in the material and its applicability to their position. Instructors also highlight the importance of hands-on facility projects in reinforcing the information conveyed in the classroom.

Figure 23: Level I and II Curriculum

Course Name
Level I
BOC 101: Building Systems Overview
BOC 102: Energy Conservation Techniques
BOC 103: HVAC Systems and Controls
BOC 104: Efficient Lighting Fundamentals
BOC 105: Environmental Health and Safety Regulations
BOC 106: Indoor Air Quality
BOC 107: Facility Electrical Systems
Level II
BOC 201: Preventative Maintenance and Troubleshooting Principles (core)
BOC 202: Advanced Electrical Systems Diagnostics (core)
BOC 203: HVAC Systems Troubleshooting & Maintenance (core)
BOC 204: HVAC Controls & Optimization (core)
BOC 210: Advanced Indoor Air Quality
BOC 211: Motors in Facilities
BOC 212: Water Efficiency for Building Operators
BOC 213: Mastering the Fundamentals of Electric Control Circuits
BOC 214: Introduction to Building Commissioning
BOC 215: Electric Motor Management

In addition to attending classes and passing all tests, students must complete a series of facility specific projects. Level I projects include developing an energy management plan and conservation goals, the review of HVAC operations and maintenance procedures, and a lighting survey. For Level II students, projects require them to describe a power quality upgrade plan for their facility (or a part of it), compare original HVAC design and operating conditions to current conditions at the facility, and create an AC controls diagram, as well as a maintenance checklist for the facility fan system.

Participants who pass an exam at the end each course and complete all coursework are eligible for certification. Certification must then be renewed each year by completing at least five hours of additional training for Level I and ten for Level II. The certification and renewal processes are all managed by NEEC on behalf of the IOUs. The requirement for continued education provides the BOC program with an opportunity to direct students to course offerings at the Energy Centers, which count towards continuing education hour requirements.[44]

Reach of the Program

According to IOU program tracking data, between February 2006 and October 2008, 1,147 participants enrolled in the BOC program. As shown in Table 2, the programs vary in size by

[44] Interviews with BOC program staff. January 2009.

utility and Southern California Edison (SCE) had the largest number of participants with 462. Overall, 95% of attendees graduated from the program and received their BOC certification.

Figure 24: BOC Participants by Utility

Utility Sponsor	Number of Enrollees	Number of Graduates	Completed Interviews
Pacific Gas & Electric (PG&E)	385	359	100
Sothern Cal Edison (SCE)	462	434	64
Southern Cal Gas (SCG)	134	134	25
San Diego Gas & Electric (SDG&E)	166	161	43
Total	1147	1088	232

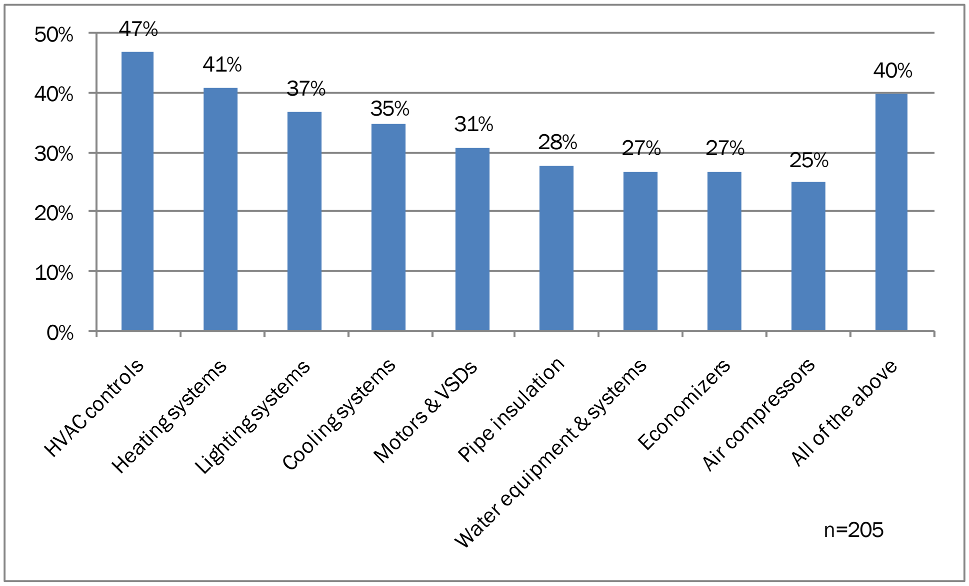
According to a survey of participants, a majority of BOC participants (88%) conduct or manage operations and maintenance (O&M) activities at their facility.[45] On average, these individuals have just over 4 years of experience in their field and just under half serve as members of O&M teams that are over 20 people in size (47%). Among those who have staff members reporting directly to them, the average number of staff members they oversee is eight.

Responses to the participant survey also indicate that the BOC program reaches O&M professionals working at a variety of facility types. More than three quarters of participants serve in government (31%), commercial (28%) or institutional (28%) buildings while a smaller percentage perform their duties in industrial facilities (10%). On average, a participant facility includes 4 buildings and covers 5,677,405 square feet.

BOC program participants have responsibility for a wide variety of systems and equipment at their facilities. The most common systems are HVAC controls. However, there are slight differences across facility types with participants who manage government (48%), commercial (55%) and institutional (50%) facilities being significantly more likely to deal with HVAC controls in their current position than those at industrial facilities (25%). Those working at commercial facilities (40%) are also significantly more likely to control water systems and equipment than their counterparts at various institutions (19%).

[45] A small percentage of BOC participants (12%) are not directly involved in O&M and among these individuals, all enrolled in the Level 1 program. The top reasons given for participation were knowledge acquisition (35%), applicability of the training to their current position (23%), and that enrollment was requested or required by their management (15%).

Figure 25: Equipment and Systems Controlled by BOC Participants (Multiple Response)



In addition, the majority of BOC participants surveyed have responsibility for controlling or reducing energy use (81%), maintaining indoor air quality (75%), and monitoring their facility's energy use (64%).

Knowledge and Behavior Change

Knowledge Change

Almost all BOC O&M participants (90%) come to the program with existing knowledge about the material covered in the training program: 45% feel they had "a lot" of prior knowledge while another 45% say they had "some" knowledge. However, when asked the degree to which their knowledge improved across the spectrum of BOC training topics, these individuals still report a moderate increase in knowledge regardless of the course level. For both Level I and II participants, the mean improvement in knowledge was 4.8 based on a 7 point scale where 1 is "not at all" and 7 is "significantly" improved.

The trainings were equally effective in increasing the knowledge of participants who had varying levels of experience with the material at the start of the series. Those with very little (4.9), some (4.9) or a lot (4.7) of knowledge all had similar gains on the 7-point knowledge scale. Level II participants with some prior knowledge of the topics reported a mean improvement in knowledge of 5.0 while those with a lot of prior knowledge had an average of 4.6.

In addition to expanded knowledge, participants report sharing information, increased professional confidence, and engagement on energy efficiency more generally. As illustrated in Figure 26 below, participants provide moderately high ratings in each of these areas.

Figure 26: Knowledge Based Training Outcomes

As a result of the BOC program…	Mean Score* (n=205)
I am more likely to encourage my organization to take steps to improve energy efficiency at my facility	6.1
I better understand how to improve energy efficiency at my facility	5.9
I have more confidence when I take steps to improve energy efficiency at my facility that the expected level of energy savings will actually occur.	5.8
I make greater contributions to O&M discussions about energy efficiency at my facility	5.6
I have increased my knowledge of what to look for when replacing equipment	5.6

* Mean on a 7 point scale where 1=Strongly Disagree and 7=Strongly Agree.

Behavior Change

Information Seeking and Sharing

The information provided through participation in the BOC training course fosters greater information exchange and information seeking behavior. For example, almost all participants (97%) shared the information they learned through the BOC training with colleagues while 61% shared information with people outside their organization. In addition, 70% searched for additional information related to the concepts taught in the course and 86% helped convince others in their organization that energy saving action is needed.

Participants also perform many of these behaviors with greater frequency and confidence after the training. Seventy three percent of participants strongly agree that they recommend energy efficient technologies or practices to their management more often and that they are better prepared to evaluate energy efficient options.[46] Furthermore, 64% strongly agree that their recommendations regarding energy efficient technologies or practices are viewed by their management as more informed.

Procedural, Maintenance and Equipment Related Practices

Participation in BOC training leads a majority of enrollees to modify the way in which they perform their O&M duties. In fact, 69% of participants made changes to their O&M procedures as a result of participating in BOC training. Those who took the Level II series (79% compared to 66% of Level I) and those who received their certification (72% compared to 59% of un-certified participants) are significantly more likely to have made procedural changes.

Eighty three percent of participants went further and took steps to save energy at their facility. Those that serve industrial (90%), government (88%), and commercial (86%) facilities are significantly more likely to have made efforts to save energy than those employed at institutional facilities (72%). At a minimum, approximately half of participants conducted one of the activities listed in the table below since completing their BOC training.

[46] This percentage and the that following it represents a score of six or seven on a scale of 1 to 7 where 1 is “strongly disagree” and 7 is “strongly agree”.

In a number of cases (marked with an asterisk), Level II students are significantly more likely to perform the activity than their Level I colleagues.

Figure 27: Activities Conducted Since Completing the BOC Training

Activities Conducted	Percentage of Participants (n=170)
Equipment Installation	
Install energy efficient lighting*	71%
Install new motors*	68%
Install lighting controls*	64%
Install energy management system or thermostat	63%
Install pipe insulation	59%
Install variable frequency drives	58%
Install air handler seals/gaskets*	45%
Maintenance Activities	
Perform motor maintenance*	75%
Conserve water and/or wastewater as a result of actions	71%
Perform maintenance on chillers/cooling towers*	68%
Perform maintenance on unitary equipment*	67%
Perform maintenance on economizers*	67%
Perform maintenance on boilers	67%
Perform maintenance on air compressors*	64%
Perform air compressor leak reduction	46%

Note: The inclusion of an asterisk next to any activity indicates cases where Level II students are significantly more likely to have performed the activity than their Level I colleagues.

On average, participants performed 10 activities after completing the program and 11% performed all of activities listed above, Participants also indicate that the training provided by the BOC program had a moderate impact on their decision to perform these activities. The mean level of program influence was 5.3, although 43% of participants rated the training's affect a 6 or 7 on a seven point scale where 1 is "not at all" and 7 is "very much.

Although a majority of participants (86%) also performed these activities before completing the BOC training program, 95% report performing them more efficiently and 69% report performing the activities more frequently since completing the training program. In terms of future activity, 79% of O&M participants are very likely (a rating of six or seven) to make an effort to save energy at their facility during the next 12 months.

As documented by other evaluations of the BOC program, the actions of O&M professionals also have an impact on facility energy usage. For example, the Northeast Energy Efficiency Partnership (NEEP) developed an estimate of energy savings associated with actions taken as a result of the program that has been used as a reference by the Midwest Energy Efficiency Alliance (MEEA) and those utilities for which MEEA administers the program. NEEP estimates that the program saves 0.35 kWh/square foot per enrollee (including savings from rebated actions) and 0.18 kWh/square foot per enrollee (excluding rebated actions).[47]

Energy savings estimates can differ dramatically across jurisdictions, however, based on differences in average building size, the types of projects implemented, and the degree of influence that the BOC program had on participants' decisions to implement projects. For example, NEEP's estimates are *gross* savings estimates and therefore do not consider that the energy saving actions might only have been partially influenced by the program. In addition, savings estimates developed as part of evaluations from other jurisdictions range from 0.02 kWh/ square foot per graduate to 0.06 kWh/square foot. Despite the variation, these estimates are one indicator of the influence of the program on energy saving actions and their associated energy savings.

Overall Value and Influence of the BOC Program

As demonstrated above, the BOC program provides O&M professionals with enhanced training that enables them to better understand the energy efficiency options available to them, and encourages them to take steps to reduce energy use either for the first time or more frequently. The program also fosters the dissemination of energy efficiency information within the participant's professional networks and organizations.

Participants clearly believe the BOC training is influential in their decision-making regarding energy efficiency actions. Among participants that made efforts to save energy, 44% said the training affected their decision to perform the activities "very much" (a rating of 6 or 7 on the 7 point scale where 1 is "not at all" and 7 is "very much"). The average response was 5.25, which indicates a moderately high influence for the program.

In addition, over half of BOC participants have either participated (38%) or plan to participate (19%) in a utility sponsored energy efficiency program. It is likely that the presence of utility representatives at BOC training sessions and the use of utility program, rate, and other information by instructors help to educate participants about the opportunities available to them through their utilities.[48] Awareness of these program options is a critical first step in reaching a decision to participate.

[47] RLW Analytics, "Impact and Process Evaluation – Building Operator Certification (BOC) Program – Final Report", prepared for Northeast Energy Efficiency Partnerships. June 2005.

[48] Interviews with the BOC program administrator and instructors, as well as course observation.

Overall, all BOC participants generally agree that they have been able to reduce energy usage, enhance comfort and save money at their facility as a result of the BOC training program.

Figure 28: Additional BOC Training Outcomes

I have been able to…	Mean Rating* (n=205)
Enhance the comfort of the facility occupants	6.3
Save money at my facility	5.6
Save energy or reduce energy demand at my facility	5.6

*Note: Mean ratings are based on a seven point scale where 1 is "strongly disagree" and 7 is "strongly agree."

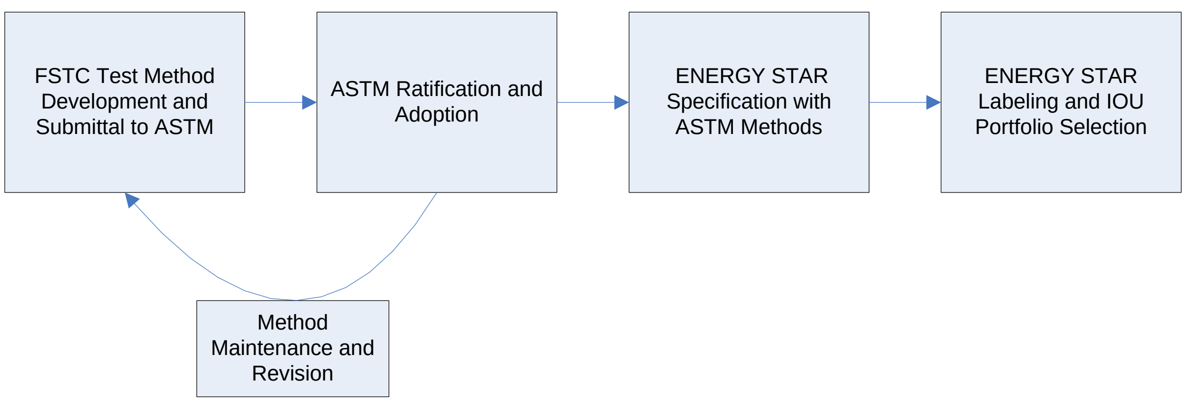
D.2 Food Service Training Center: Test Methods

Over the last 17 years, the Food Service Technology Center (FSTC) has led the effort to establish test methods for commercial food service equipment. The FSTC's activity in this area has been instrumental in the designation of commercial food service equipment as ENERGY STAR certified, as well as identifying equipment for inclusion in Investor Owned Utility (IOU) energy efficiency program portfolios. Much, if not all, of this activity would not have been possible in the same period of time without the contribution of the FSTC.

The FSTC aims to increase energy efficiency in the commercial food service industry at the state, national and international level. The foundation of this effort is FSTC's test method development and equipment testing, both of which serve to close gaps in product knowledge among manufacturers, utility and government policy-makers, and end-users. The Center has amassed an extensive database of equipment types and their performance levels by using the test methods in-house to assess commercial food service products. This test data, as well as the methods themselves, are highly valuable to both California's utilities and the U.S. Environmental Protection Agency, which use it as an input in their policy making activities.

Figure 29 summarizes the relationship between the FSTC, its test methods (ratified by ASTM International, formerly the American Society for Testing and Materials), and the entities that use them.

Figure 29: FSTC Test Method Chain of Influence



Since the Center first opened in 1992, it has developed 37 test methods, all of which have been ratified by ASTM International.[49] At present, approximately 10 test methods are under review as part of the ASTM International mandatory five year review cycle.

[49] Food Service Technology Center. "ASTM Standard Test Methods." Fischer-Nickel, Inc. 2009. Accessed: http://www.fishnick.com/testing/testmethods/.

Reach of the Program

According to FSTC staff, the rate of test method creation has increased over time as the Center has grown, and developed technical capacity and industry partnerships. For example, in 1996 just five FSTC test methods were ratified by ASTM International while in 2001 that number had increased to more than 20. The range of equipment types covered by FSTC test methods is summarized in .

The FSTC has a significant effect on people inside and outside of California as a result of its test method development and the application of those test methods along with the test data produced. Each of these activities and their associated impacts presented in Figure 29 above affect different constituencies in varying ways.

Policy Makers and Professional Organizations: FSTC test methods establish agreed upon standards within the industry that are then used by organizations and agencies within California and throughout the country. As described in a previous evaluation of the Center, "the FSTC develops test methods for use in establishing codes and standards that are then adopted, used or incorporated in codes and/or standards by various organizations (e.g., ASTM, DOE (Energy Star), CEC, ASHRAE)."[50] This cycle influences policy making processes by making greater amounts of information available for use in planning and policy development.

> ASTM International is a central player in the application of test methods in the State of California and elsewhere based on the fact that FSTC test methods must be presented to and ratified by ASTM International in order to become a common standard across the industry. As a result, the FSTC has a staff member that serves as sub-committee chair of the ASTM International Technical Committee F26 on Food Service Equipment and works behind the scenes to create consensus and buy-in around new test methods among relevant stakeholders.

Equipment Manufacturers: The work of the FSTC impacts manufacturers in a number of ways. First, according to FSTC staff, manufacturers often use the FSTC to test the efficiency levels of their equipment as part of the research and development process. Having more accurate data about the efficiency of their products has moved manufacturers towards developing more and more efficient equipment over time. For example, as the ENERGY STAR Program has become more active in the area of commercial food service, manufacturers look to FSTC testing as a way to try and achieve ENERGY STAR approval of their product, which is seen as a beneficial marketing tool. [51]

End-Users: Businesses and individuals that purchase commercial food service equipment are also affected by FSTC test methods given that the methods are used by the utilities to determine energy efficiency and therefore which products they want to incentivize. The inclusion of specific pieces of food service equipment in the portfolio can make these products more affordable and increase sales.

---

[50] Equipoise Consulting, Inc. "Final Report for Energy Efficiency in Commercial Food Service." Equipoise Consulting, Inc. April 2004.

[51] PA Consulting Group. "Pacific Gas & Electric – Process Evaluation and Strategic Assessment of the Food Services Technology Center." PA Consulting Group. February 14, 2008.

> In addition, end-users who are aware of the Center and its test methods may use it as a source of information about a piece of equipment when making a purchase decision. As outlined in a 2004 study of the FSTC, in 2003, around 20% of participants asked an equipment dealer or manufacturers how a piece of equipment scored on ASTM test methods prior to purchasing it.[52]

The Center is the only one in the United States that develops test methods for food service equipment, although others are beginning to explore the development of capabilities in this area. FSTC staff members have also consulted with manufacturers located abroad about the evolution of the test method process in the United States and lessons learned in testing commercial food service equipment to determine energy efficiency levels.[53]

Overall, interviews with FSTC, utility and ENERGY STAR staff, as well as previous evaluation efforts, illustrate that a range of entities utilize the FSTC test methods and data in ways that impact the availability, marketing, and use of energy efficient commercial food service equipment. The following sections of this report focus on the process by which the California IOUs and the ENERGY STAR program draw upon ASTM test methods.

Program Utilization

ENERGY STAR© Reliance on Test Methods

The FSTC has maintained a presence in national energy efficiency policy discussions for many years and weighed in at various points on the ENERGY STAR labeling of commercial food service equipment. The Center has been involved in every ENERGY STAR specification for commercial food service equipment to date, although often "behind the scenes", and was noted by the management of the ENERGY STAR commercial food service program.[54]

ENERGY STAR Program staff and those at the FSTC share the same view of the Center's contribution to the specification process. According to ENERGY STAR staff, the specifications developed to date have relied heavily on the availability of an ASTM test method, and the process is dependent upon the existence of product test data. The FSTC has essentially been the sole source of this data allowing the program to move forward on new specifications. Although not the focus of this study, the FSTC also helps ENERGY STAR with market research and the development of equipment descriptions.

Even in situations where an ENERGY STAR product is not yet available, the program directs people to the FSTC for information. As their guide to restaurants states, "Ask questions and check online for reviews. If no ENERGY STAR qualified models exist for the type of equipment you're looking for, don't worry—you've still got options. Ask distributors and manufacturers for energy use information, and check online for equipment reviews. The Food Service Technology Center is a great place to start."[55]

---

52 Equipoise Consulting Inc. 2004.

53 In-depth Interview with FSTC Staff. May 20 and 27, 2009.

54 In-depth Interview. ENERGY STAR Commercial Food Service Representatives. July 9, 2009.

55 U.S. Environmental Protection Agency. "ENERGY STAR Guide for Restaurants." U.S. Environmental Protection Agency. May 2007. Available: http://www.energystar.gov/ia/business/small_business/restaurants_guide.pdf.

The Role of Test Methods in IOU Portfolio Development

Similar to the experience of the ENERGY STAR Commercial Food Service Program, ASTM test methods developed with FSTC support are critical for utility program planning and decision-making. According to Pacific Gas and Electric (PG&E) staff, prior to FSTC's involvement in the field, there was no established standard for testing commercial food service equipment. Therefore, the utilities had no means by which to determine whether certain pieces of equipment were in fact more or less efficient than other pieces of equipment.[56]

In the case of the IOUs, the data collected through FSTC equipment testing is recorded and used as an input to IOU workpapers, which document the energy savings expected for various types of equipment and inform the portfolio development process. A wide range of commercial food service equipment is currently included in the energy efficiency portfolios of the IOUs. At present, there are 15 product types eligible for IOU rebates, more than half of which (69%) were reviewed using ASTM test methods for commercial food service equipment to determine the energy use of equipment and the corresponding energy efficiency requirements.

Figure 30: IOU Rebate Eligible Food Service Equipment

Product Types	ASTM Test Method Used to Determine Energy Use[57]
Commercial Combination Ovens	✓
Commercial Convection Ovens	✓
Commercial Conveyor Ovens	✓
Commercial Rack Ovens	✓
Commercial Fryers	✓
Commercial Large Vat Fryers	✓
Commercial Glass Door Refrigerators	
Commercial Griddles	✓
Commercial Energy Star® Ice Machines	
Commercial Super Efficient CEE Tier III Ice Machines	
Commercial Steam Cookers	✓
Commercial Solid Door Freezers	
Commercial Solid Door Refrigerators	
Insulated Holding Cabinets	✓
Commercial Kitchen Ventilation Control	✓

*Note: Qualifying product types are the same across all the California IOUs.

In addition to test data, the FSTC directly supplies program administrators with technical information to support the development of their programs.[58] In some instances the FSTC

[56] In-depth Interview. PG&E Commercial Food Service Program. July 31, 2009.

[57] Pacific Gas and Electric. "Food Service Electric ALL Measure Workpapers 12-01-06 Final" and "Food Service Gas ALL Measure Workpapers 8-22-06 Final." Pacific Gas and Electric. Available: http://eega2006.cpuc.ca.gov/DisplayQuarterlyReport.aspx.

staff has also made informal recommendations regarding incentive levels.[59] However, the final decision is always made by the utility program manager.

Energy Savings

As the analysis above demonstrates, the FSTC plays a critical role in identifying energy efficient commercial food service equipment and making it accessible to consumers indirectly through its support of the ENERGY STAR program and IOU energy efficiency portfolio. This process is also valuable given the energy savings generated by each piece of food service equipment promoted by the utilities. Figure 32 below presents the energy savings associated with each unit of food service equipment included in the IOU energy efficiency portfolios.

Figure 31: Ex Ante Energy Savings from Commercial Food Service Equipment

Type of Food Service Equipment	Annual Energy Savings Per Unit	
	kWh/yr	Therms/yr
Commercial Combination Oven	18,431	403
Commercial Convection Oven	2,262	323
Commercial Rack Oven Single	-	1,034
Commercial Rack Oven Double	-	2,104
Commercial Fryer	1,166	505
Commercial Large Vat Fryer	1,788	578
Commercial Griddle	1,637	89
Commercial Steam Cooker	11,166	2,084
Insulated Holding Cabinets Full Size	2,190	-
Insulated Holding Cabinets Three-Quarter Size	1,642	-
Insulated Holding Cabinets Half Size	1,095	-

Source: PG&E Mass Market NRES 4Q2008 E3 Calculator[60]

Based on program tracking data from each of the IOUs, a minimum estimate of energy savings from food service equipment between the first quarter of 2006 and the fourth quarter of 2008 can be determined. Figure 32 includes estimates from PG&E's Non-Residential Food Service Program and the Express Efficiency Programs offered by Southern California Gas (SCG) and San Diego Gas and Electric (SDRG&E), which include commercial food service items.[61] In total, 2,872 pieces of equipment evaluated using ASTM test methods were installed in the IOUs' service territory from 2006-2008.

58 Equipoise Consulting Inc. 2004.

59 In-depth Interview with FSTC Staff. May 20 and 27, 2009.

60 Pacific Gas & Electric. "Mass Market NRES 4Q2008 E3 Calculator." Available: http://eega2006.cpuc.ca.gov/

61 Data from Southern Cal Edison is not included in the table because food service equipment could not be located in their E3 Calculator.

Figure 32: Utility Estimated Energy Savings

IOU Program	Installed Units	Total Net kWh	Total Net Therms
PG&E Mass Market Non-Residential Food Services	1,166	1,661,234	323,128
SCG Express Efficiency	1,672	-	691,785
SDG&E Express Efficiency	34	215,852	6,556
TOTAL	2,872	1,877,086	1,021,469

Source: PG&E, SCG and SDG&E E3 Calculators for 4Q 2008.

Overall, the IOU commercial food service programs make a measurable contribution to the generation of energy savings across the State. While commercial food service programs serve a specialized market segment, program participation and the associated energy savings represent an important contribution to conservation energy efficiency efforts.

Overall Value of FSTC Test Methods

As demonstrated throughout this report, the FSTC plays a central role in creating the conditions necessary for policy makers to promote more efficient commercial food service equipment. Over the course of the Center's existence, its staff has directly helped the commercial food service industry become more efficient from the perspective of manufacturing and procurement. The FSTC is also indirectly involved in fostering both the ENERGY STAR specification process and the expansion of IOU energy efficiency programming in this area.

Figure 33: ASTM Test Methods

N	ASTM Test Methods	First Ratified	Current Ratification Year
1	F1275-03 Standard Test Method for Performance of Griddles	1995	2003
2	F1361-05 Standard Test Method for Performance of Open Deep Fat Fryers	1995	2005
3	F1484-05 Standard Test Method for Performance of Steam Cookers	1993	2005
4	F1496-99(2005) Standard Test Method for Performance of Convection Ovens	1993	2005
5	F1521-03 Standard Test Methods for Performance of Range Tops	1996	2003
6	F1605-95(2001) Standard Test Method for Performance of Double-Sided Griddles	1995	2001
7	F1639-05 Standard Test Method for Performance of Combination Ovens	1995	2005
8	F1695-03 Standard Test Method for Performance of Under-fired Broilers	1996	2003
9	F1696-96(2003) Standard Test Method for Energy Performance of Single-Rack Hot Water Sanitizing, Door	1996	2003

N	ASTM Test Methods	First Ratified	Current Ratification Year
	Type Commercial Dishwashing Machines		
10	F1704-05 Standard Test Method for Capture and Containment Performance of Commercial Kitchen Exhaust Ventilation Systems	1996	2005
11	F1784-97(2003) Standard Test Method for Performance of a Pasta Cooker	1997	2003
12	F1785-97(2003) Standard Test Method for Performance of Steam Kettles	1997	2003
13	F1786-97(2004) Standard Test Method for Performance of Braising Pans	1997	2004
14	F1787-98(2003) Standard Test Method for Performance of Rotisserie Ovens	1998	2003
15	F1817-97 Standard Test Method for the Performance of Conveyor Ovens		1997
16	F1920-98(2003) Standard Test Method for Energy Performance of Rack Conveyor, Hot Water Sanitizing, Commercial Dishwashing Machines	1998	2003
17	F1964-99(2005) Standard Test Method for Performance of Pressure and Kettle Fryers	1999	2005
18	F1965-99(2005) Standard Test Method for Performance of Deck Ovens	1999	2005
19	F1991-99(2005) Standard Test Method for Performance of Chinese (Wok) Ranges	1999	2005
20	F2022-00 Standard Test Method for the Performance of Booster Heaters		2000
21	F2093-01 Standard Test Method for Performance of Rack Ovens		2001
22	F2140-01 Standard Test Method for Performance of Hot Food Holding Cabinets		2001
23	F2141-05 Standard Test Method for Performance of Self-Serve Hot Deli Cases	2001	2005
24	F2142-01 Standard Test Method for Performance of Drawer Warmers		2001
25	F2143-04 Standard Test Method for Performance of Refrigerated Buffet and Preparation Tables	2001	2004
26	F2144-05 Standard Test Method for Performance of Large Open Vat Fryers	2001	2005
27	F2237-03 Standard Test Method for Performance of Upright Over-fired Broilers		2003
28	F2238-03 Standard Test Method for Performance of Rapid Cook Ovens		2003
29	F2239-03 Standard Test Method for Performance of Conveyor Broilers		2003

N	ASTM Test Methods	First Ratified	Current Ratification Year
30	F2324-03 Standard Test Method for Prerinse Spray Valves		2003
31	F2379-04 Standard Test Method for Energy Performance of Powered Open Warewashing Sinks		2004
32	F2380-04 Standard Test Method for Performance of Conveyor Toasters		2004
33	F2472-05 Standard Test Method for the Performance of Staff-Served Hot Deli Cases		2005
34	F2473-05 Standard Test Method for the Performance of Water Bath Rethermalizers		2005
35	F2474-05 Standard Test Method for Heat Gain to Space Performance of Commercial Kitchen Ventilation/Appliance Systems		2005
36	F2519-05 Standard Test Method for Grease Particle Capture Efficiency of Commercial Kitchen Filters and Extraxtors		2005
37	F2644-07 Standard Test Method for Performance of Commercial Patio Heaters	2004	2007

D.3 Energy Resource Center: Industrial End User Program Case Study

To help cut greenhouse gas (GHG) emissions and improve energy efficiency in the state, the Southern California Gas Company (SCG or the Gas Company) created the Industrial End User (IEU) program. This program is a free service that helps large industrial customers make their operations more energy efficient and reduce their energy use and greenhouse gas emissions. The program provides participants with:

- Site visits and analyses about saving energy with various industrial uses of natural gas, including process heating and steam systems, gas engines, air compressors, oxidizers and steam turbine drives
- Consultations about rebate and incentive programs
- Field observations and software modeling tools to assess the site's existing energy use and forecast potential costs and savings. These tools include the process heating assessment and survey tool and the steam system assessment tool.

Each assessment is carried out by a team consisting of account representatives (IEU specialists), engineers and service technicians. During the assessment, the IEU specialist measures the client's system performance and identifies practices and equipment that use energy inefficiently. Approximately 80% of all requested audits are for process-specific assessments with the remaining 20% being plant-wide.[62] Regardless of type, all assessments result in customers receiving an energy report and tip sheet to help them make decisions on the purchase of energy-efficient equipment and process changes.

Reach of the Program

According to program tracking data, between January 2006 and December 2008, the program made 192 site visits to industrial customers. After accounting for firms receiving more than one consultation, the total number of unique firms reached by the service was 136.

Figure 34: Number of Site Visits

Year	Initial Visits	Follow Up Visits	Additional Follow Up Visits	Total Visits	Mean Time Between 1st and 2nd Visits (Days)
2006	21	5	0	26	63
2007	50	11	1	62	96
2008	65	25	14	104	37
Total	**136**	**41**	**15**	**192**	**56**

[62] US Department of Energy. "Meeting State Carbon Emission Requirements through Industrial Energy Efficiency" Downloaded from http://www1.eere.energy.gov/industry/saveenergynow/pdfs/socalgasco_casestudy.pdf. Accessed on 12/01/09.

Of the 192 total site visits, 41 customers had follow up visits and 15 had additional follow up visits. As shown in Figure 34, the frequency of follow up visits increased over the life of the program. The mean time between the first and second visits was also reduced drastically in 2008, from 96 days in 2007 to 37 days in 2008. This is primarily a result of the additional staff and resources available to the program as it matured as well as the increased synergy between the SCG staff.

The IEU program staff does not keep track of customers' primary industry. However, program staff state that their customers represent a variety of industries and are comparable to the Los Angeles industrial base. Industries mentioned by staff include food and beverage, primary and secondary metals, petrochemical, and pharmaceuticals, among others. The firms are large customers, with annual gas usage of 400,000 therms or more.

Program Utilization

According to program staff, participants in the IEU program first learn of the program from their account executives. Each SCG account executive focuses on specific industries or markets. The account executive identifies potential participants for the IEU program, contacts them and collects the initial data for the program, including energy usage, information about the equipment and processes in place, and information about operating procedures. The IEU staff then sets up a meeting with the customer for an initial visit and to look at the firm's processes. Account executives state that their customers are generally receptive to the program because it is free and can identify potential energy savings. The account executives are proponents of the program because it helps meet their energy savings goals and is helpful to their customers.

The primary output of the assessment is a report identifying inefficient practices and equipment and recommendations to improve them.

Participants' implementation of the recommended changes often occurs in stages. Firms will typically adopt the easiest and least expensive changes to their processes first. Larger projects may take a year or more to complete as the firm must balance the timing of the improvement with its cost. For example, some firms were too busy in the beginning of the program (2007) to incorporate the recommended changes, as they would require the firm to go offline for a period of time. However, during the economic downturn in 2008, these firms likely had the time for the recommended upgrades but lacked the revenue or cash reserves to make the changes.

Factoring into this balance of timing and funding, the account executives and engineering team work together to make recommendations that are executable. The IEU staff may decide to make recommendations for only some of the reported inefficiencies. This can result in the implementation of a higher share of recommendations and more accurate savings estimates, as savings for multiple measures may overlap.

Additionally, the program funnels participants towards other SCG incentive and rebate programs. Participants are eligible to receive up to $1 million in incentives per project and up to $2 million per premise per year. The account executive can also recommend other programs to help the firm make the recommended changes. These include paying the customer for each therm saved, favorable financing, or grants.

Knowledge and Behavior Change

The IEU program staff finds that the plant assessment and subsequent report result in increased knowledge of their customers. The staff often finds that some of the inefficiencies identified in the report are known to the customer, but many are new. Additionally, the assessment and report provide the customer with a quantification of the inefficiency and recommended energy savings, which is rarely known. The level of knowledge of energy efficiency and resulting knowledge change is often related to the size and sophistication of the customer.

In addition to the energy savings analysis and report, the IEU team provides companies with trainings and workshops. These events teach plant employees about the energy saving behavior or process changes recommended by the program and train them to use the newly implemented equipment or systems. Software workshops are also available.

Overall Value and Influence of the Program

The IEU program conducts post-assessment visits to verify energy savings. In addition to the direct energy savings attributed to the program, the assessments also identify demand side management (DSM) savings that do not fall under the scope of a typical incentive program.

Direct Energy Savings

Based on the post-assessment visits from January 2006 to December 2008, the IEU program resulted in gross energy savings of 6.7 million therms and net savings of 4.5 million therms, as shown in Figure 35.

Figure 35: Energy Savings by Year

Year	EV Gross Savings	Net Therm Savings (0.8*Gth)	Total Annual Therm Usage 2006
2006	1,942,420	1,553,936	75,826,057
2007	3,737,672	2,990,138	84,197,395
2008	1,036,719	829,375	267,743,497
Total	*6,716,811*	*5,373,449*	*427,766,949*

Overall, the net therm savings resulting from the program accounted for 1.3% of the customers' total 2006 therm usage. However, this share varied widely by account.

The program tracking database reports gross energy savings for 11 accounts in 2006, 10 accounts in 2007 and 13 in 2008. As shown in Figure 36, the energy savings per customer varied considerably for each year. In 2006 and 2008, the largest shares of end user participants realized savings of 20,000 therms or less. In 2007, the largest share of end users saved between 20,000 and 50,000 therms. A relatively high share also saved more than one million therms in this year. This difference in savings by customer was not a result of the program targeting different customer groups, but simply the differences of customers who participated in the program in each year.

Figure 36: Share of Participants by Gross Energy Savings (Therms)

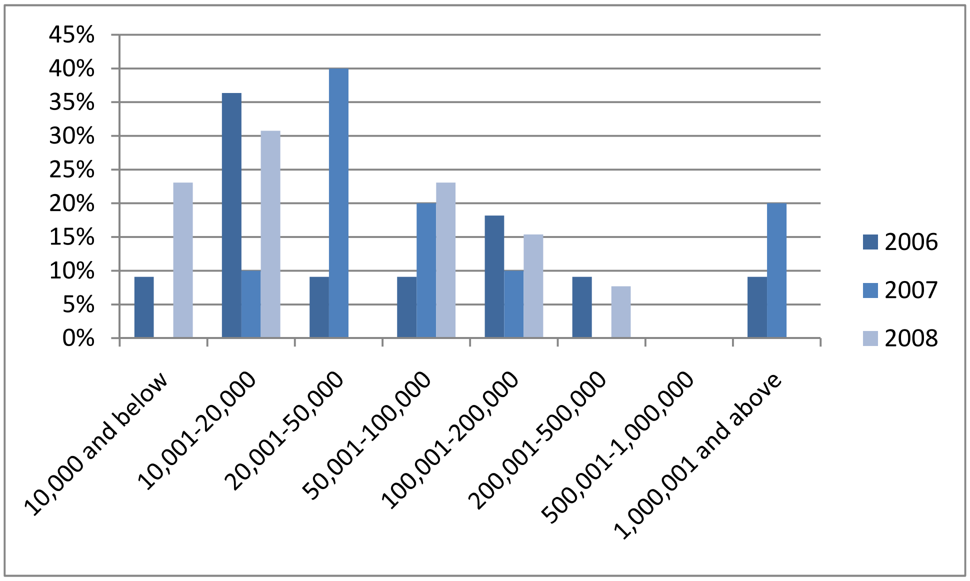
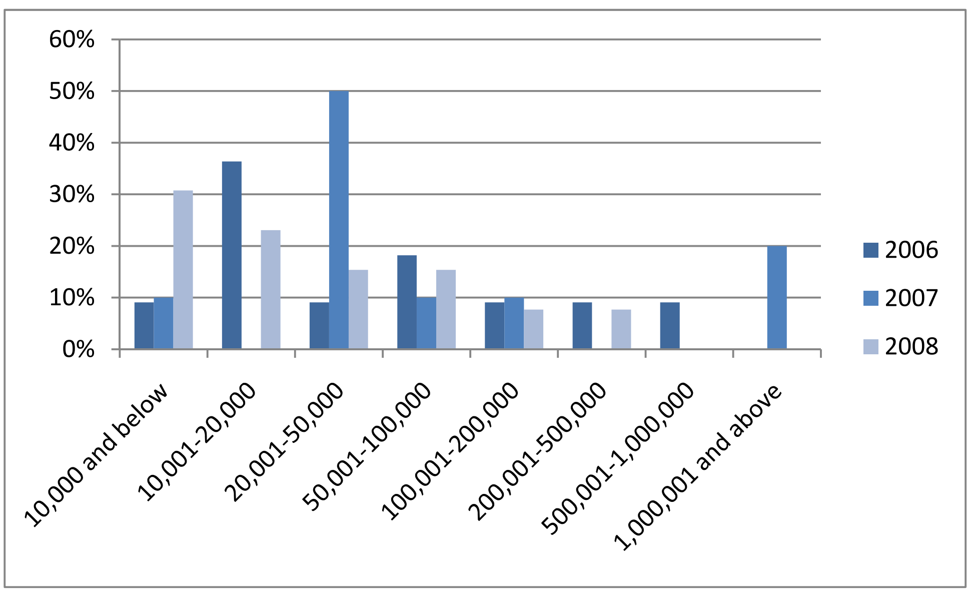


Figure 37 shows the share of program participants by net energy savings, segmented by year. The program assumes a net-to-gross ratio of 0.8. This ratio is for the utility overall. The program also uses a net-to-gross ratio of 0.74, which is associated with education and training and non-resource programs. However, because the IEU program utilizes a variety of SCG's programs, the actual net-to-gross ratio is likely closer to 0.8.

Figure 37: Share of Participants by Net Energy Savings (Therms)



DSM Savings Identified

From 2006 to 2008, the program identified 25.6 million therms of demand side management (DSM) savings for 57 participating firms. Overall, the average DSM savings identified per participant was 449,683 therms, as shown in Figure 35. The amount of DSM per participant was similar in 2006 and 2007, but increased in 2008. This increase is likely a result of the program's expansion of resources and staff, allowing for more detailed assessments of customers' facilities.

Figure 38: DSM Savings by Year (Therms)

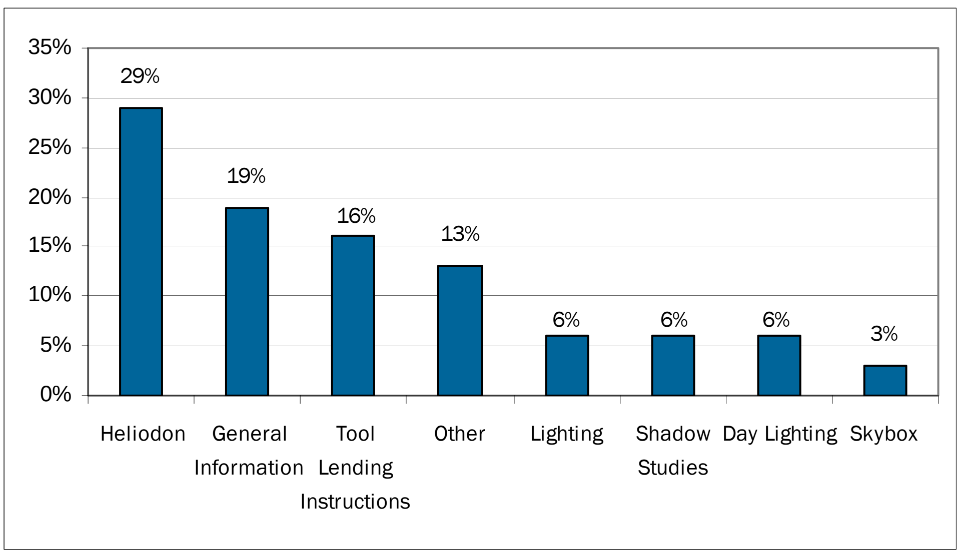
Year	DSM Identified	DSM Participants	DSM per Participant
2006	4,018,264	12	334,855
2007	5,469,842	16	341,865
2008	16,143,798	29	556,683
Total	*25,631,904*	*57*	*449,683*

D.4 Pacific Energy Center: Consultations

Pacific Energy Center (PEC) consultations are interactive and often hands-on sessions that foster changes or enhancements in an individual's energy saving behavior. Consultation sessions typically consist of one-on-one meetings between an individual or group of individuals and a PEC technical staff member. Staff members have expertise in a range of areas including architecture, fenestration, daylighting design and modeling, building systems and retro-commissioning, measurement tools and data analysis. In total, eight consultants are available to assist consultation participants.

