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2004/2005 Statewide Express Efficiency and Upstream HVAC Program Impact Evaluation

04-05 Program ID#s 1133, 1503, 1120, 1508, 1243, 1178, 1179, 1344, 1334, 1251

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Executive Summary

This Executive Summary highlights the findings from the impact evaluation of the 2004-05 Statewide Express Efficiency program (hereafter referred to as the "Express program") and the Upstream HVAC/Motors program (referred to as the "Upstream program"). The Express program is a business prescriptive retrofit program funded by California utility customers and administered under the auspices of the California Public Utilities Commission (CPUC). Express Efficiency is run on a consistent, statewide basis by the four investor-owned utilities (IOUs): Pacific Gas and Electric Company (PG&E), San Diego Gas and Electric Company (SDG&E), Southern California Edison Company (SCE) and Southern California Gas Company (SCG). The Express program offers financial incentives (rebates) to qualifying customers for installing selected energy-efficient technologies. The Upstream program is offered by the three electric IOUs and seeks to change distributors' stocking practices by encouraging manufacturers and distributors to maintain sufficient inventories of high efficiency air conditioning (AC) equipment and motors so that they are available at the time the customer is making the buying decision, typically upon failure of existing equipment. Incentives are paid to participants upon proof that a qualifying model has been delivered.

The impact evaluation of the 2004-05 Express and Upstream programs addresses several objectives. The following study: (1) verifies energy savings, (2) calculates ex post savings, (3) conducts a net-of-free-ridership analysis, and (4) estimates the overall energy and demand savings of the programs. A process evaluation of the Express and Upstream programs was also completed, which: (5) assesses customer behavior, (6) performs a market opportunities assessment, (7) conducts a vendor/distributor assessment, and (8) benchmarks program success. Results from the process assessment are presented in a separate report.

1.1 Program Activity, Realization Rates and NTFR Ratios

Table 1-1 lists the IOU program specific energy savings, the program realization rates and the net of free ridership (NTFR) ratios. The table also sums up across IOUs and programs to determine the statewide energy savings, realization rates, and net of free ridership ratio for the program.

Table 1-1: Summary of 2004-05 Express Efficiency and Upstream HVAC/Motors Programs Energy Savings Accomplishments, Realization Rates, and Net of Free Ridership Ratios

Program Name and Funding Source	Program Number	MWh Gross Ex Ante	MWh Gross Ex Post	MWh Net Ex Ante	MWh Net Ex Post	MWh Realization Rate*	MWh Net Realization Rate**	NTFR Ratio
PGE Express PGC	1133-04	219,253	101,978	210,483	76,043	0.35	0.36	0.75
PGE Express Procurement	1503-04	225,787	102,653	216,355	72,425	0.32	0.33	0.71
PGE Upstream PGC	1120-04	11,579	8,042	11,116	5,593	0.48	0.50	0.70
PGE Upstream Procurement	1508-04	15,538	11,400	14,917	7,960	0.51	0.53	0.70
SCE Express PGC	1243-04	175,351	101,461	168,337	76,797	0.44	0.46	0.76
SCE Express Procurement	1178-04	124,465	71,972	119,487	50,375	0.40	0.42	0.70
SCE Upstream Procurement	1179-04	39,256	19,654	37,686	13,891	0.35	0.37	0.71
SDGE Express PGC	1344-04	66,309	37,598	63,657	28,033	0.42	0.44	0.75
SDGE Upstream Procurement	1334-04	6,028	2,963	4,823	2,073	0.34	0.43	0.70
Total		**883,567**	**457,720**	**846,858**	**333,190**	**0.38**	**0.39**	**0.73**

* MWh realization rate = net ex post MWh / gross ex ante MWh

** MWh net realization rate = net ex post MWh / net ex ante MWh

Figure 1-1 illustrates the IOU and program specific gross ex ante and the net ex post energy savings. For the two year program cycle, the IOUs reported first year gross ex ante energy savings of 883,567 MWh. Following the on-site verification, the billing analysis, and the engineering analysis, the gross ex post energy savings were 457,720 MWh. The evaluation included a net of free ridership analysis which led to a net ex post energy savings of 333,190 MWh. Comparing the gross ex ante savings with the net ex post savings, the energy realization rate for the programs was 38% and the net realization rate was 39%. The net-of-free-ridership ratio was 73%.

Figure 1-1: 2004-05 Express Efficiency and Upstream HVAC/Motors Programs Gross Ex Ante and Net Ex Post Energy Savings by IOU and Program

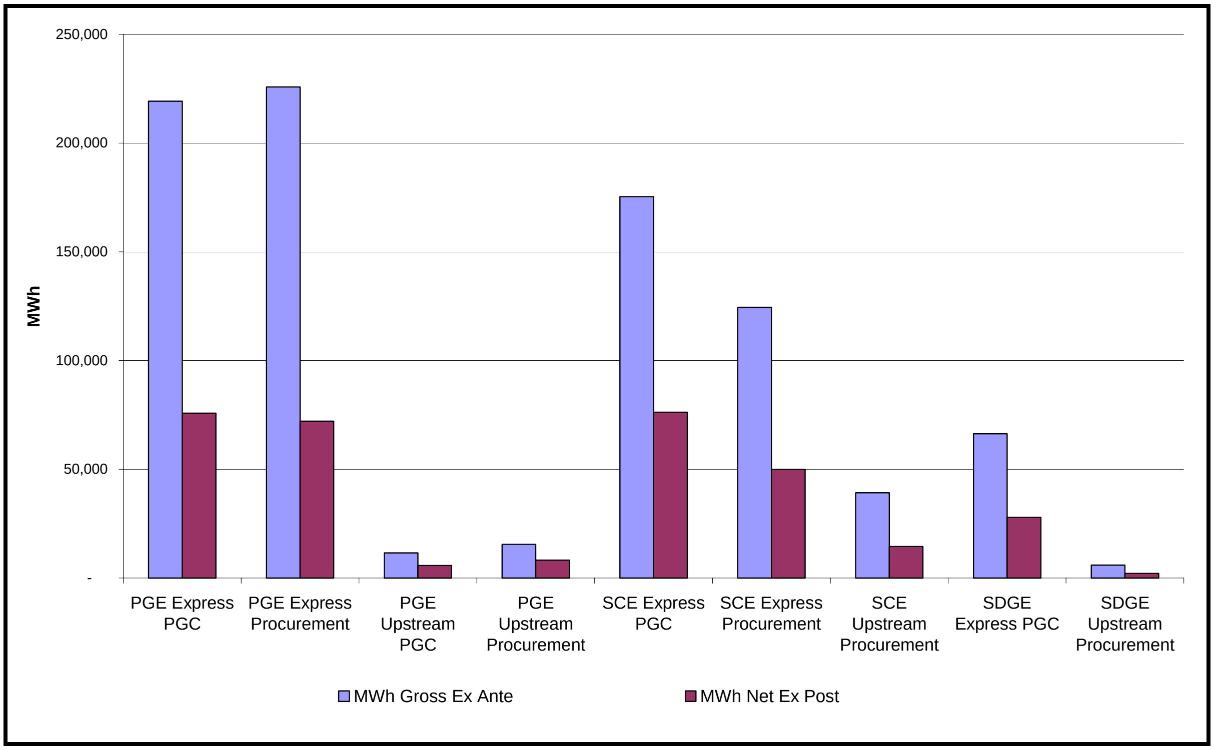


Table 1-2 lists the IOU program specific demand savings, the program realization rates and the net of free ridership ratios. ** MW net realization rate = net ex post MW / net ex ante MW

Figure 1-2 illustrates the IOU and program specific gross ex ante and the net ex post demand savings. For the two year program cycle, the IOUs reported first year gross ex ante demand savings of 163.9 MW. The evaluation included a net of free ridership analysis which led to a net ex post demand savings of 103.5 MW. Comparing the gross ex ante savings with the net ex post savings, the demand realization rate for the programs was 63% and the net realization rate was 66%. The net-of-free-ridership ratio was 75%.

Table 1-2: Summary of 2004-05 Express Efficiency and Upstream HVAC/Motors Programs Demand Savings Accomplishments, Realization Rates, and Net of Free Ridership Ratios

Program Name and Funding Source	Program Number	MW Gross Ex Ante	MW Gross Ex Post	MW Net Ex Ante	MW Net Ex Post	MW Realization Rate*	MW Net Realization Rate**	NTFR Ratio
PGE Express PGC	1133-04	30.4	27.1	29.2	20.6	0.68	0.70	0.76
PGE Express Procurement	1503-04	33.4	30.7	32.0	22.4	0.67	0.70	0.73
PGE Upstream PGC	1120-04	6.0	3.7	5.7	2.7	0.45	0.46	0.71
PGE Upstream Procurement	1508-04	8.3	5.3	8.0	3.8	0.45	0.47	0.71
SCE Express PGC	1243-04	34.6	31.0	33.2	23.8	0.69	0.72	0.77
SCE Express Procurement	1178-04	22.6	20.2	21.7	15.4	0.68	0.71	0.76
SCE Upstream Procurement	1179-04	14.8	8.8	14.2	6.3	0.42	0.44	0.71
SDGE Express PGC	1344-04	10.4	9.1	9.9	7.1	0.69	0.72	0.78
SDGE Upstream Procurement	1334-04	3.4	2.1	2.7	1.5	0.44	0.55	0.72
Total		**163.9**	**138.0**	**156.7**	**103.5**	**0.63**	**0.66**	**0.75**

* MW realization rate = net ex post MW / gross ex ante MW

** MW net realization rate = net ex post MW / net ex ante MW

Figure 1-2: 2004-05 Express Efficiency and Upstream HVAC/Motors Programs Gross Ex Ante and Net Ex Post Demand Savings by IOU and Program

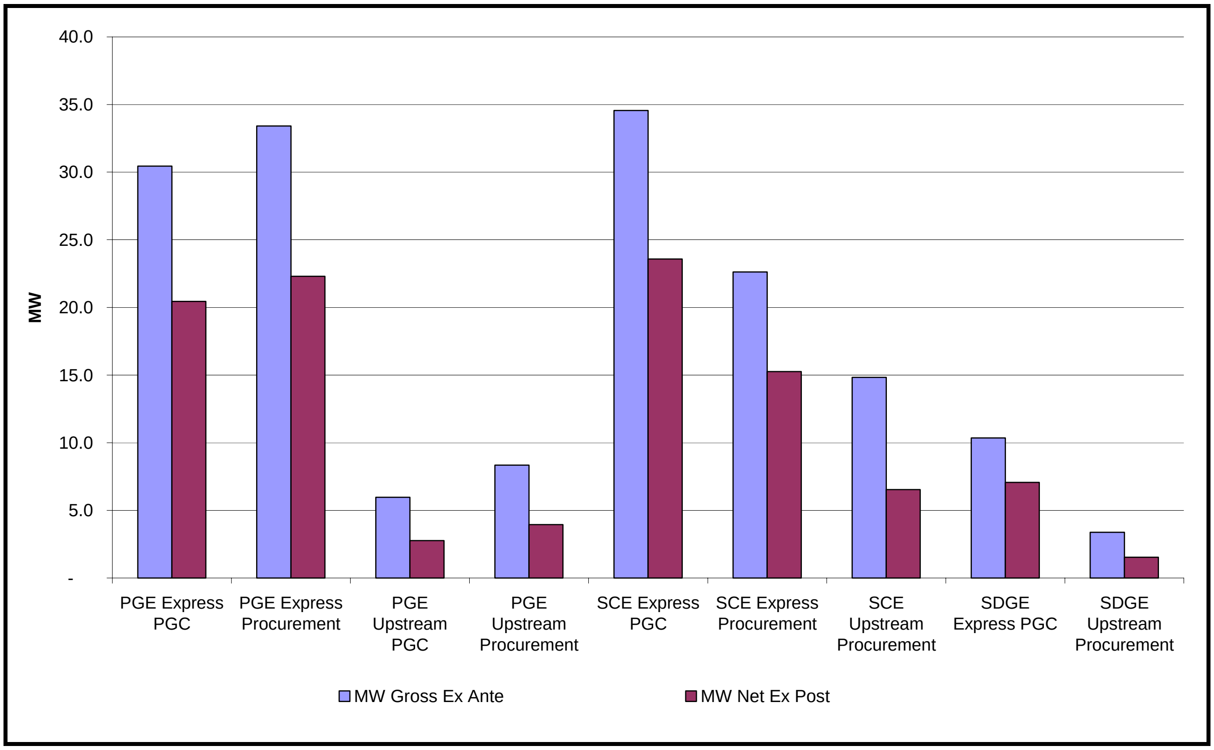


Table 1-3 lists the IOU program specific natural gas savings, the program realization rates and the net of free ridership ratios. Figure 1-3 illustrates the IOU and program specific gross ex ante and the net ex post therm savings. For the two year program cycle, the IOUs reported first year gross ex ante demand savings of 16,518,956 therms. Following the on-site verification and the engineering analysis the gross ex post therm savings were 7,762,386 therms. The evaluation included a net of free ridership analysis which led to a net ex post demand savings of 3,922,264 therms. Comparing the gross ex ante savings with the net ex post savings, the natural gas realization rate for the programs was 24%. The net-of-free-ridership ratio was 51%.

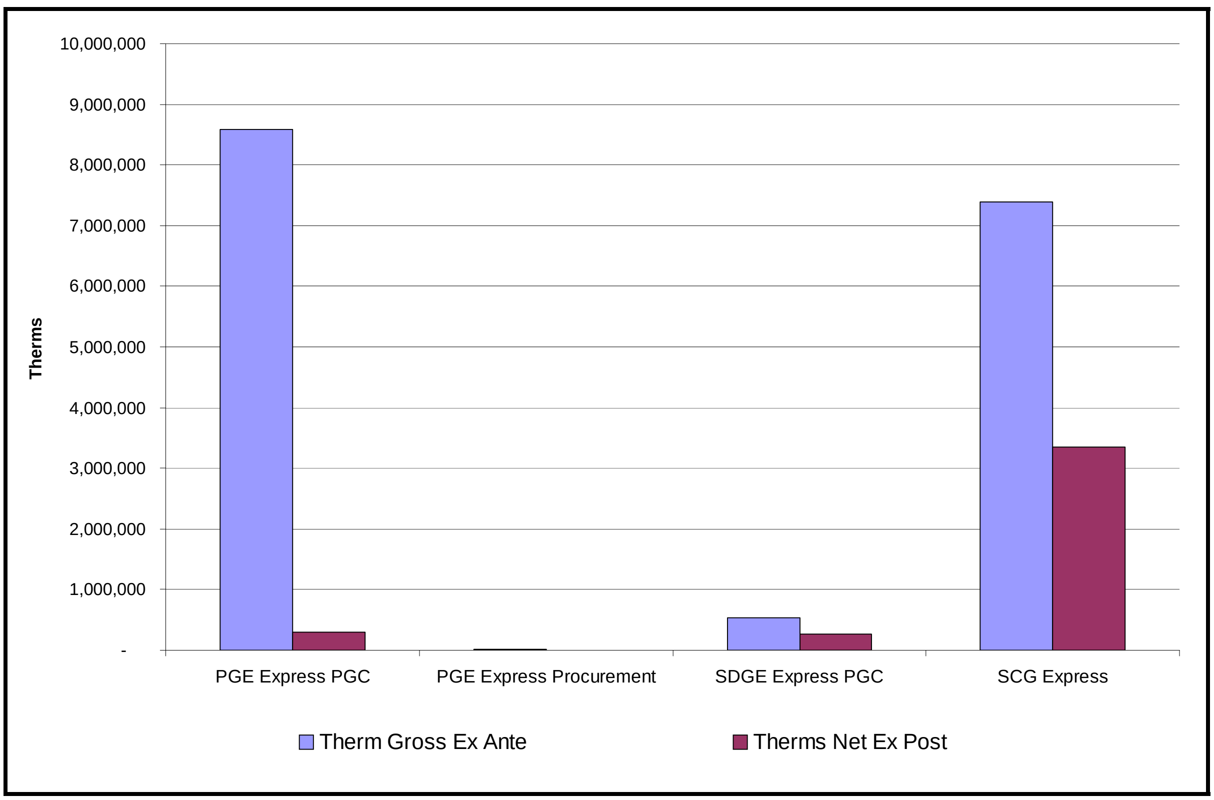
Table 1-3: Summary of 2004-05 Express Efficiency Programs Therm Savings Accomplishments, Realization Rates, and Net of Free Ridership Ratios

Program Name and Funding Source	Program Number	Therms Gross Ex Ante	Therms Gross Ex Post	Therms Net Ex Ante	Therms Net Ex Post	Therm Real. Rate*	Therm Net Real. Rate**	NTFR Ratio
PGE Express PGC	1133-04	8,589,628	506,684	8,246,039	294,061	0.03	0.04	0.58
PGE Express Procurement	1503-04	8,980	8,980	8,980	6,735	0.75	0.75	0.75
SDGE Express PGC	1344-04	532,416	508,000	511,120	269,354	0.51	0.53	0.53
SCG Express	1251-04	7,387,931	6,738,722	7,092,414	3,352,114	0.45	0.47	0.50
Total		**16,518,956**	**7,762,386**	**15,858,553**	**3,922,264**	**0.24**	**0.25**	**0.51**

* Therm realization rate = net ex post therms / gross ex ante therms

** Therm net realization rate = net ex post therms / net ex ante therms

Figure 1-3: 2004-05 Express Efficiency Gross Ex Ante and Net Ex Post Therm Savings by IOU and Program



There were a number of factors that lead to the relatively low overall realization rates. Below, a number of key measures are listed with a brief description of how some of the interim analysis steps (e.g., engineering analysis, billing analysis, NTFR analysis, etc.) affected the overall results.

CFLs were the single largest measure, contributing 33% of the overall kW and 35% of the overall kWh savings.

- Engineering results based on lighting logger monitoring reduced kWh energy saving estimates by 14%
- Billing analysis results, which incorporated the adjusted engineering estimates, reduced kWh energy savings by 49%
- EUL analysis reduced lifetime kWh energy savings by 50%
- Verification results reduced demand savings by 15%
- NTFR results reduced net savings by 16%

Overall, net energy savings for CFLs were reduced by 73% and demand savings by 28%. Lifetime net energy savings were reduced by 82%.

Linear fluorescent, delamping, and related measures contributed 23% of the overall kW and 20% of the overall kWh savings.

- Engineering results based on lighting logger monitoring reduced kWh energy saving estimates by 27%
- Billing analysis results, which incorporated the adjusted engineering estimates, reduced kWh energy savings by 14%
- Verification results reduced demand savings by 9%
- NTFR results reduced net savings by 20%

Overall, net energy savings for linear fluorescent, delamping and related measures were reduced by 50% and demand savings by 27%.

Occupancy sensors contributed 11% of the overall kW and 7% of the overall kWh savings.

- Billing analysis results reduced kWh energy savings by 34%
- Verification results reduced demand savings by 10%
- NTFR results reduced net savings by 20%

Overall, net energy savings for occupancy sensors were reduced by 47% and demand savings by 28%.

Other lighting measures contributed 3% of the overall kW and 4% of the overall kWh savings.

- Billing analysis results reduced kWh energy savings by 23%
- Verification results reduced demand savings by 10%

- NTFR results reduced net savings by 20%

Overall, net energy savings for other lighting were reduced by 40% and demand savings by 27%.

Programmable thermostats were the largest contributor to therm savings, contributing 57% of the overall therm and 13% of the overall kWh savings.

- Engineering analysis reduced therm and kWh savings by 98%
- Billing analysis, which incorporated the adjusted engineering estimates, increased kWh savings by 700%
- Verification results reduced therm savings by 9%
- NTFR results reduced net savings by 20%

Overall, net energy savings for other programmable thermostats were reduced by 99% for therm savings and 86% for kWh savings.

Central air conditioners contributed 18% of the overall kW and 6% of the overall kWh savings.

- Engineering analysis reduced kWh savings by 31% and demand savings by 35%.
- NTFR results reduced net savings by 22%

Overall, net energy savings for central air conditioners were reduced by 46% and demand savings by 51%.

Other HVAC measures contributed 3% of the overall kW and 3% of the overall kWh savings. Net kWh energy savings were reduced by 43% and demand savings were reduced by 36%, primarily due to NTFR results, which reduced net savings by 39%.

Strip curtains contributed 3% of the overall kW and 4% of the overall kWh savings.

- Engineering analysis results reduced kWh energy savings by 68%
- Verification results increased demand savings by 23%
- NTFR results reduced net savings by 52%

Overall, net energy savings for strip curtains were reduced by 85% and demand savings by 41%.

Door gaskets contributed 1% of the overall kW and 1% of the overall kWh savings.

- Engineering analysis results reduced kWh energy savings by 11%
- Billing analysis results, which incorporated the adjusted engineering estimates, reduced kWh energy savings by 5%
- Verification results decreased demand savings by 14%
- NTFR results reduced net savings by 21%

Overall, net energy savings for door gaskets were reduced by 33% and demand savings by 32%.

Net savings for ***Other refrigeration measures*** were reduced by 69%, primarily due to a reduction in NTFR results by 70%

Greenhouse heat curtains contributed 18% of the overall therm savings.

- Engineering analysis reduced therm and therm savings by 15%
- NTFR results reduced net savings by 41%

Overall, net therm savings for other greenhouse heat curtains were reduced by 50%.

Water heating measures contributed 15% of the overall therm savings.

- Engineering analysis increased therm and therm savings by 11%
- NTFR results reduced net savings by 52%

Overall, net therm savings for other greenhouse heat curtains were reduced by 47%.

2

Introduction

2.1 Background

This is the final report prepared for the 2004-05 Statewide Express Efficiency (hereafter referred to as the "Express program") and the Upstream HVAC/Motors Program (referred to as the "Upstream program"). The Express program is a business prescriptive retrofit program for customers with peak demand less than 500 kW, funded by California utility customers and administered under the auspices of the California Public Utilities Commission (CPUC).[1] Express Efficiency is run on a consistent, statewide basis by of the four investor owned utilities (IOUs): Pacific Gas and Electric Company (PG&E), San Diego Gas and Electric Company (SDG&E), Southern California Edison Company (SCE) and Southern California Gas Company (SCG). The Express Efficiency program offers financial incentives (rebates) to qualifying customers for installing selected energy-efficient technologies.

The Upstream program is offered by the three electric IOUs and seeks to change distributors' stocking practices by encouraging manufacturers and distributors to maintain sufficient inventories of high efficiency air conditioning (A/C) equipment and motors so that they are available at the time the customer is making the buying decision, typically upon failure of existing equipment. Incentives are paid to participants upon proof that a qualifying model has been delivered.

This evaluation of the PY0405 Express and Upstream programs offer both retrospective examination and prospective guidance in shaping current rebate programs for small and medium-sized nonresidential customers, and meets the objectives set forth by the California Public Utilities Commission (CPUC) in Decision R.01-08-028 for monitoring and evaluation (M&E) studies, as well as those provided in the California Evaluation Framework[2].

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1 Energy efficiency programs are funded from electric and gas public goods charge (PGC) funds, a charge applied to each customer's bill to support the provision of public goods. Public goods covered by California's PGC include public purpose energy efficiency programs, low-income services, renewable energy sources, and energy-related research and development.

2 June 2004.

This Study, prepared by an independent third party evaluation team consisting of Itron, KEMA, ECONorthwest, and NERA, provides information about energy efficient equipment retrofits and replacements for the nonresidential population, evaluation findings regarding the energy and demand savings associated with program qualifying equipment, and program guidance through concrete recommendations.

2.2 Study Objectives and Approach

The objectives of the impact evaluation of the PY0405 Express and Upstream programs are to: (1) verify energy savings, (2) calculate ex post savings, (3) conduct a net-of-free-ridership analysis, and (4) estimate overall program energy and demand savings.

This study meets these research objectives by focusing on the following:

- ***Verification of Program Performance***. Each utility's program tracking database was reviewed to verify that both Programs' accomplishments were accurately claimed. A telephone survey of a sample of 1,577 program participants was conducted to verify measure installation. In addition, 416 on-site verification audits were conducted at a sample of business locations to verify key characteristics (e.g., efficiency) of the equipment that was installed and rebated under the Express and Upstream programs. Lighting loggers were installed at approximately 250 participating CFL sites (though data from loggers at 217 sites were used), to estimate the measure's annual hours of usage. An additional survey of 302 past participants from 2002 and 2003 was analyzed to assess the CFLs' effective useful life. End use metering studies of split and packaged AC measures and motors were also conducted to develop hourly load shapes and coincident diversity factors. Program performance verification for the Express and Upstream programs are presented in Sections 4 and 5.
- ***Estimation of Ex Post Energy and Demand Savings and Net-of-Free-Ridership Ratios***. Program savings are presented in the body of the evaluation report by key segments, measure, and IOU. Energy and demand savings using current ex post savings estimates were also verified. Varied approaches were used to estimate gross ex post energy and demand savings dependent upon the characteristics of the measure being evaluated. The two primary methods used were self-report and discrete choice. The most significant differences in the approaches to estimate ex post savings exists between non-lighting and lighting measures. Energy and demand savings for the Express and Upstream programs are presented in Sections 4 and 5. The net-of-free-ridership analysis and results are presented in Section 6. Section 7 presents an integrated analysis of the results from the impact evaluation approaches and provides the finalized ex post net program level savings estimates.
- ***Longitudinal Assessment.*** Trends in participation are presented by utility, technology, customer business type, customer size, application size, and types of delivery mechanism. Participation trends are presented for program years 2000-

2005. These historic trends are analyzed to determine the effects of repealing the 500 kW aggregation eligibility requirements, a ruling that excluded chain businesses from participating in the program[3].

- ***Recommendations for Program Enhancements*** are based upon a synthesis of the results of the ex post savings study , participation trends analysis, and the findings from the the process evaluation.[4] These recommendations are in the form of tangible actions to improve the performance of the current programs. They are focused on identifying cost-effective marketing strategies and program delivery approaches, considerations for changes in incentives, potential energy efficiency measures to consider, and changes in program delivery that may result in higher customer satisfaction and increased effectiveness of the Program. A presentation of these recommendations is made in Section 8.

2.3 Overview of Research Activities

Study results are based on primary research conducted with customers and key market actors through interviews, phone surveys, on-site visits, end-use monitoring, and the analysis of participant tracking data and utility customer information databases.

2.3.1 Primary Data Collection

The primary forms of data collection included phone surveys conducted with Express program participants and nonparticipants, as well as past program participants for the CFL retention analysis, on-site and metering visits, interviews with lighting, refrigeration, motors, and HVAC vendors and distributors, and interviews with Express and Upstream program managers.

Phone Surveys

A number of telephone surveys were conducted with participants and nonparticipants of the Express program. A total of 4,340 surveys (1,577 participant surveys and 2,763 nonparticipant surveys) were conducted to support various aspects of the evaluation including verification, billing analysis, net-of-free-ridership analysis, customer behavior assessment, market opportunities assessment, and process evaluation. Note that end users of rebated motors and central air conditioning equipment were interviewed along with

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3 The aggregation rule that allowed large customers to participate in the program was effective for a portion of the 2001 program year.

4 The process evaluation of the Express and Upstream programs is presented in a separate report. However, the findings from the process evaluation were taken together with the findings from the impact evaluation to prepare the conclusions and recommendations presented in this report.

participants of the Express program.[5] A sample of end users was developed by retrieving the names of individuals who purchased upstream rebated equipment from vendors and distributors who participated in the program. Data about these end users, while not always available, were entered by into an online application tool managed by Energy Solutions by Upstream program participants who stocked and sold these measures to them. Table 2-1 and Table 2-2 present the number and proportion of participant and nonparticipant surveys conducted in each of the IOUs' service territories.

Table 2-1: Participant Surveys by IOU Service Territory

Utility	Number of Surveys	% of Total
SCE	478	30%
PG&E	765	49%
SDG&E	207	13%
SCG	127	8%
Statewide	**1,577**	**100%**

Table 2-2: Nonparticipant Surveys by IOU Service Territory

Utility	Number of Surveys	% of Total
SCE	811	29%
PG&E	1,217	44%
SDG&E	381	14%
SCG	354	13%
Statewide	**2,763**	**100%**

Participant Surveys

Two types of participant surveys were developed to support different aspects of the overall evaluation. Both contained a set of identical questions to gather information about customer and facility characteristics, languages other than English spoken at the place of business, verification of the number and type of program measures installed, changes in the number and type of measures not rebated through the program, knowledge of energy efficient equipment, awareness of energy efficiency programs, and questions to support the self-report and discrete choice net-of-free-ridership analyses. One of the two survey types contained additional questions to support the process assessment, such as satisfaction with the program, and the measures installed through the program. The second survey contained supplemental questions to support the billing analysis. The additional billing analysis questions asked

[5] The vendors and distributors who participated in the Upstream program were also interviewed and these data are used in the NTFR analysis included in this impact evaluation.

participants about the age, type, and condition of their lighting, HVAC, refrigeration, and other types of equipment in their business. It also included questions regarding the timing of the installation of energy efficient measures rebated through the Express program.

Table 2-3 and Table 2-4 present the total number of the two participant survey types that were asked and shows the distribution of the process and supplemental surveys across IOUs. As these tables show, the process assessment questions were included in approximately a quarter of the participant surveys, while those with the supplemental billing, market opportunities, and EUL retention questions were included in three-quarters of the participant surveys.

Table 2-3: Distribution of Participant Surveys by Survey Type

Survey Type	Number	% of Total
Process	418	27%
Supplemental	1,159	73%
Total	**1,577**	**100%**

The participant survey was segmented by IOU service territory and technology/end use. Table 2-4 shows the distribution of completed surveys by IOU and end use conducted with participating customers. Measures that had more significant participation received proportionally more sample.

Table 2-4: Number of Participant Surveys by IOU and End Use

End Use	PGE	SCE	SCG	SDGE	Number by End Use*	Proportion by End Use**
Agriculture	3	3	2	2	10	0.6%
Food Service	4	0	0	0	4	0.3%
HVAC	178	180	24	63	445	28%
Lighting	471	276	0	115	862	55%
Refrigeration	87	19	0	18	124	8%
Water Heating	22	0	101	9	132	8%
Total by IOU	**765**	**478**	**127**	**207**	**1,577**	**100%**

* End Use assigned to surveyed sites based on maximum savings
** Percentages are rounded for each end use and therefore do not sum to 100%

<u>*Nonparticipant Surveys*</u>

The original number of nonparticipant surveys proposed for this evaluation totaled 600; however, a large quantity of nonparticipant surveys were conducted to support a cross-program analysis Itron conducted, thereby increasing the total number of nonparticipant surveys from which data could be used. The nonparticipant surveys for the cross-program analysis were designed in such a way that they could be used to support the Express program evaluation. The nonparticipant surveys were conducted with two major groups – (1) very small, small, and medium (VSSM) nonparticipants and (2) large nonparticipants. VSSM participants are defined as those customers not who did not receive a rebate from the Express program and have a maximum energy demand of 500 kW. Large nonparticipants are defined as those customers who did not receive a rebate from the Express program and have a maximum energy demand exceeding 500 kW. Table 2-5 shows the number and the proportion of nonparticipant surveys given to very small, small, and medium customers and to large customers.

Table 2-5: Distribution of Nonparticipant Surveys by Customer Size

Size	Number of Surveys	% of Total
VSSM	2,270	82%
Large	493	18%
Total	**2,763**	**100%**

The nonparticipant surveys were also used to support the market opportunities assessment, which can be found in Section 3. Not only were nonparticipants asked about the types of measures they have installed, but they were also asked about different types of energy efficient equipment that was not present as well. These questions help to determine the types of energy efficient equipment that have yet to penetrate the market.

EUL Retention Surveys

Three hundred and two CFL participants were contacted from the PY 2002/2003 Express Efficiency Program to support this effective useful life retention analysis for CFLs. As Table 2-6 shows, 99 of these surveys were completed with participants previously contacted as part of the 2003 Express evaluation, and the remaining 203 surveys were completed with program year 2002 participants.

Table 2-6: CFL Retention Phone Survey Distribution

Size	Number of Surveys	% of Total
From 2003 evaluation	99	33%
From 2002 evaluation	203	67%
Total	**302**	**100%**

Of the 302 surveys, 43 respondents could not report the number of bulbs that had failed, and another 9 sites were removed because they reported installing a greater number of bulbs than were recorded in the tracking system, leaving a total of 250 completed surveys in the analysis dataset, which represent 44,748 bulbs.

Table 2-7: Summary of EUL Retention Surveys Used in Analysis

Description	Statistic
Total Surveys	302
Surveys Censored	
Could not provide retention data	43
Reported greater installations than tracking system	9
Surveys used in analysis	250
Number of bulbs represented	44,748

On-Site Visits

On-site audits were conducted to verify measure installation. As part of the on-site activities, lighting loggers were installed for participants of Express who had CFL, T-8, and high bay T-5 measures, end use metering was conducted for both central air conditioners and motors, and engineering and on-site verification audits were performed for all lighting and non-lighting measures rebated through the Express and Upstream programs. Each of these activities are discussed in more detail below.

- **Lighting Loggers Sites.** A total of 747 lighting loggers were initially installed for 250 lighting participants of the on-sites that had CFL, T-8s, and high bay T-5 measures installed. Of these, a total of 485 loggers installed at 217 sites were used in the analysis. These loggers were put in place in order to record data to develop hourly load shapes, estimates of annual hours of operation, and determine coincident diversity factors by measure (see Table 2-9).
- **HVAC EUM Sites.** Fifty split and packaged AC measures were monitored and analyzed to develop annual energy and peak demand savings estimates. The data were also used to verify the assumed ex-ante coincident diversity factor (CDF) and equivalent full load cooling hours (EFLCH).
- **Motors EUM Sites.** Thirty-one motor sites were included in this end-use metering study. The monitored data were analyzed to develop annual energy and peak demand savings estimates and to verify the assumed ex-ante coincident diversity factor (CDF), load factor (LF), the annual operating hours (OH).
- **Engineering Audits.** A total of 130 sites were visited to collect detailed on-site data for non-lighting that were used in updating and enhancing existing engineering algorithms to estimate energy and demand savings. Table 2-9 represents the number of sites visited based on measure stratification (a total of 155), not the 130 unique sites.

- **On-Site Verification Audits.** Verification on-sites were conducted in a total of 130 sites, which covered the measure groups listed in the onsite disposition table below. Since data for more than a single measure group was collected at some of the sites, the total number of sites visited by measure exceeds than the total number of unique sites visited. Sites were visited to collect onsite verification data

Table 2-8: Loggers Installed and Retained for Lighting Logger Analysis

Lighting Types	Loggers Installed	Loggers Retained
CFL	420	238
T8	281	219
High Bay T5	46	28
Total	**747**	**485**

Table 2-9: On-site Survey Disposition for Non-Lighting Measures

Measure Group	PG&E	SCE	SDG&E	SCG	Total*	Proportion of Total
Anti-Sweat Heater Controls	0	0	5	0	5	3%
Auto Closer	0	0	2	0	2	1%
Boiler, Water	4	1	7	0	12	8%
Clothes Washer	0	0	2	12	14	9%
Cool Roofs	3	0	0	0	3	2%
Cooler/Freezer Door Gaskets	7	4	3	0	14	9%
Greenhouse Heat Curtain	0	0	2	1	3	2%
Infrared Film for Greenhouses	1	0	0	0	1	1%
New Refrigeration Case with Doors - Low Temp	1	0	0	0	1	1%
New Refrigeration Case with Doors - Med Temp	8	0	0	0	8	5%
Night Covers	6	0	0	0	6	4%
Pipe Insulation	0	0	0	1	1	1%
Programmable Thermostats	18	6	6	11	41	26%
Strip Curtains for Walk-ins	12	4	1	0	17	11%
Tank Insulation	1	0	0	1	2	1%
VSD - AHU	8	0	1	0	9	6%
Water Boiler, Process	0	0	4	0	4	3%
Window Film	5	5	2	0	12	8%
Total	**74**	**20**	**35**	**26**	**155**	**100%**

* The total column represents the number of sites visited based on measure stratification, which is equal to 155. A total of 130 unique sites were visited.

Program Manager and Staff Interviews

A series of interviews were conducted with SCE, SCG, SDG&E and PG&E Express and Upstream program staff in September 2007. These qualitative interviews were conducted to discuss program evaluation objectives; obtain program manager input to help refine objectives and research issues that shaped subsequent interviews with vendors and customers; and to educate the evaluation team on program design, verification process, marketing activities, and vendor operations. Interview findings are reported in Appendix A and summarized in Sections 8 and 9.

Vendor and Distributor Interviews

Close to 300 participating and nonparticipating market actors (contractors/vendors, distributors, manufacturers) were surveyed in the lighting, HVAC, motors, and refrigeration industries to learn about participating vendors' experience with the program, not to conduct supply-side baseline research. Fifty-two lighting vendors that participated in the Express program were interviewed because most of the program's energy savings accomplishments came from compact fluorescents and T-8s. The survey data were used to qualitatively assess net program effects and support the customer behavior analysis and process evaluation. Results from these interviews are discussed in Sections 10 and 11.

2.3.2 Secondary Data Sources

Participant Tracking Data

Itron utilized its statewide integrated Express program database for the period 2000-2005 to assemble summary statistics on participation to date. This single statewide database merges key Customer Information System data, such as Standard Industrial Classification (SIC) codes, rate codes, usage, and demand data. Participation trends were compared over time. This analysis was used to identify gaps and unexpected trends in program participation.

IOU Work Papers

The IOU's work papers, which documents their per unit savings values for each of their measures, were reviewed for every measure. Algorithms documented in the IOU work papers served as a starting point for many of our detailed engineering analyses, as discussed in Section 4 of the report.

DEER and CEUS Data

The Database for Energy Efficient Resources (DEER) and the Commercial End Use Survey (CEUS) were two important data sources that provided valuable information on key parameters for some of the algorithms developed for the engineering analysis, such as equipment full load hours and coincident diversity factors. Sections 4 and 5 discuss in greater detail how these data sources were utilized for the Express and Upstream program measures.

IOU Quarterly Reports

We reviewed monthly and quarterly reports for IOU impact/participation goals, progress towards goals, program budgets, 2004-2005 expenditures, and marketing activities.

2.4 Report Outline

The report consists of 8 sections and 11appendices.

- **Section 1 (Executive Summary)** summarizes the high-level findings of the study and provides recommendations for future analysis.
- **Section 2 (Introduction)** provides a brief description of the Express and Upstream programs, states the study objectives, and summarizes the research activities and data collection efforts of this evaluation.
- **Section 3 (Program Activity)** summarizes the Express and Upstream program background and evolution, highlights the IOU marketing activities, and provides the 2004/2005 goals and accomplishments.
- **Sections 4 and 5 (Express and Upstream Program Impact Evaluations)** presents the results of the ex post gross savings analyses and verification efforts; a CFL effective useful life (EUL) analysis based on PY2002/03 Express program participants is also included. Appendices I, J, and K provide additional information regarding the lighting logger analysis and the engineering review included in Section 4.6.
- **Section 6 (Net-of-Free-Ridership Analysis)** includes a self-report net-of-free-ridership analysis based on both participant and vendor/distributor surveys, a discrete choice analysis, and presents net savings results.
- **Section 7 (Overall Savings Analysis)** presents a summary of the findings from the impact evaluations in Sections 4 and 5 and the net-of-free-ridership analysis in Section 6. These results are used to develop an integrated analysis used to estimate the lifetime net savings and cost-effectiveness of the Express Efficiency and Upstream HVAC and Motors Programs by IOU and funding source (PGC or Procurement).
- **Section 8 (Conclusions and Recommendations)** summarizes findings from the study, presents our conclusions based on research results, and provides suggestions for program enhancements.
- Appendix A presents the results of program staff interviews.
- Appendix B summarizes participation for the number of applications; total rebates paid, and total first year gross energy (kWh) savings by size, technology, and

business type for each utility and statewide are shown for program years 2000 through 2005.

- Appendix C provides the participant surveys.
- Appendix D provides the nonparticipant surveys.
- Appendix E includes the market actors surveys used when lighting and refrigeration distributors were interviewed.
- Appendix F contains Express participant phone survey response tables.
- Appendix G provides Upstream participant phone survey response tables.
- Appendix H provides non-participant phone survey response tables.
- Appendix I provides the detailed measure engineering reviews.
- Appendix J presents the cursory measure engineering reviews.
- Appendix K presents details to support the lighting logger analysis.

3

Program Activity

This chapter provides a general overview of the Express and Upstream programs, presents the goals and accomplishments for the California statewide program and for each of the four IOUs, and compares the activity of the 2004/05 Express program to activity during previous years. The following areas discussed in this section include the following.

- ***Program Description.*** A description of both the Express and Upstream programs is provided, along with an overview of measures rebated through these programs. A logic model and program theory description of the Express program is also included in this section.
- ***Program Performance.*** This section also presents each program's targets and accomplishments in terms of energy and demand savings, as well as the hard-to-reach (HTR) customers reached.
- ***Verification of Accomplishments.*** Accomplishments reported by the IOUs in their program tracking databases are checked against the accomplishments they report in their Energy Efficiency Annual Report Filings.
- ***Historical Participation Trends.*** Highlights in participation trends over the past six years are shown with respect to the types of measures installed, the size of the participating customers (in terms of energy demand), the types of businesses participating, and application size and cost effectiveness trends.
- ***Market Opportunities.*** The market opportunities assessment focuses upon existing and emerging energy efficiency measures that the Express Efficiency program can offer and the market segments upon which the program should be targeted.

To address these issues related to program activity, we rely on program tracking data, participant survey data, on-site verification data, program staff interviews, 2005 and 2006 IOU Annual Energy Efficiency Reports filed with the CPUC, and the latest IOU Express Efficiency and Upstream HVAC and Motors workbooks for the 2004-05 program cycle.[6]

[6] The latest available Express Efficiency program workbooks were dated Dec 2005 for PG&E, dated Feb 2006 for SCE, and dated Jan 2006 for both SDG&E and SCG.

3.1 PY0405 Express Efficiency Program Description

The 2004-2005 Express Efficiency program primarily focused on small and medium-sized business customers (those with electricity demands <500 kW) for the installation of selected lighting, refrigeration, air conditioning, food service, agricultural, and gas technologies shown to increase energy efficiency. Rebates (paid directly to the customer or the participating vendor) were paid for the retrofit or replacement of existing inefficient equipment with qualifying new energy-efficient equipment. Energy and demand savings goals as well as serving a certain percentage of hard-to-reach customers were defined in each of the utilities' program implementation plans. A full description of the hard-to-reach customer segment is presented in Section 3.3.

Since 2003, large chain accounts[7] have been eligible for the Express Efficiency program. The CPUC had excluded large chain accounts for the 2002 program year through a new eligibility requirement that precluded customers from participating in the Express program if their aggregate demand exceeded 500 kW. Small chains were eligible for the 2002 Express Efficiency program while large chains were excluded.[8]

3.2 PY0405 Upstream HVAC and Motors Program

The 2004-2005 Upstream HVAC and Motors program provides distributors with upstream incentives to stock and sell qualifying high efficiency products, such as high efficiency packaged and split air conditioners, heat pumps, package chillers, and motors. Up through the 2003 program year, incentives paid to motors and HVAC distributors serving nonresidential customers were covered by the Express Efficiency program. During the 2004-05 program cycle, the payment of incentives to upstream HVAC and motors distributors and manufacturers was removed from the Express Efficiency Program and offered as a separate program.

The Upstream HVAC and Motors program was directly targeted towards the manufacturers and distributors of high efficiency air conditioning equipment and motors who serve geographically defined HTR markets. Geographically defined HTR markets are described in more detail below.

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[7] Chain accounts are customers with two or more accounts that have the same billing address and same customer name but with more than one service address.

[8] A large chain is one whose total aggregated demand over all customer accounts is > 500 kW, or whose annual gas consumption > 250,000 therms. A small chain is one whose total aggregated demand is less than or equal to 500 kW, and whose annual gas consumption is less than or equal to 250,000 therms.

3.3 Program Performance Targets

This section presents the energy and demand performance targets for each of the IOUs and provides data gathered through primary research to show whether they met their targets for the Express and Upstream programs. An examination of each IOU's Energy Efficiency programs Annual Report, PY2004/05 program tracking database, and the latest available program workbooks was made to verify whether each utility met its performance targets.

3.3.1 Energy and Demand Savings

As in past years, performance targets for the 2004-05 program years were set in terms of energy, demand, and therm savings. Specifically, the statewide net ex ante savings accomplishments for the two-year program cycle were 778.4 GWh, 126 MW, and 15.9 million therms. As shown at the bottom of Table 3-1, the statewide program almost met its kWh target, exceeded its therm target by 75%, and fell short of meeting its kW target by approximately 20%.

Table 3-1: Summary of the 2004-05 Express Efficiency and Upstream HVAC/Motors Programs Net Energy Savings Targets and Ex Ante Accomplishments Reported in the IOUs' Energy Efficiency Filings and Latest Workbooks*

Utility	CPUC Target	Net Ex Ante Actual and Committed	% Target Reached
PG&E			
Energy Savings, MWh	389,319.6	426,857.3	110%
Demand Reduction, MW	70.6	61.2	87%
Therms Reduction (in 1,000s)	2,495.0	8,255.2	331%
SCE			
Energy Savings, MWh	290,480.0	287,823.4	99%
Demand Reduction, MW	65.1	54.9	84%
Therms Reduction (in 1,000s)	-	-	-
SDG&E			
Energy Savings, MWh	103,924.5	63,655.8	61%
Demand Reduction, MW	19.1	9..9	52%
Therms Reduction (in 1,000s)	354.3	520.0	147%
SCG			
Energy Savings, MWh	34.5	109.0	316%
Demand Reduction, MW	-	-	-
Therms Reduction (in 1,000s)	6,214.0	7,088.8	114%
Statewide			
Energy Savings, MWh	**783,758.5**	**778,445.5**	**99%**
Demand Reduction, MW	**154.8**	**126.0**	**81%**
Therms Reduction (in 1,000s)	**9,063.4**	**15,864.0**	**175%**

* The latest available workbooks for PG&E were dated Dec 2005, dated Feb 2006 for SCE, and dated January 2006 for both SDG&E and SCG. The actual and committed savings accomplishment for each of the utilities is taken from either EE filings or workbooks. SCE, SDG&E, and SCG EE filings do not disaggregate accomplishments by program. For this reason, data for SCG and SDG&E are taken from the workbooks and data for SCE comes from email correspondence with SCE.

SCG and PG&E outperformed SCE and SDG&E in reaching or surpassing its target energy savings, though SCE was close to meeting its target. Given that this utility provides natural gas and not electricity, a relatively low kWh goal is not surprising. SCG staff attributed their program's overall success to strong sales of greenhouse heat curtains, water heating measures, and programmable thermostats.[9] Thermostats generated the bulk of the kWh savings accomplishments and greenhouse heat curtains and water heating measures, such as boilers, contributed to the therms savings accomplishments. PG&E attributes its accomplishment to the popularity of lighting measures, especially CFLs and occupancy sensors. SDG&E's accomplishments for kWh savings and demand reduction were fairly low, as it met only 61% of electric energy and demand savings goals. However, it was quite high in therms savings relative to its goal. The high level of therm savings for SDG&E can be attributed to a high volume of greenhouse heat curtains rebated.

Table 3-2 summarizes the net ex ante lifecycle energy savings and TRC net resource benefits the Express Efficiency program accomplished, as claimed by the IOUs in their latest available workbooks.

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9 Appendix B shows 2004 and 2005 participation by technology.

Table 3-2: Summary of 2004-05 Express Efficiency Energy Accomplishments: Lifecycle Net Ex Ante Energy Savings and TRC Net Resource Benefits Reported in the IOUs' Energy Efficiency Filings and Latest Workbooks*

Utility	Net Ex Ante Actual and Committed
PG&E	
Energy Savings, Lifecycle GWh	4,734.15
Therms Reduction (in 1,000s), Lifecycle	90,842.00
TRC Benefits, (in $1,000s)	$138,659.91
SCE	
Energy Savings, Lifecycle GWh	3,962.41
Therms Reduction (in 1,000s), Lifecycle	-
TRC Benefits, (in $1,000)	$108,369.29
SDG&E	
Energy Savings, Lifecycle GWh	746.96
Therms Reduction (in 1,000s), Lifecycle	3,916.10
TRC Benefits, (in $1,000s)	$46,196.66
SCG	
Energy Savings, Lifecycle, GWh	1.20
Therms Reduction (in 1,000s), Lifecycle	83,967.58
TRC Benefits, (in $1,000s)	$45,164.15
Statewide	
Energy Savings, Lifecycle GWh	9,444.72
Therms Reduction (in 1,000s), Lifecycle	178,725.68
TRC Benefits, (in $1,000s)	$338,390.01

* The latest available workbooks for PG&E were dated Dec 2005, dated Feb 2006 for SCE, and dated Jan 2006 for both SDG&E and SCG. The lifecycle net energy savings and TRC net resource benefits are not disaggregated to the program level in the IOUs' EE filings. The data in this table are taken from each of the IOUs' latest available workbooks for Express Efficiency.

3.3.2 Comparison of Savings Accomplishments

In addition to comparing the IOUs' goals to their accomplishments as reported in each utility's latest available program workbooks, an additional verification step was carried out by comparing program level energy, demand, and therm savings accomplishments reported in the IOU program tracking databases to the program accomplishments each utility presented in its 2006 Energy Efficiency Annual Report Filings.[10] Table 3-3 through Table 3-7 present this comparison of the total reported energy, demand, and therm savings accomplishments for each utility by program type (note, there were no therm savings reported for the Upstream HVAC/Motors program).

Table 3-3: Verification of Net Ex Ante IOU Energy Savings (in MWh) for Express Efficiency*

Utility	EE Filings/Workbooks	Database	% Diff from Filings
PG&E	426,857	426,837	0.0%
SCE	287,823	287,823	0.0%
SDG&E	63,656	63,657	0.0%
SCG	109	109	0.0%

* SCE's energy savings data were not disaggregated by program in its EE Annual Report. This information for the Express Efficiency program is instead reported based on e-mail correspondence with SCE, dated December 16, 2006. SDG&E and SCG savings for Express were also not disaggregated by program in their EE filings. Energy savings for these IOUs are taken from their latest available workbooks.

Table 3-4: Verification of IOU Net Ex Ante Energy Savings (in MWh) for Upstream HVAC/Motors

Utility	EE Filings	Database	% Diff from Filings
PG&E	26,033	26,033	0.0%
SCE*	37,849	37,686	-0.4%
SDG&E	4,835	4,823	-0.3%
SCG	-	-	-

* SCE's Upstream energy savings data are taken from the 2005 and 2006 EE Filings.

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10 The IOUs reported their PY2004-2005 accomplishments by program in their 2006 Energy Efficiency Annual Reports. The accomplishments for the entire program period are compared to the PY2004/05 Express and Upstream program tracking databases.

Table 3-5: Verification of Net Ex Ante IOU Demand Savings (in kW) for Express Efficiency*

Utility	EE Filings/Workbooks	Database	% Diff from Filings
PG&E	61,215	61,208	0.0%
SCE	54,889	54,889	0.0%
SDG&E	9,938	9,937	0.0%
SCG	-	-	-

* SCE's demand savings data were not disaggregated by program in its EE Annual Report. This information for the Express Efficiency program is instead reported based on e-mail correspondence with SCE, dated December 16, 2006. SDG&E and SCG savings for Express were also not disaggregated in their EE filings. Demand savings for these IOUs are taken from their latest available workbooks.

Table 3-6: Verification of Net Ex Ante IOU Demand Savings (in kW) for Upstream HVAC/Motors

Utility	EE Filings	Database	% Diff from Filings
PG&E	13,745	13,745	0.0%
SCE*	14,500	14,235	-1.8%
SDG&E	2,710	2,704	-0.2%
SCG	-	-	-

* SCE's Upstream demand savings data are taken from the 2005 and 2006 EE Filings. Each filing reports the annual energy savings for Express and therefore the savings are summed to arrive at a program cycle figure.

Table 3-7: Verification of Net Ex Ante IOU Therm Savings (in Therms) for Express Efficiency*

Utility	EE Filings/Workbooks	Database	% Diff from Filings
PG&E	8,255,248	8,255,019	0.0%
SCE	-	-	-
SDG&E	519,987	511,120	-1.7%
SCG	7,088,790	7,092,414	0.1%

* SDG&E and SCG therm savings for Express were not disaggregated by program in their EE filings. Therm savings for these two IOUs are taken from their latest available workbooks.

As the above tables show, the total energy, demand, and therm savings across these two sources of data align very closely. The percentage difference in total energy savings was less than 1% for both the Express and Upstream programs. Demand savings were also closely aligned for both programs with the slight exception of SCE's demand savings reported for its Upstream HVAC/Motors program. This difference potentially stems from the fact that SCE's Energy Efficiency Annual Report filings for the Upstream HVAC/Motors program were reported as rounded values, while an exact estimate of demand savings was calculated from the database. Therm savings are only reported for the Express program since there were no therm savings from the Upstream program. The therm savings were closely aligned for PG&E and SCG, with a less than 2% difference in reported accomplishments for SDG&E.

Table 3-8 presents a matrix showing the funding sources (PGC and/or Procurement) are used for each IOU's Express and Upstream programs during the 2004-05 program cycle. Table 3-9 through Table 3-13 break out the energy, demand, and therm savings by program and funding source for each of the utilities and compares these to the accomplishments reported in the EE filings at this further disaggregated level. Based on these tables, it is clear that the Express and Upstream programs were not funded by both PGC and procurement funds for each IOU. SDG&E and SCG funded their Express programs with PGC dollars only and all of the utilities except SCG (which does not offer the Upstream program) offered procurement-funded Upstream HVAC/Motors programs. At this level, we continue to see a close alignment of savings across the two reporting sources. The differences in demand savings for SCE's Upstream program and therm savings for SDG&E's Express program are again seen in these tables, which shows that the difference in reporting occurs for SCE's procurement-funded Upstream program and for SDG&E's PGC-funded Express program.