According to both program data provided by Pacific Gas and Electric (PG&E) and responses to a participant survey, the largest percentage of consultation participants spent their sessions using the Heliodon and commercial end-use customers were more likely than either residential end-use customers or market actors to use this tool.[63] General information about energy efficiency (19%) and instruction for using tools from the Tool Lending Library (23%) were the second and third most common consultation subjects. Of those surveyed as part of the case study effort, one to two people had consultations that covered each of the following topics as well: lighting, shadow studies and the use of the Skybox. The breadth of subjects covered by the PEC is illustrated in **Error! Reference source not found.** below.

Figure 39: Topics Covered in Consultations (n=31)



The consultation process draws upon multiple resources offered by the Center and introduces the PEC to participants as a resource for energy efficiency knowledge acquisition and energy assessment tools. Links between the consultations service, the Center's Tool Lending Library, and its courses are particularly notable. In addition, staff will direct participants to other tools within the Center, such as the overcast sky simulator that are related to the participant's project.

[63] The Heliodon uses an architectural scale model to determine how to make a building more responsive to sunlight and shading. According to the PEC, "heliodons provide an effective tool for the visualization and calculation of solar effects at the window, building, or site scale."

The duration of the consultation varies depending on the project. Two thirds of consultations took more than an hour while the remaining third were under 60 minutes. Those participants using the Heliodon or studying daylighting were more likely than others to report a consultation of one to three hours in length. As expected, consultation sessions involving the simulation of various environmental conditions such as lighting and shading, are the most time intensive.

Reach of the Program

According to PG&E program tracking data, between January 2006 and June 2007, 179 consultations took place at the PEC. After accounting for individuals receiving more than one consultation, the total number of unique individuals reached by the service was 158.

These 158 individuals were the target population for a telephone survey. However, incomplete contact information prevented 42 people from being contacted leaving a sample of 113 individuals. We attempted to contact all 113 participants and completed interviews with 31. Based on this survey effort, it is estimated that consultations primarily serve market actors as the majority of survey respondents (71%) could be characterized as such while a smaller percentage of respondents are residential (19%) and commercial (10%) end-use customers. Additional information about each of these groups is provided below:

- Almost all market actors (91%) provide engineering or architectural services to their customers with lighting and HVAC services as the second and third most common areas of work. The majority of market actors participating in consultations supply some level of service to business customers with 67% reporting that they work most often with the commercial market segment.
- All commercial end-use respondents describe their business facility as an office (with two out of three from small companies with a single leased location).
- Residential end-use customer respondents are all highly educated and middle-aged. Single-family detached homes are the most common types of residences (5/6) with the additional respondent living in an apartment building with more than five units. Income levels are diverse and range from between $20,000 to $50,000 and $100,000 to $149,999 per year.

In general, the information presented in consultations is readily dispersed by participants. All residential and commercial end-use customers reported that they had shared what they learned with those around them whether with friends, neighbors, or colleagues inside and outside one's organization.

Program Utilization

Nearly half of the survey respondents first learned about the consultation service directly from the PEC either during a previous visit to the Center (26%) or as a result of participation in a class offered at the Center (23%). The website (10%) and PG&E specifically (3%) also provide information about the service. In addition, professional communication through colleagues also plays a role in educating people about the availability of consultations, and other sources of information include contractors and unidentified mailings.

Recurring consultations are fairly common among the consultation participants surveyed. Fifty five percent of all respondents had been to the PEC for a consultation before. According to PEC staff, participants frequently come in to discuss a particular project and based on their experience interacting with the Center, later return to follow-up on another new project.

Knowledge and Behavior Change

Knowledge Change

Overall, the consultations have served as both an explanatory and confidence building tool for participants. Irrespective of the topic discussed, all participants felt the consultations provided them with new information. In particular, participants affirmed that they learned about energy efficient changes they could make to their client's facilities and homes. Several questions in the participant survey asked about knowledge gained through the consultation. Combined into a knowledge scale, the average knowledge gain was 6.6 on a scale that ranged from 1 to 7.[64]

The influence of the consultations on awareness is also relatively high. Participants were asked to rate how much the consultation increased their awareness of efficiency opportunities using a scale from 1 to 7 and the average increase in awareness was 5.6.

In terms of professional confidence, commercial end-users and market actors both shared the perception that their consultations provided greater reassurance about the energy savings generated by energy efficiency projects. More specifically, two out of three commercial end-users strongly agreed (a rating of six or seven) that as a result of the consultation, they have more confidence that when they take steps to improve the energy efficiency at their facility that the expected level of savings will actually occur. Likewise, 82% of market actors strongly agree that they have more confidence when making recommendations for improving energy efficiency at their client's facilities that the expected level of savings will actually occur.

The evaluation team's onsite observation of a consultation session also supports self-reported claims of increased awareness of energy efficiency and knowledge of energy efficiency practices as a result of the consultation. The participants observed appeared to have limited technical knowledge at the outset, but the PEC staff member walked the group through how the Heliodon could be used to correctly position solar panels, locate exterior shading opportunities and identify potential glare problems. The participants had all of their questions answered and seemed very interested in the information conveyed by the PEC staff member.

Market Actor Behavior Change

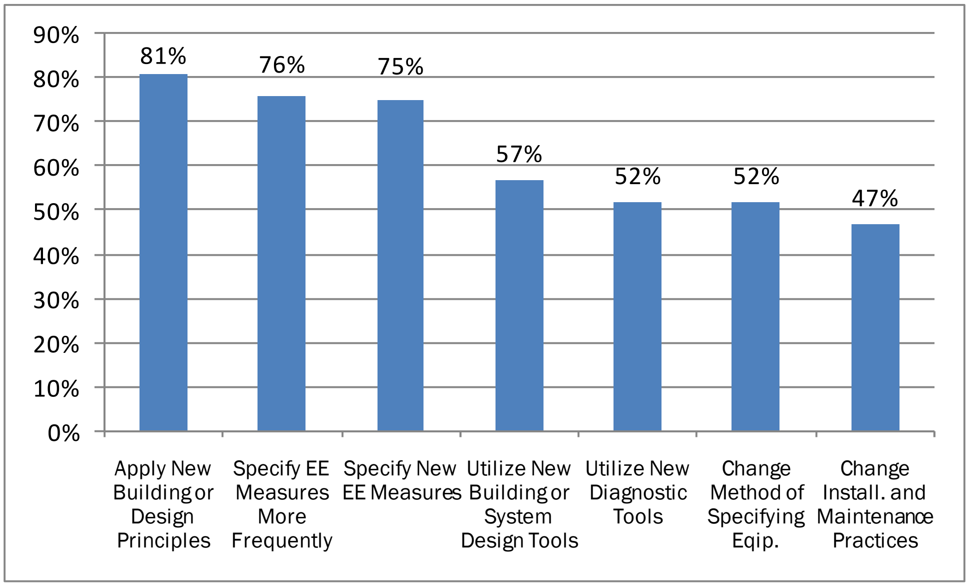
Because market actors can apply what they learn from a consultation to multiple jobs, the impact of a consultation with a market actor can extend beyond this single individual. This

[64] The knowledge scale is the average response to three questions asked of each commercial and market actor participant. Only one question was asked of residential participants. One question is common to all respondents while the other two vary by participant type.

appears to be the case as nearly all market actors who had a consultation (95%) said they changed their services as a result of what they learned.

Informing this change in behavior is the fact that the consultations clearly taught the market actor participants about new energy efficient practices and technologies. Market actors that made changes to their services are applying new design principles (81%) and specifying energy efficiency measures more frequently (76%) or that they were unfamiliar with prior to the consultation (75%).

Figure 40: Changes Made to the Services Market Actors Provide as a Result of the Consultation (n=21)



In addition, 68% of market actors strongly agree that they were more likely to recommend energy efficient equipment, designs or practices to their clients as a result of the consultation.

An additional benefit of the consultation service is that the changes in practice encouraged through the sessions appear persistent among market actors. For example, 77% percent of market actors state that the changes they made have become standard practice for them.

Market actors also believe that their actions have an impact on energy usage. Over three quarters of the market actors participating in the survey (77%) believe the changes they have made to the service they provide to their clients as a result of the consultation has resulted in measurable energy savings at their client's facilities. While it was not possible to calculate exact savings estimates, slightly more than one third (36%) characterize these savings as significant while the remainder (41%) describe the savings as moderate.

Figure 41: Market Actor Professional Development
and Associated Estimates of Energy Savings

	Market Actors (n=22)
Applied information learned during the consultation to enhance services	95%
Enhancement became standard practice	77%
Measurable energy savings	77%
Significant	36%
Moderate	41%

End-user Behavior Change

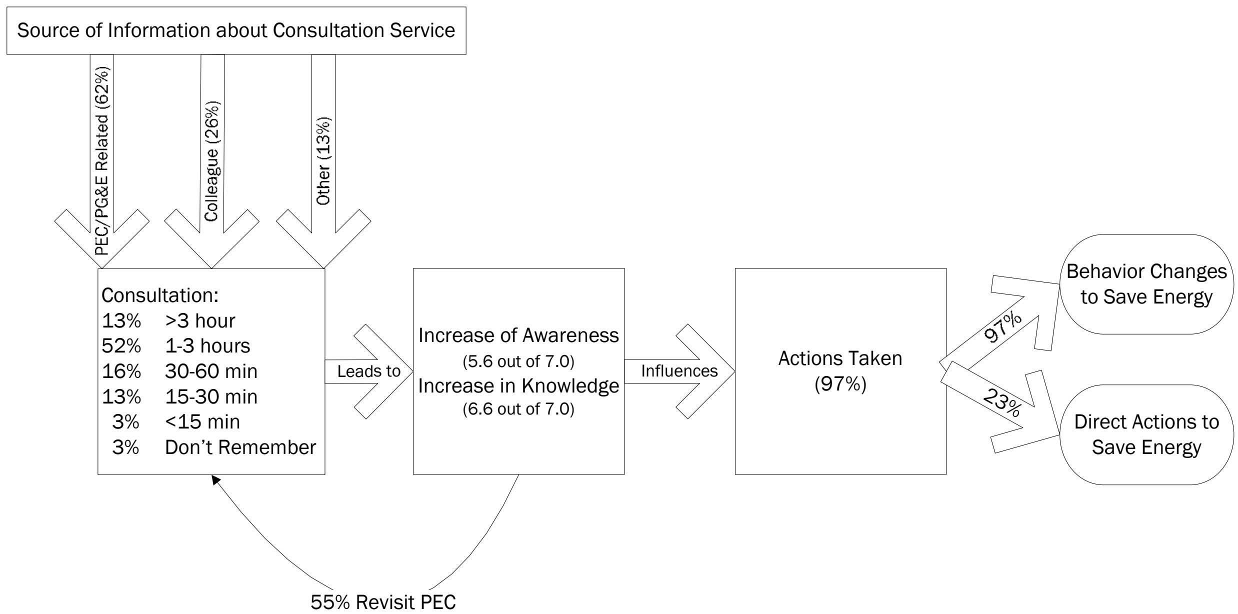
While end-users make up a smaller percentage of consultation participants, we found that five out of the six residential and two out of the three commercial end-use customers responding to the survey said they made efforts to save energy using what they learned in their consultations. Among residential end-use customers that made the effort to save energy four of five utilized new home design principles and three of five implemented new energy efficient measures and made use of home design tools (3/5) they were unfamiliar with prior to the consultation.

Both of the commercial end-users that made the effort to save energy reported that they implemented building or system design principles or elements, utilized diagnostic tools or practices, and building or system design tools or practices they were unfamiliar with prior to the consultation. In addition, one commercial participant installed energy efficient measures more frequently than prior to the consultation and made changes to the way they install and maintain energy consuming equipment.

Overall Value and Influence of the Consultations

As demonstrated above, in general, a PEC consultation results in increases in both awareness and knowledge of energy efficiency measures and practices, which influence and enable participants to take energy saving actions. Figure 42 below provides a visual representation of the process by which the consultations affects knowledge and awareness of energy efficiency, as well as energy saving actions.

Figure 42: Consultation Summary



In addition, the consultations had a moderate level of influence on participant's decisions to try and save energy. Using a scale from one to seven, where one means "not at all influential" and seven means "very influential," participants were asked how much influence the information provided in the consultation had on their decision to make the effort to save energy at their facilities or home. As illustrated in Figure 43, market actors and end-users reported that the consultations had a large amount of influence.

Figure 43: Degree of Consultation Influence

How much did the consultation…	Market Actors (n=22)	Residential EUC (n=6)	Commercial EUC (n=3)
Influence your decision to make the effort to save energy	6.3	5.8	6.0
Overall Influence Index (0-1)	.83	.80	.82

To assess the overall influence of the consultations on both behavior changes and actions taken, an index was created using the influence question presented above, as well as those related to knowledge and awareness). According to the index, the consultations had a relatively high degree of influence on the energy saving behaviors and direct actions of all participants. The mean score across each group of participants was roughly 0.8.

D.5 Retro Commissioning Workshop Series

Since May 2005, the Pacific Gas & Electric Company's (PG&E) Pacific Energy Center (PEC) has offered a twelve session Existing Building Retro-commissioning Workshop Series (EBRCx) designed to increase knowledge of commissioning and provide hands-on experience to building professionals. The workshop series is holistic in nature and exposes participants to the entire commissioning process while ensuring relevant practice at one's own facility. Class topics include: the retro-commissioning (RCx) process, fundamentals of mechanical systems, logging and trending, control, water-side and airside RCx opportunities, and a look at other systems such as two pump systems and booster pumps. Participants also learn about energy savings calculations, cost/benefit calculations and persistence. Commissioning incentive programs are covered during one of the final classes as well.

According to an EBRCx instructor, participants are typically facility operators and facility managers responsible for multiple facilities, or consultants and engineers providing commissioning services to their clients. The distribution of participants from each of these professional communities is relatively even and class sizes are kept small to ensure that interactive activities are possible.

The EBRCx Program has been modified over time to give participants the greatest possible opportunity to implement what they learn and share their experiences with others. For example, as of 2008, the PEC required that enrollees have both a base level of technical knowledge and a designated project at their facility where they can apply the concepts presented in the courses. This is essential to the completion of project-based homework and the presentation of those assignments at the beginning of each class.

The program also draws upon other resources offered by the Center, particularly the Tool Lending Library, which provides the tools needed for various commissioning related activities. As described by interviewed participants:

- *"We're using PG&E's lending library to provide all of the electrical monitoring equipment…the awareness of and familiarity with PG&E's lending library was an asset for us to use on the projects."*
- *"I have gone back and borrowed a couple of tools from the lending library and I didn't really know about that before I took this retro-commissioning class. [As a result], I'm better able to look at trends and trend data myself, analyze it and kind of figure out if anything needs to be changed."*

As demonstrated by this and the other case studies, the Center's educational tools complement one another and provide mutually reinforcing resources to professionals seeking additional training.

Reach of the Program

According to PG&E program tracking data, between January 2006 and October 2008, 109 individuals participated in the EBRCx workshop series. The 109 EBRCx participants were the target of a combined telephone and internet survey effort and interviews were completed with 45 individuals.

Figure 44: Overview of EBRCx Participants

Participant Type	Number Enrolled	Completed Interviews
Market Actor	-	31
Commercial End-User	-	9
Other	-	5
TOTAL	109	45

Based on this survey effort, it is estimated that the largest group of EBRCx participants are market actors (69%) followed by commercial end-users (20%). An additional 11% did not fit into our survey classification and are best described as “other”. Almost one half of market actors provide engineering or architectural support services (45%) followed by facility operations and maintenance (32%), and services related to HVAC systems (26%) or research and consulting (26%). Over half of market actors serve business customers (55%) and among those who serve businesses, almost all (91%) work most often with the commercial sector.

The majority of commercial end-use respondents consider their companies large in size (56%) and 67% own the facility in which the company is located. Fifty six percent of commercial end-users work for a college or university while 22% describe their business as an office or government.

The “other” respondents are well educated with more than half completing college or graduate school (3/5). These respondents also range in age from 18-24 years of age to 55-64 years old.

Information presented in the workshop series is also disseminated to others outside the classroom. For example, almost all commercial end-user respondents (8/9) reported sharing the information they learned with a colleague.

Knowledge and Behavior Change

Knowledge Change

While participants came to the EBRCx workshop series with a range of prior experience, in general, all felt they gained valuable information about commissioning, as well as practice with the process. The following comments from depth-interviews with participants illustrate this point:

- *“You know, I knew a lot of the stuff being a mechanical engineer – in theory from the design side – but never from actually going through a commissioning process and the course taught me that.”*

- *"I would say that my previous understanding of building systems was pretty superficial going into the course and I think as a result of even the three or four weeks I was able to go, I was able to just dive a lot deeper into [the] different building systems at each participant's facility."*

In addition, individual participants noted improvements in their knowledge related to the design of pump and fan applications and the use of data logging equipment. More generally, the workshop series' courses were seen as enabling participants to ask the right questions about retro-commissioning, to identify and include retro-commissioning measures in projects, and to communicate why retro-commissioning is valuable to plant managers.

Among participants reached by the survey, almost all (98%) indicated the workshop series provided them with new information. In addition, when asked a series of questions about the amount of knowledge they gained by taking the courses, participants reported moderately high levels of knowledge gain (a mean of 5.6 on a scale ranging from 1 to 7).

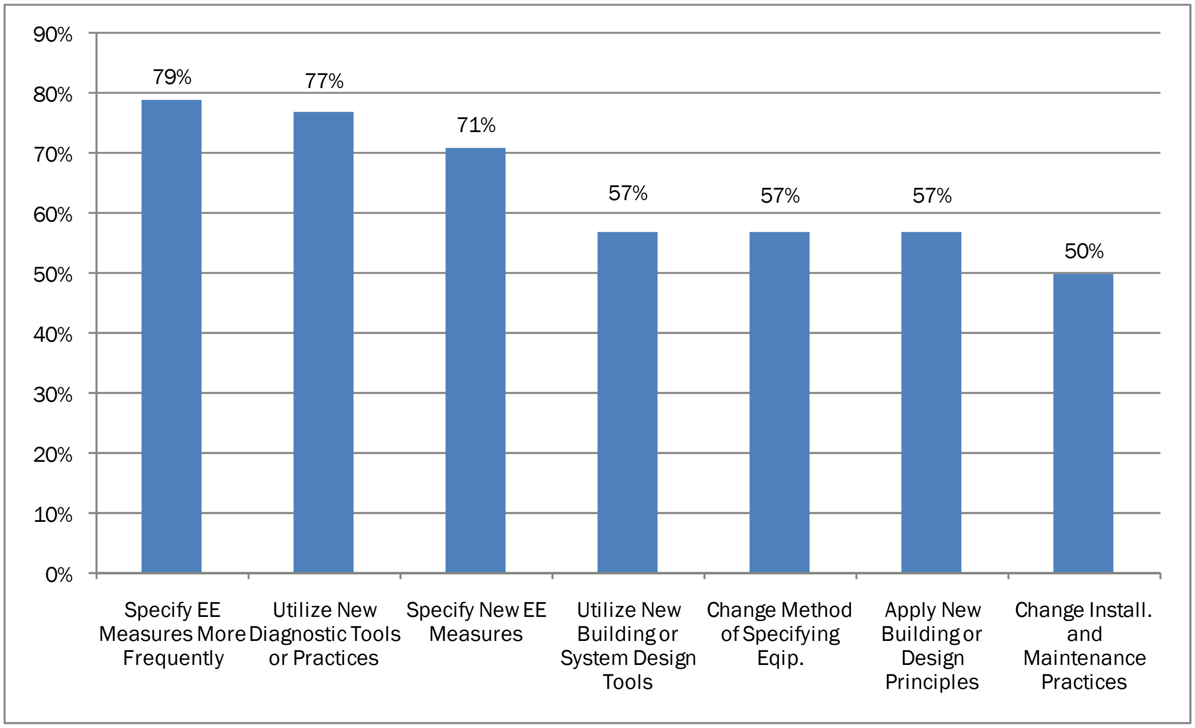
The EBRCx program also had a moderately high influence on participant awareness of energy efficiency opportunities either at their home, place of business or client facilities. For example, participants were asked to rate how much the courses caused them to increase their awareness of such opportunities using a scale from 1 to 7 and the average influence on awareness was 5.2.

Along with these changes in knowledge and awareness came added confidence in recommendations and actions to save energy among commercial end-users and market actors. Seventy one percent of market actors strongly agree (a rating of six or seven) that as a result of taking the course, they have more confidence that when they make energy efficiency recommendations for their client's facilities that the expected energy savings will actually occur. Slightly more than half of commercial end-users (55%) provided a similar rating when asked about their level of confidence in the realization of expected energy savings associated with steps they take at their facility to be more efficient.

Market Actor Behavior Change

Eighty one percent of market actors said they changed or enhanced the services they provide to their clients as a result of what they learned in the EBRCx series. In general, the most common changes among market actors involved using new tools and practices, specifying new energy efficient equipment and specifying this equipment more frequently than before the series.

Figure 45: Changes Made to the Services Market Actors Provide as a Result of the EBRCx Series (n=14)



Depth interviews with participating market actors added additional detail about actual projects implemented based on the training received. Anecdotal comments from the depth interviews highlighted activities including:

Air conditioning cycle modification,

Repair of variable speed drives, and

Improvements to ventilation and air flow systems, including repair of dampers and use of outside air flow.

In general, market actors believe these actions have led to measurable energy savings. As presented in Figure 46, the largest group of market actors report moderate savings (48%) while close to one quarter (23%) report significant savings. It is also evident that many of the changes made by market actors as a result of enrolling in the EBRCx series persist and become part of their professional practice (68%).

Figure 46: Market Actor Professional Development
and Associated Estimates of Energy Savings

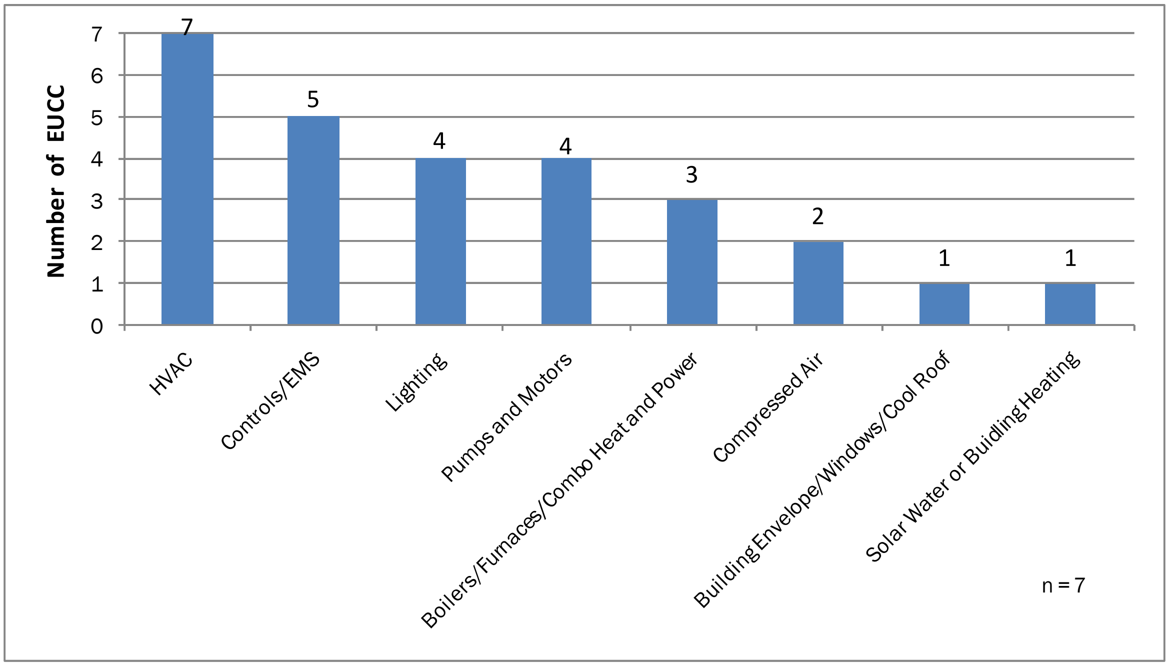
	Market Actors (n=31)
Applied concepts taught in the course to enhance services	81%
Enhancements became standard practice	68%
Measurable energy savings	74%
Significant	23%
Moderate	48%
Measurable but insignificant	3%

Commercial End-User Behavior Change

In general, the survey effort indicates that commercial end-user participants apply what they learned in the EBRCx workshop series to save energy at their facility. All of the commercial end-user respondents reported making an effort to save energy at their facility or facilities using the concepts they learned in the course.

As illustrated in Figure 47, among the seven participating commercial end-users for which we have additional information, all made changes related to HVAC and over half made changes related to controls and emergency management systems (5/7), lighting (4/7) and pumps and motors (4/7). When asked to outline the changes made, commercial survey respondents described adding a variable frequency drive to constant volume pumps and fans, implementing a static pressure reset, selecting more efficient boilers, and commissioning projects on HVAC and digital controls. Additionally, one of the commercial end-users that participated in depth interviews installed energy efficient motors while another conducted lighting retro-fits and installed energy efficient lighting technology.

Figure 47: Areas Where Commercial End-Users Took Steps to Save Energy



Commercial end-users also frequently report searching for additional information related to the course concepts (9/9), helping convince others at their organization that energy saving actions are needed (8/9), and helping convince people outside their company that specific actions help to save energy (6/9).

Overall Value and Influence of RCx Course Offerings

In-depth interviews with EBRCx participants revealed high levels of satisfaction with the training they received. Benefits mentioned by individual participants include the value of learning about documentation and baseline procedures, as well as how to present data to building owners in a way they can understand. The hands-on, facility based approach of the course was also seen as a major advantage of enrolling.

The workshop series also provides a venue to educate participants about other utility energy efficiency programs and encourage them to utilize other educational options available. For example, as part of the depth interview process, one participant mentioned convincing a customer to apply for rebates and another participant said that he is currently trying to get incentives for most of his projects. A third individual noted he participated in PG&E's Core Retro-Commissioning Program.

In general, the EBRCx program had a moderate level of influence on participant's efforts to try and save energy. Using a scale from one to seven, where one means "not at all influential" and seven means "very influential," participants were asked how much influence the information presented in the courses had on their decision to make the effort to save energy at their facility or their client's facility. As illustrated in Figure 48, market actors reported the greatest level of influence.

Figure 48: Degree of EBRCx Influence

How much did the consultation…	Market Actors (n=25)	Commercial EUC (n=9)
Influence your decision to make the effort to save energy	5.6	4.6
Overall Influence Index (0-1)	.78	.67

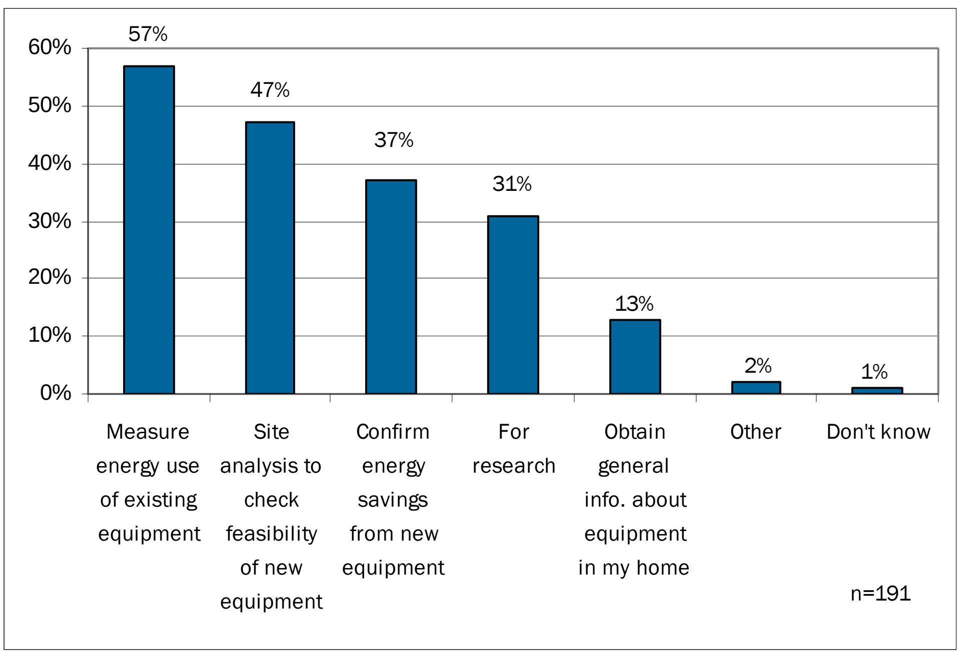
An index was created using the influence question presented above, as well as those related to knowledge and awareness to assess the overall influence of the program on both behavior changes and actions taken. Based on the index, the EBRCx program had a moderate impact on the energy saving behaviors and direct actions of all participants. The mean score across both market actors and commercial end-users is 0.73.

D.6 Tool Lending Library

The Pacific Gas and Electric (PG&E) Pacific Energy Center (PEC) and Energy Training Center, Stockton (ETC), the Southern California Edison (SCE) Agricultural Technology Application Center (AgTAC), and the California Center for Sustainable Energy (CCSE) all feature Tool Lending Libraries (TLL). Each of these TLLs provide borrowers with access to a select inventory of tools, as well as staff guidance on the function and appropriate application of those tools. The goal of the tool lending program is to enable borrowers to gain hands-on experience with energy efficiency tools, learn about energy efficiency practices and identify energy efficiency project opportunities by using the tools.

According to responses to a participant survey, tools are most frequently used to assess the energy use and savings of equipment and in many cases, the information provided by the tools is used in the site analysis process related to facility equipment improvements (see **Error! Reference source not found.**). However, uses differ by borrower type. More specifically, commercial respondents (45%) and market actors (41%) are significantly more likely to borrow tools in order to confirm energy savings of new, recently installed equipment than residential borrowers (10%). Compared to commercial borrowers (34%), market actors are also significantly more likely to borrow tools to do site analysis for a new building or for measuring the feasibility of new equipment such as a photovoltaic system (53%).

Figure 49: Reasons for Borrowing Tools
(Multiple Response)



Reach of the Program

According to program tracking data, between January 2006 and June 2007, the number of tool loans at each Center ranged from 33 to more than 8,000. Statistics for each Center, as well as the number of unique individuals reached by the service are presented in **Error! Reference source not found.**. In terms of volume, the PEC is the largest (and has been lending tools for longer than the other centers) while the other libraries operate on a much smaller scale.

Figure 50: TLL Borrower Population

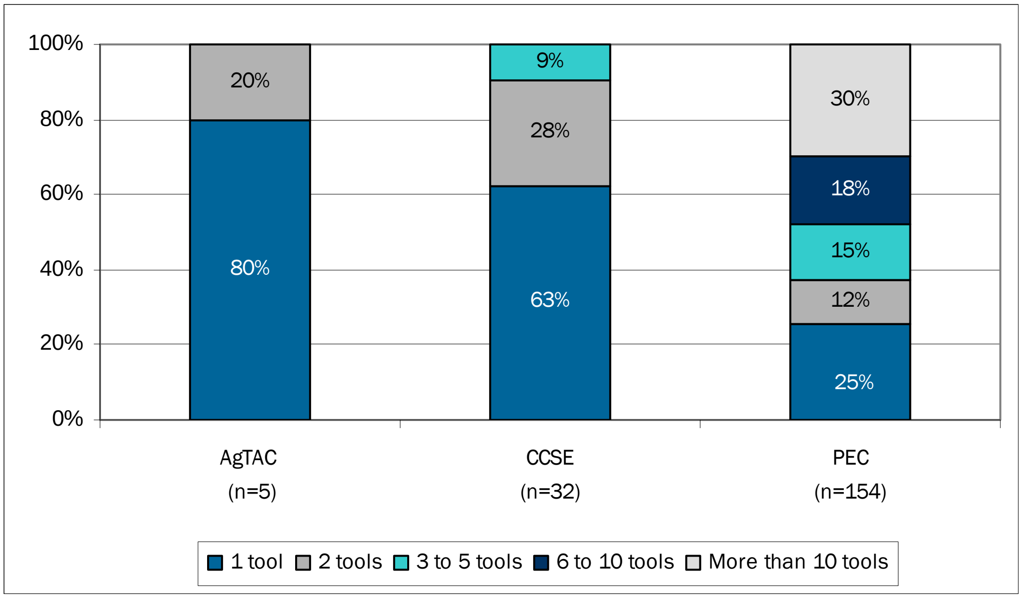
Energy Center	Size of Tool Inventory	Total # of Loans	Unique Borrowers	Completed Interviews
AgTAC	51	33	23	5
CCSE	71	146	97	32
ETC	3	48	33	0
PEC	>100	8956	526	154
TOTAL		9183	679	191

The 679 unique borrowers from the Center libraries were the target population for a telephone survey. However, incomplete contact information prevented 40 people from being included in the survey effort, a disproportionate number of which borrowed from the ETC where complete contact information was not collected for participants. For this reason, ETC borrowers were excluded from the participant sample. We attempted to contact all of the remaining 639 people who borrowed tools during the study time period, and completed interviews with 191.

There is also a range of borrowing levels between the different tool libraries' users. For example, at AgTAC and CCSE, it is common for borrowers to take out a single tool from the library.[65] In contrast, the larger inventory available at the PEC allows for a much higher level of borrowing activity than is possible at the smaller libraries. Almost half of PEC borrowers (48%) took out six tools or more compared to none at the other libraries.

[65] Data on the number of tools borrower per visitor is drawn from utility program tracking data.

Figure 51: Number of Tools Borrowed by Library Patrons



Based on the survey effort, market actors are the most frequent users of the tool lending services of the Energy Centers (60%) followed by commercial (25%) and residential end-users (15%).

- The majority of market actors work most frequently with the commercial market segment (67%), although 20% work with institutional clients. Over half of market actors (54%) provide some form of engineering or architectural service to customers while a large percentage also deal specifically with lighting (38%) and HVAC technologies (36%).
- The largest percentage of commercial end-user borrowers is involved in industrial processes, manufacturing or assembly (21%). Seventeen percent of commercial respondents borrowing tools use them at institutions of higher education and 15% in office buildings. Almost three quarters of commercial borrowers (72%) own their own facility and 81% percent are either medium-sized (36%) or large (45%) businesses. About half of commercial businesses (49%) have between one and four locations in the state of California.
- Residential respondents are highly educated. None of the borrowers has completed less than trade or technical school. Eighty percent of residential respondents live in single family detached homes over half of which were built before the 1970s (63%). Sixty seven percent of these single family homes are approximately 1,000-2,999 square feet in size.

Program Utilization

Nearly one third of the survey respondents learned about the TLL through participation in a course offered by the Center (32%). A sizable percentage of borrowers also learned about the TLL as a result of a previous visit to the Center (22%) or from a colleague (19%). Market actors are significantly more likely to have learned about the TLL because of previous usage (11%) than residential end-users (3%).

Some Center's tend to serve borrowers that have more or less prior experience with these types of tools. For example, while roughly half of all borrowers (52%) have used the tool they borrowed (or one like it) before, PEC borrowers are significantly more likely to have previously used the tool they borrow than those visiting other centers (55% compared to 20% at AgTAC and 44% at CCSE). A small number of borrowers rely upon the instruction and technical support available from TLL staff. Only 15% of borrowers require detailed instruction on how to use the tools; 51% of borrowers need only a quick overview of how to use the tool(s) and 32% needed no instruction at all.

Knowledge and Behavior Change

Knowledge Change

Borrowers reported substantial knowledge acquisition as a result of borrowing a tool or tools. Overall, 69% of respondents reported learning something new about how to save energy by using the tools and in general, borrowers affirmed that they learned how to improve energy efficiency at their homes, places of business or client facilities. For example, several questions in the participant survey asked about the knowledge gained from borrowing a tool or tools. Combined into a knowledge scale, the average knowledge gain was 6.3 on a scale from 1 to 7.[66]

Many respondents also acknowledge that in addition to enhancing their ability to implement energy efficient solutions, they gained awareness and confidence related to improving energy efficiency as a result of using the tools. Participants were asked to rate how much the tool loan increased their awareness of energy efficiency opportunities, and on a scale from 1 to 7, the average increase in awareness was 5.4. Likewise, based on a similar 7 point scale, participants expressed strong agreement that as a result of using the tool(s), they have more confidence when they take steps to improve energy efficiency that the expected level of energy savings will actually occur (an average score of 6.2).

[66] The knowledge scale is the average response to three questions asked of each commercial and market actor participant. Only one question was asked of residential participants. One question is common to all respondents while the other two vary by participant type.

Market Actor Behavior Change

Because market actors may work with numerous clients, the impact of borrowing and learning how to use a given tool can benefit many individuals and projects. The extent to which tool based knowledge is applied is evident by the 89% percent of market actors who changed their services as a result of what they learned from borrowing the tool(s). In particular, almost half of market actors modified the way in which they size, specify and maintain energy consuming equipment.

Figure 52: Changes Made to the Services Market Actors Provide as a Result of the Tool Loan

Service Change Due to Tool Use	Percentage Making Change (n=102)
Specify energy efficient measures more frequently than prior to using the tool(s)	55%
Change the methods you use to size and specify new energy consuming equipment	52%
Specify measures of which you were unfamiliar with prior to using the tool(s)	43%
Change the manner in which you install or maintain energy consuming equipment	46%
Apply building or system design principles or elements of which you were unfamiliar with prior to using the tool(s)	41%

In addition, the changes made by market actors appear to be persistent. According to survey respondents, 83% of the market actors that made changes report that they have become standard practice.

Market actors also believe that their actions have an impact on their customer's energy usage. In fact, 87% of market actors participating in the survey believe the changes they have made to the service they provide to their clients as a result of borrowing a tool(s) has resulted in measurable energy savings at their client's facilities. Roughly one third (32%) characterize these savings as significant while another 40% describes the savings as significant.

Figure 53: Market Actor Professional Development and Associated Estimates of Energy Savings

	Market Actors (n=114)
Applied information provided by tools to enhance services	89%
Enhancement became standard practice	75%
Measurable energy savings	78%
Significant	32%
Moderate	40%
Insignificant	4%
Don't know	2%

End-user Behavior Change

Tool loans also had an effect on commercial and residential end-users. Seventy nine percent of commercial borrowers implemented measures to save energy at the their facilities, and 63% of residential borrowers made an effort to save energy at their home using information acquired by using the tools. The tool loans facilitate participation in other utility programs. Among the borrowers who took energy saving action as a result of the tool loan, 34% of commercial and 23% of residential borrowers received additional assistance from another utility program.

Figure 54: Change in Behavior of Residential and Commercial Borrowers

	Residential (n=30)	Commercial (n=47)
Implemented energy saving measures as a result of borrowing tools	63%	79%

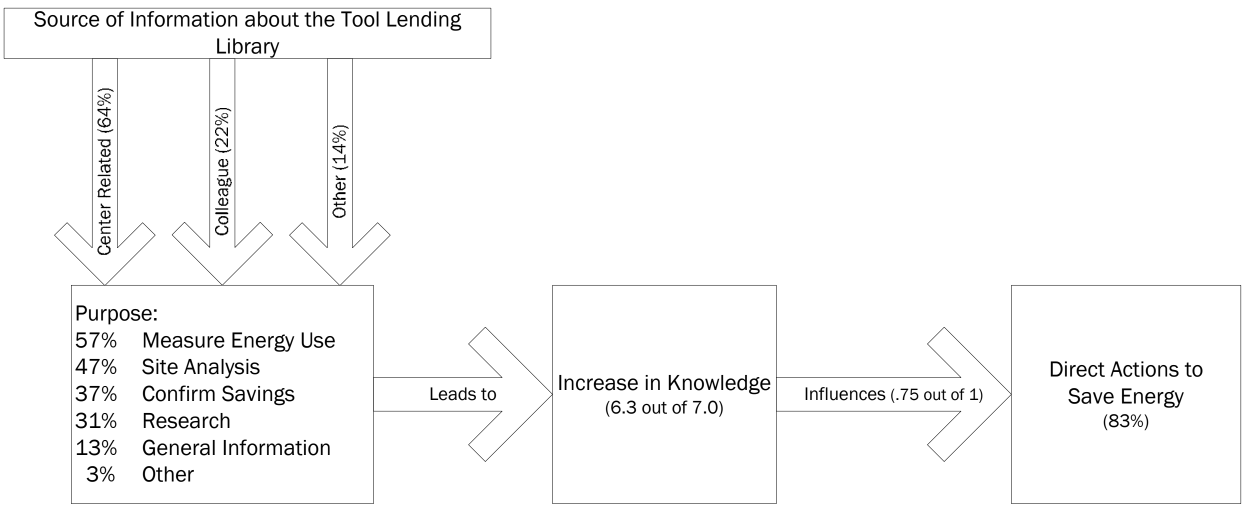
In general, these energy saving activities are also likely to continue. For example, a large percentage of both types of borrowers are very likely (a rating of six or seven on a seven point scale where one is "not at all likely" and seven is "very likely) to make an effort to save energy at their home (57%) or facility (70%) over the next year using information from the borrowed tools as well. Borrowers that made energy saving changes are also likely to use the same or similar tools in the future. Nearly two-thirds of commercial borrowers (65%) and nearly half of residential borrowers (47%) have had reason to use the tool again. The majority once again borrowed the tool (67%) while approximately and one-quarter purchased the tool (22% residential and 25% commercial).

Furthermore, a large majority of commercial end-users strongly agree that they are better prepared to evaluate energy efficiency options (74%) and management views their recommendations as more informed (70%). A smaller majority (57%) also say they recommend energy efficient practices more often as a result of borrowing the tool(s).

Overall Value and Influence of the Consultations

Tool loans lead to energy saving behavior by providing all market segments with actionable information about the energy use of currently owned equipment, as well as the feasibility of implementing more energy efficient measures at various facilities or residences. This information then allows individuals to make decisions about specific energy saving projects, and also to better understand how they can assess energy efficient options in their work. Figure 55 below provides a visual representation of the process by which tool loans affect knowledge and awareness of energy efficiency, as well as energy saving actions.

Figure 55: Tool Lending Summary



As the right-hand side of the figure illustrates, the tool loans have a high level of influence on borrowers' decisions to try and save energy. On a seven point scale where one is "not at all influential" and seven is "very influential", market actors (6.2) and commercial end-users (6.1) on average reported the tool loans had a large degree of influence while residential end-users reported a moderate level of average influence (5.0).

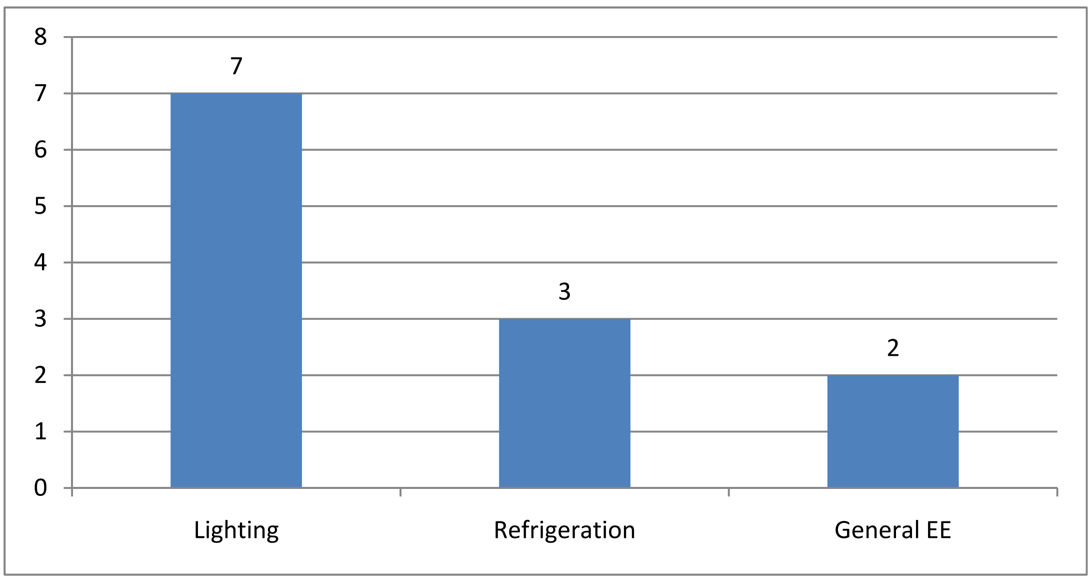
To assess the overall influence of the tool loans on both behavior changes and actions taken, an index was created using the influence question presented above, as well as those related to knowledge and awareness. According to the index, the mean score across all groups of participants was 0.75. As a result, the borrowing experience had a relatively high degree of influence on the energy saving behaviors changes and direct actions of all participants.

D.7 Technology and Testing Centers: Customized Trainings

The Technology and Testing Centers (TTC) provide customized trainings to both internal and external audiences on a range of energy efficiency topics including specific end-use technologies such as refrigeration, lighting and HVAC. In addition, TTC works collaboratively with customers to create specialized sessions that address specific questions or gaps in knowledge among a particular company's staff. These trainings are developed and held on an as needed basis and serve as a flexible program component that complements the more formal course offerings of the CTAC.

Given the use of customized trainings as a supplementary activity for those customers with expressed need, this type of customer training occurs infrequently. Based on program tracking data, the TCC held 12 sessions from January 2006 to December 2008. During this period, customized sessions were concentrated in the areas of energy efficient lighting (7/12) followed by refrigeration (3/12) and general energy efficiency (2/12). The format and structure of these sessions is inherently diverse, however. Training sessions can range from presentations on new technologies, to seminars on how to take advantage of other Energy Center resources, such as the Tool Lending Library.

Figure 56: Number of TTC Customized Training Sessions in Each Focus Area (n=12)



The structure and content of customized training sessions is most often determined through discussion with the customer, at times in conjunction with the customer's account representative. The customer is responsible for outlining the topic or topics they would like covered and explaining the intended audience, including the challenges this group may have encountered in fulfilling their duties given a lack of knowledge. Once this information has been provided, TTC staff members develop a customized training and gain final approval from the customer on the syllabus and materials.

Reach of the Program

As previously mentioned, because of the specialized nature of the training sessions, they occur infrequently. During the three-year evaluation period (January 2006 – December 2008), TTC developed a total of 12 customized training sessions for customers, an average of one session per quarter. The majority of the sessions (10/12) targeted commercial end-users, while the TCC aimed the others at market actors.

Error! Reference source not found. provides a general sense of the level of attendance at some of the training sessions. Unfortunately, the TTC did not track attendees during the evaluation period and those attendee records available are inconsistent.

Figure 57: TTC Customized Training Sessions

Training Title	Date	Target Audience	Attendees
Refrigeration Basics and Maintenance Strategies for Supermarkets	7/7/2006	VONS Supermarket Employees	19
Lighting Technology Seminar	9/22/2006	Avery Dennison Employees	8
Foodservice Refrigeration: Advanced level	11/2/2006	N/A	N/A
Introduction to Tool Lending program	11/9/2006	N/A	N/A
Refrigeration Basics and Maintenance Strategies for Supermarkets	2/28/2007	VONS Supermarkets Employees	30
Demand Response & Associated Technologies Training	8/16/2007	Federal & State Facility Building Managers	N/A*
Gardco Lighting Seminar	9/21/2007	Gardco Lighting Employees	N/A**
Illuminating Engineering Society - Inland Empire Chapter	9/26/2007	Illuminating Engineering Society Members	N/A**
SCE Food For Thought: Cutting-Edge High-Tech Symposium	11/26/2007	Foodservice Customers	N/A*
Free Contractor Workshop for the Express Program	4/21/2008	Lighting Contractors	61
CBS Executive Meeting	8/18/2008	N/A	N/A*
Energy Efficiency Tour of CTAC for Affiliates of the Holy Angels Church	10/16/2008	Church Business Managers	39

* Specific attendees were not available, however we were provided with the contact information for the SCE customer representative.
** Specific attendees were not available, however we were provided with a single point of contact for the customer.

We attempted to reach out to the attendees of the seven courses for which we had contact information either for all participants or a single point of contact for a qualitative phone interview. We completed interviews with at least one participant in three of the seven courses, four market actors and three commercial end-users. The end-users were from a large materials manufacturing company and two area churches. The market actors provided lighting and general electric services, and one served as a lighting manufacturer's representative.

Program Utilization

Customized training is not a program that the TTC actively promotes and customers make use of the service more often as a result of pull strategies than push strategies, although both do take place. According to TTC program managers, customers most often learn about the opportunity for customized training sessions via their account representatives. However, customers also frequently approach their account representatives to ask for training. As described by one participant, "I had attended another similar class to that earlier from Southern California Edison and then I asked Edison to do it for all of my team."

Market actors may learn about the opportunity to attend customized sessions designed by the TTC, such as a free seminar on the Express Efficiency Program, from sources such as Energy Center publications or other utility mailings. For example, market actor participants interviewed report first hearing of the opportunity for customized training sessions at the TTC via one of several methods including an email, mailers, the SCE website or an industry association.

Knowledge and Behavior Change

Knowledge Change

The customized training provided some amount of new information to all participants we interviewed though the amount that was new varied. Some reported that just a portion was new while others reported that all the information was new. For those who gained only a small amount of new information, their experience at the training session still moved them closer to implementing efforts to save energy that they were already considering.

In terms of information relevant to taking energy saving actions, three of the seven participants reported that they learned about specific energy savings actions that they were not aware of prior to the training. Only one participant reported not learning about any specific energy savings actions, while the other three either could not recall or did not specifically address this in the interview.

Behavior Change

Many of the participants we spoke with reported taking specific energy savings action, which is consistent with the TTC's focus on presenting information about energy efficient technologies including lighting, HVAC and refrigeration equipment. In fact, all of the end-users we spoke with reported undertaking lighting retrofits at their facilities. One participant reported conducting "22 lighting retrofits [at] 22 sites within North America," While the focus of the TTC training sessions is on specific energy saving technologies, a number of the training sessions held during the evaluation period included information about potential behavioral changes, such as proper refrigeration system maintenance. However, among the end-users we interviewed only one recalled making specific changes to their energy saving behaviors (turning off lights when not in use) as a result of the training session.

Program channeling is also a focus of the customized training sessions at TTC. In fact, one of the sessions offered during the evaluation period was specifically focused on the available technologies that can be installed under the Express Efficiency program. All of the market actors we spoke to that attended this training session reported using the Express Efficiency program more often, while one of the market actors went so far as to report that making use of the Express Efficiency program had become a standard practice.

Additionally, one of the end-users we interviewed was a member of the Archdiocese of Los Angeles and reported that not only can he now recommend available energy efficiency programs and technologies to the churches and schools within the parishes he represents; he can also recommend residential energy efficiency programs to his parishioners.

Overall Value and Influence of the Trainings

The TTC offers customized training sessions as a way of addressing specific questions that customers have regarding energy efficient technologies and practices. It is clear that this tailored and collaborative approach to training is effective as those that participate in the training sessions overwhelmingly report taking energy saving action. Moreover, the market actors (and in some cases end-users) that attend training sessions are being channeled into IOU resource acquisition programs, which provides another potential venue for stimulating additional energy savings.

Additionally, the trainings provide a cost-effective and flexible way for employers to provide targeted training to their employees reducing key barriers to potential participation such as financial and time constraints. As stated by one participant:

> *"I think the classes are a great value and get my people to start thinking about other ways [to do things]. Every one of them is responsible for identifying an energy efficiency opportunity and there again, that's tied to their performance goals. In a time when we don't have a lot of, you know, no one wants to spend money on training, CTAC's offering something that will help us reduce our operating costs, but at the same time, doesn't cost us anything."*

In sum, the ad hoc nature of the customized training service creates a learning environment for participants where the information they gain through training has an immediate and direct impact on their work.

APPENDIX E: CCI INDEX METHODOLOGY

In more typical resource acquisition programs, participation is defined as using program support to install a particular measure or take a specific action. When we measure net effects for these type programs , a net-to-gross ratio is applied to gross energy impacts to *screen out* free-riders, that is, program participants "who would have implemented the program measure or practice in the absence of the program."[67] The default assumption is that the participant took the actions as a result of the program (i.e., gross savings) and we ask questions to disprove this assumption.

For non-rebate programs such as information, education and training, we are forced to consider a different approach for determining net savings. Information, education, and training programs have "participants" that are often hard to find, or may not even know they are participants (in the case of marketing program efforts). When we attempt to look at energy savings for these informational programs, we are "building up" the savings; we cannot assume that participation equates with taking energy saving action. The default assumption for each person touched is that they learned something that would change future energy saving actions. As such, we must adjust the standard concept of net-to-gross (screening out savings) for information, education and training programs.

Based on background research on how to best measure the impact of informational campaigns, we developed survey questions that combine to create a cognitive change index (CCI) that we use as a proxy for net savings analysis.[68] In this appendix, we present information on the background and development of the CCI. Because the CCI is a new way of calculating net behavior change, we use data collected through our surveys to show how we construct the index and to test its validity.

This remainder of this section is organized as follows:

A discussion on the unique characteristics of information, education, and training programs, and the constructs we need to measure to assess net behavior change.

A discussion of the specific survey questions asked in our participant surveys that we use in the CCI calculation.

A presentation of the algorithm used to calculate the CCI.

---

[67] California Energy Efficiency Evaluation Protocols: Technical, Methodological and reporting Requirements for Evaluation Professionals. April 2006. TecMarket Works Team, p 226.

[68] In August 2008, the Evaluation Team worked with the CPUC and MECT to arrive at an agreed upon method for calculating net behaviors for all three evaluation efforts led by Opinion Dynamics: the Statewide Marketing & Outreach programs, Statewide Education and Training Program, and the Information and Education Programs. It was agreed that Opinion Dynamics would adjust the questions used in the CCI calculation based on the program differences but use the same approach (i.e., calculate the CCI) for all three of the evaluation efforts.

An analysis to test whether the questions appear to be a valid measurement of net behavior change.

Unique Characteristics of Information, Education and Training

Standard net-to gross (NTG) questions about whether the respondent would have "paid the additional amount on their own" do not work since information, education and training do not provide any form of direct incentive or financial support. Moreover, batteries of questions such as the current California non-residential NTG battery asks to rate program effects (that is, rebates or incentives) relative to other effects. However, the other effects considered are typically not applicable for training programs. When we attempt to understand the net effects of information and training programs, we need to consider the following:

Information, education and training are not as tangible as a financial rebate.

- While some efforts like trainings may occur on a particular day, other efforts such as a community event, advertising, receiving a brochure or visiting a website are harder to attribute to one particular day, and may be difficult for an individual to recall even if they were exposed, much less when. Even details about a training can be difficult to remember as time passes. This makes causality difficult to assess well.[69]

Information, education and training cannot always be separated from other efforts. That is, these efforts often lead to the next step in a web of related behaviors and influences that ultimately lead to the energy saving action.

- Notably, even with rebates or financial incentives, there is at some point in time education about both the rebate and the measure or action that occurs prior to the customer taking any action. As such, "education" cannot always be teased apart from the more tangible rebate (e.g., How much did learning about the rebate affect your action versus how much did the actual rebate affect your action? These are difficult to separate.)[70]

Information, education and training are generally thought of as contributing to actions; they lay the groundwork for the ability to take reasonable actions. However, they are not usually the sole reason (or even a critical reason) for taking action.

- While it may be a more critical factor if the respondent was totally unaware of the action prior to the effort, asking what would have been done in the absence of seeing an advertisement, attending a training, or viewing a brochure is not as likely to provide valuable information as it becomes too hypothetical and abstract

[69] Roger Tourangeau (in *The Science of Self-Report. Implications for Research and Practice*) calls this an encoding error – people never form a representation of an event or what is formed is so sketchy "as to render retrieval difficult or impossible" (p. 31).

[70] This difficulty is similar to when Tourangeau writes "What we retrieve from memory often consists of our current beliefs about an incident, beliefs that reflect what we actually experienced (and remember), what we did not experience but infer, and what we learned later on." (p 35)

to obtain valid measurements. For example, if the question is asked, *If you did not know about this action, what do you think you would have done?* The obvious response is: *Not do that action.* However, it is highly likely that learning more about an action provided the "tipping point" that, combined with the ability to make a purchase or take an action not required financing, brought about energy saving actions.

We researched previously created scales designed to measure cognitive change. We reviewed three sources:

- Marketing Scales Handbook. A Compilation of Multi-Item Measures. Gordon C. Bruner II and Paul J. Hensel. 1992 American Marketing Association.
- Handbook of Marketing Scales. Multi-Item Measures for Marketing and Consumer Behavior Research. William O. Bearden and Richard G. Netemeyer. 1999. Sage Publications Inc.
- Marketing Scales Handbook. A Compilation of Multi-Item Measures for Cosumer Behavior & Advertising. Volume IV. Gordon C Bruner II, Paul J. Hensel, Karen E. James. 2005. Thomson Higher Education.

Ultimately, we choose a scale from the last source that had a Cronbach's alpha of 0.79 (i.e. is based on questions that measure the same construct) and dealt with cognitive change.

E.1 Survey Questions Used in the CCI Calculation

The CCI determines cognitive change based on three specific concepts:

(1) Was the information presented new?

(2) Was there a cognitive change based on the information?

(3) Direct self-report of program influence on actions taken.

This core set of questions was asked of all participants.

Concept 1 – Was the information learned new?

Program theory indicates that the courses must be responsible for increasing knowledge to be given credit for actions taken. Therefore, if the information was not new or did not move forward existing plans then the course information was not part of the reason why actions were taken. To measure this concept, we asked the following two questions:

- C1_1. Did the course(s) provide you with any new information? (Yes=1, No=0)

If the respondent indicated a “No” to C1_1, they were asked C1_2.

- C1_2. Although you don’t think the course information was new, did your participation in the course(s) move you any closer to implementing efforts to save energy that you were already considering? (Yes=1, No=0)

Because both these questions are given equal value, it is the maximum of these two values that is used in the calculation of the CCI.

Concept 2 – Was there a cognitive change based on the information?

The course must create a cognitive change before actions taken are considered attributable to the program. Although similar to concept 1 as both are attempting to measure cognitive change, it is different from concept 1 because it is measuring a range of change, not a dichotomous value.

We tailored the wording for the following four questions to work well for each of the respondent types (i.e., commercial, residential, and market actor survey respondents).

The following three questions were all asked on a 7 point scale where 1 means ‘not at all’ and 7 means ‘a great deal’:

- C2_1. How much did the course(s) cause you to think differently about energy efficiency opportunities?
- C2_2. How much did the course(s) cause you to want to make energy efficiency changes?
- C2_3. How much did the course(s) increase your awareness of energy efficiency opportunities?

The last question was asked on a 7 point scale where 1 means ‘strongly disagree’ and 7 means ‘strongly agree’:

- C2_4. The course(s) [was/were] a good way to explain the importance of taking advantage of energy efficiency opportunities.

Our value for Concept 2 is the mean of these four questions.

Concept 3 – Self-report of influence on actions taken

The third measure is a direct self-report of influence of program information on actions taken.

This question was asked on a 7 point scale where 1 means ‘not at all influential’ and 7 means ‘very influential’:

- C3_1. How much influence did the information provided in the course(s) have in your decision to make the changes?

E.2 CCI Algorithm

The algorithm used to calculate the CCI is shown below:

CCI = W1[max of C1_1 and C1_2] +*
W2[(average of (C2_1, C2_2, C2_3, C2_4)-0.17)/0.17] +*
W3[(C3_1-0.17)/0.17]*

Where:
W1=0.1
W2=0.7
W3=0.2

W1, W2, and W3 represent the weights assigned to each concept. We chose the weights based on the relevancy of each research question and our confidence that respondents were able to accurately provide answers. Because the three concepts do not share the same scale and for ease of computation of net behaviors, we standardized the scales of Concepts 2 and 3 so that they ranged from 0 to 1. This required us to apply a factor of .17 to each Concept, as shown in the formula above.

Application of CCI to Energy Savings

The CCI questions were asked only once of each respondent. We did not believe it was practical to ask about the influence of the course on each action or behavior change participants made. As such, the CCI is applied to all energy saving actions for which we were able to calculate energy savings. We calculate net energy savings by multiplying the CCI by gross savings:

*Net kWh Savings = Gross kWh Savings * CCI*

E.3 Analysis to Determine Validity of CCI

In the next section, we conduct a series of tests to determine whether the CCI is a valid approach. For this analysis, we use data from our course participant surveys to verify that the CCI calculation approach is robust (i.e., appears to measure what we expected and shows variation).

Comparison of Level of Influence Index to Direct Influence Question

We assumed that the calculated index should not be wildly different than a self-reported influence (concept 3). Figure 58 shows the variation within the CCI, including all three concepts for those who made a change while, Figure 59 is just the direct influence question.

Figure 58: CCI with all 3 concepts

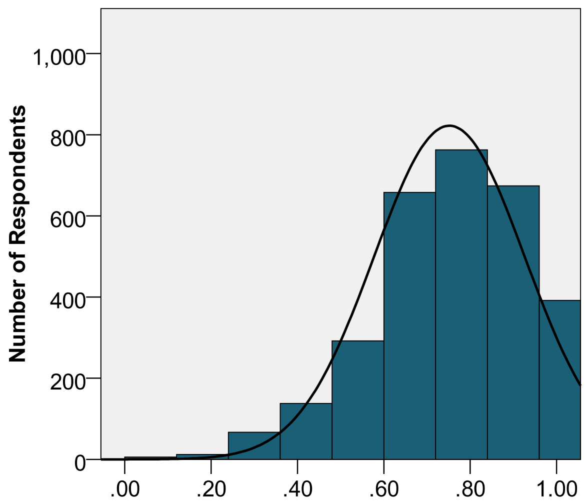
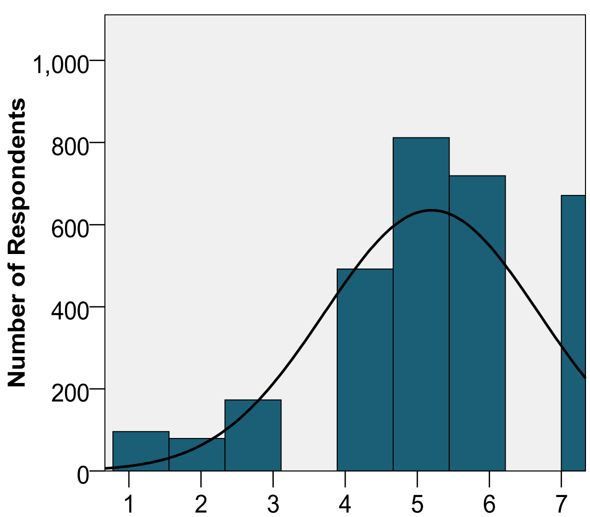


Figure 59: Direct Influence Question



The two graphs show a similar distribution. Both the CCI and the direct program influence question (i.e. Concept 3) are skewed to the left indicating greater program influence. That both measures come to the same conclusion on program influence provides support for use of the CCI.

CCI Question Correlations

The index must be viewed as similar concepts by the respondent to be a successful index. To test this, we calculated a Cronbach's alpha[71] for the questions. This value indicates whether the questions "hang together" as a concept. Information from the first tracking survey had a Cronbach's alpha of 0.85, which supports the use of the CCI as a reliable index.

CCI Value Variation

We also looked at the variation within the CCI value by first computing it using our planned weighting and then by changing the number of questions within the index and lastly, changing their weights.

Table 85. Variation by Number in CCI and Weighting

Test	CCI Value
CCI (Concept1 * .1) + (Concept2*.7) + (Concept3*.2)	0.75
Two Concepts (Concept1 * .2) + (Concept2*.8)	0.74
Three Concepts (Concept1 * .25) + (Concept2*.25) + (Concept3*.5)	0.78

As shown Table 85, there is little variation when changing the number of concepts or weights. The amount of variation is quite small and suggests that different weighting schemes .

Taking Action and CCI

Concept 2 of the CCI measures change in energy efficiency attitudes due to course participation and is the most heavily weighted component of the CCI. The course must create a cognitive change before actions taken are considered attributable to the program.

To test the validity of our measure of cognitive change, we examined whether Concept 2 was associated with taking energy saving action. If it is not, Concept 2 may not be measuring what we want it to. The results indicate that the more participant attitudes towards energy savings changed, the more likely they were to take energy saving action. This finding supports the validity of the questions as an influence concept.

Table 86. Relationship to Taking Action and CCI

Concept 2: Cognitive Change	% Taking Action

[71] Cronbach's alpha is a statistical test that measures the internal reliability or consistency of a number of items within a scale or index. The value ranges from 0 to 1.0 with values towards the higher end (above 0.70) suggesting that the items are measuring the same thing.

	All	Market Actors	Commercial End-Users	Residential End-Users
Low (1.0 - 2.50)	28%	29%	32%	20%
Moderate (2.51 - 5.50)	62%	65%	72%	32%
High (5.51 - 7.0)	82%	89%	86%	57%

APPENDIX F: END-USER ENGINEERING ANALYSIS METHODOLOGY

This Appendix describes the methods used by Summit Blue Consulting to estimate gross energy (kWh and therm) and demand (coincident peak kW) savings for respondents of the Energy Centers surveys. Savings methods leveraged core California-based secondary resources (e.g., DEER, CEUS, reports on CALMAC.org) and models (eQUEST) wherever possible. Where data from these sources was not adequate, not reflective of the range of participant conditions, or was internally inconsistent, additional secondary sources and engineering calculations were used.

A total of eleven analyses were conducted for the following end-uses:

- Boilers/Hot Water
- Building Envelope
- Combined Heat and Power (CHP)
- Compressed Air
- Controls/Energy Management Systems (EMS)
- Cooking, Food Service, and Refrigeration
- Heating, Ventilation, and Air Conditioning (HVAC)
- Lighting
- Motors and Pumps
- Pools
- Renewables
- Water Management

The following sections describe the methods used to estimate gross savings for measures in each of these end-uses.

F.1 Boilers/Hot Water

This section describes the gross savings methodology for the Boilers/Hot Water survey. Twenty of the 44 Wave 1 respondents for whom Summit Blue received responses reported quantifiable energy saving actions. From Wave 1, quantifiable energy savings were identified for 19 of the 25 actions specified in the survey. For Wave 2, 30 of the 46 respondents reported quantifiable energy saving actions. For Wave 2, the survey was revised to include 13 actions. Respondents reported quantifiable savings for 11 of the actions. Figure 60 lists the measures specified in the Wave 1 and 2 surveys and the number of respondents for which quantifiable energy savings were identified.

Figure 60: Measures in the Boilers/Hot Water Surveys

Measure	Measure Presence		Number of respondents with quantifiable savings	
	Wave 1	Wave 2	Wave 1	Wave 2
Installed or replaced tankless water heater	X	X	6	5
Installed or replaced tank storage water heater	X	X	6	5
Installed or replaced tank storage boiler	X		3	0
Installed or replaced condensing boiler	X		1	0
Installed new or replaced high efficiency boilers		X	0	5
Installed a condensing boiler, cogeneration, or other heat recovery approaches		X	0	3
Installed new piping	X		3	0
Increased hot water storage	X	X	0	0
Installed a pumped water storage system	X		0	0
Installed structured plumbing	X	X	3	4
Installed pipe insulation	X	X	5	14
Installed low-flow fixtures	X		10	0
Installed low-flow faucets or faucet aerators		X	0	5
Installed low-flow showerheads or showerhead aerators		X	0	7
Reduced temperature set points	X		5	0
Changed mix water temperature	X		0	0
Other hot water distribution changes		X	0	0
Installed a fuel/air control	X		1	0
Installed oxygen trim controls	X		0	0
Installed excess combustion air controls	X		1	0
Installed flow rate controls	X		0	0
Installed demand controls	X		3	0
Installed or updated control strategy or made operation changes		X	0	12
Performed repair or maintenance measures	X	X	9	13
Other quantified measures	X		2	0
No tech		X	0	8

Summit Blue used the Database of Energy Efficiency Resources (DEER) 2008 Update (Itron, Inc. 2009) and 2005 Update (Itron, Inc. 2006) and additional secondary sources as needed to estimate energy impacts for the actions reported. Only natural gas energy savings (in therms) were quantified for this module (with exception for two measures for two respondents in Wave 2). For Wave 1, it was assumed that all respondents heated water with natural gas-fired water heaters or boilers.[72] For Wave 2, respondents were asked what type

[72] Respondents were not asked to provide their water heater or boiler fuel types in the survey. In California, approximately 95 percent of commercial hot water and approximately 90 percent of non-solar residential hot

of fuel is used. Two respondents reported heating water with electricity. No savings were quantified for one respondent because information was not sufficient, and electricity savings for the other respondent were captured.

The following subsections describe the savings estimate approach for each of the measures.

Installed or Replaced Tankless Water Heater

For Wave 1, six respondents reported that they installed a tankless water heater. For the five respondents that indicated that their tankless water heater replaced an existing water heater, the analysis used the annual energy savings (therms/year) from the DEER 2008 residential tankless water heater measure with DEER 2008's assumption for Customer Average as the baseline. For the remaining respondent that indicated that their tankless water heater was for a new application, the analysis used the annual energy savings (therms/year) from the DEER 2008 residential tankless water heater measure with current code requirements ("Code Baseline" in DEER 2008) as the baseline. The same methodology was applied for Wave 2. Of the five respondents with quantified savings, one reported new installations and replacements, two indicated replacements only, and the final two indicated new installations only.

DEER 2008 contains no tankless water heater measure for commercial applications. For Wave 1, the savings for commercial tank storage water heaters were estimated by multiplying the percentage savings for analogous residential applications to the baseline commercial loads obtained from DEER 2008. For Wave 2, the savings for commercial respondents were estimated by multiplying the residential savings per square foot by the number of square feet reported by the respondent.

One respondent in Wave 2 indicated that new electric tankless water heaters were installed. As a result, kWh and kW savings were calculated and no therm savings were realized for this respondent.

Installed or Replaced Tank Storage Water Heater

For Wave 1, six respondents reported that they replaced their water heater(s) with a more efficient tank storage water heater. The analysis used DEER 2008 annual energy savings (therms/year) for replacing a residential tank storage water heater, based on the DEER 2008 Customer Average assumptions for the baseline water heater energy consumption. For building types not present in DEER 2008 for this measure, energy savings were calculated using the following equation:

$$therms = m * conv * (T_{out} - T_{in}) \times \left(\frac{1}{EF_{base}} - \frac{1}{EF_{eff}} \right)$$

water is heated by natural gas; therefore, all systems described in this survey were assumed to be fueled by natural gas. Sources: California Commercial End Use Survey (Itron, Inc. 2006) and the California Statewide Residential Appliance Saturation Survey (RASS) (KEMA 2004).

Figure 61 describes the parameters in this equation.

Figure 61: Tank Storage Water Heater Algorithm Parameters

Parameter	Description	Value	Units	Source
therms	annual energy savings	-	therms	Calculated
M	annual hot water use	respondent-specific	gallons	Survey responses and DEER 2008
conv	conversion factor for heating water	0.0000829	therms/°F/gallon	Conversion factor
Tout	hot water temperature	130	°F	(Lutz 2005) page 7
Tin	inlet temperature	climate zone-specific	°F	(CEC 2005)
EFbase	energy factor for baseline water heater	building type-specific or, if unknown, assumed to be 0.53	-	Survey responses and DOE 1991 standard
EFeff	energy factor for efficient water heater	building type-specific or, if unknown, assumed to be 0.66	-	Survey responses and DEER 2008

No respondents were assigned savings for installing a new tank storage water heater in Wave 1.

For Wave 2, energy savings were calculated for all five respondents who reported installing new or replacing tank storage water heaters. Similarly to the Wave 1 approach, the DEER 2008 Customer Average was the assumed baseline for respondents replacing tank storage waters, and the code requirements ("Code Baseline" in DEER 2008) were the assumed baseline for respondents installing new units. DEER 2008 savings per square foot were multiplied by the square feet reported by the respondent and the total number of water heaters installed or replaced.

Installed or Replaced Tank Storage Boiler

For Wave 1, three respondents installed or replaced a tank storage boiler. Although the survey asked more generally about a respondent's "water heating system," it was assumed that the systems for these three respondents were most likely boilers, based on responses to questions about storage capacity and building type. The energy savings from replacing a tank storage boiler were calculated using the following equation:

$$therms = \left(\frac{C_1}{E_1} - \frac{C_2}{E_2}\right) \times LF \times T \times conv$$

Figure 62 describes the parameters in this equation.

Figure 62: Tank Storage Boiler Algorithm Parameters

Parameter	Description	Value	Units	Source
therms	annual energy savings	-	therms	Calculated
C_1	capacity of old boiler	respondent-specific	kBtuh	Survey responses
C_2	capacity of new boiler	respondent-specific	kBtuh	Survey responses
E_1	efficiency of old boiler	respondent-specific	AFUE	Survey responses
E_2	efficiency of new boiler	respondent-specific	AFUE	Survey responses
T	annual operating hours	2000	hours	Assumes 40-hour work week, 50 week/year
LF	load factor	0.8	-	Estimate; based on mechanical systems design rule of thumb to oversize by 20%
conv	conversion factor	0.01	therms / kBtuh	kBtuh to therms conversion factor

This measure was not included in the Wave 2 survey (see "Installed New or Replaced High Efficiency Boiler" for similar measure).

Installed or Replaced Condensing Boiler

For Wave 1, the analysis approach for the calculation of energy savings from a condensing boiler is the same as the approach for a conventional boiler. The energy savings from installing a condensing boiler were calculated using the following equation:

$$therms = \left(\frac{C_1}{E_1} - \frac{C_2}{E_2}\right) \times LF \times T \times conv$$

Figure 63 describes the parameters in this equation.

Figure 63: Condensing Boiler Algorithm Parameters

Parameter	Description	Value	Units	Source
therms	annual energy savings	-	therms	Calculated
C_1	capacity of old boiler	respondent-specific	kBtuh	Survey responses
C_2	capacity of new boiler	respondent-specific	kBtuh	Survey responses
E_1	efficiency of old boiler	respondent-specific	AFUE	Survey responses
E_2	efficiency of new boiler	respondent-specific	AFUE	Survey responses
T	annual operating hours	2000	hours	Assumes 40 hour work week, 50 weeks/year
LF	load factor	0.8	-	Engineering judgment; based on standard assumption that systems are oversized by 20%
conv	conversion factor	0.01	therms / kBtuh	kBtuh to therms conversion factor

This measure was not included in the Wave 2 survey (see “Installed New or Replaced High Efficiency Boiler” for similar measure).

Installed New or Replaced High Efficiency Boiler

For Wave 2, four respondents installed or replaced high efficiency boilers. Several respondents indicated the same number of new boilers and replacement boilers. It was determined that these respondents replaced old boilers with new units and that only savings would be counted for the new units. Figure 64 shows the data requirements, sources, and treatment of missing or irregular data for this analysis.

Figure 64: High Efficiency Boiler Algorithm Parameters

Data Requirements	Source	Treatment of Missing/Irregular Data
Number of boilers	Survey	If replacement and new boilers equal, only assume savings for new units
Square feet	Survey	If missing, use average of similar buildings
Building type	Survey	
kBtu/square foot	CEUS(Itron, Inc., 2006)	
AFUE (before)	Survey	Engineering judgment: Assume 80%
AFUE (after)	Survey	Engineering judgment: Assume 90%

The annual energy savings in therms were calculated using the following equation:

$$Savings = \frac{AFUE(after) - AFUE(before)}{AFUE(before)} * \frac{kBtu_{CEUS\_per\_sqft}}{100} * Square\_feet * Boilers$$

Where:

Savings is the estimated annual energy savings in therms;

AFUE(after) is the boiler efficiency after action taken;

AFUE(before) is the boiler efficiency before action taken;

$kBtu_{CEUS\_per\_sqft}$ is the kBtu per square foot from CEUS for water heating for a particular building type;

Square feet is the size of the building reported by the respondent; and

Boiler is the number of boilers installed or replaced.

A fifth respondent in Wave 2 indicated savings for this measure, however, open-ended responses indicated that a water heater was installed. A similar approach used to quantify savings in Wave 1 was applied to this respondent. Figure 65 shows the data requirements, sources, and treatment of missing or irregular data for this respondent.

Figure 65: Parameters for Respondent who Installed Water Heaters

Data Requirements	Source	Treatment of Missing/Irregular Data
Number of water heaters	Survey	If replacement and new water heaters equal, only assume savings for new units
Square feet	Survey	If missing, use average of similar buildings
Hot water consumption	DEER (for specific building type, per square foot, per year)	
Building type	Survey	
Temperature(hot)	Survey	Engineering judgment: Assume 130°F
Temperature (cold)	CEC(CEC, 2005)	
Energy Factor (before)	Survey	Engineering judgment: Assume 0.53 EF
Energy Factor (after)	Survey	Engineering judgment: Assume 0.66 EF

The annual energy savings in therms were calculated using the following equation:

$$Savings = \left(\left(Water * Sqft * C * \frac{T_{hot} - T_{cold}}{EF_{before}}\right) - \left(Water * Sqft * C * \frac{T_{hot} - T_{cold}}{EF_{after}}\right)\right) * Water\_Heater$$

Where:

Savings is the estimated annual energy savings in therms;

Water Heater is number of units installed or replaced;

Water is the DEER estimate for annual hot water usage per square foot;

Sqft is the square feet or size of the building reported by the respondent;

C is a conversion factor (0.000829 therms/°F/gal);

T_{hot} is the water temperature of the water heater;

T_{cold} is the inlet water temperature;

EF_{before} is the water heater energy factor before the action; and

EF_{after} is the water heater energy factor after the action;

Installed a Condensing Boiler, Cogeneration, or Other Heat Recovery Approaches

This measure was not included in the Wave 1 survey.

For Wave 2, four respondents reported action on this measure and quantifiable savings were calculated for three. The open-ended responses provide the majority of the details used to determine the savings for each of these respondents.

For two respondents, cogeneration equipment was installed. Based on the information in the open-ended responses it was determined that waste heat from these equipment were captured and used to preheat water. Electricity savings were also calculated for one of these respondents because electricity is generated in addition to hot water. Engineering judgment regarding cogeneration system efficiency was used to estimate the percentage of waste heat that is captured for water heating.

Savings were also quantified for a third respondent who claimed installation of a boiler. Savings were estimated using the same approach use for the measure "Installed or Replaced Condensing Boiler." Engineering judgment and information from other respondents was used to estimate the condensing boiler and operating characteristics.

Installed New Piping

For Wave 1, for the three respondents that reported installing new piping, it was assumed that energy savings are only from adding insulation. Insufficient information was provided to determine whether or not savings were achieved from the other potential benefits of installing new piping.

The energy savings calculation methodology for installing insulation on piping is stated below under the measure "Installed Pipe Insulation".

This measure was not included in the Wave 2 survey.

Increased Hot Water Storage

Savings for this measure were not quantified, because increasing hot water storage would only result in peak demand savings for electric water heaters or non-energy benefits meeting water heating load. For Wave 1 it was assumed that all water heating needs are met by gas-fired water heaters or boilers, and it was confirmed that the two respondents reporting for this measure in Wave 2 use gas for their heating. As a result, no savings are reported for the respondents that indicated an increase in hot water storage.

Installed a Pumped Water Storage System on New or Existing System

For Wave 1, there were no respondents that mentioned installing a pumped water storage system on an existing system and only one respondent that indicated installation of pumped water storage on a new system; however, this respondent did not provide enough information to quantify savings.

This measure was not included in the Wave 2 survey.

Installed Structured Plumbing

For Wave 1, three respondents indicated that they installed structured plumbing. Literature review indicated that the energy saving features and typical savings achieved with a structured plumbing system are very similar to the DEER 2005 Point-of-Use Water Heaters measures (Acker and Klein 2006).[73] Thus, for Wave 1 the energy savings for structured plumbing were calculated by applying the percent savings in the DEER 2005 measures to the baseline water heating energy consumption for each respondent.

For Wave 2, six respondents indicated that they installed structured plumbing. Two respondents did not have quantifiable savings. Three respondents indicated that they installed demand-controlled pumping, and savings were estimated with the approach used in Wave 1. DEER 2005 Point-of-Use Water Heaters measure savings were scaled to the square feet reported by the respondent. Additionally, one respondent indicated they shortened plumbing distances. Savings were estimated by assuming that shortening plumbing distances was equivalent to adding pipe insulation. The approach used in the measure "Installed Pipe Insulation" was applied to this respondent.

Installed Pipe Insulation

For Wave 1, five respondents reported installing pipe insulation. Energy savings for this measure were assumed to be equivalent to reducing the water temperature setting by 2°F[74].

[73] 10 percent in non-residential (D03-909) and 15 percent in residential (D03-940) applications.

[74] US DOE, EERE article Insulate Hot Water Pipes for Energy Savings (DOE, EERE 2009) states that insulating hot water pipes can raise water temperature 2°F to 4°F.

The savings estimate algorithm for this action can be found in the “Reduced Temperature Setpoints” measure.

For Wave 2, 14 respondents reported installing pipe insulation. The same approached used in Wave 1 was use to estimate these savings. Additionally, the 2°F temperature reduction was modified for four respondents. One respondent indicating significantly larger insulation lengths and thicknesses and the temperature difference was increased to reflect this. Three respondents indicating smaller insulation lengths (i.e., a smaller portion of piping was insulated) and thicknesses and the temperature difference was decreased to reflect fewer savings.

Installed Low-Flow Fixtures or Replaced Existing Fixtures with Low Flow Fixtures

For Wave 1, 10 respondents indicated that they installed low-flow fixtures. It was assumed that the savings associated with low flow-fixtures were entirely attributable to the reduction of heated water usage.

Nine respondents specifically mentioned installing low-flow showerheads and three respondents mentioned faucet aerators (or low flow rate faucets).[75] For both measures, savings from DEER 2005[76] were assigned to each respondent, based on building type and climate zone. For building types not present in the DEER 2005 savings estimates for this measure, savings were estimated to be the average savings of the other respondents.

Several respondents also mentioned installing low-flow toilets. Savings were not included for low-flow toilets because toilets only save cold water.

For Wave 2, the survey was modified to separate low-flow fixtures into two measures for faucets and showerheads. These measures are presented in the following sections.

Installed Low-Flow Faucets or Faucet Aerators

For Wave 2, nine respondents indicated that they installed low-flow faucets or faucet aerators. Four respondents did not have enough information to quantify savings, and savings were quantified for the remaining five. The approach used in the Wave 1 measure “Installed Low Flow Fixtures or Replaced Existing Fixtures with Low Flow Fixtures” was also applied to these respondents. For building types not present in the DEER 2005 savings estimates, savings for the closest matching building type were used for Wave 2 respondents. Additionally, it is assumed that low-flow fixtures and aerators result in the same savings.

Installed Low-Flow Showerheads or Showerhead Aerators

For Wave 2, the same approach taken for the measure “Install Low-Flow Faucets or Faucet Aerators” is applied to the respondents reporting action on this measure. Savings were quantified for seven of the eight respondents.

---

[75] Two respondents installed both low-flow showerheads and faucet aerators.

[76] DEER 2005, measures D03-934: Faucet Aerators and D03-937: Low-Flow Showerhead.

Reduced Temperature Setpoints

For Wave 1, six respondents reported reducing their water heater temperature setpoints; savings were quantifiable for five of these respondents.[77] The following equations were used to calculate the energy savings for this measure:

$$PercentSavings = \frac{T_f - T_{in}}{T_i - T_{in}}$$

$$therms = Baseline \times PercentSavings$$

Where

PercentSavings is the proportion of savings, relative to the baseline energy consumption.

T_i is the initial (old) set point temperature (°F); based on survey responses or, if unknown, assumed to be 130°F (Lutz 2005).

T_f is the final (new) set point temperature (°F); based on survey responses or, if unknown, assumed to be 120°F.[78]

T_{in} is the inlet water temperature (°F) to the water heater.

Baseline (therms) is the baseline annual energy usage for heating water, calculated for each respondent.

therms is the annual energy savings.

This algorithm is based on the energy savings algorithm in the CEC's Solar Water Heating Calculator Form (CEC 2005).

This measure was not included in the Wave 2 survey.

Changed Mix Water Temperature

For Wave 1, the analysis approach chosen for this measure was the same as the analysis approach for reducing the temperature set points. Changing the mix water temperature changes the amount of hot water entering the system and this has a similar effect on the system temperature and energy consumption. However, neither of the two respondents for this measure reported temperature changes that would have led to energy savings.

This measure was not included in the Wave 2 survey.

---

[77] One respondent reported a new temperature set point that was the same as the old temperature set point.

[78] This assumption based on the most common response provided by the other survey respondents and engineering judgment.

Other Hot Water Distribution Changes

For Wave 2, the Wave 1 survey was expanded to capture any additional changes to hot water distribution systems that might be reported in open-ended responses. Four respondents reported actions for this measure. However, for three respondents, savings were captured in other measures and not included here in order to eliminate double counting. The final respondent did not provide enough information to determine savings.

Installed a Fuel/Air Control

For Wave 1, two respondents reported installing a type of fuel/air control. The savings for one respondent was quantified in this measure and the savings for the other respondent was quantified under the measure for "Installed Excess Combustion Air Controls" to avoid double-counting.

Savings were estimated to be 5 percent of baseline boiler energy consumption.[79] Baseline energy consumption of each boiler was calculated using the following equation:

$$Baseline = \left(\frac{C}{E}\right) \times LF \times t \times conv$$

Where:

- *Baseline* is the annual energy consumption of each boiler (therms)
- *C* is the boiler capacity; based on survey responses (kBtuh)
- *E* is the efficiency of the boiler (AFUE)
- *LF* is the load factor; assumed to be 0.8[80]
- *t* are the annual operating hours (hours); based on a 40-hour work week, 50 weeks/year
- *conv (therms/kBtuh)* is the conversion factor from kBtuh to therms (0.01)

This measure was not included in the Wave 2 survey.

Installed Oxygen Trim Controls

For Wave 1, the savings for the single respondent who reported installing oxygen trim controls were quantified in "Installed Excess Combustion Air Controls" to avoid double-counting.

This measure was not included in the Wave 2 survey.

---

[79] This is a conservative estimate of savings, based on the DOE's Consumer's Guide for Industry Plant Managers & Engineers (DOE, EERE n.d.), which estimates savings for this measure in the range of 2 percent to 15 percent.

[80] Estimate; based on mechanical systems design rule of thumb to oversize systems by 20 percent.

Installed Excess Combustion Air Controls

For Wave 1, one respondent reported installing excess combustion air controls. This respondent also claimed savings for other combustion control measures that could be considered a subset of installing excess combustion air controls (i.e., installing fuel/air control, oxygen trim controls, and flow rate controls). All savings for this respondent's combustion control actions were quantified here to avoid double-counting.

Savings were estimated to be 5 percent of baseline boiler energy consumption.[81] Baseline energy consumption of each boiler was calculated using the following equation:

$$Baseline = \left(\frac{C}{E}\right) \times LF \times t \times conv$$

Where:

- *Baseline* is the annual energy consumption (therms) of each boiler.
- *C* is the boiler capacity (kBtuh) - based on survey responses.
- *E* is the efficiency (AFUE) of the boiler.
- *LF* is the load factor; assumed to be 0.8.[82]
- *t* are the annual operating hours (hours); based on a 40 hour work week, 50 weeks/year.
- *conv* is the conversion factor (therms/kBtuh) from kBtuh to therms (0.01).