Table 3-8: Express and Upstream Programs by IOU/Funding Source

Program	Funding Source	
	PGC	Procurement
Express Efficiency	PG&E SCE SDG&E SCG	PG&E SCE
Upstream HVAC/Motors	PG&E	PG&E SCE SDG&E

Table 3-9: Verification of Net Ex Ante IOU Energy Savings (in MWh) Disaggregated by Funding Source for Express Efficiency

Utility	PGC			Procurement		
	EE Filings	Database	%Diff	EE Filings	Database	%Diff
PG&E	210,483	210,483	0.0%	216,375	216,355	0.0%
SCE	168,337	168,337	0.0%	119,487	119,487	0.0%
SDG&E	63,656	63,657	0.0%	0	0	0.0%
SCG	109	109	0.0%	0	0	0.0%

Table 3-10: Verification of Net Ex Ante IOU Energy Savings (in MWh) Disaggregated by Funding Source for Upstream HVAC/Motors

Utility	PGC			Procurement		
	EE Filings	Database	%Diff	EE Filings	Database	%Diff
PG&E	11,116	11,116	0.0%	14,917	14,917	0.0%
SCE	0	0	0.0%	37,849	37,686	-0.4%
SDG&E	0	0	0.0%	4,835	4,823	-0.3%
SCG	0	0	0.0%	0	0	0.0%

Table 3-11: Verification of kW Net Ex Ante IOU Demand Savings Disaggregated by Funding Source for Express Efficiency

Utility	PGC			Procurement		
	EE Filings	Database	%Diff	EE Filings	Database	%Diff
PG&E	29,228	29,226	0.0%	31,987	31,981	0.0%
SCE	33,175	33,175	0.0%	21,714	21,714	0.0%
SDG&E	9,938	9,937	0.0%	0	0	0.0%
SCG	0	0	0.0%	0	0	0.0%

Table 3-12: Verification of kW Net Ex Ante IOU Demand Savings Disaggregated by Funding Source for Upstream HVAC/Motors

Utility	PGC			Procurement		
	EE Filings	Database	%Diff	EE Filings	Database	%Diff
PG&E	5,733	5,733	0.0%	8,011	8,011	0.0%
SCE	0	0	0.0%	14,500	14,235	-1.8%
SDG&E	0	0	0.0%	2,710	2,704	-0.2%
SCG	0	0	0.0%	0	0	0.0%

Table 3-13: Verification of Net Ex Ante IOU Therm Savings Disaggregated by Funding Source for Express Efficiency

Utility	PGC			Procurement		
	EE Filings	Database	%Diff	EE Filings	Database	%Diff
PG&E	8,246,268	8,246,039	0.0%	8,980	8,980	0.0%
SCE	-	-	-	-	-	-
SDG&E	519,987	511,120	-1.7%	0	0	0.0%
SCG	7,088,790	7,092,414	0.1%	0	0	0.0%

3.3.3 Hard-to-Reach

The CPUC has encouraged the utilities to connect with hard-to-reach (HTR) nonresidential customers. These customers do not have easy access to program information or generally do not participate in energy efficiency programs due to a language, business size, geographic, or tenant barrier. The CPUC defines these HTR segments as:

- Language – Primary language spoken is other than English,
- Business Size – Very small (<20 kW in peak demand) and/or less than ten employees,
- Geographic – Businesses in areas other than the San Francisco bay area, San Diego area, Los Angeles basin, or City of Sacramento, and
- Tenant – customers who lease rather than own their facilities.

Each of the IOUs set goals to reach a certain percentage of participants who fall into the HTR category. Table 3-14 reports the hard-to-reach goals set for each IOU, the IOU-reported HTR accomplishments provided in their final program narratives for the Express program, and Itron's estimated hard-to-reach accomplishments based on tracking data and responses from participants during the phone survey. A comparison of the goals to Itron's estimated accomplishments yields different results regarding the success each IOU had in reaching their HTR goals than when the goals are compared to the IOU-reported accomplishments.

When the goals are compared to the IOU-reported HTR reach accomplishments, all of the IOU with the exception of SCE met or surpassed their targets. Only 37% of SCE's Express program participants were HTR when its goal was 40%. This information, which was retrieved from SCE's Express Efficiency monthly report narrative (Feb 2006), states that its program continues to focus on HTR customers or, those "who traditionally are less likely to install energy efficient technologies due to geographic, ethnic, and other market barriers." It is possible that the goal and accomplishments for SCE did not take into account those HTR customers who lease rather than own their business, since this criterion was not mentioned. PG&E far surpassed its goal of 41% since virtually all of PG&E's Express Efficiency program participants could be classified as HTR. Note also that SCG surpassed its goal while SDG&E just met its HTR goal, based on the reported data from the IOUs.

Itron developed weighted results from phone survey data and tracking data to estimate the percentage of Express program participants that fell into the HTR category. Geographical data such as zip codes, and business size were taken from the tracking data, while information regarding leasing versus owning, languages spoken other than English, and number of employees were used from participant phone survey data. Since Itron only had participant phone survey data, the HTR accomplishments were weighted up to the population. This explains the difference in HTR accomplishments calculated by Itron and those reported by the IOUs. As the table shows, Itron's estimates for each of the IOU's, with the exception of PG&E, exceed the accomplishments reported by the IOUs. Based on these results, all four IOUs met their HTR targets.

Table 3-14: Hard-to-Reach Goals, Reported Accomplishments, and Verification from IOU's Program Tracking Databases*

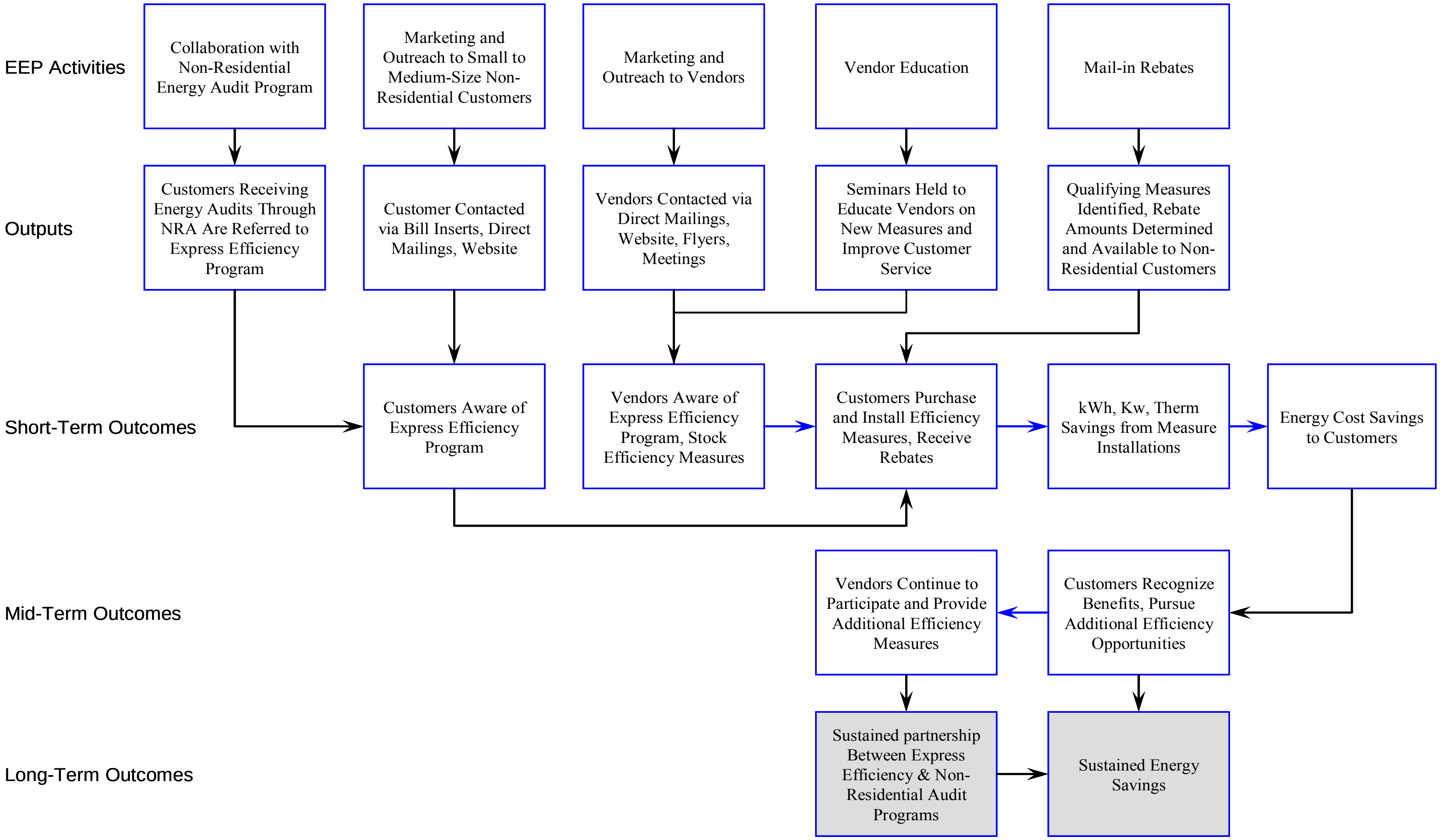
Hard-to-Reach	SCE	SCG	PG&E	SDG&E
Goals	40%	43%	41%	63%
Weighted Results from Phone Survey Data/Tracking Data	71%	79%	77%	77%
Reported by IOU	37%	73%	99%	63%

* Express Efficiency program narratives provide the HTR reported accomplishments and goals presented in this table. SCE's program narrative is dated Feb 2006, PG&E's is dated Dec 2005, and SDG&E's and SDG&E's are dated Jan 2006.

3.4 Logic Model

This section presents the logic model and underlying program theory for the 2004-05 Statewide Express Efficiency program, which targets commercial customers and provides financial incentives for a range of equipment measures that deliver electricity and gas savings. The logic model diagram (Figure 3-1) is presented on the next page and shows the linkages between program activities and the direct outputs resulting from those activities. These outputs in turn will result in program outcomes that eventually lead to achieving the overarching program goals. Following the logic diagram, the program theory is presented that provides additional detail on the program activities, outputs, and outcomes.

Figure 3-1: Logic Model Diagram



* Shaded boxes indicate induced outcomes that are outside of the direct program influence.

Altogether, the following subsections present the program theory for the Express Efficiency program. The program theory builds on the program logic model and provides additional detail on program activities, outputs, and outcomes.

3.4.1 Express Efficiency Program Activities

This subsection describes the program activities that are carried out through the Express program.

Collaboration with Nonresidential Energy Audit Program. Express Efficiency and the Nonresidential Audit programs work together to provide energy audits and rebates to nonresidential customers. Customers who receive an energy audit are referred to the Express Efficiency program for rebates. Likewise, customers receiving rebates through Express Efficiency are offered audits if they have not already had one.

Marketing and Outreach to Small to Medium-Sized Nonresidential Customers. Small to medium-size nonresidential customers are contacted about the p through bill inserts, direct mailings, and utility websites. Information is distributed in multiple language formats as necessary depending on the customer make-up. Program updates and rebate forms will be available through the websites.

Marketing and Outreach to Vendors. Vendors are contacted to participate in the program via direct mailings, utility websites, flyers, and meetings.

Vendor Education. Seminars are held regularly to educate vendors on additions to the list of eligible energy efficiency measures and to assist with customer service. Assistance is also available to vendors to increase their product lines in order to better meet the needs of customers.

Mail-in Rebates. The primary goal of the program is to provide rebates to customers who purchase energy efficiency measures either through the Nonresidential Audit program or on their own. A list of measures that qualify for rebates is continually updated and made available to customers along with the rebate amounts.

3.4.2 Short-Term Outcomes

Express program activities result in a variety of outputs, which then lead to outcomes or program results. This and the following two subsections describe the short term outcomes, mid term outcomes, and long term outcomes that stem from the outputs of the Express program activities.

Customers Aware of Express Efficiency Program. Customers become aware of Express Efficiency either by receiving an energy audit through the Nonresidential Energy Audit program or by receiving mailings and bill inserts.

Vendors Aware of Express Efficiency Program and Stock Efficiency Measures. Once vendors become aware of Express Efficiency through the various marketing tools in place, they will seek out efficiency measures to stock their stores in order to meet customer demand.

Customers Purchase and Install Efficiency Measures, Receive Rebates. When customers purchase eligible energy efficiency measures and install them in their buildings they will receive rebates through Express Efficiency. Customers receive rebates by submitting a program rebate form along with a proof-of-purchase to their IOU.

Energy and Demand Savings from Measure Installations. Customers who install efficiency equipment will see immediate reductions in their energy use in these areas.

Energy Cost Savings to Customers. The nonresidential customers will have reduced energy costs from the use of energy efficient appliances in their buildings.

3.4.3 Mid Term Outcomes

Customers Recognize Benefits, Pursue Additional Efficiency Opportunities. Customers will see the cost savings they are achieving by installing efficiency measures and seek out additional opportunities to lower their energy consumption.

Vendors Continue to Participate and Provide Additional Efficiency Measures. In response to customer demand and seeing the benefits of the program, vendors will continue to participate. They will make additional efficiency measures available to their customers.

3.4.4 Long-Term Outcomes

Sustained Partnership between Express Efficiency and Nonresidential Audit Programs. A program goal is to maintain and improve the link between the Nonresidential Audit program and Express Efficiency. Customers will be better served through the partnership of these two programs.

Sustained Energy Savings. Customers will continue to realize energy savings as long as energy efficient measures are in place. These energy savings will grow as customers install additional equipment.

3.5 Longitudinal Assessment

The longitudinal assessment presents historical participation trends, performance targets, and program delivery mechanisms of the Express program over PY2000 through PY2005. Though the Upstream HVAC/Motors component of the Express program was created as a separate program beginning with the 2004/05 program cycle, it is included in the longitudinal assessment for consistency with the program data from earlier years.

3.5.1 Historical Participation Trends

Below we highlight some of the key trends in participation over the six year period with respect to the types of measures installed, the size of participating customers, and the types of businesses participating in the program. Detailed participation summaries for the number of applications, total rebates paid, and total first year gross energy (kWh) savings by size, technology, and business type for each utility and statewide are shown for PY2000 through PY2005 in Appendix B (Participation Data Tables).

Customer Size Trends

Figure 3-2 and Figure 3-3 present the trends in participation from 2000 to 2005 by the size of the participating customer. These figures present the annual distribution of applications that were rebated and the annual percentage of energy savings by customer size and year. Customers are categorized as very small (less than 20 kW), small (20-100 kW), medium (100-500 kW), or large (greater than 500 kW). Though the Express program was primarily designed to serve small and medium customers, the category of large customers exists (1) because large customers were served in some small capacity by the Express program and (2) due to the manner in which customers were classified in each utility's Customer Information System (CIS) data. The bar chart presented in Figure 3-3 shows how each size category contributed to program savings and the numbers appearing above each bar indicate the average kWh savings per application for each of the size categories in a given year. A similar interpretation explains the numbers above each of the bars in Figure 3-5 and Figure 3-8 as well.

With respect to the number of customers participating, PY2000 saw a large proportion of very small participants, primarily due to the vendor bonus that were paid as an incentive to vendors when they marketed rebated equipment to this customer group. In PY2000, 86% of the applications rebated through the Express program were submitted by very small customers, compared to 42% in 2001, approximately 50% in program years 2002 and 2003, and just around 30% in 2004 and 2005. In 2001, large customers were allowed to participate in the program for a portion of the year, thus accounting for 14% of the applications and 45% of the energy savings. In 2002 and 2003, large customers were again no longer eligible to participate as can be seen from the small fraction of applications rebated for them over this two-year period.

In 2003, about half of all Express applications were submitted by very small customers, however this group of customers comprised only a fifth of the energy savings. Participation was very similar between 2002 and 2003 in every size category. During the 2004 and 2005 program years, there is a significant increase in large customer participation, with 17% of all applications rebated in 2004 and 22% of all applications rebated in 2005 coming from large customers. The participation of very small customers decreased to less than a third in 2004 and decreased slightly further in 2005. Overall, we do see a slight trend towards medium and large customers and away from very small customers submitting applications to the Express program. The same holds true regarding energy savings over the six-year period over which the program is examined.

Figure 3-2: Applications Rebated by Customer Size, PY2000-2005

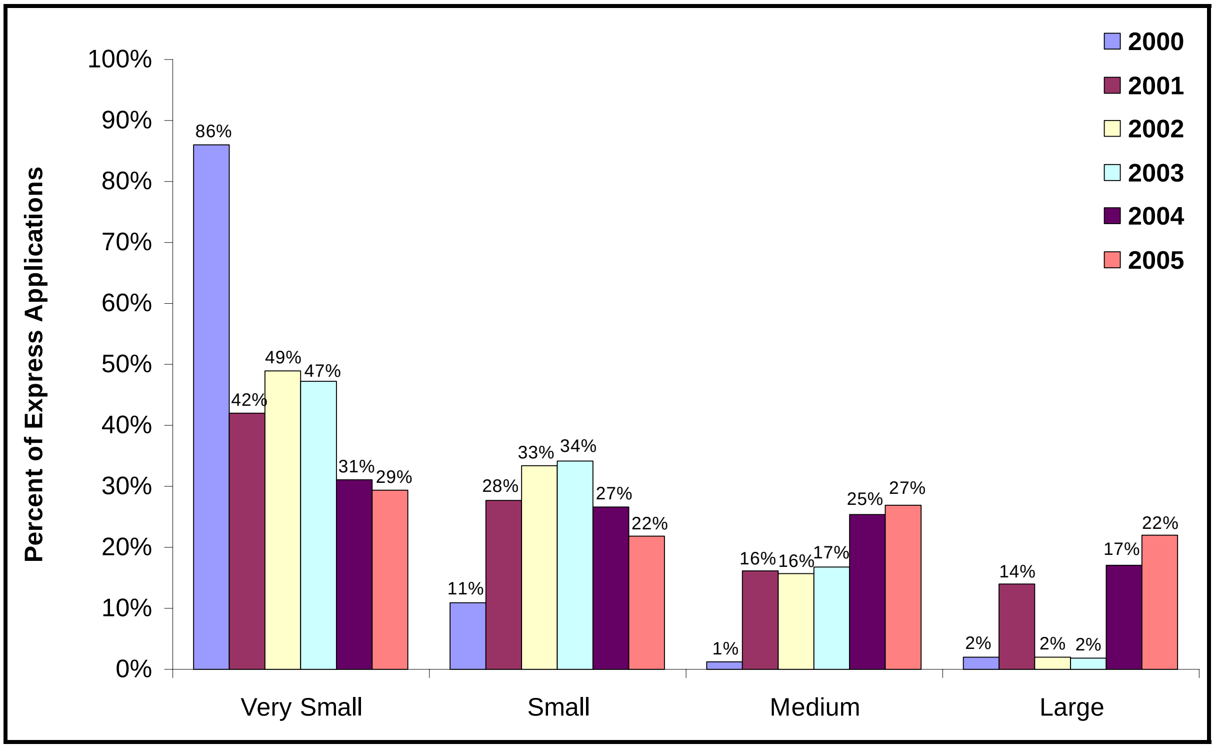
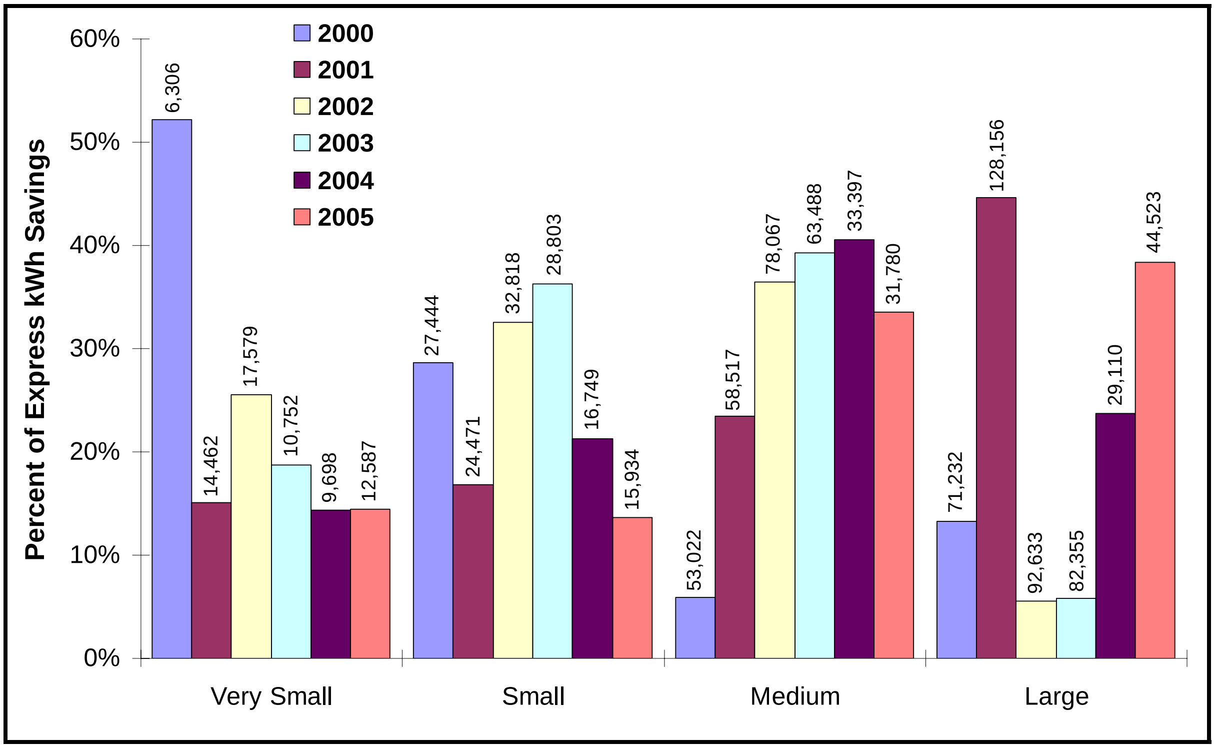


Figure 3-3: Net Ex Ante kWh Energy Savings by Customer Size, PY2000-2005*



* Note: Numbers above each bar indicate the average kW savings per application.

Technology/Measure Group Trends

Figure 3-4 through Figure 3-6 present the trends in participation from 2000 to 2005 among six key measure groups: CFLs, T-8s, miscellaneous lighting, HVAC, motors, and other measures (e.g., refrigeration, water heating, etc.). Figure 3-4 presents the percentage of applications that were rebated for a given year that contained any of these measures. Figure 3-5 and Figure 3-6 respectively show the percentage of energy savings and rebates paid per year by technology.

Lighting dominated the program as shown in Figure 3-4 through Figure 3-6 (especially in 2002 and 2003), however there is a noticeable shift away from lighting measures and towards HVAC measures in the percentage of applications and rebate dollars paid during the 2004-05 program cycle. This is evident in Figure 3-4, which shows a drop in the percentage of CFL rebated applications from 54% in 2003 to just below 20% in 2005, and an increase in HVAC applications rebated from 13% in 2003 to 45% in 2005. Data presented in Figure 3-6 further emphasizes this trend by presenting a drop in the percentage of rebated dollars paid away from lighting measures and towards HVAC measures by 2005. However, upon further examination of Figure 3-5, it is clear that lighting measures still contribute the largest levels of energy savings for Express Efficiency.

Figure 3-4: Applications Rebated by Technology, PY2000-2005

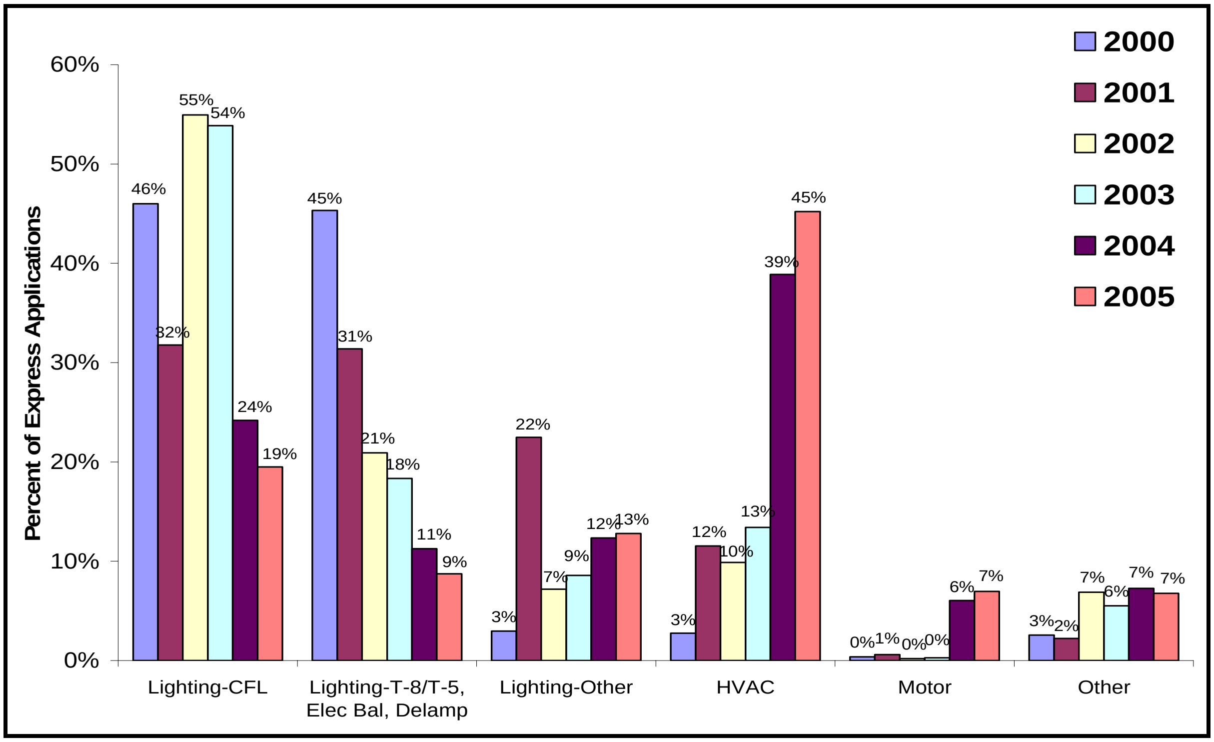
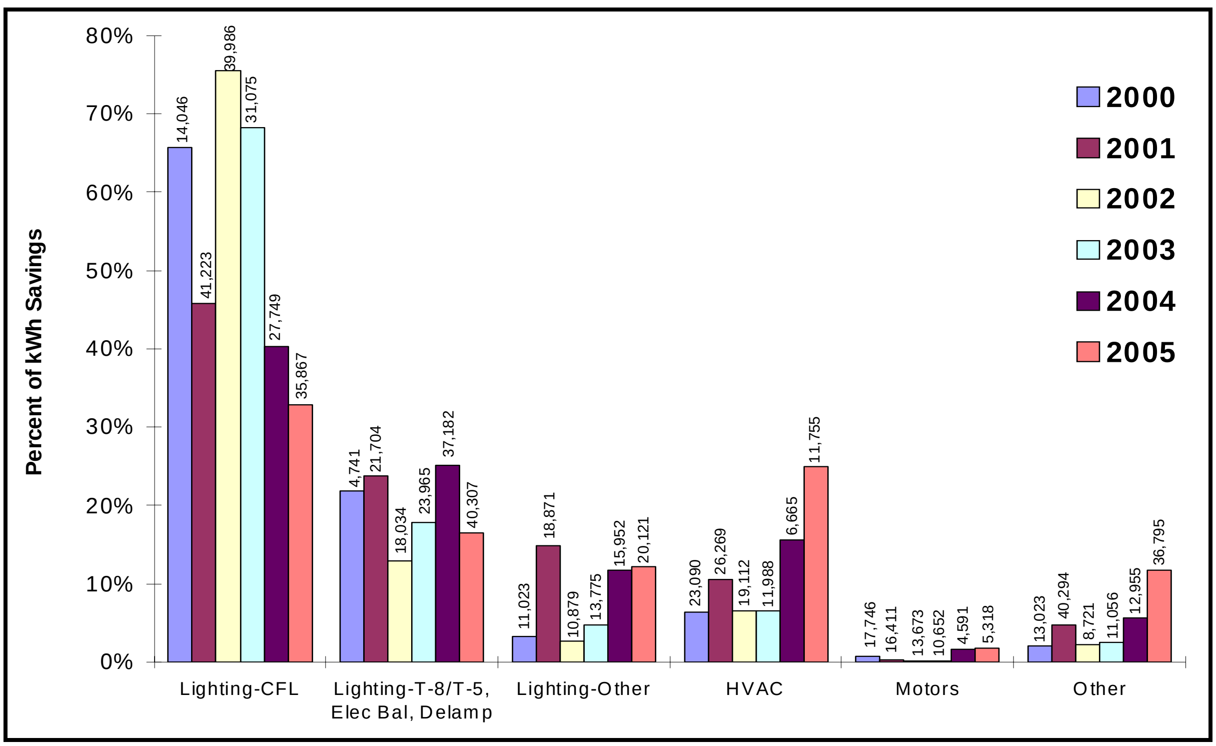
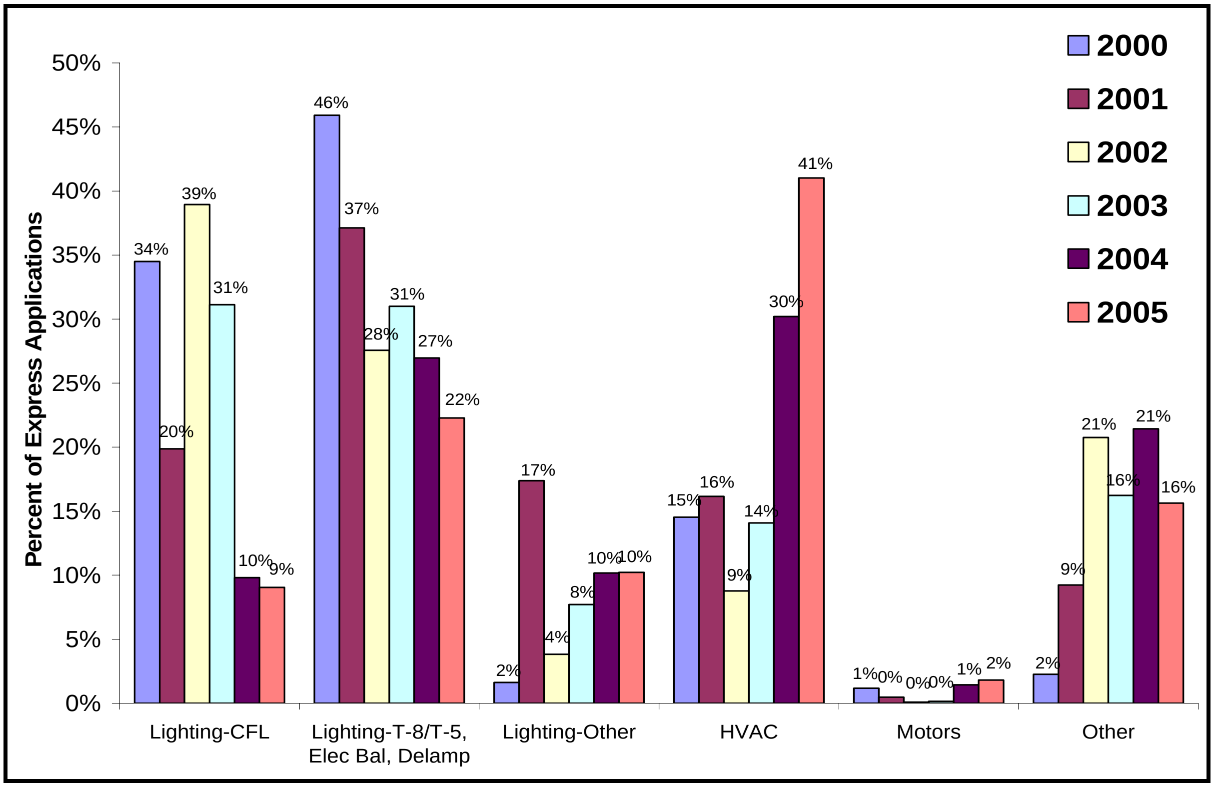


Figure 3-5: Average Measure Net Ex Ante kWh Energy Savings by Technology, PY2000-2005



* Note: Numbers above each bar indicate the average kW savings per application.

Figure 3-6: Rebate Dollars Paid by Technology, PY2000-2005



<u>Business Type Trends</u>

Figure 3-7 and Figure 3-8 present the trends in participation from 2000 to 2005 among five key business type groups: office, miscellaneous commercial, retail, restaurants and groceries, and other. Shown again are the percentage of applications and the percentage of energy savings within a given year.

The trends among business types again follow the changes that have occurred with program eligibility and incentives. In 2000, when the program was focused on very small customers and vendors received bonuses for seeking this customer group out, many of the small retail, restaurant, and grocery stores participated in the Express program. When larger customers were admitted for a single year in 2001, we saw more activity among the office and "other" (primarily institutional) business types. In 2002 when CFL installations dominated and smaller customers were again emphasized, many miscellaneous commercial establishments participated (e.g., personal services and community services). In 2003, participation was fairly even across all of the business categories.[11] In program years 2004 and 2005, more than a third of the total participants were from the "other" business types, while the participation of the retail category further decreased.

[11] It is important to note that over half of the "other" business type is comprised of records in the program tracking data for which we were unable to obtain valid SIC codes to create the business type classification.

Figure 3-7: Applications Rebated by Business Type, PY2000-2005

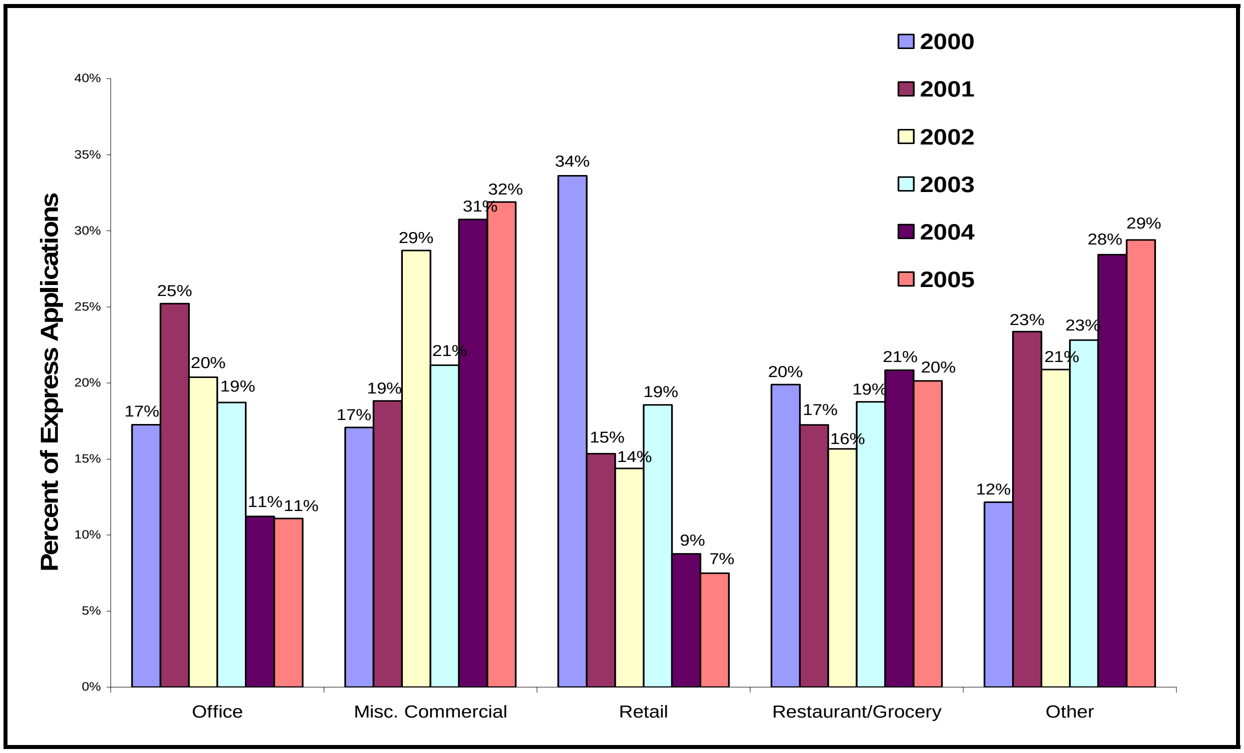
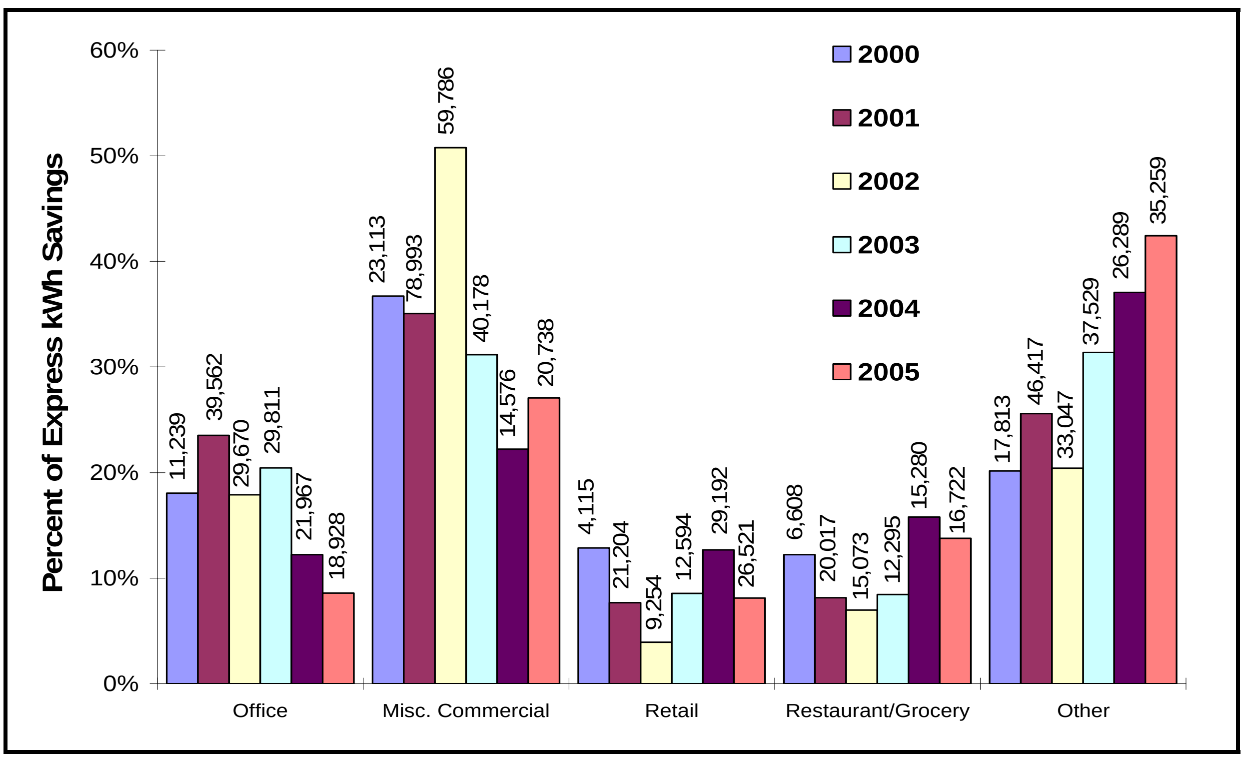


Figure 3-8: Average Measure Net Ex Ante kWh Energy Savings by Business Type, PY2000-2005



* Note: Numbers above each bar indicate the average kW savings per application.

3.5.2 Historical Express Efficiency Summary

Table 3-15 summarizes the number of Express Efficiency applications, unique locations, rebate dollars, program budgets, and energy savings over the past six years. The large number of applications and unique locations participating in the Express Efficiency program in 2000 reflects the impact of vendor bonuses, which rewarded vendors for their recruitment of smaller customers into the program. Far fewer applications were submitted in 2001; however, Express Efficiency energy savings rose by close to 60% from the previous year. This is likely a reflection of programmatic change that allowed large customers (those with energy demand > 500kW) into the program for a portion of 2001. Even though the total rebate dollars paid in 2002 were less than half of what they were in the previous year, the 2002 Express Efficiency still managed to garner almost 70% as much savings as 2001. These relatively high savings underscore the cost-effectiveness of CFLs, as these were pushed heavily during 2002 and 2003. The budget during program year 2003 was similar to the budget in 2002, but savings dropped off slightly – saving about 90% of 2002 levels. This may be a reflection of higher rebate levels in 2003.

Compared to 2002 and 2003, the 2004 program year showed a rising trend in the number of applications submitted, total rebate dollars paid, and in the total program budget, but the energy savings for this year did not continue this upward trend. In fact, energy savings in 2004 fall between the savings totals achieved in 2002 and 2003. In 2005, however, Express Efficiency had the largest program budget and yielded the highest energy savings over the six-year history. The installed energy savings in 2004 followed by a sharp rise in 2005 could be explained by the fact that the Express program was run for a two-year cycle, thus allowing the utilities to evaluate their accomplishments at the end of 2004 and revise program strategies, funding, and program marketing to improve program performance in the following year. In fact, during the course of program manager interviews, one stated that there is a benefit associated with running a program on a two-year cycle because it allows the utilities "to get through a program year and really assess how the program is doing. You can look back and determine whether there might be a need to shift funds."

Another noticeable trend in Table 3-15 shows that the number of unique applications submitted closely reflects the number of unique sites participating in the program over most of the Express program (suggesting a ratio close to one application to one site). This trend seemed to end with the 2004-2005 program cycle. During these years, the number of unique applications submitted per site is, on average, greater than one per site. In fact, by 2005, the ratio was closer to one and a half-to-one. This is not surprising as one of the program managers of Express Efficiency explained that a unique application had to be submitted for each measure during the 2004-2005 program cycle. Any site choosing to install more than one type of rebated measure would have to submit additional applications.

Table 3-15: Historical Express Efficiency Summary[12]

Program Year	Unique Sites	Unique Applications	Rebate Dollars (mil$)	Net Ex Ante Energy Savings (GWh)	Total Program Budgets (mil$)
2000	25,745	27,606	$28.6	296.7	$39.0
2001	10,681	11,072	$30.9	467.0	$45.6
2002	8,400	9,628	$12.9	318.7	$20.1
2003	9,342	9,573	$12.7	278.5	$21.4
2004	10,625	15,762	$19.4	295.6	$37.8
2005	14,129	23,707	$30.1	551.3	$46.3

Table 3-16 presents the average rebate size per application, the average kWh savings per application, and the average program cost per kWh energy savings (both first year saving and lifecycle) over the six year period. During the 2000 program year, Express Efficiency focused upon recruitment of smaller customers through the provision of vendor bonuses in exchange for their service of this customer group. As noted earlier, Express allowed larger customers into the program for a portion of the 2001 program year, as is reflected by the relatively large rebate and kWh saving per application. The improved cost-effectiveness in 2001 stems from a reduction in fixed costs associated with the application, rebate incentive, and inspection processing. The 2002 and 2003 program years focused heavily on rebating CFLs, thus allowing the program to again focus on serving smaller customers. From a cost per kWh saved perspective, these two years were the most cost-effective, however they very well may have halted the program's potential to rebate a wider variety of measures. In fact, as stated in the Express Efficiency evaluation from 2003, "many potential T-8 retrofits may have been ignored by contractors marketing the program in order to get an easy CFL sale."

Looking over the historical performance of the cost effectiveness measures shows that Express Efficiency has evolved into a program that successfully meets a wide range of objectives including the maximization of energy savings while at the same time rebating a larger mix of measures and providing rebates to smaller customers as well. Up until the

12 Accurate program budget information in 2000 and 2001 that corresponded directly to the savings and rebate information contained in the program tracking databases was not available for all utilities. Therefore, the statewide program budgets for 2000 and 2001 were estimated based on rebate amounts and kWh savings for some utilities. Program budgets for 2004 reflect the cumulative and committed funds through December 2004, with 2005 budget numbers equal to difference between total program budget for the 2004/05 program cycle and the cumulative and committed funds through December 2004. The cumulative and committed funds through December 2004 were not available for PG&E, therefore the budget for this IOU was divided in half and summed to the cumulative and committed funds of the other IOUs through December 2004, with the remaining budget summed to the 2005 estimated budget of each of the other utilities. Although these are budgets, the overall results are directional and unlikely to be affected by small changes in each IOU's budgets.

2004-2005 program cycle, the Express program seemed to be "experimenting" with meeting different program objectives. Now the Express Efficiency program has reached equilibrium with regard to its diverse program objectives and accomplishments.

Table 3-16: Historical Job Size and Cost-Effectiveness

Cost Effectiveness/PY	2000	2001	2002	2003	2004	2005
Rebate/Application	$1,036	$2,793	$1,335	$1,323	$1,230	$1,269
kWh Savings/Application	10,749	42,182	33,101	29,091	18,755	23,257
Program Budget (Cents)/First Year kWh	13.1	9.8	6.3	7.7	12.8	8.4
Program Budget (Cents)/Lifecycle kWh	0.0126	0.0085	0.0065	0.0075	0.0107	0.0069

3.5.3 Program Delivery Mechanisms

Historically, rebates for HVAC and motors equipment were paid to vendors and distributors through the Express Efficiency program while it simultaneously offered rebates to end users of lighting, refrigeration, water heating, and other Express measures. While it was common knowledge that contractors and distributors were the main drivers of the Express program, end users were known to directly participate in program through purchases of lighting and other measures. Motors and central air conditioners were almost exclusively sold through distributors however, and since end users rely heavily upon their advice and inventory, it was natural to break out the rebates for CACs and motors distributors into a separate program. By creating the Upstream HVAC and Motors program, the IOUs could focus on HVAC and motors distributors exclusively and not concern themselves with generalizing their marketing efforts towards end users as well.

4

Express Program Impact Evaluation

This section presents the results of the impact assessment conducted for energy saving measures offered through the 2004/2005 Express Efficiency Program. Section 5 follows this section and covers the 2004/2005 Upstream HVAC and Motors Program impact evaluation activities and results. The objective of these study components is to verify program performance and estimate ex post gross energy and demand savings. These gross savings results, along with estimated net-of-free-ridership ratios for key measures, are used to calculate program level estimates of net savings and the corresponding realization rates on the ex ante savings estimates. The net-of-free-ridership analysis for both Express and Upstream Programs is presented in Section 6.

We first begin with a discussion of data sources and an overview of the methodology used to calculate gross impacts. This is followed by a detailed discussion of the verification of program performance using application verification, a billing analysis, a lighting logger analysis, an EUL CFL retention study using PY 2002/2003 Express program participants, and the engineering analysis.

4.1 Data Sources

The impact assessment for the 2004/2005 Express and Upstream Program evaluation relies on data from five primary sources: utility billing data, program tracking data, participant and nonparticipant telephone surveys, on-site verification and logger/metering data, observed weather data and utility work papers.

Participant tracking system data for the Express and Upstream Programs were provided by each of the IOUs involved in this evaluation (PG&E, SCE, SDG&E, and SCG) in support of this evaluation. Data were provided for program years 2004 and 2005. The tracking system contains dates of participation, program measure descriptions, quantity installed, incentive amounts, estimated gross kWh, kW, and therm savings per unit, and the net-of-free-ridership ratios that were applied by the utility for each measure to calculate the net ex ante kWh, kW and therm savings. The tracking database is linked to the utility billing databases via customer account numbers. However, 15% of the records in the tracking system could not be linked because the site identifiers could not be merged with the billing data. Efforts were made to merge the two datasets by business name and address. This was somewhat successful, but many were not identifiable. In addition, site identifiers for PG&E were in some cases found entered as dummy values instead of account numbers. The results of the merge of tracking data with IOU billing data are presented in Table 4-1.

Table 4-1: Merging Tracking Data with IOU Billing Data

Utility	Total Records in Tracking Database	Number of Records Not Linked	Percentage of Records Not Linked
PG&E	37,658	3,587	10%
SCE	25,729	5,817	23%
SDG&E	5,626	1,001	18%
SCG	1,522	170	11%

Utility monthly billing data were also provided by each of the California IOUs. These billing data included business name, customer account numbers, addresses, kWh and therm usage, and bill read dates. Billing data were provided for all 2004/2005 Express and Upstream participants and a sample of nonparticipants at each utility and spanned the period from January 2003 through late 2007.

As part of this evaluation, telephone survey data were collected from 1,577 participants and 2,763 nonparticipants. These data were used to support all of the gross and net impact analyses, the process evaluation, and the market opportunities assessment.

Weather data files were obtained from DTN/Meteorlogix[13] for 20 climate regions throughout the state. These 20 climate regions are the 20 CEUS climate regions. Data for 16 climate regions were then used for the billing analysis. A ZIP code to climate zone mapping system was used to assign weather data to each site based on ZIP code. Daily heating and cooling degree days (HDD and CDD) were calculated based on the hourly temperature data from January 2003 through October 2007. HDD and CDD were chosen to represent weather patterns, as these have the most direct relationship with energy needs and consumption. Cumulative HDD over a billing period are generally well correlated with space heating demand over that period. Similarly, CDD are proportional to cooling needs, for those with air conditioning.

A total of 416 on-site surveys were conducted for the verification of measures rebated by the 2004/05 Express program. These visits were not only used to verify the installation of rebated measures, but to ensure these measures were operating properly as well. Of the 416

[13] DTN/Meteorlogix is a provider of weather and market data; http://www.dtnmeteorlogix.com/

sites, 286 were visited to verify lighting measures (see Table 4-3) and 130 were visited to verify non-lighting measures (see Table 4-8).

4.2 Application Verification

The application verification activity was used to verify that applications were correctly entered into the Program tracking systems, for a sample of applications. Applications were requested from the IOUs randomly to verify tracking information across rebated measures. Additionally, it was used to verify that the rebated equipment was program qualifying by comparing the vendor invoices attached to the applications with the program qualifying requirements for each measure.

To ensure all key parameters were entered correctly into the Program tracking system, 284 customer applications were verified across the four IOUs. This verification also ensured that all rebated equipment was Program qualifying. Of the 284 applications, 153 reviewed focused on non-lighting measures installed across the state (57 within PG&E territory, 48 within SCE territory, 18 within SCG territory, and 55 within SDG&E territory). The remaining 131 applications were for lighting.

4.2.1 PG&E

Itron randomly selected 105 of PG&E's applications across different measures for verification. For each of these rebate applications, the corresponding vendor invoices were also obtained to check whether rebated equipment was indeed program qualifying. The payee, measure description, quantity, and rebate amounts were compared with the entries in PG&E's tracking database. The rebated measures were then matched up with the list of qualifying products. All available invoices were correctly entered in the tracking database.

The tracking database contained the "Check Payable To" names and addresses, and the names and addresses of the contact persons; it did not however provide the customer names. Customer information was, however, included on the sample of applications received. The application forms also included information regarding installation dates, which were not found in the tracking database.

4.2.2 SCE

Itron randomly selected 106 of SCE's applications across different measures for verification. For each of these rebate applications, the corresponding vendor invoices were also obtained. The payee, measure description, quantity, and rebate amounts were compared with the entries in SCE's tracking database. The rebated measures were then matched up with the list of qualifying products. All available invoices were correctly entered in the tracking database, with the exceptions noted below.

A few verification exceptions were noted in the case of SCE.

- Itron noted that one application form showed only 5% of the total rebate applied related to measures that qualified under the program. The tracking data shows the total rebate amount for this application with a project status of "Pending."
- The tracking spreadsheet has a rebate amount 33% in excess of the check issued amount stated on the application form. According to the tracking data, the rebated measure is an efficient evaporator fan motor-SP to PSC, while the application form states that the rebated measure is an efficient evaporator fan motor-ECM with a per-unit rebate that has been changed on the form from $20 to $15.
- Itron noted that two of the application forms that had the measure "Special Doors with Low Anti-Sweat Heat low temp" showed a total and per-unit rebate amount that did not match the information in the tracking data. The total rebate amounts for these two applications in the tracking data are 350% higher than those in the forms. According to the tracking data, the rebate per unit had been calculated as $175 for these two applications and other applications with this measure. The application form states a per unit rebate amount of $50.

4.2.3 SDG&E

Itron randomly selected 55 of SDG&E's applications across different measures for verification. For each of these applications, the rebate applications and corresponding vendor invoices were obtained for verification. The payee, measure description, quantity, and rebate amounts were compared with the entries in SDG&E's tracking database. All available invoices were correctly entered in the tracking database. The rebated measures were then matched up with the list of qualifying products. The tracking data provided the Installation Date, but not the Check Issued Dates.

4.2.4 SCG

Itron randomly selected 18 of SCG's applications across different measures for verification. For each of these measures, the rebate applications and corresponding vendor invoices were obtained for verification. The payee, measure description, quantity, and rebate amounts were compared with the entries in SCG's tracking database. All available invoices were correctly entered in the tracking database. The rebated measures were then matched up with the list of qualifying products. The tracking data provided the installation date, but not the check issued dates.

Table 4-2: Applications Requested by IOU and Measure

Utility	CFLs	T8s	Other Lighting	Programmable Thermostats	Split/Packaged A/C Systems	Motors	Other HVAC	Refrigeration	Water Heating	Building Shell	Food Service	Pumping and Process	Total Requested	Total Received
PG&E	8	8	8	8	16	16	8	8	8	8	8	8	112	105
SCE	8	8	8	8	16	16	8	8	0	8	8	8	104	106
SDG&E	4	4	4	4	8	8	4	4	4	4	4	4	56	55
SCG				5					8			5	18	18

4.3 On-Site Verification

4.3.1 Lighting Measures

The lighting on-site survey/audit data were used as the primary vehicle for verifying installation of measures within the lighting end use, rebated under the 2004-05 Express Efficiency program. Telephone surveys were conducted for 697 program participants across 12 facility type classifications who had installed lighting measures to verify their participation in the Express program. The phone surveys were used to recruit customers for the on-site audits and to gather customer- and site-specific information. Engineers conducted verifications at sites where survey respondents had agreed to on-site audits. A census was attempted of all sites that agreed to the on-site verifications.

Table 4-3 shows the distribution of sites and verified units for the on-site audits by business type and demand group. As shown, offices, retail establishments, and community service sites, along with the miscellaneous commercial category, had the highest number of sites verified as part of the on-site audit.