This measure was not included in the Wave 2 survey.

Installed Flow Rate Controls

For Wave 1, the savings for the single respondent that reported installing oxygen trim controls were quantified in "Installed Excess Combustion Air Controls" to avoid double-counting.

This measure was not included in the Wave 2 survey.

[81] This is a conservative estimate of savings, based on the DOE's Consumer's Guide for Industry and Plant Managers & Engineers (DOE, EERE n.d.), which estimates savings for this measure in the range of 2 percent to 15 percent.

[82] Estimate; based on mechanical systems design rule of thumb to oversize systems by 20 percent.

Installed Demand Controls

For Wave 1, three respondents reported installing demand controls on their water heating system. It was assumed that the actions and savings from the demand controls are equivalent to the savings for the DEER 2005 measure for installing a circulation pump time clock.[83] The 6 percent savings assumed in DEER 2005 were applied to the respondent's calculated baseline water heating energy consumption to find the estimated savings in therms.

This measure was not included in the Wave 2 survey.

Installed or Updated Control Strategy or Made Operation Changes

For Wave 2, all actions affecting controls and operations (which are presented as individual measures in Wave 1) are consolidated into a single measure. Twelve respondents reported savings for this measure. This measure includes the following actions (actions similar to those found in Wave 1), as shown in Figure 66:

Figure 66: Control Strategy and Operation Changes

Actions Taken by Respondents	Analysis Approach
Reduced temperature setpoints	Wave 1, "Reduced Temperature Setpoints" measure
Changed mix water temperature	Wave 1, "Change Mix Water Temperature" measure
Fuel/Air controls	5% savings of baseline consumption
Oxygen trim controls	5% savings of baseline consumption
Excess combustion air controls	5% savings of baseline consumption
Flow rate controls	5% savings of baseline consumption
Demand controls	Wave 1, "Installed Demand Controls" measure
Other controls	Savings based on open-ended responses

Reduced temperature setpoints: Savings were quantified for eight respondents.

Changed mix water temperature: Two respondents indicated action for this measure. However, these respondents also reported savings for reduced temperature setpoints. Savings were not quantified to avoid double-counting savings.

Fuel/Air Controls: Savings were quantified for four respondents. Baseline operating consumption levels were determined using information from CEUS (Itron, Inc., 2006) and building size as reported by respondents. Savings due to fuel/air controls, oxygen trim controls, excess combustion air controls, and flow rate controls are assumed to be 5 percent of the total consumption. (DOE, Combustion, 2009)

[83] DEER 2005, Measure D03-910: Non-Residential Water Heating Measure Savings Estimates – Circulation Pump Time Clock.

Oxygen trim controls: One respondent reported action for this measure. Savings were not quantified to avoid double-counting because control savings were also reported in the "Fuel/Air controls" measure.

Excess combustion air controls: One respondent reported action for this measure. Savings were not quantified to avoid double-counting because control savings were also reported in the "Fuel/Air controls" measure.

Flow rate controls: Two respondents reported action for this measure. Savings were not quantified for one respondent to avoid double-counting because control savings were also reported in the "Fuel/Air controls" measure. Savings were quantified for the other respondent using the same approach used for the "Fuel/Air controls" measures.

Demand controls: Savings were quantified for seven respondents.

Other controls: Savings were quantified for five respondents out of nine respondents reporting other control actions. Savings were determined from responses to open-ended questions. Two respondents indicated savings as a percentage of baseline consumption. One respondent indicated cost savings and DOE's EIA cost data (DOE, Natural Gas Summary, 2009) was used to convert cost savings to energy savings. One respondent indicated that demand controls were installed and that approach was applied to determine savings. The final respondent indicated that insulation was replaced on several pipes and valves. Engineering judgment determined that this action produced savings that are equivalent to 2 percent of the baseline energy consumption level. This approach results in savings similar to the approach used to estimate savings for the "Installed Piping Insulation" measure.

Performed Repair or Maintenance Measures on Piping, Boiler, or Central System

For Wave 1, out of 12 respondents that reported performing repair or maintenance measures on their water heating system, unique savings were calculated for nine respondents, with the other three respondent's actions quantified elsewhere or suggesting no actual savings.

Measures were broken down into water heater maintenance measures and boiler maintenance measures. It was assumed that the maximum percent savings that would likely be achieved through either type of maintenance measures is 2.5 percent.

Water heater maintenance measures were quantified by ascribing each of the 10 measures with 0.25 percent savings. Respondents were then assigned a total savings percentage based on the number of measures they implemented. For instance, a respondent that implemented five water heater maintenance measures would achieve 1.25 percent of the total possible 2.5 percent energy savings. This total percentage was then applied to each respondent's baseline water heating energy consumption to find energy savings.

Each of the four boiler maintenance measure was assigned half of the lowest value found in a literature review of typical percent savings, as shown in Figure 67.

Figure 67. Savings as Percent of Baseline Consumption for Boiler Maintenance Measures

Boiler Maintenance Measure	Value Range	Assigned Value	Source
Check and reduce condensate system losses	2-5%	1%	DOE, FEMP(2005)
Check and reduce blowdown loss	0.5-1%	0.25%	DOE, FEMP(2005)
Check and reduce stack loss	1% for every 40° reduction in air temp	0.25%	Oregon Department of Energy (n.d.)
Check and reduce boiler scaling	2-3%	1%	DOE, FEMP(2005)

As with the water heater maintenance measures, the percent savings for each boiler maintenance measure were aggregated up to a total of 2.5 percent and then applied to the respondent's baseline water heating energy consumption.

The same analysis approach implemented in Wave 1 was applied for the Wave 2 respondents. Savings were quantified for 13 of the 15 respondents.

Other Quantified Measures

For Wave 1, two respondents indicated taking additional actions that were not explicitly mentioned in the survey questions. Their actions were quantified as described below:

> One respondent reported making their boiler more efficient and installing new heat exchangers. As a conservative estimate, 5 percent savings were assumed for this respondent's actions because it was not apparent if the two responses should be treated as mutually exclusive. The assumed savings percentage was then applied to the respondent's baseline water heating energy consumption to find total energy savings.
>
> The other respondent reported that they "adjusted and flushed reheat coils." This action was considered system maintenance and treated consistently with the other maintenance measures by assuming 0.25 percent savings and applying these savings to the respondent's baseline water heating energy consumption.

This measure was not included in the Wave 2 survey.

No Technical Knowledge

For Wave 2, 23 respondents claimed that they had no technical knowledge of the hot water changes that were made in their facilities and buildings. Adequate information was available for eight respondents where actual changes to hot water systems could be verified and savings could be estimated. Six respondents claimed that new boilers and hot water heaters were installed. However, limited information was available from respondents. As a result DEER 2008 estimates for savings from installing new water heaters and boilers were used for these respondents. Finally, two respondents reported insulating piping and structured plumbing actions. The approaches used for those measures were also applied to these respondents.

F.2 Building Envelope

This section describes the gross savings methodology for the Building Envelope survey. All 28 Wave 1 respondents for whom Summit Blue received responses reported quantifiable energy saving actions. From Wave 1, quantifiable energy savings were identified for eight of the nine actions specified in the survey.

Of 94 Wave 2 respondents for whom Summit Blue received responses, 64 reported quantifiable energy saving actions. Of these, 26 were assigned savings based on measure details given, and the other 38 (who claimed no technical knowledge) were assigned average savings per square foot for each measure that they reported taking. From Wave 2, quantifiable energy savings were identified for 11 of the 16 actions specified in the survey. Figure 68 lists the measures specified in the Wave 1 and 2 surveys and the number of respondents for which quantifiable energy savings were identified.

Figure 68: Measures in the Wave 1 and 2 Building Envelope Survey

Measure	Measure Presence		Number of respondents with quantifiable savings	
	Wave 1	Wave 2	Wave 1	Wave 2
Install Temperature Barriers	X		11	0
Install Floor Insulation		X	0	5
Install Wall Insulation		X	0	5
Install Roof/Ceiling Insulation		X	0	4
Install Radiant Barrier		X	0	2
Install Other Temperature Barrier		X	0	0
Install Roof Framing / Cool Roof	X		5	0
Install High R-Value Roof Framing		X	0	3
Install Cool Roof		X	0	10
Installed Other Roof Framing		X	0	0
Install Energy Efficient Windows	X	X	18	16
Install Window Framing	X	X	2	0
Install Window Film	X		1	0
Installed Reflective Window Film		X	0	3
Install Standard Window Film		X	0	1
Install Window Shading	X	X	13	6
Weather Stripping and Caulking	X	X	19	13
NFRC Site-Build Certification	X	X	2	0
Cost-Benefit Analysis	X		0	0
No Technical Knowledge		X	0	38

Savings estimates were determined by modeling in the building energy simulation tool eQUEST (James J. Hirsch and Associates n.d.), which provides default parameters for many commercial building types in California. A separate building model was developed for each respondent, based on their responses and using eQUEST default values (by building type and size) for all other building details.

A significant contribution to uncertainty in this analysis was that most respondents were not asked or did not provide their building size. Because all building envelope measures save energy through the HVAC system, savings are directly correlated to building size. Additional uncertainty came from commercial respondents with new construction who reported installing energy efficient equipment, but it was unclear if this equipment was more efficient than the current Title 24 specifications.

Residential eQUEST models were developed by Summit Blue and calibrated to typical consumption data in several climate zones representing the range of California climates. The models were divided into three general climate zones (*Northern Coastal*, *Southern Coastal*, and *Inland*) and calibrated to electric and gas Unit Energy Consumption (UEC) data from the California Residential Appliance Saturation Survey (RASS) (KEMA 2004). Calibration was achieved by varying heating and cooling equipment efficiencies, window area, wall and ceiling insulation, lighting and equipment power densities, and heating and cooling thermostat set points. Models were calculated to within 2 percent of the relevant UEC values.

In order to meet the heating and cooling UEC targets, heating and cooling set points were set out of reasonable range in many cases. This compensates for the observed phenomenon of households using AC and heating intermittently, even when conditions would suggest continuous usage.

In order to adjust the residential eQuest prototype models to the specifics of each respondent, changes were made based on responses regarding building characteristics. Figure 69 details the changes made for each survey response:

Figure 69: Residential eQuest Modeling Assumptions

Parameter	Assumption	Source
Are your walls insulated?		
Yes	R-13 Batts	*Title 24 general requirement*
No	R-3	*Engineering judgment*
Don't know		
Built pre-1980s	R-6.5	*1/2 of Title-24 requirements, assumption from DEER 2008*
1980s	R-9	*2/3 of Title-24 requirements, assumption from DEER 2008*
Post 1980s	R-13 Batts	*Title-24 general requirements, assumption from DEER 2008*
Is your ceiling insulated?		
Yes	R-19 Batts	*Title-24 general requirement*

Parameter	Assumption	Source
No	R-5	*Engineering judgment*
Don't know		
Built pre-1980s	R-9.5	*1/2 of Title-24 requirements, assumption from DEER 2008*
1980s	R-12	*2/3 of Title-24 requirements, assumption from DEER 2008*
Post 1980s	R-19 Batts	*Title-24 general requirements, assumption from DEER 2008*
Is your floor insulated?		
Yes	R-30	*eQuest default*
No	R-5	*Engineering judgment*
Energy efficient furnace	AFUE 90	Based on middle range estimate for Energy Star furnaces, http://www.energystar.gov/index.cfm?c=furnaces.pr_furnaces
Energy efficient AC	input equivalent EIR to stated SEER value	
SEER 12	0.233	*eQuest values; from listed EIR after inputting a given SEER value in wizard mode*
SEER 13	0.212	*eQuest values; from listed EIR after inputting a given SEER value in wizard mode*
SEER 14	0.194	*eQuest values; from listed EIR after inputting a given SEER value in wizard mode*

Because building size and HVAC type are difficult to adjust in the models from respondent to respondent, these differences were accounted for by applying adjustment factors to overall savings values produced by the models. These adjustment factors are shown in Figure 70:

Figure 70: Residential Modeling Savings Adjustment Factors

Parameter	Assumption	Source
Size Adjustment Factor	sqrt (actual sq ft/model sq ft)	Engineering judgment; Wall area scales with approximately the square root of floor area, envelope losses scale approximately with wall area
AC Type Factor	0.37 for Room AC, 0.53 for Evap AC, 0.4 for Don't Know	Room: EIA Residential Energy Consumption Survey (RECS); Evap: CA Residential Appliance Saturation Survey (RASS); Don't know: weighted average based on the percentage of homes with each type of AC from the CA RASS
AC Use Factor:		Assumption
Not used at all	0	
Turned on only a few days and nights	0.1	
Turned on quite a bit/Intermittent Usage	1	
Turned on just about all summer/Constant Usage	1.5	
Heating Type Factor	0.37 for Room Heat	Assumption, based on value for Room AC

Because the energy savings from building envelope measures are not additive, total savings for each respondent were determined by modeling all respondent reported measures at once. For each respondent, the attribution of savings to individual measures was then done by modeling a single measure at a time and determining the relative impact of each measure. The following equation summarizes this approach:

$$Savings_i = Savings\_Total * \frac{Savings\_eQUEST_i}{\sum_{j=1}^{n} Savings\_eQUEST_j}$$

Where:

Savings$_i$ is the reported savings (kWh/kW/therms) for measure *i*.

Savings_Total is the total reported savings (kWh/kW/therms) for all measures, as determined from modeling all measures together in a single eQUEST model.

Savings_eQUEST$_i$ is the savings for implementing a single measure, *i*, as determined by modeling measure *i* individually in eQUEST.

$\sum_{j=1}^{n} Savings\_eQUEST_j$ is sum of savings from all (measures 1 though *n*) single-measure runs of eQUEST

The eQUEST results for certain commercial building simulations were uncharacteristically low, in which case, DEER 2005 and/or estimates given by the respondents of their dollars per year savings were used to determine a more appropriate savings estimate.

The following subsections state the pre- and post-measure assumptions for respondents who did not provide pre- and/or post-measure specifications.

Install Temperature Barriers

Residential – Base case and efficient case eQuest models were adjusted to match the insulation specifications provided by the respondent. Where no insulation information was provided, the following insulation changes were made: floor from R-4 to R-19, ceiling from R-11 to R-30, walls R-6 to R-13.

Commercial, Wave 1 – From eQUEST default to R-30 batt roof, R-12 walls, R-4 interior walls, R-10 under slab.

Commercial, Wave 2 – Base case and efficient case eQUEST models were built to match the insulation specifications provided by the respondent. When base case conditions were not specified, eQUEST default insulation types and levels were used.

Install Roof Framing / Cool Roof

Residential – Roof absorptivity from 0.6 to 0.35.

Commercial, Wave 1 – Roof absorptivity from 0.6 to 0.4.

Commercial, Wave 2 – Base case and efficient case eQUEST models were built to match the roof color and type specifications provided by the respondent. When base case conditions were not specified, eQUEST default roof type and absorptivity (0.6) were used.

Install Radiant Barrier

Residential/Commercial – A radiant barrier was modeled in eQUEST via the addition of an R-5 insulation layer to the attic (Res) or roof (Comm.). NOTE: eQuest does not model radiant heat transfer; by default the addition of a “radiant barrier” results in additional insulation. The R-value of insulation added varies with the roof type, but is approximately R-5.

Install Energy Efficient Windows

Residential – Base case and efficient case eQuest models were adjusted to match the window specifications provided by the respondent. Where no window information was provided, windows were upgraded from single pane vinyl frames to double pane low-e, vinyl frames.

Commercial, Wave 1 – From eQUEST default to double pane, low-e with insulated fiberglass/vinyl frames.

Commercial, Wave 2 – Base case and efficient case eQUEST models were built to match the window specifications provided by the respondent. When base case conditions were not specified, eQUEST default window types were used. Because respondents were only asked to provide the total square footage of window area upgraded on each façade, and not the percent of total area, it was assumed that 100 percent of the window area on a façade that received an upgrade was upgraded.

Install Window Framing

Residential – Aluminum to vinyl.

Commercial, Wave 1 – No commercial respondents reported this measure.

Commercial, Wave 2 – All respondents that reported implementing this measure also reported installing new energy efficient windows. As such, the base and efficient case framing information was used in the base and efficient new window models and the savings were captured and reported there.

Install Window Film

Residential – Added tint to baseline windows for "standard" film, changed to reflective windows for "reflective" film.

Commercial, Wave 1 – From eQUEST default to double reflective glass type.

Commercial, Wave 2 – Base case and efficient case eQUEST models were built to match the window film specifications provided by the respondent. When base case conditions were not specified, it was assumed that no window film was present. For the commercial respondents that also reported installing new energy efficient windows, it was assumed that the "film" installed was a part of the new window and that information was used to model the efficient window case. As such, the savings were captured and reported there.

Install Window Shading

Residential – From no shading to 3 ft. deep overhang, extending 1 ft. on either side of each south facing window. If shades were specified on east and west windows, assumed 6 ft. deep overhang extending 1 ft. on either side, post-measure only. If fins were specified, assumed 2 ft fins on either side of east and west windows, extending from the entire height of the window.

Commercial, Wave 1– From no shading to 3 ft. deep overhang, extending 1 ft. on either side of each south facing window. If shades were specified on east and west windows, assumed 6 ft. deep overhang extending 1 ft. on either side, post-measure only.

Commercial, Wave 2 – Base case and efficient case eQUEST models were built to match the shading specifications provided by the respondent. When base case conditions were not specified, assumed no shading.

Weather Stripping and Caulking

Residential – Decrease air changes per hour (ACH) by 0.025 for each area (walls, windows, attic, floor) identified.

Commercial, Wave 1 – Decrease ACH by 0.025 for each area (walls, windows, attic, floor) identified.[84]

Commercial, Wave 2 – For any commercial building with a floor area of 2000 square feet of less, base case ACH = 0.5. Decrease ACH by 0.025 for each area (walls, windows, attic, floor) identified. Energy savings for commercial weather stripping measures in larger buildings are assumed to be zero.[85]

NFRC Site-Build Certification

Residential – No residential respondents reported this measure in Wave 1. For Wave 2, 1 respondent reported this measure, but was assigned no savings, since the measure is appropriate only to commercial buildings.

Commercial, Wave 1 – Assumed 2 percent savings from eQUEST default consumption.

Commercial, Wave 2– No commercial respondents reported this measure.

Cost-Benefit Analysis

- There are no energy savings associated with this measure.

No Technical Knowledge

Commercial, Wave 2– The savings per implemented measure for each facility were estimated to be 25 percent of the measure savings (normalized per square foot area) averaged over the survey respondents who provided technical knowledge for this measure.

[84] The only commercial building to report this measure was only 1,300 square feet, therefore, the residential assumption was reasonable.

[85] Engineering judgement. Commercial HVAC systems require a minimum outdoor air input in their HVAC systems (specified in either cfm or % of supply flow). As a result, almost all commercial buildings already have positive pressure throughout. There is then some kind of return relief damper (or in some cases an exhaust fan) that extracts air from the building. When you seal up the building better, the building continues to have even higher internal pressure, which makes the outdoor air fan work a little harder, and air flows out other cracks or the relief damper opens further. You will get some reduction in infiltration as a result, but because the airflows are basically swamped by the HVAC system, you'll barely see any difference at all. Depending on the system, there are either very small savings or no savings.

F.3 Combined Heat and Power (CHP)

This section describes the gross savings methodology for combined heat and power measures. For Wave 1, these measures were included in the Controls/EMS survey. Only one of the four Wave 1 respondents for whom Summit Blue received responses reported quantifiable energy saving actions. This respondent reported taking all three measures specified in the survey; as described below, all savings for this respondent were attributed to a single measure to avoid double counting. For Wave 2, there was a separate CHP module. Summit Blue received responses from five Wave 2 respondents; two reported taking actions that could result in energy savings, although neither provided enough technical information to quantify these savings. An additional Wave 2 respondent reported taking an action that would not result in energy savings. Figure 71 lists the measures specified in the survey and the number of respondents for which quantifiable energy savings were identified.

Figure 71: CHP Measures in the Controls/EMS Survey

Measure	Measure Presence		Number of respondents with quantifiable savings	
	Wave 1	Wave 2	Wave 1	Wave 2
Install CHP with a boiler/furnace system	X		1	0
Install CHP with an HVAC system	X		1	0
Arrange chillers in parallel for optimal absorption chiller loading to fully utilize waste heat recovery	X		1	0
Changes made to CHP to save energy		X	0	0

The following is a summary of the reported actions of the four Wave 1 respondents and corresponding analysis conducted by Summit Blue:

Respondent #1 – Reported taking all three actions. To avoid double counting of what was presumably a single, multi-functional system, savings for only the “Install CHP with a Boiler/Furnace System” were calculated. *Ultimately, savings were estimated for only this measure and respondent*.

Respondent #2 – Reported the “Parallel Chiller” measure, but the information provided was inconsistent with the measure and with the respondent’s building specifications. No savings were calculated.

Respondent #3 – Reported the “Parallel Chiller” measure but provided insufficient information to estimate savings.

Respondent #4 – Provided the same answer for every question in the online Controls/EMS survey. Responses were assumed to be unreliable and no savings were estimated.

The following is a summary of the reported actions of the three Wave 2 respondents who reported taking action:

Respondent #1 – Reported installing a catalytic converter. A catalytic converter is a device used to reduce the toxicity of engine emissions by converting nitrogen oxides to nitrogen (and oxygen), carbon monoxide (and oxygen) to carbon dioxide, and unburnt hydrocarbon fuel to carbon dioxide and water. This process is applied to engine exhaust gas and does not affect the efficiency of the engines. Therefore, a installing a catalytic converter (or replacing an older one) would not result in energy savings.

Respondent #2 – Reported installing air/fuel ratio controls. While this action would result in energy savings, this respondent did not indicate fuel type of these engines (natural gas being one of several options), the size of these systems, or the operating hours of these systems. Therefore, no savings could be estimates.

Respondent #3 – Reported installing air/fuel ratio controls. Similar to Respondent #2, this respondent did not indicate fuel type of these engines (natural gas being one of several options), the size of these systems, or the operating hours of these systems. Therefore, no savings could be estimates.

Install CHP with a Boiler/Furnace System

The Wave 1 respondent provided the following information about their actions:

The respondent installed a new CHP system.

The CHP prime mover is a reciprocating engine.

The waste heat from the system is used for hot water and an absorption chiller.

The respondent uses 90 percent of their waste heat.

In order to complete the analysis, the parameter values shown below in Figure 72 were assumed, based on a review of projects in the California Public Utilities Commission's Self Generation Incentive Program (SGIP) (Itron, Inc. 2009) and typical system characteristics.

Figure 72: CHP Survey – Summary of Analysis Parameters and Assumptions

Variable	Description	Value	Source
kW_{gen}	Electrical Capacity (kW)	600	A 600 kW reciprocating engine (size not specified by respondent), based on the average reciprocating engine capacity in SGIP.(Itron, Inc. 2009) **Note: As a result of this assumption, the actual system (and savings) might reasonably be as small as half of the estimated size to as large as 10 times that estimated size.**
HeatToElec	Heat to Electric Ratio	1.43	The ratio assumed for this analysis is implied from the typical system efficiencies listed below.
Eff_{gen}	Electrical System Efficiency	35%	Average for reciprocating engines in SGIP. (Itron, Inc. 2009)
$Eff_{heat+gen}$	Total System Efficiency (available electrical and thermal energy)	85%	Typical for reciprocating engine system of this size.
$Percent_{AC}$ $Percent_{HW}$	Distribution of End-Use Applications for Waste Heat	45%	Because the respondent did not specify how much of their waste heat goes to water heating versus an absorption chiller, it was assumed that 45% of their waste heat (half of utilized waste heat) goes to each application.
COP_{AC}	Coefficient of Performance (COP)	0.7	For a typical single-effect, CHP driven absorption chiller.
COP_{EC}	Coefficient of Performance (COP)	5	For a typical electric chiller. Assumes that the respondent would have otherwise removed the heat using an electric chiller.
EFLH	Equivalent Full Load Annual Hours of Operation (hours)	1752	This assumes a capacity factor of 0.2, which is the average observed for natural gas fired reciprocating engine CHP systems in California as part of SGIP in 2008 (Itron, Inc. 2009).
kWhToTherms	Conversion Factor	0.0341	Unit conversion.

With the information provided by the respondent and the assumptions listed above in Figure 72, the savings estimates were calculated using the following approaches:

Electricity Savings:

$$kWh_{gen} = kW_{gen} * EFLH$$

$$kWh_{AC} = \left(kWh_{gen} * HeatToElec * Percent_{AC}\right) * \left(\frac{COP_{AC}}{COP_{EC}}\right)$$

$$kWh_{total} = kWh_{gen} + kWh_{AC}$$

Demand Savings:

$$kW_{AC} = \left(kWh_{gen} * HeatToElec\right) * \left(\frac{COP_{AC}}{COP_{EC}}\right)$$

$$kW_{total} = kW_{gen} + kW_{AC}$$

Natural Gas Savings:

$$therms_{HW} = kWh_{gen} * HeatToElec * Percent_{HW} * kWhToTherms$$

$$therms_{gas} = \left(\frac{kWh_{gen}}{\eta_{gen}}\right) * kWhToTherms$$

$$therms_{total} = therms_{HW} - therms_{gas}$$

Where

kWh_{gen} is the annual electrical energy (kWh) generated by the CHP system.

kW_{gen} is the electrical capacity (kW) of the CHP system, as discussed above.

EFLH is the equivalent full load annual hours of operation (hours), as discussed above.

kWh_{AC} is the electric chiller annual electrical energy offset by the absorption chiller.

HeatToElec is the ratio of useful thermal energy to electrical energy generated by the CHP system, as discussed above.

$Percent_{AC}$ is the percentage of useful CHP waste heat utilized by the absorption chiller.

COP_{AC} is the coefficient of performance of the absorption chiller, as discussed above.

COP_{EC} is the coefficient of performance of the electric chiller, as discussed above.

kWh_{total} is the total reduction in annual electrical energy purchase by the site as a result of self generation and electric chiller load offsets.

kW_{AC} is the electric chiller coincident peak demand offset by the absorption chiller. It is assumed that all heat recovered during coincident peak periods is used by the absorption chiller.

kW_{total} is the total reduction in coincident peak power purchased by the site as a result of self generation and electric chiller load offsets. It is assumed that the peak offsets from the CHP system are 100 percent coincident with the peak demand of the grid.

$therms_{HW}$ is the annual thermal energy for hot water that is offset by CHP waste heat.

$Percent_{HW}$ is the percent of useful CHP waste heat that is used for hot water.

kWhToTherms is a conversion factor to convert energy from units of kWh to units of therms.

$therms_{gas}$ is the annual natural gas (therms) consumed by the CHP system.

Eff_{gen} is the electrical efficiency of the CHP system.

$therms_{total}$ is the net reduction in natural gas consumption at the site, i.e. the natural gas offsets from heat recovery less the natural gas consumed by the CHP system. This is a negative number.

Install CHP with an HVAC System

For Wave 1, only one respondent – the same one who installed the CHP with boiler/furnace system – reported taking this action. However, it was assumed that only a single CHP system was installed by this respondent. All savings were accounted for in the first measure.

Arrange Chillers in Parallel

For Wave 1, only one respondent – the same one who installed the CHP with boiler/furnace system – reported taking this action. However, it was assumed that only a single CHP system was installed by this respondent. All savings were accounted for in the first measure.

F.4 Compressed Air

This section describes the gross savings methodology for the Compressed Air survey. All eight of the Wave 1 respondents for whom Summit Blue received responses reported quantifiable energy saving actions. From Wave 1, quantifiable energy savings were identified for seven of the eight actions specified in the survey. Multiple actions specified in Wave 1 were broken out and analyzed independently in Wave 2.

Twelve of the 17 respondents in Wave 2 reported quantifiable energy saving actions. From Wave 2, quantifiable energy savings were identified for 14 of the 22 actions specified in the survey.

Figure 73: Measures in the Compressed Air Survey

Measure	Measure Presence		Number of respondents with quantifiable savings	
	Wave 1	Wave 2	Wave 1	Wave 2
Replaced existing compressors with more efficient units	X	X	4	1
Installed additional compressors	X	X	1	0
Installed or replaced VFDs	X	X	1	1
Installed or replaced auxiliary equipment	X	X	3	3
Made changes to design of existing compressed air system • Changed location of compressor • Reconfigured piping	X	X	4	0
Made changes to operation of existing compressed air systems • Reduced overall system run time • Eliminated or reduce unnecessary uses • Replaced end use equipment with equipment that operates at lower pressure • Replaced end use equipment with equipment that uses another energy source • Sequenced compressors • Adjusted compressor staging • Changed use of existing storage capacity • Installed individual or multiple compressor controls	X	X	4	9
Made changes to compressed air system repair and maintenance practices • Performed preventive maintenance on compressors • Performed preventive maintenance on components • Changed air filters or upgraded filters • Fixed system leaks	X	X	7	11
Installed or replaced other components	X	X	0	0
Installed new heat recovery equipment		X	0	0
Changed source of air from indoor to outdoor		X	0	0
Other changes to the operation of the system		X	0	0

lists the measures specified in the survey and the number of respondents for which quantifiable energy savings were identified.

Figure 73: Measures in the Compressed Air Survey

Measure	Measure Presence		Number of respondents with quantifiable savings	
	Wave 1	Wave 2	Wave 1	Wave 2
Replaced existing compressors with more efficient units	X	X	4	1
Installed additional compressors	X	X	1	0
Installed or replaced VFDs	X	X	1	1
Installed or replaced auxiliary equipment	X	X	3	3
Made changes to design of existing compressed air system • Changed location of compressor • Reconfigured piping	X	X	4	0
Made changes to operation of existing compressed air systems • Reduced overall system run time • Eliminated or reduce unnecessary uses • Replaced end use equipment with equipment that operates at lower pressure • Replaced end use equipment with equipment that uses another energy source • Sequenced compressors • Adjusted compressor staging • Changed use of existing storage capacity • Installed individual or multiple compressor controls	X	X	4	9
Made changes to compressed air system repair and maintenance practices • Performed preventive maintenance on compressors • Performed preventive maintenance on components • Changed air filters or upgraded filters • Fixed system leaks	X	X	7	11
Installed or replaced other components	X	X	0	0
Installed new heat recovery equipment		X	0	0
Changed source of air from indoor to outdoor		X	0	0
Other changes to the operation of the system		X	0	0

Engineering calculations were used to estimate energy and demand savings. For each respondent and measure, the base annual energy consumption for the original system configuration were calculated; then depending on the measure type, the same equations were used to calculate the new system configuration's energy consumption (which is subtracted from the base consumption to obtain savings) or a percentage reduction was applied to the base consumption.

The equation used to calculate pre- and post-measure annual energy (kWh) consumption was:

$$kWh = Number\_of\_Units * HP * Conversion_{HPtoKW} * Hours * Loading * \frac{1}{\eta}$$

Where:

kWh is the annual energy consumption of the measure

Number_of_Units is the number of units affected by the measure, as reported by the respondent.

HP is the average horsepower of the units replaced, as reported by the respondent.

$Conversion_{HPtoKW}$ is the conversion factor for converting horsepower to kilowatts (0.745)

Hours is the annual runtime hours of the units, as reported by the respondent.

Loading is the motor loading factor, i.e., the percentage of total operating hours that the units run on full load (assumed to be 0.68 (Green Motors Practices Group 2008)).

η is the efficiency of the units, based on the horsepower and age of the compressor as reported by the respondent (Figure 74).

Figure 74: Assumptions Used for Unknown Efficiencies

HP	Pre-EPAct Efficiency (Old NEMA) (original compressors manufactured before 1997)	EPAct Efficiency (original compressors manufactured in 1997 or later)	NEMA Efficiency (new compressors)
1	78.1%	80.1%	81.7%
1.5	81.3%	83.8%	85.8%
2	82.6%	84.7%	86.7%
3	84.2%	86.3%	87.7%
5	85.8%	87.2%	88.8%
7.5	87.2%	88.7%	90.3%
10	88.1%	89.5%	91.0%
15	89.1%	90.4%	91.7%
20	89.9%	90.6%	92.0%
25	90.7%	91.6%	92.8%
30	91.0%	91.8%	93.0%
40	91.6%	92.6%	93.5%
50	91.7%	92.8%	93.9%
60	92.5%	93.4%	94.4%
75	93.0%	93.6%	94.4%
100	93.3%	93.9%	94.8%
125	93.3%	94.2%	95.0%
150	93.8%	94.6%	95.3%
200	94.1%	94.8%	95.6%

Source: Consortium for Energy Efficiency (CEE) *Premium Efficiency Motors Initiative Efficiency Specifications*, (CEE 2009).

The demand savings were estimated similarly, by calculating the difference between the peak demand of the original compressor(s) and the peak demand of the more efficient compressor(s). The following equation was used to estimate coincident peak demand:

$$kW = Number\_of\_Units * HP * Conversion_{HPtoKW} * Loading * \frac{1}{\eta} * Coincidence$$

Where:

kW is the system coincident peak kW demand from the compressor system.

Number_of_Units, *HP*, $Conversion_{HPtoKW}$, *Loading*, and η are the same as in the *kWh* equation above.

Coincidence is peak coincidence factor, which was assumed to be 75 percent[86]

[86] Based on the average coincidence factor for industrial equipment in LBNL's report, *Electricity Use in California: Past Trends and Present Usage Patterns* (Brown and Koomey 2002).

Replaced Existing Compressors with More Efficient Units

In Wave 1, four respondents reported replacing existing compressors with more efficient units. Savings were calculated by using the equations for annual energy consumption and peak demand for both the original compressor system configuration and for the new compressor system and calculating the difference to obtain the energy and demand savings. The efficiency of the original system was assumed to be either the pre-EPAct standard or the EPAct standard, depending on the reported age of the system (see 2nd and 3rd columns in Figure 74).

In Wave 2, savings were calculated for one respondent, using the savings equations stated above.

Installed Additional Compressors

In Wave 1, five respondents reported installing additional compressors; however, two of these respondents appeared to be duplicating the same specifications listed in the previous replacement measure, and two respondents did not provide enough details to quantify savings, so savings were calculated for only one respondent. Savings were calculated similarly to the previous measure, except that the baseline efficiency was assumed to be the EPAct standard (3rd column in Figure 74).

In Wave 2, there were no respondents with quantifiable savings for this measure.

Installed or Replaced VFDs

In Wave 1, one respondent reported installing a VFD on a compressor system. Energy savings from this maintenance were estimated to be 10 percent of total energy consumption of the original system (calculated using the equation for energy consumption specified at the beginning of the Compressed Air section).[87] Demand savings were similarly estimated to be 10 percent of the compressor system's peak demand.

In Wave 2, three respondents reported installing a VFD on a compressor system. Two of these respondents did not provide enough details to calculate savings, so savings were calculated for one respondent using the savings equations stated above.

Installed or Replaced Auxiliary Equipment

In Wave 1, three respondents reported installing or replacing auxiliary equipment. Based on DOE's Motor Challenge Program assumptions (DOE 2001), the savings from these measures were assumed to be 5 percent of the existing system (calculated using the equation for energy consumption specified at the beginning of the Compressed Air section). Demand savings were similarly estimated to be 5 percent of the compressor system's peak demand. For this measure, the *post-measure* energy and peak demand consumption were calculated by using the equations specified at the beginning of the Compressed Air section, and the

---

[87] ACEEE's Online Guide to Energy-Efficient Commercial Equipment (ACEEE 2004) states that premium lubrication can result in 3-20 percent energy savings in motors. However, because the respondent simply stated that they greased bearings and did not specify whether they used premium lubrication, a conservative estimate of 1 percent savings was used.

pre-measure energy and demand consumption were determined by assuming a 5 percent savings from pre-measure to post-measure.

In Wave 2, savings were calculated for three respondents, using the savings equations stated above and applying a percentage savings. Air storage receivers were estimated to provide 5 percent savings based on a range of 3 percent to 7 percent. [88] Coolers were estimated to provide 7 percent savings based on an inlet temperature decrease from 30°C to 10°C.[89] Condensate separators and dryers were conservatively estimated to provide 1 percent savings each.

Made Changes to Design of Existing Compressed Air System

In Wave 1, four respondents reported making changes to the design of existing compressed air system; all four reported reconfiguring piping and two additionally reported changing the location of the compressor. Based on DOE's Motor Challenge Program assumptions, the savings from these system design changes were assumed to be 5 percent of the total energy consumption of the original system. For this measure, the post-measure energy and peak demand consumption were calculated by using the equations specified at the beginning of the Compressed Air section, and the pre-measure energy and demand consumption were determined by assuming a 5 percent savings from pre-measure to post-measure.

In Wave 2, six respondents reported changing the design of a compressed air system. Since no detail was given regarding the nature of the changes, no savings were justified in Wave 2.

Made Changes to Operation of Existing Compressed Air Systems

In Wave 1, there are five sub-measures under the umbrella of operational changes to existing compressed air systems: reducing overall system run time, replacing end use equipment with equipment that operates at lower pressure, sequencing compressors, changing use of existing storage capacity, and installing individual or multiple compressor controls. Only four respondents reported implementing at least one of these changes to system operations; two respondents reported multiple changes to system operations. To be conservative and avoid overestimating savings when respondents made multiple changes, only the largest savings value from this group of operations measures was used in the final savings estimates.

In Wave 2, each sub-measure was surveyed and evaluated as an independent action rather than under the umbrella of operational changes. Additional measures were added including: reducing overall system pressure, eliminating or reducing unnecessary uses, replacing end use equipment with equipment that uses another energy source, and adjusting compressor staging.

[88] DOE Motor Challenge Program, DOE Improving Performance

[89] Krarti, "Energy Audit of Building Systems." p.318

Reduced Overall System Run Time

In Wave 1, one respondent reported reducing the overall run time of the compressed air system. Savings were calculated by first using the base energy consumption calculations, and then scaling the baseline consumption by the ratio of new run time hours to old run time hours.

In Wave 2, six respondents reported reducing system run time. Four of these respondents did not provide enough details to calculate savings, so savings were calculated for two respondents using the savings equations stated above.

Other Changes to System Operations

In Wave 1, for the other four system operations changes, the savings were calculated by applying a percentage reduction to the base energy consumption (or base peak demand) as calculated with the equation at the beginning of this section (see Figure 75 for the specific percentages used for each measure).

Figure 75. Energy and Demand Savings from Changes to Operation of Existing Systems

Measure	# of Respondents with Quantifiable Savings		% Savings (kWh and kW)	Source
	Wave 1	Wave 2		
Replaced end use equipment with equipment that operates at lower pressure	1	4	1% per 2 psi reduction	(PG&E 1997)
Sequenced compressors	1	3	5%	DOE Motor Challenge Program(DOE 2001)
Changed use of existing storage capacity	2	1	5%	
Installed individual or multiple compressor controls	1	0	4% for individual; 12.5% for multiple	
Adjusted compressor staging	N/A	1	5%	

In Wave 2 for the other eight system operations changes, savings were calculated using engineering equations for pressure and flow reductions, and savings were calculated using a percent savings for all other actions. The percentage savings from Wave 1 actions were applied where applicable. For changes to system pressure, the percent savings is calculated as the percent change of the natural log of pressure ratio:[90]

$$\%savings = \ln(pressure\ ratio\ new)/\ln(pressure\ ratio\ old)$$

[90] Krarti, "Energy Audit of Building Systems." page 319

Made Changes to Compressed Air System Repair and Maintenance Practices

For Wave 1 and Wave 2, there are four measures under the umbrella of changes to system repair and maintenance practices: preventive maintenance on compressors, preventive maintenance on components, changing or upgrading air filters, and fixing system leaks. For Wave 1, seven out of the eight respondents reported doing at least one of the repair and maintenance measures, and five of those respondents reported doing two or more of these measures. To be conservative and avoid overestimating savings, only the largest savings value from this group of repair and maintenance measures was used in the final savings estimates.

For these measures, the post-measure energy and peak demand consumption were calculated by using the equations specified at the beginning of the Compressed Air section, and the pre-measure energy and demand consumption were determined by assuming the percentage savings stated in Figure 76.

Figure 76. Energy and Demand Savings from Changes to Repair and Maintenance Practices

Measure	# of Respondents with Quantifiable Savings		% Savings * (kWh and kW)
	Wave 1	Wave 2	
Performed preventive maintenance on compressors	6	9	3.5%
Performed preventive maintenance on components	3	6	5%
Changed air filters or upgraded filters	2	9	2%
Fixed system leaks	5	10	5% for minor leaks; 10% for moderate leaks; 15% for significant leaks

*Source: DOE Motor Challenge Program (DOE 2001)

F.5 Controls/Energy Management Systems (EMS)

This section describes the gross savings methodology for the Controls/EMS survey. 11 of the 14 Wave 1 respondents for whom Summit Blue received responses reported quantifiable energy saving actions, as did 12 of the 17 Wave 2 respondents for whom Summit Blue received responses for. From Wave 1, quantifiable energy savings were identified for 19 of the 48 actions specified in the survey. For Wave 2, actions were grouped in to seven broader measures; quantifiable energy savings were identified for six of these seven measures. Figure 77 lists the measures specified in the survey and the number of respondents for which quantifiable energy savings were identified.