Table 4-3. Sample Size for Onsite Lighting Verification by Business Type and Demand Group

Business Type/Size	< 20 KW		> 20 KW		Total	
	#Sites	# Units	#Sites	# Units	#Sites	# Units
College/University	1	462	2	580	3	1,042
Community Service	14	769	25	6,299	39	7,068
Grocery	1	188	7	622	8	810
Health Care	8	401	4	867	12	1,268
Lodging	11	3,812	16	5,826	27	9,638
Misc. Commercial	25	2,331	33	8,285	58	10,616
Office	19	2,183	21	7,778	40	9,961
Personal Service	11	390	5	2,456	16	2,846
Restaurant	13	567	10	513	23	1,080
Retail	27	4,663	12	7,516	39	12,179
School	7	732	7	8,478	14	9,210
Warehouse	3	181	4	438	7	619
Total	**140**	**16,679**	**146**	**49,658**	**286**	**66,337**

Units vary by measure. The unit of measure for CFLs is lamps while the unit of measure for High Bay T5s is fixtures.

Itron visited 286 sites and verified 24 lighting measures, grouped into seven categories—compact fluorescent bulbs (CFLs), T-8 fluorescent fixtures (T-8), High Bay T-5 fixtures (High Bay), delamping, occupancy sensors, photocells, and other measures (this category contains induction fixtures, metal halide fixtures, and electronic ballasts)—as part of the analysis. Data were collected during these visits to assess lighting and fixture counts, hours of operation, and overall site characteristics. The site visits and the data collected therein also aided in the installation of lighting loggers to enable assessment of the annual hours of operation for CFLs, T-8, and High Bay fixtures. The lighting logger analysis is described in greater detail later in this section of the report.

This section presents the percentage of units that were verified by specific measure among all of the on-site surveys conducted. Table 4-4 shows both the percentage of measures that were found in place and operable, and the number that were reported as having failed, removed or in storage for all measure types across all building types. The verified proportion of the lighting measures is the number of measures that were verified as having been received by the participant, which includes the stored, removed, failed, and currently installed fractions. The last column represents the number of verified items minus the number of stored items. Note that the verification credit is given for lighting that was removed or failed. This is the onsite verification rate used in the integrated analysis presented in Section 7.

Table 4-4: Verification Findings for all Lighting Measure Types

Measure Type	Verified – Received (a)	Stored (b)	Removed (c)	Failed (d)	Currently Installed (a-b-c-d)	Verified – Stored (a-b)
CFL	89%	3%	3%	2%	81%	**86%**
T8 & Delamping	82%	1%	1%	1%	80%	**81%**
High Bay	86%	0%	0%	0%	86%	**86%**
Other*	90%	2%	1%	0%	87%	**88%**

* Other Measures include Induction Fixtures, Metal Halide Fixtures, and Electronic Ballasts

Table 4-5, Table 4-6, and Table 4-7 provide installation verification rates specifically for CFLs, T8s, and High Bay T5s by facility type. Verification rates tended to vary by facility type and in some cases were less than or greater than 100%. Less than 100% verified means measures were not found on premises. More than 100% verified means indicates that onsite surveyors found more of a measure than the rebated number. For CFLs, the college/university and retail segments had the highest verification rates while warehouses had the lowest verification and installation rates. Verification rates for T8s were very high for a large number of segments, but warehouses had very low verification and installation rates. Verification of High Bay T-5s yielded results that were completely opposite with warehouses having a high verification rate and the college/university segment having a low rate of verification.

Table 4-5: Verification Findings by Facility Type – CFL

Facility Type	Verified – Received (a)	Stored (b)	Removed (c)	Failed (d)	Currently Installed (a-b-c-d)	Verified – Stored (a-b)
College/University	95%	0%	0%	2%	93%	**95%**
Commun. Service	81%	4%	0%	1%	76%	**77%**
Grocery	67%	0%	0%	0%	67%	**67%**
Health Care	92%	0%	10%	10%	73%	**92%**
Lodging	93%	0%	3%	1%	88%	**92%**
Misc. Commercial	88%	8%	2%	3%	76%	**81%**
Office	84%	7%	8%	5%	65%	**77%**
Personal Service	74%	7%	0%	0%	67%	**67%**
Restaurant	83%	4%	7%	10%	62%	**78%**
Retail	95%	2%	3%	1%	90%	**93%**
School	53%	9%	1%	1%	42%	**44%**
Warehouse	38%	0%	0%	0%	38%	**38%**

Table 4-6: Verification Findings by Facility Type – T-8

Facility Type	Verified – Received (a)	Stored (b)	Removed (c)	Failed (d)	Currently Installed (a-b-c-d)	Verified – Stored (a-b)
College/University	100%	0%	0%	0%	100%	**100%**
Commun. Service	100%	0%	5%	0%	94%	**100%**
Grocery	93%	0%	2%	3%	88%	**93%**
Health Care	98%	0%	0%	5%	94%	**98%**
Lodging	N/A	N/A	N/A	N/A	N/A	**N/A**
Misc. Commercial	87%	1%	0%	0%	86%	**86%**
Office	98%	5%	0%	1%	92%	**93%**
Personal Service	100%	0%	0%	1%	99%	**100%**
Restaurant	99%	0%	0%	2%	96%	**99%**
Retail	98%	2%	0%	1%	95%	**96%**
School	100%	1%	0%	1%	98%	**99%**
Warehouse	22%	0%	0%	0%	22%	**22%**

N/A means there were no T8s within this building type.

Table 4-7: Verification Findings by Facility Type – High Bay T-5

Facility Type	Verified – Received (a)	Stored (b)	Removed (c)	Failed (d)	Currently Installed (a-b-c-d)	Verified – Stored (a-b)
College/University	46%	0%	0%	0%	46%	**46%**
Commun. Service	100%	2%	0%	0%	98%	**98%**
Grocery	100%	0%	0%	0%	100%	**100%**
Health Care	N/A	N/A	N/A	N/A	N/A	**N/A**
Lodging	N/A	N/A	N/A	N/A	N/A	**N/A**
Misc. Commercial	79%	0%	0%	0%	79%	**79%**
Office	99%	0%	0%	0%	99%	**99%**
Personal Service	100%	0%	0%	0%	100%	**100%**
Restaurant	N/A	N/A	N/A	N/A	N/A	**N/A**
Retail	99%	0%	0%	0%	99%	**99%**
School	100%	0%	0%	0%	100%	**100%**
Warehouse	86%	0%	0%	0%	86%	**86%**

N/A means there were no High Bay T-5s within this building type.

4.3.2 Non-Lighting Measures

On-site audits of non-lighting[14] measures were also completed as part of the evaluation of the 2004/2005 Express Efficiency program. These sites were recruited during Express

[14] On-site verification of lighting is provided separately.

participant phone surveys conducted by the CATI center. These sites were stratified by utility and end use. During the on-site audits, information including the removal, installation, and storage of units was obtained. Itron recruited 174 sites from the phone surveys. Of the 174 recruited sites, on-site audits were completed at 130. Table 4-8 represents the number of sites visited based on measure stratification. Programmable thermostats represent the largest number of total non-lighting sites visited by measure followed by strip curtains and clothes washers.

Table 4-8: Sample Sizes for Non-Lighting Measures by Utility

Measures	SCE	PG&E	SCG	SDG&E	Total
Programmable Thermostats	6	18	11	6	41
VSD - AHU	0	8	0	1	9
Anti-Sweat Heater Controls	0	0	0	5	5
Auto Closers	0	0	0	2	2
Cooler/Freezer Door Gaskets	4	7	0	3	14
New Refrigeration Case with Doors - Low Temp	0	1	0	0	1
New Refrigeration Case with Doors - Med Temp	0	8	0	0	8
Night Covers	0	6	0	0	6
Strip Curtains for Walk-ins	4	12	0	1	17
Cool Roofs	0	3	0	0	3
Window Film	5	5	0	2	12
Boilers, Water	0	4	7	1	12
Clothes Washers	0	0	12	2	14
Pipe Insulation	0	0	1	0	1
Tank Insulation	0	1	1	0	2
Water Boilers, Process	0	0	4	0	4
Greenhouse Heat Curtains	0	0	1	2	3
Infrared Film for Greenhouses	0	1	0	0	1

The approach used to collect on-site data differed by measure. Certain measures such as programmable thermostats, clothes washers, and auto closers are based on units. Examples of measures expressed in linear feet are anti-sweat heater controls and night covers. Water boilers (for process and in general) are the only measures reported by MBTuh. Greenhouse gas curtains and window film are two examples of measures reported by square feet. Horsepower is only reported by variable speed drives (air handling units).

Table 4-9: Verification Findings for Non-Lighting Measures

Measures	Percent Verified
Programmable Thermostats	93%
VSD - AHU	137%
Anti-Sweat Heater Controls	78%
Auto Closer	100%
Cooler/Freezer Door Gaskets	86%
New Refrigeration Case with Doors - Low Temp	100%
New Refrigeration Case with Doors - Med Temp	97%
Night Covers	103%
Strip Curtains for Walk-ins	123%
Cool Roofs	101%
Window Film	105%
Boiler, Water	100%
Clothes Washer	92%
Pipe Insulation	100%
Tank Insulation	99%
Water Boiler, Process	100%
Greenhouse Heat Curtain	100%
Infrared Film for Greenhouses	100%

The verification rates for the non-lighting measures are presented in Table 4-9. The reason some percentages do not equal 100% is that they were not found on the premise. Some sites claimed to have more units than the number that had been rebated. That would explain why some of these numbers are greater than 100%. Seven measures had an installation and operational rate of 100%. Tank insulation had an installation and operational rate of 99%.

4.4 Billing Analysis

The objective of the billing analysis is to determine the first-year energy impacts for measures installed under the Express Efficiency program. For the billing analysis, a statistically adjusted engineering (SAE) model was implemented for lighting, HVAC, refrigeration measures and strip curtains. The billing analysis is specified using customer billing data, independent variables gathered during the telephone survey, customer-tracking data that indicate the timing of the Express Efficiency measure installation, and energy impacts associated with measures installed under the Express Efficiency program.

The results of the billing regression analysis are estimated as ratios, termed “SAE coefficients,” of realized impacts to the engineering energy impact estimates. These realized impacts represent the fraction of the engineering estimate actually observed or detected in the statistical analysis of the billing data. The SAE coefficients are relative to the ex ante impact estimates.

As discussed in detail below, the billing regression analysis was conducted on a sample of telephone surveyed participants. Because many Express Efficiency participants installed measures under multiple end uses, one integrated billing analysis was used to model the lighting, HVAC, refrigeration, and strip curtain end uses.

The model is dependent on extensive billing data, requiring 12 months of pre- and post-program participant billing data. The first step of the modeling process develops the dependent variable as the difference between the participant's monthly consumption in a given period and the same period 12 months prior. The monthly value of differenced consumption is then explained by independent variables that include the engineering estimates of savings during the 12-month period following program participation. The estimated coefficient on the engineering estimates of saving are the SAE realization rates.

4.4.1 Data Sources for the Billing Analysis

The billing regression analysis for Express uses data from several different data sources: Express program tracking databases from PG&E, SCE, and SDG&E, their monthly billing data from January 2003 to August 2007, telephone survey data, weather data from Weather Bank, and engineering adjustments to the utility ex ante savings assumptions. A summary of the data elements used in the regression analysis is presented below.

Program Tracking Data

The participant tracking system for Express Efficiency participants contains information about program application, rebate and technical information about installed measures, rebate amounts, installation date, and ex ante energy savings estimates.

Billing Data

The three electric utilities provided billing data for each meter at the participant facilities. The meter-level data were aggregated up into site-level consumptions. The billing data had bill read dates from January 2003 to August 2007.

The billing data were reviewed at the meter and the site level. The review identified sites with anomalous billing data at the meter and the site level. Anomalous bills were examined to determine Itron's ability to roll up the meter level bills to the site level.

Another data quality analysis compared annual consumption to annual estimated savings. This made it possible to identify discrepancies between actual consumption and expected savings for each site. Large estimated savings relative to site-level bills may indicate that it was not possible to adequately roll up the meter level bills into a site <u>or</u> that the ex ante savings are too high.

Weather Data

Actual daily heating and cooling degree days were obtained at the start of the project for sixteen weather stations within California. The weather data were associated with consumption based on the monthly read dates found in the billing data. Once the appropriate degree days were identified for each billing month of consumption, they were summed to a monthly value and compared to the previous year's degree days for the month of interest.

Telephone Survey Data

Telephone surveys were undertaken for a sample of Express Efficiency participants. The data collected in the telephone survey supply information on energy-related changes at each site for the billing period covered by the billing regression. Site-level changes included changes in equipment, remodeling, changes in employment, and changes in square footage. If a site reported changes, they were queried about the timing of the change.

The telephone survey data were merged with the program tracking, billing, and weather data. The ability to merge the survey data with available billing data limited the size of the population available for analysis.

Savings Impacts and Engineering Adjustments to Savings

The utility claimed ex ante savings estimates were examined by Itron, and adjustments were made to many of the ex ante savings. Prior to the billing analysis, adjustments were made to the ex ante savings assumptions used by the utilities for the lighting, refrigeration, thermostat, strip curtains measures. The adjustments to the ex ante savings were associated with an engineering review of the savings values based on the IOU work papers and adjustments due to field verification of work paper assumptions with actual Express participants.[15] Appendix I and Appendix J present the cursory and in-depth engineering analyses completed for Express and Upstream measures and explains how and why adjustments were made to the ex ante savings for the measures reviewed.

Lighting

For the lighting ex ante savings, the utility assumed hours of use by market sector were examined and compared to hours of use observed in the Express lighting logger analysis. The ex ante hours of use and the resultant savings were adjusted to be consistent with the hours use observed for the lighting loggers by business type. Adjusting the ex ante lighting

[15] Adjustments do not include data from the onsite verification of installation activities.

assumptions to be consistent with the lighting logger hours results in uniform ex ante lighting savings by business type across utilities. The ex ante hours of use and the adjusted hours of use are presented in the lighting logger section.

HVAC

The utility ex ante assumptions of savings were used for all HVAC measures other than programmable thermostats. The engineering evaluation of the ex ante utility assumptions for programmable thermostats used verification data from 38 Express Efficiency sites. The verification process determined that approximately 75% of the thermostats had not been programmed and are therefore assumed to not achieve electricity or gas savings. The lack of programming for the programmable thermostats led the engineers to reduce the estimate of ex ante savings to only 2.4% of the utilities' ex ante savings assumptions.[16]

The Express Efficiency ex ante savings assumptions for air conditioning units are derived from the expected savings between current baseline code energy usage and the expected usage of the high efficiency technology. Changes in baseline code or the standard level of efficiency over time implies that the pre-installation technology is likely to use more energy than the baseline code measure's usage. Even without changes in standards or baseline efficiency, degradation of the air conditioning unit associated with wear and tear from multiple years of usage, is likely to imply that the pre-installation technology will use more energy than the baseline code measure's usage. The ex ante savings impacts calculated relative to a baseline or standard level efficiency for HVAC measures are likely to be less than the savings impacts that would have been calculated based on the pre-existing units efficiency level. Consequently, an observed SAE savings realization rate in excess of one does not imply that the standards-based impact used for the Express Efficiency program is too high or too low. An observed SAE savings realization rate in excess of one implies that the observed reduction in the bills associated with the installation of an air conditioning unit exceeds the ex ante standards-based impact assumption. The larger than expected observed change in consumption could be due to changes in standards or the degradation of the pre-existing air conditioning unit.

Given concerns about the influence of degradation and changes in standards on the difference between pre-installation usage and post-installation usage, Itron does not believe that the billing analysis results should be used to calculate the realization rate for A/C and other HVAC measures.[17] The estimated billing realization rates for programmable thermostats,

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16 If non-programmed programmable thermostats are saving energy, this will be observed in the billing analysis results.

17 These measures, installed through the Express Efficiency Program, will be included in the billing analysis. The installation of the measures will impact changes in usage and these impacts need to be controlled for

however, are not impacted by changes in codes or degradation and can be used to calculate programmable thermostat realization rates.

Refrigeration

A review of the utility work papers, their claimed savings values, and the verification process led to some adjustments for the utility ex ante refrigeration savings assumptions. Table 4-10 lists the engineering adjustment for refrigeration measures. Two refrigeration measures—night covers and strip curtains—were found to have engineering adjustments to their savings levels that differed substantially from their utility ex ante savings values. For night covers, the verification process determined that the covers were applied, on average, for 10.6 hours per night while the work papers assumed six hours per night. The longer hours of usage leads to a higher engineering estimate of savings for night covers than was claimed in the ex ante utility work papers. For strip curtains, the verification process found that the work papers assumed that too high a percentage of the curtains were applied to freezers relative to what was observed in the verification sites. The lower incidence of application of strip curtains to freezers, relative to coolers, led to the majority of the reduction in the engineering realization rate of savings.

Table 4-10: Engineering Adjustments to Ex Ante Savings Assumptions for Refrigeration Measures

Measure	Engineering Realization Rate
Auto Closer	76%
Glass Refrigeration Doors	110%
Night Covers	177%
Gaskets	80%
Strip Curtains	32%

The team also reviewed the per unit claimed savings for refrigeration measures to ensure that all utilities were claiming similar values for similar measures and that these values were comparable to those used during the engineering analysis. This process revealed that SCE's claimed savings for cooler and freezer door gaskets differed significantly from the ex ante savings assumption used by the other utilities and from the assumptions found in the utility work papers. SCE's door gasket savings were 20 times too high. Review of the work papers showed that the assumed door perimeter was 20 feet. Given that SCE's savings are 20 times too high and the door perimeter is 20 feet, it appears that SCE erroneously assumed that the savings in the work paper were per linear foot when they were per door. SCE's claimed savings for door gaskets were divided by 20 prior to the billing analysis.

within the billing analysis. The estimated coefficients for A/C and other HVAC measures can be used to understand changes in usage.

4.4.2 Data Aggregation

The billing analysis was performed at the site level, necessitating an aggregation of the account level billing data to a unique site level. To form unique commercial site levels, all account-level billing data had to be aggregated to the site level. Information on the billing customer's name, the site's street address, ZIP code, and market sector were all used to aggregate billing data to the site level. The site development process attempts to maintain an accurate count of site-level meters as sites expand, contract, or experience meter and account change outs.

Once the billing data were aggregated to the site level, the billing data, tracking data, and the phone survey data were merged. During this aggregation process, care was taken to ensure that the Express impacts for the multiple measures across multiple time periods were aggregated to the site level. The aggregation process maintains the ability to analyze the impacts by measure and time period or to aggregate the impacts across end uses.

The merging of the survey, tracking, and billing data led to the development of the analysis database by Site ID. Table 4-11 lists the number of sites by utility associated with the progressive merges of the three data sources. Sites included as participant survey sites completed phone survey data collection for lighting, HVAC or refrigeration measure installations under the 2004-2005 Express Efficiency program. Sites included as participant survey sites with tracking data were surveyed sites that could be merged to their tracking data.

Table 4-11: Merged Survey, Tracking, and Billing Data by Utility

Utility	Participant Survey Data	Survey + Tracking Data	Survey + Tracking + Billing Data
PG&E	648	646	610
SCE	421	421	385
SDG&E	186	185	175
Total	1,255	1,252	1,170

The final column of Table 4-11 lists the number of sites with participant survey, tracking, and billing data. When an SAE billing analysis is used to model the change in consumption attributable to the installation of program measures, it is necessary to have billing data from a 12-month period prior to measure installation and as much post-installation data as possible.

Billing data were made available from January 2003 through August 2007. It was not always possible to match the survey and tracking data to a site in the billing data. For approximately 5% of the PG&E and SDG&E sites and 8% of the SCE sites, it was not possible to merge the site and tracking database with a billing record that obviously belonged with these data. For some of these sites, it is likely that the business moved or discontinued operation between the installation of the rebated measure and the request for billing data.

4.4.3 Data Censoring

Multiple types of screens were applied to the aggregated dataset prior to undertaking the billing analysis. The screens applied to the aggregated dataset include screens for excessive ex ante savings, excessive site-level changes outside the Express Efficiency program, a business type screen, and a check for sites with unusual billing data or excessive outlier influence during the billing analysis.

Sites were removed if the ex ante value of the Express Efficiency savings exceeded 40% of the site's pre-installation yearly billing data.[18] Table 4-12 lists the distribution of sites censored due to excessive savings by utility and the type of measures installed at the site. The sum of the number of sites listed can exceed the total number of sites censored if the site installed multiple measures.

Censoring due to excessive ex ante savings relative to site-level billing data led to the elimination of 21% of the aggregated PG&E sites. Disaggregating the PG&E censored sites; the lighting end use installations represented the majority of the censored sites. Approximately 34% of the PG&E sites that installed CFLs were censored due to excessive savings, with 17% of sites installing T8s and 23% of sites installing other lighting. Only 6% of the PG&E sites that installed A/C measures were censored, with 19% of the sites installing programmable thermostats, and 18% of refrigeration sites were censored due to excessive savings.[19] Approximately 19% of the SCE sites were censored due to excessive ex ante savings with the lighting end use most highly represented in the censored sites. Twenty six percent of sites installing CFLs and 25% of sites installing T8s were censored due to excessive savings. Approximately 19% of SDG&E's aggregated sties were censored due to excessive savings. For SDG&E, sites installing lighting measures accounted for the majority of the sites with excessive savings. Twenty eight percent of the SDG&E sites that installed CFLs were censored due to excessive savings, 23% of the sites installing other lighting

[18] The engineering adjustments and lighting logger adjustments to savings were implemented prior to calculating the distribution of savings relative to the billing data. For example, if a site installed programmable thermostats, the thermostat ex ante savings were multiplied by 0.024 or 2.4% prior to determining the ratio of ex ante savings to usage. Conversely, if the site installed night covers, the ex ante savings were multiplied by the engineering realization rate of 177% prior to determining the ratio of ex ante savings to usage. The censoring was based on annual savings and annual usage to ensure that the censoring was not due to the savings shape used to allocate savings across months.

[19] The large number of sites censored that reported installing CFLs may indicate that sites are purchasing CFLs for multiple locations on one application or sites are placing CFLs in storage.

measures and 15% of the sites installing T8s. For the censored sites, it is likely that the site aggregation process was not able to accurately line up all of the billing data with the site tracking and survey data. Alternatively, these sites may have ex ante savings that are excessive for the size of the actual site or its billing data.

Table 4-12: Distribution of Sites Censored due to Excessive Savings

Measure Group	PG&E		SCE		SDG&E	
	Number of Sites Censored	% of Sites with the Measure Censored	Number of Sites Censored	% of Sites with the Measure Censored	Number of Sites Censored	% of Sites with the Measure Censored
HVAC	28	15.7%	20	16.4%	5	9.3%
A/C Measures	3	6.1%	11	13.1%	5	16.7%
Prog. T-stat	25	18.8%	8	21.0%	0	0%
Other HVAC	0	0%	1	33%	0	0%
Lighting	117	24.8%	61	22.5%	30	25.8%
CFL	91	34.2%	42	25.8%	17	27.9%
T8	27	17.5%	31	25.2%	6	14.7%
Other Lighting	61	23.3%	34	24.5%	12	23.1%
Refrigeration	10	18.2%	1	8.3%	0	0%
Strip Curtains	12	28.6%	1	11.1%	1	50%

Sites were also removed if they were unable to answer questions concerning changes in site-level square footage, employment levels, or remodels. In addition, sites were removed if the survey participant stated that the employment level at the site had increased or decreased by more than 30% or if the site-level square footage had increased or decreased by more than 30%. Substantial changes in square footage and employment levels can work to mask the observed impacts associated with changes in the installation of high efficiency measures. Excessive change was observed in 35% of PG&E sites, 35% of SCE sites, and 30% of SDG&E sites.[20]

The team also chose to delete sites with standard consumption patterns that were considered outside the norm expected during the ex ante savings calculations. This process led to the elimination of sites listed as universities, ranches, farms, or nurseries. Usage patterns in the agricultural sector tends to be highly focused on the growing season and are unlikely to show usage or savings patterns that are similar to those found in other market sectors. The site

[20] Attempts were made to analyze the usage per square foot instead of usage. These attempts, however, were of limited usefulness given the self-reported nature of square footage and the poor quality of information associated with the timing of square footage changes and the size of the change.

aggregation process used to determine the site ID and to merge survey, billing, and tracking data led to the universities including all meters associated with the university. It was not possible to isolate the building receiving the installation of the high efficiency technology. The inability to isolate the impacted meter and the unusual usage patterns associated with this market sector led the team to delete these sites from the billing analysis.

Additionally, sites were censored if the number of accounts changed over time. Changes in the number of accounts associated with a site can indicate that the site or business expanded, contracted, or that the account or site aggregation process missed a new meter associated with a meter change-out. If the analysis misses a new meter associated with meter change-outs, and the lost meter is a primary meter, or is the meter associated with the area or appliance retrofit through the Express Efficiency program, including the site in the analysis could bias the observed realization rate.

The final elimination of sites occurred during the modeling process. Sites were eliminated if they installed "other" measures under the Express Efficiency program, if they were found to have unusual billing records, or if they were found to have excessive influence.[21] Five PG&E sites installed other measures while no SCE or SDG&E sites were still in the dataset that had installed other measures. The few sites, combined with the high level of ex ante saving claimed by these sites, led to their elimination from the billing regression dataset. During the billing analysis, a review of results and residuals pointed to 23 additional sites with unusual bills or excessive influence on the parameter estimates. These sites were dropped to ensure a more robust estimation that was not unduly influenced by outliers.[22]

[21] Sites with excessive influence are often outliers in terms of size of the site or other changes at the site.

[22] Given the self-reported nature of the survey information, it is possible that many of these outliers were associated with changes in square footage, employment, and/or production that were not accurately captured during the phone surveys. It is also possible that the outliers may be associated with meter change-outs and incomplete billing information.

Table 4-13: Database Used in Billing Regression Analysis

Utility	Aggregation Data Sites	Prior – Excessive Savings	Prior – Excessive Change	Prior-Agriculture - Universities	Prior – Changing in Accounts	Prior – Sites Installing "Other" Measures – Sites with Unusual Bill or Excessive Influence
PG&E	610	485	315	311	280	267
SCE	385	313	201	201	197	188
SDG&E	175	142	98	98	95	91
Total	**1,170**	**940**	**614**	**610**	**572**	**546**

4.4.4 Model Specification

The billing regression analysis for the Express Efficiency program evaluation used a first differenced model to provide unbiased and robust estimates. The key feature of the approach is that the specification models the year-to-year change in monthly consumption. Modeling the monthly change in consumption helps to isolate the program impacts, separating the program impacts from other observed, site-specific changes.

Model Structure

The approach used to estimate realized savings for the Express Efficiency program is a traditional first difference monthly SAE framework. This is a typical specification for studying pooled panel data where ex ante engineering estimates are available. The model structure explains the yearly change in monthly energy usage as a function of time, changes in weather, the ex ante savings associated with the installation of Express Efficiency lighting, programmable thermostats, other HVAC, refrigeration and strip curtain measures, the installation of measure outside Express Efficiency, remodeling, and changes in the site square footage. The model was estimated using the population of participants with usable billing, tracking, and survey data.

Model Specification

The end-use model specification is written as:

$$kWh_{it} - kWh_{it-12} = \beta_1 + \beta_2 \Delta HDD_{it} + \beta_3 \Delta CDD_{it} + \beta_4 LTSav_{it} * BType_{LT} + \beta_5 HVACSav_{it} * BType_{HVAC} + \beta_6 TSTATSav_{it} * BType_{HVAC} + \beta_7 REFSav_{it} + \beta_8 SCurtSav_{it} + \beta_9 Change_{it} * SQFT_i + \beta_{10} \mathrm{Remodel}_{it} * SQFT_i + \beta_{11} \Delta IncSQFT_{it} + \varepsilon_{it}$$

where the following definitions apply:

$kWh_{it} - kWh_{it-12}$	=	The change in monthly electricity consumption for site *i* between month *t* and month *t-12*.
ΔHDD_{it}	=	change in heating degree days from previous year's month for site *i* and month *t* in site *i*'s climate zone (i.e., $HDD_{it} - HDD_{it-12}$)
ΔCDD_{it}	=	change in cooling degree days from previous year's month for site *i* and month *t* in site *i*'s climate zone (i.e., $CDD_{it} - CDD_{it-12}$)
$LTSav_{it}$	=	an engineering estimate of the monthly lighting savings at site *i* in month t
$BType_{LT}$	=	a binary indicator of the site's business type. Lighting business types include office, retail, restaurant, community service centers and churches, hotel/motels, industrial, and all others.
$HVACSav_{it}$	=	an engineering estimate of the monthly HVAC savings at site *i* in month *t*. The HVAC savings do not include programmable thermostat savings.
$BType_{HVAC}$	=	a binary indicator of the site's business type. HVAC business types include hotels, schools, and all others.
$TSTATSav_{it}$	=	an engineering estimate of the monthly programmable thermostat savings at site *i* in month *t*
$BType_{HVAC}$	=	a binary indicator of the site's business type. HVAC business types include hotels, schools, and all others.
$REFSav_{it}$	=	an engineering estimate of the monthly refrigeration savings at site *i* in month *t*. The refrigeration savings do not include strip curtain savings.
$SCurtSav_{it}$	=	an engineering estimate of the monthly strip curtain savings at site *i* in month *t*
$Change_{it}$	=	a binary indicator that site *i* installed a lighting, HVAC, or refrigeration measure outside the Express Efficiency program in the current month or within the previous 12 months
$SQFT_i$	=	the site-level self-reported square footage
$Remodel_{it}$	=	a binary indicator that site *i* remodeled in the current month

or within the previous 12 months

$\Delta IncSQFT_{it}$ = the increase in square footage reported by site *i* in the current month or within the previous 12 months

Each coefficient in the model shows the impact on the change in consumption given a one-unit change in the explanatory variable that it describes. The model does not estimate an intercept coefficient because the model is specified in first differences. This specification implicitly eliminates the constant intercept term. The following is a brief description of each of the coefficients in the model and how they are interpreted.

β_1 = a constant term

β_2 = the change in kWh given a per-unit change in the 12-month change in heating degree days

β_3 = the change in kWh given a per-unit change in the 12-month change in cooling degree days

β_4 = the change in kWh given a per-unit change in the lighting engineering estimate of savings. Coefficients are estimated for multiple business types.

β_5 = the change in kWh given a per-unit change in the HVAC engineering estimate of savings. Coefficients are estimated for multiple business types.

β_6 = the change in kWh given a per-unit change in the programmable thermostat engineering estimate of savings. Coefficients are estimated for multiple business types.

β_7 = the change in kWh give a per-unit change in the refrigeration engineering estimate of savings.

β_8 = the change in kWh give a per-unit change in the strip curtain engineering estimate of savings.

β_9 = the change in kWh given a change in equipment outside the Express program in the 12 months times the site-level square footage. The coefficient gives the change in kWh per square foot during year of the installation.

β_{10} = the change in kWh given a site-level remodel in the past12 months times the site-level square footage. The coefficient gives the change in kWh per square foot during year of the remodel.

β_{11} = the change in kWh given a per-unit increase in square footage.

The model is designed to control for a variety of non-Express Efficiency changes at the site. The influences of changes in weather were recognized through the inclusion of variables reflecting changes in heating and cooling degree days. The influence of changes in equipment outside the Express Efficiency program were considered. The interaction of the change in equipment variable with the site-level square footage allows the impact of the change in equipment to differ depending on the size of the site as measured by the site's square footage. The change in consumption associated with a site-level remodel is considered with the inclusion of the remodel variable. The variable is interacted with the site-level square footage to allow the change in consumption associated with a remodel to vary depending upon the size of the site.

The model specification was first analyzed using ordinary least squares (OLS). The residuals from the model were analyzed for the presence of non-spherical disturbances and both heteroskedasticity and autocorrelation were detected in the model errors. To control for non-spherical disturbances, feasible generalized least squares (FGLS) was used. A Hausman test was used to determine if the coefficient estimates between the OLS and FGLS were consistent. The results from the Hausman test indicate that the coefficients are consistently estimated.

4.4.5 Model Estimates

This section presents the results from the model estimation. The difference between actual consumption in month *t* and month *t-12* was used as the dependent variable in the SAE model. The engineering estimates of savings and additional change variables were used to explain the change in actual usage between the two monthly consumption values that were 12 months apart.

Table 4-14 lists the coefficient estimates for the SAE model. The SAE model combines all lighting savings and non-programmable thermostat HVAC savings into a site-level savings estimate for these end uses. Analysis of the site-level savings for the individual lighting measures (CFLs, T8s, and other lighting) and the individual HVAC measures (air conditioning measures and other HVAC measures) indicated that several sites installed multiple measures. Attempting to model individual lighting and HVAC measures led to problems with multicollinearity. The model groups the HVAC and lighting measures into aggregate savings values by business type.

The building types analyzed for lighting and HVAC measures differed due to the number of sample points, hours of usage, and the types of measures installed. For the HVAC realization rates, hotels were analyzed separately because hotels installed packaged terminal air conditioning units with lower per unit levels of savings while other sites installed split and packaged systems with higher per-unit savings. Schools were also chosen as a separate business type for HVAC measures due to their unusual operating hours during the summer cooling season. The lower summer operating hours could be associated with a lower realization rate for schools. All other business types were grouped together due to the limited number of sample points.

Lighting Realization Rates

Realization rates for lighting measures were estimated for 6 individual business types and one aggregated or "All Other" business type. The business type segmentation was determined based upon a combination of requirements for adequate sample size and business similarities.

The realization rates for lighting measures were statistically significant at the 85% confidence level or better for all segments except restaurants. We will utilize the resulting realization rates for these segments, which include values of 51% for offices, 169% for retail, 82% for community services, 52% for industrial, 63% for other, and only 9% for hotel/motel.[23]

The resulting realization rate for restaurants was 99% but insignificant. Therefore, we will not apply the realization rate, and instead will simply utilize the adjusted engineering estimates based on the lighting logger data. However, this is effectively using a 100% realization rate which is nearly identical to the 99% result.

These estimated lighting realization rates apply to CFLs, T8 measures, and other lighting. Other lighting includes high bay lighting, but was largely made up of lighting sensors. The lighting logger analysis substantially changed the ex ante operating hours for many of the CFL and T8 measures by building types. The lighting sensors were adjusted to ensure that the ex ante sensor savings were consistent across the utilities by type of measure.

[23] The ex ante lighting savings are reflective of the lighting logger usage. Segments with highly variable lighting usage may require more lighting logger points. Hotels and motels have very different hours of use depending upon the area of application: common area versus lodging rooms. The low realization rate may be due to the area of application for sites in the billing analysis differing significantly from the lighting logger sites.

Table 4-14: Monthly First Differenced SAE Model for the 2004-2005 Express Efficiency Program

Regressor	Coefficient	T-Statistic
Constant	599.645	4.93
Summer * Change in Cooling Degree Days	24.902	5.64
Non-Summer * Change in Cooling Degree Days	5.639	0.78
Winter * Change in Heating Degree Days	-14.426	-2.93
Non-Winter * Change in Heating Degree Days	4.808	1.45
Lighting Savings Estimate For Offices	-0.513	-8.15
Lighting Savings Estimate For Retail	-1.686	-5.54
Lighting Savings Estimate For Restaurants	-0.980	-1.01
Lighting Savings Estimate For Community	-0.829	-1.52
Lighting Savings Estimate For Hotel/Motel	-0.086	-1.49
Lighting Savings Estimate For Industrial	-0.516	-3.90
Lighting Savings Estimate For All Other	-0.625	-6.19
HVAC Savings Estimate For Hotels	-4.156	-1.51
HVAC Savings Estimate For Schools	-0.207	-0.19
HVAC Savings Estimate For All Other	-2.797	-6.71
Thermostat Savings Estimate For Hotels	-12.147	-17.58
Thermostat Savings Estimate For Schools	-1.749	-0.08
Thermostat Savings Estimate For All Other	13.977	0.97
Refrigeration Savings Estimate	-0.952	-2.43
Strip Curtain Savings Estimate	-0.085	-0.08
Change Outside Express * Square Footage	0.0007	0.29
Remodel * Square Footage	0.005	1.12
Square Footage Increase	-0.018	-0.07
Adjusted R Squared = 0.030		

Programmable Thermostats and HVAC Realization Rates

The estimated realization rate for programmable thermostats in hotels was 1,215%. The realization rate applies to the engineering ex ante estimates of savings which were only 2.4%

of the utility ex ante estimates. The application of the billing realization rate to the engineering estimate implies that the observed bill savings for programmable thermostats are 29% of the utility ex ante estimate in the hotel segment. The higher realization rate for the hotel segment may indicate that hotels program their thermostats more often than the general business community does. The realization rate for programmable thermostats in schools and other business were not statistically different from zero. For these two segments, we will utilize the adjusted engineering estimates, which are only 2.4% of the utility ex ante estimates.

The estimated realization rate for other HVAC equipment installed through Express Efficiency within the "Other" business segments was 280% and was statistically significant. This realization rate is consistent with the hypothesis that the usage of the pre-existing HVAC equipment was significantly higher than the code based assumption of pre-existing usage used to calculate the ex ante savings impacts. The estimated realization rates for the hotel/motel and schools business segments were not statistically significant. Itron does not support usage of the billing realization rates to determine code based estimates of HVAC impacts. Therefore, we will rely on adjusted engineering estimates for these measures.

Refrigeration and Strip Curtain Realization Rates

The estimated realization rate for refrigeration measures was 95% and the estimated coefficient was statistically significant. Engineering based savings adjustments were made to the utility ex ante savings assumptions prior to implementing the billing analysis. The estimated refrigeration realization rate should be applied to the engineering ex ante assumptions. For example, the engineering based ex ante savings assumptions for night covers was 177% of the utility assumptions. Applying the billing realization rate to the engineering adjustment would imply a realization rate that is approximately 167% of the ex ante utility assumption.[24]

The estimated realization rate for strip curtains is approximately zero and is statistically insignificant. Therefore, we will rely on the results of the engineering analysis, which are only 32% of the utility work paper value.

Application of Realization Rates

It is important to note that the resulting SAE realization rates correspond to the adjusted engineering estimates that were developed and applied consistently to each IOU, as opposed to the ex ante savings estimates. The ex ante savings estimates for some measures varied

[24] Prior to implementing the billing analysis, adjustments were made to the savings assumptions for SCE's cool and freezer door gaskets. These savings were reduced by a factor of 20 due to an apparent misunderstanding concerning the units of the work paper savings.

significantly from one IOU to another, which would create issues by applying a single realization rate across all IOUs. This issue was mitigated by creating a consistent set of engineering estimates that were applied to all IOUs in the same manner.

Therefore, the overall realization rate on the ex ante savings will be the product between the SAE realization rate and the engineering realization rate (or the ratio between the adjusted engineering estimate and ex ante value).

4.5 Lighting Logger Analysis

4.5.1 Introduction

This section summarizes the assessment of annual hours of operation associated with compact fluorescent lamps (CFLs) and high efficiency linear fluorescents (T8/T5 and High Bay fixtures) that were installed as part of the 2004-05 Statewide Express Efficiency program.

The primary objective of this study is to develop annual operating hours specifically for the 2004-05 Express Efficiency program. However, a secondary objective was to develop annual operating hours for a number of key market segments that would ideally aid in future planning. Lighting loggers were installed in over 250 sites; however, due to a number of issues that will be discussed in detail, only 217 sites were used for the final analysis. Although this sample size allowed for a diverse number of market segments to be studied by business type, and in some cases customer size, for three key lighting technologies (CFL, T8/T5, and High Bay fixtures), many of the sample sizes at the segment-technology level are not large enough to provide reliable results. Therefore, readers are cautioned to note the sample sizes and confidence intervals presented and take these into consideration when applying segment-level results.

4.5.2 Approach

Because the overriding objective of this study was to produce a current, accurate, and program-specific estimate of hours of operation for CFLs and high efficiency linear fluorescents, an emphasis was placed on primary data-guided research activities. Site visits and the installation of lighting loggers used to capture the actual operating schedules for a sample of program participant sites constituted the foundation for this study. The goal of these site visits was to characterize the application of CFLs and high efficiency linear fluorescents among participants, and not the general lighting usage at the site. A telephone survey of the same sites was bolstered with a telephone survey of nearly 400 additional participants by using a comparison of the stated operating schedules to compare to the logged sites. Lighting schedules developed from the samples were segmented by business type and customer size (demand) and were then aggregated to a program-wide estimate of annual hours of operation using measure counts from the program tracking database to weight the individual segments.

4.5.3 Organization

Sections 4.4.4 through 4.4.6 of the report provides a detailed account of the methods employed to develop the hours of operation. The subsection first outlines the sample selection, segmentation, and sources of data, providing full counts of both sites and bulbs for all sources. The next subsections outlines the specific methods used to integrate these data sources, with a focus on how the different data were used to leverage and validate one another.

The final estimates for annual hours of operation are presented in 4.4.7 through 4.4.11 along with summaries of some key intermediate steps. In addition, these subsections discuss some of the issues that arose during the analysis and presents some alternatives—along with strong caveats—to the overall program estimate.

4.5.4 Methodology

This section describes the methodology underlying the assessment of the annual hours of operation for the three technologies installed as part of the 2004-05 Express Efficiency program. They include compact fluorescent bulbs (CFLs), T8 fluorescent fixtures (T8) and High Bay T-5 fixtures. The section begins with a discussion of sample selection and the different data sources and then provides a detailed explanation of how those sources were integrated to calculate a program-wide estimate of the annual hours of operation for CFL, T8, and High Bay lighting.

<u>Data Sources</u>

The evaluation of annual hours of operation relied on the integration of four different sources of data, each of which is described briefly below:

- ***2004-05 Program Tracking Data.*** Counts of bulb and fixture installations and customer characteristics for the overall participant population were obtained from the tracking database.
- ***Telephone Survey.*** Phone surveys were conducted for 697 program participants across 14 business type classifications who had installed lighting measures to verify their participation in the 2004-05 Express Efficiency program. Responses were gathered for a series of questions aimed at ascertaining which measures were installed at each site under the program and how the equipment was used. These data were merged with the other data sources to aid in the analysis of the lighting logger results. The phone survey also enabled recruitment of sites for verification visits and lighting logger installations.

- **Site Visits.** Engineers conducted verifications at sites where survey respondents had agreed to the installation of lighting loggers. Data were collected during these visits to assess lighting and fixture counts, hours of operation, and overall site characteristics. A census of all participants that agreed to the installation of lighting loggers was attempted.
- **Lighting Loggers.** Logger data for three different technologies gathered from 485 loggers installed at 217 participant sites[25] across the different business segments were used in this analysis. Surveyors installed loggers at various locations at the participant sites based on site characteristics, measures installed, and usage patterns. The loggers were installed to assess the actual on-off schedules of program-related lamp and fixture installations.

The most critical sources for the assessment were the logger data and the telephone survey, which provided the primary basis of comparison of actual schedules (logger data) with stated business operation schedules (phone survey). Data collected from the site visits provided a means to corroborate the results from the telephone survey and aided in the overall cleaning and validation of the logger data. Finally, program tracking data provided the final set of weights to allow the expansion of the sample to produce a program-wide estimate of actual and stated schedules.

Logger Installation

The Express Efficiency research plan called for lighting loggers to be installed at 250 sites. The loggers were to be distributed between CFLs, linear fluorescent fixtures, and High Bay fixtures based on what the participants actually installed under the 2004-05 Program. Recruitment for the logger study was done as part of the phone survey; the study was briefly described and respondents were specifically asked if Itron could install lighting loggers at their site. A census of sites agreeing to the loggers during the phone survey was attempted except for the Assembly segment, which was limited due to the overabundance of sites agreeing to their installation. However, even some of those who originally agreed to the study refused to allow installation of the loggers once the surveyors were on site.

Once on-site, surveyors attempted to logger every activity area where rebated CFLs and linear fluorescent lamps were installed. Activity areas are defined as areas at the premise that have different operating schedules. However, site contacts restricted access to some areas at a few of the sites that were visited. Within each activity area, the lamps and fixtures that were logged were selected at random. Installation of logging equipment was also not always possible due to a variety of other reasons. Engineers were limited in their efforts to install

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[25] A subset of the logged sites installed both CFLs and linear fluorescents under the Program and in some cases, both types of lighting were logged. Adding the total number of sites logged by measure would yield 240 sites, which would double counts these sites, but these are still sample points for different fixture types.

monitoring equipment at sites where fixtures were too high and could not be reached, or were not accessible for any other reason, or where there was no place on a fixture to install a logger, or where there was too much ambient light to be able to logger efficiently.

Itron ultimately visited over 280 sites and installed 747 loggers at 263 sites. Table 4-15, Table 4-16, and Table 4-17 provide a distribution of sites visited and loggers installed by facility type and demand group for CFLs, T8s, and High Bays respectively.

Table 4-15: Distribution of Sites and # of Loggers Installed by Segment – CFL

Business Type/Size	< 20 KW		> 20 KW		Total	
	Sites Installed	Loggers Installed	Sites Installed	Loggers Installed	Sites Installed	Loggers Installed
Assembly	-	-	-	-	31	71
Grocery	-	-	-	-	6	15
Health Care	-	-	-	-	14	28
Industrial	-	-	-	-	2	4
LodgingGuest_Room	-	-	-	-	16	70
LodgingOther	-	-	-	-	15	30
Misc Commercial	11	25	6	11	17	36
Office	14	28	13	38	27	66
Restaurant	-	-	-	-	21	39
Retail	15	31	4	9	19	40
School	-	-	-	-	9	19
Warehouse	-	-	-	-	1	2
Total	**40**	**84**	**23**	**58**	**178**	**420**

Table 4-16: Distribution of Sites and # of Loggers Installed by Segment – T8-T5

Business Type/Size	< 20 KW		> 20 KW		Total	
	Sites Installed	Loggers Installed	Sites Installed	Loggers Installed	Sites Installed	Loggers Installed
Assembly	-	-	-	-	7	20
Grocery	-	-	-	-	6	16
Health Care	-	-	-	-	5	14
Industrial	-	-	-	-	10	20
LodgingGuest_Room	-	-	-	-	-	-
LodgingOther	-	-	-	-	-	-
Misc Commercial	16	42	10	23	26	65
Office	14	38	5	15	19	53
Restaurant	-	-	-	-	3	7
Retail	11	25	12	33	23	58
School	-	-	-	-	8	24
Warehouse	-	-	-	-	2	4
Total	**41**	**105**	**27**	**71**	**109**	**281**

Table 4-17: Distribution of Sites and # of Loggers Installed by Segment – High Bay

Business Type/Size	< 20 KW		> 20 KW		Total	
	Sites Installed	Loggers Installed	Sites Installed	Loggers Installed	Sites Installed	Loggers Installed
Assembly	-	-	-	-	1	2
Grocery	-	-	-	-	1	2
Health Care	-	-	-	-	-	-
Industrial	-	-	-	-	5	10
LodgingGuest_Room	-	-	-	-	-	-
LodgingOther	-	-	-	-	-	-
Misc Commercial	5	14	3	7	8	21
Office	-	-	-	-	-	-
Restaurant	-	-	-	-	-	-
Retail	1	2	1	3	2	5
School	-	-	-	-	1	1
Warehouse	-	-	-	-	3	5
Total	**6**	**16**	**4**	**10**	**21**	**46**

Logger Equipment Installed

The lighting loggers used in the M&E effort for the Express Efficiency project were manufactured by two different companies, Onset (HOBOs) and Dent Instruments (SMARTlogger™ CT-version). Two different models of the HOBO loggers—the U9 and H06—were used. The loggers record on/off transition times (time-of-use, or TOU) for the monitored lighting fixture. These TOU lighting loggers use a built-in light sensor that responds to the presence or absence of light. When lights are in use, the data logger records an "ON" state with a time and date stamp and the same information is recorded when the lights are turned "OFF."

Of the two HOBO models used, the Hobo U9 is the newer model. The U9 lighting logger can record up to 43,000 on/off state changes. This logger has both a push-button and a programmable reset/start and a sensitivity threshold adjustable from 10 to 100 lumens/m^2. The light sensitivity is increased by turning the sensitivity adjustment screw *counter-clockwise* and the logger has two LED lights—one red and one green. When the logger detects light, the green LED blinks. When no light is detected, the red LED blinks. The HOBO H06 is very similar to the U9 in its configuration and recording of data, but there are significant differences, including the absence of a push button reset/start, the sensitivity of the logger is increased by turning the adjustment screw *clockwise* (the opposite of the U9), and it does not use a USB data cable for data downloading. Data for both loggers were downloaded and processed using Onset's proprietary software.

The Dent clamp-on CT current loggers were used exclusively to monitor CFL's installed in plug-in table, floor, and wall lamps (primarily lodging sites). The CT logger records current flow on/off events rather than light events. CT loggers were used for these applications because the HOBO loggers could not be physically installed in these fixtures, and to minimize loss of the loggers by theft. Dent's SMARTware software was used to download and process the data.

Quality Control Process

The 747 loggers were installed over a four-month period in two waves that overlapped each other. As the loggers were retrieved, the data were downloaded and a few initial quality control checks were conducted. These included testing to see if there was a minimum of three weeks of data recorded and that there were no large gaps in the data that might indicate that the logger was temporarily moved or that the battery failed. The data for all loggers that passed this initial QC process were then compiled into a master database that could be easily used for analysis. Next, the more detailed QC analysis was conducted. This included identifying "flickering" which is explained in more detail below.

Data Issues

The combination of the quality control process and issues with missing/stolen loggers resulted in 485 of the 747 loggers being retained in the analysis. The three most prevalent issues accounting for the loss of logger data were:

- **Missing, Stolen, or Damaged Loggers.** The problem of theft was primarily encountered in lodging sites where the loggers were placed in guest rooms and could be easily removed by guests or cleaning staff; these loggers were never recovered. In total, there were 46 loggers for which data was not able to be downloaded; primarily due to theft.
- **Failed/Faulty Loggers with Insufficient Data.** Loggers that did not collect sufficient data may have been the result of faulty batteries, loggers falling off and/or not being replaced correctly, and/or other mechanical issues. Loggers were expected to record a minimum of three weeks of data with a target of four to five weeks. If the logger recorded significantly fewer days than this, the entire logger data was discarded.
- **Flickering.** The issue with flickering was pervasive with the loggers that were used for this project. "Flickering" is defined as multiple short-duration (seconds) on/off events that occur for an extended period, especially in lieu of "normal" logger operation. Specifically, any minute of data with more than two transitions recorded were flagged as flicker minutes, hours with more than five such flicker minutes were flagged as flicker hours. A logger with more than 15% of its hours flagged as flicker hours was deleted from the analysis.

  An example of flickering in the logger transition data is presented in Table 4-18.

Table 4-18: Example of Flickering in Lighting Logger Data

Date and Time	Light Sensor		Date and Time	Light Sensor
9/19/2007 11:48	1		9/19/2007 12:20	0
9/19/2007 11:49	0		9/19/2007 12:20	1
9/19/2007 11:49	1		9/19/2007 12:20	0
9/19/2007 11:49	0		9/19/2007 12:21	1
9/19/2007 11:50	1		9/19/2007 12:21	0
9/19/2007 11:50	0		9/19/2007 12:22	1
9/19/2007 11:50	1		9/19/2007 12:22	0
9/19/2007 11:51	0		9/19/2007 12:29	1
9/19/2007 12:02	1		9/19/2007 12:29	0
9/19/2007 12:02	0		9/19/2007 12:47	1
9/19/2007 12:02	1		9/19/2007 12:47	0
9/19/2007 12:02	0		9/19/2007 12:47	1
9/19/2007 12:17	1		9/19/2007 12:48	0
9/19/2007 12:17	0		9/19/2007 12:48	1
9/19/2007 12:20	1		9/19/2007 12:48	0

Close examination of the data where flickering was encountered showed no systematic pattern that applied to all the meters and that could be used to globally repair the data. Instead, each dataset was evaluated individually and the data were corrected if possible or discarded. The cause is still not completely known, however, the most plausible reasons from subsequent investigations are susceptibility of the U9 loggers to ambient lighting and incorrect sensitivity adjustment partially due to the U9's non-standard adjustment configuration.

The HOBO U9 loggers that were the primary logger used for this study are capable of sensing light at an angle ±30 degrees from the source and up to 5 ft. away. This could make it more susceptible to ambient lighting sources, especially if not set correctly. Setting the logger "correctly" may have been difficult as well. As noted by RLW in a recent side-by-side logger test for the CPUC,[26] the sensitivity adjustment for HOBO U9 loggers is unique in that is the *opposite* of the older model HOBOs, as well as any of the DENT loggers. As such, it is counter-intuitive that turning the dial clockwise decreases sensitivity. In addition, there are no "+" and "-" symbols on the HOBO loggers to assist in that determination; instead the red and green LEDs serve that purpose. Investigations also revealed that the older generation HOBO loggers check the light state every 0.5 second whereas the U9 HOBOs and

[26] RLW installed HOBO U6, HOBO U9 and DENT loggers in side-by-side installations at PG&E's Pacific Energy Center (PEC). This was part of an investigation of lighting loggers conducted as part of the CPUC 06-08 Evaluation efforts.

DENT loggers only check the light state every second. However, all monitored fixtures should have used electronic ballasts, and the frequency of the electronic ballasts is much higher than either of these sampling rates, so this cannot be the cause of flickering.

Table 4-19, Table 4-20, and Table 4-21 provide a comparison of the count of sites visited and loggers installed, with the sites and loggers retained in analysis.

Table 4-19: Distribution of Sites and # of Loggers Installed and Retained in Analysis by Segment – CFL

Business Type/Size	< 20 KW				> 20 KW				Total			
	Sites Installed	Sites Retained	Loggers Installed	Loggers Retained	Sites Installed	Sites Retained	Loggers Installed	Loggers Retained	Sites Installed	Sites Retained	Loggers Installed	Loggers Retained
Assembly	-	-	-	-	-	-	-	-	31	23	71	46
Grocery	-	-	-	-	-	-	-	-	6	4	15	8
Health Care	-	-	-	-	-	-	-	-	14	8	28	21
Industrial	-	-	-	-	-	-	-	-	2	2	4	2
LodgingGuest_Room	-	-	-	-	-	-	-	-	16	12	70	37
LodgingOther	-	-	-	-	-	-	-	-	15	9	30	14
Misc Commercial	11	6	25	12	6	3	11	5	17	9	36	17
Office	14	11	28	21	13	9	38	20	27	20	66	41
Restaurant	-	-	-	-	-	-	-	-	21	13	39	21
Retail	15	12	31	20	4	3	9	6	19	15	40	26
School	-	-	-	-	-	-	-	-	9	4	19	5
Warehouse	-	-	-	-	-	-	-	-	1	-	2	-
Total	**40**	**29**	**84**	**53**	**23**	**15**	**58**	**31**	**178**	**119**	**420**	**238**

Table 4-20: Distribution of Sites and # of Loggers Installed and Retained in Analysis by Segment – T8/T5

Business Type/Size	< 20 KW				> 20 KW				Total			
	Sites Installed	Sites Retained	Loggers Installed	Loggers Retained	Sites Installed	Sites Retained	Loggers Installed	Loggers Retained	Sites Installed	Sites Retained	Loggers Installed	Loggers Retained
Assembly	-	-	-	-	-	-	-	-	7	7	20	17
Grocery	-	-	-	-	-	-	-	-	6	6	16	12
Health Care	-	-	-	-	-	-	-	-	5	5	14	12
Industrial	-	-	-	-	-	-	-	-	10	8	20	18
Lodging - Guest Rooms	-	-	-	-	-	-	-	-	-	-	-	-
Lodging - Other	-	-	-	-	-	-	-	-	-	-	-	-
Misc Commercial	16	14	42	32	10	8	23	17	26	22	65	49
Office	14	10	38	25	5	5	15	14	19	15	53	39
Restaurant	-	-	-	-	-	-	-	-	3	3	7	5
Retail	11	10	25	20	12	9	33	28	23	19	58	48
School	-	-	-	-	-	-	-	-	8	8	24	17
Warehouse	-	-	-	-	-	-	-	-	2	1	4	2
Total	**41**	**34**	**105**	**77**	**27**	**22**	**71**	**59**	**109**	**94**	**281**	**219**

Table 4-21: Distribution of Sites and # of Loggers Installed and Retained in Analysis by Segment – High Bay

Business Type/Size	< 20 KW				> 20 KW				Total			
	Sites Installed	Sites Retained	Loggers Installed	Loggers Retained	Sites Installed	Sites Retained	Loggers Installed	Loggers Retained	Sites Installed	Sites Retained	Loggers Installed	Loggers Retained
Assembly	-	-	-	-	-	-	-	-	1	-	2	-
Grocery	-	-	-	-	-	-	-	-	1	1	2	1
Health Care	-	-	-	-	-	-	-	-	-	-	-	-
Industrial	-	-	-	-	-	-	-	-	5	4	10	8
Lodging - Guest Rooms	-	-	-	-	-	-	-	-	-	-	-	-
Lodging - Other	-	-	-	-	-	-	-	-	-	-	-	-
Misc Commercial	5	4	14	5	3	3	7	5	8	7	21	10
Office	-	-	-	-	-	-	-	-	-	-	-	-
Restaurant	-	-	-	-	-	-	-	-	-	-	-	-
Retail	1	-	2	-	1	1	3	3	2	1	5	3
School	-	-	-	-	-	-	-	-	1	1	1	1
Warehouse	-	-	-	-	-	-	-	-	3	3	5	5
Total	**6**	**4**	**16**	**5**	**4**	**4**	**10**	**8**	**21**	**17**	**46**	**28**

4.5.5 Logger Data used in Analysis

As explained above, Itron visited over 280 sites and installed 747 loggers at 263 sites. Of these, the final usable analysis dataset consisted of 485 loggers at 217 sites. Table 4-22, Table 4-25, and Table 4-28 present the counts of premises in the logger sample and their respective loggers across the three measure types.[27] Table 4-23, Table 4-26, and Table 4-29 provide a distribution of lighting measure installation across the business segments while Table 4-24, Table 4-27, and Table 4-30 provide a distribution of quantities of measures installed by all 2004-05 Express Efficiency Program participants. These tables show the distribution of sites, loggers and lamps/fixtures for sites where loggers were installed and for participants by business type and demand group (where applicable). Only miscellaneous commercial, offices, and retail are split out by the demand groups categorized as very small (<20 kW) and other (>20 kW). These segments were split out in an attempt to be more consistent with the market segments used in the Database for Energy Efficient Resources (DEER) in order to provide better input to future DEER updates. The tables are grouped by lamp/fixture type, which included CFLs, linear fluorescent T8 and T-5 fixtures, and High Bay T-5 fixtures.

An objective of the study was to develop annual operating hours for a number of key market segments that would ideally aid in future planning. As mentioned, given the large number of market segments and technology combinations being studied, many of the sample sizes were not large enough to provide reliable results. In the participant tracking data, NAICS and SIC information was not always available or accurate in order to segment a customer into the proper market segment. As part of the on-site visits, Itron was able to determine the correct market segment for many of these customers. Using this information, customers were reclassified into the proper market segment to improve the reliability of the market segment-level results. However, it is important to note that for the purposes of developing program level results, customers were weighted using their original classification in the tracking data as this was necessary to create unbiased program level results. Therefore, when comparing the lamp counts for the logger sample and participant population (e.g., Table 4-23 and Table 4-24), there is a large discrepancy in the Miscellaneous Commercial segment as sites could be reclassified for the logger sample, but not the population.

The analysis of the lighting logger results for the lodging segment led to the disaggregation of the logger results into installations in guest rooms and those in common areas. The tracking data, however, do not contain the information needed to separate tracking installation data into guest rooms and common areas. Therefore, the logger data presented in

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27 While the initial plan was to sample an equal number of sites from each segment, this was not possible primarily due to the availability of sites within certain segments. Essentially, a census of the participant population was recruited for the study in nearly every segment.

Table 4-23 includes two rows for lodging whereas the tracking data presented in Table 4-24 includes only one row of lodging data.

The usage profile for lighting measures for lodging is significantly different than the profile for other business segments. Due to the different usage profile, Itron developed a separate estimate of annual operating hours for CFLs installed through the Express program for lodging and all other businesses.

Compact Fluorescent Lamps

Table 4-22 provides counts of sites and loggers that were retained in the analysis. Of the 119 sites with CFLs, there was a large concentration of loggers in assembly, offices, and guest rooms. For offices, the number of loggers retained was evenly distributed across the demand groups but with the other building types, the very small demand group had more loggers than the higher demand group.

Table 4-22: Distribution of Sites and # of Loggers Retained by Segment – CFL

	< 20 KW		> 20 KW		Total	
Business Type/Size	**Sites Retained**	**Loggers Retained**	**Sites Retained**	**Loggers Retained**	**Sites Retained**	**Loggers Retained**
Assembly	-	-	-	-	23	46
Grocery	-	-	-	-	4	8
Health Care	-	-	-	-	8	21
Industrial	-	-	-	-	2	2
LodgingGuest_Room	-	-	-	-	12	37
LodgingOther	-	-	-	-	9	14
Misc Commercial	6	12	3	5	9	17
Office	11	21	9	20	20	41
Restaurant	-	-	-	-	13	21
Retail	12	20	3	6	15	26
School	-	-	-	-	4	5
Warehouse	-	-	-	-	-	-
Total	**29**	**53**	**15**	**31**	**119**	**238**

Table 4-23 presents a distribution of the CFL lamps represented by the 238 loggers listed in Table 4-22. The largest concentration of lamps across logged sites is in lodging guest rooms (32%), followed closely by lodging, other areas (29%). The loggers in office, assembly, and the retail segments each represent approximately 10% of the lamps loggered.

Table 4-23: Distribution of All Lamps for Logger Sites by Segment – CFL

Business Type/Size	< 20 KW		> 20 KW		Total	
	CFLs	% of Total	CFLs	% of Total	CFLs	% of Total
Assembly	-	-	-	-	1,055	8.8%
Grocery	-	-	-	-	45	0.4%
Health Care	-	-	-	-	405	3.4%
Industrial	-	-	-	-	28	0.2%
LodgingGuest_Room	-	-	-	-	3,827	32.0%
LodgingOther	-	-	-	-	3,515	29.4%
Misc Commercial	189	1.6%	38	0.3%	227	1.9%
Office	402	3.4%	1,057	8.8%	1,459	12.2%
Restaurant	-	-	-	-	258	2.2%
Retail	564	4.7%	442	3.7%	1,006	8.4%
School	-	-	-	-	137	1.1%
Warehouse	-	-	-	-	-	0.0%
Total	**1,155**	**9.7%**	**1,537**	**12.9%**	**11,961**	**100.0%**

As would be expected the distribution of lamps in the participant population has similar distributions to the logged sites. This distribution is presented in Table 4-24. Hotel/motel, as it is categorized in the population, garners 42% of the total lamps installed under the program.[28] Assembly, offices, and retail represent approximately 19%, with restaurants higher than the logger data indicate at just fewer than 10% versus the 2.2% represented by the sites where loggers were installed.[29]

[28] The tracking data do not allow for the disaggregation of lodging into guest rooms and other areas.

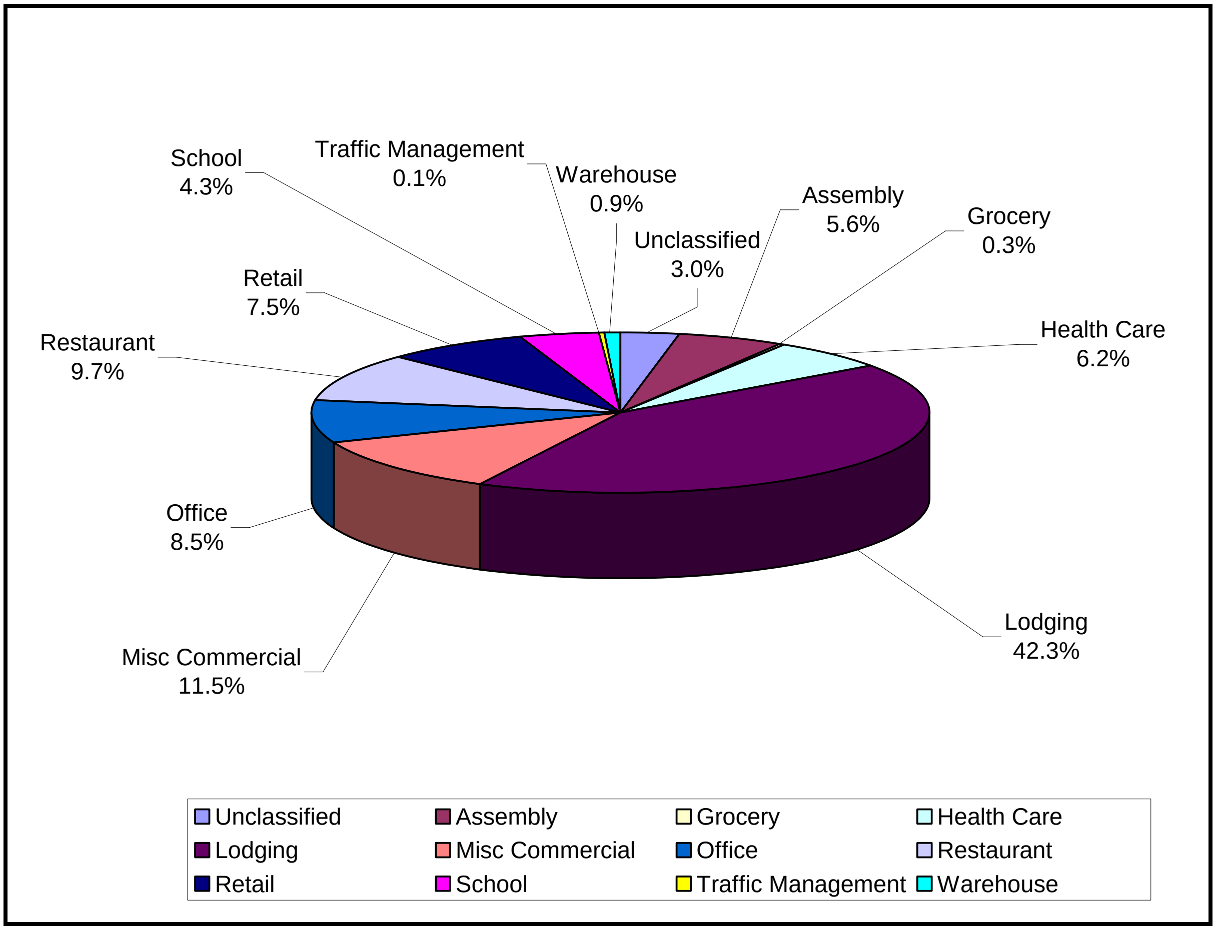
[29] The difference between the distribution in Table 4-23 and Table 4-24 is due to the sites that were willing to allow Itron to install lighting loggers.

Table 4-24: Distribution of All Lamps for Participants by Segment – CFL

Business Type/Size	< 20 KW		> 20 KW		Total	
	CFLs	% of Total	CFLs	% of Total	CFLs	% of Total
Unclassified	-	-	-	-	32,014	3.0%
Assembly	-	-	-	-	61,143	5.6%
Grocery	-	-	-	-	3,772	0.3%
Health Care	-	-	-	-	67,043	6.2%
Industrial	-	-	-	-	93	0.0%
Lodging	-	-	-	-	458,293	42.3%
Misc Commercial	22,379	2.1%	102,475	9.5%	124,854	11.5%
Office	18,154	1.7%	74,133	6.8%	92,287	8.5%
Restaurant	-	-	-	0.0%	104,833	9.7%
Retail	27,390	2.5%	54,124	5.0%	81,514	7.5%
School	-	-	-	-	46,982	4.3%
Traffic Management	-	-	-	-	1,302	0.1%
Warehouse	-	-	-	-	10,020	0.9%
Total	**67,923**	**6%**	**230,732**	**21%**	**1,084,150**	**100%**

Figure 4-1 illustrates the participation of the segments as a percentage of total program CFL installations. As shown, CFL installations were unevenly distributed among the segments. Nearly half of the CFLs installed under the program were installed in lodging.

Figure 4-1: Percentage of Program CFL Installations by Study Segment for the 2004-2005 Express Efficiency Program



Linear Fluorescent T8 and T5 Fixtures

Table 4-25 presents the distribution of sites and loggers retained in the analysis for linear fluorescent T8 and T5 fixtures. While the number of sites monitored with loggers installed to record the usage of T8s was fewer than CFLs, the number of loggers retained in analysis was 219, very close to the total CFL loggers. As would be expected, the largest concentration of linear fluorescent fixtures loggered was in miscellaneous commercial buildings, offices, and retail. Table 4-26 presents information on the number of T8 and T5 fixtures represented by the loggers listed in Table 4-25. The data presented in Table 4-26 indicate that the loggers account for a large concentration of linear fluorescents in schools, miscellaneous, offices, and retail. This distribution is very similar to the distribution of loggers installed. Schools represent more fixtures per logger because more fixtures are controlled by a single switch in schools than in offices leading to their higher distribution of fixtures in Table 4-26.

Table 4-25: Distribution of Sites and # of Loggers Retained in Analysis by Segment – T8/T5

Business Type/Size	< 20 KW		> 20 KW		Total	
	Sites Retained	Loggers Retained	Sites Retained	Loggers Retained	Sites Retained	Loggers Retained
Assembly	-	-	-	-	7	17
Grocery	-	-	-	-	6	12
Health Care	-	-	-	-	5	12
Industrial	-	-	-	-	8	18
Lodging - Guest Rooms	-	-	-	-	-	-
Lodging – Other	-	-	-	-	-	-
Misc Commercial	14	32	8	17	22	49
Office	10	25	5	14	15	39
Restaurant	-	-	-	-	3	5
Retail	10	20	9	28	19	48
School	-	-	-	-	8	17
Warehouse	-	-	-	-	1	2
Total	**34**	**77**	**22**	**59**	**94**	**219**

Table 4-26: Distribution of All Lamps for Logger Sites by Segment – T8/T5

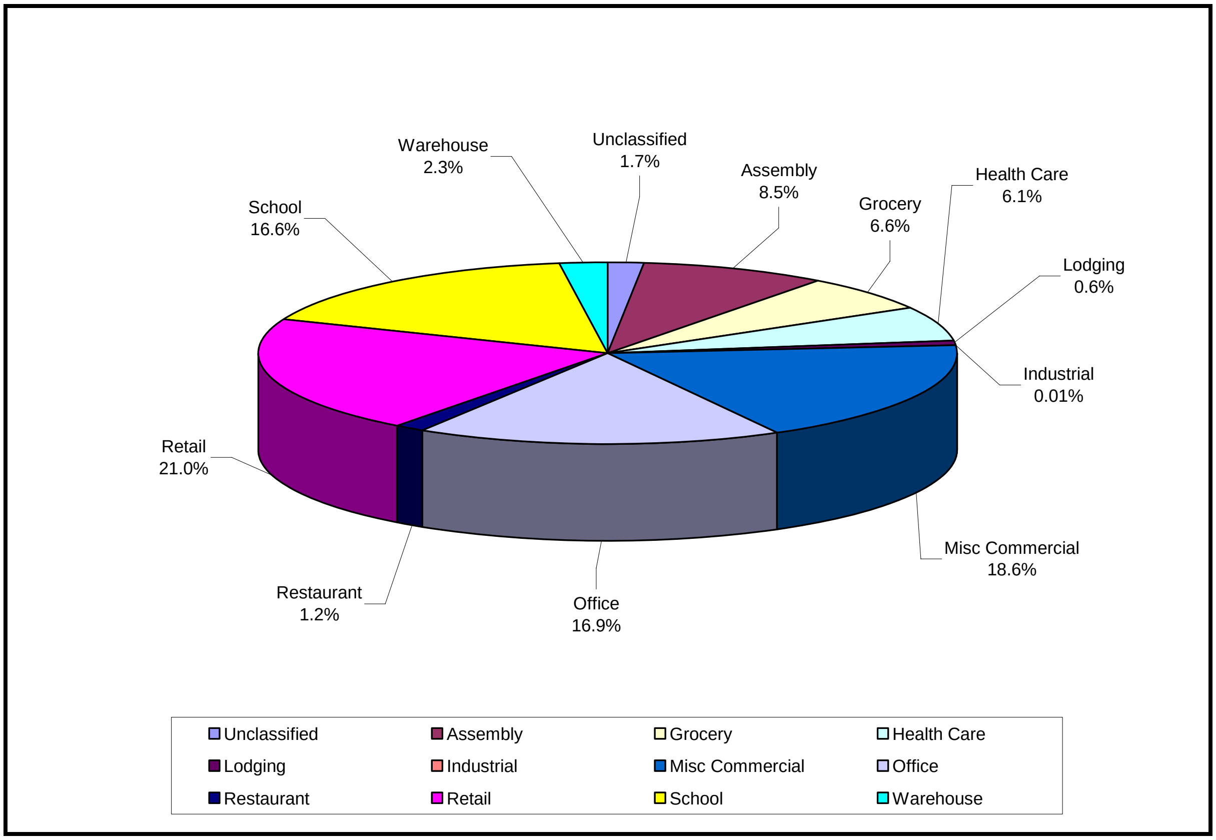
Business Type/Size	< 20 KW		> 20 KW		Total	
	Fixtures	% of Total	Fixtures	% of Total	Fixtures	% of Total
Assembly	-	-	-	-	1,836	9.5%
Grocery	-	-	-	-	693	3.6%
Health Care	-	-	-	-	763	4.0%
Industrial	-	-	-	-	1,971	10.2%
Lodging – Guest Room	-	-	-	-	-	-
Lodging – Other	-	-	-	-	-	-
Misc Commercial	916	4.8%	1,840	9.6%	2,756	14.3%
Office	1,180	6.1%	1,220	6.3%	2,400	12.5%
Restaurant	-	-	-	-	158	0.8%
Retail	725	3.8%	2,672	13.9%	3,397	17.7%
School	-	-	-	-	5,225	27.2%
Warehouse	-	-	-	-	32	0.2%
Total	**2,821**	**14.7%**	**5,732**	**29.8%**	**19,231**	**100.0%**

Table 4-27: Distribution of All Lamps for Participants by Segment – T8/T5

Type/Size	< 20 KW		> 20 KW		Total	
	Fixtures	% of Total	Fixtures	% of Total	Fixtures	% of Total
Unclassified	-	-	-	-	21,194	1.7%
Assembly	-	-	-	-	105,667	8.5%
Grocery	-	-	-	-	81,846	6.6%
Health Care/Hospital	-	-	-	-	76,443	6.1%
Hotel/Motel	-	-	-	-	8,026	0.6%
Industrial	-	-	-	-	170	0.0%
Misc Commercial	26,486	2.1%	205,170	16.4%	231,656	18.6%
Office	18,205	1.5%	192,923	15.5%	211,128	16.9%
Restaurant	-	-	-	-	14,578	1.2%
Retail	26,399	2.1%	235,097	18.8%	261,496	21.0%
School	-	-	-	-	207,270	16.6%
Traffic Management	-	-	-	-	-	-
Warehouse	-	-	-	-	28,516	2.3%
Total	**71,090**	**6%**	**633,190**	**51%**	**1,247,990**	**100%**

As shown in Table 4-27 and Figure 4-2, T8s installed under the program were relatively evenly distributed among four segments including schools, offices, retail, and miscellaneous commercial buildings.

Figure 4-2: Percentage of Program T8 Installations by Study Segment for the 2004-2005 Express Efficiency Program



High Bay T5 Fixtures

Table 4-28 presents the distribution of sites and loggers retained in analysis for High Bay fluorescent fixtures. As would be expected, the largest concentration of linear fluorescent fixtures needing loggers is in industrial buildings, warehouses, and miscellaneous commercial buildings.

Table 4-28: Distribution of Sites and # of Loggers Installed and Retained in Analysis by Segment – High Bay

Business Type/Size	< 20 KW		> 20 KW		Total	
	Sites Retained	Loggers Retained	Sites Retained	Loggers Retained	Sites Retained	Loggers Retained
Assembly	-	-	-	-	-	-
Grocery	-	-	-	-	1	1
Health Care	-	-	-	-	-	-
Industrial	-	-	-	-	4	8
Lodging - Guest Rooms	-	-	-	-	-	-
Lodging - Other	-	-	-	-	-	-
Misc Commercial	4	5	3	5	7	10
Office	-	-	-	-	-	-
Restaurant	-	-	-	-	-	-
Retail	-	-	1	3	1	3
School	-	-	-	-	1	1
Warehouse	-	-	-	-	3	5
Total	**4**	**5**	**4**	**8**	**17**	**28**

Table 4-29: Distribution of All Lamps for Logger Sites by Segment – High Bay

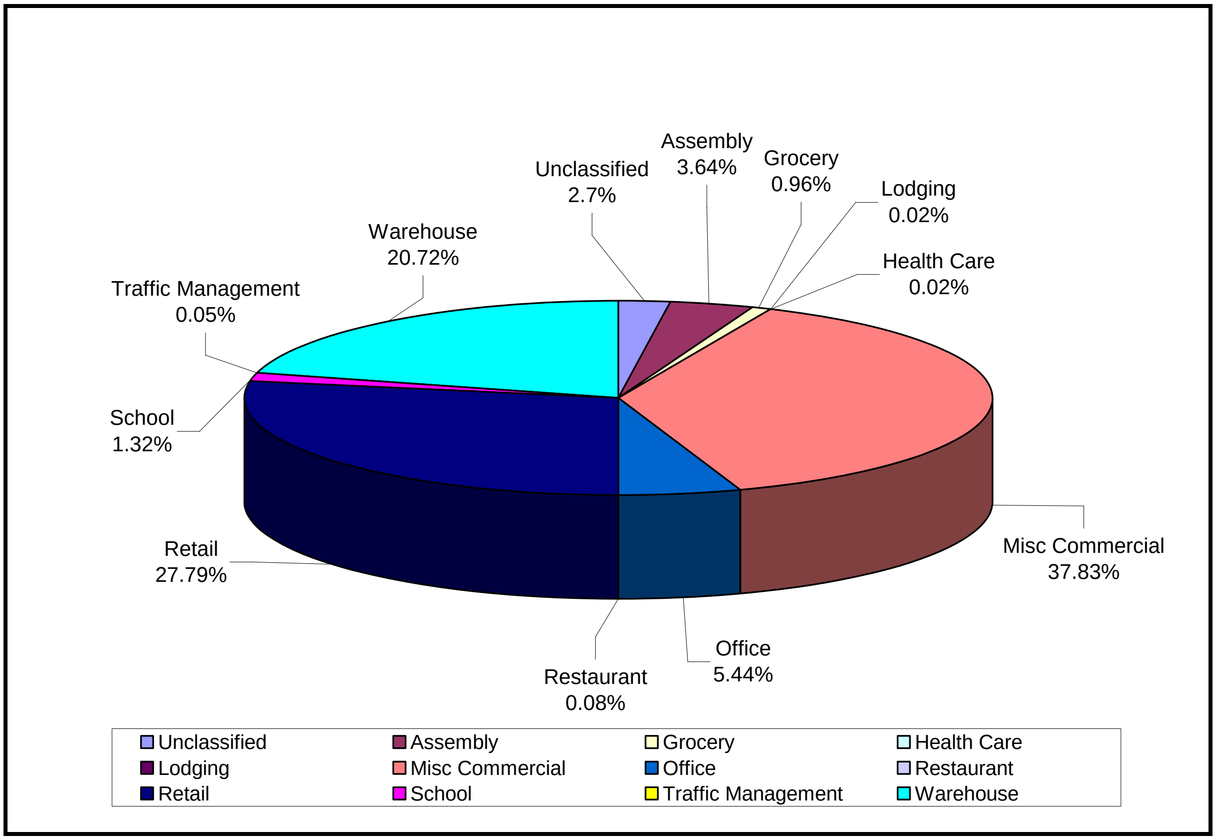
Business Type/Size	< 20 KW		> 20 KW		Total	
	Fixtures	% of Total	Fixtures	% of Total	Fixtures	% of Total
Assembly	-	-	-	-	-	-
Grocery	-	-	-	-	4	0.5%
Health Care	-	-	-	-	-	-
Industrial	-	-	-	-	189	21.6%
Lodging – Guest Rooms	-	-	-	-	-	-
Lodging – Other	-	-	-	-	-	-
Misc Commercial	75	8.6%	255	29.1%	330	37.6%
Office	-	-	-	-	-	-
Restaurant	-	-	-	-	-	-
Retail	-	-	210	23.9%	210	23.9%
School	-	-	-	-	36	4.1%
Warehouse	-	-	-	-	108	12.3%
Total	**75**	**9%**	**465**	**53%**	**877**	**100.0%**

Table 4-30: Distribution of All Lamps for Participants by Segment – High Bay

Business Type/Size	< 20 KW		> 20 KW		Total	
	Fixtures	% of Total	Fixtures	% of Total	Fixtures	% of Total
Unclassified	-	-	-	-	1,967	2%
Assembly	-	-	-	-	3,341	4%
Grocery	-	-	-	-	883	1%
Health Care/Hospital	-	-	-	-	16	0%
Hotel/Motel	-	-	-	-	17	0%
Industrial	-	-	-	-	-	-
Misc Commercial	1,756	2%	32,974	36%	34,730	38%
Office	260	0%	4,737	5%	4,997	5%
Restaurant	-	-	-	-	72	0%
Retail	713	1%	24,801	27%	25,514	28%
School	-	-	-	-	1,209	1%
Traffic Management	-	-	-	-	46	0%
Warehouse	-	-	-	-	19,024	21%
Total	**2,729**	**3%**	**62,512**	**68%**	**91,816**	**100.0%**

Figure 4-3 illustrates the distribution of High Bay T5 installations across the various segments.

Figure 4-3: Percentage of Program High Bay Installations by Study Segment for the 2004-2005 Express Efficiency Program

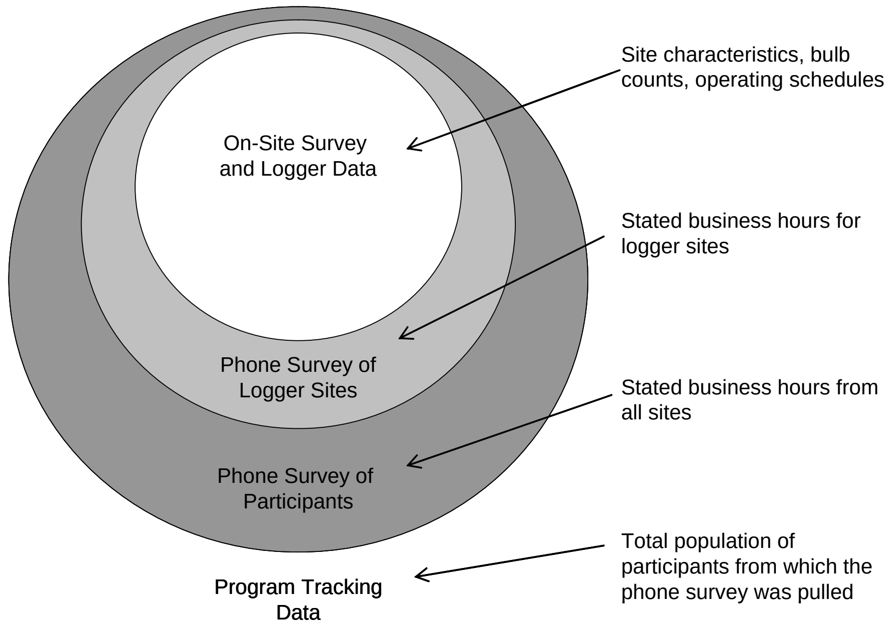


4.5.6 Data Integration and Lighting Schedule Development

The evaluation of hours of operation is based on a nested sample design in which each of the previously discussed data sources is used to adjust and validate those that precede it. The core of the analysis is the lighting logger sample, which provides the most accurate assessment of actual lighting schedules. Included in this are the data collected during the site visits when the loggers were installed. These data play an important role in the aggregation of the logger data as well as provide secondary information on lighting schedules.

The schedules derived from the loggers are manually compared to reported business operating hours from the telephone survey of the logger sites. This comparison, at the individual site level, acts as a quality check of actual versus stated hours of operation. Figure 4-4 provides a graphical illustration of the nested data sources.

Figure 4-4: Nested Data Sources



Lighting logger data (represented in the innermost circle at the top in Figure 4-4) provide the most accurate data for assessing actual hours of operation. For a monitored fixture, a lighting logger registers the time and date the fixture is turned on or off. Multiple loggers—up to seven—were installed at each site in the areas where CFLs, T8s, and High Bay fixtures were installed, covering each "schedule group" (a group of similar fixtures that operate together). The loggers remained in place for four to five weeks to collect data. Upon removal, the data from the loggers were processed to produce an hourly on-off profile for each logger.

Data from the on-site survey serve multiple purposes. First, they contribute site-specific details, secondary estimates of operating hours and operating factors, and other technical factors that are difficult to collect over the telephone. More importantly, they provide the data on verified bulb counts necessary to produce a weighted average schedule for each site. During installation, each logger was assigned to a schedule group and the number of lamps and fixtures in each schedule group was recorded. These lamp and fixture counts were used to develop weights to be applied in the aggregation of individual loggers into an overall site schedule. Figure 4-5 presents an example of how CFL counts were applied as weights to the CFL site level shapes. The same logic applies to T8s and High Bay fixtures. In the example, there are two schedule groups and five loggers. The count of CFLs in each schedule group was divided evenly among its loggers. These counts were then divided by the total CFL count to create the weights.

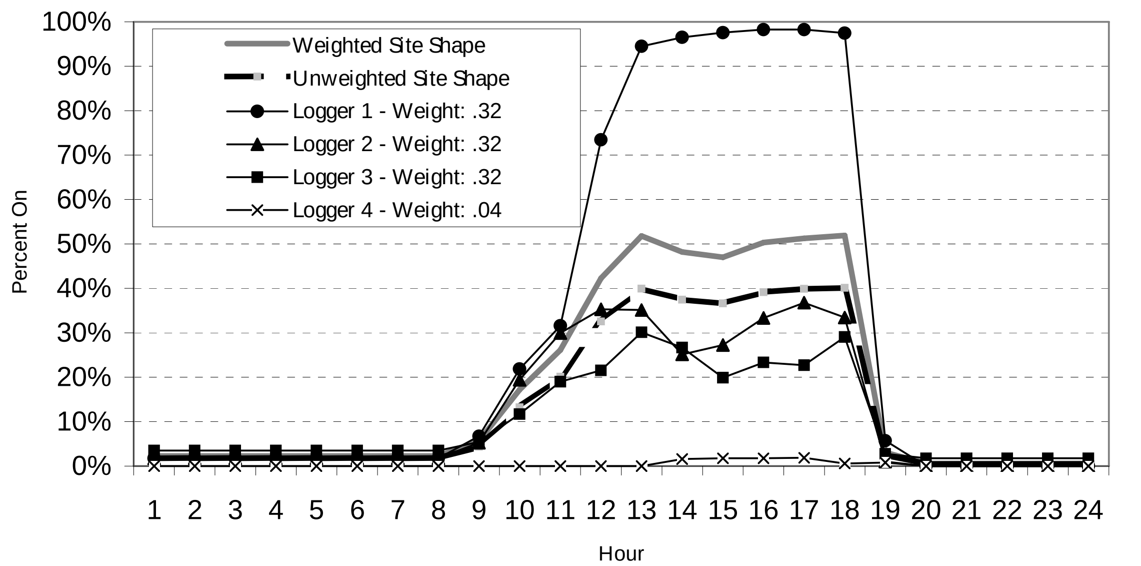
Figure 4-5: Logger Weight Calculation Example

Loggers	Schedule Group	CFLs
3	1	120
2	2	60

Logger No.	Schedule Group	CFLs	Weight
1	1	40	22%
2	1	40	22%
3	1	40	22%
4	2	30	17%
5	2	30	17%

This step is particularly important to deal with cases where a small number of bulbs has been installed in areas of a site that are not representative of the principal use for CFLs in the facility as a whole. For example, if there are 10 bulbs installed in a storage area of a site that has 100 total bulbs, the logger associated with that schedule group will be assigned a weight of 10%. These weights were used in aggregating the multiple loggers into average hourly operating schedules for each day of the week and hour for each site. Figure 4-6 provides an example of how this weighting affects the final shape for a site with four loggers by showing the individual logger shapes along with overall site averages with and without weights. Note the shape for Logger 4, which is barely perceptible at the bottom of the chart. The schedule group for this logger represents only 4% of the total bulbs. Without applying weights during aggregation, the average schedule would be around 10 percentage points below what it should be.

Figure 4-6: Weighted Versus Non-Weighted Site Schedule Example



The telephone survey data—gathered for both the logger sites and a broader participant sample, henceforth referred to as the “logger site” and “participant” surveys, respectively—provide the stated hours of operation for different premises. These data were used to create hourly arrays for each day of the week that reflects when a given premise is open. Unlike the logger data, which reflect a percentage of time that the lights are on, the stated schedules are a binary value to reflect an on or off state, with the assumption that 100% of the lights are on during a premise’s business hours. The comparison of these stated schedules with the observed schedules from the loggers becomes the basis for the quality control checks performed on the data prior to aggregating them to the segment level.

After manually comparing the site-level shapes to the reported operating hours, the next step is to weight the shapes to the segment level. The weights used to create these shapes are the number of bulbs/fixtures at the site divided by the total number of bulbs in the segment. A weighted average hourly shape is created for each day of the week. The shapes are representative of the three equipment types for each of the twelve segments. Weights for the aggregation of schedules across segments were based on actual installations associated with the twelve segments.

4.5.7 Results

This section presents the results for the assessment of annual hours of operation for CFLs, T8s, and High Bay fixtures installed as part of the 2004-2005 Express Efficiency program. The methodology involved numerous intermediate steps that required detailed analysis of the individual segments. Many of these steps are of heuristic value in understanding the final estimates and clearly merit discussion in this section.

It is important to note that the final operating schedules presented in this report were developed to represent the typical CFLs, T8s, and High Bay fixtures installed under the 2004-2005 Express Efficiency program. Nearly half of all CFLs rebated through the 2004-2005 Express Efficiency program were installed in the lodging business segment. As explained above, the lodging segment has been broken into two segments and Itron developed a separate estimate of annual operating hours for CFLs installed through the Express Efficiency Program.

4.5.8 Annual Operating Hours

Although this report has repeatedly warned about using the results for individual segments, the disproportionate representations in Figure 4-1, Figure 4-2, and Figure 4-3 will inevitably provoke curiosity about how the individual segment results influenced the final numbers.

Table 4-31, Table 4-32, and Table 4-33 present the average annual stated and observed hours of operation for the 12 building types. Overall, the individual results are reasonable characterizations of their respective segments, with annual hours within expected ranges.

It is important to note that the stated hours of operation are business operating hours and are not diversified (meaning 100% of the lamps are assumed to be on during the open business hours). Therefore, there is an expectation that the stated hours will be higher for many business types where some lamps are typically left off during open hours, such as in offices. Furthermore, depending on the typical location of the bulbs, differences in stated and actual operating hours may differ more significantly.

The largest discrepancies between observed and stated business operating hours are in lodging and industrial buildings. Lodging is not surprising given that lodging respondents report being open 24 hours/day, referring to having someone at the front desks, but the expected operating hours of CFLs in guest rooms is quite low. Industrial buildings are more likely to install CFLs in offices and restrooms where usage is less as opposed to the warehouse/manufacturing areas that are more likely to have High Bay fixtures. Also shown in Table 4-31 is that small retail stores are one of the few segments where the stated hours are less than the observed. This was also found during the 2003 Express Efficiency Evaluation.

Retail stores often turn the lights on and start working both before the store opens and after it closes.

Table 4-31: Stated and Observed Annual Operating Hours by Business Type for CFLs Installed Through the 2004-2005 Express Efficiency Program

Business Type	Self-Report Business Hours			Observed Operating Hours		
	<20 kW	>20 kW	All	<20 kW	>20 kW	All
Assembly	-	-	3,890	-	-	4,085
Grocery	-	-	3,622	-	-	2,550
Health Care	-	-	4,603	-	-	2,566
Industrial	-	-	3,286	-	-	789
Lodging	-	-	-	-	-	-
LodgingGuest_Room	-	-	8,760	-	-	868
LodgingOther	-	-	8,760	-	-	7,288
Misc Commercial	3,666	4,785	-	2,124	5,027	-
Office	3,315	5,033	-	1,738	3,564	-
Restaurant	-	-	5,251	-	-	5,288
Retail	2,706	3,968	-	3,557	3,714	
School	-	-	3,767	-	-	2,782
Traffic Management	-	-	-	-	-	-
Warehouse	-	-	-	-	-	-

Table 4-32: Stated and Observed Annual Operating Hours by Business Type for T8/T5s Installed Through the 2004-2005 Express Efficiency Program

Business Type	Self-Report Business Hours			Observed Operating Hours		
	<20 kW	>20 kW	All	<20 kW	>20 kW	All
Assembly	-	-	4,290	-	-	3,798
Grocery	-	-	5,108	-	-	4,543
Health Care	-	-	4,782	-	-	2,502
Industrial	-	-	4,072	-	-	3,184
Lodging	-	-	-	-	-	-
LodgingGuest_Room	-	-	-	-	-	-
LodgingOther	-	-	-	-	-	-
Misc Commercial	3,162	5,199	-	3,098	3,430	-
Office	2,958	3,430	-	1,897	3,642	-
Restaurant	-	-	4,960	-	-	3,854
Retail	3,218	2,453	-	2,348	3,090	-
School	-	-	2,168	-	-	2,684
Traffic Management	-	-	-	-	-	-
Warehouse	-	-	3,080	-	-	2,332

Table 4-33: Stated and Observed Annual Operating Hours by Business Type for High Bays Installed Through the 2004-2005 Express Efficiency Program

Business Type	Self-Report Business Hours			Observed Operating Hours		
	<20 kW	>20 kW	All	<20 kW	>20 kW	All
Grocery	-	-	3,795	-	-	1,149
Industrial	-	-	4,228	-	-	4,574
Misc Commercial	4,868	3,065	-	2,665	4,538	-
Office	-	-	-	-	-	-
Retail	-	4,631	-	-	7,218	-
School	-	-	5,070	-	-	3,570
Warehouse	-	-	5,761	-	-	4,189

4.5.9 Annual Operating Hours – Confidence Intervals

Table 4-34 presents 90% confidence intervals for various estimates of annual hours of operation for CFLs. Of principal concern are the confidence intervals for the two overall estimates – with and without lodging. Overall, the 90% confidence interval surrounding the annual hours of operation for CFLs, including lodging lies between 2,709 and 3,323 hours, which is a relative precision of 10.2%. Excluding lodging, the figure lies between 2,782 and 3,300 hours, which is a relative precision of 8.5%. For the estimates of individual segments, the small number of sites renders many of the confidence intervals large and imprecise. In addition, for two segments, the confidence intervals are meaningless. For example, the industrial segment has a relative precision well in excess of 100%, and lower and upper bounds that defy logic.

* The small number of sites in some segments renders the confidence intervals at the individual segment level impossible to calculate and achieve meaningful values. In addition, segments with highly variable usage require a larger number of sites to calculate meaningful confidence intervals.

Table 4-35 and Table 4-36 present 90% confidence intervals for various estimates of annual hours of operation for T8s and High Bays respectively. No lodging sites were visited that installed T8s or High Bays under the program, so only one estimate of overall annual operating hours is presented. For T8s, these intervals signify a 90% confidence interval surrounding the annual hours of 2,812 and 3,384 hours, with a relative precision of 9.2%. For High Bays, the 90% confidence interval for the average annual hours of operation is 4,453 and 6,144 hours, which is a relative precision of 16%.

Table 4-34: 90% Confidence Intervals for Annual Hours of Operation for CFLs Installed Through the 2004-2005 Express Efficiency Program

Business Type	Size	Sites	Average Annual Hours	Lower 90% CI	Upper 90% CI	Relative Precision
Assembly	All	23	4,085	2,898	5,271	29%
Grocery	All	4	2,550		.	.
Health Care	All	8	2,566	2,118	3,015	17%
Industrial	All	2	789		.	.
LodgingGuest_Room	All	12	868	262	1,473	70%
LodgingOther	All	9	7,288	5,770	8,805	21%
Misc Commercial	< 20 kW	6	2,124	466	3,781	78%
	> 20 kW	3	5,027	1,499	8,555	70%
Office	< 20 kW	11	1,738	799	2,678	54%
	> 20 kW	9	3,564	2,000	5,129	44%
Restaurant	All	13	5,288	4,466	6,110	16%
Retail	< 20 kW	12	3,557	2,594	4,521	27%
	> 20 kW	3	3,714	2,809	4,620	24%
School	All	4	2,782	1,300	4,264	53%
Total	**All**	**119**	**3,016**	**2,709**	**3,323**	**10.2%**
All Except Lodging	**All**	**98**	**3,041**	**2,782**	**3,300**	**8.5%**

* The small number of sites in some segments renders the confidence intervals at the individual segment level impossible to calculate and achieve meaningful values. In addition, segments with highly variable usage require a larger number of sites to calculate meaningful confidence intervals.

Table 4-35: 90% Confidence Intervals for Annual Hours of Operation for T8/T5s Installed Through the 2004-2005 Express Efficiency Program

Business Type	Size	Sites	Average Annual Hours	Lower 90% CI	Upper 90% CI	Relative Precision
Assembly	All	7	3,798	2,420	5,177	36%
Grocery	All	6	4,543	3,085	6,000	32%
Health Care	All	5	2,502	1,194	3,811	52%
Industrial	All	8	3,184	1,883	4,485	41%
Misc Commercial	< 20 kW	14	3,098	2,744	3,452	11%
	> 20 kW	8	3,430	2,143	4,717	38%
Office	< 20 kW	10	1,897	1,352	2,442	29%
	> 20 kW	5	3,642	1,009	6,274	72%
Restaurant	All	3	3,854	1,824	5,884	53%
Retail	< 20 kW	10	2,348	1,666	3,030	29%
	> 20 kW	9	3,090	2,532	3,648	18%
School	All	8	2,684	1,905	3,463	29%
Warehouse	All	1	2,332	.	.	.
Total	**All**	**94**	**3,098**	**2,812**	**3,384**	**9.2%**

* The small number of sites in some segments renders the confidence intervals at the individual segment level impossible to calculate and achieve meaningful values. In addition, segments with highly variable usage require a larger number of sites to calculate meaningful confidence intervals.

Table 4-36: 90% Confidence Intervals for Annual Hours of Operation for High Bays Installed Through the 2004-2005 Express Efficiency Program

Business Type	Size	Sites	Average Annual Hours	Lower 90% CI	Upper 90% CI	Relative Precision
Grocery	All	1	1,149	.	.	.
Industrial	All	4	4,574	3,481	5,667	24%
Misc Commercial	< 20 kW	4	2,665	1,391	3,940	48%
	> 20 kW	3	4,538	330	8,746	93%
Retail	< 20 kW	-	-	-	-	0%
	> 20 kW	1	7,218	.	.	.
School	All	1	3,570	.	.	.
Warehouse	All	3	4,189			
Total	**All**	**17**	**5,298**	**4,453**	**6,144**	**16.0%**

* The small number of sites in some segments renders the confidence intervals at the individual segment level impossible to calculate and achieve meaningful values. In addition, segments with highly variable usage require a larger number of sites to calculate meaningful confidence intervals.

4.5.10 Average Daily Operating Hours

This section presents the total hours by day type for both stated and observed operation schedules by segment and day type. Table 4-37 presents these data for the sites that installed CFLs under the 2004-2005 Express Efficiency Program, while Table 4-38 and Table 4-39 present similar data for sites that installed T8s and High Bay fixtures.

Table 4-37: Observed and Stated Daily Average Hours by Type of Day[30] for CFLs Installed Through the 2004-2005 Express Efficiency Program

		Daily Average Operating Hours			
		Weekday	Saturday	Sunday	Overall Average
Assembly	Stated	12.2	6.2	8.0	10.7
	Observed	11.3	10.9	10.8	11.2
Grocery	Stated	11.0	9.5	5.5	10.0
	Observed	7.4	6.3	6.0	7.0
Health Care	Stated	14.8	7.9	7.2	12.7
	Observed	8.6	4.7	2.3	7.1
Industrial	Stated	12.3	2.7	-	9.2
	Observed	2.2	2.0	2.0	2.2
LodgingGuest_Room	Stated	24.0	24.0	24.0	24.0
	Observed	2.3	3.0	2.4	2.4
LodgingOther	Stated	24.0	24.0	24.0	24.0
	Observed	19.9	20.1	20.0	20.0
Misc Commercial (Very Small)	Stated	11.7	7.8	4.9	10.1
	Observed	7.1	4.3	1.5	5.9
Misc Commercial (Other)	Stated	15.0	9.5	8.0	13.2
	Observed	12.0	18.1	17.8	13.7
Office (Very Small)	Stated	10.9	5.4	4.2	9.2
	Observed	5.4	3.2	3.4	4.8
Office (Other)	Stated	15.8	10.7	7.9	13.9
	Observed	11.8	5.3	4.6	9.9
Restaurant	Stated	14.6	14.2	13.7	14.4
	Observed	14.2	15.1	15.0	14.5
Retail (Very Small)	Stated	8.3	7.4	3.5	7.5
	Observed	10.0	10.6	7.7	9.8
Retail (Other)	Stated	12.4	8.7	6.2	11.0
	Observed	10.6	10.0	8.4	10.2
School	Stated	12.7	4.8	4.8	10.4
	Observed	8.1	6.5	6.8	7.7
Warehouse	Stated	9.0	-	-	6.4
	Observed	-	-	-	-

[30] Observed refers to logger data results, and stated refers to customer self reported responses about business operating hours during the phone survey.

Table 4-38: Observed and Stated Daily Average Hours by Type of Day[31] for T8 Installed Through the 2004-2005 Express Efficiency Program

		Average			
		Weekday	Saturday	Sunday	Overall Average
Assembly	Stated	13.5	9.0	6.5	11.9
	Observed	12.4	6.7	4.8	10.5
Grocery	Stated	14.0	14.6	13.4	14.0
	Observed	12.7	12.6	11.1	12.5
Health Care	Stated	14.3	12.7	8.0	13.2
	Observed	7.6	5.7	4.7	6.9
Industrial	Stated	13.4	7.2	4.8	11.3
	Observed	11.3	3.5	1.9	8.9
Misc Commercial (Very Small)	Stated	11.4	4.1	0.8	8.8
	Observed	9.7	6.7	4.9	8.6
Misc Commercial (Other)	Stated	17.0	12.0	4.0	14.4
	Observed	11.0	5.9	5.5	9.5
Office (Very Small)	Stated	11.0	1.6	1.2	8.3
	Observed	6.3	2.9	2.5	5.3
Office (Other)	Stated	10.0	8.0	8.0	9.4
	Observed	11.1	8.4	6.4	10.0
Restaurant	Stated	16.0	8.0	8.0	13.7
	Observed	11.0	10.2	9.0	10.6
Retail (Very Small)	Stated	10.0	8.7	3.7	8.9
	Observed	7.8	4.6	2.2	6.5
Retail (Other)	Stated	7.5	7.5	2.5	6.8
	Observed	10.1	5.7	3.7	8.6
School	Stated	8.5	0	0	6.1
	Observed	8.5	4.9	4.6	7.4
Warehouse	Stated	10.0	10.0	-	8.6
	Observed	6.8	8.3	2.6	6.4

[31] Observed refers to logger data results, and stated refers to customer self reported responses during the phone survey.

Table 4-39: Observed and Stated Daily Average Hours by Type of Day[32] for High Bays Installed Through the 2004-2005 Express Efficiency Program

		Average			
		Weekday	**Saturday**	**Sunday**	**Overall Average**
Grocery	Stated	11.0	9.0	9.0	10.4
	Observed	3.1	4.2	2.6	3.2
Industrial	Stated	15.8	4.0	-	11.8
	Observed	15.4	7.7	4.0	12.7
Misc Commercial (Very Small)	Stated	16.5	6.0	6.0	13.5
	Observed	9.4	2.9	2.2	7.4
Misc Commercial (Other)	Stated	11.5	2.5	-	8.6
	Observed	15.2	10.5	1.9	12.6
Retail (Other)	Stated	13.0	13.0	11.0	12.7
	Observed	20.1	19.3	18.8	19.8
School	Stated	16.0	9.0	9.0	14.0
	Observed	14.0	-	-	10.0
Warehouse	Stated	17.0	14.0	12.0	15.9
	Observed	13.0	8.7	7.4	11.6

4.5.11 Lighting Load Shapes

<u>Stated vs. Observed Schedules</u>

This section provides examples of comparisons made between stated and observed operating schedules by hour of the day. Since there are too many combinations of segments and measures types to show in this report, this section presents very small retail stores as an example. However, the remainder of the graphs can be found in Appendix J. Nevertheless, these numbers are presented to show the general shape associated with the two schedules. It is interesting to note that the two schedules differ primarily in magnitude and not overall shape.

Figure 4-7 presents two 24-hour daily profiles for very small retail stores with CFLs, with the stated schedules represented by the bars and observed hours represented by the solid line. (Figure 4-8 presents similar data for those with T8s.) The y-axis in the graph represents the weighted average percentage of CFLs on in a given hour throughout the year. For example, in the hour ending at 10:00 a.m., approximately 65% of CFLs were actually on while survey respondents stated that nearly 80% of their sites were open at that time. For most small retail sites, the logger data showed the lights going on before the stated schedule of operation. One

[32] Observed refers to logger data results, and stated refers to customer self reported responses during the phone survey.

reason for the somewhat high percentage between 7:00 p.m. and 6:00 a.m. was because some of the small retail sites visited had installed the CFLs in exterior fixtures. Furthermore, the loggers also recorded some sites where interior CFLs occasionally remain on overnight.