Figure 77: Measures in the Controls/EMS Survey

Measure	Measure Presence		Number of respondents with quantifiable savings	
	Wave 1	Wave 2	Wave 1	Wave 2
Install heating/cooling time clock	X		0	0
Install heating and cooling reset controls (based on outside air, return air, or zone demand)	X		0	0
Replace thermostat with a thermostat having an adjustable proportional band or dead band	X		4	0
Install a chilled water valve and cold deck sensor/controller	X		2	0
Convert to variable-primary-flow chilled water system from a primary-secondary system	X		0	0
Install variable air volume (VAV) fan controls on constant-volume system	X		1	0
Install outdoor air control (i.e. outside air damper and economizer)	X		2	0
Install ultra low leakage dampers	X		1	0
Install air handling unit high efficiency air filtration	X		2	0
Install a Static Adjustment from Volume (SAV) flow control calibrated using INCITe	X		0	0
Cool centrifugal and absorption chillers with water rather than air by separating condenser water loops	X		0	0
Use centrifugal chillers instead of other types of chillers when the setpoint is 65°F or lower	X		0	0
Use auxiliary cooling for high cooling load area such as a hospital operating room	X		0	0
Switch from running multiple chillers at part-load to a primary/secondary pumping scheme	X		0	0
Stop supplying heating and cooling simultaneously	X		0	0
Provide only the heating or cooling actually needed	X		3	0

Measure	Measure Presence		Number of respondents with quantifiable savings	
	Wave 1	Wave 2	Wave 1	Wave 2
Supply cooling and heating from the most efficient source	X		0	0
Modulate the mixed air temp warmer in winter, cooler in summer, based on return air temp or zone averaging	X		0	0
Increase thermostats' proportional band	X		1	0
Adjust thermostat set points	X		3	0
Optimize outdoor air control	X		5	0
Adjust existing heating and cooling reset controls	X		4	0
Block out heating to internal zones	X		0	0
Resheave the fan	X		0	0
Reduce fan energy consumption by using tight ducts	X		0	0
Make changes to the pressure balance of the HVAC system	X		3	0
Decrease entering condenser water temp	X		2	0
Increase chilled water supply temp	X		0	0
Use PCL Operating sequences	X		0	0
Separate the heating/cooling dampers and install new dampers plus controls so they operate independently	X		2	0
Installed lighting management system that included occupancy sensors, daylighting controls, and lighting time clocks	X		2	0
Installed occupancy sensors	X		0	0
Installed daylighting controls	X		0	0
Installed lighting time clock	X		0	0
Updated lighting management system	X		0	0
Installed or modified controls to a lighting system		X	0	4
Turned off lights in empty rooms, and lighting systems after employees leave for the evening	X		0	0
ALL CHP MEASURES QUANTIFIED HERE: Use a parallel chiller arrangement for optimal absorption chiller loading to fully utilize waste heat recovery	X		0	0
Use combined heat and power with a boiler/furnace system	X		0	0
Use combined heat and power with an HVAC system	X		0	0
Install a new EMS system	X		2	0
Update an Energy Management System (EMS or EMCS)	X		0	0
Installed or modified a new or replacement EMS		X	0	2
Made changes to air-side equipment and controls on HVAC		X	0	4

Measure	Measure Presence		Number of respondents with quantifiable savings	
	Wave 1	Wave 2	Wave 1	Wave 2
Made changes to water-side equipment and controls on HVAC		X	0	1
Made changes to system-wide controls on HVAC		X	0	1
Use a Discharge Air Regulation Technique (DART)	X		0	0
Run equipment only when needed	X		3	0
Conduct a walk-through/Screening Analysis Audit	X		0	0
Use software in order to find problem areas within the building	X		0	0
Use high performance Zero-Energy Home designs	X		0	0
Reduce peak loads for air conditioning, forced air ducts, water heating, major appliances, and lighting	X		0	0
Other	X		3	0
No technical knowledge		X	0	4

Quantified Measures

For all measures, savings were estimated by applying a measure-specific percent savings (determined from DEER (Itron, Inc. 2009)(Itron, Inc. 2006)) to the baseline energy consumption assumed for each respondent (determined from CEUS (Itron, Inc. 2006)). Energy savings for this module were computed from the following equations:

$$kWh = SquareFootage * PercentAffected * EndUseIntensity_{electric} * PercentSavings_{measure}$$

$$kW = kWh * EnergyToDemand$$

$$therms = SquareFootage * PercentAffected * EndUseIntensity_{NG} * PercentSavings_{measure}$$

Where:

kWh is the annual electric energy savings

SquareFootage is the average building size, which was assumed from the EIA Commercial Building Energy Consumption Survey (CBECS) (EIA 2004)).

PercentAffected is the percent of conditioned floor area affected by the measure, which was obtained from survey response if available or otherwise assumed to be 50 percent.

$EndUseIntensity_{electric}$ is the baseline annual electric load intensity (kWh/square foot), for the end-uses affected by the measure. These values were obtained from CEUS.

PercentSavings$_{measure}$ is the measure-specific percent energy savings from baseline consumption. Secondary sources were used to determine these percentages; the values and sources are stated in Figure 78.

kW is the coincident peak demand savings

EnergyToDemand is the ratio of demand savings to energy savings (kW/kWh) for specific end-uses and climate zones; these ratios were derived from DEER measures.

therms is the annual natural gas savings

EndUseIntensity$_{NG}$ is the baseline annual natural load intensity (kWh/square foot), for the end-uses affected by the measure. These values were obtained from CEUS.

Figure 78 lists the 19 quantifiable measures, their affected loads, and the source of the percentage savings estimate.

Figure 78: Controls/EMS Module – Summary of Quantified Measures

Quantified Measures	Wave	Affected End-Use Loads	Source
Replace thermostat with a thermostat having an adjustable proportional band or dead band	1	HVAC	25% of DEER 2005 Measure D03-073 (Install Programmable Thermostat)
Install a chilled water valve and cold deck sensor/controller	1	Whole-Building	DEER 2005 Measure D03-046: Replace 3-way valves in CHW loop with 2-way
Install VAV fan controls on constant-volume system	1	HVAC	DEER 2005 Measure D03-050: VAV box retrofit on constant volume system
Install outdoor air control (i.e. outside air damper and economizer)	1	Whole-Building	DEER 2005 Measures D03-058 (Packaged system Economizer retrofit) and D03-059 (Central HVAC system Economizer retrofit)
Install ultra low leakage dampers	1	HVAC	estimate
Install air handling unit high efficiency air filtration	1	HVAC	Matela (2007)
Provide only the heating or cooling actually needed	1	HVAC	DEER 2005 Measure D03-073: Install programmable thermostats in older buildings
Increase thermostats' proportional band	1	HVAC	5% of DEER 2005 Measure D03-073: Install programmable thermostats in older buildings
Adjust thermostat set points	1	HVAC	Matthews (n.d.) and eQUEST
Optimize outdoor air control	1	HVAC	DEER 2005 Measure D03-055: Base ventilation rate 25% higher than required

Quantified Measures	Wave	Affected End-Use Loads	Source
Adjust existing heating and cooling reset controls	1	HVAC	DEER 2005 Measures D03-044 (Chilled Water Loop temperature control) and D03-045 (Hot Water Loop temperature control)
Make changes to the pressure balance of the HVAC system	1	HVAC	Based on the Testing, Adjusting and Balancing (TAB) procedure in the Energy Star Building Manual (EPA 2008)
Decrease entering condenser water temp	1	HVAC	Webster (2003) page 9
Increase chilled water supply temp	1	Whole-Building	DEER 2005 Measure D03-044 (Chilled Water Loop temperature control)
Separate the heating/cooling dampers and install new dampers plus controls so they operate independently	1	HVAC	Liu and Claridge (1999)
Installed lighting management system that included occupancy sensors, daylighting controls, and lighting time clocks[91]	1	Lighting	DEER 2005 Measure D03-005: Add daylighting controls to side-lit space w/ cont. ctrl
Installed or modified controls to a lighting system	2	Lighting	[Same approaches as Wave 1 lighting controls measures]
Install a new EMS system	1	HVAC	DEER 2005 Measure D03-072: Suite of EMS measures
Installed or modified a new or replacement EMS	2	HVAC	DEER 2005 Measure D03-072: Suite of EMS measures
Made changes to air-side equipment and controls on HVAC	2	HVAC	DEER 2005: D03-044, D03-045, D03-050, D03-051, D03-060, D03-071
Made changes to water-side equipment and controls on HVAC	2	HVAC	DEER 2005 Measure D03-044 (Chilled Water Loop temperature control)
Made changes to system-wide controls on HVAC	2	HVAC	DEER 2005 Measure D03-073: Install programmable thermostats in older buildings
Run equipment only when needed	1	Whole-Building	DEER 2005 Measure D03-011: Plug Loads reduced by 5%
Other	1	HVAC	Watson (2005), 10% of DEER 2005 Measure D03-072 (Suite of EMS measures)

[91] Because the other lighting measures mentioned in the Controls module are within the scope of this measure, all lighting measures were quantified in this measure to avoid double-counting savings. It was assumed that the DEER daylighting measure was an accurate proxy for this suite of measures. Adding savings from each of the measures would lead to significant double-counting.

Quantified Measures	Wave	Affected End-Use Loads	Source
No technical knowledge	2		

The savings estimates in this section are particularly rough for the following reasons:

Uncertainty in savings estimates from controls measures is large, as actual savings depend in large part on the applicability of a measure and the specifics of the implementation.

Building size information was not collected in the first wave of this survey; significant additional uncertainty in savings estimates is due to this omission.

Many of the measures reported here have some overlap; effort was taken to discount savings for particular measures to avoid double counting, but this still adds another level of uncertainty.

In light of these caveats, the savings reported in this analysis should be viewed as a *rough* estimate of the *maximum* reasonable impacts for each measure, with actual impacts likely being somewhat less.

Combined heat and power measures were included in the Wave 1 Controls/EMS survey. These measures were removed from this analysis and analyzed separately because the measures implemented by the respondents were not consistent with the intent of the module.

If a respondent reported implementing measures at more than one facility, 25 percent of the savings estimated for their primary facility were assumed to have been achieved at each additional facility.

Measures Not Quantified

Savings methodologies were not developed for 29 of the 48 Wave 1 measures in the Controls/EMS module. Figure 79 lists these measures and the reasons for not developing savings methodologies.

Figure 79: Controls/EMS Module – Summary of Measures Not Quantified

Not Quantified Measures	Reason for Not Quantifying
Install heating/cooling time clock	No respondents
Install heating and cooling reset controls	No respondents
Convert to variable-primary-flow chilled water system from a primary-secondary system	No respondents
Install a Static Adjustment from Volume (SAV) flow control calibrated using INCITe	No respondents
Cool centrifugal and absorption chillers with water rather than air by separating condenser water loops	No respondents
Use centrifugal chillers instead of other types of chillers when the setpoint is	No respondents

Not Quantified Measures	Reason for Not Quantifying
65°F or lower	
Use auxiliary cooling for high cooling load area such as a hospital operating room	No savings
Switch from running multiple chillers at part-load to a primary/secondary pumping scheme	No respondents
Stop supplying heating and cooling simultaneously	No respondents
Supply cooling and heating from the most efficient source	Savings captured in other measure(s)
Modulate the mixed air temp warmer in winter, cooler in summer, based on return air temp or zone averaging	Savings captured in other measure(s)
Block out heating to internal zones	Insufficient information from respondent(s)
Resheave the fan	No respondents
Reduce fan energy consumption by using tight ducts	No respondents
Use PCL Operating sequences	No respondents
Installed occupancy sensors	Savings captured in other measure(s)
Installed daylighting controls	Savings captured in other measure(s)
Installed lighting time clock	Savings captured in other measure(s)
Updated lighting management system	Savings captured in other measure(s)
Turned off lights in empty rooms, and lighting systems after employees leave for the evening	Savings captured in other measure(s)
Use a parallel chiller arrangement for optimal absorption chiller loading to fully utilize waste heat recovery	Analyzed as a separate CHP module
Use combined heat and power with a boiler/furnace system.	Analyzed as a separate CHP module
Use combined heat and power with an HVAC system.	Analyzed as a separate CHP module
Update an Energy Management System (EMS or EMCS)	No respondents
Use a Discharge Air Regulation Technique (DART)	No respondents
Conduct a walk-through/Screening Analysis Audit	No respondents
Use software in order to find problem areas within the building	Insufficient information from respondent(s)
Use high performance Zero-Energy Home designs	No respondents
Reduce peak loads for air conditioning, forced air ducts, water heating, major appliances, and lighting	No respondents

F.6 Cooking, Food Service, and Refrigeration

This section describes the gross savings methodology for the Cooking, Food Service, and Refrigeration survey. Seven of the nine Wave 1 respondents for whom Summit Blue received responses reported quantifiable energy saving actions. From Wave 1, quantifiable energy savings were identified for 22 of the 25 actions specified in the survey.

Of 37 Wave 2 respondents for whom Summit Blue received responses, six reported quantifiable energy saving actions. All six were assigned savings based on measure details given. From Wave 2, quantifiable energy savings were identified for 19 of the 28 unique actions specified in the survey.

Figure 80 lists the measures specified in the Wave 1 and 2 surveys and the number of respondents for which quantifiable energy savings were identified.

Figure 80: Measures in the Compressed Air Survey

Measure	Measure Presence		Number of respondents with quantifiable savings	
	Wave 1	Wave 2	Wave 1	Wave 2
Installed fryer(s)	X	X	1	1
Installed warming and holding cabinet(s)	X	X	1	1
Installed steamer(s)	X	X	1	2
Installed griddle(s)	X		1	0
Installed broiler(s)	X		1	0
Installed oven(s)	X	X	3	3
Installed new ventilation equipment	X		1	0
Installed new refrigeration equipment	X		4	0
Installed new water elements	X		3	0
Made changes to existing cooking equipment	X		0	0
Made changes or installed components to existing ventilation systems	X		2	0
Made changes or installed components to existing display refrigerators	X		1	0
Install display refrigerators		X	0	1
Made changes or installed components to existing refrigerated storerooms/walk-ins	X		2	0
Installed refrigerated storerooms/walk-ins		X	0	0
Made changes or installed components to existing refrigerated cabinets	X		1	0
Installed refrigerated cabinets		X	0	0
Made changes or installed components to existing ice machines	X		1	0
Installed ice machines		X	0	0

Measure	Measure Presence		Number of respondents with quantifiable savings	
	Wave 1	Wave 2	Wave 1	Wave 2
Made changes or installed components to existing prep tables	X		1	0
Installed new high efficiency compressor		X	0	1
Installed new components to the compressor		X	0	1
Made changes or installed components to existing hot water heater	X		2	0
Installed high efficiency water heater		X		2
Made changes or installed components to existing ware washer	X		0	0
Installed low flow energy efficient ware washers		X	0	0
Installed vending machines		X	0	1
Moved placement of appliances		X	0	0
Moved back kitchen equipment		X	0	0
Installed hood side panels		X	0	1
Made other changes		X	0	1
Made changes to the operations, repair, and maintenance of cooking equipment	X	X	0	0
Made changes to the operations, repair, and maintenance of ventilation equipment	X		4	0
Made changes to the operations, repair, and maintenance of display refrigerators	X		2	0
Made changes to the operations, repair, and maintenance of refrigerated storerooms/walk-ins	X		1	0
Made changes to the operations, repair, and maintenance of refrigerated cabinets	X		2	0
Made changes to the operations, repair, and maintenance of ice machines	X		2	0
Made changes to the operations, repair, and maintenance of prep tables	X		1	0
Undefined (Made changes to the operations, repair, and maintenance of existing cooking, ventilation, refrigeration, or water equipment)		X	0	1
Turned off exhaust hood when kitchen closed		X	0	1
Fully load dish rack		X	0	1
Turn off dish machine when kitchen closed		X	0	0
Fix all leaks, damaged racks, was curtains		X	0	1
Clean ware washer fixtures		X	0	1
Made other changes to operation of ware washer		X	0	0
Made other operational changes to existing hot water heater		X	0	0
Made changes to the operation of refrigerated cabinets		X	0	1
No technical knowledge		X	0	0

Where available, savings were calculated using the EPA's ENERGY STAR savings calculator worksheets (EPA 2009) or Pacific Gas and Electric's Food Services Technology Center (FSTC 2009), or taken from unit savings values given in the 2008 and 2004-2005 updates of the Database of Energy Efficiency Resources (Itron, Inc. 2009)(Itron, Inc. 2006). Preference was given to the 2008 updated values; where DEER 2008 did not cover the measures of interest, DEER 2005 values were used. Where energy savings calculators and DEER measures were not applicable, baseline energy consumption and percent savings values were sourced from secondary literature review to determine overall savings.

In Wave 1, savings were not quantified for the following three measures:

Made changes to existing cooking equipment – One respondent reported taking this action, but the responses suggested that some of these actions were covered under the ice machine operations measure; the rest of the responses for the measure did not suggest quantifiable savings.

Made changes or installed components to existing ware washer – No respondents reported taking this action.

Made changes to the operations, repair, and maintenance of cooking equipment - No savings assigned for any of the four respondents who reported taking this measure because their open-ended answers either referred to installation of new equipment (covered in other measures) or to an unrelated improvement (lighting system).

In Wave 2, any measure which a respondent reported implementing but for which they did not provide sufficient data to analyze, the measure is coded as such with an action code. Figure 81 provides the list of action codes uses in this particular survey.

Figure 81: Action Codes used in Wave 2 Commercial Kitchen Survey

Action Code	Action Code Description
1	reported, savings quantified
2	no measure reported
3	reported, savings computed in another measure
4	reported, only propane savings
5	reported, insufficient information
6	reported, market actor
7	reported, no action yet taken
8	reported, did not result in savings
10	savings outside the scope of this module

The following subsections describe the savings estimate approach for each of the actions identified by respondents with quantifiable savings. Please note that not all measure heading match the specific measure name in each survey, as the unique measures varied slightly between Wave 1 and 2. Instead, refer to the introductory text immediately following the heading to determine which measures are encompassed.

Installed New Cooking Equipment

Savings for installing new, energy-efficient cooking equipment were calculated using savings calculators from Energy Star (fryers, warming and holding cabinets, steamers) or the Food Services Technology Center (griddles, broilers, ovens). In Wave 1, one respondent reported taking action in five of these areas, another in two, and a third respondent for one.

For electric equipment, peak demand savings were determined by applying an energy/peak factor (W peak demand savings/ kWh energy savings) of 0.228 derived from DEER 2005 (using the average for all electric cooking measures) to the energy savings taken from the savings calculators.

- The exception was warming and holding cabinets: The Energy Star calculator was used to provide peak demand values which were used to calculate coincident demand savings.
- Gross peak demand savings values were converted to coincident peak demand using an assumed coincidence factor of 0.9, the value used in DEER 2005 for cooking measures.
- In cases where the new equipment used a different fuel than the old, savings were given as the entire consumption of the old unit, with the addition of negative savings of the entire consumption of the new unit.[92]

Installed New Ventilation Equipment

Savings for upgrading HVAC equipment were quantified for one Wave 1 respondent using DEER 2008. The other four Wave 1 respondents who reported taking action on this section reported taking similar actions under other measures, and were therefore assigned zero savings for this measure to avoid double-counting.

Installed New Refrigeration Equipment

Four Wave 1 respondents and two Wave 2 respondent installed new, efficient refrigeration equipment. Energy savings values were taken from a literature review, and coincident peak demand savings were derived from these values using a demand/energy ratio (W peak demand savings/ kWh energy savings) of 0.11[93] and a coincidence factor of 0.9. [94]

---

[92] For example, upgrading from a gas oven to an efficient electric oven would result in large gas savings and a smaller, *negative* electric savings.

[93] The demand/energy ratio was calculated as the ratio of average peak demand (W) savings to average energy (kWh) savings for all DEER 2005 grocery refrigeration measures.

Savings for efficient display refrigerators were assumed to be the average savings reported in the US DOE's *Commercial Refrigeration Equipment Technical Support Document* (DOE n.d.).[95]

Savings for efficient walk-in refrigerators were assumed to be 31.5 percent of a baseline consumption of 16,200 kWh/yr (NRCAN 2009).

Savings for refrigerated cabinets and reach-in refrigerators were determined from the *Energy Star Commercial Refrigerators Calculator* (EPA 2009).

Savings for an efficient ice machine were assumed to be 561 kWh (baseline of 5,925 kWh) based on the Energy Star Ice Machine calculator, assuming a self contained unit (EPA 2009).

Savings for refrigerated prep tables were assumed to be 55 percent of a baseline of 2,658 kWh/yr.[96]

One Wave 2 respondent installed a new refrigerator. DEER 2008 and survey responses were used to estimate the savings for this respondent.

Installed New Water Elements

Three Wave 1 and 2 Wave 2 respondents reported installing new ware washers or water heaters. Energy savings values were taken from DEER 2008, 2005 and the *Energy Star Commercial Dishwasher Savings Calculator*, and coincident peak demand savings were derived from these values using a peak (W)/energy (kWh) ratio of 0.22 and a coincidence factor of 0.9.[97]

Savings for efficient ware washers were calculated with the *Energy Star Commercial Dishwasher Savings Calculator*, normalized by racks washed per day: 280 racks per day were assumed, unless .[98]

For Wave 1, savings for efficient water heaters were taken from DEER 2005, assuming that all instantaneous water heaters were gas-fired. For Wave 2, savings for efficient water heaters were taken from DEER 2008.

---

[94] The coincidence factor was an engineering judgment based on load shapes for refrigeration electricity use in restaurants from the California Commercial End-Use Survey (CEUS) (Itron, Inc. 2006); peak load falls around 2 PM, but demand from 4-6 PM is no more than 3 percent less than the total.

[95] Table D.3.8.

[96] Baseline - Average of eight models tested by the Food Service Technology Center (Zabrowski, Cowen and Miner 2003)

Savings - Energy Star Restaurants Guide (EPA 2007),

[97] Demand/energy ratio was derived from residential water heater savings values in DEER 2005; these values for commercial water heaters were not available.

To determine the coincidence factor, it was assumed that water heating loads parallel cooking loads, thus it is appropriate to apply the same coincidence factor as for cooking measures.

[98] Savings for the two different models of ware washer specified varied significantly due to size differences. Therefore, we assumed that the total dish load would remain constant and used the assumed number of racks per day for the larger unit. Source: Energy Star Commercial Dishwasher Savings Calculator (EPA 2009).

Installed New Vending Machines

One Wave 2 respondents reported installing 4 new efficient vending machines. Survey responses were used in the Energy Star Vending Machine calculator to estimate annual energy savings.[99]

Made Changes to Existing Cooking Equipment

One Wave 1 respondent reported making changes in this area; however, no savings were assigned to either of the two actions reported. The first action, "thermal energy storage" was assumed to be accounted for in another measure ("making off-peak ice"). For the second measure, "moving equipment back to maximize exhaust hood overhang and reduce rear gaps", not enough information was provided to quantify savings.

Made Changes or Installed Components to Existing Ventilation Equipment

Two Wave 1 respondents and one Wave 2 respondent reported actions with quantifiable savings through installing efficient supply fan motors or installing ventilation hood components; two more Wave 1 respondents did not provide enough information to quantify savings.

Savings from efficient supply fan motors were taken from DEER 2005, using assumed motor capacity of 43 hp.[100]

Savings from installing an engineered proximity hood or additional venting hoods were assumed to be 25 percent of baseline end-use consumption, based on an SCE *Design Guide*.[101] Coincident peak demand savings were found by scaling gross peak savings by a coincidence factor of 0.9, the value used in DEER 2005 for these types of measures.

Made Changes or Installed Components to Existing Refrigeration Equipment, including Prep Tables

Two Wave 1 respondents reported installing components to existing refrigeration equipment. One Wave 2 respondent reported installing components to existing prep tables. Energy savings values were taken from several secondary sources. Coincident peak demand

[99] Energy Star Vending Machine Savings Calculator, found at: http://www.energystar.gov/index.cfm?c=vending_machines.pr_vending_machines

[100] The assumed supply fan motor horsepower is the eQuest default for a 50,000 square foot mid-rise office building – the respondent specified building size and type.

[101] Savings: conservatively assumed to be half of the 54% reduction reported for an optimized system with engineered proximity hood and canopy hood, as an example in: "Design Guide 1: Improving Commercial Kitchen Ventilation System Performance", (Food Service Technology Center 2004) pages A-5 and B-5,

Baseline: Derived from estimates of the total square feet served, total energy use and peak demand of ventilation equipment in: "Makeup Air Effects on Commercial Kitchen Exhaust System Performance", (Brohard, et al. 2002).

savings were derived from these values using a peak (W)/energy (kWh) ratio of 0.11 and a coincidence factor of 0.9.[102]

The upgrades to a display refrigerator reported (new compressor, condenser, condenser fan and motor, evaporator fan and motor, and insulation) were assumed to amount to the same savings as installing a new, efficient display refrigerator. Savings were assumed to be 50 percent of baseline end-use consumption for a beverage merchandiser from a DOE's *Energy Savings Potential for Commercial Refrigeration Equipment*.[103]

The upgrades to a walk-in refrigerator reported by one respondent (new compressor, condenser, condenser fan, evaporator fan motor) were assumed to amount to 80 percent of the savings of installing a new, efficient walk-in refrigerator. Savings were assumed to be 31.5 percent of baseline end-use consumption, based on Natural Resources Canada's *Walk-in Commercial Refrigeration*.[104]

Savings from installing strip curtains on a walk-in refrigerator were taken as the average from a study by Portland Energy Conservation, Inc, assuming 2.5 hr/day with the door open and 365 days per year of operation (Moore 2009).

Savings from adding insulation to a refrigerated cabinet were assumed to be 2.2 percent, based on the US DOE's *Energy Savings Potential for Commercial Refrigeration Equipment* (Arthur D. Little, Inc. 1996).

One Wave 1 respondent reported installing components to an ice machine as well as installing a new complete unit. Savings assigned for installing components were the same as for installing a new ice machine: 20 percent of baseline end-use consumption of 5000 kWh/yr.[105]

Wave 1 savings from improving insulation to an existing prep table were assumed to be 33 percent of the savings of installing a new, energy efficient prep table.[106] Wave 2 savings from installing a new efficient compressor to the existing prep tables were assumed to be 33 percent of the savings of installing a new, energy efficient prep table, and the savings from installing a new glycol system were assumed to be have that.[107]

---

[102] The peak/energy ratio was calculated as the ratio of average demand savings to average energy savings for all DEER 2005 grocery refrigeration measures.

The coincidence factor was an estimate based on load shapes for refrigeration electricity use in restaurants from the California Commercial End-Use Survey (CEUS).

[103] Baseline: *Energy Savings Potential for Commercial Refrigeration Equipment* (Arthur D. Little, Inc. 1996)

Savings: *Energy Star Restaurants Guide* (EPA 2009)

[104] Baseline load and savings percentage taken from Natural Resources Canada, Walk-in Commercial Refrigeration (NRCAN 2009).

[105] Baseline: *Energy Savings Potential for Commercial Refrigeration Equipment* (Arthur D. Little, Inc. 1996)

Savings: *Energy Star Restaurants Guide* (EPA 2007)

[106] estimate, no secondary source found

[107] estimate, no secondary source found

Made Changes or Installed Components to Existing Water Elements

Three respondents reported making changes to existing water heaters or ware washers.

Savings for upgrading hot water heaters were taken from DEER 2008. One Wave 1 respondent and two Wave 2 respondents reported replacing the units entirely, and were assigned savings accordingly. Another Wave 1 respondent reported replacing the hot water pump, which was assumed to result in 5 percent of the savings from upgrading the entire water heater.[108]

One Wave 1 respondent who reported installing components to an existing ware washer gave no information on the action taken, and was assigned no savings.

One Wave 2 respondent reported fully loading the dishwasher. Using energy consumption data from the Energy Star Consumer Dishwasher Calculator, based on survey data inputs and default calculator values, and assuming that the dishwasher loads were reduced by three runs per day (based on survey responses) savings were estimated.[109]

One Wave 2 respondent reported fixing all leaks, damaged racks and wash curtain as well as cleaning their ware washer. Data regarding the operation of this ware washer was put into the Energy Star Consumer Dishwasher Calculator to determine the base line annual energy consumption. A one percent savings value was applied for each of these measures.[110]

Made Changes to the Operations, Repair, and Maintenance of Cooking Equipment

Five Wave 1 respondents reported taking action in this area, but no savings were assigned for any respondents; open-ended answers either referred to installation of new equipment (covered in other measures) or to an unrelated improvement (e.g., lighting system).

Made Changes to the Operations, Repair, and Maintenance of Ventilation Equipment

Five Wave 1 respondents and 1 Wave 2 respondent reported making changes to the O&M of ventilation equipment. Energy savings were taken from a literature review, and peak demand savings were derived from these values using a peak (W)/energy (kWh) ratio of 0.228 and a coincidence factor of 0.9.[111]

---

[108] estimate, no secondary source found

[109] The consumer dishwasher calculator was used for the Wave 2 respondent due to the assumption that a residential-style under the counter dishwasher was the ware washer in this building. Energy Star Consumer Dishwasher Calculator, found at: http://www.energystar.gov/ia/business/bulk_purchasing/bpsavings_calc/CalculatorConsumerDishwasher.xls

[110] estimate, no secondary source found

[111] The peak/energy ratio is the average of the peak/energy ratio for all cooking measures in DEER 2005, and the coincidence factor is the value used for cooking measures in DEER 2005.

Baseline energy consumption for an exhaust hood was assumed to be 75,000 kWh per year, based on 5,760 hours per year of operation and an average flow rate of 8,000 cfm.[112]

Savings from turning off the ventilation hood when kitchen is not in use were calculated by determining the percent reduction in operating hours (from survey responses) and applying that percent savings to the baseline above. No demand savings were assigned for this measure because it was assumed that the kitchen would be open during the 4-6 PM peak period; savings would therefore occur off-peak.

Savings from installing side panels on a ventilation hood were assumed to be 12.5 percent, based on 50 cfm/linear foot reduction from a 400 cfm/linear foot baseline.[113]

Made Changes to the Operations, Repair, and Maintenance of Refrigeration Equipment

Two Wave 1 respondent and one Wave 2 respondent reported taking this action. Savings were taken from DEER 2005 where applicable, or from literature review and engineering judgment. For measures not taken from DEER, demand savings were derived with a peak(W)/energy (kWh) of 0.11 and a coincidence factor of 0.9.[114]

Savings from implementing subcooling and reducing temperature lift were taken from the corresponding DEER 2005 measures.

Peak demand savings from producing ice during off-peak periods was assumed to be half of the total peak demand for the ice maker.[115]

For maintenance measures, a total maximum savings of 10 percent of energy use was assumed.[116]

Cleaning condenser and evaporator coils were each assumed to account for 10 percent of the total maintenance savings.[117]

---

[112] Energy consumption: *Energy Star Restaurants Guide* (EPA 2007)

Operating hours: from *Commercial Kitchen Ventilation Design Guide 2* (Architectural Energy Corporation and Fisher Nickel, Inc. 2002)

Flowrate: based on the examples in *Commercial Kitchen Ventilation Design Guides 1 and 2* (FCSI 2006).

[113] Savings: conservatively assumed half of the maximum reduction in *Commercial Kitchen Ventilation* Food Services Consultants International White Paper (FCSI 2006)

Baseline: conservatively based on an unlisted, wall-mounted canopy hood serving heavy-duty equipment, in *Commercial Kitchen Ventilation Design Guide 1* (Food Service Technology Center 2004)

[114] Energy/peak factor was calculated as the average demand savings/average energy savings for all DEER 2005 grocery refrigeration measures.

The coincidence factor is based on load shapes for refrigeration electricity use in restaurants from the California Commercial End-Use Survey (CEUS).

[115] estimate; the survey provided no information on how much ice was made off-peak.

[116] Based on estimates of up to 50% (Carbon Trust 2009) and 5-10% (Focus on Energy 2009)

[117] estimate, no secondary source found

The total savings from the list of 11 "other" maintenance measures given was assumed to account for 30 percent of the total possible maintenance savings; actual savings assigned were scaled by the number out of 11 that each respondent indicated implementing.[118]

[118] estimate, no secondary source found

F.7 Heating, Ventilation, and Air Conditioning (HVAC)

This section describes the gross savings methodology for the HVAC survey. 60 of the 132 Wave 1 respondents and 70 of the 121 Wave 2 respondents for whom Summit Blue received responses reported quantifiable energy saving actions. From Wave 1, quantifiable energy and demand savings were identified for all 19 of the actions specified in the survey. Quantifiable energy and demand savings were identified for 16 of the 20 actions specified in Wave 2. Figure 82 lists the measures specified in the survey and the number of respondents for which quantifiable energy savings were identified.

Figure 82: Measures in the HVAC Survey

Measure	Measure Presence		Number of respondents with quantifiable savings	
	Wave 1	Wave 2	Wave 1	Wave 2
Replaced Chillers	X	X	5	4
Replaced Packaged Units	X	X	22	9
Replaced Heat Pump	X	X	6	2
Replaced Gas Furnaces	X	X	12	6
Replaced Boilers	X	X	5	4
Installed New Chillers	X	X	5	4
Installed New Packaged Units	X	X	3	0
Installed New Heat Pump	X	X	5	0
Installed New Gas Furnaces	X	X	3	1
Installed New Boilers	X	X	4	1
Replaced Air Handling Components	X		21	0
Replaced Controls/Set Points	X		17	0
Replaced Heating/Cooling Equipment	X		10	0
Installed New Air Handling Components	X	X	2	8
Installed New Controls/Set points	X	X	0	11
Installed New Heating/Cooling equipment	X	X	2	4
Optimized Controls	X	X	19	18
Optimized Air Handling Equipment	X	X	13	12
Optimized Other Parts of HVAC		X	0	0
Made Changes To Maintenance Practices	X	X	20	23
Replaced Fan System		X	0	5
Installed New Fan System		X	0	2
Made Changes to an Existing Fan System		X	0	0

The following general approach to gross impact estimation was used:

Where available, unit savings values given in the Database of Energy Efficiency Resources (DEER) were scaled by quantities given in survey responses to arrive at overall savings figures. Preference was given to the updated DEER 2008 (Itron, Inc.

2009) values when applicable; DEER 2005 (Itron, Inc. 2006) values were used for measures not found in the 2008 update.

Where DEER measures were not applicable, percent savings values sourced from secondary literature review were applied to baseline energy intensities from the CA Commercial End-Use Survey (CEUS) (Itron, Inc. 2006) to determine overall savings.

In order to avoid double counting, zero savings were assigned to all but one measure in a number of cases in which it appeared that a respondent answered questions for multiple measures based on one action.

For cases in which respondents replaced inefficient systems with efficient systems of *greater* capacity, zero savings were assumed.

For cases in which respondents replaced inefficient systems with efficient systems of *less* capacity, gains in efficiency due to running at full load more frequently were not accounted for. The uncertainty of the baseline did not justify this level of precision.

Respondents who did not provide any information about the action taken were assigned average savings realized by the other respondents, scaled by building size.

Where building size information was not available, the median value for survey respondents who did provide this information (10,000 square feet) was used.

The following subsections describe the savings estimate approach for each of the actions reported by respondents.

Replaced (or Installed New) Chillers

10 Wave 1 and eight Wave 2 respondents reported replacing or installing new chillers. In four Wave 1 cases and four Wave 2 cases, the same respondent provided information for both replacing and installing a new chiller; no savings were assigned for installing new chillers in those cases, except for two Wave 2 cases that occurred in new construction. Savings values from DEER 2008 were used, calculated from a customer average baseline for existing chillers and a code minimum baseline for new chillers, with the following assumptions:

Air-cooled screw chillers were assumed for respondents that specified scroll chiller. Efficiencies for scroll chillers range from 0.8 to 1.2 kW/ton:[119] this analysis assumed an efficiency of 1.008 kW/ton.

For absorption chillers, DEER savings values were determined using a (electric) centrifugal chiller as a baseline and thus could not be used. In these cases, gas savings were assumed to be 25 percent of the DEER efficient model baseline gas usage.[120]

---

[119] Based on a review of available models at trade and manufacturer websites (FacilitiesNet 2009) (Carrier 2009) (Trane 2009)

[120] Based on an assumed improvement from COP 0.8 to 1.0 (typical of single-effect and double-effect absorption chillers, respectively) from (New Buildings Institute 1999)

For respondents that did not specify chiller type, a water-cooled screw chiller was assumed, due to the prevalence of that type of system in the relevant size range (24 to 250 tons).

Where no capacity information was provided, respondents were assigned a cooling capacity based on the average tons per square foot computed from those respondents who provided both building size and cooling capacity.

Respondents that specified neither chiller size nor building area were assigned the average savings of all other respondents, scaled by building size.

Replaced (or Installed New) Packaged Units

27 Wave 1 and nine Wave 2 respondents reported replacing or installing new packaged air conditioning units. In twelve cases in Wave 1 and five cases in Wave 2, the same respondent provided information for both replacing and installing new packaged units; no savings were assigned for installing new units in those cases. Savings values from DEER 2008 were used, calculated from a customer average baseline for existing units and a code minimum baseline for new units, with the following assumptions:

If efficiency information was not given, the following efficiencies were assumed, based on Energy Star minimum levels and available DEER options: 13 SEER for <65 kbtuh; 11.5 EER for 65-239 kbtuh; 10.8 EER for 240-759 kbtuh; 10.2 EER for 760+ kbtuh (EPA 2003).

In cases where efficiency information did not match exactly with an entry in DEER 2008, the closest available value was used. This is assumed to be more accurate than using DEER 2005 values, which were significantly revised in the 2008 update.

Replaced (or Installed New) Heat Pumps

12 Wave 1 and two Wave 2 respondents reported replacing or installing new packaged heat pumps. In five cases in Wave 1, the same respondent provided information for both replacing and installing new heat pumps; no savings were assigned for installing new units in those cases. Savings values from DEER 2005 were used (no update was made to these values in the 2008 version): for existing units, the DEER customer average baseline was used and for new units, the code minimum baseline was used. The following assumptions were made:

- For the <65 kbtu/h size range, efficiency was matched to specifications as best as possible, otherwise SEER 13 was assumed for upgrades.
- For the 65-134 kbtu/h size range, standard DEER efficiency of EER 11 was assumed for upgrades: respondent information was either missing or deemed unreliable.
- A 33 percent improvement in efficiency was assumed for the replacement of an air-source heat pump with a ground source heat pump.[121]

[121] Based on an EERE estimate of up to 44% improvement in energy efficiency (DOE 2009)

Replaced (or Installed New) Gas Furnaces

16 Wave 1 and seven Wave 2 respondents reported replacing or installing new gas furnaces. In seven Wave 1 cases and one Wave 2 case, the same respondent provided information for both replacing and installing new gas furnaces; no savings were assigned for installing new units in those cases. Savings values from DEER 2005 were used (no update was made to these values in the 2008 version): for existing units, the DEER customer average baseline was used and for new units, the code minimum baseline was used. The following assumption was made:

> For the efficient case, the DEER 2005 standard 94 percent AFUE was assumed because respondent information on efficiency was incomplete and often incomprehensible.

Replaced (or Installed New) Boilers

Nine Wave 1 and five Wave 2 respondents reported replacing or installing new boilers. In three Wave 1 cases and one Wave 2 case, the same respondent provided information for both replacing and installing new boilers; no savings were assigned for installing new units in those cases. Savings values from DEER 2005 were used (no update was made to these values in the 2008 version): for existing units, the DEER customer average baseline was used and for new units, the code minimum baseline was used. The following assumption was made:

> Assumed DEER 2005 standard 85 percent (large boiler) and 84.5 percent (small boiler) AFUE for the efficient case, because respondent information on efficiency was incomplete and often incomprehensible.

Replaced (or Installed New) Air Handling Components

24 Wave 1 and eight Wave 2 respondents reported replacing or installing new components in an air-handling unit. In seven cases in Wave 1, the same respondent provided information for both replacing and installing new components; no savings were assigned for installing new components in those cases. Replacing air handling equipment was not included as an option in Wave 2. Savings values from DEER 2005 were used (no update was made to these values in the 2008 version): for existing units, the DEER customer average baseline was used and for new units, the code minimum baseline was used. The following assumptions were made:

> In Wave 1, building size was not a specific question for this section; to determine size, answers for other sections by the same respondent were referenced. Where multiple sizes were given by one respondent, judgment was used to decide which to use based on the specified building type.
>
> For duct insulation upgrades, the standard DEER 2005 efficient duct insulation of R-8 was assumed.
>
> - Respondents who specified "installed duct insulation" on new projects received no savings: Title-24 *requires* duct insulation in new buildings.

Respondents who claimed to install efficient motors but did not specify the size of those motors were assigned a size based on the answer of the one respondent who did, scaled by building size.

- Due to the uncertainty introduced by this assumption, savings from installing efficient motors should be viewed as rough estimates

Respondents who specified "installed new VSD" for new projects received no savings: Title-24 has *required* VSDs on new large supply fans since 1992.

For respondents who specified a VAV conversion or adjustment, 50 percent of the DEER savings for VAV conversion were assumed because respondents did not specify whether they implemented a conversion or an adjustment.

Replaced (or Installed New) Controls or Changed Set Points

21 Wave 1 and 11 Wave 2 respondents reported replacing or installing new controls or changing control set points. In five cases in Wave 1, the same respondent provided information for both replacing and installing new controls; no savings were assigned for installing new components in those cases. Replacing controls or changing set points was not included as an option in Wave 2. Savings values from DEER 2005 were used (no update was made to these values in the 2008 version): for existing units, the DEER customer average baseline was used and for new units, the code minimum baseline was used. The following assumptions were made:

In Wave 1, building size was not a specific question for this section; to determine size, answers for other sections by the same respondent were referenced. Where multiple sizes were given by one respondent, judgment was used to decide which to use, based on specified building type.

Where respondents claimed to implement demand control ventilation, the DEER "reduce over-ventilation" measure was used; this measure consists of reducing outdoor air ventilation to Title-24 minimum levels from 25 percent excess.[122]

Where respondents claimed to install an energy management system (EMS) or a heating/cooling time clock, corresponding DEER measures were used, with standard assumptions based on building type and vintage.

- For both of these measures, no savings were assigned if the respondent claimed to install an EMS or time clock in a new building; Title-24 requires these measures in new construction.
- Two respondents gave open-ended responses related to thermostat setpoints; these respondents were assigned the savings from the DEER programmable thermostat measure.

[122] This is in agreement with studies cited within the "Advanced VAV Design Guide" (Hyderman, et al. 2003)

Replaced (or Installed New) Heating or Cooling Equipment

20 Wave 1 and four Wave 2 respondents reported replacing or installing new heating or cooling equipment. In five cases in Wave 1, the same respondent provided information for both replacing and installing new equipment; no savings were assigned for installing new equipment in those cases. Replacing heating or cooling equipment was not included as an option in Wave 2. Savings values from DEER 2005 were used (no update was made to these values in the 2008 version): for existing units, the DEER customer average baseline was used and for new units, the code minimum baseline was used. The following assumptions were made:

In Wave 1, building size was not a specific question for this section; to determine size, answers for other sections by the same respondent were referenced. Where multiple sizes were given by one respondent, judgment was used to decide which to use based on specified building type.

In Wave 1, cooling capacity was not a specific question for this section; to determine capacity, answers for other sections by the same respondent were referenced. Where multiple systems were described by the same respondent, capacity was summed.

- Where no previous capacity information was available, respondents were assigned cooling capacity based on a tons-per-square-foot average computed over those respondents who provided both building size and cooling capacity.

Savings from a direct evaporative cooler were assumed to be 30 percent greater than for an indirect cooler, based on average saturation effectiveness of 0.85 for direct and 0.65 for indirect (Foster 1998).

For respondents that specified a retrofit of reheat coils, it was assumed that the reheat coils were upgraded to a fan-powered mixing box.

Where respondents specified installing a heat recovery system, an air-to-air heat exchanger was assumed.

Optimized Controls

23 Wave 1 and 18 Wave 2 respondents reported making changes to optimize the control of HVAC systems. Depending on the specifics of the action taken, savings were calculated using DEER 2005 or by applying a savings percentage from a literature review to baseline energy consumption and peak demand data from CEUS:

Changes in thermostat set points were assumed to result in 1 percent energy and demand savings per degree change in set point (Matthews n.d.) and 0.2 percent savings per hour per week reduction in overall system run time.[123] Baseline end-use intensities for heating and cooling were obtained from CEUS; demand savings were taken as a percentage of CEUS cooling demand only because the statewide peak occurs in the summer.

[123] Based on representative eQuest building simulation model runs for a small office in climate zone 6.

- Where specific information was not available, a 2°F change in heating and cooling set points was assumed, as was a five hours per week reduction in operating hours.

Maximum savings from installing occupancy sensors were assumed to be half of the 25 percent reduction in outdoor air used in the DEER over-ventilation measure.[124] The information provided by the respondents was too sparse to conduct a more thorough analysis.

Optimization of VAV terminal boxes was assumed to result in savings of 4 percent of electricity and 14 percent of gas used for heating and cooling.[125]

For respondents who reported optimizing economizer controls or changing heating and cooling delivery set point temperatures, savings were determined from DEER 2005.

Where peak demand savings were calculated using a percent savings approach, demand savings were scaled by a coincidence factor of 0.85 to produce coincident peak savings.[126]

In Wave 1, building size was not a specific question for this section; to determine size, answers for other sections by the same respondent were referenced. Where multiple sizes were given by one respondent, judgment was used to decide which to use, based on the specified building type.

In Wave 1, cooling capacity was not a specific question for this section; to determine capacity, answers from other sections by the same respondent were used. Where multiple systems were described by the same respondent, capacity was summed.

- Where no previous capacity information was available, respondents were assigned cooling capacity based on the tons-per-square-foot average computed over those respondents who provided both building size and cooling capacity.

Optimized Air Handling Equipment

18 Wave 1 and 12 Wave 2 respondents reported making changes to optimize the functioning of air handling systems. Depending on the specifics of the action taken, savings were calculated using DEER 2005 or by applying a savings percentage from a literature review to baseline energy consumption and peak demand data from CEUS:

For respondents who specified duct leak reduction, savings were taken from the duct sealing measure from DEER 2008, assuming the low reduction.

For respondents who specified installing duct insulation, optimizing economizer function and heat recovery system optimization, savings were taken from DEER 2005.

---

[124] This is based on the assumption that most of the savings from installing occupancy sensors are due to the reduced need to condition outdoor air when spaces are unoccupied.

[125] This is half of the reported savings for switching from "single maximum" to "double maximum" control in a PG&E report for a CEC Title 24 2008 workshop (Stein and Hydeman 2006)

[126] Estimate, based on high coincidence of HVAC use with CA summer peak.

- For heat recovery system optimization, 5 percent of the savings from DEER 2005 for installing an air-to-air heat recovery system were assumed.[127]

Savings for pressure balancing the air-handling system were assumed to be 3 percent of the total heating and cooling energy use from CEUS.[128]

Savings from optimizing air filters were assumed to be 5 percent of the total heating and cooling energy from CEUS.[129]

Where peak demand savings were calculated using a percent savings approach, demand savings were scaled by a coincidence factor of 0.85 to produce coincident peak savings.[130]

In Wave 1, building size was not a specific question for this section; to determine size, answers for other sections by the same respondent were referenced. Where multiple sizes were given by one respondent, judgment was used to decide which to use, based on specified building type.

In Wave 1, cooling capacity was not a specific question for this section; to determine capacity, answers from other sections by the same respondent were used. Where multiple systems were described by the same respondent, capacity was summed.

- Where no previous capacity information was available, respondents were assigned cooling capacity based on a tons-per-square-foot average computed over those respondents who provided both building size and cooling capacity.

Made Changes to Maintenance Practices

43 Wave 1 and 23 Wave 2 respondents reported making changes to the maintenance of HVAC systems. The maximum possible savings from baseline energy consumption was assumed to be 15 percent,[131] applied to the heating and cooling energy use determined in CEUS.

Each maintenance change action was given a weighting factor, based on relative importance in optimizing overall system maintenance.[132] Respondents were assigned points for each action which was reported to be done more frequently after the course than before. Total savings were then calculated by scaling the 15 percent total by the ratio of assigned maintenance change points to total possible points. Figure 83 states the points assigned to each possible action.

---

[127] Conservative estimate, based on stated efficiency of 60 to 75 percent range depending on installation, type of media, and air velocity. Assumed optimization could capture 1/5th of this gap. From *CRC Handbook of Energy Efficiency* (Kreith and West 1997)

[128] Conservative estimate based on claimed savings potential of up to 10 percent for an entire system Testing, Adjusting and Balancing (TAB) procedure in the *Energy Star Building Manual* (EPA 2008):

[129] *Choosing the Right Air Filter and Filter Media* (Matela 2007)

[130] Estimate, based on high coincidence of HVAC use with CA summer peak.

[131] 15% is a conservative estimate based on an article in Building Operating Management (Piper 2009).

[132] Estimate, no secondary source found.

Figure 83: HVAC Maintenance Change Points

Action	Priority	Points
Adjust bypass dampers	Medium	2
Clean or replace the filters	High	3
Check fan blades for tightness	Medium	2
Lubricate fan motor	Low	1
Adjust operating pressures	High	3
Evaluate vent system	Medium	2
Clean blower wheel	Low	1
Inspect valves	Medium	2
Tighten electrical connections	Low	1
Evaluate safety controls	Low	1
Measure temperature difference	High	3
Adjust thermostat calibration	High	3
Check start and run capacitors	Low	1
Check start and run delays	Medium	2
Measure voltage differences	Low	1
Measure amperage draw	Low	1
Test fan limit switch	Low	1
Test thermocouple	Medium	2
Max Maintenance Change Points		32

Demand savings were scaled by a coincidence factor of 0.85 to determine coincident peak savings.[133]

Replaced (or Installed New) Fan Systems

Seven Wave 2 respondents reported replacing or installing new fan systems. In one case, the same respondent provided information for both replacing and installing new equipment; based on the survey responses, it was determined that the respondent should be assigned savings for both actions. This measure was not included in the Wave 1 HVAC survey. Savings values from DEER 2005 were used (no update was made to these values in the 2008 version): for existing units, the DEER customer average baseline was used and for new units, the code minimum baseline was used. The following assumptions were made:

133 Estimate, based on high coincidence of HVAC use with CA summer peak.

All respondents reported that the fans were used for building cooling. The analysis assumes that all of the fans replaced or installed by respondents were HVAC supply fans and the savings resulted from increasing the fan motor efficiency.

Respondents were asked to provide the total number of fans, the old number of fans, and the new number of fans installed. The analysis used the total number of fans as the primary input, except for the respondent that both replaced and installed fans—in this case, the old number of fans was used to determine savings from replacements and the difference between the new and old number of fans was used to determine savings from newly installed fans.

Savings were calculated on a per horsepower basis. Respondents provided information about their fan motor horsepower as a size range. Savings were calculated using the average of the horsepower range reported by respondents. If the horsepower size range reported for the old fans was different from the range for the new fans, savings were assigned using information provided for the old fans. If no information was provided, respondents were assigned the average of the horsepower reported by other respondents.

If the respondent reported changing the old fans from constant speed to variable speed, and this change was not captured elsewhere in the analysis, the respondent was also assigned savings for installing variable frequency drives on a per horsepower basis.

Made Changes to an Existing Fan System

- Two Wave 2 respondents reported replacing or installing new heating or cooling equipment. The open-ended responses provided by the respondents did not indicate quantifiable energy savings. No savings were assigned for this measure. This measure was not a part of the Wave 1 HVAC survey.

F.8 Lighting

This section describes the gross savings methodology for the Lighting survey. All 62 of the Wave 1 respondents and 114 of the 183 Wave 2 respondents for whom Summit Blue received responses reported quantifiable energy saving actions. From Wave 1, quantifiable energy savings were identified for nine of the ten actions specified in the survey. For Wave 2, the survey was modified and updated to include 14 actions and energy savings were identified for all of these actions. Figure 84 lists the measures specified in the Wave 1 and 2 surveys and the number of respondents for which quantifiable energy savings were identified.

Figure 84: Measures in the Lighting Survey

Measure	Measure Presence		Number of respondents with quantifiable savings	
	Wave 1	Wave 2	Wave 1	Wave 2
Install, replace, or remove linear fluorescent lights at a commercial site	X	X	19	23
Install, replace, or remove exit signs at a commercial site	X	X	18	13
Install, replace, or remove high bay lighting at a commercial site	X	X	6	7
Install, replace, or remove CFLs at a commercial site	X	X	20	18
Change other type of lighting		X	0	1
Install occupancy sensors and/or daylighting controls at a commercial site	X		22	0
Install lighting controls: occupancy sensors, dual technology occupancy sensors, daylighting, or combination of controls		X	0	31
Install other lighting controls		X	0	2
Reduce hours of operation at a commercial site	X	X	12	4
Change the time of day of lighting equipment use		X	0	1
Make other changes to the operation of lighting equipment		X	0	1
Change lighting repair and maintenance practices at a commercial site	X	X	0	6
Replace incandescent lamps with CFLs at a residential site	X	X	25	51
Replace hard-wired fixtures with CFL fixtures at a residential site	X	X	14	8
Reduce hours of operation at a residential site	X	X	20	36
No tech	X	X	0	18

Savings were not calculated for the measure "Changed lighting repair and maintenance practices" for Wave 1 due to redundancy (savings were captured under other measures) or insufficient data provided. However, savings were calculated for six respondents in Wave 2. Controls measures in Wave 2 were consolidated into the measure “Install lighting controls: occupancy sensors, dual technology occupancy sensors, daylighting, or combination of controls” to eliminate redundant savings. Additionally in Wave 2, several savings reported by respondents for “Reduce hours of operation at a commercial site” and “Change the time of day lighting equipment is in use” were omitted due to redundant savings captured by other measures.

The primary source of savings values was DEER (Itron, Inc. 2009). These savings estimates were adjusted by reported hours of operation, building size, HVAC interactions, and other details provided by respondents. The California Commercial End-Use Survey (Itron, Inc. 2009) was also utilized to quantify savings.

The following subsections describe the savings estimate approach for each of the actions reported by respondents.

Commercial Lighting - Upgraded, Installed, or Removed Lighting

Savings were determined for three commercial lighting measures. These measures included changes made to linear fluorescents, exit signs, and high bay commercial lighting.

For Wave 1, savings were estimated for 19 respondents who upgraded, installed, or delamped linear fluorescent lighting; 18 respondents who upgraded, installed, or delamped exit signs; 6 respondents who upgraded, installed, or delamped high bay lighting; and 20 respondents who switched from incandescent lighting to CFLs.

For Wave 2, savings were estimated for 23 respondents who upgraded, installed, or delamped linear fluorescent lighting; 13 respondents who upgraded, installed, or delamped exit signs; 7 respondents who upgrade, installed, or delamped high bay lighting; and 18 respondents who switched from incandescent lighting to CFLs. Wave 2 also includes a measure for “Changed other type of light” for which savings were estimated for 1 respondent. It was determined from survey responses that this respondent switched incandescent lighting to CFLs. Savings for this respondent were estimated similarly to other respondents who switched lighting from incandescent to CFLs.

For Wave 1, the same methodology was used for each lighting type. For Wave 2, DEER 2008 savings per fixture for linear fluorescents, exit signs, and CFLs were applied to respondent-specific information. For high bays, survey responses (e.g., quantity and type of lights, operation characteristics) were used to determine savings.

Figure 85 displays the data requirements, sources, and treatment of missing or irregular data for this analysis.

Figure 85: Data Requirements for Commercial Lighting Upgrade/Install/Delamp Measure

Data Requirements	Source	Treatment of Missing/Irregular Data
Original Lamp Type	Survey	If missing, assume most common type from other responses
Current Lamp Type	Survey	

Data Requirements	Source	Treatment of Missing/Irregular Data
Original Ballast Type	Survey	match to closest available DEER measure; if missing, assume most common type from other responses
Current Ballast Type	Survey	
Original Lamp Length	Survey	if missing, assume most common type from other responses
Current Lamp Length	Survey	
Original Watts per Lamp	Survey	use average/median of other responses (whichever results in more conservative savings estimate)
Current Watts per Lamp	Survey	
Original Number of Lamps per Fixture	Survey	if missing, use average/median of other responses (whichever results in more conservative savings estimate); For exit signs, if no response, assume 1, cap at 2
Current Number of Lamps per Fixture	Survey	
Annual Hours of Operation	Survey/DEER assumptions by building type	if missing, use average of other responses;
Commercial Sector (Building Type)	Survey	
Energy Savings (kWh per fixture, therms per fixture)	DEER (based on all of the above factors); For high bays, calculated from survey data	Calculated using survey data when DEER data not available (for linear fluorescents)
Demand Savings (kW per fixture)	DEER (based on all of the above factors) ; For high bays, calculated from survey data	Calculated when DEER data not available (for linear fluorescents)
Original Number of Fixtures	Survey	For linear fluorescents and CFLs, if no response, CEUS watts/square foot data to calculate quantity of fixtures(Itron, Inc., 2006); For exit signs, if no response, DEER data for building type
Current Number of Fixtures	Survey	
HVAC Interaction Factor (kWh/kWh, therms/kWh, and kW/kW)	LBNL(Sezgen & Koomey, 1998); Engineering judgement (adjustments made based on HVAC systems)	If HVAC system information not known, assume interaction factors for gas heating and central AC
Coincidence Factor	Report(RLW Analytics, 2007)	

The annual energy savings (for both kWh and therms[134]) were calculated using the following equation for linear fluorescents and CFLs:

$$Savings = DEER\_Savings \; * Fixtures * \frac{Hours}{DEER\_Hours} * HVAC\_Interaction$$

[134] Note that the gas savings (measured in therms) are actually negative savings due to the HVAC interaction (higher efficiency lighting emits less heat and thus increases the building's heating needs).

Where:

- *Savings* is the estimated annual energy savings (same equation for positive kWh and negative therm savings);
- *DEER_Savings* is the DEER deemed savings (both kWh and therms) based on the survey responses on lamp type, ballast type, lamp length, watts per lamp, and number of lamps per fixture for both the original configuration and the new, efficient configuration;
- *Fixtures* is the number of fixtures, which was obtained from the survey;
- *Hours* is the reported annual hours of operation;
- *DEER_Hours* is the DEER annual hours of operation; and
- *HVAC_Interaction* is the HVAC interaction factor. Interaction factors were derived from ratios of whole building to end-use savings for similar measures in DEER. The interaction factors were adjusted if HVAC systems were different than the assumed HVAC system of gas heat and central AC.

For peak demand savings for linear fluorescents and CFLs, DEER peak demand savings per fixture were multiplied by the number of fixtures and adjusted interaction factors.

For exit signs, the DEER assumed hours of operation were applied to determine savings. As a result the kWh, kW, and therm savings were all determined by multiplying the savings per fixture by the number of fixtures (while omitting the hour adjustment term). DEER savings per fixture are whole building savings assuming gas heat and central AC. If a respondent indicated an HVAC system other than that assumed by DEER the final savings values were adjusted to account for the different interaction factor.

For high bays and where DEER savings values were not available for a particular lighting type, the following equations were used to calculate energy savings. For kWh savings:

$$Savings = \frac{Watts_{pre} - Watts_{post}}{1000} * Hours * HVAC\_Interaction$$

Where:

- *Savings* is the estimated annual energy savings (same equation for positive kWh and negative therm savings);
- $Watts_{pre}$ is the product of the lamp wattage, the number of fixtures, and the number of lamps per fixtures for the original lighting configuration as reported in the survey;
- $Watts_{post}$ is the product of the lamp wattage, the number of fixtures, and the number of lamps per fixtures for the new, more efficient lighting configuration as reported in the survey;
- *Hours* is the reported annual hours of operation; and
- *HVAC_Interaction* is the HVAC interaction factor. Interaction factors were derived from ratios of whole building to end-use savings for similar measures in DEER. The

interaction factors were adjusted if HVAC systems were different than the assumed HVAC system of gas heat and central AC.

For kW, or peak demand, savings:

$$Savings = \frac{Watts_{pre} - Watts_{post}}{1000} * HVAC\_Interaction * Coincidence$$

Where:

- *Savings* is the estimated peak demand savings, in kW;
- $Watts_{pre}$ is the product of the lamp wattage, the number of fixtures, and the number of lamps per fixtures for the original lighting configuration as reported in the survey;
- $Watts_{post}$ is the product of the lamp wattage, the number of fixtures, and the number of lamps per fixtures for the new, more efficient lighting configuration as reported in the survey;
- *HVAC_Interaction* is the HVAC interaction factor. Interaction factors were derived from ratios of whole building to end-use savings for similar measures in DEER. The interaction factors were adjusted if HVAC systems were different than the DEER assumed HVAC system of gas heat and central AC; and
- *Coincidence* is the coincidence factor.[135]

For therm savings:

$$Savings = kWh\_Savings_{End-use} * HVAC\_Interaction$$

Where:

- *Savings* is the estimated savings, in therms (which results in negative savings);
- $kWh\_Savings_{End-use}$ is the electrical savings resulting from the lighting change; and
- *HVAC_Interaction* is the HVAC interaction factor (in this case a ratio of negative therms to kWh saved). Interaction factors were derived from ratios of whole building to end-use savings for similar measures in DEER. The therms interaction factor was adjusted if the heating system was anything other than gas heating (e.g., gas heating supplemented by solar heating).

Commercial Lighting - Installed Lighting Controls

For Wave 1, savings were estimated for 22 respondents who reported installing lighting controls. For Wave 2, savings were estimated for 33 respondents. The Wave 2 analysis was revised to identify five different measures of lighting control savings (the first four were later combined to eliminate redundant savings). Figure 86 summarizes the data requirements, sources, and treatment of missing and irregular data for this analysis.

[135] Coincidence factors were determined from the RLW Analytics report (RLW Analytics 2007) referenced previously.

Figure 86: Data Requirements for Commercial Lighting Controls Analysis

Data Requirements	Source	Treatment of Missing/Irregular Data
Lighting Control Type	Survey	If control type is not fully specified, assume occupancy sensors: on/off
Number of Controls	Survey	
Number of Fixtures Controlled	Survey	If missing, but number of controls is provided, assume one fixture per control; else use average of other responses
Wattage of Controlled Fixtures	Survey	For missing, use common/standard wattages associated with type of light controlled (i.e., 32W for T8s)
Annual Hours of Operation	Survey	For missing, use DEER assumptions by building type
Percentage of Time Occupied	Survey	Note: not used in this analysis - DEER assumptions used instead because self-reported percentages were suspect.
Building size	Survey	For missing, use average of other respondents or DEER size assumptions
Commercial Sector (Building Type)	Survey	
Energy Savings from Daylighting Controls/Photo Sensors (kWh per kW controlled, therms per kW controlled)	DEER 2005 (based on control type, sector, climate zone)	
Energy Savings from Occupancy Sensors (kWh per kW controlled, therms per kW controlled)	DEER 2005 (based on control type, sector, climate zone)	
Demand Savings from Daylighting Controls/Photo Sensors (peak W per kW controlled)	DEER 2005 (based on control type, sector, climate zone)	
Demand Savings from Occupancy Sensors (peak W per kW controlled)	DEER 2005 (based on control type, sector, climate zone)	
HVAC Interaction Factor (kWh/kWh, therms/kWh, and kW/kW)	LBNL (Sezgen and Koomey 1998); Engineering judgement (adjustments made based on HVAC systems)	If HVAC system information not known, assume interaction factors for gas heating and central AC
Baseline consumption data	CEUS watts/square foot (Itron, Inc., 2006)	

For Wave 2, several lighting control configurations were identified and DEER 2005 data was used to estimate savings. Figure 87 shows the lighting control configurations reported by respondents and how the data from DEER was applied to estimate savings.

Figure 87: Data Requirements for Commercial Lighting Controls Analysis

Controls Configuration	DEER 2005 Data Measure(s) Applied
Daylighting	Daylighting
Dual technology occupancy sensors and daylighting	Daylighting + Daylighting
Occupancy sensors and photo sensors	Daylighting + Occupancy Sensors
Occupancy sensors	Occupancy Sensors

Energy savings for each respondent was determined from DEER 2005 data (as shown above) that was then aggregated as percentages of baseline consumption as determined by CEUS for each building type and building size.

Energy savings (kWh and therms) from lighting controls were calculated using the following equation:

$$Savings = \frac{Savings_{DEER}}{kW_{controlled}} * \frac{Watts}{1000} * Fixtures * \frac{Hours}{DEER\_Hours} * HVAC\_Interaction$$

Where:

Savings is the estimated annual energy savings (same equation for positive kWh and negative therm savings);

$Savings_{DEER}$ is the savings estimate from DEER 2005 based on control type, sector, and climate zone;

$kW_{controlled}$ is the factor that normalizes the DEER 2005 savings to savings per controlled kW;

Watts is the wattage per fixture, obtained from the survey;

Fixtures is the number of fixtures, obtained from the survey;

Hours is the annual hours of operation obtained from the survey;

DEER_Hours is the annual hours of operation assumed in DEER; and

HVAC_Interaction is the HVAC interaction factor. Interaction factors were derived from ratios of whole building to end-use savings for similar measures in DEER. The interaction factors were adjusted if HVAC systems were different than the assumed HVAC system of gas heat and central AC.

Peak demand savings from lighting controls were calculated using the following equation:

$$Savings_{kW} = \frac{Savings_{DEER}}{kW_{controlled}} \frac{Watts}{1000} * Fixtures * HVAC\_Interaction$$

Where:

> $Savings_{kW}$ is the coincident peak demand savings (kW);
>
> $Savings_{DEER}$ is the savings estimate from DEER 2005 based on control type, sector, and climate zone;
>
> $kW_{controlled}$ is the factor that normalizes the DEER 2005 savings to savings per controlled kW;
>
> *Watts* is the fixture wattage, obtained from the survey;
>
> *Fixtures* is the number of fixtures controlled, obtained from the survey; and
>
> *HVAC_Interaction* is the HVAC interaction factor. Interaction factors were derived from ratios of whole building to end-use savings for similar measures in DEER. The interaction factors were adjusted if HVAC systems were different than the assumed HVAC system of gas heat and central AC.

The savings for each measure were then found as a percentage of the baseline whole building consumption. Baseline whole building consumption data was calculated using information from CEUS (Itron, Inc., 2006). All of the savings percentages were then multiplied together to find the aggregate percentage savings. Finally, the aggregate percentage savings were multiplied by the baseline whole building consumption data to determine the total savings for each respondent.

Wave 2 also included the measure “Install other lighting controls” for which savings were calculated for two respondents. The first respondent indicated that a timer had been installed. Savings per fixture from DEER 2005 for timeclock controls was applied. The same approach to determine savings as described for the respondents who installed controls also applied. The second respondent indicated that a single lighting system was divided into two points of control so that half of a building’s lights could be turned off for a portion of the day. Savings were determined from survey information (number of fixtures, wattages, operating characteristics, etc.).

Commercial Lighting - Changed Lighting Repair and Maintenance Practices

For Wave 1, savings were not calculated for respondents who reported changes in lighting repair and maintenance practices because these savings were redundant (i.e., captured in other measures’ savings calculations) or because the respondent did not provide enough details on improved practices to calculate savings. For Wave 2, savings were not calculated for the majority of respondents because of similar redundant savings or missing information. However, for Wave 2, six of the 33 respondents reporting did have quantifiable savings. Savings were generally calculated from information provided in open ended responses to survey questions. DEER savings estimates, CEUS building characteristics, and LBNL derived interactions were used to supplement savings calculations. Savings calculation approaches similar to those used for other measures were applied to determine these savings, when appropriate. Finally, some respondents also claimed operating cost savings and energy consumption reductions. Information on electricity prices from DOE's Energy Information Administration(DOE, Average Retail Price of Electricity to Ultimate Customers: Total by End-Use Sector, 2009) was applied to convert cost savings to energy savings.

Commercial Lighting - Changed Lighting System Operations

For Wave 1, savings were calculated for 12 respondents who indicated that they changed their lighting system operations by reducing the number of hours of use. Wave 2 expanded this measure to include "Change the time of day of lighting equipment use" and "Make other changes to the operation of lighting equipment." Savings were calculated for 6 respondents in Wave 2. Savings for several respondents were omitted from these measures because these respondents also claimed savings due to lighting control measures. It is assumed that any lighting system operation changes are a result of control changes. Therefore, those respondents were not included in these measures to eliminate redundant savings. Figure 88 summarizes the data requirements, sources, and treatment of missing and irregular data for this analysis.

Figure 88: Data Requirements for Commercial Lighting System Operation Change Analysis

Data Requirements	Source	Treatment of Missing/Irregular Data
Number of Fixtures Affected	Survey	For missing data, CEUS watts/square foot to calculate number of fixtures
Wattage	Survey	For missing data, use median value of other respondents
Original Annual Hours of Operation	Survey	For missing data, use DEER assumptions by building type
Current Annual Hours of Operation	Survey	For missing data, reduce original hours per year by average percentage reduced for other respondents; if current hours are same as original but said they reduce, assume they reduce by average percentage other respondents reduced
HVAC Interaction Factor (kWh/kWh, therms/kWh, and kW/kW)	LBNL (Sezgen and Koomey 1998) Engineering judgement (adjustments made based on HVAC systems)	If HVAC system information not known, assume interaction factors for gas heating and central AC
Reduction in lighting load during peak demand period	Survey	Engineering judgment: assume lighting load reduced by 25 percent
Coincidence Factor	RLW Analytics (2007)	

Electricity savings were calculated using the following formula:

$$Savings_{kWh} = \frac{Watts}{1000} * Fixtures * \left(Hours_{pre} - Hours_{post}\right) * HVAC\_Interaction$$

Where

- $Savings_{kWh}$ is the annual energy (kWh) savings
- *Watts* is the wattage per fixture, obtained from the survey
- *Fixtures* is the number of fixtures, obtained from the survey
- $Hours_{pre}$ is original annual hours of operation, obtained from the survey
- $Hours_{post}$ is new, reduced annual hours of operation, obtained from the survey
- *HVAC_Interaction* is the HVAC interaction factor, determined from an LBNL study (Sezgen and Koomey 1998). Interaction factors were derived from ratios of whole building to end-use savings for similar measures in DEER. The interaction factors were adjusted if HVAC systems were different than the assumed HVAC system of gas heat and central AC.

Gas (therms) savings were calculated as the product of the electricity savings and a therms-per-kWh HVAC interaction factor determined from the same LBNL study.

For the measure “Reduce the hours of operation at a commercial site” it is assumed that there are no peak demand savings. For the measure “Changed the time of day of lighting equipment” it is assumed that there are only peak demand savings. Peak demand savings for this measure are calculated as 25 percent of the total controlled wattage.

A final respondent indicated savings in the measure “Make other changes to the operation of lighting equipment.” It was determined that this respondent applied lighting controls (which were not captured in the controls measures). Savings were calculated with DEER 2005 savings estimates for daylighting controls. The same approach described previously for lighting controls was applied to this measure.

Residential Lighting - Replaced Existing Incandescent Light Bulbs with CFLs

For Wave 1, savings from upgrading from incandescent to CFL light bulbs were calculated for 27 residential respondents out of a total of 29 who reported switching to CFLs (two respondents did not provide enough information to calculate savings). Additionally for Wave 2, savings were calculated for all of the 51 respondents who reported switching to CFLs.

Figure 89 shows the data requirements and their sources for this measure.

Figure 89: Data Requirements for Residential Lighting Incandescent to CFL Analysis

Data Requirements	Source	Treatment of Missing/Irregular Data
CFL Wattage	Survey	if given wattage is 40+ watts, assume they gave incandescent equivalency and convert to CFL wattage, for missing data, use average of other respondents
Number of Lamps	Survey	For missing data, use average of other respondents, cap number of lamps at a ratio of one lamp per 100 square feet
Hours per Year	Survey	For Wave 1, cap hours per day at DEER assumption of 2.18, assume 6.7 days per week, 49 weeks per year (average of other responses) for missing data. For Wave 2, use DEER hours assumption
Home Vintage	Survey	assume pre-1970 because 58% of CA homes were built prior to 1975 (KEMA 2004)
Square Footage of Home	Survey	For Wave 1, for missing data, use average square footage by home vintage from RASS. For Wave 2, not applicable
Energy Savings per Lamp (kWh, therms)	DEER (based on CFL wattage, vintage, climate zone, HVAC system)	
Demand Savings per Lamp (kW)	DEER (based on CFL wattage, vintage, climate zone, HVAC system)	
HVAC Interaction Factor (kWh/kWh, therms/kWh, and kW/kW)	LBNL (Sezgen and Koomey 1998), Engineering judgement (adjustments made based on HVAC systems)	If HVAC system information not known, assume interaction factors for gas heating and central AC

Energy and demand savings were calculated by using DEER savings estimates per bulb and multiplying by the number of installations reported by the respondent. The following equations were used to calculate annual energy savings (kWh) and peak coincident demand savings (kW):

$$Savings_{kWh} = SavingsPerLamp_{kWh} * NumberOfLamps * HVAC\_Interaction$$

$$Savings_{kW} = SavingsPerLamp_{kW} * NumberOfLamps * HVAC\_Interaction$$

Where:

$Savings_{kWh}$ is the annual energy savings (kWh);

$SavingsPerLamp_{kWh}$ is the annual savings (kWh) per lamp, obtained from DEER;

NumberOfLamps is the number of lamps, obtained from the survey;

$Savings_{kW}$ is the coincident peak demand (kW) savings;

$SavingsPerLamp_{kW}$ is coincident peak demand savings (kW) per lamp, obtained from DEER; and

HVAC_Interaction is the HVAC interaction factor, determined from an LBNL study (Sezgen and Koomey 1998). Interaction factors were derived from ratios of whole building to end-use savings for similar measures in DEER. The interaction factors were adjusted if HVAC systems were different than the assumed HVAC system of gas heat and central AC.

The following equation was used to calculate the annual therm savings:

$$Savings = kWh\_Savings * HVAC\_Interaction$$

Where:

- *Savings* is the estimated savings, in therms (which results in negative savings);
- *kWh_Savings* is the electrical savings resulting from the lighting change; and
- *HVAC_Interaction* is the HVAC interaction factor (in this case a ratio of negative therms to kWh saved). Interaction factors were derived from ratios of whole building to end-use savings for similar measures in DEER. The therms interaction factor was adjusted if the heating system was anything other than gas heating (e.g., gas heating supplemented by solar heating).

Residential Lighting - Replaced Existing Hard-Wired Light Fixtures with Compact Fluorescent Fixtures

For Wave 1, 16 respondents reported replacing existing hard-wired light fixtures with compact fluorescent fixtures; savings were quantified for all 16 respondents. For Wave 2, 20 respondents reported action for this measure and savings were quantified for 8 respondents. If respondents reported savings in the previous measure ("Replacing existing incandescent light bulbs with CFLs"), then the savings from this measure and less the previous measure were applied. If savings from this measure were less than the savings from the previous measure then no savings were quantified (assuming all savings were already captured in the first measure). This approach was used to eliminate redundant savings because it was estimated that respondents reported savings for the same action within each of these two measures.

The savings methodology used for this measure is very similar to the previous measure. Figure 90 shows the data requirements and their sources for this measure.

Figure 90: Data Requirements for Residential Lighting Hard-Wired Incandescent to CFL Analysis

Data Requirements	Source	Treatment of Missing/Irregular Data
CFL Wattage	Survey	If given wattage is 40+ watts, assume they gave incandescent equivalency and convert to CFL wattage. for missing data, use average of other respondents
Number of Fixtures	Survey	For missing data, use average of other respondents
Number of Lamps per Fixture	Survey	For missing data, use average of other respondents
Hours per Year	Survey	For missing data, Wave 1, cap hours per day at DEER assumption of 2.18, assume 6.25 days per week, 46 weeks per year (average of other responses). For Wave 2, use DEER hours assumption
Home Vintage	Survey	Assume pre-1970 because 58% of CA homes were built prior to 1975 (KEMA 2004)
Energy Savings per Bulb (kWh, therms)	DEER (based on CFL wattage, vintage, climate zone, HVAC system)	
Demand Savings per Bulb (kW)	DEER (based on CFL wattage, vintage, climate zone, HVAC system)	
HVAC Interaction Factor (kWh/kWh, therms/kWh, and kW/kW)	LBNL (Sezgen and Koomey 1998), Engineering judgement (adjustments made based on HVAC systems)	If HVAC system information not known, assume interaction factors for gas heating and central AC

Energy and demand savings were calculated using DEER savings estimates per bulb and multiplying by the number of installations reported by the respondent. The following equations were used to calculate annual energy savings (kWh) and peak coincident demand savings (kW):

$$Savings_{kWh} = SavingsPerLamp_{kWh} * NumberOfLamps * HVAC\_Interaction$$

$$Savings_{kW} = SavingsPerLamp_{kW} * NumberOfLamps * HVAC\_Interaction$$

Where:

$Savings_{kWh}$ is the annual energy savings (kWh);

$SavingsPerLamp_{kWh}$ is the annual savings (kWh) per lamp, obtained from DEER;

NumberOfLamps is the number of lamps, obtained from the survey;

$Savings_{kW}$ is the coincident peak demand (kW) savings;

SavingsPerLamp$_{kW}$ is coincident peak demand savings (kW) per lamp, obtained from DEER; and

HVAC_Interaction is the HVAC interaction factor, determined from an LBNL study (Sezgen and Koomey 1998). Interaction factors were derived from ratios of whole building to end-use savings for similar measures in DEER. The interaction factors were adjusted if HVAC systems were different than the assumed HVAC system of gas heat and central AC.

The following equation was used to calculate the annual therm savings:

$$Savings = kWh\_Savings * HVAC\_Interaction$$

Where:

- *Savings* is the estimated savings, in therms (which results in negative savings);
- *kWh_Savings* is the electrical savings resulting from the lighting change; and
- *HVAC_Interaction* is the HVAC interaction factor (in this case a ratio of negative therms to kWh saved). Interaction factors were derived from ratios of whole building to end-use savings for similar measures in DEER. The therms interaction factor was adjusted if the heating system was anything other than gas heating (e.g., gas heating supplemented by solar heating).

Residential Lighting - Reduced the Number of Hours Lights Are Used in the Home

For Wave 1, 20 respondents reported reducing the number of hours that they used the lights in their homes. For Wave 2, 41 respondents reported reducing their hours and savings were quantified for 36 respondents. The savings were calculated in a similar manner to the commercial reduced lighting hours measure. Figure 91 shows the data requirements and their sources for this measure.

Figure 91: Data Requirements for Residential Light Operation Hour Reduction Analysis

Data Requirements	Source	Treatment of Missing/Irregular Data
Wattage	Survey	If missing data, average of other responses
Number of Fixtures	Survey	If missing data, do not quantify savings (not enough information to make an assumption)
Annual Reduced Hours	Survey	If missing data, average of other responses
HVAC Interaction Factor (kWh/kWh, therms/kWh)	LBNL (Sezgen and Koomey 1998), Engineering judgement (adjustments made based on HVAC systems)	If HVAC system information not known, assume interaction factors for gas heating and central AC

Energy savings (kWh) were calculated using the following formulas:

$$Savings = \frac{Wattage}{1000} * Fixtures * Annual\_Reduced\_Hours * HVAC\_Interaction$$

Where:

Savings is the annual energy (kWh) savings;

Wattage is fixture wattage;

Fixtures is the number of fixtures;

Annual Reduced Hours is the change in annual hours of operation; and

HVAC Interaction is the HVAC interaction factor, determined from an LBNL study (Sezgen and Koomey 1998). Interaction factors were derived from ratios of whole building to end-use savings for similar measures in DEER. The interaction factors were adjusted if HVAC systems were different than the assumed HVAC system of gas heat and central AC.

The following equation was used to calculate the annual therm savings:

$$Savings = kWh\_Savings * HVAC\_Interaction$$

Where:

- *Savings* is the estimated savings, in therms (which results in negative savings);
- *kWh_Savings* is the electrical savings resulting from the reduced hours; and
- *HVAC_Interaction* is the HVAC interaction factor (in this case a ratio of negative therms to kWh saved). Interaction factors were derived from ratios of whole building to end-use savings for similar measures in DEER. The therms interaction factor was adjusted if the heating system was anything other than gas heating (e.g., gas heating supplemented by solar heating).

No Technical Knowledge

For Wave 2, 79 respondents claimed that they had no technical knowledge of the lighting changes that were made in their facilities and buildings. Adequate information was available for 18 respondents where actual changes to lighting could be verified and savings could be estimated. The majority of these respondents claimed operating cost savings and energy consumption reductions. Similar to the “Changed lighting repair and maintenance practices” measure, DOE’s EIA electricity prices (DOE, Average Retail Price of Electricity to Ultimate Customers: Total by End-Use Sector, 2009) and CEUS building characteristic data (Itron, Inc., 2006) were applied to calculate savings.

F.9 Motors and Pumps

This section describes the gross savings methodology for the Motors and Pumps survey. Five of the six Wave 1 respondents for whom Summit Blue received responses reported quantifiable energy saving actions. From Wave 1, quantifiable energy savings were identified for five of the nine actions specified in the survey.

Eight of the 31 respondents in Wave 2 reported quantifiable energy saving actions. From Wave 2, quantifiable energy savings were identified for 7 of the 14 actions specified in the survey.

Figure 92 lists the measures specified in the survey and the number of respondents for which quantifiable energy savings were identified.

Figure 92: Measures in the Motors and Pumps Survey

Measure	Measure Presence		Number of respondents with quantifiable savings	
	Wave 1	Wave 2	Wave 1	Wave 2
Replaced existing motors with more efficient units	X	X	4	8
Installed new motor	X	X	0	0
Replaced existing pumps with more efficient units	X	X	1	4
Installed new pump	X	X	0	0
Installed VFD on motor	X	X	0	1
Redesign or replace piping	X	X	0	4
Eliminated distribution system losses	X	X	1	0
Check for shaft alignment or damage	X	X	3	1
Performed other motor maintenance	X	X	1	1
Implement a demand reduction program		X	0	3
Installed ASD or VSD drive on existing motor		X	0	0
Redesign motor/pump system		X	0	0
Maintain voltage levels		X	0	0
Perform other pump maintenance		X	0	0

No quantifiable savings were identified for the following measures:

Installed new motor – all respondents who reported taking this action also report replacing motors; all savings were attributed to replacing motors.

Installed new pump - all respondents who reported taking this action also report replacing pumps; all savings were attributed to replacing pumps.

Installed ASD or VSD on motor – not enough information was provided by respondents to estimate savings, or savings were attributed to installing VFD on motor.

Redesigned motor/pump system – savings were attributed to redesigning or replacing piping.

Maintained voltage levels – not enough information was provided by respondents to estimate savings

Performed other pump maintenance – savings were attributed to performing other motor maintenance.

Engineering calculations were used to estimate energy and demand savings. For each respondent and measure, the base annual energy consumption of the original motor configuration was calculated; then depending on the measure type, the same equation was used to calculate the new motor's energy consumption (which was subtracted from the base consumption to obtain savings) or a percentage reduction was applied to the base consumption.

The equation used to calculate annual energy (kWh) consumption was:

$$Savings_{kWh} = Number\_of\_Units * HP * Conversion_{HPtoKW} * Hours * Loading * \frac{1}{\eta}$$

Where:

$Savings_{kWh}$ is the annual kWh savings the measure

Number_of_Units is the number of units (motors or pump motors) affected by the measure, as reported by the respondent.

HP is the average horsepower of the units replace, as reported by the respondent.

$Conversion_{HPtoKW}$ is the conversion factor for converting horsepower to kilowatts (0.745)

Hours is the annual runtime hours the units, as reported by the respondent.

Loading is the motor loading factor, i.e. the percentage of total operating hours that the units run on full load (assumed to be 0.68)[136]

η is the efficiency of the units, based on the horsepower and age of the compressor as reported by the respondent (Figure 93).

If the unit efficiency was not specified in the survey data, the assumptions specified in Figure 93 were used.

[136] The motor loading factor assumption of 0.68 was obtained from Regional Technical Forum submittal, *Quality Motor Rewinding an Energy Efficiency Measure* (Green Motors Practices Group 2008).

Figure 93: Assumptions Used for Unknown Efficiencies

Horsepower	Assumed Baseline Motor Efficiency (EPAct Efficiency Standard)	Assumed New Motor Efficiency (NEMA Efficiency Standard)
1	80.1%	81.7%
1.5	83.8%	85.8%
2	84.7%	86.7%
3	86.3%	87.7%
5	87.2%	88.8%
7.5	88.7%	90.3%
10	89.5%	91.0%
15	90.4%	91.7%
20	90.6%	92.0%
25	91.6%	92.8%
30	91.8%	93.0%
40	92.6%	93.5%
50	92.8%	93.9%
60	93.4%	94.4%
75	93.6%	94.4%
100	93.9%	94.8%
125	94.2%	95.0%
150	94.6%	95.3%
200	94.8%	95.6%

Source: Consortium for Energy Efficiency (CEE) *Premium Efficiency Motors Initiative Efficiency Specifications*, (CEE 2009).

Demand savings were estimated in a similar fashion, by calculating the difference between the peak demand of the original motor(s) and the peak demand of the more efficient motor(s). The following equation was used to estimate coincident peak demand:

$$kW = Number\_of\_Units * HP * Conversion_{HPtoKW} * Loading * \frac{1}{\eta} * Coincidence$$

Where:

kW is the system coincident peak kW demand from the motor(s).

Number_of_Units, *HP*, $Conversion_{HPtoKW}$, *Loading*, and η are the same as in the *kWh* equation above.

Coincidence is the peak coincidence factor, which was assumed to be 75 percent.[137]

[137] Based on the average coincidence factor for industrial equipment in (Brown and Koomey 2002).

Replaced Existing Motors with More Efficient Units

In Wave 1, five respondents reported replacing existing motors with more efficient units; one of these respondents did not provide enough details to calculate savings, so savings were calculated for four respondents, using the savings equations stated above.

In Wave 2, nine respondents reported replacing existing motors with more efficient units; one of these respondents did not provide enough details to calculate savings, so savings were calculated for eight respondents, using the savings equations stated above.

Replaced Existing Pumps with More Efficient Units

In Wave 1, two respondents indicated that they replaced existing pumps with more efficient units. One of these respondents did not provide enough details to calculate energy savings. For the second respondent, savings were calculated using the savings equations stated above. However, the respondent indicated that they had done a post-installation assessment of energy savings which resulted in 25,000 annual kWh savings, which was significantly lower than the savings calculated based on the survey responses (likely due to the difficulty of estimating runtime hours and motor loading factor); to be conservative, the respondent's estimate of 25,000 kWh was used. To estimate demand savings for this respondent, it was assumed that the pump's demand remains constant over all hours of the year, and thus the kWh savings estimate was divided by 8760 to obtain the peak demand (kW) savings.

In Wave 2, five respondents indicated that they replaced existing pumps with more efficient units. One of these respondents did not provide enough details to calculate energy savings so savings were calculated for four respondents using the equations stated above.

Installed VFD on Motor

In Wave 1, there were no respondents with quantifiable savings for this measure.

In Wave 2, four respondents indicated that they installed VFD's on existing motors. Three of these respondents did not provide enough details to calculate energy savings so savings were calculated for one respondent. Savings were calculated as a percentage of total baseline consumption using the average percent savings from VFD applications on HVAC systems from DEER 2005 – 25 percent.

Redesigned or Replaced Piping

In Wave 1, there were no respondents with quantifiable savings for this measure.

In Wave 2, six respondents indicated that they redesigned or replaced piping to improve flow. Two of these respondents did not provide enough details to calculate energy savings so savings were calculated for six respondents. Savings were calculated as a percentage of total baseline consumption by conservatively applying engineering curves from DOE EERE documentation.[138] Based on this document moving from slightly incorrect pipe diameter to correct pipe diameter is conservatively estimated to result in 20 percent savings.

[138] DOE EERE, "Energy Tips: Reduce Pumping Costs through Optimum Pipe Sizing"

Information regarding the flow rate, old and new pipe diameters, pipe material, pipe lengths and pipe bends would be required to make a more accurate estimate.

Eliminated Distribution System Losses

In Wave 1, one respondent indicated that they eliminated distribution system losses. Energy savings from eliminated distribution system losses were estimated to be 1 percent of total energy consumption of the motors, based on an estimation of 3 percent to 10 percent total savings from optimizing motor operations and maintenance.[139] Demand savings were similarly estimated to be 1 percent of the motor's peak demand.

In Wave 2, there were no respondents with quantifiable savings for this measure.

Check for Shaft Alignment or Damage

In Wave 1, three respondents indicated that they checked for shaft alignment or damage. Energy savings from eliminated distribution system losses were estimated to be 0.5 percent of total energy consumption of the motors (calculated using the equation for motor energy consumption specified in the previous subsection on replacing motors), based on an estimation of 3 percent to 10 percent total savings from optimizing motor operations and maintenance.[140] Demand savings were similarly estimated to be 0.5 percent of the motor's peak demand.

In Wave 2, three respondents indicated that they checked for shaft alignment or damage. Two of these respondents did not provide enough details to calculate energy savings so savings were calculated for one respondent using the equations stated above. Since it's unclear whether misalignments were actually found or just checked for, energy savings are estimated to be 1 percent of total energy consumption.