Figure 4-7: Average Daily Stated and Observed Schedules for CFLs Installed Through the 2004-2005 Express Efficiency Program – Retail – Very Small

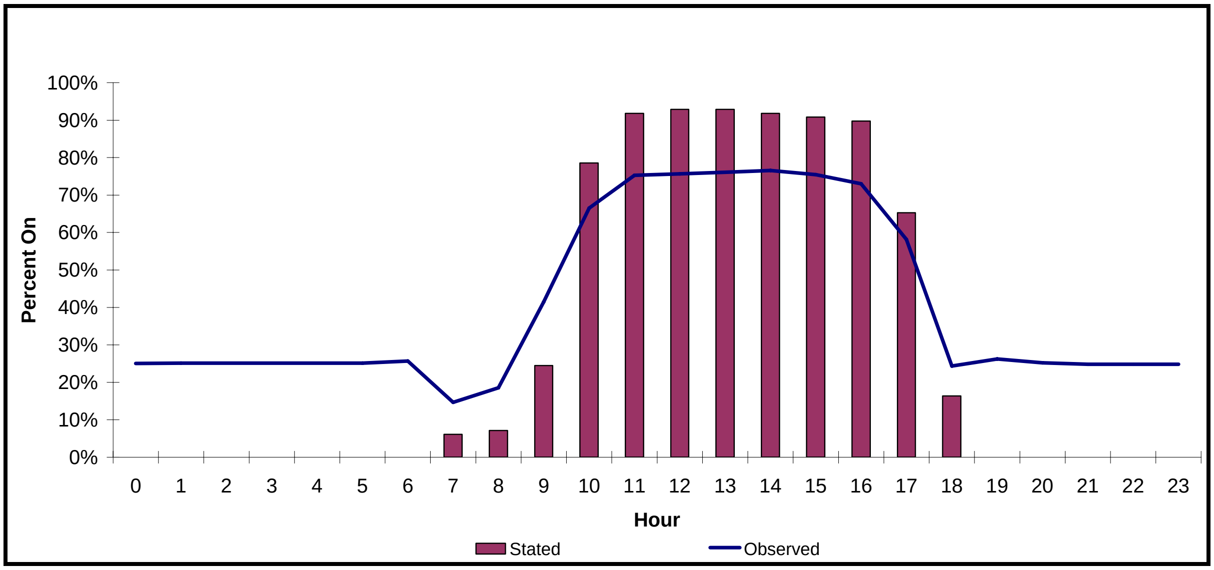
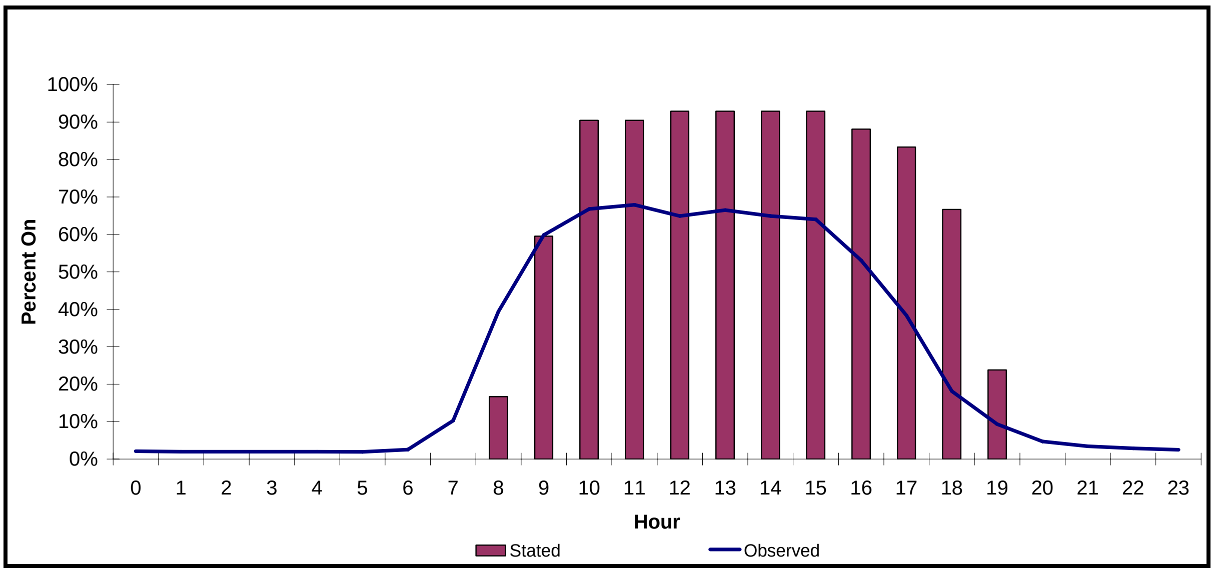


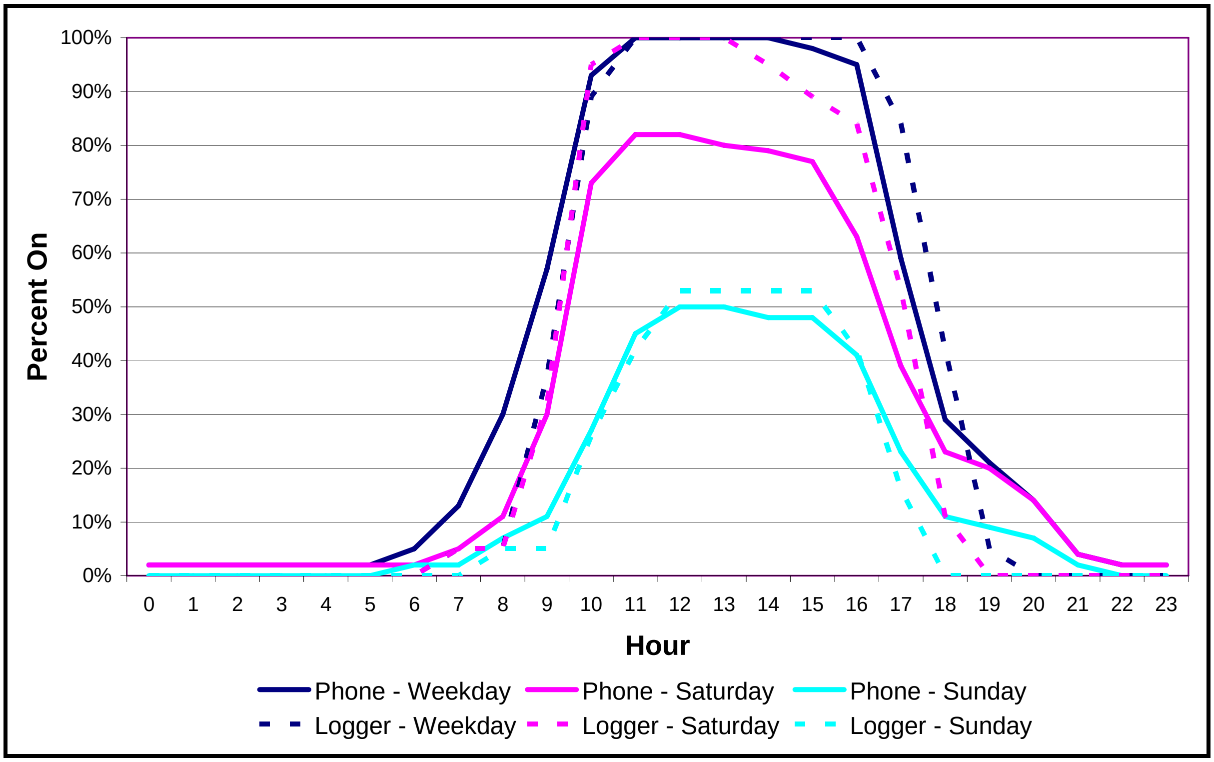
Figure 4-8: Average Daily Stated and Observed Schedules for T8/T5s Installed Through the 2004-2005 Express Efficiency Program – Retail – Very Small



<u>Stated Schedules: Phone Respondents vs. Logged Sites</u>

Comparisons were also made between the stated business operating schedules for the entire set of sites that responded to the phone interview and those that had loggers installed. For those segments with a reasonable sample size, the results from the phone survey and the loggers were very similar. For example, Figure 4-9 presents these data for the small retail segment. As shown, on average, logged sites are more likely to be open on Saturdays than the overall respondents of the phone survey, but when they are open, on average, they appear to close earlier. The operating schedules on weekdays are very similar with the logged sites opening later, but staying open later also. Similar graphs for the other segments and measure types can be found in Appendix J.[33]

Figure 4-9: Stated Operating Schedules All Phone Respondents vs. Logged Sites – Retail – Very Small



Lighting Load Shapes

Finally, hourly load shapes associated with the lighting logger estimates and 90% confidence intervals for these estimates are presented in Table 4-40, Table 4-41, and Table 4-42 for the three measure types. The hour value represents the "hour ending" for an interval. That is, 12 represents the period from 11:00 a.m. to 12:00 p.m. The values in these shapes represent the average percentage of time that CFLs were on for a given hour throughout the year. For example, for CFLs in the small office segment at hour 14 (1:00 p.m. to 2:00 p.m.), lights were on 39% of the time. Multiply this by 365 for the annual value of 142 hours.

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33 Note that for the lodging segments, stated and observed schedules were not compared as respondents always reported being open 24 hours.

Table 4-40: Load Shapes for CFLs Loggered Through the 2004-2005 Express Efficiency Program

Hour	Assembly			Grocery			Health Care		
	Lower 90CI	Mean	Upper 90CI	Lower 90CI	Mean	Upper 90CI	Lower 90CI	Mean	Upper 90CI
1	30.9%	48.0%	65.1%	0%*	26.3%	66.1%	0%*	1.4%	6.4%
2	29.2%	46.6%	64.1%	0%*	18.6%	63.5%	0%*	1.7%	6.6%
3	28.2%	45.1%	61.9%	0%*	17.0%	62.9%	0%*	2.6%	7.5%
4	22.9%	40.0%	57.1%	0%*	18.0%	63.3%	0%*	5.6%	11.3%
5	28.4%	45.3%	62.2%	0%*	17.5%	63.2%	0%*	5.3%	11.0%
6	22.5%	38.9%	55.2%	0%*	17.0%	64.2%	0%*	1.5%	6.6%
7	23.9%	39.8%	55.8%	0%*	17.8%	65.6%	0%*	1.6%	7.1%
8	23.9%	39.1%	54.4%	0%*	19.9%	70.3%	4.3%	13.8%	23.4%
9	31.1%	45.7%	60.3%	0%*	28.4%	75.9%	37.9%	53.5%	69.0%
10	36.0%	51.1%	66.1%	0%*	31.4%	77.7%	62.1%	73.0%	84.0%
11	38.4%	53.0%	67.7%	0%*	37.7%	83.9%	60.8%	73.4%	86.0%
12	38.9%	53.6%	68.3%	0%*	36.9%	83.5%	61.8%	74.3%	86.7%
13	31.9%	47.7%	63.4%	0%*	34.3%	80.3%	60.6%	73.0%	85.3%
14	29.3%	45.5%	61.7%	0%*	36.1%	80.0%	58.9%	70.7%	82.6%
15	28.7%	44.8%	60.9%	0%*	36.1%	80.0%	57.2%	69.6%	82.1%
16	27.2%	42.8%	58.4%	0%*	39.1%	81.3%	53.8%	65.8%	77.7%
17	24.9%	40.3%	55.6%	0%*	35.2%	76.0%	48.1%	58.7%	69.4%
18	27.5%	43.6%	59.7%	0%*	33.7%	71.9%	22.4%	33.2%	44.1%
19	31.3%	46.9%	62.5%	0%*	35.3%	70.9%	2.3%	10.8%	19.3%
20	35.6%	51.3%	67.0%	0%*	33.9%	69.4%	0.0%	7.8%	15.6%
21	40.6%	56.4%	72.2%	0%*	32.1%	68.3%	0%*	5.5%	12.2%
22	37.8%	53.9%	70.0%	0%*	32.8%	68.9%	0%*	4.8%	11.0%
23	34.5%	51.2%	67.8%	0%*	31.0%	68.2%	0%*	2.9%	7.9%
24	32.6%	49.5%	66.4%	0%*	34.5%	70.8%	0%*	2.1%	7.0%

* The small number of sites in some segments renders the confidence intervals at the individual segment level impossible to calculate and achieve meaningful values. In addition, segments with highly variable usage require a larger number of sites to calculate meaningful confidence intervals. It may be possible to calculate one side of the confidence interval, but the other side may be outside the acceptable range of 0 – 100%.

Table 4-40 (cont'd.): Load Shapes for CFLs Loggered Through the 2004-2005 Express Efficiency Program

Hour	Industrial			LodgingGuest_Room			LodgingOther		
	Lower 90CI	Mean	Upper 90CI	Lower 90CI	Mean	Upper 90CI	Lower 90CI	Mean	Upper 90CI
1	0%*	14.3%	100%*	0.6%	6.6%	12.5%	76.9%	92.5%	100%*
2	0%*	14.3%	100%*	0.2%	5.6%	11.1%	76.8%	92.5%	100%*
3	0%*	14.3%	100%*	0%*	4.9%	10.3%	76.9%	92.5%	100%*
4	0%*	14.3%	100%*	0%*	4.2%	8.9%	77.0%	92.6%	100%*
5	0%*	14.3%	100%*	0%*	3.7%	8.3%	77.4%	92.7%	100%*
6	0%*	14.3%	100%*	0%*	4.4%	9.0%	77.2%	92.6%	100%*
7	0%*	14.3%	100%*	0.1%	4.9%	9.8%	77.8%	92.8%	100%*
8	-	0.0%	-	0.0%	7.4%	14.7%	42.8%	70.9%	98.9%
9	0%*	0.7%	2.4%	0.8%	9.5%	18.3%	43.6%	71.4%	99.2%
10	0%*	0.6%	2.0%	2.2%	11.0%	19.7%	43.7%	71.5%	99.4%
11	0%*	4.0%	14.2%	3.9%	12.5%	21.2%	43.5%	71.7%	99.9%
12	0%*	2.7%	9.6%	2.4%	10.9%	19.5%	43.7%	71.8%	99.9%
13	0%*	1.8%	6.4%	1.9%	10.2%	18.6%	43.5%	71.7%	99.9%
14	0%*	2.0%	7.3%	1.9%	10.2%	18.4%	43.4%	71.6%	99.8%
15	0%*	2.0%	7.0%	2.7%	11.0%	19.2%	43.1%	71.5%	99.9%
16	0%*	1.7%	6.3%	0%*	8.2%	16.4%	42.8%	71.3%	99.8%
17	0%*	0.9%	3.1%	2.3%	10.6%	18.9%	43.4%	72.0%	100%*
18	0%*	14.3%	100%*	4.7%	13.8%	22.8%	48.4%	75.5%	100%*
19	0%*	14.3%	100%*	5.5%	20.7%	36.0%	78.2%	92.9%	100%*
20	0%*	14.3%	100%*	6.4%	19.3%	32.2%	78.0%	92.9%	100%*
21	0%*	14.3%	100%*	5.7%	13.8%	21.9%	78.7%	93.1%	100%*
22	0%*	14.3%	100%*	5.8%	13.6%	21.5%	78.6%	93.0%	100%*
23	0%*	14.3%	100%*	4.0%	11.5%	19.0%	77.7%	92.8%	100%*
24	0%*	14.3%	100%*	2.2%	8.6%	15.0%	77.4%	92.7%	100%*

* The small number of sites in some segments renders the confidence intervals at the individual segment level impossible to calculate and achieve meaningful values. In addition, segments with highly variable usage require a larger number of sites to calculate meaningful confidence intervals. It may be possible to calculate one side of the confidence interval, but the other side may be outside the acceptable range of 0 – 100%.

Table 4-40 (Cont'd.): Load Shapes for CFLs Loggered Through the 2004-2005 Express Efficiency Program

Hour	Misc Commercial > 20 kW			Misc Commercial < 20 kW			Office > 20 kW		
	Lower 90CI	Mean	Upper 90CI	Lower 90CI	Mean	Upper 90CI	Lower 90CI	Mean	Upper 90CI
1	0%*	48.3%	100%*	0%*	2.5%	5.2%	0%*	17.9%	42.3%
2	0%*	48.3%	100%*	0%*	2.2%	4.4%	0%*	17.8%	42.2%
3	0%*	48.3%	100%*	0.0%	1.2%	2.5%	0%*	17.8%	42.1%
4	0%*	48.2%	100%*	0.0%	1.2%	2.5%	0%*	17.8%	42.1%
5	0%*	48.3%	100%*	0.0%	1.2%	2.5%	0%*	17.8%	42.1%
6	0%*	48.9%	100%*	0.0%	1.2%	2.5%	0%*	18.0%	42.3%
7	0%*	30.2%	66.1%	0%*	2.7%	5.4%	0%*	19.5%	44.4%
8	0%*	31.2%	66.3%	0.8%	26.8%	52.7%	8.4%	31.0%	53.5%
9	0%*	32.2%	67.1%	6.2%	36.5%	66.9%	57.9%	68.8%	79.7%
10	0%*	68.3%	100%*	8.5%	42.4%	76.2%	62.2%	72.8%	83.3%
11	0%*	68.5%	100%*	11.1%	45.1%	79.2%	61.9%	73.2%	84.6%
12	0%*	68.2%	100%*	13.6%	48.0%	82.4%	61.8%	73.4%	84.9%
13	0%*	68.2%	100%*	16.0%	49.5%	83.1%	61.4%	72.8%	84.2%
14	0%*	67.5%	100%*	12.3%	47.6%	82.9%	62.9%	73.1%	83.3%
15	0%*	66.4%	100%*	10.6%	46.8%	82.9%	60.8%	71.4%	82.0%
16	0%*	66.3%	100%*	8.6%	44.9%	81.2%	58.3%	69.9%	81.4%
17	0%*	65.7%	100%*	7.7%	43.4%	79.1%	55.6%	67.6%	79.6%
18	16.9%	85.0%	100%*	13.1%	44.5%	75.9%	20.8%	39.4%	58.0%
19	11.3%	83.9%	100%*	6.0%	37.0%	67.9%	16.8%	37.2%	57.6%
20	7.9%	83.3%	100%*	2.9%	30.0%	57.2%	9.3%	31.4%	53.4%
21	0%*	48.1%	100%*	1.4%	18.9%	36.3%	0%*	22.1%	47.1%
22	0%*	48.2%	100%*	0%*	10.4%	20.9%	0%*	19.9%	45.0%
23	0%*	48.3%	100%*	0%*	3.8%	7.6%	0%*	18.7%	43.3%
24	0%*	48.3%	100%*	0%*	2.7%	5.4%	0%*	18.2%	42.6%

* The small number of sites in some segments renders the confidence intervals at the individual segment level impossible to calculate and achieve meaningful values. In addition, segments with highly variable usage require a larger number of sites to calculate meaningful confidence intervals. It may be possible to calculate one side of the confidence interval, but the other side may be outside the acceptable range of 0 – 100%.

Table 4-40 (Cont'd.): Load Shapes for CFLs Loggered Through the 2004-2005 Express Efficiency Program

Hour	Office < 20 kW			Restaurant		
	Lower 90CI	Mean	Upper 90CI	Lower 90CI	Mean	Upper 90CI
1	0%*	9.5%	21.7%	24.2%	48.6%	73.0%
2	0.2%	12.5%	24.8%	22.9%	46.6%	70.4%
3	0%*	9.2%	21.1%	14.1%	33.9%	53.8%
4	0%*	7.6%	18.9%	2.8%	22.6%	42.4%
5	0%*	7.6%	18.9%	3.8%	23.7%	43.5%
6	0.9%	12.9%	25.0%	14.7%	38.5%	62.3%
7	0%*	13.2%	29.1%	22.6%	45.8%	69.0%
8	0%*	12.0%	26.4%	28.4%	51.6%	74.8%
9	11.9%	25.8%	39.7%	35.6%	58.9%	82.2%
10	18.7%	33.2%	47.7%	39.9%	62.9%	85.9%
11	19.7%	34.5%	49.4%	47.3%	69.3%	91.4%
12	21.2%	36.5%	51.7%	56.0%	75.8%	95.5%
13	21.1%	37.3%	53.6%	59.4%	78.4%	97.4%
14	22.2%	39.0%	55.7%	60.5%	79.1%	97.8%
15	20.5%	37.9%	55.3%	58.4%	76.6%	94.9%
16	19.4%	35.8%	52.3%	52.9%	72.7%	92.5%
17	15.5%	29.3%	43.1%	47.9%	67.4%	86.8%
18	4.1%	16.7%	29.4%	64.9%	80.6%	96.2%
19	0%*	11.1%	23.9%	62.4%	79.5%	96.6%
20	0%*	9.4%	20.3%	61.6%	79.1%	96.7%
21	0.6%	12.8%	24.9%	61.2%	79.0%	96.8%
22	0.4%	12.9%	25.5%	53.0%	71.2%	89.5%
23	0.4%	12.8%	25.2%	30.1%	53.7%	77.3%
24	0%*	9.6%	21.8%	26.0%	50.9%	75.8%

* The small number of sites in some segments renders the confidence intervals at the individual segment level impossible to calculate and achieve meaningful values. In addition, segments with highly variable usage require a larger number of sites to calculate meaningful confidence intervals. It may be possible to calculate one side of the confidence interval, but the other side may be outside the acceptable range of 0 – 100%.

Table 4-40 (Cont'd.): Load Shapes for CFLs Loggered Through the 2004-2005 Express Efficiency Program

Hour	Retail > 20 kW			Retail < 20 kW			School		
	Lower 90CI	Mean	Upper 90CI	Lower 90CI	Mean	Upper 90CI	Lower 90CI	Mean	Upper 90CI
1	-	0.0%	-	3.2%	25.0%	46.8%	0%*	44.5%	99.6%
2	-	0.0%	-	3.3%	25.1%	46.9%	0%*	43.3%	99.3%
3	-	0.0%	-	3.3%	25.1%	46.9%	0%*	41.9%	99.0%
4	-	0.0%	-	3.3%	25.1%	46.9%	0%*	40.7%	98.9%
5	-	0.0%	-	3.3%	25.1%	46.9%	0%*	41.2%	98.9%
6	-	0.0%	-	3.3%	25.1%	46.9%	0%*	40.7%	98.9%
7	0.0%	0.0%	0.0%	3.9%	25.7%	47.5%	0%*	7.3%	17.1%
8	0%*	5.6%	15.4%	-2.2%	14.7%	31.5%	0%*	8.6%	18.1%
9	0%*	43.5%	87.7%	2.4%	18.6%	34.7%	0%*	16.9%	38.4%
10	42.7%	73.0%	100%*	21.6%	41.4%	61.3%	0%*	22.0%	55.6%
11	91.1%	95.4%	99.8%	48.0%	66.5%	85.0%	0%*	24.7%	62.2%
12	96.2%	98.7%	100%*	58.8%	75.3%	91.7%	0%*	25.1%	64.5%
13	96.6%	98.8%	100%*	59.2%	75.7%	92.1%	0%*	24.9%	64.3%
14	99.9%	100.0%	100%*	59.6%	76.1%	92.6%	0%*	24.4%	62.1%
15	100.0%	100.0%	100%*	59.9%	76.6%	93.2%	0%*	24.8%	60.1%
16	100.0%	100.0%	100%*	59.0%	75.5%	91.9%	0%*	22.6%	51.7%
17	99.7%	99.9%	100%*	57.1%	73.0%	88.9%	22.0%	26.1%	30.3%
18	56.8%	84.8%	100%*	41.1%	58.1%	75.1%	11.7%	23.1%	34.5%
19	0%*	44.0%	100%*	8.0%	24.4%	40.7%	9.9%	24.9%	40.0%
20	0%*	36.9%	100%*	5.3%	26.3%	47.3%	0%*	49.1%	100%*
21	0%*	29.7%	100%*	3.8%	25.2%	46.6%	0%*	49.1%	100%*
22	0%*	10.0%	54.1%	3.3%	24.9%	46.4%	0%*	47.3%	100%*
23	0%*	0.5%	2.8%	3.3%	24.8%	46.4%	0%*	46.3%	100%*
24	-	0.0%	-	3.3%	24.8%	46.4%	0%*	45.7%	100%*

* The small number of sites in some segments renders the confidence intervals at the individual segment level impossible to calculate and achieve meaningful values. In addition, segments with highly variable usage require a larger number of sites to calculate meaningful confidence intervals. It may be possible to calculate one side of the confidence interval, but the other side may be outside the acceptable range of 0 – 100%.

Table 4-41: Load Shapes for T8/T5s Loggered Through the 2004-2005 Express Efficiency Program

Hour	Assembly			Grocery			Health Care		
	Lower 90CI	Mean	Upper 90CI	Lower 90CI	Mean	Upper 90CI	Lower 90CI	Mean	Upper 90CI
1	0%*	0.2%	0.7%	0%*	21.1%	50.1%	0%*	15.5%	47.3%
2	0%*	0.2%	0.6%	0%*	20.7%	49.9%	0%*	13.0%	41.4%
3	0%*	0.1%	0.5%	0%*	19.8%	49.4%	0%*	7.7%	24.3%
4	0.0%	0.8%	1.6%	0%*	20.3%	49.7%	0%*	3.5%	11.1%
5	5.3%	25.0%	44.8%	0%*	22.3%	50.7%	0%*	1.7%	5.1%
6	12.3%	41.3%	70.3%	8.1%	45.2%	82.3%	0%*	1.4%	4.0%
7	13.3%	44.3%	75.3%	9.9%	51.1%	92.3%	0%*	4.5%	16.5%
8	16.2%	47.9%	79.7%	19.6%	56.5%	93.4%	4.7%	19.1%	33.4%
9	23.3%	55.5%	87.8%	51.9%	77.2%	100%*	16.2%	34.2%	52.2%
10	57.1%	74.4%	91.8%	54.5%	79.6%	100%*	32.7%	54.9%	77.1%
11	60.7%	76.1%	91.6%	53.9%	78.5%	100%*	43.1%	66.1%	89.2%
12	60.6%	77.5%	94.4%	53.4%	78.0%	100%*	38.4%	65.1%	91.7%
13	59.7%	79.7%	99.8%	52.4%	77.0%	100%*	26.2%	58.4%	90.6%
14	50.6%	74.7%	98.9%	51.8%	76.6%	100%*	23.9%	57.5%	91.0%
15	55.5%	75.8%	96.1%	47.4%	68.9%	90.3%	22.6%	57.0%	91.5%
16	56.5%	76.2%	95.9%	46.9%	67.5%	88.1%	19.7%	51.8%	83.9%
17	53.5%	73.1%	92.6%	47.5%	68.7%	89.9%	20.2%	46.8%	73.3%
18	41.8%	64.6%	87.4%	22.1%	51.2%	80.3%	18.9%	40.8%	62.8%
19	29.3%	52.1%	74.9%	18.3%	51.0%	83.6%	14.4%	29.4%	44.3%
20	22.1%	45.3%	68.5%	19.2%	53.6%	87.9%	0%*	15.0%	33.2%
21	18.8%	43.6%	68.4%	19.2%	53.1%	87.0%	0%*	11.2%	30.4%
22	2.5%	19.6%	36.6%	11.0%	45.6%	80.2%	0%*	9.0%	25.6%
23	1.0%	3.0%	5.0%	3.5%	37.5%	71.5%	0%*	10.4%	29.4%
24	0%*	0.7%	1.6%	-	25.9%	54.7%	0%*	16.4%	48.7%

* The small number of sites in some segments renders the confidence intervals at the individual segment level impossible to calculate and achieve meaningful values. In addition, segments with highly variable usage require a larger number of sites to calculate meaningful confidence intervals. It may be possible to calculate one side of the confidence interval, but the other side may be outside the acceptable range of 0 – 100%.

Table 4-41 (cont'd.): Load Shapes for T8/T5s Loggered Through the 2004-2005 Express Efficiency Program

Hour	Industrial			Misc Commercial > 20 kW			Misc Commercial < 20 kW		
	Lower 90CI	Mean	Upper 90CI	Lower 90CI	Mean	Upper 90CI	Lower 90CI	Mean	Upper 90CI
1	0%*	11.0%	29.3%	0%*	13.7%	33.2%	0%*	0.9%	3.0%
2	0%*	11.0%	29.4%	0%*	12.9%	32.3%	0%*	0.9%	3.0%
3	0%*	10.9%	29.2%	0%*	12.5%	31.9%	0%*	0.9%	3.1%
4	0%*	10.7%	28.8%	0%*	12.4%	31.8%	0%*	1.0%	3.3%
5	0%*	10.9%	28.9%	0%*	12.4%	31.7%	0%*	2.0%	5.2%
6	0%*	13.7%	31.9%	5.3%	22.5%	39.7%	0%*	4.1%	10.7%
7	0%*	23.0%	47.4%	37.8%	56.7%	75.7%	2.4%	9.4%	16.4%
8	0%*	25.8%	53.0%	44.3%	63.5%	82.7%	58.6%	68.1%	77.6%
9	68.2%	75.6%	83.1%	50.4%	66.9%	83.4%	70.3%	78.7%	87.0%
10	68.3%	75.7%	83.1%	56.4%	73.4%	90.4%	74.9%	83.6%	92.3%
11	68.5%	75.8%	83.1%	57.6%	75.0%	92.3%	75.1%	84.0%	92.9%
12	68.7%	76.0%	83.4%	55.5%	75.2%	95.0%	74.8%	83.9%	93.0%
13	68.7%	76.1%	83.4%	58.1%	77.2%	96.2%	70.0%	79.1%	88.2%
14	68.6%	76.1%	83.6%	57.3%	75.7%	94.2%	68.9%	79.0%	89.0%
15	68.2%	75.7%	83.2%	53.7%	72.8%	91.9%	66.8%	78.0%	89.1%
16	67.8%	75.3%	82.9%	43.9%	60.1%	76.3%	64.7%	76.3%	88.0%
17	59.6%	71.5%	83.4%	24.9%	42.3%	59.6%	59.9%	72.4%	84.8%
18	0%*	17.2%	41.8%	5.5%	25.6%	45.7%	20.8%	37.8%	54.9%
19	0%*	12.9%	33.7%	3.4%	23.3%	43.2%	2.0%	9.0%	16.1%
20	0%*	12.6%	33.1%	0%*	19.5%	40.5%	0%*	2.3%	5.0%
21	0%*	12.4%	32.8%	0%*	15.7%	35.6%	0%*	1.3%	3.6%
22	0%*	12.3%	32.7%	0%*	13.0%	32.1%	0%*	1.1%	3.4%
23	0%*	12.3%	32.6%	0%*	12.6%	31.7%	0%*	0.9%	3.1%
24	0%*	11.3%	30.1%	0%*	13.0%	32.1%	0%*	0.9%	3.1%

* The small number of sites in some segments renders the confidence intervals at the individual segment level impossible to calculate and achieve meaningful values. In addition, segments with highly variable usage require a larger number of sites to calculate meaningful confidence intervals. It may be possible to calculate one side of the confidence interval, but the other side may be outside the acceptable range of 0 – 100%.

Table 4-41 (cont'd.): Load Shapes for T8/T5s Loggered Through the 2004-2005 Express Efficiency Program

Hour	Office > 20 kW			Office < 20 kW			Restaurant		
	Lower 90CI	Mean	Upper 90CI	Lower 90CI	Mean	Upper 90CI	Lower 90CI	Mean	Upper 90CI
1	0%*	20.7%	52.1%	0%*	1.0%	3.1%	0%*	0.3%	1.5%
2	0%*	21.7%	56.4%	0%*	0.6%	1.8%	0%*	0.2%	1.2%
3	0%*	21.2%	55.9%	0%*	0.6%	1.7%	0.0%	0.0%	0.1%
4	0%*	21.5%	57.3%	0%*	0.8%	2.8%	0%*	0.2%	0.8%
5	0%*	22.8%	61.4%	0%*	0.9%	3.1%	0%*	7.2%	23.6%
6	0%*	22.9%	61.7%	0%*	1.1%	3.9%	0%*	15.7%	51.0%
7	0%*	23.9%	64.9%	0%*	5.0%	11.6%	0%*	22.2%	59.3%
8	0%*	29.8%	68.2%	12.5%	24.5%	36.4%	22.7%	49.4%	76.0%
9	22.9%	50.7%	78.6%	18.3%	32.7%	47.1%	36.2%	72.2%	100%*
10	33.9%	59.6%	85.2%	27.2%	37.3%	47.5%	55.1%	85.6%	100%*
11	39.9%	63.9%	87.8%	40.7%	52.1%	63.4%	71.6%	91.0%	100%*
12	44.6%	66.9%	89.1%	28.1%	46.7%	65.2%	70.5%	91.0%	100%*
13	49.5%	70.4%	91.3%	35.6%	52.5%	69.3%	71.4%	91.6%	100%*
14	48.6%	69.0%	89.3%	40.8%	56.5%	72.3%	71.2%	91.4%	100%*
15	47.8%	67.9%	88.0%	38.8%	55.4%	72.0%	70.0%	91.0%	100%*
16	39.6%	63.6%	87.7%	33.6%	51.5%	69.4%	35.2%	80.7%	100%*
17	33.4%	60.1%	86.8%	24.0%	43.3%	62.5%	11.1%	71.0%	100%*
18	17.3%	51.8%	86.3%	7.0%	27.3%	47.6%	5.9%	66.2%	100%*
19	13.6%	46.5%	79.5%	2.7%	18.5%	34.3%	0%*	60.5%	100%*
20	2.1%	38.1%	74.1%	0%*	4.8%	13.0%	0%*	39.1%	90.1%
21	0%*	31.9%	69.9%	0%*	3.8%	10.3%	0%*	16.8%	69.3%
22	0%*	29.7%	68.4%	0%*	3.3%	9.2%	0%*	9.6%	42.4%
23	0%*	27.3%	66.6%	0%*	2.7%	7.8%	0%*	4.0%	13.3%
24	0%*	22.6%	56.3%	0%*	2.4%	7.4%	0%*	1.0%	2.8%

* The small number of sites in some segments renders the confidence intervals at the individual segment level impossible to calculate and achieve meaningful values. In addition, segments with highly variable usage require a larger number of sites to calculate meaningful confidence intervals. It may be possible to calculate one side of the confidence interval, but the other side may be outside the acceptable range of 0 – 100%.

Table 4-41 (cont'd.): Load Shapes for T8/T5s Loggered Through the 2004-2005 Express Efficiency Program

Hour	Retail > 20 kW			Retail < 20 kW		
	Lower 90CI	Mean	Upper 90CI	Lower 90CI	Mean	Upper 90CI
1	0%*	3.4%	7.7%	0%*	2.1%	5.5%
2	0%*	2.7%	5.9%	0%*	2.0%	5.2%
3	0%*	2.5%	5.6%	0%*	2.0%	5.2%
4	0%*	2.5%	5.7%	0%*	2.0%	5.2%
5	0%*	2.8%	6.2%	0%*	2.0%	5.2%
6	0.1%	6.4%	12.7%	0%*	1.9%	5.1%
7	11.2%	24.9%	38.5%	0%*	2.5%	5.9%
8	20.6%	38.8%	57.0%	0%*	10.2%	20.9%
9	35.9%	55.8%	75.7%	23.5%	39.4%	55.2%
10	48.7%	62.9%	77.0%	47.4%	59.8%	72.2%
11	60.6%	68.9%	77.1%	53.8%	66.8%	79.8%
12	63.4%	71.0%	78.7%	54.2%	67.9%	81.6%
13	63.4%	71.3%	79.2%	49.5%	64.9%	80.3%
14	63.0%	70.8%	78.6%	52.5%	66.5%	80.5%
15	62.5%	70.3%	78.2%	51.1%	64.9%	78.7%
16	62.2%	69.8%	77.4%	50.4%	64.0%	77.7%
17	56.1%	66.4%	76.7%	35.8%	53.1%	70.3%
18	48.6%	61.2%	73.7%	16.6%	38.4%	60.2%
19	26.6%	43.9%	61.2%	1.0%	18.1%	35.2%
20	5.3%	27.3%	49.3%	0%*	9.3%	18.8%
21	0%*	15.3%	34.4%	0%*	4.7%	9.9%
22	0%*	7.7%	16.6%	0%*	3.4%	8.1%
23	0%*	4.1%	10.1%	0%*	2.9%	7.6%
24	0%*	4.2%	10.1%	0%*	2.5%	6.5%

* The small number of sites in some segments renders the confidence intervals at the individual segment level impossible to calculate and achieve meaningful values. In addition, segments with highly variable usage require a larger number of sites to calculate meaningful confidence intervals. It may be possible to calculate one side of the confidence interval, but the other side may be outside the acceptable range of 0 – 100%.

Table 4-41 (cont'd.): Load Shapes for T8/T5s Loggered Through the 2004-2005 Express Efficiency Program

Hour	School			Warehouse		
	Lower 90CI	Mean	Upper 90CI	Lower 90CI	Mean	Upper 90CI
1	0.0%	0.2%	0.4%	-	0.7%	-
2	0%*	0.2%	0.4%	-	0.0%	-
3	0%*	0.2%	0.4%	-	0.0%	-
4	0%*	0.2%	0.4%	-	0.0%	-
5	0%*	0.2%	0.4%	-	1.1%	-
6	0%*	9.2%	20.0%	-	2.2%	-
7	0%*	16.9%	36.8%	-	2.4%	-
8	10.0%	27.1%	44.3%	-	8.6%	-
9	44.1%	63.5%	82.9%	-	29.3%	-
10	61.0%	74.4%	87.7%	-	56.6%	-
11	57.9%	75.0%	92.2%	-	63.2%	-
12	60.0%	77.6%	95.2%	-	66.5%	-
13	63.0%	79.8%	96.7%	-	65.4%	-
14	54.5%	74.8%	95.1%	-	66.4%	-
15	50.9%	72.3%	93.7%	-	64.0%	-
16	48.3%	69.3%	90.3%	-	60.8%	-
17	24.3%	38.0%	51.8%	-	54.8%	-
18	4.4%	19.6%	34.7%	-	45.2%	-
19	2.9%	16.3%	29.7%	-	26.7%	-
20	1.7%	13.2%	24.7%	-	10.8%	-
21	0.6%	10.8%	20.9%	-	5.8%	-
22	0%*	2.0%	5.8%	-	2.8%	-
23	0%*	0.5%	2.0%	-	3.4%	-
24	0%*	0.3%	1.1%	-	2.4%	-

* The small number of sites in some segments renders the confidence intervals at the individual segment level impossible to calculate and achieve meaningful values. In addition, segments with highly variable usage require a larger number of sites to calculate meaningful confidence intervals. It may be possible to calculate one side of the confidence interval, but the other side may be outside the acceptable range of 0 – 100%.

Table 4-42: Load Shapes for High Bays Loggered Through the 2004-2005 Express Efficiency Program

Hour	Grocery			Industrial			Misc Commercial > 20 kW			Misc Commercial < 20 kW		
	Lower 90CI	Mean	Upper 90CI	Lower 90CI	Mean	Upper 90CI	Lower 90CI	Mean	Upper 90CI	Lower 90CI	Mean	Upper 90CI
1	-	0.0%	-	-	18.7%	45.6%	-	28.6%	100%*	-	0.0%	-
2	-	0.0%	-	-	16.9%	42.9%	-	28.6%	100%*	-	0.0%	-
3	-	0.0%	-	-	15.1%	41.0%	-	28.6%	100%*	-	0.0%	-
4	-	0.0%	-	-	21.0%	52.3%	-	28.6%	100%*	-	0.0%	-
5	-	0.0%	-	4.8%	36.0%	67.3%	-	28.6%	100%*	-	0.0%	-
6	-	0.0%	-	24.8%	60.2%	95.7%	-	33.0%	100%*	-	3.4%	9.0%
7	-	0.0%	-	40.4%	72.1%	103.9%	-	53.9%	100%*	-	23.6%	50.6%
8	-	18.3%	-	43.7%	73.4%	103.2%	-	59.5%	100%*	44.4%	70.2%	96.1%
9	-	25.0%	-	52.2%	76.0%	99.8%	69.8%	79.7%	89.5%	46.4%	73.5%	100%*
10	-	27.3%	-	70.7%	81.5%	92.4%	70.3%	82.6%	95.0%	52.9%	74.6%	96.2%
11	-	33.7%	-	74.7%	82.7%	90.7%	69.1%	83.8%	98.6%	29.3%	67.1%	100%*
12	-	31.4%	-	74.3%	83.4%	92.4%	67.7%	84.8%	100%*	28.3%	66.1%	100%*
13	-	32.1%	-	71.5%	81.1%	90.6%	65.6%	84.3%	100%*	27.2%	65.2%	100%*
14	-	32.1%	-	70.4%	78.0%	85.6%	65.3%	83.0%	100%*	22.2%	63.2%	100%*
15	-	31.7%	-	62.9%	70.2%	77.5%	64.7%	83.5%	100%*	22.6%	63.5%	100%*
16	-	29.4%	-	41.2%	61.2%	81.1%	67.2%	80.3%	93.5%	22.8%	63.6%	100%*
17	-	29.2%	-	22.9%	51.6%	80.2%	56.6%	74.2%	91.8%	22.7%	61.9%	100%*
18	-	25.5%	-	18.7%	48.3%	77.8%	-	54.1%	126.5%	3.7%	40.7%	77.7%
19	-	0.0%	-	17.3%	47.7%	78.0%	-	37.4%	100%*	-	4.4%	15.8%
20	-	0.0%	-	16.2%	47.4%	78.6%	-	29.9%	100%*	-	0.4%	2.2%
21	-	0.0%	-	16.3%	47.3%	78.3%	-	29.3%	100%*	-	0.2%	1.1%
22	-	0.0%	-	16.2%	45.9%	75.6%	-	28.7%	100%*	0.0%	0.0%	0.0%
23	-	0.0%	-	15.5%	34.1%	52.7%	-	28.6%	100%*	0.0%	0.0%	0.0%
24	-	0.0%	-	-7.8%	20.4%	48.5%	-	28.6%	100%*	-	0.0%	-

* The small number of sites in some segments renders the confidence intervals at the individual segment level impossible to calculate and achieve meaningful values. In addition, segments with highly variable usage require a larger number of sites to calculate meaningful confidence intervals. It may be possible to calculate one side of the confidence interval, but the other side may be outside the acceptable range of 0 – 100%.

Table 4-42 (cont'd.): Load Shapes for High Bays Loggered Through the 2004-2005 Express Efficiency Program

Hour	Retail > 20 kW			School			Warehouse		
	Lower 90CI	Mean	Upper 90CI	Lower 90CI	Mean	Upper 90CI	Lower 90CI	Mean	Upper 90CI
1	-	34.0%	-	-	0.0%	-	-	22.5%	100%*
2	-	34.7%	-	-	0.0%	-	-	22.5%	100%*
3	-	37.2%	-	-	0.0%	-	-	22.3%	100%*
4	-	44.6%	-	-	0.0%	-	-	22.5%	100%*
5	-	84.1%	-	-	0.0%	-	-	22.5%	100%*
6	-	91.7%	-	-	0.0%	-	-	30.4%	100%*
7	-	99.7%	-	-	0.0%	-	-	48.7%	100%*
8	-	100.0%	-	-	71.4%	-	-	53.7%	100%*
9	-	100.0%	-	-	71.4%	-	1.0%	55.9%	100%*
10	-	100.0%	-	-	71.4%	-	35.6%	71.5%	100%*
11	-	100.0%	-	-	71.4%	-	57.9%	80.6%	100%*
12	-	100.0%	-	-	71.4%	-	73.6%	87.3%	100%*
13	-	100.0%	-	-	71.4%	-	87.7%	95.0%	100%*
14	-	100.0%	-	-	71.4%	-	86.6%	95.7%	100%*
15	-	100.0%	-	-	71.4%	-	78.7%	90.0%	100%*
16	-	98.7%	-	-	71.4%	-	58.5%	80.0%	100%*
17	-	98.6%	-	-	71.4%	-	13.0%	60.2%	100%*
18	-	98.6%	-	-	71.4%	-	-	32.6%	100%*
19	-	97.5%	-	-	71.4%	-	-	30.7%	100%*
20	-	97.4%	-	-	71.4%	-	-	29.2%	100%*
21	-	93.9%	-	-	71.4%	-	-	27.0%	100%*
22	-	83.7%	-	-	0.0%	-	-	26.7%	100%*
23	-	50.9%	-	-	0.0%	-	-	25.3%	100%*
24	-	33.6%	-	-	0.0%	-	-	24.0%	100%*

* The small number of sites in some segments renders the confidence intervals at the individual segment level impossible to calculate and achieve meaningful values. In addition, segments with highly variable usage require a larger number of sites to calculate meaningful confidence intervals. It may be possible to calculate one side of the confidence interval, but the other side may be outside the acceptable range of 0 – 100%.

4.6 EUL Retention Analysis

This section summarizes the retention study of compact fluorescent lights (CFLs) performed as part of the PY2004/2005 Express Efficiency Evaluation. More specifically, the study focus is on screw-based CFLs rebated and installed through the PY2002/2003 Express Efficiency program. The text that follows describes the Study's objectives, methods, and results of this Study of screw-in compact fluorescent lights.

4.6.1 Study Background

This effective useful life (EUL) study is an ad hoc analysis activity designed to meet CFL measurement needs using readily available methods. For a number of years, the IOUs have been using an EUL of eight years for screw-based CFL measures. This was a result of the CPUC Energy Policy Manual only having EUL data for modular CFL bulbs. The EUL for modular CFLs is based on a 32,000-hour manufacturer rated lifetime ballast, and an annual operating hour estimate of 4,000 hours. However, around 2002, the IOUs started rebating integral CFLs, which had only an 8,000 hour rated lifetime. Integral CFLs now comprise nearly all screw-based CFL installations. The 2003 Express Efficiency study found that the average rated lifetime of the integral bulbs being installed under the program was 7,962, and a lighting logger study found that the average annual hours of operation was 2,709. Using the average rated lifetime, this would have resulted in a EUL of just under three years.

Effective useful life, however, is not only a function of equipment failures, but also early removals that may occur because of remodels, or customers not liking the product. This would have the effect of reducing the EUL. Conversely, it has been shown that average on-times (and therefore the amount of on-off switching that occurs) affect bulb life, with longer on-times resulting in longer hours of life, and more frequent switching shortening life.[34] The manufacturers' rated life is based on laboratory standard testing that uses a 3 hours/on-20 minutes off switch cycle. The 2003 and 2004-05 Express lighting logger studies have shown that on cycles typically approach six to eight hours, implying that bulb lifetime is likely to exceed the rated life.

The study implements an approach reflective of the EUL measurement approach used to conduct many of the IOUs pre-1998 energy efficiency incentive programs. These studies utilized primary data collection and classical survival analysis techniques. The pre-1998 program studies were usually investigating measures that had 12 to 16 year expected measure lives. Many of these studies developed data collection panels where customers were visited on site approximately a year after participating, and then visited on site or called on the phone over the course of a number of years (at a minimum again after three to four years and

[34] See 1999 Specifiers Report on CFLs published by the National Lighting Product Information Program. http://www.lrc.rpi.edu/nlpip/publicationDetails.asp?id=114&type=1

eight to nine years in order to conduct the 4th and 9th year retention studies). Sometimes, measures were "tagged"[35] for easy identification.

This study differs in important ways from those pre-1998 EUL studies. First, screw-based CFLs have a much shorter measure life than previously studied measures, at only a few years. These customers were not visited after the first year, and lamps were not tagged. Instead, customers were called about four to six years after installation and asked to self-report bulb failures. Reliance on self-report techniques in this study raises some concerns that failures may be under-reported. The reasoning behind this concern is that bulb changes may occur seamlessly and proceed unnoticed by the respondent. Another significant concern is that respondents will be unable to report the failure dates accurately, as changing a bulb is neither a memorable nor an uncommon experience. In addition, when failures are reported, they might be reported later than they actually occurred due to "telescoping."[36] This tendency will tend to exaggerate the persistence of the CFL measure, as would the under-reporting of measure failures.

Therefore, it was likely that that the data collected would not be as accurate and unbiased as those collected for previous EUL studies. However, Itron felt that the data collection and analysis would allow for a relatively cost-effective study to be conducted, providing evidence that would aid in developing a more reliable EUL estimate for CFLs. Clearly, the eight-year measure life is excessive. However, are these lamps failing after 8,000 hours, as the manufacturers have rated, or are the longer on-times leading to longer bulb life?

Answering these questions and developing a more reliable estimate of the EUL are the primary reasons for this study.

4.6.2 Study Objectives

For this study, the objective is to estimate the survival function for screw-based CFLs installed under the Express Efficiency program during Program years 2002 and 2003. In this case, the survival function describes the percentage of CFL bulbs installed that are still operable and in place at a given time. Survival analysis is the process of analyzing empirical failure/removal data in order to model a measure's survival function. As much as possible, we have attempted to employ classical survival analysis techniques in this Study approach.

35 Physically labeled with a unique identifier.

36 "Telescoping" is a term for the natural tendency for people to report historical events as occurring more recently than they did. What evidence do we have for this with CFLs? What about the opposite trend? Say someone who is unhappy with the CFLs because he feels they lasted less than promised? That respondent may easily "microscoping"… ie, the opposite of telescoping.

At the time of this study, measures were in place between four and six years (none of the bulbs were rebated prior to 2002, and follow-up data collection was conducted in 2004 and 2007.

Our overall approach consists of four analyses.

- Compile summary statistics on the raw retention data.
- Visually inspect the retention data, by simply calculating the cumulative percentage of equipment that had failed in a given month, and plotting the percentage over time.
- Develop a trend line from the survival plots. Using the plots developed above, a trend line is estimated using standard linear regression techniques. We model the trend as a linear and an exponential function. In each case, we used the resulting trend line to estimate the EUL.
- Develop a survival function using classical survival techniques. We modeled the survival function assuming five of the most common survival distributions: exponential, logistic, lognormal, Weibull, and gamma. In each case, we used the resulting survival function to estimate the EUL.

4.6.3 Data Sources and Censoring

Three hundred and two CFL participants were contacted during September 2007 in support of this Study. All the participants were part of the Express Efficiency Program in the program years 2002 or 2003. Ninety-nine of these surveys were completed with participants previously contacted as part of the 2003 Express evaluation[37] and the remaining 203 surveys were completed with program year 2002 participants, who were not previously contacted.

Nine sites were identified that reported installing more bulbs than were recorded in the tracking system. These sites are removed from the database due to the likelihood that non-program bulbs could be included in the respondents' reported failure statistics. Non-program bulbs may have different rated life and other manufacturer characteristics than program bulbs.

Table 4-43 below summarizes the data censoring that took place in support of this analysis. In summary, out of the 302 surveys, 43 respondents could not report the number of bulbs that had failed. Another nine sites were removed because they reported installing a greater number of bulbs than were recorded in the tracking system, leaving 250 completed surveys in the analysis dataset, which represent 44,748 bulbs.

[37] Participants were contacted in the fall of 2004.

Table 4-43: Summary of Data Censoring

Description	Statistic
Total Surveys	302
Surveys Censored	
Could not provide retention data	43
Reported greater installations than tracking system	9
Surveys used in analysis	250
Number of bulbs represented	44,748

4.6.4 Analysis Overview

As discussed previously, the purpose of a retention study is to collect data on the fraction of measures in place and operable in order to produce a revised estimate of its EUL.

First, we construct the empirical survival function to evaluate the data collected to see if there is enough data to support an estimate. For this step, we compiled summary statistics of the raw retention data, and visually inspected the empirical survival function over the first four to seven years. Lastly, the empirical data was used to forecast the survival function using basic linear regression techniques. We analyzed both a linear trend, as well as an exponential trend (which is one of the most common forms of a survival function).

Next, we used classical survival analysis techniques to estimate the survival function using five of the most commonly referenced survival distributions: exponential, logistic, lognormal, Weibull, and gamma.

The overall approach consists of four analysis steps:

- Compile summary statistics on the raw retention data.
- Visually inspect the retention data.
- Develop a trend line from the survival plots.
- Develop a survival function using classical survival techniques.

The details surrounding each of these steps are provided below.

4.6.5 Summary Statistics

As discussed above, the first step of our analysis was to compile summary statistics on the sample retention data. These statistics include the following:

- The number of bulbs installed at the site,
- The number of units still operable and in place,
- The number of units that had failed, been removed and been replaced,

- The number of failed units that had been replaced under warranty, and
- The percentage of units that had failed, been removed or been replaced

For this analysis, equipment that is replaced under warranty is counted as if it is still operable and in place. Table 4-44 summarizes this data.

Table 4-44: Summary Statistics

Description	Bulbs	Percent
Total Surveyed	44,748	100%
Fail/Replace/Remove	23,198	52%
Bulbs in place and operational September 2007	21,550	48%
Replaced under Warranty (included as operational)	714	2%

4.6.6 Visual Inspection

For this step, Itron developed an empirical survival function that was observed from the raw retention data over the first four to six years of the CFL's installed life. To develop the empirical function, the monthly value for the percentage of equipment that was in place and operable was calculated. Although this appears to be a straightforward calculation, there are two issues that arise:

- The dates associated with failures and removals are not always well populated, and
- Not all customers are surveyed over the same length of time.

Missing Failure Dates

Two common terms used in classical survival analysis are "left-hand censoring" and "right-hand censoring."

- Left-hand censoring means that it is known that a failure/removal has occurred, but it is unknown when the failure/removal occurred. It is only known that the failure/removal occurred before a certain date.
- Right-hand censoring means that at the last time the customer was surveyed, a failure/removal had not occurred, so the time when the equipment will fail or be removed is unknown.
- Interval censored data means that the date of failure/removal is not known specifically, but the upper and lower bounds of that date are known.

It is not a practical approach to ask respondents to report a separate date for each bulb that failed or was removed. Instead, respondents reported the date of the first failure/removal, and the date of the most recent failure/removal. Creating a known interval over which the failures/removals took place.[38] Thus, the failure/removal data gathered over the phone is "interval censored."

The survival function estimation procedures discussed below are capable of handling right-hand censored data and interval censored data. However, for this more simplistic task, some assumptions are required. In order to develop the empirical distribution, an estimate of *each* failure date is needed. We considered four different approaches to estimating the failure dates:

1. Choose the earliest possible date. This would be the date of the first failure/removal as reported by the respondent, or the installation date.
2. Choose the latest possible date, which would be the date of the most recent failure/removal reported by the respondent, or the date of the survey.
3. Choose the midpoint between the two dates above.
4. Generate a random date between the two dates above, based on a uniform distribution.

In Figure 4-11 below, the survival functions based on each of these methods is presented.

Resolving the issue of the differing intervals between installation and the survey, which is referred to below as "survey length", remains.

Survey Length

The topic of right-hand censoring is directly related to the issue of customer survey length. The issue of having customers surveyed at the same time is not much of a concern. Because the empirical survival function looks only at the percentage of equipment that has failed in each month since installation, it is not necessary to have each customer's installation date occur at the same time.

What is more problematic is that some customer follow-up surveys were conducted 44 months after their installation, and others had follow-up surveys conducted 66 months after installation. Therefore, when we calculate the percentage of equipment in place and operating for, say, month 47 there will be some customers who were last surveyed 46 months (or less) after their installation date. For these customers, if a failure/removal occurred prior to month 47, then we know the unit is not operable and in place during month 47. However, if the equipment did not fail or become removed prior to month 47, we cannot say for certain

[38] An alternative approach to this line of questioning would be to ask respondents to report the percent of the bulbs operational (or the percent failed) at 6 month intervals since installation. This would likely reveal more detail on the shape of the survival function, and should be considered as a data collection method should a self-report approach to retention analysis be used for CFLs or a similar technology in the future.

if the equipment is still in place and operable in month 47. This leaves us with three alternatives for developing our empirical distribution. When we are calculating the percent of equipment operable and in place for month M, but the equipment was last surveyed prior to month M, we can:

1. Not include the equipment at all, regardless if a failure/removal occurred prior to month M,
2. Only include the equipment if a failure/removal occurred prior to month M, because it is known that the equipment has failed or was removed in month M, or
3. Include the equipment regardless of failure/removal, and assume the equipment is still operable if it has not failed or been removed prior to month M.

Clearly, the third option overstates the percent of equipment that is in place and operable. Also, the second option is likely to understate the percent of equipment that is in place and operable, because you are not counting equipment that was operating up to month M, which is still likely to be operating in month M. Finally, the first option is probably the only unbiased estimate, but has the potential to result in a survival function that violates the non-increasing property. In other words, because the sample size changes for each month, it is possible that in one month the percent operable and in place could exceed the previous month's percentage (which violates the non-increasing property of a survival function.)