Performed Other Motor Maintenance

In Wave 1, one respondent indicated that they performed other motor maintenance (specifically, the respondent reported that they greased bearings). Energy savings from this maintenance were estimated to be 1 percent of total energy consumption of the motors (calculated using the equation for motor energy consumption specified in the previous subsection on replacing motors).[141] Demand savings were similarly estimated to be 1 percent of the motor's peak demand.

In Wave 2, two respondents indicated that they had performed other motor maintenance. One of these respondents did not provide enough details to calculate energy savings so

[139] Esource's *Drivepower Technology Atlas* Series (Howe, et al. 1999) indicates that optimal operations and maintenance practices could save 3 to 10 percent of all drive power.

[140] Esource's *Drivepower Technology Atlas* Series (Howe, et al. 1999) indicates that optimal operations and maintenance practices could save 3 to 10 percent of all drive power.

[141] ACEEE's Online Guide to Energy-Efficient Commercial Equipment (ACEEE 2004) states that premium lubrication can result in 3 to 20 percent energy savings in motors. However, because the respondent simply stated that they greased bearings and did not specify whether they used premium lubrication, a conservative estimate of 1 percent savings was used.

savings were calculated for one respondent using the equations stated above. Savings from this maintenance were estimated to be 1 percent of total consumption.

Implemented Demand Reduction Program

In Wave 1, there were no respondents with quantifiable savings for this measure.

In Wave 2, five respondents indicated that they had implemented a demand reduction program. Two of these respondents did not provide enough details to calculate energy savings so savings were calculated for three respondents using the equations stated above and applying a percent reduction to estimate demand savings. It was assumed that half of demand could be shifted from peak to off-peak hours resulting in 50 percent peak savings. Since peak load shifting was assumed as opposed to load shedding, there was no basis for energy savings estimates.

F.10 Pools

The Pools survey consisted of one open-ended question asking respondents to describe changes made to their pool as a result of participating in the Pools training.

The responses from the five Wave 1 survey participants are discussed below:

Respondent #1: The single quantifiable energy saving action identified out of the responses was "pool pump." The methodology for estimating savings for this measure is described below.

Respondent #2: One respondent reported switching pool sweep cleaners. However, conversation with an industry technician indicated that switching pool sweep cleaners may or may not lead to energy savings, depending on a number of other factors, such as the filtration system or presence of a booster pump. Thus, no savings were assumed for this respondent due to a lack of additional information.

Respondent #3: This respondent reported changing light bulbs, installing a ceiling fan, and installing a new furnace. No savings were identified as being relevant to the Pools module.

Respondents #4 and #5: No information was provided about actions taken.

The responses from the three Wave 2 survey participants are discussed below:

Respondent #1: This respondent did not report taking any energy savings actions.

Respondent #2: This respondent reported turning off lights when leaving his/her building. This action is not relevant to energy savings from pools, nor were any details of the scale of the measure provided. No energy savings were estimated.

Respondent #3: This respondent reported installing variable speed motors on pumps, solar pool heating, and LED lighting.

The methods used for estimating savings for the actions reported above are described in the following subsections:

Replaced Pool Pump with More Efficient Pump

The single quantifiable energy saving action identified out of the Wave 1 responses was "pool pump." Because no additional information was provided, it was assumed that this residential respondent modified an existing single-speed pool pump in accordance with the DEER 2005 Swimming Pool Pump measure and achieved the savings reported for that DEER 2005 measure.[142]

Installed Variable Speed Pumps

For the Wave 2 respondent that reported installing variable speed pumps, DEER 2005 2-speed pool pump measure[143] was used.

[142] DEER 2005: D03-966.

[143] DEER 2005: D03-967.

Installed LED Lighting

Savings for this action were not quantified because it was unclear from the Wave 2 respondent's responses whether or not this was *pool* lighting, nor were any details of hours of operation of the lighting provided. Savings were not quantified for this action.

Installed Solar Pool Heating

For the Wave 2 respondent that reported installing solar pool heating, the solar energy simulation tool, RETScreen (Natural Resources Canada) was used to estimate energy savings, assuming a 1,000 ft^2, uncovered pool heated to 78°F from October through April.

F.11 Renewables

This section describes the gross savings methodology for the Renewables survey. 33 of the 94 Wave 1 respondents for whom Summit Blue received responses reported quantifiable energy saving actions, as did 51 of the 73 Wave 2 respondents. From Wave 1, quantifiable energy savings were identified for all five of the actions specified in the survey; for Wave 2, the list of actions was expanded to ten, nine of which quantifiable energy savings were identified for. Figure 94 lists the measures specified in the survey and the number of respondents for which quantifiable energy savings were identified.

Figure 94: Measures in the Renewables Survey

Measure	Measure Presence		Number of respondents with quantifiable savings	
	Wave 1	Wave 2	Wave 1	Wave 2
Installed a Photovoltaic System	X	X	12	30
Made Changes to a Photovoltaic System		X	0	3
Installed a Solar Hot Water Heating System	X	X	2	7
Made Changes to a Solar Hot Water Heating System		X	0	6
Installed a Solar Pool Heating System	X	X	2	2
Made Changes to a Solar Pool Heating System		X	0	1
Installed a Solar Radiant Floor Heating System	X	X	15	2
Made Changes to a Solar Radiant Floor Heating System		X	0	3
Other Installations	X	X	2	2
Other Changes Made		X	0	0

Summit Blue used a variety of resources, combined with engineering analyses, to estimate energy and demand impacts for the various actions taken by the sample sites.

For Wave 1, no information was provided about fuel types; solar thermal energy was assumed to displace natural gas, and photovoltaic energy was assumed to displace electricity. For Wave 2, respondents provided their heating fuel types (natural gas or electricity).

All energy savings (kWh and therms) were calculated using a similar analysis approach:

- The appropriate baseline load (e.g., electricity consumption, water heating requirements, etc.) was estimated for each respondent from the U.S. DOE Energy Information Agency's Residential Energy Consumption Survey (EIA 2009);
- The percentage of baseline load met by the respondent's renewables system was applied to find the total load displaced by the renewables; and
- The load displaced by the renewables was converted into energy savings achieved by avoiding conventional fossil fuel-fired systems.

The same approaches were employed for both new and existing systems; however, only 10 percent of the savings calculated through this approach were reported for respondents that made modifications on existing systems. 10 percent is a conservative estimate based on an input analysis using the renewables project modeling software RETScreen (Natural Resources Canada n.d.), which examined the savings impacts of altering different aspects of solar thermal and photovoltaic systems.

If a respondent reported implementing measures at more than one facility, 25 percent of the savings estimated for their primary facility were assumed at each additional facility. There were seven "additional" sites identified in the Renewables survey results, implying a total of 40 sites with quantifiable savings.

Photovoltaic System

15 Wave 1 respondents and 33 reported installing or modifying a photovoltaic system. Energy savings for this measure were computed from the following equation:

$$kWh = SquareFootage * E\_Intensity * PercentFromPV$$

Where:

kWh is the annual electricity savings (kWh)

SquareFootage is the building floor area (square feet), based on survey responses or assumed from building type

E_Intensity is the average energy intensity (kWh/ft^2-yr) of electricity consumed, based on building type from CEUS (commercial) and EIA data[144] (residential)

PercentFromPV is the portion of electricity consumed that comes from the photovoltaic system; based on survey responses or, if no response was given, the average of similar respondents' answers.

Demand savings were estimated by applying a ratio of energy savings to demand savings (kWh/kW) to the calculated energy savings. Representative ratios for each climate zone were determined from PVWatts, an NREL calculator for photovoltaic installation savings (NREL n.d.).

Solar Hot Water Heating System

Two Wave 1 and 13 Wave 2 respondents reported installing or modifying a solar water heater. The following equation was used to calculate the savings for residential customers:

$$therms_{res} = \frac{WH_{res} * PercentFromSWH}{\eta_{res}}$$

Where:

[144] EIA, "Residential Energy Consumption Survey 2005 (EIA 2009) *Section L: Housing Unit Square Footage*.

$therms_{res}$ is the annual natural gas savings (therms) for a residential respondent

WH_{res} is the annual thermal energy (in therms, reference mains temperature) embodied in hot water consumption for a residential respondent[145].

PercentFromSWH is the portion of heated water consumed that comes from the solar water heater; based on survey responses or, if no response was given, the average of the other respondents' answers.

η_{res} is the efficiency of the default, natural gas water heater[146]

The commercial solar water heating savings calculations used a similar approach, except that the annual consumption of heated water was based on the building square footage:

$$therms_{comm} = \frac{SquareFeet * NG\_Intensity * PercentFromSWH}{\eta_{comm}}$$

Where:

$therms_{comm}$ is the annual natural gas savings (therms) for a commercial respondent

SquareFeet is the respondent's building's floor area (square feet), or assumed by building type if the respondent did not provide this information.

NG_Intensity is the average energy intensity (Btu/ft^2-yr) of natural gas consumed for water heating; based on building type from CEUS end-use data.

PercentFromSWH is the portion of heated water consumed that comes from the solar water heater; based on survey responses or, if no response was given, the average of the other respondents' answers.

η_{comm} is the efficiency of the default natural gas water heater[147]

Solar Pool Heating System

Two Wave 1 and three Wave 2 respondents modified their solar pool heating system. RETScreen was used to determine pool heating loads, based on survey responses regarding the pool. The savings calculation was then the same as for the residential solar hot water measure described above.

Solar Radiant Floor Heating System

15 Wave 1 and five Wave 2 respondents reported changes to their solar radiant floor heating system as a result of this training. Energy savings for this measure were calculated from the following equation:

---

[145] Assumed to be 143.7 therms/year, which assumes 350 days per year of demand and daily consumption of 41,105 Btu/day of heated water, the average for a residence as stated in the Solar Rating and Certification Corporation's, *Directory of SRCC Certified Solar Water Heating System Ratings* (SRCC 2009).

[146] Assumed to be 0.60, based on California Solar Energy Industries Association, *The Value Proposition of Solar Water Heating in California* (CALSEIA 2009).

[147] Assumed to be 0.78, based on California Solar Energy Industries Association's, *The Value Proposition of Solar Water Heating in California* (CALSEIA 2009).

$$therms = SH * PercentFromRFH * (1 - ReductionFactor)$$

Where:

therms is the annual therm savings

SH is the annual natural gas consumption of a residential respondent for space heating (in therms).[148]

PercentFromRFH is the portion of space heating needs that are offset by the radiant floor system; based on a survey response and literature review.[149]

ReductionFactor is the adjustment factor that accounts for the losses within the solar water heating system and any usage of an auxiliary natural gas heater.[150]

Application of this approach involves the following assumptions about each respondent's space heating system:

- Respondents installed radiant floor heating systems that use solar-heated water, which is the most common type, rather than solar-heated air or electric radiation from PV panels.
- Respondents replaced either a conventional forced air heating system or a radiant floor heated with a conventional water heater. All savings were assumed to be natural gas, because no information was provided about the fuel type of the respondent's displaced water or space heating systems and the most common fuel type for water and space heating in California is natural gas.
- A therm of radiant floor heating has the same heating efficacy as a therm of conventional forced air heating.[151]
- The annual natural gas consumption for space heating (taken from EIA) is assumed to be the total delivered natural gas consumption, which includes the natural gas lost to the inefficiencies of a natural gas furnace.

Other

Two Wave 1 and two Wave 2 respondents reported unique, quantifiable actions as part of their open-ended responses. The reported actions were installation of a solar water heater and a photovoltaic system. Because no additional information was provided, it was assumed for each measure that these two respondents achieved the same savings as another respondent with similar characteristics.

---

[148] Assumed to be 17.3 million Btu/year (delivered), based on the average per California household from the Energy Information Administration's Residential Energy Consumption Survey (EIA 2009), *Table SH8. Average Consumption for Space Heating by Main Space Heating Fuel Used, 2005 - Million British Thermal Units (Btu) per Household*.

[149] Assumed to by 60 percent from: Midwest Renewable Energy Association, *Solar Hydronic Radiant Floor Heating Systems* (MREA 2000).

[150] Assumed to be 30 percent, based on: California Solar Energy Industries Association, *The Value Proposition of Solar Water Heating in California* (CALSEIA 2009).

[151] *Farnham Construction: Hailey, ID*, Toolbase Services (Toolbase 2005).

F.12 Water Management

This section describes the gross savings methodology for the Water Management survey. This survey was administered solely in Wave 2. Four of the eight Wave 2 respondents for whom Summit Blue received responses reported quantifiable energy saving actions. From Wave 2, quantifiable energy savings were identified for five of the eight actions specified in the survey.

Figure 95 lists the measures specified in the survey and the number of respondents for which quantifiable energy savings were identified.

Figure 95: Measures in the Motors and Pumps Survey

Measure	Number of respondents with quantifiable savings
	Wave 2
Replaced existing motors with more efficient units	1
Replaced existing pumps with more efficient units	0
Installed VFD on motor	1
Changed the sizing or flow rate of pump	0
Redesigned motor/pump system	0
Implemented demand reduction program	1
Changed water Supply process	2
Changed water treatment process	1

Engineering calculations were used to estimate energy and demand savings. For each respondent and measure, the base annual energy consumption of the original motor configuration was calculated; then depending on the measure type, the same equation was used to calculate the new motor's energy consumption (which was subtracted from the base consumption to obtain savings) or a percentage reduction was applied to the base consumption.

The equation used to calculate annual energy (kWh) consumption was:

$$Savings_{kWh} = Number\_of\_Units * HP * Conversion_{HPtoKW} * Hours * Loading * \frac{1}{\eta}$$

Where:

Savings$_{kWh}$ is the annual kWh savings the measure

Number_of_Units is the number of units (motors or pump motors) affected by the measure, as reported by the respondent.

HP is the average horsepower of the units replace, as reported by the respondent.

Conversion$_{HPtoKW}$ is the conversion factor for converting horsepower to kilowatts (0.745)

Hours is the annual runtime hours the units, as reported by the respondent.

Loading is the motor loading factor, i.e. the percentage of total operating hours that the units run on full load (assumed to be 0.68)[152]

η is the efficiency of the units, based on the horsepower and age of the compressor as reported by the respondent (Figure 96).

If the unit efficiency was not specified in the survey data, the assumptions specified in Figure 96 were used.

Figure 96: Assumptions Used for Unknown Efficiencies

Horsepower	Assumed Baseline Motor Efficiency (EPAct Efficiency Standard)	Assumed New Motor Efficiency (NEMA Efficiency Standard)
1	80.1%	81.7%
1.5	83.8%	85.8%
2	84.7%	86.7%
3	86.3%	87.7%
5	87.2%	88.8%
7.5	88.7%	90.3%
10	89.5%	91.0%
15	90.4%	91.7%
20	90.6%	92.0%
25	91.6%	92.8%
30	91.8%	93.0%
40	92.6%	93.5%
50	92.8%	93.9%
60	93.4%	94.4%
75	93.6%	94.4%
100	93.9%	94.8%
125	94.2%	95.0%
150	94.6%	95.3%
200	94.8%	95.6%

Source: Consortium for Energy Efficiency (CEE) *Premium Efficiency Motors Initiative Efficiency Specifications*, (CEE 2009).

Demand savings were estimated in a similar fashion, by calculating the difference between the peak demand of the original motor(s) and the peak demand of the more efficient motor(s). The following equation was used to estimate coincident peak demand:

$$kW = Number\_of\_Units * HP * Conversion_{HPtoKW} * Loading * \frac{1}{\eta} * Coincidence$$

Where:

[152] The motor loading factor assumption of 0.68 was obtained from Regional Technical Forum submittal, *Quality Motor Rewinding an Energy Efficiency Measure* (Green Motors Practices Group 2008).

kW is the system coincident peak kW demand from the motor(s).

Number_of_Units, *HP*, $Conversion_{HPtoKW}$, *Loading*, and η are the same as in the *kWh* equation above.

Coincidence is the peak coincidence factor, which was assumed to be 75 percent.[153]

Replaced Existing Motors with More Efficient Units

In Wave 2, two respondents reported replacing existing motors with more efficient units. One of these respondents did not provide enough details to calculate savings, so savings were calculated for one respondent, using the savings equations stated above.

Installed VFD on Motor

In Wave 2, savings were calculated for one respondent. Savings were calculated as a percentage of total baseline consumption using the average percent savings from VFD applications on cold and hot water loops from DEER 2005 – 25 percent.

Implemented Demand Reduction Program

In Wave 2, savings were calculated for one respondent using the equations stated above and applying a percent reduction to estimate demand savings. It was assumed that half of demand could be shifted from peak to off-peak hours resulting in 50 percent peak savings. Since peak load shifting was assumed as opposed to load shedding, there was no basis for energy savings estimates.

Changed Water Supply Processes

In Wave 2, savings were quantified for two respondents. Changes indicated were for five of nine potential actions including: implementing system leak detection and repair, managing well production and draw down, promoting water conservation, and implementing reduction programs for high volume users. A maximum percent savings was conservatively assumed at 10 percent. Each sub-action was assumed to provide an equal portion of the maximum potential savings.

Changed Water Treatment Processes

In Wave 2, three respondents indicated that they had changed wastewater treatment processes. Two did not supply sufficient information to justify savings, so savings were quantified for one respondent. Changes indicated were for 2 of 15 potential actions including: reducing freshwater consumption and recovering excess heat from wastewater. A maximum percent savings was conservatively assumed at 10 percent. Each sub-action was assumed to provide an equal portion of the maximum potential savings.

---

[153] Based on the average coincidence factor for industrial equipment in (Brown and Koomey 2002).

APPENDIX G: MARKET ACTOR ENGINEERING ANALYSIS METHODOLOGY

This Appendix describes the methods used by Summit Blue Consulting (now a part of Navigant Consulting) to estimate gross energy (kWh and therm) and demand (coincident peak kW) savings for respondents of the Energy Centers market actor surveys. *Market actors* are defined as energy service professionals, building designers and engineers, building service technicians (e.g., electricians, HVAC installers, and plumbers), and any other individuals who professionally install, service, or design buildings and building equipment. In other words, they are professionals that "touch" multiple energy efficiency projects.

Respondents of these surveys attended Energy Center courses between October 2007 and July 2008. Gross savings were quantified for the actions taken for the period between the last course attended and the present time[154]. For each market actor, savings were quantified as the total amount of savings achieved by the respondent after the course was taken (and not as yearly savings).

The market actor survey design required a more general approach than did designing the end-user surveys; the expanded scope of these respondents meant that less detail could be asked about individual projects. Instead, surveys and open-ended interviewing focused on collecting the most general information about the building types, quantities, and sizes that projects were done in, and the general types of projects and equipment that were specified or implemented.

Savings methods leveraged core California-based secondary resources (e.g., DEER[155] , CEUS[156], reports on CALMAC.org) and models (eQUEST[157]) wherever possible. Where data from these sources was not adequate, not reflective of the range of participant conditions, or was internally inconsistent, additional secondary sources and engineering calculations were used.

A total of three analyses were conducted for market actors for the following end-uses:

- Building Envelope
- Heating, Ventilation, and Air Conditioning (HVAC)
- Lighting

---

[154] October 1, 2009 was used as the cutoff date for savings.

[155] The 2008 DEER update (Itron, Inc. 2009) was used where possible. Where 2008 did not cover measures of interest, (Itron, Inc. 2006) was used.

[156] (Itron, Inc. 2006)

[157] (James J. Hirsch and Associates n.d.)

The following sections describe the methods used for each market actor to estimate gross savings for measures in each of these end-uses. Gross savings are summarized and the influence factor used as a proxy for a net to gross ratio is also stated[158].

G.1 Lighting

This section describes the gross savings methodology use to analyze savings from the market actors Lighting survey. Market actors reported performing work on a variety of building types (spanning both residential and commercial) and sizes and with various types of equipment. A total of nine market actors responded to the survey. Savings were quantified for six; two respondents' actions did not result in quantifiable savings and information was not available for one respondent.

Several respondents indicated upgrading lighting equipment (e.g., T8s to T5s) and did not indicate the lamp wattages. For these respondents, the current lighting market was reviewed to determine the most common wattages for the various types of lamps installed. These common wattages were used to estimate energy savings.

Building operating hours were typically not supplied by the market actors. Secondary sources, including survey respondents from the lighting module, were reviewed to estimate lighting hours of operation.

HVAC interaction factors used for the non-market actor Energy Center analysis were also used here to determine the whole building kWh and kW savings, and the therms increase.

Each subsection below summarizes the reported actions and resulting gross savings for a respondent.

Respondent 2102745

Table 87: Respondent 2102745 Savings

Gross kWh Savings	25,654
Gross Peak kW Savings	0.5
Gross therm Savings	-170
Influence Factor	0.31

This respondent is a lighting architect serving large residential projects in the San Francisco Bay Area by specifying work to contractors and advising home owners on lighting approaches. The respondent indicated that California's Title 24 drives most of the lighting efficiency measures that are installed into homes, but that the Energy Center courses provided additional information on energy efficient lighting and optimized lighting controls. Overall, the courses provided knowledge to reinforce business practices that had already been implemented. The respondent estimated that the courses made them 5% more knowledgeable about energy efficient lighting and lighting optimization.

---

158 ODC provided these influence factors to Summit Blue; they were not determined as part of this gross savings analysis.

The analysis approach assumed that in the absence of the Energy Centers courses, the respondent would have installed lighting to comply with California's Title 24 energy efficiency requirements. The assumed impact of the program was a specification of 5% more efficient equipment, and 5% reduction in the number of lamps specified, due to lighting design optimization.

DEER 2008 data for single family residences was referenced to obtain code baseline energy consumption. This baseline consumption was scaled to reflect the typical size home for which the respondent performs work (10,000 square feet), which was several times larger than the assumed size in DEER for newer homes (2,300 square feet).

Respondent 2106416

This respondent did not provide information from which savings could be quantified.

Respondent 2106655

This respondent is a residential architect focusing on green building design with 20 years of experience using daylighting controls. The respondent indicated in the survey that the Energy Center courses did not have an influence on current daylighting control strategies and CFL installation methods.

The respondent indicated that the courses did provide information to help promotional and sales efforts for CFLs and LEDs. Although the respondent learned about LEDs, they are not currently installing them. The respondent also indicated that they attended the course "Improve Lighting and Building Design." However, the course did not result in any energy savings. It only provided information to improve lighting distributions (which did not result in lighting reductions) and lighting specification to contractors.

This respondent did not identify any energy savings actions influenced by the courses; no savings were quantified for this respondent.

Respondent 2202864

Table 88: Respondent 2202864 Savings

Gross kWh Savings	29,269
Gross Peak kW Savings	1.4
Gross therm Savings	-187
Influence Factor	0.70

This respondent is a part-time electrical installer who completes approximately two projects per month. The respondent indicated that they do not provide lighting designs to projects and therefore, did not implement any lighting optimization plans for any projects. However, the respondent did report that after attending Energy Center courses the number CFLs, LEDs, and T5s installed increased in each project. Table 89 shows the changes in installation practices.

Table 89: Installation Levels for CFLs, LEDs, and T5s

	Percent of Lamps per Project	
Lamp Type	Before Course	After Course
INSTALL MORE CFLs IN PLACE OF INCANDESCENT LAMPS (RESIDENTIAL)		
Incandescent	75%	50%
CFLs	25%	50%
INSTALL MORE LEDs IN PLACE OF CFLs (RESIDENTIAL)		
CFLs	100%	50%
LEDs*	0%	50%
INSTALL MORE T5s IN PLACE OF T8s (COMMERCIAL – RESTAURANT AND RETAIL)		
T8s	75%	50%
T5s	25%	50%

*Respondent indicated that LEDs were only installed in 2 projects. Savings only quantified for two projects.

The approach used for respondent 2102745 was also applied to this respondent to determine savings from residential projects.

For the commercial installations (T8s to T5s), California Commercial End-Use Survey (CEUS) data was used to determine baseline lighting loads. Percentage savings typical of a T8 to T5 replacement were applied to the baseline to determine savings.

Respondent 2204223

Table 90: Respondent 2202864 Savings

Gross kWh Savings	16,201
Gross Peak kW Savings	3.5
Gross therm Savings	-57
Influence Factor	0.62

This respondent is an account manager for an electrical distribution company whose customers are primarily electrical contractors. This respondent is in a sales related position and does not install lighting equipment. Additionally, the respondent does not typically specify lighting, except for a small number of residential and commercial projects (approximately 10 per year). The quantified savings calculated for this respondent are based on these projects.

For residential projects, the number of CFLs specified per project did not increase. The respondent claimed that Title 24 already had stringent CFL requirements in place. However, LED installations did increase. Similarly for commercial projects, the respondent reported specifying more T5s in place of high intensity discharge (HID) lamps. Table 91 shows the change in specifying practices.

Table 91: Installation Levels for LEDs, and T5s

	Percent of Lamps per Project	
Lamp Type	Before Course	After Course
INSTALL MORE LEDs IN PLACE OF CFLs (RESIDENTIAL)		
CFLs	95%	90%
LEDs	5%	10%
INSTALL MORE T5s IN PLACE OF HIDs (COMMERCIAL)		
HIDs	20%	10%
T5s	80%	90%

The same approach used for respondent 2102745 was also applied to this respondent. As for previous respondents, percentage savings typical of these measures were applied to baseline energy intensities from DEER 2008 (residential) and CEUS (commercial).

Respondent 2205406

Table 92: Respondent 2205406 Savings

Gross kWh Savings	52,542
Gross Peak kW Savings	12.9
Gross therm Savings	-171
Influence Factor	1.00

This respondent is an electrical distributor, primarily for commercial projects. Similarly to respondent 2204223, they do not specify lighting designs. However, Energy Center courses made this respondent more knowledgeable of the different energy efficient products available as well as the associated rebates. As a result, the respondent now sells some T5s where he would have sold metal halides otherwise. The respondent reported increasing T5 installations from 60% to 75%.

The respondent provided the number of fixtures (15 per project x 25 projects per year). The respondent did not know the hours of operation of these fixtures: average hours of operation specified by non-market actors for similar building types and fixtures were assumed.

Respondent 2407400

Table 93: Respondent 2407400 Savings

Gross kWh Savings	8,822,328
Gross Peak kW Savings	645.0
Gross therm Savings	-54,029
Influence Factor	0.70

This respondent is an electrical contractor who works on multi-family homes (approximately 50 units per building) and commercial buildings, including lodging, office, storage, and manufacturing buildings. The respondent reported performing approximately 150 residential projects and 100 commercial projects per year. After the Energy Center courses, the respondent reported that for each of these projects, energy efficient lighting is installed and lighting levels are optimized. Additionally, the respondent reported that they now use diagnostic tools, including savings and cost analysis calculators, to maximize energy savings. Finally, the respondent reported that they have improved maintenance practices to reduce costs to the customers.

For lighting equipment changes, Table 94 shows the change in installation practices.

Table 94: Installation Levels for LEDs, and T5s

	Percent of Lamps per Project	
Lamp Type	Before Course	After Course
INSTALL MORE CLFs IN PLACE OF INCANDESCENTS)		
Incandescents	90%	0%
CFLs	10%	100%
INSTALL MORE T5s IN PLACE OF HIDs		
HIDs	85%	0%
T5s	15%	100%

As for previous respondents, DEER 2008 and CEUS were used to determine baseline loads, and percentage savings for the types of substitution specified in Table 94. Savings were increased by 5% to account for the respondents use of diagnostic tools to improve savings.

No savings were quantified for the improvements to maintenance that the respondent reported. It was assumed that these maintenance improvements only reduce costs and do not provide energy savings.

Respondent 2500437

This respondent is an electrical contractor for residential and commercial projects who also conducts electrical sales (respondent reported having a lighting showroom). The respondent reported that after attending the Energy Center courses, they are now more aware of the pros and cons of LEDs and about the ENERGY STAR program.

The respondent indicated that the number of CFLs installed in residential projects did not change. However, as a result of the course, they now only install ENERGY STAR certified CFLs. Savings were not quantified for this measure because ENERGY STAR criteria does not distinguish between low efficiency and high efficiency CFLs. Therefore, although the *quality* of specified lights may have improved, it is assumed that the *wattages* of the lamps did not decrease.

Similarly for commercial fluorescent lighting projects, the respondent indicated that they now focus on ENERGY STAR products. Again, savings were not quantified because ENERGY STAR criteria does not necessarily result in reduced wattages for linear fluorescent fixtures.

Finally, the respondent indicated that Energy Center courses supplied knowledge regarding LEDs. However, it was reported that installation and specification practices did not change.

No savings were quantified for this market actor.

Respondent 2901405

Table 95: Respondent 2901405 Savings

Gross kWh Savings	25,931
Gross Peak kW Savings	5.3
Gross therm Savings	-102
Influence Factor	0.40

This respondent is an architect who specifies and designs lighting projects while the actual installation is conducted by other contractors. After attending the Energy Center courses, the respondent indicated that they now have a better understanding of lighting control products and methods. Additionally, the respondent learned that previous projects had been over-lamped. As a result of Energy Centers training, projects now have optimized lighting levels. As a result, savings were attributed to increased lighting control levels and lighting optimization.

For lighting controls, DEER 2005 savings data for daylighting controls were assigned. DEER 2005 data is based on a per controlled wattage basis. Similar to previous respondents, the total controlled wattage was estimated using CEUS data. Because the respondent had prior knowledge of lighting controls, it was assumed that only one-third of the DEER 2005 daylighting control savings were achieved as a result of increased use of daylighting controls.

For lighting optimization, the respondent reported that previous lighting projects were over-lamped by one-third to one-half. Savings resulting from lighting optimization were calculated by reducing the total lamp count by 42 percent (the average of 33 and 50 percent). Baseline lamp counts were determined from the respondent's survey information.

G.2 Heating, Ventilation, and Air Conditioning (HVAC)

This section describes the gross savings methodology use to analyze savings for the market actors responding to the HVAC survey. A total of ten market actors responded to the survey, and savings were quantified for all.

Market actors reported performing work on a variety of building types (residential and commercial) and sizes and with various types of equipment. The analysis approach for the HVAC market actors relied primarily on DEER 2008 data and DEER 2005 where measures of interest could not be found in DEER 2008. DEER savings were scaled by quantities reported in surveys. If DEER data was not applicable, percentage savings were determined from secondary literature sources and applied to baseline energy consumption characteristics. Baseline characteristics were estimated using CEUS data and respondents' survey information (e.g., building size). For unknown building sizes, the average of the other respondents was assumed. For respondents who did not provide enough information to estimate savings directly, the average savings of the other respondents was assumed and scaled based on reported building size.

Respondent 2108804

Table 96: Respondent 2108804 Savings

Gross kWh Savings	1,301,462
Gross Peak kW Savings	0
Gross therm Savings	201
Influence Factor	0.40

This respondent is project manager for a construction company that installs building automation and monitoring systems for mechanical and electrical systems. As a result of the Energy Center courses, this respondent optimized their HVAC system operation practices during evening hours and utilizing economizers.

The market actor now specifies chiller unit operations that are 20% lower during the evening hours. Savings were quantified as 10% of the 20% reduction to reflect the reduction in total operation during off-peak evening hours.

Economizer savings were quantified using DEER 2005 and scaling based on the tonnage reported by the respondent. The DEER 2005 baseline operating characteristics assumes that no economizer is installed.

Neither action resulted in coincident peak kW savings: night-time operations reductions are not during system peak times (afternoon/early evening) and economizers would not be utilized during system peak events (which correlate with high temperature).

Respondent 2108834

Table 97: Respondent 2108834 Savings

Gross kWh Savings	45,536
Gross Peak kW Savings	36.8
Gross therm Savings	-691
Influence Factor	0.82

This respondent is a resource efficiency manager at a large military base containing offices, hospitals, hotels, and industrial facilities. He reported retrofitting economizers onto existing HVAC systems.

Similar to the approach used for estimating economizer savings for respondent 2108804, savings were obtained from DEER 2005 and scaled based on the reported tonnage. A Title 24 baseline was assumed. The survey information indicates that this market actor is involved in 5 projects per year where economizers are installed for systems with an average of 15 tons of cooling capacity. Savings were quantified for economizer installations assuming Title 24 baseline operating characteristics.

Respondent 2201942

Table 98: Respondent 2201942 Savings

Gross kWh Savings	271,708
Gross Peak kW Savings	136.4
Gross therm Savings	1,500
Influence Factor	0.73

This respondent is an HVAC contractor who performs an estimated 24 residential and commercial HVAC retrofits per year. He reported that after attending Energy Center courses, he now

installs high efficiency air conditioning equipment

optimizes HVAC equipment sizing

insulates and seals ducts

uses HVAC diagnostics to optimize performance

High efficiency air conditioner impacts were determined from DEER 2008 and then scaled based on the reported equipment size. The respondent indicated that residential equipment is typically 4 tons while commercial equipment is 15 tons. Based on survey information, it was assumed that this type of project represented one-third (eight total) of the total projects completed per year. Additionally from survey information, 25% of savings is attributed to residential projects and the remaining is assigned to commercial projects.

For optimized HVAC equipment sizing, savings from DEER 2008 were scaled to the reported tonnage was referenced to estimate savings. Maintaining the same approach used for respondent 2108804, a 20% reduction in operating capacity was assumed. Savings were distributed between residential and commercial projects and this type of project was assumed to represent one-third of the projects completed per year.

For duct insulation and sealing, savings were obtained from DEER 2008 and scaled to the tonnages reported for residential and commercial projects. The same distribution of projects (25% residential, 75% commercial) was applied to quantify a total savings. Duct optimization was assumed to account for one-sixth (four total) of the projects completed per year.

For improving HVAC diagnostics and optimization techniques, savings were assumed to be 3% of the total heating and cooling energy consumption. CEUS data was used to estimate that energy consumption for commercial buildings while DEER 2008 data was used for residential buildings. The same distributions for residential and commercial projects were applied to calculate total savings from this measure. This type of project was assumed to account for one-sixth of the projects completed per year.

Respondent 2205953

Table 99: Respondent 2205953 Savings

Gross kWh Savings	0
Gross Peak kW Savings	0
Gross therm Savings	422
Influence Factor	0.84

This respondent is an HVAC general contractor who performs work on small offices, restaurants, and residential buildings. The work is divided equally across residential and commercial buildings. This respondent reported that after attending the Energy Center courses they now install high efficiency furnaces and optimize furnace size.

Savings from installing high efficiency furnaces were obtained from DEER 2008 (residential) and DEER 2005 (commercial): furnace savings estimates for commercial buildings are not available in DEER 2008. Survey information indicates that all of the heating systems in the buildings they work on are supplied by gas. Therefore, only therm savings are quantified for this measure.

Savings from optimizing furnace size were determined by assuming a 20% reduction in baseline equipment capacity and using DEER 2008 (residential) and DEER 2005 (commercial) baseline operating characteristics.

Respondent 2207749

Table 100: Respondent 2207749 Savings

Gross kWh Savings	3,598
Gross Peak kW Savings	3.5
Gross therm Savings	419
Influence Factor	0.82

This respondent is a residential HVAC contractor who performs installations in residences ranging in size from 1,000 to 5,000 square feet. After attending Energy Center courses, this respondent reported

installing high efficiency furnaces

installing high efficiency air conditioners

optimizing HVAC equipment sizing

insulating and sealing ducts

For savings from high efficiency furnaces and air conditioners, DEER 2008 was used to estimate savings. DEER savings are scaled to reflect the typical size of equipment installed by this market actor. 60 kBtu/h is the reported size for the typical furnace installation. High efficiency furnace installations are assumed to account for half of the projects completed per year (five total). The typical air conditioner installed is reported as 3 tons. High efficiency air conditioners are this type of project was assumed to account for one-fifth (two total) of the projects completed per year.

Savings for optimizing HVAC equipment size were determined by assuming a 20% reduction in capacity. This type of project was also assume to account for one-fifth (two total) of the projects completed per year.

Savings for duct optimization by insulation and sealing equipment were estimated using DEER 2008. Duct optimization was assumed to account for one-tenth (one total) of the projects completed per year.

Respondent 2207936

Table 101: Respondent 2207936 Savings

Gross kWh Savings	384,950
Gross Peak kW Savings	250.2
Gross therm Savings	1,009
Influence Factor	0.76

This respondent is a mechanical contractor who specializes in HVAC and plumbing projects for both residential and commercial building types. He performs approximately 100 HVAC projects per year in residential buildings (50%), retail buildings (25%), and small office buildings (25%). After the Energy Center courses, this respondent now

Installs high efficiency air conditioners

Insulates and seals ducts

Uses improved HVAC diagnostic and optimization tools

Savings from installing high efficiency air conditioners were obtained from DEER 2008, scaled to a typical tonnage installed by the respondent.

Savings from optimizing duct performance by insulating and sealing equipment were obtained from DEER 2008.

Savings from improving HVAC diagnostics and optimization techniques were assumed to be 3% of the total heating and cooling energy consumption. CEUS data was used to estimate that energy consumption for commercial buildings while DEER 2008 data was used for residential buildings.

Respondent 2400459

Table 102: Respondent 2400459 Savings

Gross kWh Savings	59,603
Gross Peak kW Savings	30.3
Gross therm Savings	1,211
Influence Factor	0.58

This respondent is an air conditioning and refrigeration service technician who services equipment in existing grocery and restaurant building types. This market actor reported performing approximately 50 projects per year. As a result of attending Energy Center courses, this respondent now works with improved HVAC diagnostics and optimization techniques. As for the previous respondents, a 3% savings in the total heating and cooling energy was assumed to result from these improved methods. CEUS data was used to estimate baseline building energy consumption.

Respondent 2706290

Table 103: Respondent 2706290 Savings

Gross kWh Savings	269,715
Gross Peak kW Savings	114.1
Gross therm Savings	20,413
Influence Factor	0.70

This respondent is an energy consultant who works on projects involving residential and commercial retrofits, building mechanical designs, drafting, and Title 24 compliance. This market actor provides consulting services for hotel (25% of projects), retail (25% of projects), restaurant (25% of projects), and residential (25% of projects) building type projects. After the Energy Center courses, this respondent now performs duct insulation and sealing. Savings were quantified for this measure by using DEER 2008 estimates for duct sealing that were scaled to the typical size of equipment worked on by this respondent.

Respondent 2802624

Table 104: Respondent 2802624 Savings

Gross kWh Savings	17,027
Gross Peak kW Savings	6.0
Gross therm Savings	182
Influence Factor	0.76

This respondent is a systems engineer who designs HVAC systems in restaurant, small office, and residential buildings. After attending Energy courses, this respondent optimizes HVAC equipment size in project specifications and performs duct optimization. This respondent completes approximately one project per year where techniques learned from Energy Center courses are applied.

Savings for HVAC equipment sizing optimization were estimated by assuming a 20% reduction in equipment capacity reduction. DEER 2008 was used to estimate baseline operating characteristics.

Savings for duct optimization were obtained from the DEER 2008 duct sealing measure.

Respondent 2802841

Table 105: Respondent 2802841 Savings

Gross kWh Savings	12,921
Gross Peak kW Savings	7.5
Gross therm Savings	24
Influence Factor	0.70

This respondent works for an HVAC company that performs work in small offices (80%) and residential buildings (20%). This respondent implements approximately 10 projects per year. After attending Energy Center courses, this respondent now installs high efficiency air conditioners and insulates and seals ducts.

Savings for installing high efficiency air conditioners were obtained from DEER 2008 and scaled to the typical equipment tonnage installed by this market actor.

Savings for optimizing duct installations by insulating and sealing equipment were obtained from DEER 2008.

G.3 Building Envelope

This section describes the gross savings methodology use to analyze savings for the market actors responding to the Building Envelope survey. Market actors reported performing work on a variety of building types (spanning both residential and commercial) and sizes and with various types of equipment. A total of 10 market actors responded to the survey. Savings were quantified for all 10 respondents.

In preparation for this analysis, eQUEST was used to model a range of energy efficiency measures applied to a panel of residential and commercial building models.

For each respondent, the appropriate blend of building models (based on reported building types served) was used to determine an average savings per square foot for a particular measure, and this savings was applied to the total square feet of building served. Although savings were estimated on a measure by measure basis, savings per respondent were capped at the maximum reasonable savings achieved by implementing a full suite of building envelope energy efficiency measures (as determined by the initial eQUEST models described above). This ceiling on savings was imposed to avoid double counting savings from actions with interacting impacts.

Respondent 2206754

Table 106: Respondent 2206754 Savings

Gross kWh Savings	104,975
Gross Peak kW Savings	61
Gross therm Savings	13,039
Influence Factor	1.00

This respondent provides residential green homes, building performance, and green building performance consulting on HVAC and building envelope technologies. As a result of the course, this respondent now feels better versed on the subjects and better able to consult his clients; he now recommends improved insulation, improved windows, air sealing, and minimization of thermal bypassing (e.g., insulating electrical boxes).

Respondent 2202577

Table 107: Respondent 2202577 Savings

Gross kWh Savings	874
Gross Peak kW Savings	0.51
Gross therm Savings	103
Influence Factor	0.88

This respondent is the energy efficiency coordinator for a city. Since the course, she has provided green building consultations for the public and recommends insulation installation and upgrades, window upgrades, cool and green roofs, and air sealing.

Respondent 2709371

Table 108: Respondent 2709371 Savings

Gross kWh Savings	8,613
Gross Peak kW Savings	9.29
Gross therm Savings	-1.39
Influence Factor	0.61

This respondent is a green energy consultant and teacher. As a result of the course, he now specifies cool and green roofs.

Respondent 2209567

Table 109: Respondent 2209567 Savings

Gross kWh Savings	0.00
Gross Peak kW Savings	0.00
Gross therm Savings	-0.60
Influence Factor	1.00

This respondent's company is a full service energy consulting company, which does HERS testing as their main source of business. As a result of the course, he intends to recommending improved insulation to contractors, but has had the opportunity yet. He has been specifying some weather sealing measures; the estimated impact from this action was a negligible increase in natural gas consumption.

Respondent 2702723

Table 110: Respondent 2702723 Savings

Gross kWh Savings	5,446
Gross Peak kW Savings	2.09
Gross therm Savings	1,449
Influence Factor	0.85

This respondent does remodeling and home performance retrofitting. Since the course, he installs more/improved insulation, installs cool/green roofs, conducts air sealing, and uses advanced framing techniques.

Respondent 2708508

Table 111: Respondent 2708508 Savings

Gross kWh Savings	223,515
Gross Peak kW Savings	77
Gross therm Savings	2,535
Influence Factor	0.65

This respondent is the principle architect for education/institutional projects. Since taking the courses, he has provided more up-front energy analysis for early design schemes, allowing clients to make energy/cost saving decisions early on in the projects. Typically this results in higher efficiency insulation and windows.

Respondent 2203589

Table 112: Respondent 2203589 Savings

Gross kWh Savings	6,957
Gross Peak kW Savings	2.64
Gross therm Savings	1,864
Influence Factor	0.49

This respondent is contractor that does retro-insulation and window replacements in existing homes. Since the courses, he now does air sealing and has changed the way he insulates existing homes.

Respondent 2206974

Table 113: Respondent 2206974 Savings

Gross kWh Savings	248
Gross Peak kW Savings	0.09
Gross therm Savings	66
Influence Factor	1.00

This respondent is an energy efficiency consultant and since the courses has changed his communication with the client: he can describe different options better and is more confident and informed in advising clients. Typically, he is recommending improved insulation and air sealing.

Respondent 2209124

Table 114: Respondent 2209124 Savings

Gross kWh Savings	1,556.48
Gross Peak kW Savings	0.59
Gross therm Savings	417.21
Influence Factor	0.94

This respondent is a building performance contractor, whole house whole energy auditor, and provides home evaluation and mediation. Since the courses, he has changed how he does all aspects of home performance (including insulation and windows), HVAC systems, air infiltration, installation of insulation, and combustion safety.

Respondent 2201829

Table 115: Respondent 2201829 Savings

Gross kWh Savings	140,998
Gross Peak kW Savings	53
Gross therm Savings	37,794
Influence Factor	0.68

This respondent is a Title 24 Green Building Professional. Since the courses, he spends more time talking with designers and contractors about better techniques for a tighter envelope, with improved insulation and windows.

APPENDIX H: EVALUABILITY ASSESSMENT

A full evaluability assessment is an exploratory activity that aims to determine whether a program is considered *evaluable*. A program can be evaluated if specific propositions are largely true: 1) program goals and priority information needs are well defined, 2) program goals are plausible, 3) relevant performance data can be obtained at reasonable cost, and 4) intended users of the evaluation results have agreed on how they will use the information.

H.1 Evaluability Assessment of Education, Training and Outreach Programs

In order to determine whether all line items in the Education, Training and Outreach Program budgets were appropriate for inclusion in this evaluation, ODC gathered information on each of the program efforts covered by conducting interviews with Center personnel. We learned that the Energy Centers alone did not make up the full Education, Training and Outreach Program budget for both PG&E and SCE. Table 116 shows the different program components within the overall budget and whether they are included in our evaluation effort. There are two line items that required more information and were subjected to an evaluability assessment to determine whether they should be included in the evaluation. Based on our review of program materials and additional interviews with Center personnel, we determined that neither of the programs should be included in this evaluation effort. The remainder of this Appendix outlines how we came to this conclusion for these program components.

Table 116: 2006-2008 Total Program Budgets

IOU Program	Overall Budget	Program Effort	Allocated Budget	Evaluation Recommendation
PGE2010: PG&E Education and Training Program	$37.3 million	Pacific Energy Center (PEC)	$11.2 million	Covered in current approach
		Food Service Technology Center (FSTC)	$6.1 million	Covered in current approach
		Energy Training Center (ETC)	$3.3 million	Covered in current approach
		Builder Operator Certification	$0.8 million	Covered in current approach
		Integrated Audits	**$16 million**	**Evaluability Assessment**
SCE2513: SCE Education, Training and Outreach Program	$24.3 million	Customer Technology Application Center (CTAC)	$8.8 million	Covered in current approach
		Agricultural Technology Application Center (AgTAC)	$4.2 million	Covered in current approach
		Technology and Test Centers (TTC)	$2.1 million	Covered in current approach
		Builder Operator Certification	$1.5 million	Covered in current approach
		Chinese Language Efficiency Outreach	$0.8 million	Covered under evaluation of Information Programs (CG3)
		Education Training & Outreach	**$1.3 million**	**Evaluability Assessment**
		Energy Design Resources	$2.5 million	Exclude
		Mobile Education Unit	$1.4 million	Exclude
		Nonresidential Remote Energy Audits	$1.1 million	Exclude
		Outreach	$0.7 million	Exclude
SCG3503: SCG Education and Training Program	$6.5 million	SCG ERC	$6.5 million	Covered in current approach
SDGE3009: California Center for Sustainable Energy/Energy Resource Center Partnership	$4.1 million	SDG&E Energy Resource Center	$1.3 million	Covered in current approach
		California Center for Sustainable Energy	$2.8 million	Covered in current approach

H.1.1 PG&E Integrated Audits ($16 million, 43% of overall budget)

Program Overview

The Integrated Audit program provides energy audit options for all non-residential customers. The program offers a variety of audit options to small and medium business customers who have less than 200 kW demand. These include do-it-yourself audits, available online (English and Spanish versions), CD-ROM, mail-in, and interactive telephone formats, and traditional integrated energy audits performed by trained auditors. The audits provide recommendations and tips for energy conservation, energy efficiency, rebate program and incentive information, and links for qualifying measures.

The program offers Integrated Energy Audits to commercial, industrial, institutional and agricultural customers with between 200 kW and 500 kW demand. PG&E account representatives conduct the audits at facilities with standard lighting and HVAC equipment, and appliances.

Engineering consultants conduct audits in 500 kW and larger facilities, complex facilities and those facilities with special needs. These audits include: a survey of the processes, systems, equipment, buildings and support equipment; Analysis of no & low-cost investment opportunities in energy conservation, energy efficiency, demand response and self-generation; and the development of an integrated audit report with an implementation plan for the recommended best practices and energy projects. For each recommended measure, the integrated audit report includes a detailed analysis of energy and demand savings, energy cost savings, installed project cost, and simple payback period or return on investment.

Initial discussions with the CPUC indicated that integrated audits were not included in our original evaluation scope. While the Evaluation Team anticipates that this program effort generates significant energy savings because the audits are used to channel participants to resource acquisition programs, we expect that the savings resulting from the audits are accounted for under the evaluation of those programs either as directly channeled savings or participant spillover. However, the discovery that this was a large part of the overall Education and Training budget for PG&E lead us to feel that assessment of this program should be reconsidered. Given that we did not know how resource acquisition programs used audits in their evaluations, we recommended that the Evaluation Team conduct an abbreviated evaluability assessment.[159] This effort looked at two components: 1) how other evaluators are using audit information in their assessments across all IOUs, and 2) if these audits are not being assessed, a cost-effective way to determine indirect impacts from non-residential audits.

[159] A full evaluability assessment is not being recommended as it is broader in context and includes a look at program goals, performance criteria, and whether the goals are plausible as well as how data can be collected for a reasonable cost.

Findings and Recommendations

Based on a review of evaluation plans from the Commercial Facilities, Major Commercial, PG&E Agriculture and Food Processing, PG&E Fabrication, Process and Manufacturing, and Small Commercial Contract Groups, it is clear that energy savings attributable to integrated audits are accounted for to some degree in the evaluation of resource acquisition programs. While the language and terminology used to describe audits varies across programs, four of the five contract groups oversee at least one program with a PG&E audit component and all but one of the groups plans to evaluate their impact. One contract group indicates there are audits in the programs they are evaluating, but not within PG&E programs.

Within the Commercial Facilities Group, audits play an important role in determining what energy savings measures should be implemented in supermarkets and grocery stores (PGE2066), schools (PGE2077) and university campus housing (PGE2050). As such, the Group's evaluation plan specifies that the measures implemented as a result of audits will be verified and analyzed accordingly.

Similarly, the PG&E Fabrication, Process and Manufacturing Group is responsible for a wide range of programs in which audits are recognized as contributors to potential energy savings. For example, the Wastewater Process Efficiency Initiative (PGE2062) utilizes energy audits, while the Heavy Industry Energy Efficiency Program (PGE2042), California Wastewater Process Optimization Program (PGE2046), Refinery Energy Efficiency Program (PGE2064), AIM (Assessment, Implementation and Monitoring) of Compressed Air Systems (PGE2081), ECOS Air (PGE2084), and the Commercial and Industrial Boiler Efficiency Program (PGE2087) rely upon general audits. For all of these programs, the energy savings that flow from audits are addressed through an indirect gross impact analysis with special attention paid to documenting changes made based on audit recommendations, and engineering analysis of the measures implemented.

The Small Commercial Group's Retail Stores Program (PGE2003) is the only program to mention integrated audits by name and to evaluate them as part of a full impact assessment. According to the evaluation plan, there will be "a total of 500 customer surveys and 50 M&V on-sites to support billing analysis, net-to-gross analysis and engineering analysis."[160]

In contrast to the contract groups mentioned above, budgetary constraints excluded the consideration of indirect impacts, such as those from audits, from the PG&E Agriculture and Food Processing Group's evaluation plan. Likewise, while noting the important role of audits in encouraging program participants to implement non-incentivized energy saving measures, indirect impact analysis is a relatively low evaluation priority for the Major Commercial Group.

[160] Itron, Inc. "Small Commercial Contract Group Direct Impact Evaluation." December 14, 2007. Pp. 48.

Table 117: Summary of Audit Coverage by Evaluation Contract Group

Contract Group	Audit Coverage	Evaluation Plan
Commercial Facilities	3 programs featuring audits: • PGE2066, PGE2077 and PGE2050	PGE2066 and 2077 are covered by Protocol Guided Direct Impact Assessments in which program data is used to identify measures installed based on audit recommendations and a specific methodology is used to estimate energy savings from each technological improvement.
Major Commercial	While there are no PG&E programs within this group that claim energy savings from audits, evaluators acknowledge their potential behavioral impacts across all commercial programs.	Indirect savings from audits are a low priority for this evaluation.
PG&E Agriculture and Food Processing	3 programs featuring audits: • PGE2065, PGE2049, PGE2069	Due to budgetary constraints, the indirect effects of agriculture and food processing programs are not assessed. However, the potential impact of audits is noted.
PG&E Fabrication, Process and Manufacturing	7 programs featuring audits: • PGE2062, PGE2042, PGE2046, PGE2064, PGE2081, PGE2084, PGE2087	The effect of audits is captured through indirect gross impact analysis. Telephone surveys targeting those who received audits and technical assistance are planned.
Small Commercial	1 PG&E program featuring integrated audits: • PGE2003	A full impact assessment including customer surveys and onsite engineering visits is planned.

Thus, despite the mixed levels of attention, emphasis, and evaluation coverage, our evaluability assessment indicates that integrated audits are generally encompassed by other evaluation efforts. As a result, we did not include PG&E Integrated Audits in this evaluation.

H.1.2 SCE Education, Training, and Outreach ($1.3 million, 5% of overall budget)

Program Overview

The SCE program manager indicated that this component of the program budget represents the administrative budget allocated to the utility for the administration and management of the Education, Training and Outreach Program.

Findings and Recommendations

Because the budget allocated to this program effort is administrative in nature and used exclusively for the administration and management of the Education, Training and Outreach Program, we do did not include this line item in our evaluation.

Appendix I: Works Cited

ACEEE. (2004). *Online Guide to Energy-Efficient Commercial Equipment: 2004 Online Edition.* Retrieved from http://www.aceee.org/ogeece/ch1_index.htm

Acker, L., & Klein, G. (2006). Benefits of Demand-Controlled Pumping. *Home Energy* (September/October 2006), 18-23.

Architectural Energy Corporation and Fisher Nickel, Inc. (2002). *Design Guide 2 - Improving Commercial Kitchen Ventilation System Performance.* for the California Energy Commission.

Arthur D. Little, Inc. (1996). *Energy Savings Potential for Commercial Refrigeration Equipment - Final Report.* U.S. Department of Energy.

Brohard, G., Swierczyna, R., Sobiski, P., Smith, V., & Fisher, D. (2002). *Makeup Air Effects on Commercial Kitchen Exhaust System Performance.* California Energy Commission.

Brown, R. E., & Koomey, J. G. (2002). *Electricity Use in California: Past Trends and Present Usage Patterns.* Berkeley, CA: Lawrence Berkeley National Laboratory.

CALSEIA. (2009). *The Value Proposition of Solar Water Heating in California.* Rio Vista, CA: California Solar Energy Industries Association.

Carbon Trust. (2009). *Refrigeration: Maintenance*. Retrieved from http://www.carbontrust.co.uk/energy/startsaving/tech_refrigeration_maintenance.htm

Carrier. (2009). *Carrier website*. Retrieved from http://www.carrier.com

CEC. (2005). Solar Water Heating Calculation Form. In *Title 24, Part 6 of the California Code of Regulations: 2005 Building Energy Efficiency Standards.* California Energy Commission.

CEE. (2009). *CEE Premium Efficiency Motors Initiative - Efficiency Specifications.* Retrieved from CEE - Consortium for Energy Efficiency: http://www.cee1.org/ind/motrs/CEE_NEMA.pdf

DOE. (2009, December 16). *Average Retail Price of Electricity to Ultimate Customers: Total by End-Use Sector*. Retrieved December 30, 2009, from http://www.eia.doe.gov/cneaf/electricity/epm/table5_3.html

DOE. (2009, March 31). *Combustion*. Retrieved December 31, 2009, from http://www.energysavers.gov/industry/combustion.html#opp2

DOE. (n.d.). *Commercial Refrigeration Equipment Final Rule Technical Support Document, Appendix D.* Retrieved from Building Technologies Program: http://www1.eere.energy.gov/buildings/appliance_standards/commercial/refrig_equip_final_rule_tsd.html

DOE. (2001). *Determining Electric Motor Load and Efficiency.* U.S. Department of Energy - Motor Challenge.

DOE. (2009, December 29). *Natural Gas Summary*. Retrieved December 29, 2009, from http://tonto.eia.doe.gov/dnav/ng/ng_sum_lsum_dcu_SCA_a.htm

DOE. (2009). *Your Home - Benefits of Geothermal Heat Pump Systems.* Retrieved from U.S. Department of Energy - Energy Efficiency & Renewable Energy website: http://www.energysavers.gov/your_home/space_heating_cooling/index.cfm/mytopic=12660

DOE, EERE. (2009). *Insulate Hot Water Pipes for Energy Savings.* Retrieved from US DOE, EERE website: http://www.energysavers.gov/your_home/water_heating/index.cfm/mytopic=13060

DOE, EERE. (n.d.). *Reduce excess air used for combustion.* Retrieved from A Consumer's Guide to Energy Efficiency and Renewable Energy: Industry Plant Managers and Engineers: http://www.energysavers.gov/industry/combustion.html#opp2

DOE, FEMP. (2005). *Actions You Can Take to Reduce Heating Costs.* Retrieved from US DOE, EERE, FEMP website: http://www1.eere.energy.gov/femp/pdfs/om_combustion.pdf

EIA. (2004). Commercial Buildings Energy Consumption Survey 2003, Public Use Microdata. U.S. Department of Energy, Energy Information Agency.

EIA. (2009). Residential Energy Consumption Survey 2005 - Public Use Microdata. U.S. Department of Energy, Energy Information Agency.

EIA. (2009, February). Residential Energy Consumption Survey 2005 - Public Use Microdata: 2005. U.S. Department of Energy, Energy Information Agency.

EPA. (2008). *ENERGY STAR Building Upgrade Manual, Chapter 5.* U.S. Environmental Protection Agency.

EPA. (2003). *ENERGY STAR Program Requirements for Light Commercial HVAC.* Retrieved from http://www.energystar.gov/ia/partners/product_specs/eligibility/lchvac_elig.pdf

EPA. (2009). *ENERGY STAR Qualified Products*. (U.S. Environmental Protection Agency and U.S. Department of Energy) Retrieved from http://www.energystar.gov/index.cfm?fuseaction=find_a_product.

EPA. (2007). *Putting Energy into Profits: ENERGY STAR Guide for Restaurants.* Retrieved from http://www.energystar.gov/ia/business/small_business/restaurants_guide.pdf

FacilitiesNet. (2009). *Facilities Net website*. Retrieved from www.facilitiesnet.com

FCSI. (2006). *Commercial Kitchen Ventilation - "Best Practice" Design and Specification Guidelines.* Foodservice Consultants Society International.

Focus on Energy. (2009). *Commercial Refrigeration Incentives*. Retrieved from http://www.focusonenergy.com/Incentives/Business/commercial_refrigeration.aspx

Food Service Technology Center. (2004). *Design Guide 1 - Improving Commercial Kitchen Ventilation System Performance - Selecting & Sizing Exhaust Hoods.* for the California Public Utilities Commission.

Foster, R. E. (1998). Evaporative Air-Conditioning Contributions to Reducing Greenhouse Gas Emissions and Global Warming. *ASRAE 1998 Summer Meeting.* Toronto: American Society of Heating, Refrigeration and Air-Conditioning Engineers.

FSTC. (2009). *Life-Cycle and Energy Cost Calculators.* Retrieved from Food Service Technology Center: http://www.fishnick.com/saveenergy/tools/calculators/

Green Motors Practices Group. (2008). *Quality Motor Rewinding an Energy Efficiency Measure, Regional Technical Forum Submittal, Post-Approval Revision 1.1.* Regional Technical Forum Submittal.

Howe, B., Lovins, A., Houghton, D., Shepard, M., & Stickney, B. (1999). *Drivepower Technology Atlas Series, Volume IV.* Boulder, CO: E Source, Inc.

Hyderman, M., Taylor, S., Stein, J., Kolderup, E., & Hong, T. (2003). *Advanced Variable Air Volume System Design Guide.* California Energy Commission.

Itron, Inc. (2006). *2004-2005 Database for Energy Efficient Resources (DEER) Update Study.* California Energy Commission and California Public Utilities Commission.

Itron, Inc. (2006). *California Commercial End Use Survey (CEUS).* online database, California Energy Commission.

Itron, Inc. (2009). *CPUC Self-Generation Incentive Program: Eight-Year Impact Evaluation Revised Final Report.* California Public Utilities Commission.

Itron, Inc. (2009). *Database for Energy Efficient Resources (DEER), 2008 Update.* California Public Utilities Commission. Californa Energy Commission and California Public Utilities Commission.

James J. Hirsch and Associates. (n.d.). eQUEST 3.6.

KEMA. (2004). *California Statewide Residential Appliance Saturation Survey, 2003.* online database, California Energy Commission.

KEMA Inc. (2005). *CFL Metering Study - Final Report.* prepared for PG&E, SDG&E, and SCE.

Kreith, F., & West, R. E. (1997). *CRC handbook of energy efficiency.* CRC Press.

LBNL. (n.d.). *Glossary of Energy Terminology.* Retrieved from Home Energy Saver: http://hes.lbl.gov/hes/glossary_dat.html#Ins

Liu, M., & Claridge, D. E. (1999, August). The maximum potential energy savings from optimizing cold deck and hot deck reset schedules for dual duct VAV systems. *Journal of solar energy engineering* , 171-175.

Lutz, J. (2005). Estimating Energy and Water Losses in Residential Hot Water Distribution Systems. *(LBNL-57199)* .

Matela, D. (2007, September 1). Choosing the Right Air Filter and Filter Media. *HPAC Engineering* .

Matthews, K. (n.d.). *Facilities Managment Resources Sustainability - Improve Your VAV Control Strategy to Improve Your Bottom Line.* Retrieved from FMLink website: http://www.fmlink.com/ProfResources/Sustainability/Articles/article.cgi?USGBC:200805-22.html

Matthews, K. (n.d.). *Facilities Managment Resources Sustainability - Improve Your VAV Control Strategy to Improve Your Bottom Line.* Retrieved from FMLink website: http://www.fmlink.com/ProfResources/Sustainability/Articles/article.cgi?USGBC:200805-22.html

Moore, S. (2009, June 2). *Evaluation of Energy Savings for Strip Curtains - Presentation to the Regional Technical Forum.* Retrieved from Northwest Power and Conservation Council: http://www.nwcouncil.org/energy/rtf/meetings/2009/06/New%20Strip%20Curtain%20June%20RTF%20presentation%20FINAL%20090106pm.ppt

MREA. (2000). *Solar Hydronic Radiant Floor Heating Systems.* Midwest Renewable Energy Association.

Natural Resources Canada. (n.d.). RETScreen Clean Energy Project Analysis Software, Version 4. available at http://www.retscreen.net/ang/home.php.

New Buildings Institute. (1999). *Absorption Chillers.* Southern California Gas Company, New Buildings Institute.

NRCAN. (2009). *Walk-in Commercial Refrigeration.* Retrieved from http://oee.nrcan.gc.ca/industrial/equipment/commercial-refrigeration/index.cfm?attr=24

NREL. (n.d.). PV Watts - A Performance Calculator for Grid-Connected PV Systems - Version 1. National Renewable Energy Laboratory.

Oregon Department of Eenrgy. (n.d.). *Top Five Natural Energy Savings Opportunities in Six Industry Sectors.* Retrieved from OREGON.gov: http://egov.oregon.gov/ENERGY/CONS/Industry/topfivegassavings.shtml

PG&E. (1997). *Efficiency Improvements in Industrial Compressed Air Systems.* Pacific Gas and Electric Company.

Piper, J. (2009, March). *HVAC Maintenace and Energy Savings.* Retrieved from facilities net website: http://www.facilitiesnet.com/hvac/article/HVAC-Maintenance-and-Energy-Savings--10680

RLW Analytics. (2007). *2005 Coincidence Factor Study.* United Illuminating Company and Connecticut Light and Power.

Sezgen, O., & Koomey, J. (1998). *Interactions Between Lighting and Space Conditioning Energy Use In U.S. Commercial Buildings.* Berkeley, CA: Lawrence Berkeley National Laboratory.

SRCC. (2009). *Directory of SRCC Certified Solar Water Heating System Ratings.* Solar Rating and Certification Corporation.

Stein, J., & Hydeman, M. (2006). *July 13th, 2006 Workshop Report DDC to the Zone Level 1: VAV Zone Minimums.* Pacific Gas and Electric.

Toolbase. (2005). *Radiant Floor Heating - Dry System Hydronic.* Retrieved from http://www.toolbase.org/FieldEvaluations/FieldSummary.aspx?ContentDetailID=564

Trane. (2009). *Trane website*. Retrieved from http://www.trane.com

Watson, D. (2005, December). *Measure Information Template: California Building Energy Efficiency Standards Update for 2008.* Retrieved from 2008 Building Energy Efficiency Standards:
http://www.energy.ca.gov/title24/2008standards/prerulemaking/documents/2005-10-24+25_workshop/2005-12-19_WATSON_LBL.PDF

Webster, T. (2003). *Chiller Controls-related Energy Saving Opportunities in Federal Facilities.* Berkeley, CA: Lawrence Berkeley National Laboratory.

Zabrowski, D., Cowen, D., & Miner, S. (2003). *Refrigerated Prep Table Performance Testing.* Fisher-Nickel, Inc. and Food Service Technology Center.

APPENDIX J. UTILITY COMMENTS ADDRESSED IN FINAL REPORT

J.1 SDG&E Comments

Though SDG&E provided multiple comments, they dealt with two main issues. These comments are addressed as Comment #1 and Comment #2 and group the comments accordingly.

Comment #1

a) Prior to getting access to this report last week, we were not aware of your decision to evaluate this partnership program as two separate entities. The report states "The SDG&E Program consists of two distinct units, the San Diego Energy Resource Center (SDERC) and the California Center for Sustainable Energy (CCSE), which occupy the same location." This statement is somewhat misleading. As the 2006-2008 CPUC approved concept paper outlines, "The San Diego Energy Resource Center (SDERC) is a collaborative effort between two existing successful programs – SDREO's Energy Resource Center and SDG&E's statewide Education and Training Program. SDERC is a local (SDG&E Territory) program that provides energy efficiency information, education and outreach. The combined program will serve both the residential and non-residential sectors." Thus, the SDG&E Program is called the San Diego Energy Resource Center and it is a partnership between SDG&E and CCSE (formerly SDREO). It is true that SDG&E and CCSE are distinctly different organizations, but the SDERC is a product of both organizations and the designation of SDG&E as SDERC throughout the report and CCSE as CCSE does not make sense to us. We are both SDERC, and together share goals for the program.

b) On page 14 the report breaks out the Resource Center and California Center for Sustainable (CCSE) Energy out separately. In actuality, the overarching program is called the Energy Resource Center and SDG&E and CCSE are partners in this program

Response

Based on the interviews with staff at both the SDG&E and CCSE, it was decided early in the evaluation to treat the units as separate Centers. The reasoning for this approach is discussed in the first "Early Feedback Memo" dated May 19, 2008. Interviews with Center staff showed the Centers to have different missions and target markets. Through keeping the Centers separate for the evaluation was the right approach, it appears that the wrong labels were used in the evaluation. When SDERC is referenced, what is actually meant is SDG&E. All such references of this kind will be changed throughout the report.

The relevant section from the Early Feedback Memo, which explains the rational in greater detail, follows:

In the evaluation plan for the Education, Training and Outreach programs includes the eight physical Energy Centers. The locations of these Centers are shown in the last column of Table 118. Through the initial interviews, however, the Centers were assessed and it was determined that the SDG&E Program consists of two distinct units: SDG&E and CCSE occupying a single physical space.

Table 118: Energy Center Location and Utility Program Information

Energy Center	Utility	Utility Program	Location of Physical Center
Pacific Energy Center (PEC)	Pacific Gas and Electric	PGE2010 – Education and Training	San Francisco
Education and Training Center (ETC)			Stockton
Food Service Technology Center (FSTC)			San Ramon
Agricultural Technology Application Center (AgTAC)	Southern California Edison	SCE2513 – Education, Training and Outreach	Tulare
Customer Technology Application Center (CTAC)			Irwindale
Technology and Test Centers (TTC)			Irwindale
Energy Resource Center (SCG ERC)	Southern California Gas	SCG3503 – Education and Training	Downey
Energy Resource Center (SDERC)	San Diego Gas and Electric	SDGE3009 – CCSE Energy Resource Center Partnership	San Diego
California Center for Sustainable Energy (CCSE)			

Based on interviews with directors for each Center it is clear that while the CCSE and SDG&E offer their courses in the same physical space, they seem to have differing mission and key objective strategies. The SDERC targets the non-residential sector and mostly uses the Center for training courses and as a channeling mechanism for resource acquisition programs. The CCSE seems to have a much broader mission, "to create a sustainable energy future", placing an emphasis on three areas: (1) clean and renewable distributed generation; (2) green construction; and (3) energy efficiency. The CCSE targets a larger audience of both residential and non-residential sectors through multiple activities including: workshops; outreach at community events; technical consultations; a demonstration area exhibiting multiple energy efficient technology, green construction materials and distributed generation; and an energy efficiency tool lending library.

Through the ODC evaluation teams' initial exploration into the SDERC, it was discovered that the SDG&E and the CCSE schedule, market, plan and execute different activities funded by the SDGE3009 Program and often operate independently of one another including having separate administrative support staff, tracking databases and budgets. As such, ODC recommended to the CPUC that SDG&E and CCSE be treated as two independent Centers for evaluation. The table below summarizes how the SDG&E and the CCSE compare and contrast in relation to their program efforts. A more detailed description of each Center is provided in Appendices H and I.

Table 119: Comparing and Contrasting SDG&E and CCSE Efforts Funded by the SDGE3009 Program

SDERC	SDG&E	CCSE
Physical Space	SDG&E staff only uses the SDERC for classroom space.	CCSE staff offices and activities are located at the SDERC. The SDERC is maintained by CCSE.
Courses	System specific courses for contractors (LEED, HVAC, NATE Cert., Electrical Installation & Training, Title 24 Compliance, Preventing Compressor Failures, eQuest software), customized trainings for businesses (HVAC systems and central plant operations in hospitals or healthcare facilities, lighting and equipment in food service).	Specific Energy Efficient measures or technology for architects, designers & builders (lighting, exit signs, pathway systems, windows and compressors), Green building or green design workshops for architects and designers (selling green, green buildings and climate change, EE design training, EE operations, specifying green, energy economics and environment), Commissioning (building and retro) and renewables (Solar Water Heating).
Online Courses	Offered by SDG&E	Not offered by CCSE
Target Market	Non-residential focus primarily on contractors and commercial & industrial building operators/facilities.	Both a non-residential and residential focus for all activities at the Center, however the workshops focus primarily on non-residential: architects, designers, builders and some commercial and industrial building operators/facilities.
Technical Assistance	Informally through SDG&E account managers, encourages participation in tech assistance provided by CCSE	Formal technical assistance for energy efficiency options and financing through engineers on CCSE staff.
Energy Resource Library and Tool Lending Program	Encourages participation in the Library and Tool Lending	Manages the library and tool lending program.
Exhibit Area	Encourages participation in the Exhibit Area. Fills and maintains the marketing collateral for SDG&E programs.	Develops and maintains the demonstrations/exhibits and the marketing collateral for CCSE and 3rd Party programs.
Marketing and Outreach	Email blasts are edited and executed through SCG ERC, markets workshops through SDG&E's website. Attends a minimal number of events on an informal basis.	Manages own website for CCSE, website markets CCSE courses, manages newsletter and email blasts for CCSE courses and activities. Attends many events in the community on a formal basis.

Comment #2

a) On page 16 the report states that "CCSE had a goal of offering 150 training sessions according to IOU quarterly reports. As Table 17 shows, our evaluation concluded the Center conducted 74 sessions, falling short of their goal by 76 sessions." This information is incorrect. CCSE had a goal of offering 50 training sessions and therefore far exceed our goal as we provided a total of 84 workshops according to the quarterly reports.

b) Table 72 on page 133 of the Appendix A, is called SDG&E 2008 Performance Metrics, but the table above it is SCG 2006-2008 Performance Metrics. Is this table supposed to only reflect 2008 or all three years? In this table, the report state that CCSE had a goal of 150 onsite workshops and achieved 156. According to our Q4 Quarterly report we had a goal of 50 worksops and completed 84. We are confused about other elements of Table 72 as well, such as the goal of 135 for technical assistance since our records show that goal was 45.

c) In Volume One, Appendix A, Page 131, the authors state that "CCSE's goal of 150 training sessions fell short." However, According to our scope of work with SDG&E for January 1, 2006 – December 31, 2008, we were "to provide a total of 50 workshops on energy efficiency. SDG&E planned to provide a minimum of 35-40 workshops per year."

d) On page 16 the report states that "CCSE had a goal of offering 150 training sessions according to IOU quarterly reports. As Table 17 shows, our evaluation concluded the Center conducted 74 sessions, falling short of their goal by 76 sessions." This information is incorrect. CCSE had a goal of offering 50 training sessions and therefore far exceed our goal as we provided a total of 84 workshops according to the quarterly reports.

e) On page 16 of Volume Two, the authors state that "CCSE had a goal of offering 150 training sessions according to IOU quarterly reports." In actuality the Q4 2008 quarterly report filed with the CPUC states that CCSE completed 84 workshops cumulatively against a goal of 50 and that SDG&E completed 34 workshops cumulatively against a goal of 25. We do not understand than how the report arrived at a goal of 150 for CCSE and a completion of 74 based on the quarterly reports or a goal of 50 for SDG&E and a completion of 133

Response

The Centers' goals were misinterpreted as being yearly goals whereas they are actually the goals for the entire three-year evaluation period. ODC has adjusted the tables accordingly and both SDG&E and CCSE exceeded their goals in terms of number of training sessions held.

J.2 SCE and PG&E Comments

Comment #1

Can you please provide clarification on how you extrapolate the energy savings from your energy center samples to the general energy center participants? For the third party report, you were able to include the actual worksheet in the report. Can you please provide that level of details for this evaluation?

Response

ODC did not present this information for ease of reporting. However, these tables will be added to Volume II of the final report.

Comment #2

We noticed in the individual energy center calculation of gross versus net energy analysis, different CCI values may be used for energy, demand and therm savings. Can you explain why?

Response

The same number was used for energy, demand and therm savings. We assume you compared the ratio of gross to net savings for each and came up with different ratios, which gives the appearance of different CCI values being used. The different ratios are due to different number of survey respondents who have energy, peak, and therm savings and not different ratios being applied. For example, in Table 50 on p. 91, ODC calculated HVAC savings for 70 participants. The actions of the 70 varied and not all realized energy, demand and therm savings. Some only saved kWh, some therms, etc. Therefore, one cannot directly compare the ratios of the gross and net savings for the totals to estimate the CCI that was applied.

This information will be added to the text to make it clearer that though there is at least one category of savings for each participant for whom savings were calculated, not all have savings in each category.

Comment #3

As you have stated, there are great deal of uncertainty surrounding these indirect savings estimates giving the characteristics of the participants. In fact, you have observed significant variability in the savings derived. What do you see as the risks of generalizing these savings on a going forward basis? And, how can we mitigate them from a program design perspective?

Response

The CPUC is confident in ODC's method for calculating energy savings for end-users. However, as noted in the report, the savings reported likely underestimate total savings due to the challenges in estimating savings for market actors. ODC discusses these challenges and their characterization of the savings achieved by some typical market actors in Section 10.

Program implementers need to consider the overarching goals of the Energy Centers—if energy savings become the main goal of the Energy Centers (a position the evaluation team does not support), then substantive changes to the portfolio of training efforts should be considered. For example, the focus of the trainings may need to shift to end uses that generate a great deal of energy savings per installation, as one energy saving action for a large energy consuming piece of equipment can overshadow hundreds of changes in lighting fixtures.

As an indirect impact program, energy savings is not the sole criteria for program success. As is noted on p. 5 of Volume I, that, "Decision 05-04-051 (April 21, 2005) directs the following for Education and Training Programs:

"For schools, universities and other training programs, the performance basis should be based on: a) attitude, awareness and knowledge of students; b) reasonable impacts on energy savings or intention to act based on students' actions."

Thus, this evaluation had two main charges: identify changes in attitudes, awareness, and knowledge of energy efficiency, and quantify net energy savings for key components of the programs. "

The CPUC believes that program reach, participant knowledge gain and attitude change are important criteria for program effectiveness.

Comment #4

Given the finding that participant characteristics are critical to behavior outcome, you have recommended to collect more detailed program tracking data for the statewide Energy Center Program. Can you be more explicit on the essential characteristics that we need to pay attention to and why? We are looking for a deeper level explanation than what has been provided in the report.

Response

ODC recommends creating a shared registration system across all California Energy Centers to better track course participants who take multiple courses at more than one center. This centralized registration system would assign each participant an identification number so Centers can track the course taking behavior of participants. This would give the Centers more frequent information on how participants are using the Centers for workforce education and training.

ODC recommends collecting additional information on the participant's reason for taking the course (i.e., for use at work or in their home), profession, years working in profession, and existing knowledge of the course topic. Ideally, this last item could be compared to a post-training follow-up assessment of knowledge gain due to the course. This information would allow the Centers to know who they are reaching, how people are using the Centers, and the effectiveness of the training.

More detailed recommendations on this subject are provided on pp. 125-126 of Volume I.

Comment #5

It would seem that participant characteristics in combination of selected course offerings really drove the indirect energy savings (i.e., more than just the characteristics of the participants). What kind of conclusion can we draw from your study findings in terms of offering more high-energy impact classes versus fewer lower-energy impact classes? And how would this kind of approach affect the overall curriculum design of the energy centers, which are set out to provide comprehensive coverage for participants? Is that the outcome we really want to achieve?

Response

The response to this comment is similar to the response to comment #3 above. ODC recommends that energy savings is just one goal of the Centers and just one among many performance metrics. As the comment indicates, providing comprehensive training is another worthy goal. The evaluation showed that the Centers provided a large number of courses on a wide variety of subjects. Course participants reported that comparable training was not easily available or affordable. Moreover, the evaluation showed that the training was effective at increasing participants' knowledge of energy efficiency actions and energy efficiency opportunities. The Centers are providing a service that is not entirely captured by short term energy savings.

ODC recommendations in Section 12 also address this comment. ODC recommends on p. 124 that program goals and performance metrics are acknowledged and clearly defined by the utilities and the CPUC so that there is a shared understanding of the goals. In addition, on pp. 126 ODC recommends that future evaluations continue to measure more than just energy savings. Finally, on p. 127 ODC recommends that future evaluations focus on market actors. The impact of the Energy Centers on market actors is more difficult to capture, but likely even larger than what we identified for end-users. The impact also likely takes place over a longer time horizon and has the potential to transform local markets.

Comment #6

Appendix E, CCI, we have the a few concerns and thoughts about the CCI design: (In this section, you will find a series of comments from several M&E team members)

We do question if concept 1 and concept 2 are truly independent from each other. Perhaps the other alternative is to combine the value concept 1 and 2, then compare to concept 3. The CCI is also vulnerable to self-selection bias which cannot be avoided. In the case of Energy Centers where the indirect impact energy savings can be substantial, what other kinds of triangulation methodology should we consider?

Response

Concepts 1 and 2 are correlated and are viewed as a strength as it indicates that index items do measure similar concepts. As noted, in the test of index reliability, the Cronbach's alpha of the items was 0.85.

For future evaluations, ODC suggests asking some additional questions on alternative reasons for taking action as well as failure to do so. As an indirect impact program, the information provided by the training may have been the tipping point for taking an action that was already being considered. Inquiring about intentions to act prior to participating in the training and other factors that influenced the action would provide an additional estimate of the role the training played in the decision.

Comment #7

Concern for reliability and validity of the CCI--all the questions seem to be overlapping, so that raises the reliability score. The attempt showing the index is valid consists of comparing the entire index with responses to one of the components of the index: it's no wonder that they look alike. This is just another measure of reliability (that the questions measure the same thing) not a measure of validity (that the questions are measuring the critical concept).

Response

Establishing the validity of the index was a difficult task and one that is shared by -evaluators attempting to create a measure that can be used to estimate net savings. ODC did attempt to establish the predictive validity of Concept 2 of the CCI, which is the most heavily weighted concept by examining the association between Concept 2 and taking energy saving action. They showed that attitude change, as measured by Concept 2, is associated with taking action (Results in Table 86 of Appendix E, Volume I).

Comment #8

The first concept: "newness of information" is based on an assumption that new information is necessary to produce cognitive change. We don't completely agree with rationale for the "Newness" parameter, and that exposure to new information is necessary to produce cognitive change that leads to action. In many cases, cognitive change and subsequent behavioral changes ARE a result of repeated exposure in which case, the information is inherently NOT new. It may actually be the case that hearing the message for the 5th time from multiple sources leads to increased credibility (and strength) of the message and thus eventual the behavior change – rather than hearing the message for the first time. This will be especially true if the action we are looking for involves a bigger commitment on the part of the respondent (financially or behaviorally). The CCI did ask the follow-up question " Although you don't think .... Did your participation in the course move you ... to implementing efforts to save energy...?" This follow-up gets closer to ascertaining a potential effect, but it is asked and lumped with, given equal weight w/ the first question – yet these are very different types of questions. The first question is an indirect question asked with the assumption that new=>cognitive change, but respondents are not asked if they thought differently, or implemented change based on the new information as they are in the follow-up question. This is presumably handled in the next battery of questions. We also do not see the benefit of asking as a dichotomous value. For most respondents, neither of these questions can be answered as a simple yes or no (e.g., there was some new info and some not new info) – and they would yield more accurate responses/data if they were scaled as they did the next battery of questions. The fact that they applied considerably less weight (.1) to this concept provides some indication that they acknowledge that it is a less sound predictor (relevancy) in their model.

Response

This comment is a fair criticism of the CCI and its use for the evaluation of education and training programs. ODC, with the CPUC's oversight, developed the CCI for use in the evaluation of two programs in addition to this one: (1) the Statewide Marketing and Outreach Programs and (2) Education & Information Programs. The intention was to have an index that could be used across all three indirect impact programs. Certain aspects of the CCI are a better fit for the evaluation of informational programs than training programs. Many of the course participants were professionals who quite possibly had already been exposed to information on the course materials through their work. Asking a question about the degree to which the course information was new would have provided greater variability in the responses. Indeed, ODC found that nearly all course participants (95%) said that at least some of the course information was new. This concept does not do a good job distinguishing participants and therefore cannot play much of a role in the index. The low weight assigned to it also ensured that it did not as and it wsa believed that other factors were more important.

The comment proposes that hearing the same information multiple times could have greater influence on behavior change than hearing it for the first time. Characteristics of the information source, such as perceived level of expertise and trustworthiness, likely also impact whether or not someone acts on the information. These are interesting empirical questions but not the focus of this evaluation. These questions would be worthy subjects of future evaluations.

Comment #9

The 2nd concept is built on what appear to be four reasonable questions aimed at getting at the role of the course in inducing (1) cognitive change (2) desire to make changes (3) awareness (4) strength/value of venue. I do think, however, that awareness should have been asked first, AND that there probably should have been "intent" to make changes question – which is different than "desire". It would seem these are attempts to get at intent but asked the question in a strange / awkward way that asks folks about their desire to make changes. Asking "…did it cause you to want to make ee changes" is VERY different to than asking "… did it increase your likelihood to make changes". E.g., I want to change my light bulbs is different than I plan to change my light bulbs.

Response

We agree that these questions are about the *desire* to make energy efficiency changes and not the *intent* to make changes. This was deliberate the desire was to measure changes in cognition. That is, how people think about taking energy efficiency actions. The hypothesis was that cognitive change leads to action or intent to act in the future if insufficient time has passed for actions to be taken. Later in the survey it was asked whether the respondent had acted, and if not, intended to do so in the future. The results presented in Table 86 of Appendix E of Volume I show that attitude change as measured by Concept 2, is in fact, related to taking energy saving action.

Comment #10

Concept 3 was based on one direct influence question – The one issue we have with the way this concept is defined is in that folks are given ONE opportunity to give a general level of influence on what appear to potentially be multiple changes that they may or may not have done based on information learned via the course. This seems like a very simplistic and imprecise way to measure the programs direct influence. It seems that we need to understand both how many changes were made AND the extent to which the decisions to make those changes were impacted by having participated in the course. In other words, based on their model if a person made one of a possible 20 EE changes but the program REALLY influenced (score a 7) that one change it would be identified as a higher impact than a person who made 20 changes with a more moderate report (score a 5) of influence. These are very different outcomes and both very meaningful.

Evaluation Team Response

ODC considered asking about the influence of the course on each action taken but it would not have been practical. It was necessary to ask the respondent numerous detailed questions to estimate energy savings. ODC did not want to add to the respondent burden by attempting to produce different net savings estimates for each action taken.

Additionally, even if it were practical, there was concern that that attempting to estimate net savings for each action taken as a result of an indirect impact program would give a false sense of precision of the savings estimates. Based on knowledge of the way people learn, we believed that people can not differentiate with specificity the exact influence on one action taken versus another action taken from the same course. As a result, it would not be possible to measure net savings for each action reliably.

This was borne out in the research as many participants took multiple courses and multiple actions. In ODC's in-depth interviews with participants, it was found that course participants do not associate specific courses with specific actions in their minds. They know they attended training sessions and they know they learned things that they apply in different areas of their work. They can give details about the changes they made after they took the training. They can also talk about how the training influenced their decision to make the changes. However, they tend to group multiple trainings and multiple actions together in their thinking about the Energy Center courses, as one would expect from educating a person about several concepts within a course or several courses.

Comment #11

In Appendix E, for concept 2, you talked about "mean" of the four survey questions, do you really mean to say "average" here? Your formula in that section indicated "average".

Response

Average can refer to "mean, median, or mode", we used "mean" to be more specific.

Comment #12

There are sufficient questions and concerns for CCI design and implementation, we would like to request a workshop to jointly explore the ramification of CCI so all can fully appreciate the implication of its usage in the portfolio of indirect impact programs which may range from Marketing Education Outreach to Information, Education, Training and Outreach (i.e., Workforce Education Training and Outreach) programs.

Response

The CPUC would welcome a venue that provides this type of interaction regarding all aspects of the CCI.

Comment #13

In the third-party report, you have provided references on how the CO2 reduction values that are derived using the DOE data. Can you please include that reference in this report as well?

Response

Yes, this reference will be added to Volume II.

Comment #14

It would seem that the indirect savings estimate for market actors could be significant. And recommendations are made to further that research. Is this research something we can expect during early part of the 2010-2012 program cycle so the inputs could be used for 2013 and beyond program plans?

Response

This is an evaluation aspect that can be discussed with the CPUC for analysis in the 2010-2012 program evaluations.

Comment #15

It is most unfortunate that BOC classes weren't subject to the same high level of study investment as the Energy Centers. The BOC class offerings are much like the classes offered by the Energy Centers. We really missed an opportunity to quantify indirect energy savings potential here. However, we do appreciate the detailed information you have provided as a case study.

Likewise, it is equally unfortunate; Tool Lending Library (TTL) did not receive the extra analysis. Likewise, TTL like services can help push the participants learning into the higher stages of learning, according to learning principles outlined in adult learning, thus making behavior changes possible. Again, we appreciate the extra information you provided in the case study.

Response

We are glad that the case studies were informative.