Even with the potential problems suggested with the first option, Itron feels this is the most accurate method.

Solutions

Figure 4-10 and Figure 4-11 were developed in an attempt to address each of the issues discussed above. First, Figure 4-10 provides the percentage of customers that had a survey length (defined as number of months the follow-up survey was conducted after installation) greater or equal to a given number of months. This illustrates the percentage of the customers that would contribute to the calculated percentage of operating equipment in option one above. Figure 4-10 shows that half of the sample had a survey length of at least 58 months.

Figure 4-10: Percentage of Equipment with Survey Length Greater than or Equal to a Given Month

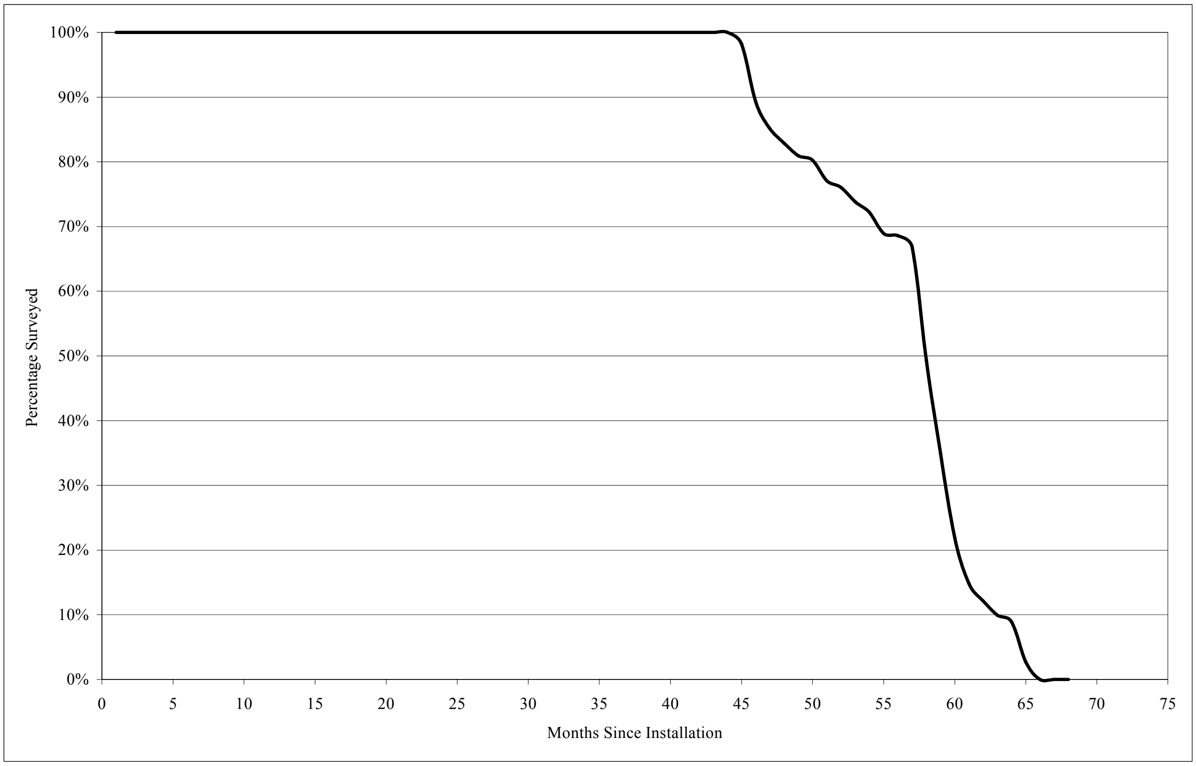


Figure 4-11 illustrates the sensitivity of using alternative methods for populating missing failure/removal dates for the CFL measure. The plot is restricted to the first 62 months for the reasons stated above. In addition, the plot does not include the equipment in the estimate of the survival function if the survey date occurred prior to month M.

Overall, the survival functions vary quite significantly across the four missing failure date approaches. Again, this is a result of the limited ability to gather specific dates of failure for each studied bulb.

Itron chose to populate the missing failure dates with a random date. This approach was selected for three reasons. First, the random date falls between the earliest and latest dates. Second, the random date is smoother than the other possible choices. Third, the random date does not force multiple failure/removals to occur all on the same day, as the other methods would.

Figure 4-11: Empirical Survival Function for All Months - Comparison of Approaches for Populating Missing Failure Dates

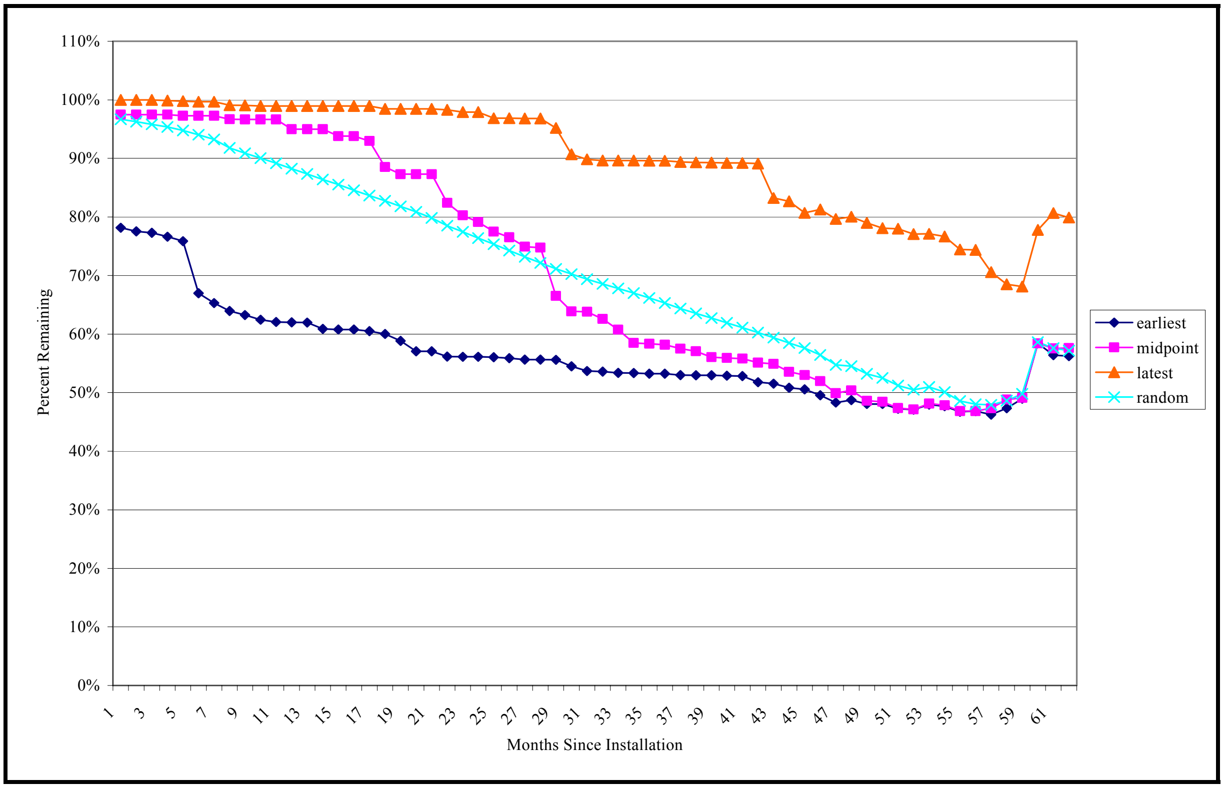
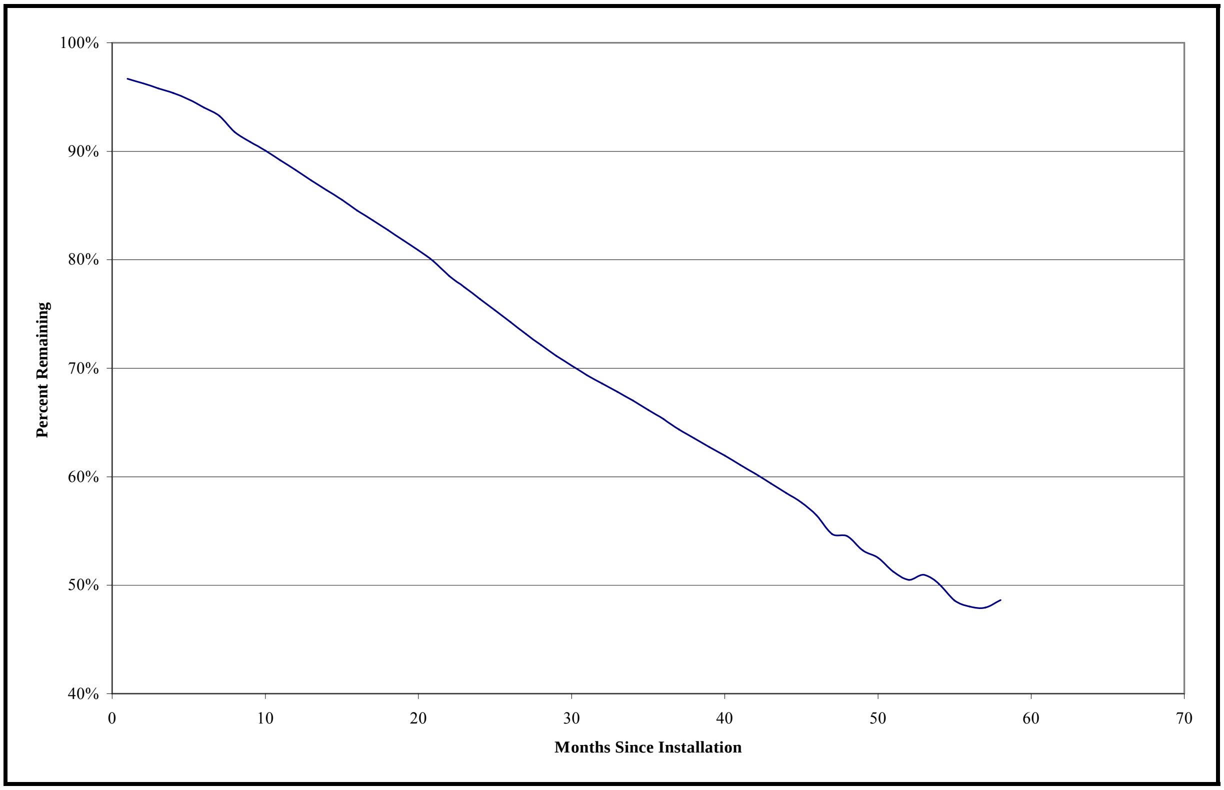


Figure 4-12 presents the final empirical survival function developed for the CFL measure.

This survival function is based on the following assumptions:

1. For missing failure/removal dates, generate a random date (based on a uniform distribution) during the known interval the failure/removal took place, or between installation and survey date if the former is unavailable
2. To estimate the percentage of equipment operable and in place in month M, do not include the equipment if the survey length is less than month M, regardless if a failure/removal occurred prior to month M.

Figure 4-12: Final Empirical Survival Function



4.6.7 Trend Lines

Based on the empirical survival functions presented above, trend lines are developed to estimate the survival function over the life of the measure, and to estimate the CFL EUL.

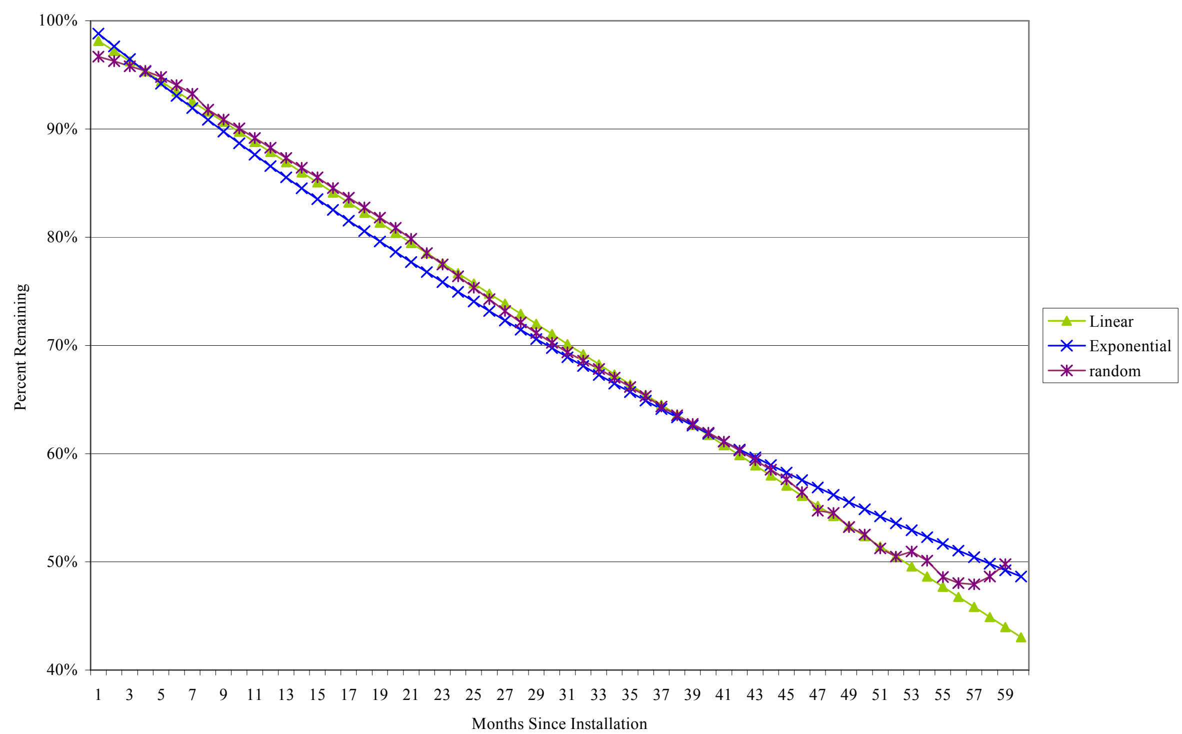
Two trend lines were estimated using linear regression:

1. The first trend line was assumed to have a linear relationship over time. Therefore, the trend line was developed using a linear regression with the percentage of equipment operable and in place as the dependent variable, and the month as the independent variable.
2. The second trend line was assumed to follow the exponential distribution, which is one of the most common distributions used in survival analysis. The trend line was developed using linear regression by transforming the percentage of equipment operable and in place. The natural log of the percentage of equipment operable and in place was used as the dependent variable, and the month as the independent variable. Although the exponential distribution is appropriate for many survival functions, we do not expect the CFLs survival function to asymptotically approach zero, as the exponential function does.

Figure 4-13 compares the linear and exponential survival functions with the empirical function developed above. This exhibit illustrates how well the linear and exponential trends compare to the empirical data.

As discussed above, due to the large time intervals provided by respondents for possible failure/removal dates, the shape of the empirical function is largely a function of the assumptions we make about the interim failure dates. The smoothing of the failure dates through the assumption of a uniform distribution results in a function very close to the linear model. However, at the tail end of the empirical function the rate of failure picks up, which is not captured in either the linear or exponential trend line. .

Figure 4-13: Comparison of Empirical Survival Function, Linear Trend Line and Exponential Trend Line



As we will discuss in more detail in Section 4, neither the linear nor the exponential approach is recommended for the final study results. Developing a trend line on empirical data in this manner is not optimal. The empirical data is interval and right hand censored, meaning that for many failures/removals, the time of the event is unknown; and it is also unknown when currently operating equipment may fail. This trend line and empirical estimation approach does not statistically correct for censored data in the way that classical survival analysis approaches do, as discussed in the following section.

Table 4-45 below summarizes the parameter estimates, associated t-statistics, and EUL estimates for the linear and exponential trend line analysis. The empirical survival function developed above also produces an estimate of EUL, as it crosses the 50% mark at 4.3 years.

Table 4-45: Summary of Linear and Exponential Trend Line EUL Estimates

Trend Line Specification	Intercept	t-statistic	Slope	t-statistic	EUL
Linear	1.0	669.5	-0.01	-185.0	4.3
Exponential	-	-	0.01	133.4	4.8
Actual					4.3

4.6.8 Classical Survival Analysis

This step in the approach is founded on applying classical survival analysis techniques to the retention data in order to develop a survival function for CFLs. Itron modeled the CFL survival function using five of the most common survival distributions: exponential, logistic, lognormal, Weibull, and gamma. In each case, the resulting distribution was plotted and visually compared it to the empirical function developed above. The resulting survival function was also used to estimate the EUL.

Some of the same issues faced when developing the empirical survival function also need to be addressed when using classical survival analysis. The problem of right-hand censoring is not an issue when using modern statistical software for survival analysis. These packages are capable of handling right-hand censored data.

It was necessary to adjust the standard errors that were directly output to account for the false assumption that incidence of failures and removals associated with each bulb in the sample were independent. It is likely that the failure and removal rates associated with measures installed at the same site are correlated. For example, when a CFL removal occurs, it is possible that many of the CFLs may be removed. To a lesser extent, failures are correlated since they may all come from the same manufacturing lot, they are all likely to be installed under the same circumstances, and they are used in a similar manner. See Section 4.5.10 for a fuller discussion of the calculation of standard errors.

Figure 4-14 below depicts the estimated survival functions using five classical functional forms. The empirical function is shown as well for comparison. With the exception of the gamma distribution, all the survival functions do a reasonably good job of fitting the empirical data. The log normal, logistic and Weibull functions have the attractive property of lower hazard rates during the early part of the life cycle and increasing somewhat as time moves on – a shape expected for CFLs.

Figure 4-14: Exponential, Logistic, Lognormal, Weibull and Gamma Survival Functions Based on LIFEREG Procedure

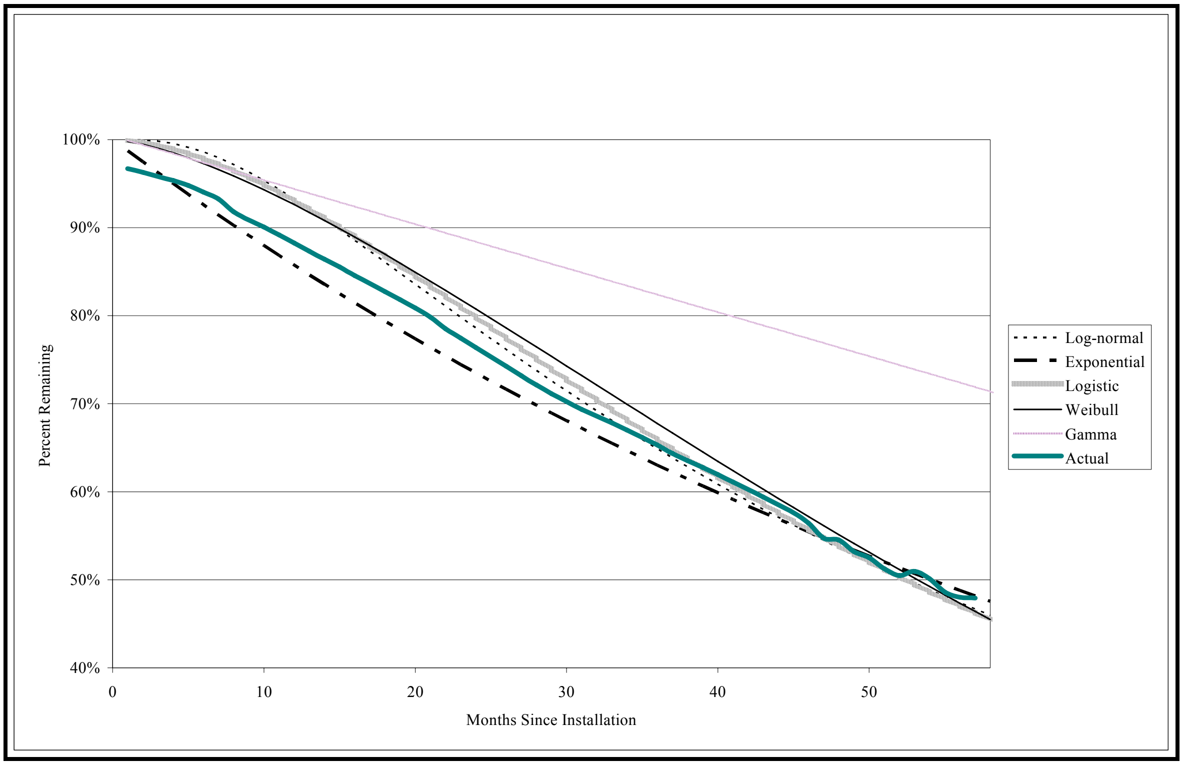


Table 4-46 below summarizes the parameter estimates, standard errors and associated EUL estimates for each of the five classical survival function specifications. Ninety percent confidence bounds are also presented in the table. With the exception of the gamma distribution, which clearly does not fit the data, the remaining survival functions cluster around the empirical data and range from an EUL of 4.3 years for the logistic and log normal functions to 4.5 for the exponential function. The exponential function has the best log likelihood score, due to its superior fit during the earlier month of the analysis.

Table 4-46: Summary of Linear Classical Survival Function Estimation Results and Associated CFL EUL Estimates

	Intercept	Scale	EUL in Years	90% Confidence Interval	
				Lower Bound	Upper Bound
Exponential			4.5	4.0	5.0
Parameter Estimate	4.4	1.0			
Standard Error	0.01	0.00			
Logistic			4.3	4.0	4.7
Parameter Estimate	4.0	0.6			
Standard Error	0.01	0.00			
Log-Normal			4.3	3.9	4.7
Parameter Estimate	4.0	1.0			
Standard Error	0.01	0.01			
Weibull			4.4	4.1	4.7
Parameter Estimate	4.2	0.7			
Standard Error	0.01	0.01			
Gamma			8.3	7.5	9.2
Parameter Estimate	3.7	1.1			
Standard Error	0.02	0.01			

4.6.9 Final Results

With the exception of the Gamma distribution, both modeled and empirical data produce an EUL estimate between 4.3 and 4.5 years. Applying the 2,709 annual operating hour estimate from the PY2003 Express Efficiency Evaluation, the 4.3 years EUL implies a bulb life of 11,650 hours, well in excess of the mean rated life (just under 8,000 hours).

The PY2003 and PY04/05 logger studies find mean on-times to be closer to six hours, exceeding the standard testing on-time cycle by 100%. The hours of useful life of a CFL bulb in relation to its rated life is well understood to be directly linked to the length of on-time cycles, with shorter on-times associated with shorter lifetime hours of operation. To better understand this phenomenon, an excerpt from the NLPIP[39] Specifier Report on Screwbase Compact Fluorescent Lamp Products (June 1999, Volume 7, Number 1)[40] follows:

> *"Rated lamp life is the number of hours at which half the lamps in a large test group have failed under standard testing conditions (which includes a 3 hour on, 20 minute off switching cycle.) A CFL will fail when the emissive coating on its electrodes is all dissipated by evaporation or sputtering (Voorlander and Raddin*

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[39] National Lighting Product Information Program

[40] http://www.lrc.rpi.edu/nlpip/publicationDetails.asp?id=114&type=1

> *1950; Covington 1971). Although the inert fill gas used in CFLs protects the electrodes from bombardment by mercury ions, loss of emissive coating is unavoidable. Therefore, if a CFL is started less frequently than the standard 3 hour on 20 minute off cycle, it will have a life longer than its rated life, but if it is started more frequently than the standard cycle, it will have a life shorter than its rated life."*

This Specifiers Report included the results of long-term performance testing of CFL products. The purpose of the testing project was to study the effect of different operating cycles used in typical residential applications on the life of CFL products, as well as to document how other characteristics such as ballast technologies, manufacturers, and lamp shapes effect bulb life.

The NLPIP identified 11 different CFL products to test from six different manufacturers. Six different operating cycles were selected to represent possible residential applications for CFL products, ranging from 5 minutes on /20 off to 3 hours on /20 minutes off (the standard lamp testing cycle.) The mean resulting bulb life hours increase by a factor of three when moving from a five-minute to the three-hour on-time cycles.

In July of 2005, the NLPIP published a supplement to the CFL Specifier Reports, which examined the impact of bulb placement to hours of life. The study chose CFLs manufactured by five different companies. Testing employed the standard three hours on and 20 minutes off switching pattern. The results varied widely by manufacturer, with two of the five manufacturer's bulbs exceeding the rated life by 150 to 200% under all bulb orientations; and a third manufacturer exceeded rated life by these margins under three of the four orientations. It was also interesting to note that some manufacturers' survival curves are very flat, with many bulbs substantially outperforming the rated life, while others are more straight up and down, with observed bulb-life clustering around the rated life.

From these studies, it is reasonable to conclude that switching time has a very significant and consistent impact on bulb life, with shorter on-times leading to shorter hours of bulb life, and vice versa. Also, long term bulb performance varies widely by manufacturer, and it is not uncommon to find many bulbs exceed their rated life by a substantial margin, even when operated under the standard testing switch cycle (three hours on, 20 minutes off).

Unfortunately, no studies could be identified that specifically examine hours of bulb life with switching cycle on-times in excess of three hours. Still, the data on the lower end of the operating cycle scale suggests that longer on-time cycles are quite likely to yield mean bulb lifetimes greater than rated life.

If increasing the on-time from five minutes to three hours triples the rated life, it does not seem out of the realm of possibility that extending it from three to six hours would lengthen life beyond the rated life by 50%, seen in this analysis. On the other hand, given the manufacturer specific survival curves published in 2005 by the NLPIP, the specific mix of bulbs and/or manufacturers could, by itself be responsible for a substantially longer observed mean bulb life relative to rated life, even at the standard 3 hours on 20 minutes off cycling. However, the NLPIP data do indicate that the relationship between rated life and on-time is logarithmic, where increasing on-time length has diminishing returns on increasing rated life. Therefore, increasing the on-time cycle from 3 to 6 hours will not double the rated life, but a 50% increase is feasible.

Based on these findings, it is recommended that the empirical survival function results be accepted as the final outcome of the study. The empirical result is selected over the models because the empirical data provides enough attrition to yield a solid estimate of EUL, which is confirmed by the models. The empirical result consists of a mean bulb life of 4.3 years, corresponding with 11,650 hours at the expected annual operating hours of 2709. Because of the relationship between on-time cycles and measure life, Itron does not recommend taking the result of 11,650 hours and dividing it by the annual operating hours to obtain an EUL for a given business type. For example, if the annual operating hours for a specific business type were half of the 2,709, that would not imply the measure life would double to 8.6 years. If the annual operating hours were half that of the average, then the on-time length would also likely be reduced significantly, thereby reducing the measure life.

These results may also help to refine the EUL applied to the PY 2004/2005 Express Efficiency program. The 2004-05 Express lighting logger study indicated that the average annual operating hours was approximately 3,016. As mentioned above, increasing the on-time length has diminishing returns on increasing the measure life, but there is likely a small increase in measure life due to the increased annual operating hours. If we were to ignore any increase in measure life due to the increased annual operating hours, then the 11,650 hours of measure life would imply an EUL of 3.9 years. Therefore, the EUL is in the range of 3.9 and 4.3 but likely closer to 3.9 than 4.3 due to the logarithmic nature of the relationship between measure life and on-time cycle.[41] Itron recommends using a four-year EUL for all CFLs installed under the 2004-05 Express Efficiency program. The results do not support using different EULs for different segments that have higher or lower annual operating hours on average because of the relationship between measure life and on-time cycle.

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[41] We feel 4.3 is an upper bound, as this would imply that the relationship between rated life and on-time length is linear (rated life increases proportional to on-time length). However, test data indicate the relationship is logarithmic, where increases in on-time length (especially for relatively long on-time lengths) result in proportionally smaller increases to measure life.Can we see the test data and better yet the full report in an appendix?

As discussed above, the self-report method as applied in this study may under-report failures. Respondents may not be aware of all failures, and will have a tendency to "telescope" the dates of failure – both leading to exaggerated estimates of persistence. A good example of suspicious self-reporting is the fact that 20% of the sites (representing 10% of the bulbs) report a failure rate of less than 5%. All of the bulbs were in place for more than four years, and can be expected to have been operating between 10,000 and 16,000 hours, rendering such a failure rate suspicious. Even more troubling are the 44 sites reporting zero bulb failures. These sites are associated with an average installation size of 60, again rendering zero failures highly suspicious. The CFL EUL results presented in this study require further refinement in upcoming evaluation cycles, and a downward adjustment in the EUL of CFLs is the likely outcome of such refinement.

Given the shortcomings of this study, further study of screw-based CFL bulb life in commercial applications is needed. In particular, a more tightly controlled and objective data collection method should be employed to collect future data on CFL retention. This should include on-site verification and follow up, with "tagging" of program measures. In addition, evaluators would benefit from a better understanding of the response in mean CFL bulb life to switching times in excess of the 3 hours on/20 minutes standard testing cycle. How much effort are we talking about here? Shouldn't it also focus on business type?

4.6.10 Notes on Precision

The SAS output provided the standard errors for the 50th percentile (or median). Because the analysis was conducted on the unit of measure (i.e. a bulb) and not a site, the standard errors from SAS were grossly underestimated. SAS treats each observation in the dataset as independent. However, it is likely that there is significant correlation in the observations that are common to a single site. For example, when a removal occurs, it is likely that many bulbs are removed at once. Failures are also correlated since they are likely to come from the same manufacturing lot installed under the same circumstances, and, importantly, used in a similar manner.

If it is believed there is 100% correlation of failure/removal for all bulbs within a site, the standard error could simply multiply the standard error calculated from SAS by the square root of the ratio of the number of units to sites. Therefore, if there were an average of 100 units installed per measure, we would multiply by the square root of 100 or 10.

Skinner and Kish[42] both offer a theoretical approach to solving the problem of estimating a standard error when the data are not identical and independently distributed (IID). They define this problem as a design effect, which is the case when the sample is not a simple

[42] Skinner, C. J., "Analysis of Complex Surveys," John Wiley & Sons, 1989, pp. 23-46.
Kish, L., "Survey Sampling," John Wiley & Sons, 1965, pp. 162.

random sample that is IID, but rather is a cluster sample such as the CFL data. In these data, each site contains a cluster of sample points.

Skinner developed a design effect factor, "Deff," that can be used to adjust the standard error obtained from SAS to estimate the true standard error:

$$Deff = \frac{StdErr_{TRUE}{}^2}{StdErr_{SAS}{}^2}$$

where,

$StdErr_{TRUE}$ is the actual standard error associated with the median EUL
$StdErr_{SAS}$ is the standard error associated with the median EUL obtained from SAS

Skinner estimated the design effect factor as:

$$Deff = 1 + (n-1) * \tau$$

where,

n = the average number of sample points per cluster (or, in this case, per site)
= $\frac{N_{Units}}{N_{Sites}}$
τ = the intra-cluster correlation

Skinner's method is the basis for the calculation of the standard errors of the CFL EUL reported here. Removals are a small part of the overall failure rate, but have a high degree of site-specific correlation. At the same time, failures have a low to moderate degree of site-specific correlation, but are a larger part of the overall failure rate. Therefore, we assume an overall inter-cluster correlation of 0.5, and apply Skinner's method to calculate the standard errors, as shown in equation (6):

$$Deff\,(Eq.6) = 0.5 + 0.5 * (\frac{N_{Units}}{N_{Sites}}) = 1 + (n-1) * 0.5$$

4.7 Engineering Analysis

The engineering analysis for the Express Efficiency program was completed by Itron in order to update and enhance existing engineering algorithms to estimate energy, demand, and therm savings for measures rebated by the Express program during the 2004-2005 program years. This review entailed a number of steps in order to develop a comprehensive engineering analysis, including a review of measure specific IOU work papers, analysis of telephone survey and on-site data collected as part of the evaluation of the program, and the utilization of other secondary resources such as CEUS and DEER.

There are several dozens of individual measures offered under the Express program. The top 22 measures contribute over 95% of the programs savings in terms of kW, kWh, and therms. An in-depth engineering analysis was completed for these 22 high impact measures. For most of the measures subject to an in-depth engineering review, the review results in either an updated algorithm or updated parameters that can be used to enhance the existing algorithm results to better represent the 2004-05 participant population. The engineering review presented in Appendix I identifies the algorithms being recommended, and all of the contributing parameters that comprise the algorithm. The data sources used to propagate each parameter are identified in the detailed review for each measure. The data sources include the 130 on-sites, the participant surveys, and existing data sources such as the participant tracking, CEUS, DEER, or CIS data.

For the remaining measures that comprise approximately 5% of savings, a cursory engineering review that primarily is comprised of a review of the IOU's technical work papers is completed. Although no ex post engineering savings estimates are developed for these low priority measures, the cursory review does identify potential issues with some of these measures and highlights measures where future research could be conducted to enhance the ex ante estimates. The cursory reviews are provided in Appendix J.

A summary of the findings for the measures subject to in-depth engineering review are presented in Table 4-47.

The two key measures that had realization rates significantly less than one, were programmable thermostats and strip curtains. There were two primary factors that reduced the programmable thermostat estimate. The first was that the engineering onsite visits found that approximately 75% of the units were not being programmed, which resulted in no savings. Furthermore, the conditioned space associated with each programmable thermostat was only about 12% of that assumed in the ex ante workpapers.

There were also two primary drivers affecting the strip curtain realization rate. The first was that the engineering onsite visits found that the door open time was only about 1.2 hours per day, compared to 3 hours per day in the ex ante workpapers, or 60% less. Furthermore, the onsite sample found that only 17% of the strip curtains were associated with freezers, as opposed to the 20% ex ante assumption. Because savings is five to six times higher for freezers, this difference resulted in about an 8% additional reduction in savings.

Table 4-47: Summary List of In-depth Review of Major Impact Measures

Section #	Measure Group	Measure Name	Engineering Realization Rate
1	Building Shell	Greenhouse Heat Curtain	85%
2	Building Shell	Window Film	80%
3	HVAC-Other	Programmable Thermostats	kWh = 2.4% Therm = 1.9%
4	HVAC-Other	VSD – AHU	100%
5, 6, 7	Lighting-CFL	CFL	* See Logger Analysis
8	Lighting-Other	High Bay T5	* See Logger Analysis
9	Lighting-Other	LED Exit Sign	100%**
10	Lighting-Other	Occ-Sensor - HighBay	100%**
11	Lighting-Other	Occ-Sensor – Ceiling	100%**
12	Lighting-Other	Occ-Sensor - Wall box	100%**
13	Lighting-T-8/T-5, Elec Bal, Delamp	T8 El Ballast	* See Logger Analysis
14	Lighting-T-8/T-5, Elec Bal, Delamp	Delamp	* See Logger Analysis
15	Refrigeration	Cooler/Freezer Door Gaskets	80%
16	Refrigeration	Efficient Evaporator Fan Motors – ECM	100%**
17	Refrigeration	Strip Curtains for Walk-ins	32%
18	Water Heating	Boiler, Water	143%
19	Water Heating	Clothes Washer	117%
20	Water Heating	Pipe Insulation	100%
21	Water Heating	Tank Insulation	201%
22	Water Heating	Boiler, Process	76%

** No adjustment made to the workpaper savings estimates.

5

Upstream Program Impact Evaluation

The impact evaluation for the Statewide Upstream HVAC and Motors (Upstream) Program validates the methods used to estimate gross savings during the 2004-2005 program cycle, develops more up-to-date inputs, provides ex post savings and realization rates, and generates more accurate lookup tables that can be used for both evaluation and implementation purposes. Analysis of program ex post savings, completed by KEMA, Inc., includes an engineering review of current ex ante gross savings methods and monitoring of end-use equipment (both HVAC and motors) through an on-site metering study.

For HVAC measures, KEMA developed a revised list of equivalent full load cooling hour (EFLCH) and coincident diversity factor (CDF) estimates based on updated data sources, namely the Database for Energy Efficient Resources (DEER) and the Commercial End-Use Survey (CEUS). This list included EFLCH and CDF by building type and climate zone, as opposed to the IOU work papers, which present estimates by building type only. Specifically, we disaggregated the CEUS data and mapped it to DEER data points. This approach required review of the CEUS survey data to retrieve detailed building descriptions. Updated EFLCH and CDF estimates were then used to calculate revised ex ante savings estimates. Additionally, KEMA also revised the Program HVAC savings by first re-calculating them, based on the ex-ante assumptions from the work papers (as opposed to the actual savings tracking method used by the IOUs) and second, by using the revised list of EFLCH and CDF.

For motor measures, DEER assumes operating hours vary by building/industry type specific to certain industrial SIC codes. The Upstream program assumes operating hours are uniform across building type. The evaluation team was therefore unable to recalculate program savings per the DEER database since the program data were not specific in regards to building type. The evaluation team developed new gross savings estimates for motor measures based on the ex-ante assumptions listed in the program work papers.

5.1 Data Sources

The impact assessment for the Upstream Program evaluation relies on data from eight primary sources: utility billing data, Program tracking data, Program work papers, Program filing (PIP and E3), 2005 DEER database, participant and non-participant telephone surveys, on-site verification and logger/metering data, and weather data.

Participant tracking system data for the Upstream programs were provided by each of the IOUs involved in this evaluation (PG&E, SCE, SDG&E, and SCG) in support of this evaluation. Data were provided for program years 2004 and 2005. The tracking system contains dates of participation, program measure descriptions, quantity installed, incentive amounts, estimated gross kWh and kW savings per unit, and the net-of-free-ridership ratios that were applied for each measure to calculate the net kWh and kW savings.

Table 5-1 and Table 5-2 show the breakdown of the program accomplishments as provided in the program databases.

Table 5-1: IOU Breakdown of Upstream Net Program Savings

Utility	kW	kWh
PG&E	13,745	26,032,882
SCE	14,235	37,685,756
SDG&E	2,704	4,822,620
Total	**30,684**	**68,541,258**

Table 5-2: Split of Program Savings by End Use

End Use	kW	kWh
Motors	2,497	14,526,951
HVAC	28,187	54,014,307
Total	**30,684**	**68,541,258**

The tracking database is linked to the utility billing databases via customer account numbers. However many of the records in the tracking system could not be linked because the site identifiers could not be merged with the billing data. Efforts were made to merge the two datasets by business name and address. This was somewhat successful, but many were not identifiable. In addition, site identifiers for PG&E were in some cases found entered as dummy values instead of Account Numbers.

Program work papers and filings were used to verify and adjust the utility savings claims per unit. Additionally, the work paper method for calculating savings was used for the ex-post analysis. The DEER database A/C and motor savings were also used to benchmark the program ex-ante and ex-post savings estimates per unit type.

Utility monthly billing data were also provided by each of the California IOUs. These billing data included business name, customer account numbers, addresses, kWh and Therm usage, and bill read dates. Billing data were provided for all Upstream participants and a sample of non-participants at each utility and spanned the period from January 2003 through late 2007. As part of this evaluation telephone survey data were collected from participants and non-participants. These data were used to support all of the gross and net impact analyses, the process evaluation, and the market opportunities assessment.

On-site data collection was conducted for A/C and motors. The on-site A/C surveys included continuous monitoring of current (amps), spot measurement of voltage, estimated operation schedules, and nameplate information. The on-site motor surveys included nameplate information, annual operation schedules, measurement of the motor operation schedule, spot power measurements of the load on the motor if it was constant, and continuous monitoring of amps or kW, if the motor load varied.

Weather data files were obtained from National Oceanic and Atmospheric Administration (NOAA) for the climate regions where A/C metering was conducted. More details of the use of the weather data is provided in the analysis section.

5.2 Verifying Program Accomplishments

To verify the program accomplishments the team compared the energy and demand savings from the IOU Final Report Workbooks to those in the program tracking database and verified IOU-specific samples of rebate applications. Described here is the approach, analysis, and results of the IOU gross savings estimates and any modifications made to these estimates for use in calculating ex post savings.

The first step to verifying program accomplishments was to verify rebate applications. A random sample of rebate applications was obtained from each utility. Through the verification process, KEMA determined if the measure, site, and distributor information was entered correctly into utility tracking databases. Next, the results of the application verification were expanded to the population and gross savings were re-estimated. The results of this verification analysis are presented in Section 5.2.1.

Second, through an engineering review of utility work papers and by talking with program staff when necessary, KEMA assessed the methods used by utilities to estimate gross savings. For HVAC and motor measures, we determined how utilities estimated equipment demand reduction, energy savings, and coincident demand. The utilities' methodologies were then applied to the data available in the program tracking database and an attempt was made to replicate the gross savings estimates. The IOU Final Report Workbooks matched the Program Tracking databases as shown in Table 5-3.

Table 5-3: Program Savings Comparison – May 2006 Program Filing and Program Tracking Database

	MWh		kW	
	May '06 Filings	**Program Tracking Db**	**May '06 Filings**	**Program Tracking Db**
PG&E	26,033	26,033	13,745	13,745
SCE	37,849	37,686	14,500	14,603
SDG&E	4,835	4,823	2,710	2,704
Total	68,717	68,541	30,955	31,052
% Difference		-0.26%		0.32%

5.2.1 Application Verification

Central air conditioner (CAC) and motor distribution firms that participated in the 2004-2005 Upstream Motors and HVAC Rebate Program were responsible for submitting rebate applications to the IOUs. Distributor representatives submitted the applications to the IOUs using an online rebate application tool set up and managed by a third party (Energy Solutions). The IOUs paid rebates directly to the distributors based on output from the electronic tool. The tool captured electronic records of program applications, and each of the IOUs maintained its own separate rebate tracking database.

Verification Methods

Evaluators attempted to compare 100 rebate applications from the IOUs' tracking databases with the rebate records captured by the online rebate application tool. The 100 rebate applications included 70 HVAC measure applications and 30 motor applications.

To select applications for verification, the top five motors distributors and top five CAC distributors were first identified for each of the three IOUs (PG&E, SCE and SDGE) based on the number of rebate applications submitted. A random number was generated for every rebate application and rebate applications were then sorted by IOU, distributor, and ascending random number.

Table 5-4 displays the total number of CAC and motor rebate applications selected for verification by IOU. For CAC rebate applications, 55 of the total 70 verification applications were proportionally allocated across the utilities among the top distributors. Among these distributors, applications were selected based on the random numbers generated in the previous step. These allocations were then adjusted per IOU/distributor combination to ensure minimum of 10 distributors per IOU, 20 applications per IOU, and two applications per distributor. The remaining 15 CAC rebate applications were randomly selected from the remaining distributors within each IOU service territory.

For motor rebate applications, the 30 verification applications were allocated evenly across the top five distributors within each IOU (two applications per distributor).

Table 5-4: Initial Targets for Number of Applications Selected for Verification by IOU and Measure Type

IOU	Measure Type		Total Applications Selected
	CAC	Motors	
SCE	25	10	35
PG&E	24	10	34
SDG&E	21	10	31
Total	**70**	**30**	**100**

These initial targets were adjusted as the result of a complication regarding the ways in which the IOUs and online tool recorded and compiled application information. The online application form allowed distributors' representatives to submit rebate applications (for multiple measures installed at multiple locations) under a single application number. PG&E tracked applications in a similar fashion (allowing several measures/installation sites on one application) but SCE's and SDG&E's databases associated only one measure with each of the application numbers from the online application database.

The program contractor provided evaluators with a lookup table that showed reference numbers for several of the SCE and SDG&E tracking databases associated with application numbers from the rebate application tool, and based on this guide, KEMA was able to identify 59 of the 65 applications initially identified for verification. Six of the SCE applications could not be cross-referenced in this fashion (five CAC applications and one motor application). This difficulty in cross-referencing arose because of a category mismatch, where the measures had been incorrectly included in the wrong sample (those not cross-referenced in the HVAC sample were Motor measures, and vice versa). Rebate application data at Energy Solutions was stored in separate databases and requested via separate data requests. Therefore, application numbers for motor measures requested as part of the HVAC data request were not "found" in the HVAC database. The data would have been located in the Motors database, but these application numbers were not included in the Motors data request. Unfortunately, this error was discovered late in the verification process, where time did not allow for an additional data request, so these measures were dropped from the analysis.

Because each PG&E application referenced multiple measures, evaluators reduced the total number of applications to verify for PG&E from 34 to 21. As shown in Table 5-5, these 21 PG&E applications represented 559 measures. The table also shows the number of applications and measures ultimately selected for verification among SCE and SDG&E applications.

Table 5-5: Final Number of Applications and Measures Selected for Verification by IOU and Measure Type

IOU	HVAC		Motors		Revised Total # of Apps Selected	Total Measures Represented by Selected Applications
	Number of Applications	Number of Measures	Number of Applications	Number of Measures		
PG&E	12	208	9	306	21	559
SDG&E	21	21	10	10	31	31
SCE	20	20	9	9	29	29
Total	**53**	**249**	**28**	**325**	**81**	**619**

Verification Results

The one-to-one correspondence between SDG&E and SCE application numbers simplified the verification process for the 60 measures (reduced from 66 due to the category mismatch described previously) associated with applications from these two IOUs. Each of the 60 measures was successfully verified. Records output from the online rebate application tool also showed that the 60 applications selected for verification actually represented 60 rebated measures.

With the one to one correspondence between application numbers and rebate measures in the SCE and SDGE databases, all of the rebate applications for which we had data (e.g., not discarded due to category mismatch), were successfully verified for these two utilities. Note that efforts were not made to locate the other "unmapped" rebate measures that were present on the same rebate application when submitted to the program managing contractor's database.

Analysis of the PG&E data was more complicated. In total, 514 out of 619 rebate measures in the contractor database were successfully matched to an equivalent measure in the PG&E rebate tracking database, giving an overall verification rate of 83%. For each rebate application but one, there was at least one matched rebate measure in the utility database. Virtually every instance of an unmatched rebate measure represented a case where there was an extra measure in the contractor database that was missing in the PG&E database. It was impossible to tell whether those measures were not present at all in the PG&E database, or were located under a different application number, in the manner of the SCE and SDGE "unmapped" rebate measures.

Recommendations

More consistency between the utility databases and the contractor database would simplify retrieval of information and verification of data. Including multiple rebate measures, each going to unique locations, under a single rebate application number caused confusion and made verification difficult. Ideally, the rebate databases at the utility level and contractor level should use the same names for data fields, and sufficient data to accurately identify a rebate measure, including the complete site address, and efficiency information about the installed rebate would be present in both databases. Finally the same rebate application number should be used by both parties, to eliminate the need for a data dictionary, mapping rebates from contractor to utility database.

5.3 Replication Results

We begin this section by providing background on utility methods for calculating program savings. Next, we provide an alternative method for calculating savings using both DEER and CEUS data sources. Finally, we replicate program savings using the IOU actual approach, the IOU work paper method, and then the alternative method.

5.3.1 Background

Calculating ex post savings for HVAC equipment requires assumptions about equipment demand reduction, energy savings, and coincident demand. Understanding utilities' assumptions about these is key to the analysis. Below we review how the utilities calculated equipment demand reduction, energy savings, and coincident demand and how their assumptions about these calculations may impact program savings estimates. We outline the utilities' approach as described in the program work papers and the approach used for tracking purposes in the utilities' databases, which resulted in the gross savings, reported for the Program.

Equipment Demand Reduction (Non-coincident kW)

Single-package and split system, air-cooled or water-cooled air conditioners have various metrics that can quantify efficiency. These are Energy Efficiency Ratio (EER), Seasonal Energy Efficiency Ratio (SEER), and Integrated Part Load Value (IPLV).[43] EER, SEER, and

[43] EER is measured at 92°F and SEER at 82°F. IPLV is the efficiency based on conditions at 100%, 75%, 50%, and 25%.

IPLV are the equipment performance ratings used for calculating savings. They are considered to be poor indicators of actual energy usage in climates where the average ambient conditions are significantly different then the rated conditions. When used for energy savings calculations, it can be assumed that the baseline and high efficiency measures will vary proportionally. The end result is the relative differences in efficiency, not the absolute energy consumption of the baseline and high efficiency case.

Which efficiency metric to use in energy savings calculations is not clear cut. For under 65kBtu units, manufacturers usually only document a rated SEER value, but larger units are documented with EER and/or IPLV values.

HVAC equipment demand (kW) was calculated by the program as follows:

$$kW = 12 \text{ x } (Tons/(EER \text{ or } SEER \text{ or } IPLV)$$

Demand reduction was calculated as the difference between the new efficient unit and the Title 20 or Title 24 baseline (i.e., code baseline). Title 20 applies for units less than 20 tons and Title 24 applies for units greater than or equal to 20 tons.

$$kW_{reduction,<20tons} = kW_{Title20} - kW$$
$$kW_{reduction,\geq 20tons} = kW_{Title24} - kW$$

Annual Energy Savings

Utilities calculated annual energy savings (kWh) by multiplying equipment demand reduction by equivalent full load cooling hours (EFLCH). EFLCH refers to the hours an air conditioning unit is assumed to operate if it operates at full load based on the conditions.

$$kWh_{savings} = kW_{reduction} xEFLCH$$

Table 5-6 presents the EFLCH values used for the 2004-2005 Upstream program as shown in SCE and PG&E program work papers. SDG&E used the same EFLCH values as those included in PG&E's work papers. The source of the EFLCH differs by utility. PG&E used two different studies.[44] SCE's was established by 84 samples of different building types and climate zones, which ranged from 6,602 to 851 hours, with an average of 2,453 hours.

[44] The EFLCH are those used by PG&E's 2004-2005 Express Efficiency program. They are based on two sources. One source was the hours of operation study by PG&E's Energy Efficiency Services Department in 1994 in conjunction with HBRS and Barakat and Chamberlin. This was the source for the schools K-12 and hotel/motel market segments. The study developed statistically valid measures of hours for only two sectors. EFLCHs were estimated based on customer self report of cooling use and application of an adjustment factor to convert from cooling system use to EFLCH. The source for the remaining market

Table 5-6: IOU Equivalent Full Load Cooling Hours for HVAC Technologies[45,46]

Market Sector	EFLCH		% Difference
	SCE	PG&E and SDG&E	
Office	1,340	1,000	-34%
Retail	1,580	800	-98%
University	1,439	1,200	-20%
School	1,439	500	-188%
Grocery	1,660	600	-177%
Restaurant	2,148	1,300	-65%
Health Care/Hospital	5,261	1,900	-177%
Hotel/Motel	3,327	700	-375%
Warehouse	3,486	300	-1062%
Process Industrial	N/A	800	N/A
Assembly Industrial	2,473	2,100	-18%
All Other	2,835	1,200	-136%
Overall Average	**2,400**	**1,033**	**-132%**

Coincident Demand

The coincident diversity factor (CDF) adjusts for the load shape of the end use at the utility system peak and for diversity (i.e., not all equipment is in use at any given time). CDF should be dependent on climate zone, building type, and vintage.

$$kW_{coincident} = CDFxkW_{reduction}$$

Table 5-7 presents the CDF values used for the 2004-05 Upstream HVAC incentives by SCE, PG&E, and SDG&E.

segments was the EFLCH report by PG&E's Mechanical and Nuclear Engineering (M&NE) Department in 1994 in conjunction with Bentley Engineering. EFLCHs were estimated for twelve building types in nine climate zones within PG&E's service territory. These building types include offices, colleges, schools, retail stores, grocery/liquor stores, hotels/motels, hospitals, health facilities, restaurants, warehouses, assembly industrial, process industrial, and data processing centers. To prepare the ELCFH estimates, a computer based building simulation model for each facility was developed to estimate the cooling plant's annual energy consumption and peak load for each facility type.

45 The EFLCH values are taken from supplemental tables of SCE's 2004-05 Express Efficiency HVAC Work Papers.

46 The EFLCH values are those used by PG&E and SDG&E's Express program. This table is from the PG&E 2004-05 program work papers.

Table 5-7: Coincident Diversity Factors for HVAC Technologies[47]

Market Sector	CDF
Office	0.87
Retail	0.85
University	0.73
School	0.24
Grocery	0.83
Restaurant	0.86
Health Care/Hospital	0.89
Hotel/Motel	0.77
Warehouse	0.80
Process Industrial	0.75
Assembly Industrial	0.75
All Other	0.78
Average	**0.76**

For motors, the IOU work papers base the savings on three factors, Load Factor (LF), CDF, and annual operating hours (annual OH). The calculations are as follows:

$$Coincident\ kW\ reduction = CDF \times kW\_Savings$$

$$Annual\ kW\ savings = kW\_Savings \times Annual\ Operating\ Hours$$

Capacity (or horsepower, HP) and efficiency values are from the motor nameplate. The work papers assume a baseline efficiency and the minimum required for premium efficiency as the retrofit efficiency. The work papers assume a LF of 0.75 and a CDF of 0.74.[48] The annual operating hours was assumed to 4,700 independent of motor size or application.[49]

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47 Quantum Consulting, 1997. "Evaluation of Pacific Gas & Electric Company's 1995 Nonresidential Energy Efficiency Incentives Program for Commercial Sector HVAC Technologies," Protocol Table 11. March. Page 5. The CDF is calculated by 0.877 x the operating factor between the hours of 3-4pm. The 0.877 is the undiversified peak duty cycle calculated from end use metering data collected by the study and is the average of the five highest weekday peak duty cycle events. The school's number uses 0.27 for the 3-4pm operating factor based on phone surveys.

48 Motors are generally oversized to allow a safety margin. Surveys compiled by Nadel et al. (1991) and SRC (1991) show 65% load factors. PG&E's 1994 program year measurement and evaluation studies for the commercial and industrial sector found this estimate to be low stating "The PG&E Express savings calculations assume average load factors of 65% and average peak coincidence factors of 64%. For the evaluation, a number of motors were measured to have higher load factors…More importantly, most of the motors were operating continuously during the summer peak hours, and the estimated coincidence factors were much higher than assumed by PG&E" (Xenergy 1996B, page 3-3). Given that the study did not provide new values for load factor or coincidence factor (possibly because of small sample size) and to retain a conservative but more realistic estimate, the load factor for motors was increased by 15% from 0.65

5.3.2 Engineering Review

The goal of the engineering review was to develop a revised list of EFLCH and CDF estimates based on updated data sources, namely DEER and CEUS. Potentially, it was assumed that field logger data could be used to validate any approach offered. These revised EFLCH and CDF estimates were used to calculate revised program savings estimates.

One key difference in our approach to developing revised EFLCH estimates is to break down EFLCH values by building type and climate zone, as opposed to building type only; utility work papers document that they used building type exclusively to develop EFLCH estimates. In viewing DEER savings for A/C units, the sensitivity of climate zone, building type, vintage, and unit size range varies, where climate zone and building type are the variables most influential on affecting air conditioning usage. Therefore, it is believed that any savings calculations for package A/C units must take into account climate variations.

We used both DEER and CEUS datasets to provide the most current and comprehensive data for the state of California. DEER provides the savings data and CEUS provides information on existing building stock. There are several challenges with comparing and combining the DEER and CEUS data. For example, DEER is more disaggregated than CEUS in that DEER has values for more building types and for four different vintages of existing construction (whereas CEUS has fewer building types and does not have data for every building vintage in every climate zone).

The following outlines three methods of lining up DEER and CEUS that we considered:

- **Map the DEER building type categories to the CEUS building type categories.** This approach would require a method for developing and applying weights to building types for aggregation. For example, DEER has values for both "sit-down" and "fast food" types of restaurants but CEUS has only one "restaurant" category. In order to map DEER to CEUS values, we would need to determine the

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to 0.75. Similarly, the CDF was increased 15% from 0.64 to 0.74. The Upstream program uses these values.

49 The hours of operation vary dramatically between applications and customers. A study done by the New England Power Service Company (1989) on hours of operation for commercial and industrial motors found median use of 4,000-5,000 hours per year. In the early 1990s, the PG&E Express Efficiency program used 4,100 annual operating hours for the energy and economic analysis. This number was considered conservative and in the absence of other data, was a good approximation of the operating patterns. The 1994 program year measurement and evaluation studies for motors in the commercial and industrial sectors found that this number was indeed much lower than actual practice (Xenergy 1996B). Given that the study did not provide a new figure for motor operating hours (possibly because of small sample size) and to retain a conservative but more realistic estimate, the annual operating hours for motors was increased by 15% to 4,700 hours per year.

appropriate weight for each disaggregated type of restaurant in order to come up with value for all restaurants combined.

- **Disaggregate the CEUS data and map it to DEER data points.** This approach requires review of the CEUS survey data to retrieve detailed building descriptions. CEUS data do not have data points in every climate zone, vintage, and building type to provide sufficient information to make a complete mapping to the DEER data. With the limited dataset available from CEUS, it is only possible to develop building vintage weights by building type independent of climate zone**.**
- **Develop new building type categories and map both DEER and CEUS to these types.**

We selected the second approach because we have the data required to implement it, and, compared to the other two approaches, it is the most straightforward and efficient way to arrive at more precise revised EFLCH and CDF estimates.

Mapping CEUS to DEER

We used CEUS building population data to develop weighted averages of the building's population across the vintages for each building type statewide. These averages were used to simplify the DEER savings data. DEER data are provided by building type, by vintage, by climate zone. Since vintage variation is expected to be minimal and vintage was not collected as part of the 2004/05 program, the CEUS data are used to reduce the number of DEER data points. If the CEUS data were not sufficient, i.e., such as, no data points across vintages, a straight average across vintages of the DEER data was utilized for the development of program savings estimates (i.e., calculating EFLCH and CDF) by building type and by climate zone.[50] The DEER savings data were then aggregated to values by climate zone and by building type (averaging across the building vintages).

From the simplified DEER kWh and peak kW savings data, revised EFLCH and CDF estimates can be calculated as follows:

- **Noncoincident demand reduction:** DEER provides the baseline and retrofitted unit efficiencies. The full load kW reduction can then be calculated from the delta EER or delta SEER (measure demand reduction) provided.

$$kW = 12\ x \left(\frac{1}{EER\ existing} - \frac{1}{EER\ retrofit} \right)$$

- **EFLCH:** The DEER kWh savings is divided by the noncoincident kW reduction value.

[50] CEUS sampling strategy did not include stratification for vintage. Therefore, some building types did not have data points in more than one vintage.

$$EFLCH = \frac{DEER\ kWh\ savings}{kW}$$

- **CDF:** The DEER peak kW savings is divided by the full noncoincident kW reduction value.

$$CDF = \frac{DEER\ peak\ kW\ savings}{kW}$$

DEER Data

The Database of Energy Efficient Resources (DEER) contains a wealth of information.[51] The database contains savings for various measures including, in this case, data for various HVAC units that were rebated in the Upstream Program. DEER was used to calculate the updated values for EFLCH and CDF produced through this research and analysis. DEER weather sensitive measure data (EImpact and PImpact) are provided by climate zone, by building type, and by vintage.[52] There are six vintages.

- Built before 1978
- Built between 1978 and 1992
- Built between 1993 and 2001
- Built between 2002 and 2005
- Built 2006 and later (measures as new construction for nonresidential)
- Built 2006 and later (measures as retrofit for nonresidential)

The latter two building vintages are not included in the values developed for this analysis, as they are not relevant to a program that occurred prior to 2006.

The various building types are as follows.[53]

- Assembly
- Education – Primary School
- Education – Removable Classroom
- Education – Secondary School
- Education – Community College
- Grocery
- Health/Medical – Hospital

[51] http://eega.cpuc.ca.gov/deer/

[52] EImpact and PImpact are the kWh and peak kW savings above baseline, respectively. Baseline efficiency assumptions vary by vintage.

[53] The DEER database does not have savings results for packaged A/C units for the following building type codes: Education – University, Lodging – Hotel, Lodging – Motel, Storage – Unconditioned, and Retail – 3 Story Large. It is assumed that these building types do not have packaged A/C units.

- Health/Medical – Clinic
- Lodging – Hotel (Guest Rooms)
- Office – Large
- Office – Small
- Restaurant – Sit Down
- Restaurant – Fast Food
- Retail – Single Story large
- Retail – Small
- Storage – Conditioned
- Storage – Refrigerated

The DEER data also provide savings information by package unit type and size. The various types are as follows (excluding package terminal units, heat pumps, and evaporative cooled units).

- Unitary system A/C (< 65k, single phase)
- Unitary system A/C (< 65k, 12 SEER, 3 phase before 2008) – Tier 1
- Unitary system A/C (< 65k, 13 SEER, 3 phase before 2008) – Tier 2
- Split system A/C (< 65k, single phase)
- Split system A/C (< 65k, 3 phase before 2008)
- Unitary system A/C (65-134k)
- Unitary system A/C (135-239k)
- Unitary system A/C (240-759k)
- Unitary system A/C (>= 760k)

The amount of data available for various combinations can amount to over 9,000 unique observations from the four vintages, 17 building types, nine unit types, and 16 climate zones. In order to simplify these data, we made the following assumptions to allow for averaging or weighted averages across categories.

- Weighted average across four vintages using CEUS data.
- Average of the EFLCH and CDF across the different unit types.[54,55]

This simplification takes into account that these independent variables, i.e., vintage and unit type, are less significant in assessing per ton on EFLCH and CDF distribution. Therefore,

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[54] High efficiency packaged unitary system A/C (65-134k) was not included in the analysis, since the DEER data were incorrectly modeled for this size category.

[55] This average may be changed to a weighted average based on the distribution of unit size per the program tracking data.

the various combinations are now just for the 17 building types multiplied by the 16 climate zones, resulting in approximately 272 unique observations of EFLCH and CDF.

Analysis to Calculate EFLCH and CDF from DEER

To simplify the data, the following steps were taken.

Weighting Vintages by Building Type

- Commercial End Use Survey (CEUS) data was used to determine the distribution of building stock across vintages. KEMA used the weighting of square footage of building types in each of the four vintage categories.
- Certain assumptions were made to map CEUS building types to DEER building types. In some cases, the mapping results in the same data set used across different DEER building types, such as primary and secondary schools, since CEUS does not disaggregate at that level nor has enough data for calculating building vintage distribution for each building type in each climate zone.
- The weighted average is the same average for all climate zones since there was not a big enough population in each climate zone to develop averages by climate zone.
- This weighting is applied to DEER data across the vintages and then the kWh and kW values are summed across the four vintages to result in one savings number by building type by climate zone by unit type.

Calculating Demand Reduction

- Demand reduction was calculated for each unit type using the following equation:

$$kW = 12\ x \left(\frac{1}{EER\ existing} - \frac{1}{EER\ retrofit} \right)$$

- The unit EER value is extracted from the DEER database and the DEER final report.
- Table 5-8 shows the efficiencies for each vintage and retrofit case in DEER by unit type.

Table 5-8: Efficiency by HVAC Unit Type

Type	Pre-1978	79-92	93-01	02-05	Retrofit
Split system A/C (< 65k, single phase)	8.5	9.5	10	10	14
Unitary system A/C (< 65k, single phase)	8.3	9.3	9.7	9.7	14
Split system A/C (< 65k, 3 phase)	N/A	N/A	N/A	N/A	N/A
Unitary system A/C (< 65k, 12 SEER, 3 phase)	8.3	9.3	9.7	9.7	12
Unitary system A/C (< 65k, 13 SEER, 3 phase)	8.3	9.3	9.7	9.7	13
Unitary system A/C (135-239k)	7.7	8.3	8.3	9.5	10.8
Unitary system A/C (240-759k)	7.7	8.3	8.3	9.3	10
Unitary system A/C (>= 760k)	7.7	8	8	9	10

Calculating EFLCH and CDF

- The demand reduction value by unit type and by vintage is then used to calculate EFLCH and CDF.
- EFLCH is calculated by taking the kWh savings and dividing by the demand reduction (averaged across vintages).
- CDF is calculated by taking the kW savings and dividing by demand reduction.

Averaging the Data

- The data are then averaged across unit types. The distribution was determined according to the upstream program's distribution of unit type is installed. The actual weights from the program data were re-distributed to not include evaporator cooled and 65-134kBtuh sized units. Table 5-9 shows the program's distribution, as well, as the weights used in the analysis of CDF/EFLCH.[56]

[56] Distribution weights calculated here do not include the 65-135 kBtuh size category, evaporative cooled units, and combine certain categories to match the unit types available in DEER.

Table 5-9: 2004-2005 Program Distribution of A/C Units

Measure	Weight
Tier 1, <65kBtuh,Split system	N/A
Tier 1, <65kBtuh,Single package system	0.279
Tier 2, <65kBtuh,Split system	N/A
Tier 2, <65kBtuh,Single package system	0.404
Tier 3, <65kBtuh,Split system	0.001
Tier 3, <65kBtuh,Single package system	0.015
>= 65 kBtuh and < 135 kBtuh, Single/Split system	N/A
>= 135 kBtuh and < 240 kBtuh, Single/Split system	0.148
>=240 kBtuh, Single/Split system	0.150
<760 kBtuh, Single/Split system	1

- Table 5-9 above does not list the weights values for split system of Tier 1 and 2 because there are a small number of these measures installed in the program and DEER data do not differentiate.
- The data are then summarized by climate zone and building type and averaged across the packaged unit types as shown in Table 5-10. The median is also presented, as compared to the IOU work papers estimates. For almost every building type, the IOU numbers are greater than the calculated EFLCH and CDF from the DEER analysis. Table 5-10 lists the EFLCH for all 16 climate zones and various building types.

Table 5-10 compares the DEER values with those of the utilities for EFLCH and CDF. It is important to note that the definition in DEER for peak kW savings which affects the CDF value is different than the 04-05 IOU program work paper definition.[57]

[57] The updated peak kW definition used by DEER and the California IOUs is defined as the average peak demand impact as would be "seen" at the electric grid level, averaged over the nine hours, between 2pm and 5pm during the three consecutive weekday period which contains the weekday with the highest temperature of the year.

Table 5-10: Comparison of EFLCH and CDF between DEER, PG&E/SDG&E, and SCE

Building Type	EFLCH			CDF		
	DEER	PG&E/ SDG&E	SCE	DEER	PG&E/ SDG&E	SCE
Office	875	1000	1340	0.59	0.87	0.87
Retail	992	800	1580	0.67	0.85	0.85
University	1523	1200	1439	0.62	0.73	0.73
School	356	500	1439	0.28	0.24	0.24
Grocery	525	600	1660	0.54	0.83	0.83
Restaurant	690	1300	2148	0.6	0.86	0.86
Health Care/Hospital	698	1900	5261	0.52	0.89	0.89
Hotel / Motel	1331	700	3327	0.59	0.77	0.77
Warehouse	1000	300	3486	0.63	0.8	0.8
Process Industrial	803	800	N/A	0.61	0.75	0.75
Assembly Industrial	934	2100	2473	0.73	0.75	0.75
Other	832	1200	2835	0.56	0.78	0.78

Table 5-11 and Table 5-12 show the values of EFLCH and CDF for different building types and climate zones with respect to DEER.

Table 5-11: EFLCH Values for All Climate Zones and Building Types

Cimate Zone	Assembly	School	Education University	Grocery	Healthcare	Lodging	Manufacturing	Office	Restaurant	Retail	Storage	Warehouse Refrigerated	Education Re-locatable Classroom	Average
1	235	208	1750	48	269	1103	535	585	190	452	305	610	109	508
2	750	301	1403	424	559	1153	700	728	561	816	502	839	220	705
3	541	283	1543	202	464	1169	611	693	367	699	368	719	190	623
4	988	367	1520	471	718	1319	780	833	684	1010	567	974	255	827
5	639	339	1525	245	561	1264	651	769	446	901	520	1017	250	717
6	678	323	1444	321	600	1296	703	823	490	864	497	910	234	724
7	934	406	1588	423	765	1495	841	983	670	1091	657	1169	294	888
8	1109	472	1601	608	862	1537	919	1016	830	1217	755	1256	335	980
9	1210	464	1571	674	907	1514	921	1006	885	1230	747	1220	323	994
10	1176	425	1500	728	864	1463	937	997	890	1199	787	1213	306	975
11	997	310	1423	607	709	1240	800	821	733	961	609	896	214	809
12	920	315	1399	533	649	1235	763	803	689	924	555	863	221	776
13	1296	413	1590	836	876	1487	1004	1029	983	1235	840	1182	292	1019
14	1006	317	1378	697	733	1243	830	923	761	996	677	956	231	839
15	1850	613	1817	1247	1301	1848	1280	1365	1412	1666	1180	1572	422	1366
16	613	138	1321	342	337	930	574	625	458	616	348	595	139	557
Avg	934	356	1523	525	698	1331	803	875	690	992	620	1000	252	832

Table 5-12: CDF Values for All Climate Zones and Building Types

Climate Zone	Assembly	School	Education University	Grocery	Healthcare	Lodging	Manufacturing	Office	Restaurant	Retail	Storage	Warehouse Refrigerated	Education Re-locatable Classroom	Average
1	0.256	0.082	0.615	0.083	0.227	0.393	0.276	0.400	0.178	0.340	0.249	0.498	0.180	0.284
2	0.851	0.347	0.654	0.622	0.593	0.646	0.695	0.646	0.707	0.751	0.579	0.670	0.449	0.629
3	0.658	0.300	0.617	0.390	0.433	0.506	0.480	0.466	0.462	0.574	0.349	0.491	0.391	0.465
4	0.948	0.301	0.608	0.670	0.660	0.635	0.666	0.594	0.729	0.789	0.577	0.672	0.401	0.632
5	0.520	0.223	0.533	0.318	0.374	0.495	0.450	0.501	0.428	0.582	0.382	0.593	0.333	0.439
6	0.358	0.152	0.448	0.202	0.274	0.414	0.375	0.384	0.264	0.386	0.237	0.361	0.230	0.313
7	0.645	0.248	0.554	0.392	0.445	0.550	0.539	0.529	0.515	0.599	0.432	0.580	0.323	0.488
8	0.701	0.331	0.633	0.496	0.532	0.630	0.598	0.621	0.607	0.672	0.545	0.683	0.437	0.573
9	0.880	0.332	0.643	0.667	0.639	0.689	0.704	0.672	0.727	0.778	0.623	0.726	0.426	0.652
10	0.921	0.332	0.632	0.736	0.649	0.683	0.753	0.684	0.770	0.805	0.660	0.725	0.432	0.673
11	0.804	0.277	0.584	0.637	0.584	0.599	0.626	0.605	0.648	0.697	0.559	0.626	0.373	0.582
12	0.832	0.369	0.693	0.656	0.587	0.634	0.672	0.645	0.693	0.739	0.557	0.609	0.480	0.624
13	0.907	0.414	0.731	0.770	0.646	0.688	0.786	0.711	0.758	0.817	0.703	0.739	0.523	0.703
14	0.832	0.341	0.652	0.739	0.627	0.647	0.743	0.682	0.712	0.779	0.670	0.692	0.455	0.658
15	0.903	0.416	0.752	0.815	0.709	0.726	0.835	0.771	0.790	0.849	0.792	0.827	0.543	0.745
16	0.758	0.165	0.585	0.559	0.420	0.572	0.577	0.594	0.634	0.677	0.484	0.666	0.406	0.532
Avg	0.736	0.289	0.621	0.547	0.525	0.594	0.611	0.594	0.601	0.677	0.525	0.635	0.399	0.562

Shortcomings of the Analysis

- Mapping CEUS building types into DEER building types requires some significant assumptions.
- DEER results for unitary system A/C 65-134kBtuh is incorrect. Adding in the demand reduction unitary system A/C (65-134kBtuh) to the analysis will also provide a more comprehensive set of data results.
- Weighted averages across unit types and vintages simplify the operation of these systems. However, the most sensitive variable in determining a unit's EFLCH and CDF is climate zone and then building type.
- "Demand reduction was calculated as the difference between the new efficient unit and the Title 20 or Title 24 baseline (i.e., code baseline)."

5.3.3 Replicating Program Savings

The replication of both air conditioning and motors savings are presented in this section.

Air Conditioning

To replicate program A/C savings per the work papers, one needs to know the unit type, building type, quantity, tons, and installed efficiency. The IOU work papers have measure demand reduction by unit type, as shown in Table 5-13. For units <65kBtuh, the installed unit efficiency is the minimum efficiency required. For units >65kBtuh, the installed unit efficiency used in the demand reduction calculation is based on the average efficiency installed in the program, as of a certain date. The baseline is Title 20 or Title 24 efficiency. Therefore, it is assumed that installed efficiency is irrelevant in calculating savings, since the measure demand reduction is provided in the work papers. Building type is necessary for the savings calculation for indicating the appropriate EFLCH and CDF (Table 5-11 and Table 5-12).

Using the following equations should replicate the savings indicated in the IOU databases:

$$Annual\ Energy\ Savings = Quantity \times tons \times Measure\ Demand\ Reduction_{unit\ type} \times EFLCH$$

$$Coincident\ Demand\ Reduction = Quantity \times tons \times Measure\ Demand\ Reduction_{unit\ type} \times CDF$$

Table 5-13: Equipment Efficiency

Size Category	Sub-Category	Baseline Efficiency	Retrofit Efficiency[58]	Measure Demand Reduction	Minimum Efficiency	DEER Base Efficiency
Tier 1 < 65 kBtuh	Split System	10 SEER	13 SEER	0.277	11.0 EER or 13.0 SEER	N/A
	Single Package	9.7 SEER	12 SEER	0.237	11.0 EER or 12.0 SEER	9.0
Tier 2 < 65 kBtuh	Split System w/TXV	10 SEER	13 SEER	0.277	11.6 EER or 13.0 SEER	N/A
	Single Package	9.7 SEER	13 SEER	0.314	11.3 EER or 13.0 SEER	9.0
Tier 3 < 65 kBtuh	Split System w/TXV	10 SEER	14 SEER	0.343	12.0 EER or 14.0 SEER	9.3
	Single Package	9.7 SEER	14 SEER	0.380	11.6 EER or 14.0 SEER	9.0
Tier 2 ≥ 65 kBtuh and < 135 kBtuh	Split System and Single Package	8.9 EER	11.1 EER	0.267	11.0 EER or 11.4 IPLV	8.9
Tier 2 ≥ 135 kBtuh and < 240 kBtuh	Split System and Single Package	8.5 EER	11.3 EER	0.350	10.8 EER 11.2 IPLV	8.6
Tier 2 ≥ 240 kBtuh	Split System and Single Package	9.3 EER	10.5 EER	0.147	10.0 EER 10.4 IPLV	8.5

58 Efficiency for the work paper calculation.

Both values for SCE and PG&E should be reduced by 5.4% to account for program overlap with the Savings By Design (SBD) program for new construction. SDG&E did not provide incentives for high efficiency packaged units under SBD.

The major problem in performing this replication is that there are many entries in the IOU databases that are missing building type information. All of SDG&E entries do not have building type. PG&E savings calculations adhered to the method in the work papers. However, when building type data are not provided, a straight average across building types is used in the analysis.

Unit savings estimates using SCE's method (Table 5-14) were calculated based on the following assumptions:

- Independent of building type, straight average across the EFLCH (2,453, but used 2,440 to be conservative) and CDF (0.76) values shown in Table 5-11 and Table 5-12.
- For units < 65kButh, converted the baseline SEER value to an EER value using this equation:

$$0.693264 + (0.848113 \times SEER)$$

- Annual kWh and kW savings do not include SBD discount. Additionally, these are non-coincident peak kW savings.
- For units >65kBtuh, used higher baseline EER values than the other IOUs, but it is unclear exactly how the demand reduction values are calculated.

Table 5-14: SCE Savings by Unit Type

Unit Type	kWh	kW
<65 kBtuh Package single Tier 1-air cooled	620	0.254
<65 kBtuh Split System single Tier 1- air cooled	529	0.217
<65 kBtuh Package single Tier 2 - air cooled	691	0.283
<65 kBtuh Split System single Tier 2- air cooled	669	0.274
<65 kBtuh Package single Tier 3 - air cooled	759	0.311
<65 kBtuh Split System Tier 3 - air cooled	752	0.308
65-135 kBtu air cooled, package or split Tier 2	259	0.106
135-240 kBtu air cooled, package or split Tier 2	281	0.115
>240 kBtu air cooled, package or split Tier 2	307	0.126

Unit savings estimates using SDG&E's method (Table 5-15) were calculated based on the following assumptions:

- Independent of building type, straight average across EFLCH (1,033) and CDF (0.76), see Table 5-11 and Table 5-12.
- No SBD discount is included.
- Measure demand reduction is from Table 5-13.

Table 5-15: SDG&E Savings by Unit Type

Unit Type	kWh	kW
<65 kBtuh Package single Tier 1-air cooled	245	0.180
<65 kBtuh Split System single Tier 1- air cooled	286	0.210
<65 kBtuh Package single Tier 2 - air cooled	325	0.239
<65 kBtuh Split System single Tier 2- air cooled	286	0.210
<65 kBtuh Package single Tier 3 - air cooled	393	0.289
<65 kBtuh Split System Tier 3 - air cooled	354	0.261
65-135 kBtu air cooled, package or split Tier 2	276	0.203
135-240 kBtu air cooled, package or split Tier 2	361	0.266
>240 kBtu air cooled, package or split Tier 2	152	0.112

The steps of replicating A/C savings are as follows:

- Replicate database savings with the savings filed in the utilities' program implementation plans (PIPs).
- Since the method in the PIPs is different than the work papers filed by SCE, the savings were replicated based on the work papers. If the database did not have a building type description, then the average value across all building types was used.
- Apply DEER data summary. If climate zone and building type are both available, the proper value from the DEER analysis was applied. Otherwise, average across building types was calculated. Finally, if climate zone is not provided, an average across utility specific climate zones is used for the analysis.

Table 5-16 summarizes the results shown in Table 5-17, which provides the results by IOU and by unit type. For both PG&E and SDG&E, the database (and PIPs) matched the work paper assumptions. SCE's data differed. In all cases, the DEER estimates for kW are lower than the IOU estimates. SCE work paper estimates for kWh savings were higher than those based on the PIPs.

Table 5-16: Difference in Program Savings Estimates

Utility	Source	kW	kWh
PG&E	PIPs:DEER	13.8%	20.9%
SCE	PIPs:Workpapers	2.4%	-15.8%
SCE	Workpapers: DEER	24.0%	61.1%
SCE	PIPs:DEER	25.8%	54.9%
SDG&E	PIPs:DEER	15.5%	0.7%

* A positive percentage indicates the amount by which the first data source listed is higher than the second data source. A negative percentage indicates the amount by which the first data source listed is less than the second data source

Table 5-17: Comparison of Replicated Program Savings Results by IOU and Unit Type

IOU	Unit Type	PIP Estimates		Work Paper Estimates		DEER Estimates	
		kW	kWh	kW	kWh	kW	kWh
PG&E	< 65 KBTU/HR, AIR-COOLED, SINGLE PA/CKAGE (TIER I)	1,747	2,632,082			1,555	2,097,988
	< 65 KBTU/HR, AIR-COOLED, SPLIT SYSTEM (TIER I)	32	51,062			33	40,451
	< 65 KBTU/HR, AIR-COOLED, SPLIT-SYSTEM (TIER II)	106	156,000			93	117,849
	< 65 KBTU/HR, AIR-COOLED, SINGLE PA/CKAGE (TIER II)	3,637	5,543,930			3,209	4,290,691
	< 65 KBTU/HR, AIR-COOLED, SINGLE PA/CKAGE (TIER III)	230	344,718			195	264,006
	< 65 KBTU/HR, AIR-COOLED, SPLIT-SYSTEM (TIER III)	5	9,939			6	7,671
	> 240 KBTU/HR, AIR-COOLED, SPLIT-SYS/SNG PKG (TIER II)	922	1,293,100			760	1,044,169
	>= 65 & < 135 KBTU/HR, AIR-COOLED, SPLIT-SYS/SNG PKG (TIER II)	3,623	5,317,127			3,015	4,137,333
	>= 135 & <= 240 KBTU/HR, AIR-COOLED, SPLIT-SYS/SNG PKG (TIER II)	2,271	3,240,901			1,969	2,703,168
	PG&E Total	**12,573**	**18,588,860**			**10,835**	**14,703,326**
SCE	< 65 KBTU/HR, AIR-COOLED, SINGLE PA/CKAGE (TIER I)	3,886	9,480,817	2,330	7,453,794	2,001	3,019,806
	< 65 KBTU/HR, AIR-COOLED, SPLIT SYSTEM (TIER I)	31	76,672	19	77,480	18	25,016
	< 65 KBTU/HR, AIR-COOLED, SPLIT-SYSTEM (TIER II)	224	550,075	115	441,048	109	160,433
	< 65 KBTU/HR, AIR-COOLED, SINGLE PA/CKAGE (TIER II)	5,545	13,530,416	4,886	12,516,199	3,159	4,595,484
	< 65 KBTU/HR, AIR-COOLED, SINGLE PA/CKAGE (TIER III)	95	230,923	87	275,545	70	104,424
	< 65 KBTU/HR, AIR-COOLED, SPLIT-SYSTEM (TIER III)	19	46,476	16	51,266	13	21,013
	> 240 KBTU/HR, AIR-COOLED, SPLIT-SYS/SNG PKG (TIER II)	854	2,084,139	847	2,478,371	589	894,856
	>= 65 & < 135 KBTU/HR, AIR-COOLED, SPLIT-SYS/SNG PKG (TIER II)	1,723	4,204,163	2,882	9,004,250	2,467	3,625,864
	>= 135 & <= 240 KBTU/HR, AIR-COOLED, SPLIT-SYS/SNG PKG (TIER II)	719	1,754,845	1,605	4,718,093	1,298	1,956,398
	SCE Total	**13,096**	**31,958,526**	**12,788**	**37,016,044**	**9,724**	**14,403,295**
SDG&E	< 65 KBTU/HR, AIR-COOLED, SINGLE PA/CKAGE (TIER I)	550	747,543			470	759,194
	< 65 KBTU/HR, AIR-COOLED, SPLIT-SYSTEM (TIER II)	15	21,061			13	22,802
	< 65 KBTU/HR, AIR-COOLED, SINGLE PA/CKAGE (TIER II)	621	844,493			476	758,194
	< 65 KBTU/HR, AIR-COOLED, SINGLE PA/CKAGE (TIER III)	95	128,621			74	113,456
	> 240 KBTU/HR, AIR-COOLED, SPLIT-SYS/SNG PKG (TIER II)	253	343,870			242	403,411
	>= 65 & < 135 KBTU/HR, AIR-COOLED, SPLIT-SYS/SNG PKG (TIER II)	469	637,591			398	616,469
	>= 135 & <= 240 KBTU/HR, AIR-COOLED, SPLIT-SYS/SNG PKG (TIER II)	384	521,687			346	549,391
	SDG&E Total	**2,387**	**3,244,865**			**2,017**	**3,222,916**

Motors

DEER and IOU work papers use the same load factor (0.75) and CDF (0.74) assumptions. Work papers operating hours are assumed to be 4,700 hours per year regardless of size category or application. DEER assumes different hours by size category and industrial type and one type for commercial facilities, as well as, different assumptions for baseline and retrofit efficiencies. SCE motor savings in the PIPs (and database) differ from the work papers. PG&E uses an SBD discount and SDG&E does not.

The steps of replicating motor savings are as follows:

- Replicate database savings with the savings filed in the PIPs by the IOUs
- Since the method in the PIPs is different than the work papers filed by SCE, the savings were replicated based on the work papers.

Replicated unit savings estimates for motors are shown in Table 5-18.

Table 5-18: Replicated Unit Savings by IOU

Horsepower	SDG&E		PG&E		SCE	
	kWh	kW	kWh	kW	kWh	kW
1	121	0.019	114	0.018	112	0.0240
1.5	146	0.023	138	0.022	136	0.0290
2	207	0.033	196	0.031	181	0.0390
3	329	0.052	311	0.049	306	0.0650
5	336	0.053	318	0.050	336	0.0710
7.5	654	0.103	619	0.097	612	0.1300
10	705	0.111	667	0.105	705	0.1500
15	932	0.147	882	0.139	932	0.1980
20	1,316	0.207	1,245	0.196	1,243	0.2640
25	4,742	0.747	4,486	0.706	5,155	1.0970
30	5,913	0.931	5,594	0.881	6,324	1.3450
40	6,643	1.046	6,284	0.989	7,477	1.5910
50	7,559	1.190	7,150	1.126	9,938	2.1150
60	8,835	1.391	8,358	1.316	10,009	2.1300
75	9,480	1.493	8,968	1.412	12,266	2.6100
100	13,011	2.049	12,308	1.938	15,246	2.4330
125	15,868	2.498	15,011	2.363	20,673	0.0200
150	18,513	2.915	17,513	2.757	21,718	3.4658
200	23,692	3.730	22,413	3.529	28,958	4.6208

The replicated program savings for PG&E and SDG&E matched the program database and PIPs exactly. Table 5-19 provides the program results by horsepower for SCE only. The program savings are 42% and 15% lower for kW and kWh, respectively.

Table 5-19: SCE Program Motor Savings Replication

	PIPs / Program Database		Work Paper	
	kW	kWh	kW	kWh
Motors 1 HP	8	35,267	6	37,392
Motors 1.5 HP	3	12,273	2	12,972
Motors 2 HP	10	47,263	8	53,312
Motors 3 HP	16	77,259	13	81,793
Motors 5 HP	24	113,864	18	112,254
Motors 7.5 HP	17	79,315	13	83,565
Motors 10 HP	34	159,048	25	156,745
Motors 15 HP	31	146,734	23	144,648
Motors 20 HP	41	190,925	31	199,200
Motors 25 HP	106	499,829	71	453,086
Motors 30 HP	159	746,738	108	688,062
Motors 40 HP	168	789,571	109	691,240
Motors 50 HP	154	725,076	86	543,400
Motors 60 HP	49	230,607	32	200,592
Motors 75 HP	73	341,485	41	260,072
Motors 100 HP	86	541,538	72	455,396
Motors 125 HP	0	158,769	19	120,088
Motors 150 HP	37	229,342	30	192,643
Motors 200 HP	80	500,394	64	403,434
Total	1,096	5,625,297	770	4,889,894

Replicating motor savings per DEER data requires simplification since the variations in DEER are based on industry sector. There is not enough building type information to complete this analysis. DEER motor savings have varying operating hours based on the industrial sector (and one category for commercial) and the size of motor. The load factor and CDF is the same as the IOU work papers in DEER. However, a replication was completed by averaging across industrial sectors and then doing a weighted average of the industrial average (86.5%) and the commercial sector (13.5%).

The following table shows the mapping of the motor size categories to the DEER motor size categories, as well as the calculated DEER motor savings per unit (weighted average across DEER building/industry type categories).

Table 5-20: DEER Motor Savings per Unit

DEER Bins (hp)	Program Data (hp)	DEER kW Savings per Unit	DEER kWh Savings per unit
1	1, 1.5, 2, 3	0.023	75
5	5, 7.5	0.070	225
10	10	0.148	523
15	15	0.167	609
20	20	0.261	955
25	25, 30, 40	0.249	1028
50	50, 60, 75	0.471	1995
100	100, 125	0.675	3494
150	150	0.728	3762
200	200	1.211	6128

The following table provides the results of the DEER replication.

Table 5-21: DEER Motor Savings Replication

Horsepower	No of units	kWh	kW
1	2352	175,802	54
5	1383	311,119	97
10	702	367,405	104
15	539	328,259	90
20	513	490,144	134
25	994	1,022,174	247
50	415	828,129	195
100	128	447,226	86
150	32	120,374	23
200	38	232,874	46
Total	7,096	4,323,504	1,077

There are several differences between DEER and the program workpapers. DEER uses variable operating hours depending on motor size and sector. Typically the operating hours increase as the motor size increases. Additionally, the assumed baseline and retrofit efficiencies vary between the two data sources. Per the IOU 04-05 workpapers, the assumed baseline efficiency for 25 hp and greater motors is not the federal minimum (EPAct), but based on the rewind efficiency. Baseline efficiency data for motors that are rewound are calculated by subtracting 0.01 from the efficiency of old (pre-EPAct) standard efficiency motors. Therefore the DEER numbers are generally lower since the delta efficiency is smaller for kW savings. The following table illustrates the differences in efficiency assumptions.

Table 5-22: Comparing IOU Workpapers and DEER Efficiencies

Horse power	Base Case	Baseline Efficiency	Minimum Qualifying Efficiency	Workpaper Retrofit Efficiency[59]	DEER Base Efficiency	DEER Retrofit Efficiency
1	New motor	0.825	0.855	0.858	0.825	0.855
1.5	New motor	0.84	0.865	0.867		
2	New motor	0.84	0.865	0.869		
3	New motor	0.865	0.895	0.897		
5	New motor	0.875	0.895	0.895	0.875	0.895
7.5	New motor	0.885	0.910	0.912		
10	New motor	0.895	0.917	0.917	0.895	0.917
15	New motor	0.91	0.930	0.93	0.91	0.93
20	New motor	0.91	0.930	0.931	0.91	0.93
25	Rewind	0.879	0.936	0.939	0.917	0.936
30	Rewind	0.879	0.941	0.941		
40	Rewind	0.89	0.941	0.943		
50	Rewind	0.897	0.945	0.946	0.93	0.945
60	Rewind	0.903	0.950	0.951		
75	Rewind	0.909	0.950	0.951		
100	Rewind	0.911	0.954	0.954	0.941	0.954
125	Rewind	0.912	0.954	0.954		
150	Rewind	0.918	0.958	0.959	0.95	0.958
200	Rewind	0.92	95.80%	0.96	0.95	0.958

The operating hours are lower (mostly for the smaller sized motors) resulting in lower kWh savings. The operating hours range from 1,500 to 7,300 hours per year with the weighted average of the operating hours by unit type shown in the following table.

Table 5-23: DEER Weighted Average Operating Hours

Horsepower	Weighted Average Operating Hours
1	3,147
5	3,147
10	3,490
15	3,490
20	3,613
25	4,180
50	4,180
100	5,105
150	5,099
200	4,999

[59] The workpaper used for its retrofit efficiency the average premium efficiency values found in the Motor Master Plus database 4.0 in 2003.

5.4 Upstream HVAC/Motors End Use Metering Study

This section presents the metering study completed for the 2004-05 Upstream HVAC and Motors program. A general discussion of recruitment challenges is followed by descriptions of the study designs for both A/C and motors segments. Results from these metering studies for each of these segments are presented last.

5.4.1 Recruitment Challenges

It is important to recall that participant data for the Upstream Program were provided by the utilities via the distributors who had received the upstream program incentives. In cleaning the database for the evaluation, we discovered that a large percentage of the contact information provided actually corresponded to the distributor or contractor as opposed to the end-use participant. Even when the end-user name and address were given, in many cases the phone numbers were missing or incorrect and required multiple phone calls and/or Internet tracking to locate the correct phone number and contact person.

The recruitment for the HVAC portion of the study went fairly quickly compared to the recruitment for the motors study. Even though KEMA was calling some 24 to 36 months after the units were installed, most HVAC participants were able to recall that they had purchased a new system. However, for motors, recall was much more difficult. Participants had purchased and installed many motors since the program and it was difficult, if not impossible, for many of them to confirm that they knew which of their motors they were being asked about.

Recruitment was also challenging for both studies because of the upstream nature of the program. Participants were also unaware that the equipment they purchased had been rebated and, as a result, they felt no obligation to take part in this effort.

In addition, the program tracking database did not contain actual model numbers or serial numbers, or the location of the installed equipment. This, coupled with the site contact's lack of familiarity, made it difficult and often impossible for our field technicians to locate the correct equipment once on site. Even after we were assured by the site contact that he or she knew which unit was rebated through the program, when the technicians arrived on site it was often found that the unit size or efficiency level did not match the information in the database. Every effort was made to ensure that meters were installed only on qualifying, high efficiency equipment. However, in some cases (most often motor sites), the field technicians were forced to walk away from a site because they could not locate the correct equipment.

Annual energy and peak demand impacts were calculated using spreadsheet models supported by the on-site post-retrofit monitoring data. This approach is consistent with IPMVP Option B, Metered Savings of Equipment Systems.

5.4.2 HVAC Metering Study Design

The proposed metering sample for the HVAC sites originally included 20 sites per utility, for a total of 60 sites. However, after reviewing the program tracking data, we revised our approach to selecting the metering sites to include the following criteria:

- *The percent of total tons of HVAC equipment rebated through the Upstream program in a given climate zone*—percent of total program savings by IOU cannot be used for stratifying the sample because the IOUs, as discussed above, used different EFLCH to estimate gross savings (SCE's EFLCH estimates were up to 1000% higher than PG&E's and SDG&E's).
- *The distribution of installed tons by utility service territory*—we selected sites that reflected the largest percentage of cooling tons installed through the program for each utility. For example, if most of SDG&E's tons were installed in climate zone 7, then we drew a sample from that climate zone. To be clear, if SCE had Upstream participants in climate zone 7, it is possible that some of those participants may have been drawn into the sample for that climate zone.
- *Building type*—HVAC performance is sensitive to building type. However, because building type information was not included in the program tracking database, we were forced to screen for building type during recruitment and monitor our site selection process to ensure a minimum number of building types were included.
- *The prevalence of unit types (sizes) installed through the program in a given climate zone*—within a particular climate zone, we selected sites that represented the predominant unit type (size). For example, if a majority of the units rebated in a climate zone were under 65 kBtuh, we attempted to install a majority of the meters in that climate zone on under 65 kBtuh units.

However, due to difficulties in pre-screening and recruiting participants for this study, we were not always able to meet these criteria for site selection. In the end, we were successful in achieving our targets by climate zone. Three climate zones (7, 10, and 12) were selected because they represented the greatest proportion of total tonnage installed through the programs.[60]

Table 5-24 presents the distribution of tonnage installed through the program by climate zone and IOU. We installed a total of 60 meters across 32 sites in climate zones 7, 10, and 12.

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60 Savings was not used as an indicator of distribution across climate zones since SCE savings data are significantly higher.

Our final sample included 17 sites for PG&E climate zone 7, 18 sites for SCE climate zone 10 and 17 sites for SDG&E climate zone 12. For eight sites, we were unable to use the metered data results so our effective analysis sample size is 52.

Table 5-24: Distribution of Tonnage Installed by Climate Zone and IOU

Utility	CZ	Percent of Tons	Number of Metered Sites
PG&E	1	0%	
	2	5%	
	3	11%	
	4	10%	
	5	1%	
	11	6%	
	12	16%	17
	13	11%	
	16	0%	
	unknown	39%	
SCE	5	0%	
	6	7%	
	8	26%	
	9	19%	
	10	31%	18
	13	4%	
	14	7%	
	15	3%	
	16	2%	
	unknown	1%	
SDG&E	6	1%	
	7	68%	17
	8	0%	
	9	0%	
	10	30%	
	14	0%	
	15	0%	

Data were collected using portable monitoring equipment. Data collection periods varied from 10 to 12 weeks (starting August through October), depending on when the monitoring equipment was installed at a particular site. The types of data collected included continuous monitoring of current (amps), spot measurement of voltage, estimated operation schedules, and nameplate information. DATApro™ Multi-Purpose 4-Channel Data Loggers were used to monitor current at 5-minute intervals.

5.4.3 Motors Metering Study Design

For motors sites, the total sample size was initially set at 20 and then increased to 32 to improve the statistical precision. Sites for motor monitoring were selected according to the following criteria:

- *The distribution of installed motors by utility service territory*—for example if 25% of the installed motors were in an IOU's territory, we aimed to hang 25%, or about eight, meters on motors in that IOU's territory.
- *Building/industry type*—motor performance is sensitive not just to building type, but also industry type. However, as indicated above, data on both building types and industry type were inadequate. Through pre-screening, we hoped to recruit sites that represented a minimum number building/industry types.
- *Motor application*—motor performance is also sensitive to the application where it does work, as well as motor size. Since the tracking database does not indicate motor application, we pre-screened motors to include only those used to run process loads and we excluded motors used to run weather-sensitive HVAC loads.

Pre-screening for both building/industry type and motor application proved too difficult given the recruitment challenges identified above. As a result, we were left with the distribution shown in Table 5-25. As shown in Table 5-26, we were successful in selecting sites that represented the majority of motors rebated through the program (1-20 HP) but were not as successful in representing sites that represented the largest share of program savings.

Table 5-25: Final Metering Sample for Motor Sites

	1-5 HP	6-20 HP	Total
PG&E	10	5	15
SCE	8	4	12
SDG&E	3	2	5
Total	**21**	**11**	**32**

Table 5-26: Distribution of Rebated Motors by HP

HP	% kWh Savings	% Quantity
1	1%	13%
1.5	0%	4%
2	1%	8%
3	1%	7%
5	2%	14%
7.5	2%	6%
10	3%	10%
15	3%	8%
20	4%	7%
25	10%	4%
30	14%	5%
40	13%	4%
50	11%	3%
60	5%	1%
75	8%	2%
100	8%	1%
125	4%	0%
150	4%	0%
200	6%	1%

DATApro™ data loggers and were used to measure motor operation profiles. Spot volts and amps measurements will be obtained to determine the load on the motor. If the motor speed is controlled by a variable-speed drive, an ELITEpro™ Poly-Phase True Power Meter, was installed to measure the motor load over time.

5.4.4 Metering Results for Packaged Air-Conditioning Units

There were 117,537 tons installed in the 2004-2005 Upstream Program. The A/C end use accounted for about 92% of kW and 79% of kWh of the Upstream program impacts. The goal of the metering study was to verify the assumed ex-ante coincident diversity factor (CDF) and equivalent full load cooling hours (EFLCH). The following section describes the method was used to calculate these values and the ex post savings for the A/C portion of the program based on the results of the metering study.

The A/C unit categories and breakdown of tons rebated by category are in Table 5-27.

Table 5-27: Distribution of Unit Types by Tons

Unit Type	Tons	Percent*
Packaged A/C (<65k 13 SEER T1)	23,317	19.8%
Packaged A/C (<65k 13 SEER T2)	35,904	30.5%
Packaged A/C (<65k 14 SEER T3)	1,075	0.9%
Packaged A/C (>240k 10 EER)	11,813	10.1%
Packaged A/C (065kto135k 11 EER)	32,415	27.6%
Packaged A/C (135kto240k 10.8 EER)	12,601	10.7%
Packaged H2O/Evap (>65k)	411	0.3%
Total	**117,537**	**100%**

*The individual percentage by unit type do not sum exactly to 100% due to rounding.

The A/C analysis involved metering of 52 sites. The 52 sites metered were distributed as shown in Table 5-28.[61]

Table 5-28: Distribution of A/C Units Metered

Utility	Climate Zone	Metered	Planned
PGE	12	17	20
SCE	10	18	20
SDGE	7	17	20

Gross impacts for space cooling measures were determined by conducting site-specific studies on the 52 packaged or split-system A/C projects. The annual energy and peak demand impacts were calculated by determining the CDF and EFLCH of the units monitored and applying the work paper method for calculating unit savings. Since the actual base case data were not recorded, the base case was assumed to be a unit of the same operating capacity as the enhanced-case unit installed at the site. The performance of the base case unit replaced is also assumed to be equal to the values of the seasonal energy equipment ratio (SEER) or the energy equipment ratio (EER), as shown above in Table 5-13, the IOU baseline efficiency, which is the Title 20/24 efficiency.

A site visit was made to each recruited facility to verify the equipment installation and obtain power measurements of the A/C unit. Each unit was checked to see if it was in operation and verified as high efficiency. The actual operating Volts and Amps were measured. Data collection periods varied from 8 - 12 weeks of portable monitoring data, depending on when the monitoring equipment was installed at a particular site. The types of data collected include power (kW), operating current (amps), estimated operation schedules, and nameplate

61 Actual number of sites metered was 60. However, eight of the sites were found to have no data or corrupted data.

information. The meter was a DATApro™ Multi-Purpose 4-Channel Amp Logger. The spot measurements include the voltage and amp measurement. The amperage drawn by the unit was also interval metered. The estimated operating schedule was reported by the site contact in the form of number of hours per day and the operating months in a year.

The amp loggers are programmed to collect 5-minute interval data. The logger captures the data for every minute and then averages the previous 5 minutes at the end of the fifth minute. A current transformer (CT) is attached to the amp logger, typically sized at 100 amps. The data that are stored in an amp logger during the metering period captures the following information:

- Date,
- End Time (5-minute intervals), and
- Average Amp.

The data are divided into the following units:

- Hour of day,
- Day Type (weekday or weekend/holiday), and
- Period Type (on peak or off peak).

The 5-minute intervals are aggregated for each hour of the day for the whole monitoring period.

To account for differences between the monitoring period and the average annual weather conditions, a degree-day regression analysis was used to determine kW usage for each hour as a function of daily ambient temperature. The daily ambient temperature used was the average of the low and high for the day. Then this value is used to calculate degree days. Degree-days for the day were calculated as the difference between the daily ambient temperature and the degree-day reference temperature, or zero if the difference was negative.

The hourly average kWh was regressed on cooling degree days (CDD) using a no-intercept regression.[62] The reference temperature used for CDD was optimized to maximize the R-squared for fit. The resulting best fit line from this regression was applied to the Typical Meteorological Year (TMY) data for the whole year to get kWh for each hour of the TMY (2007 calendar year was used). Separate regressions were calculated for weekdays and weekend/holiday days, as well as peak period.

[62] LINEST array function in Excel was used.

An R-squared value less than 0.04 is taken as the threshold point where there was very little weather interference in the operation of the unit. For all metered sites, the R-squared value was greater than 0.04. Using the results of the regressions, annual kWh usage was estimated for TMY weather. The average peak period demand is estimated as the average hourly kW, calculated from the peak period model for peak hours only (12 P.M. to 6 P.M, June - September weekday peak period).

When the regression returned a low correlation value—indicating that there was not a very good correlation between the daily kWh savings and ambient conditions—it was concluded that the A/C load was driven primarily by the internal loads of the building. There are 4 such sites found in the pool of 52 sites for the HVAC study. For these cases, we still used the same method.

Calculation Methodology for Savings

Annual kWh: The annual kWh is calculated as:

$$
\begin{aligned}
Annual\ kWh &= Annual\ Weekday\ kWh + Annual\ Weekend\ kWh \\
&= kW_{nameplate} \times EFLCH
\end{aligned}
$$

Annual kWh savings: The annual kWh savings[63] are calculated buy using following formula:

$$
\begin{aligned}
Annual\ kWh\ Savings &= Annual\ kWh \times \left(SEER_{new} / SEER_{base} - 1 \right) \\
&= kW_{nameplate} \times EFLCH \times \left(SEER_{new} / SEER_{base} - 1 \right)
\end{aligned}
$$

The values of the baseline (Title 24/20) and program SEER are taken from the work papers

Noncoincident kW savings: It is calculated as:

$$
Noncoincident\ kW\ Savings = Average\ kW\ Reduction \times \left(SEER_{new} / SEER_{base} - 1 \right)
$$

Peak kW savings: It is calculated as:

$$
\begin{aligned}
Peak\ kW\ Savings &= Average\ kW\ Reduction\ During\ Peak\ Period \times \left(SEER_{new} / SEER_{base} - 1 \right) \\
&= kW_{nameplate} \times CDF
\end{aligned}
$$

[63] SEER or EER

Calculation Methodology - EFLCH

The sum of kWh for weekdays and weekends is divided by the nameplate kW of the measure to get the equivalent full load cooling hours. The EFLCH can be calculated as:

$$EFLCH = Annual\ kWh / kW_{nameplate}$$

where nameplate kW is the following:

$$kW_{nameplate} - 3\ phase = Amps_{nameplate} \times Volts_{measured} \times 1.732$$

$$kW_{nameplate} - 1\ phase = Amps_{nameplate} \times Volts_{measured}$$

Calculation Methodology - CDF

CDF has been defined as the ratio of the average demand during the peak period to nameplate kW. The average kW is obtained by dividing the total kWh in peak period by the total number of hours in the peak period. This average kW is divided by the nameplate kW to get the CDF for each measure. The average kW is calculated as follows:

$$Peak\ kW = kWh_{onpeak} / Hours_{onpeak}$$

The CDF is calculated using the following formula:

$$CDF = Peak\ kW / kW_{nameplate}$$

Analysis Methods

The analysis methods subsection covers the weather model, model parameters, and the population values used to expand the metering sample results.

Weather Model

We had metered hourly average kW data from early August to late November for each metered unit. To determine annual energy use and peak demand under standard weather conditions, we fit a simple regression model to each unit.

The regression is of the form:

$$kW_{dh} = \beta C_d(\tau) + \varepsilon_{dh}$$

where

$C_d(\tau)$	=	$\max(0, T_d - \tau)$=cooling degree-days for day *d*
kW_{dh}	=	average metered kW for day *d*, hour *h*
T_d	=	midpoint between minimum and maximum hourly temperature for day *d*
β	=	usage per degree-day
τ	=	cooling reference temperature
ε_{dh}	=	residual error

The coefficient β is estimated by least squares regression for a given assumed reference temperature τ. The cooling reference temperature τ is selected by iterating the regression until the best (least squares) fit is obtained. The corresponding cooling coefficient β is then the final estimate for that parameter.

The regression model is fit separately for three regimes or sets of data *r*. The separate fits and corresponding coefficients are as follows:

1. All hours *h* for weekday days *d*: β_1, τ_1
2. All hours *h* for weekend/holiday days *d*: β_2, τ_2
3. Peak hours *h* only, on weekdays: β_3, τ_3

The resulting parameters were then used to calculate normal-year usage as follows. For each of the three fits, we calculate:

C_r	=	Annual average cooling degree-days per day, base τ_r from TMY temperature data
D_r	=	Average kW during regime *r*
	=	$\beta_r C_d(\tau) + \varepsilon_{dh}$

We then calculate annual kWh usage for the installed equipment as:

$$kWh_{annual} = 52 \times 24 \times (5 \times D_1 + 2 \times D_2)$$

That is, we multiply weekday demand (kW) by five and weekend demand by two for each of 52 weeks. Multiplying by 24 hours/day and 52 weeks/year gives annual kWh.

Peak period demand in kW is given directly by D_3:

$$kW_{peak} = D_3$$

Parameters

The following parameters were determined for each A/C unit from the metering data and weather models:

Nameplate kW

For single phase units

$$kW_{nameplate} = Volts \times Amps / 1000$$

For three phase units

$$kW_{nameplate} = Volts \times Amps \times 1.732 / 1000$$

where volts and amps are taken from the spot measurements.

Equivalent Full-Load Cooling Hours

$$EFLCH = Annual\ kWh / Nameplate\ kW$$

Annual kWh

kWh_{annual} is calculated as described in the weather model section

Coincidence-Diversity Factor

$$CDF = kW_{peak} / Nameplate\ kW$$

kW_{peak} is calculated as described in the weather model section.

Annual kWh Savings

$$\Delta kWh = kWh_{annual} \times \left[\left(SEER_{HI} / SEER_{Base} \right) - 1 \right]$$

where the base case SEER values are taken from the work paper.

Annual kW savings

$$\Delta kW = Average\ kW_{peak\ on} \times \left[\left(SEER_{HI} / SEER_{Base} \right) - 1 \right]$$

Population Values

In addition to the individual parameters described above, we determined corresponding population values using ratio expansion for the metering sample. The results provide population estimates and confidence intervals for units in climate zones 7, 10, and 12, the population from which the sample was drawn.

For each ratio defined for meter *j* as $r_j = y_j / x_j$, the population ratio is calculated as:

$$R = \sum_j w_j y_k \Big/ \sum_j w_j x_k$$

where w_j is the sample expansion weight for motor *j*, defined for A/C unit *j* in stratum *k* by:

$$w_j = N_k / n_k$$

The population values calculated in this way from the metering data are the following.

Population Coincidence-Diversity Factor

$$CDF_{pop} = \sum_j w_j kW_{peak\ j} \Big/ \sum_j w_j kW_{on\ j}$$

Population EFLCH

$$EFLCH_{pop} = \sum_j w_j kWh \Big/ \sum_j w_j kW_{nameplate\ j}$$

Similarly, we calculate an overall realization rate for kWh and kW savings. This is the ratio of savings Δ_m determined from the metering data to savings Δ_p in the program tracking system based on work paper assumptions for CDF, and EFLCH.

kWh Savings Realization Rate

$$R_{kWh} = \sum_j w_j \Delta kWh_{mj} \Big/ \sum_j w_j \Delta kWh_{pj}$$

kW Savings Realization Rate

$$R_{kW} = \sum_j w_j \Delta kW_{mj} \Big/ \sum_j w_j \Delta kW_{pj}$$

A/C Results

Operating Parameters

Table 5-29 and Table 5-30 show the estimates, standard errors, and 90% confidence intervals for the population estimates of Coincidence-Diversity Factor CDF, and Equivalent Full Load Cooling Hours EFLCH. Results are shown for each IOU and for the state as a whole. Also shown in each table is the corresponding work paper value.

All of the estimated parameters are smaller than the corresponding work paper assumptions, for all three IOUs. Furthermore, with the exception of EFLH for SDG&E, the 90% confidence upper bounds are also below the work paper values. That is, the correct population value is statistically significantly less than the work paper value, at 90%

confidence. The estimated CDF is under 0.3 for each IOU and the state as a whole, compared with work paper values in the 0.7 to 0.8 neighborhood. Estimated EFLH was only a little over 50% of the work paper value for the state as a whole and for PG&E.

These results indicate that compared to the program assumptions, in practice A/C units rebated by the program:

- Are used few hours in total
- Have lower peak use.

Table 5-29: Population Estimates of CDF

	Number of Observations	CDF	Standard Error	90% Confidence Interval		Work paper Value
				Lower Bound	Upper Bound	
TOTAL	50	0.27	0.03	0.22	0.32	0.76
PGE	16	0.21	0.05	0.13	0.28	0.74
SCE	18	0.29	0.06	0.19	0.39	0.74
SDGE	16	0.28	0.04	0.22	0.34	0.81

Table 5-30: Population Estimates of EFLCH

	Number of Observations	EFLH	Standard Error	90% Confidence Interval		Work paper Value
				Lower Bound	Upper Bound	
TOTAL	50	722	84	581	862	1335
PGE	16	557	150	306	808	987
SCE	18	626	121	423	829	1881
SDGE	16	979	158	713	1,244	1137

Savings Realization Rates

Based on the above results for the key operating parameters, we would expect to see savings estimates generally below the work paper values, and realization rates less than 1.0. These expectations are borne out, as shown in Table 5-31 and Table 5-32 below.

The overall energy savings realization rate is 0.72, with a 90% confidence interval upper bound of 0.91. Results across the utilities range from 0.6 for SCE to 1.1 for SDG&E. The realization rate is higher for SDG&E because it had estimated EFLCH closer to its work paper value than did the other utilities. Additionally, the SCE savings have a lower realization rate because its EFLCH estimate is a lot higher than PG&E and SDG&E ex ante assumptions, as mentioned above.

Table 5-31: Annual kWh Savings Realization Rate

	Number of Observations	RkWh	Standard Error	90% Confidence Interval	
				Lower Bound	Upper Bound
TOTAL	50	0.72	0.12	0.52	0.91
PGE	16	0.91	0.30	0.41	1.41
SCE	18	0.57	0.14	0.33	0.81
SDGE	16	1.09	0.18	0.79	1.38

For peak savings, the overall realization rate is 0.61, with a 90% confidence interval upper bound of 0.72. Results show less variation across utilities than do the energy savings realization rates. The range is 0.54 for SDG&E to 0.71 for SCE. The realization rate is lower for SDG&E because it had a similar estimated CDF to those of the other utilities, but a higher work paper estimate.

Table 5-32: Peak kW Savings Realization Rate

	Number of Observations	RkW	Standard Error	90% Confidence Interval	
				Lower Bound	Upper Bound
TOTAL	31	0.61	0.07	0.50	0.72
PGE	13	0.48	0.10	0.30	0.66
SCE	13	0.71	0.11	0.52	0.90
SDGE	5	0.54	0.05	0.45	0.63

Total Program Savings

The metering study addressed only A/C units in climate zones 7, 10, and 12. These account for 31% of the program's claimed savings (for both kWh and kW savings) and represent each IOU. However, the results found for the climate zones from which the metering sample was drawn do not necessarily apply to other climate zones. The CDF is a function of equipment sizing practices, which may vary by climate zone or other geographic factors. EFLCH is a function of the temperature distribution over the cooling season, which is climate-dependent.

To develop savings estimates for all A/C units, we consider three different approaches.

1. Assume that the estimated CDF and EFLCH found for the metered climate zones apply to all climate zones. This effectively means assuming the realization rate from the metered zones applies to all zones.[64]

[64] As described earlier, the team picked the three different climate zones with the highest savings percentage by IOU.

2. Assume that the current DEER assumptions are correct for the non-metered climate zones.
3. Assume that the ratio between metered and DEER results for the metered zones applies to all zones.

Table 5-33 and Table 5-34 show the program-level savings for these 3 different assumptions. The adjustment factors are calculated as follows:

1. The "Meter Sample Results Applied to All" is from the realization rate in the above table.
2. The DEER realization rate is the ratio of the program population divided by the program data replicated using DEER assumptions.
3. The adjusted DEER realization rate is the DEER realization rate multiplied by the adjustment calculated by the metered sample realization rate for the climate zones where metering occurred. For the remaining climate zones, the adjusted DEER realization rate is calculated as the overall ratio of the calculated DEER kWh savings and the metered kWh savings, for the sampled zones times the DEER realization rate.
4. The savings adjusted DEER values is the program estimate times the adjusted DEER realization rate.

Table 5-33: kWh Savings Estimates by Metering Status and Method for A/Cs

Climate Zones	Metered?	% Units	% Program estimated kWh savings	kWh Realization Rate			kWh Savings			
				1 Meter Sample Results Applied to All	2 DEER	3 Adjusted DEER	Program Estimate	1 Meter Sample Results Applied to All	2 DEER	3 Adjusted DEER
7	Yes	7%	5%	1.09	0.74	1.09	2,784,495	3,035,100	2,060,526	3,035,100
10	Yes	18%	21%	0.57	0.47	0.57	11,877,242	6,770,028	5,582,304	6,770,028
12	Yes	7%	5%	0.91	0.71	0.91	2,722,016	2,477,035	1,932,631	2,477,035
1	No	0%	0%	0.72	0.28	0.36	45,426	32,707	12,719	16,315
2	No	2%	1%	0.72	0.67	0.86	753,841	542,766	505,073	647,843
3	No	5%	3%	0.72	0.64	0.82	1,895,322	1,364,632	1,213,006	1,555,887
4	No	4%	3%	0.72	0.9	1.15	1,514,691	1,090,578	1,363,222	1,748,565
5	No	0%	0%	0.72	0.87	1.12	174,831	125,878	152,103	195,098
6	No	3%	4%	0.72	0.44	0.56	2,423,591	1,744,986	1,066,380	1,367,814
8	No	12%	15%	0.72	0.44	0.56	8,799,716	6,335,796	3,871,875	4,966,340
9	No	9%	11%	0.72	0.42	0.54	6,318,704	4,549,467	2,653,856	3,404,022
11	No	3%	2%	0.72	0.84	1.08	898,416	646,860	754,669	967,992
13	No	7%	6%	0.72	0.76	0.97	3,292,001	2,370,241	2,501,921	3,209,140
14	No	3%	4%	0.72	0.41	0.53	2,283,974	1,644,461	936,429	1,201,130
15	No	1%	2%	0.72	0.48	0.62	968,044	696,992	464,661	596,007
16	No	1%	1%	0.72	0.43	0.55	503,645	362,624	216,567	277,785
Unknown	No	18%	17%	0.72	0.73	0.94	9,709,987	6,991,191	7,088,291	9,091,941
TOTAL		100%	100%	0.72	0.57	0.73	56,965,942	40,781,338	32,376,234	41,528,041

Table 5-34: Peak kW Savings Estimates by Metering Status and Method for A/Cs

Climate Zones	Metered?	% Units	% Program estimated kW savings	kW Realization Rate			kW Savings			
				1 Meter Sample Results Applied to All	2 DEER	3 Adjusted DEER	Program Estimate	1 Meter Sample Results Applied to All	2 DEER	3 Adjusted DEER
7	Yes	7%	7%	0.54	0.6	0.54	2,048	1,106	1,229	1,106
10	Yes	18%	18%	0.71	0.74	0.71	5,294	3,759	3,918	3,759
12	Yes	7%	6%	0.48	0.9	0.48	1,875	900	1,688	900
1	No	0%	0%	0.61	0.32	0.27	31	19	10	8
2	No	2%	2%	0.61	0.9	0.76	544	332	490	413
3	No	5%	5%	0.61	0.67	0.57	1,386	845	929	783
4	No	4%	4%	0.61	0.95	0.80	1,106	675	1,051	886
5	No	0%	0%	0.61	0.81	0.68	117	71	95	80
6	No	3%	3%	0.61	0.56	0.47	1,013	618	567	479
8	No	12%	12%	0.61	0.69	0.58	3,613	2,204	2,493	2,103
9	No	9%	9%	0.61	0.69	0.58	2,594	1,582	1,790	1,510
11	No	3%	2%	0.61	0.91	0.77	610	372	555	468
13	No	7%	6%	0.61	0.96	0.81	1,865	1,138	1,790	1,510
14	No	3%	3%	0.61	0.75	0.63	941	574	706	595
15	No	1%	1%	0.61	0.76	0.64	397	242	302	255
16	No	1%	1%	0.61	0.85	0.72	213	130	181	153
Unknown	No	18%	21%	0.61	0.77	0.65	6,230	3,800	4,797	4,047
TOTAL		100%	100%	0.61	0.76	0.64	29,877	18,367	22,589	19,055

A/C EFLCH and CDF Variances

The metered A/C sites resulted in lower values for EFLCH and CDF, as compared to those from the IOU work papers. Yet, the A/C sample covered the three climate zones that are believed to have significant cooling requirements in the summer season. Several factors may be accounted for in this discrepancy.

- The random samples were those of equipment that has low usage.
- IOU work paper assumptions are not correct.

Work paper assumptions do not take into consideration economizer usage, A/C charge and air flow conditions, and other operational items.

DEER Results by Unit Size and Type

Table 5-35 compares the program estimates of savings with the results of applying the 2005 DEER values for CDF, EFLCH, and SEER/EER, by unit size and type:

Table 5-35: Savings Estimates by Unit Size and Type, Program and DEER

	Program Estimate - Original Database		DEER		DEER/Program	
Unit Type	**kW**	**kWh**	**kW**	**kWh**	**kW**	**kWh**
< 65 KBTU/HR, AIR-COOLED, SINGLE PA/CKAGE (TIER I)	1,747	2,632,082	1,555	2,097,988	0.89	0.80
< 65 KBTU/HR, AIR-COOLED, SPLIT SYSTEM (TIER I)	32	51,062	33	40,451	1.04	0.79
< 65 KBTU/HR, AIR-COOLED, SPLIT-SYSTEM (TIER II)	106	156,000	93	117,849	0.88	0.76
< 65 KBTU/HR, AIR-COOLED, SINGLE PA/CKAGE (TIER II)	3,637	5,543,930	3,209	4,290,691	0.88	0.77
< 65 KBTU/HR, AIR-COOLED, SINGLE PA/CKAGE (TIER III)	230	344,718	195	264,006	0.85	0.77
< 65 KBTU/HR, AIR-COOLED, SPLIT-SYSTEM (TIER III)	5	9,939	6	7,671	1.16	0.77
> 240 KBTU/HR, AIR-COOLED, SPLIT-SYS/SNG PKG (TIER II)	922	1,293,100	760	1,044,169	0.82	0.81
>= 65 & < 135 KBTU/HR, AIR-COOLED, SPLIT-SYS/SNG PKG (TIER II)	3,623	5,317,127	3,015	4,137,333	0.83	0.78
>= 135 & <= 240 KBTU/HR, AIR-COOLED, SPLIT-SYS/SNG PKG (TIER II)	2,271	3,240,901	1,969	2,703,168	0.87	0.83
PG&E Total	**12,573**	**18,588,860**	**10,835**	**14,703,326**	**0.86**	**0.79**
< 65 KBTU/HR, AIR-COOLED, SINGLE PA/CKAGE (TIER I)	3,886	9,480,817	2,001	3,019,806	0.52	0.32
< 65 KBTU/HR, AIR-COOLED, SPLIT SYSTEM (TIER I)	31	76,672	18	25,016	0.57	0.33
< 65 KBTU/HR, AIR-COOLED, SPLIT-SYSTEM (TIER II)	224	550,075	109	160,433	0.49	0.29
< 65 KBTU/HR, AIR-COOLED, SINGLE PA/CKAGE (TIER II)	5,545	13,530,416	3,159	4,595,484	0.57	0.34
< 65 KBTU/HR, AIR-COOLED, SINGLE PA/CKAGE (TIER III)	95	230,923	70	104,424	0.74	0.45
< 65 KBTU/HR, AIR-COOLED, SPLIT-SYSTEM (TIER III)	19	46,476	13	21,013	0.66	0.45
> 240 KBTU/HR, AIR-COOLED, SPLIT-SYS/SNG PKG (TIER II)	854	2,084,139	589	894,856	0.69	0.43
>= 65 & < 135 KBTU/HR, AIR-COOLED, SPLIT-SYS/SNG PKG (TIER II)	1,723	4,204,163	2,467	3,625,864	1.43	0.86
>= 135 & <= 240 KBTU/HR, AIR-COOLED, SPLIT-SYS/SNG PKG (TIER II)	719	1,754,845	1,298	1,956,398	1.80	1.11
SCE Total	**13,096**	**31,958,526**	**9,724**	**14,403,295**	**0.74**	**0.45**
< 65 KBTU/HR, AIR-COOLED, SINGLE PA/CKAGE (TIER I)	550	747,543	470	759,194	0.85	1.02
< 65 KBTU/HR, AIR-COOLED, SPLIT-SYSTEM (TIER II)	15	21,061	13	22,802	0.82	1.08
< 65 KBTU/HR, AIR-COOLED, SINGLE PA/CKAGE (TIER II)	621	844,493	476	758,194	0.77	0.90
< 65 KBTU/HR, AIR-COOLED, SINGLE PA/CKAGE (TIER III)	95	128,621	74	113,456	0.78	0.88
> 240 KBTU/HR, AIR-COOLED, SPLIT-SYS/SNG PKG (TIER II)	253	343,870	242	403,411	0.96	1.17
>= 65 & < 135 KBTU/HR, AIR-COOLED, SPLIT-SYS/SNG PKG (TIER II)	469	637,591	398	616,469	0.85	0.97
>= 135 & <= 240 KBTU/HR, AIR-COOLED, SPLIT-SYS/SNG PKG (TIER II)	384	521,687	346	549,391	0.90	1.05
SDG&E Total	**2,387**	**3,244,865**	**2,017**	**3,222,916**	**0.85**	**0.99**

5.4.5 Metering Results for Motors

There were 7,096 motors installed in the Program. The motors end use accounted for about 8% of kW and 21% kWh of the upstream program impacts. The motor analysis involved metering of 31 motors for the program evaluation. The 31 sites metered were distributed as shown in Table 5-36.

Table 5-36: Installed Meters

Utility	Installed		Planned	
	1-5 HP	6-20 HP	1-5 HP	6-20 HP
PG&E	9	4	10	5
SCE	8	5	8	4
SDG&E	3	2	3	2
Total	**20**	**11**	**21**	**11**

The site-specific impacts for high-efficiency motors were calculated using a spreadsheet model for each site. The goal was to verify the assumed ex-ante coincident diversity factor (CDF), load factor (LF), and the annual operating hours (OH). The following sections describe the method that was used to calculate these values and the ex post savings for the program based on the results of the metering study. A site visit was performed to verify the installations and obtain measurements of motor power consumption and operation profile. Data loggers were used to measure the operation schedule of the motor. Spot power measurements were obtained to determine the load on the motor if it was constant. If the motor load varied, a data logger was installed to measure the motor load over time.

The site-specific impacts for high-efficiency motors were calculated using a spreadsheet model for each project. The model used a measured load profile from on-site monitoring.

On-Site Data Collection

Three different types of loggers were used to meter the motors. There were 16 amperage (amp), eight time-of-use, and seven kW loggers. The motors with constant load applications are metered with time of use or amp loggers. The amp loggers record the average amperage over the programmed interval period. The time-of-use loggers give the percent on time for each programmed interval. The sites that involve the use of VFD on the motors are metered with kilowatts loggers. The kilowatt logger gives the value of kW for each interval.

Four-channel DATA pro™ amp loggers were used in the program study. The loggers were programmed for 5- or 15-minute interval data. The logger captures the data for every minute and then averages it at the end of fifth minute. A current transformer (CT) was attached to the amp logger. The typical size of the CT used in the study was 100 amps. The CT was always attached facing towards the load side. The data that were stored in an amp logger during the metering period captures the following information:

- Date,
- End Time (5- or 15-minute interval), and
- Average Amp.

The Smart Logger TOU™ captures the following information:

- Percent the motor is running/ON,
- Total On Time,
- Average On Time,
- Longest On Time, and
- Shortest On Time.

The ELITE Pro kilowatt loggers were programmed for 5- or 15-minute interval data. The logger captures the data for every minute and then averages it at the end of fifth or fifteenth minute. These loggers have four channels. These meters were programmed to record the recordings of amp and the kW at every interval.

On average, the duration for which the loggers were installed at each motor site for the upstream study was approximately two months. The data were divided into the following segments:

- Hour of day,
- Day Type (weekday or weekend), and
- Period Type (on peak or off peak).

The 5-minute intervals were aggregated for each hour of the day for the whole monitoring period.

The nameplate data and spot measurements recorded at the logger installation were as follows:

- Horsepower (HP),
- Efficiency,
- Power Factor,
- Measured Volts,
- Measured Amps,
- Months of Operation, and
- Operating Schedule.

Calculation

Based on the work paper methodology for calculating motor savings, the following calculations were made to determine the LF, CDF, and annual OH or EFLH.

$$kW = (kW_{nameplate})(LF)$$

$$Peak\ kW = CDF \times kW\_$$

$$Annual\ kWh = kW \times Annual\ Operating\ Hours$$

The motor demand, $kW_{nameplate}$ (capacity), is calculated as follows:

$$kW_{nameplate} = Motor\ HP \times 0.7452 / Motor\ Efficiency$$

where, motor HP and efficiency are taken from the nameplate data.

The $kW_{observed}$ is calculated from the metered values of amp and volts. In this calculation, the power factor used was recorded at the time of logger installation. For those motors for which the power factor was not clearly visible on the nameplate, a value of 0.8 is assumed (standard engineering assumption). The $kW_{observed}$ is calculated as follows:

$$kW_{observed} = kW \times PF \times 1.732$$

where

1. For constant load motors, which are metered by TOU or amp logger, kW = spot metered volts × spot metered amps or spot metered volts × metered amps, respectively,
2. For variable load motors, which are metered by amp loggers, kW = spot metered volts × metered amps,
3. For VSD motors, which are metered by kW meter, kW is taken directly from the metering data.

For each data point, the $kW_{observed}$ is calculated. Each data point is an average value over 5- or 15-minute interval data.

<u>*Load Factor*</u>

The load factor is calculated only when the motor is on, where the $kW_{observed}$ is greater than zero. This value is determined for weekday and weekends. The $kW_{ave\ observed}$ is calculated as the average for each day type:

1. For TOU loggers, the $kW_{ave\ observed}$ is based on the maximum observed % on time (for constant load motors, maximum = average when the motor is on)

   $$kW_{ave\ observed} = spot\ metered\ amps \times spot\ metered\ volts \times PF \times 1.732 \times max\,\%\,on\ time$$

2. For the amp and kW loggers, the average $kW_{observed}$ is the $kW_{ave\ observed}$

   $$kW_{ave\ observed} = average\ kW_{observed}$$

   The LF is calculated:

   $$LF = kW_{ave\ observed} / kW_{nameplate}$$

The LF for the motor is then calculated as the weighted average of the LF calculated for each day type, weekdays, and weekends, as follows:[65]

$$\begin{aligned} LF = {} & Average\ LF_{Weekday,On} \times Count\ of\ Hours_{Weekday} / Total\ Number\ of\ Hours \\ & + Average\ LF_{Weekend,On} \times Count\ of\ Hours_{Weekend} / Total\ Number\ of\ Hours \end{aligned}$$

<u>*Coincident Diversity Factor*</u>

The CDF is the average peak $kW_{observed}$ during the times metered that fall under the peak period divided by the average $KW_{observed}$.

$$CDF = Average\ Peak\ kW_{Observed} / kW_{Observed}$$

where,

1. Average Peak $kW_{observed}$ is the average kW observed during the monitoring period that were under the hours of 12:00 noon to 6:00 p.m. weekday, June-September.
2. $kW_{Observed} = (kW_{nameplate} \times LF)$

<u>*Annual Operating Hours*</u>

The average percent on time for weekday and weekend is use to calculate the annual OH for each measure is calculated as follows for constant load motors.

$$Annual\ OH = Weekday\ (Hrs/Day) \times 5 \times 365 + Weekend\ (Hrs/Day) \times 2 \times 365$$

The Hrs/Day is the average time of motor operation for weekday and weekend.

65 The weighted average is based on the hours metered on weekday versus weekend.

The equivalent full load hours (EFLH) instead of Annual OH are calculated for variable load motors controlled by a variable speed drive. The equation is as follows:

$$EFLH = kWh_{observed,\ annualized} / \left(kW_{nameplate} \times LF \right)$$

The EFLH calculation also applies to constant load motors.

Analysis Methods

The following parameters were determined for each motor from the metering data:

Nameplate kW

$$kW_{nameplate} = HP \times 0.746 / \eta_{HI}$$

with horsepower HP and efficiency η_{HI} based on the observed nameplate information.

Average kW when on

$$kWon = \frac{\begin{bmatrix} (average\ metered\ kW\ \ when\ on,\ weekdays) \times (hours/day\ on,\ weekdays) \times 5 \\ + (average\ metered\ kW\ \ when\ on,\ weekends) \times (hours/day\ on,\ weekends) \times 2 \end{bmatrix}}{\left[(hours/day\ on,\ weekdays) \times 5 (hours/day\ on,\ weekends) \times 2 \right]}$$

with average kW when on and average hours on per day determined from the metering data, separately for weekdays and weekends

Average kW during peak hours

$$kW_{peak} = average\ metered\ kW\ during\ peak\ hours$$

including all peak hours, whether the unit was on or not

Equivalent Full-Load Hours

$$EFLH = 52 \times \left[(hours/day\ on,\ weekdays) \times 5 + (hours/day\ on,\ weekends) \times 2 \right]$$

Annual kWh

$$kWh_{annual} = kW_{on} \times EFLH$$

Load Factor

$$LF = kW_{on} / kW_{nameplate}$$

Coincidence-Diversity Factor

$$CDF = kW_{peak} / kW_{on}$$

Annual kWh Savings

$$\Delta kWh = kWh_{annual} \times (\eta_{HI} / \eta_{base} - 1) = HP \times 0.746 \times (1/\eta_{base} - \eta_{HI})$$

where the base case efficiency/η_{base} is taken from the work paper value

Peak kW Savings

$$\Delta kW = kW_{peak} \times (\eta_{HI} / \eta_{base} - 1)$$

<u>*Population Values*</u>

In addition to the individual parameters described above, we determined corresponding population values using ratio expansion for the metering sample. The results provide population estimates and confidence intervals for meters of 1-20 HP, the population from which the sample was drawn.

For each ratio defined for meter *j* as $r_j = y_j/x_j$, the population ratio is calculated as:

$$R = \sum_j w_j y_j \Big/ \sum_j w_j x_j$$

where w_j is the sample expansion weight for motor *j*, defined for motor *j* in stratum *k* by:

$$w_j = N_k / n_k$$

The population values calculated in this way from the metering data are the following.

Population Load Factor

$$LF_{pop} = \sum_j w_j kW_{on\ j} \Big/ \sum_j w_j kW_{nameplate\ j}$$

Population Coincidence-Diversity Factor

$$CDF_{pop} = \sum_j w_j kW_{peak\ j} \Big/ \sum_j w_j kW_{on\ j}$$

Population EFLH (annual operating hours)

$$EFLH_{pop} = \sum_j w_j kWh_j \Big/ \sum_j w_j kW_{on\ j}$$

Similarly, we calculate an overall realization rate for kWh and kW savings. This is the ratio of savings Δ_m determined from the metering data to savings Δ_p in the program tracking system based on work paper assumptions for LF, CDF, and EFLH, as well as the baseline efficiency[66].

kWh Savings Realization Rate

$$R_{kWh} = \sum_j w_j \Delta kWh_{mj} \Big/ \sum_j w_j \Delta kWh_{pj}$$

kW Savings Realization Rate

$$R_{kW} = \sum_j w_j \Delta kW_{mj} \Big/ \sum_j w_j \Delta kW_{pj}$$

Motors Results

Operating Parameters

Table 5-37, Table 5-38, and Table 5-39 show the estimates, standard errors, and 90% confidence intervals for the population estimates of Load Factor LF, Coincidence-Diversity Factor CDF, and Equivalent Full Load Hours EFLH. Results are shown for each IOU and for the state as a whole. Also shown in each table is the corresponding work paper value.

All of the estimated parameters are smaller than the corresponding work paper assumptions, for all three IOUs. Further, for Load Factor and EFLH, the 90% confidence upper bound is also below the work paper value That is, the correct population value is statistically significantly less than the work paper value, at 90% confidence.

Motors LF, CDF, and operating hour variances

The metered motor sites resulted in lower values for LF, CDF, and annual operating hours, as compared to those from the IOU work papers. Several factors may be accounted for in this discrepancy.

- The random sample included equipment that has low usage, less fully loaded, and has lower peak use.
- IOU work paper assumptions are not correct.
- The sample aimed to include motors that were not weather dependent (no HVAC related motors) which may have skewed the sample.
- Motors metered may have been secondary motors (back-up equipment).
- Work paper assumptions do not take into consideration any VSD control and other operational variations such as industry type, application, etc.

[66] The baseline efficiency is from the work papers which equal EPA/CT-92 minimum required full-load nominal efficiency.

Some of the motors in the sample had very low usage overall and/or during peak hours. While such operating patterns may seem anomalous, they do correspond to actual observations for a randomly selected sample of motors. Moreover, generally low values were found not just for one or two strange cases but also across the sample. The confidence intervals calculated indicate the uncertainty of the findings. It is clear that the work paper assumptions are overstated. The work paper values for SCE do not match with the values in program implementation plan.

Table 5-37: Population Estimates of Load Factor

	Number of Observations	Load Factor	Standard Error	90% Confidence Interval		Work paper Value
				Lower Bound	Upper Bound	
TOTAL	31	0.35	0.04	0.28	0.43	0.75
PGE	13	0.37	0.06	0.27	0.48	0.75
SCE	13	0.34	0.04	0.27	0.42	0.75
SDGE	5	0.22	0.16	-0.05	0.49	0.75

Table 5-38: Population Estimates of CDF

	Number of Observations	CDF	Standard Error	90% Confidence Interval		Work paper Value
				Lower Bound	Upper Bound	
TOTAL	31	0.64	0.14	0.40	0.87	0.74
PGE	13	0.67	0.19	0.35	0.99	0.74
SCE	13	0.56	0.13	0.34	0.78	0.74
SDGE	5	0.65	0.08	0.52	0.78	0.74

Table 5-39: Population Estimates of Operating Hours

	Number of Observations	EFLH	Standard Error	90% Confidence Interval		Work paper Value
				Lower Bound	Upper Bound	
TOTAL	31	3,568	168	3,282	3,855	4,700
PGE	13	3,643	187	3,322	3,963	4,700
SCE	13	3,345	346	2,754	3,935	4,700
SDGE	5	3,895	246	3,474	4,316	4,700

Savings Realization Rates

Based on the above results for the key operating parameters, we would expect to see savings estimates generally below the work paper values, and realization rates less than 1.0. These expectations are borne out, as shown in Table 5-40 and Table 5-41 below. The overall realization rate is 0.39, with a 90% confidence interval upper bound of 0.5. Results across the utilities range from 0.3 to 0.4. Results for peak kW are similar. However, the confidence bounds for peak kW are broader, indicating greater variability in peak use than in annual.

Table 5-40: Annual kWh Savings Realization Rates for Motors by IOU

	Number of Observations	RkWh	Standard Error	90% Confidence Level	
				Lower Bound	Upper Bound
TOTAL	31	0.39	0.05	0.30	0.48
PGE	13	0.41	0.08	0.28	0.54
SCE	13	0.37	0.06	0.27	0.47
SDGE	5	0.27	0.19	-0.06	0.59

Table 5-41: Peak kW Savings Realization Rate for Motors by IOU

	Number of Observations	RkW	Standard Error	90% Confidence Interval	
				Lower Bound	Upper Bound
TOTAL	31	0.45	0.12	0.24	0.66
PGE	13	0.48	0.19	0.16	0.80
SCE	13	0.41	0.10	0.24	0.59
SDGE	5	0.28	0.20	-0.06	0.62

Implications for Larger Motors

The metering study addressed only motors in the range of 1-20 HP. The results do not apply directly to larger motors. To develop savings estimates for larger motors, we consider three different approaches.

1. Assume that the estimated LF, CDF, and EFLH found for the small motors applies also to all motors. This effectively means that the realization rate for small motors applies to all motors.
2. Assume that the 2004-05 DEER assumptions are correct for the larger motors.
3. Assume that the ratio of metered to DEER savings found for small motors would apply also to the larger motors.

Table 5-43 and Table 5-43 show the program-level savings for these three different assumptions. To calculate the DEER-based savings for the program population the following assumptions were made:

1. DEER savings is provided for both open and closed motors. Per the program work papers, there was an assumption that 75% are open motors 1800 rpm, 20% were

closed motors 1800 rpm, and the remaining were other. Therefore, we assumed that the 5% remaining are split between open and closed. A weighted average was calculated based on this assumption.

2. DEER savings is provided by five different industrial SIC codes, other industrial, and commercial. The differences are the operating hours by motor size. Using the participant phone survey results, we established that 83.5% of motors participants were industrial customers and 16.5% were commercial. Therefore, we calculated a straight average of the DEER savings across the six industrial categories and calculated a weighted average with the commercial savings assumption.

The adjustment factors are calculated as follows:

1. The "Meter Sample Results Applied to All" is from Table 5-40 and Table 5-41 realization rates.
2. The DEER realization rate is the ratio of the program population divided by the program data replicated using DEER assumptions (see section 5.3.3).
3. The adjusted DEER realization rate is the DEER realization rate multiplied by the adjustment calculated by the metered sample realization rate for the 1-20hp motor category. However, the 1-20 hp motor category adjusted DEER realization rate is the meter sample realization rate.
4. The savings adjusted DEER values is the program estimate times the adjusted DEER realization rate.

Table 5-42: kWh Savings Estimates by Metering Status and Method for Motors

HP	% units	% HP	% program estimated kWh savings	kWh Realization Rate			kWh Savings			
				1 Meter Sample Results Applied to All	2 DEER	3 Adjusted DEER	Program	1 Using Metering Sample Realization Rate	2 DEER	3 Adjusted DEER
1 to 20	77%	33%	17%	0.39	0.644	0.39	2,598,346	1,013,355	1,672,728	1,013,355
25 to 75	19%	48%	61%	0.39	0.196	0.12	9,440,889	3,681,947	1,850,302	1,120,931
100-200	2%	19%	22%	0.39	0.236	0.14	3,397,226	1,324,918	800,474	484,935
TOTAL	98%	100%	100%	0.39	0.28	0.17	15,436,461	6,020,220	4,323,504	2,619,221

Table 5-43: Peak kW Savings Estimates by Metering Status and Method for Motors

HP	% units	% HP	% program estimated kW savings	kW Realization Rate			Peak kW Savings			
				1 Meter Sample Results Applied to All	2 DEER	3 Adjusted DEER	Program	1 Using Metering Sample Realization Rate	2 DEER	3 Adjusted DEER
1 to 20	77%	33%	17%	0.45	1.04	0.45	459	207	479	207
25 to 75	19%	48%	63%	0.45	0.26	0.11	1679	756	442	191
100-200	2%	19%	19%	0.45	0.30	0.13	512	230	156	67
TOTAL	98%	100%	100%	0.45	0.41	0.18	2650	1193	1077	465

5.5 Upstream HVAC and Motors Realization Rates

Table 5-44 and Table 5-45 summarizes the final kW and kWh realization rates by IOU used for the upstream HVAC and motors measures, respectively. For HVAC measures, these values are based on the adjusted DEER realization rates provided in Table 5-33 and Table 5-34. For motors measures, these values are also based on the adjusted DEER realization rates provided in Table 5-42 and Table 5-43.

Table 5-44: Final kW and kWh Realization Rates for HVAC Measures by IOU

IOU	kW Realization Rate	kWh Realization Rate
PG&E	66%	92%
SCE	63%	59%
SDG&E	57%	92%

Table 5-45: Final kW and kWh Realization Rates for Motors Measures by IOU and Motor Size

HP	kWh Realization Rate			kW Realization Rate		
	PG&E	SCE	SDG&E	PG&E	SCE	SDG&E
1 to 20	0.41	0.37	0.27	0.48	0.41	0.28
25 to 75	0.13	0.10	0.09	0.13	0.10	0.07
100-200	0.16	0.12	0.10	0.13	0.14	0.07

6

Net-of-Free-Ridership Analysis

6.1 Overview of Net Impact Analysis Methods

The primary objective of net savings analyses is to determine a program's net effect on customers' electric and gas usage. This requires estimating what would have happened in the absence of the program. This estimation hinges on the level of free ridership that exists for each measure. The analysis approaches used to estimate ex-post net energy and demand savings included self-report data analyses and discrete choice modeling. Both of these approaches resulted in the estimation of a NTFR ratio that, when applied to the gross program savings estimates, calculated the ex-post net program impacts.[67]

Table 6-1 provides an overview of the measures rebated under the 2004/2005 Express Efficiency and Upstream HVAC and Motors Programs and indicates which measures were included in the self-report, net-of-free-ridership analysis and/or discrete choice analysis. Discrete choice analyses were conducted for a subset of the measures including T8s, CFLs, and split/packaged A/C systems. In addition to measures rebated through the Express Program, the research plan indicated that the self-report free-ridership analysis would also be conducted for the Upstream HVAC and motors measures. Since the participant phone surveys indicated that over two-thirds of customers who installed rebated motors under the program were not aware they had been rebated, an upstream approach for calculating NTFR ratios for motors and central air conditioners rebated was used. This approach to calculating net-of-free-ridership is appropriate for those measures rebated through the Upstream HVAC and Motors program because it is the distributors who are potentially influenced by the program to promote (and stock) program qualifying equipment, who in turn may affect decisions regarding equipment choices made by end users.

The sections below describe the net-of-free-ridership approaches used and the overall net impact analysis results for each measure analyzed. Results for the self report net-of-free-ridership analyses for the Express and Upstream Programs are presented in Section 6.2 and Section 6.3. The discrete choice model and results for a subset of Express and Upstream Program measures are presented in Section 6.4 and the final estimated net-of-free-ridership ratios are presented in Section 6.5.

[67] The net-of-free-ridership (NTFR) ratio is defined as one minus free ridership.

Table 6-1: Gross Savings and Net-of-Free-Ridership Analysis Approaches by Technology and Measure

■ Approaches Used	Contribution to Program Accomplishments			Net-of-Free-Ridership Approaches	
Measure and Technology Categories	**kWh**	**kW**	**Therms**	**Self-Report Analysis**	**Discrete Choice Analysis**
Lighting	67%	72%	0%		
CFLs	36%	34%	0%	■	■
T8/T5s	15%	18%	0%	■	■
Occupancy Sensor	7%	11%	0%	■	
Delamping	5%	5%	0%	■	
LED Exit Signs	2%	2%	0%	■	
Other Lighting	2%	2%	0%	■	
HVAC	21%	18%	57%		
Programmable Thermostats	13%	0%	57%	■	
Split or Packaged A/C Systems	6%	17%	0%		■
VSD/VFD for HVAC Fans	1%	0%	0%	■	
Other HVAC	1%	1%	0%	■	
Refrigeration	9%	5%	0%	■	
Curtains	4%	3%	0%		
Efficient Evaporator Fan Motors	1%	0%	0%		
Door Gaskets	1%	1%	0%		
Other Refrigeration Methods	2%	1%	0%		
Water Heating	0%	0%	24%	■	
Commercial Clothes Washers	0%	0%	5%		
Boilers	0%	0%	9%		
Process Boilers	0%	0%	3%		
Tank/Pipe Insulation	0%	0%	5%		
Other Water Heating	0%	0%	3%		
Building Shell	1%	2%	19%	■	
Greenhouse Gas Curtain	0%	0%	18%		
Reflective Window Film	1%	1%	0%		
Other Building Shell	0%	1%	1%		
Motors	2%	1%	0%	■	
Pumping	0%	1%	0%	■	
Food Service	0%	0%	0%	■	
Agriculture/Process	0%	0%	0%	■	

6.2 Express Efficiency Program Self-Report Net-of-Free-Ridership Analyses

6.2.1 Approach

The calculation of free ridership is a multi-step process that considers a variety of ways in which the program may influence a customer to adopt an energy-efficient measure. Two separate approaches to calculating free ridership using self-reported data were implemented. The average of these two results was taken as the final free-ridership estimate.

6.2.2 Three Criteria Approach

The first approach to estimating free ridership was analyzed from three separate perspectives, as follows:

1. Did the program influence the customer to make a purchase?
2. Did the program influence the customer to accelerate a purchase?
3. Did the program influence the customer to make a more efficient purchase than they otherwise would have?[68]

The self-report analysis for the Express Program was conducted based on the data collected during the participant surveys to estimate free ridership. Table 6-2 presents the self-reported free-ridership questions asked during the lighting participant phone surveys that were used to estimate free ridership for this approach.[69]

[68] This question was not asked in regards to greenhouse heat curtains since the addition of the curtain itself is efficient and covered by Question 1.

[69] Similar questions, possible answers, and scoring were similar for each end-use.

Table 6-2: Self-Report Free-Ridership Questions

LI42: If the rebate or cash incentive did not exist, which of the following best describes what you would have purchased…
You would NOT have purchased new equipment
You would have purchased fewer new equipment or less new equipment
You would have purchased the same quantity of equipment as you did through the program
LI43: If the rebate or cash incentive did not exist, which of the following best describes what you would have purchased…
Standard efficiency equipment or the least expensive alternative available
Less efficient than the equipment we just discussed
The same high efficiency equipment as you purchased through the program
LI44: If the rebate or cash incentive did not exist, would you have installed the rebated lighting equipment…
More than 1 year later
Within 1 year
At the same time

Based on the responses to these questions, a participant would be considered a free rider if they purchased:

- The same quantity and type of equipment, and
- The equipment at the same time, and
- The equipment with the same level of efficiency

A customer would not be considered a free rider if any of the following were true:

- Would not have purchased the equipment, or
- Would have purchased standard equipment.
- Furthermore, a very low level of free ridership was assessed if the customer would have purchased the equipment more than a year later.

Otherwise, the participant would be considered a partial free rider. In order to estimate partial free ridership, each survey response was scored as either providing some evidence towards free ridership or towards net participation. Table 6-3 illustrates how each survey response was used in calculating net participation, or full or partial free ridership.

Table 6-3: Self-Report Free-Ridership Questions

LI42: If the rebate or cash incentive did not exist, which of the following best describes what you would have purchased…	**FR SCORE**
You would NOT have purchased new equipment	FR = 0
You would have purchased fewer new equipment or less new equipment	Partial FR = 1
You would have purchased the same quantity of equipment as you did through the program	Partial FR = 0
LI43: If the rebate or cash incentive did not exist, which of the following best describes what you would have purchased…	
Standard efficiency equipment or the least expensive alternative available	FR = 0
Less efficient than the equipment we just discussed	Partial FR = 1
The same high efficiency equipment as you purchased through the program	Partial FR = 0
LI44: If the rebate or cash incentive did not exist, would you have installed the rebated lighting equipment…	
More than 1 year later	FR = 0.10
Within 1 year	Partial FR = 1
At the same time	Partial FR = 0

As stated above, if the customer indicated they would not have purchased new lighting or they would have installed standard efficiency equipment, then their free ridership is zero (FR=0.00).

If the respondent states they would have installed the rebated lighting equipment more than a year later, we give them a free ridership rate of 10% (FR = 0.10). This rate is used because there is uncertainty regarding how much later they would have actually installed the lighting. Given it is more than a year, it is likely they are a net participant.

Otherwise, the partial free ridership scores are summed. If the sum of the partial free ridership score is 0, then they are indicating they would have purchased the same quantity of equipment, with the same efficiency, at the same time, and they are a free rider (FR = 1.00).

If the sum of the partial free-ridership scores is one, then there is some evidence that the respondent may have been a partial free rider. They would have purchased either less equipment, less efficient equipment, or waited to purchase the equipment for up to a year. This respondent is designated with a 75% free-ridership rate (FR = 0.75).

If a respondent has a partial free-ridership score of two, there is now more evidence toward the customer being a net participant, since two of these three criteria are true. We designate this respondent with a 50% free-ridership rate (FR = 0.50).

Finally, if all three criteria hold true, where the score is three and a customer would have purchased less equipment, equipment that was less efficient, or at a later date within a year, then they are not likely to be a free rider. This respondent is designated with a 25% free-ridership rate (FR = 0.25).

Table 6-4 summarizes how the free-ridership values were calculated for all possible cases of survey responses.

Table 6-4: Self-Report Free-Ridership Calculation

Would have Purchased	When	How Much	Partial Score	Free-Ridership Value
Would Not have Purchased			n/a	0
Standard Efficiency	More than a year	Fewer	n/a	0
		Same Quantity	n/a	0
	Within a Year	Fewer	n/a	0
		Same Quantity	n/a	0
	Same Time	Fewer	n/a	0
		Same Quantity	n/a	0
Less Efficient	More than a year	Fewer	n/a	0.1
		Same Quantity	n/a	0.1
	Within a Year	Fewer	3	0.25
		Same Quantity	2	0.5
	Same Time	Fewer	2	0.5
		Same Quantity	1	0.75
Same Efficiency	More than a year	Fewer	n/a	0.1
		Same Quantity	n/a	0.1
	Within a Year	Fewer	2	0.5
		Same Quantity	1	0.75
	Same Time	Fewer	1	0.75
		Same Quantity	0	1

It is important to note that for a few Express measures (CFLs, programmable thermostats, strip curtains, and door gaskets), the response of purchasing less efficient equipment was not considered feasible. These measures in themselves are considered energy efficient. Therefore, because less than 5% of these customers answered the efficiency question with this response, there were removed from the analysis.

6.2.3 Program Influence Approach

The second approach to estimating free ridership relied solely on the participants stating the level of influence that the program rebate had on their decision to participate. The following question was asked of all participants:

> On a scale of 1-10, with 1 being *NOT AT ALL* Influential and 10 being *EXTREMELY* Influential, how influential was the Express Efficiency program rebate or cash incentive on your decision to install the rebated equipment?

Free ridership was calculated directly from this response, with a 1 indicating a customer was a free rider (FR = 1.00) and 10 indicating a customer was a net participant (FR = 0.00). All other values of free ridership were interpolated between these two points using the following equation:

$$Free\ Ridership = 1 - (influence\ rating - 1)/9$$

Therefore, a rating of 1 would provide a free-ridership value of 1.00, a rating of 10 would provide a zero, and a 5, for example, would provide a free-ridership value of 0.56.

6.2.4 Self-Reported Free-Ridership and Net-of-Free-Ridership Results

The results of the self-reported free-ridership analyses for the Express Program are provided in Table 6-5, along with the sample sizes used to arrive at these results. The table presents the free-ridership results for each approach by each measure evaluated, and the average of the two approaches. We began the analysis by examining measures with a sample size of approximately 50 sites or higher. Door gaskets remained in the analysis regardless of its smaller sample size because the margin of error was relatively small.[70] The measure with the lowest level of FR based on the self-report scoring method was CFLs with 19% free ridership.

Due to the upstream delivery mechanism for high efficiency split and packaged A/C systems and motors, the self-report analysis is not recommended, as discussed above. Therefore, free ridership was not estimated using this approach for these two measures. As mentioned in the beginning of this section, an upstream approach was used to conduct a self-report NTFR analysis for central air conditioners and motors (see Section 6.3).

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70 Each of the four lighting measures reported in the net of free ridership analysis have margins of error ranging from ±2% to ±5%. The three HVAC measures have margins of error ranging from ±4% to ±9%. Strip curtains and door gaskets are the only measures reported in Table 6-5 that has a margin of error greater than ±9% at ±11%.

Table 6-5: Self-Reported Free-Ridership by Measure

Self-Report FR Method	n	3 Criteria	Program Influence	Overall
Lighting				
CFLs	513	18%	20%	**19%**
T8_T5s	386	26%	19%	**22%**
LED Exit Signs	307	27%	20%	**23%**
Occupancy Sensors	125	23%	22%	**22%**
HVAC				
Programmable Thermostats	221	23%	25%	**24%**
PTACs	51	37%	15%	**26%**
Reflective Window Film	47	55%	27%	**41%**
Refrigeration				
Curtains	47	59%	48%	**54%**
Door Gaskets	24	22%	26%	**24%**

* Therm savings were converted to kWh for the purpose of comparison across fuel savings.

6.3 Upstream Program Self-Report Net-of-Free-Ridership Analyses

An upstream approach was utilized the calculation of NTFR ratios for motors and central air conditioners (CAC) for which the Upstream Motors and HVAC Program provided incentives during the 2004/2005 program period. An upstream approach to calculating net-of-free-ridership (as opposed to a downstream method based on end-user surveys) is appropriate for this program because it is delivered upstream, and thus, some end users may not fully understand that the equipment discounts are provided by the IOUs rather than the equipment suppliers (see Upstream Program process evaluation in Section 9).

During the course of in-depth interviews and CATI surveys with participating motor and CAC distributors, estimates of free ridership were elicited – the percentage of program-discounted units that would still have been sold in absence of the program – for different equipment size/efficiency categories from representatives of the equipment distribution firms.[71] The remainder of this section presents self-report NTFR ratio results for both motors and CACs and explains how overall estimates of free ridership for motors and CAC were developed.

[71] The question asked to elicit information to estimate free-ridership was, “What proportion of the rebated <SPECIFIC CAC/MOTOR MEASURE> you sold in 2004 and 2005 do you think you would have sold in California if you hadn’t participated in the program?” This was followed by a confirmation question which read, “Okay, just to confirm – you are saying that <PROPORTION STATED> < SPECIFIC CAC/MOTOR MEASURE> would have been sold anyway in California if the program rebates were not available in 2004 and 2005. Is this correct?”

Motor and CAC distributors were asked to estimate the Upstream Program's impact on their 2004/2005 sales of equipment for which the program provided incentives in terms of how their sales would have differed if the program's incentives had not been available. The evaluators asked motors distributors to provide free ridership estimates for four different motor size categories and the CAC distributors to provide estimates for five different CAC size/efficiency categories. This allows calculation of free-ridership for each measure type (motors and CACs) as well as for subcategories within each measure type.

6.3.1 Motors

The evaluators calculated free ridership rates based on interviews with distributors who received incentives through the 2004/2005 program for motors. Interviewers asked motors distributors to provide free ridership estimates for four motor size categories:

- 1 horsepower (HP);
- 1.5 HP to 5 HP;
- Greater than 5 HP up to 20 HP; and
- Greater than 20 HP.

Evaluators interviewed 71 of the total 105 motor distributors who participated in the 2004/2005 Upstream Program (68%). Three of the 71 motors distributors interviewed were unable to provide free ridership estimates. The remaining 68 motors distributors sold approximately 80% of the total motors for which the program provided incentives during the 2004/2005 period, as shown in the bottom row of Table 6-6.

For the 68 distributors who participated in the phone interviews and were able to estimate free ridership, Column A in Table 6-6 shows the number of motors for which the program provided incentives during the 2004/2005 program period by motor size category. Column B shows the distributors' self-reported free ridership estimates for each size category. Multiplying the number of program-discounted motors within each size category in Column A by the appropriate free ridership estimate in Column B yields an estimate of the number of "free rider motors" (the number of motors that would have been sold in absence of the program incentives) in Column C. For example, the table shows that participating motors distributors estimate that of the total 572 one-horsepower motors for which the program provided incentives, they would have sold approximately 294 of them in absence of the program. This proportion (51%) is the free ridership estimate for the one-horsepower motor size category which, when combined with estimates for other motor size categories, yields the program-level estimate of free ridership for motors (54%).

Table 6-6: Free-Ridership Calculation by Motor Size Category

	Column A - Number of Rebated Motors				% of Total Motors Sold through 04/05 Program	**Column B** - Self-reported Free-Ridership Percentage				**Column C** - Number of "Freerider" Motors				
Distributor*	1 HP	1.5 to 5 HP	>5 to 20 HP	>20 HP		1 HP	1.5 to 5 HP	>5 to 20 HP	>20 HP	1 HP	1.5 to 5 HP	>5 to 20 HP	>20 HP	Distributor-level freeridership ratio
Distributor 25	17	333	294	191	11.8%	50%	50%	50%	60%	9	167	147	115	52%
Distributor 37	108	280	114	64	8.0%	25%	25%	25%	25%	27	70	29	16	25%
Distributor 29	98	106	230	68	7.1%	10%	20%	40%	0%	10	21	92	0	25%
Distributor 56	5	95	114	115	4.6%	100%	100%	100%	100%	5	95	114	115	100%
Distributor 9	48	120	87	24	3.9%	12%	12%	8%	8%	6	14	7	2	10%
Distributor 26	1	45	107	77	3.2%	50%	50%	50%	50%	1	23	54	39	50%
Distributor 30	32	94	60	42	3.2%	75%	75%	75%	75%	24	71	45	32	75%
Distributor 10	115	98	12	2	3.2%	100%	100%	100%	100%	115	98	12	2	100%
Distributor 23	1	63	106	57	3.2%	0%	0%	0%	0%	0	0	0	0	0%
Distributor 61	11	140	41	27	3.1%	20%	20%	20%	20%	2	28	8	5	20%
Distributor 33	0	8	52	106	2.3%	100%	100%	100%	100%	0	8	52	106	100%
Distributor 65	2	43	60	58	2.3%	50%	60%	70%	75%	1	26	42	44	69%
Distributor 42	24	74	42	20	2.3%	50%	50%	50%	50%	12	37	21	10	50%
Distributor 46	18	62	43	13	1.9%	100%	100%	100%	100%	18	62	43	13	100%
Distributor 28	9	24	36	36	1.5%	10%	10%	25%	60%	1	2	9	22	32%
Distributor 58	43	32	12	7	1.3%	100%	100%	100%	100%	43	32	12	7	100%
Distributor 5	2	37	28	20	1.2%	100%	100%	100%	100%	2	37	28	20	100%
Distributor 35	0	32	37	7	1.1%	100%	100%	100%	100%	0	32	37	7	100%
Distributor 32	1	17	21	32	1.0%	10%	10%	10%	10%	0	2	2	3	10%
Distributor 17	0	54	3	8	0.9%	100%	100%	100%	100%	0	54	3	8	100%
Distributor 50	2	32	9	13	0.8%	0%	40%	25%	15%	0	13	2	2	30%
Distributor 43	10	23	15	4	0.7%	10%	15%	15%	15%	1	3	2	1	14%
Distributor 39	1	12	18	18	0.7%	10%	10%	10%	10%	0	1	2	2	10%
Distributor 57	2	29	10	5	0.6%	5%	5%	10%	10%	0	1	1	1	7%
Distributor 15	3	20	15	7	0.6%	100%	90%	70%	70%	3	18	11	5	81%
Distributor 16	1	9	20	15	0.6%	100%	100%	100%	100%	1	9	20	15	100%
Distributor 20	1	16	11	14	0.6%	100%	100%	100%	100%	1	16	11	14	100%
Distributor 8	5	10	16	4	0.5%	100%	100%	100%	100%	5	10	16	4	100%
Distributor 60	3	11	14	6	0.5%	100%	100%	100%	100%	3	11	14	6	100%
Distributor 4	0	6	3	20	< 0.5%	100%	100%	100%	100%	0	6	3	20	100%
Distributor 2	0	9	4	15	< 0.5%	100%	100%	100%	100%	0	9	4	15	100%
Distributor 19	2	8	14	2	< 0.5%	50%	50%	50%	50%	1	4	7	1	50%
Distributor 36	1	8	11	6	< 0.5%	100%	100%	100%	100%	1	8	11	6	100%
Distributor 7	0	10	11	4	< 0.5%	100%	100%	100%	100%	0	10	11	4	100%
Distributor 40	1	18	4	1	< 0.5%	15%	40%	40%	5%	0	7	2	0	38%
Distributor 41	1	12	8	3	< 0.5%	75%	75%	75%	75%	1	9	6	2	75%
Distributor 6	0	3	19	1	< 0.5%	100%	100%	100%	100%	0	3	19	1	100%
Distributor 62	0	2	9	11	< 0.5%	100%	100%	100%	100%	0	2	9	11	100%

* Sixty-eight of the 71 distributors in the sample could provide estimates of free ridership.

† Free-ridership estimates at the motor size level are not statistically valid and are shown for illustrative purposes only.

Table 6-6 (cont'd.): Free-Ridership Calculation by Motor Size Category

Distributor*	Column A - Number of Rebated Motors: 1 HP	1.5 to 5 HP	>5 to 20 HP	>20 HP	% of Total Motors Sold through 04/05 Program	Column B - Self-reported Free-Ridership Percentage: 1 HP	1.5 to 5 HP	>5 to 20 HP	>20 HP	Column C - Number of "Freerider" Motors: 1 HP	1.5 to 5 HP	>5 to 20 HP	>20 HP	Distributor-level freeridership ratio
Distributor 3	1	12	4	4	< 0.5%	0%	0%	0%	0%	0	0	0	0	0%
Distributor 64	0	0	8	12	< 0.5%	0%	5%	50%	70%	0	0	4	8	62%
Distributor 51	0	6	7	6	< 0.5%	0%	0%	20%	20%	0	0	1	1	14%
Distributor 63	0	2	4	13	< 0.5%	0%	15%	15%	0%	0	0	1	0	5%
Distributor 49	0	4	4	6	< 0.5%	100%	100%	100%	100%	0	4	4	6	100%
Distributor 55	0	6	6	2	< 0.5%	100%	100%	100%	100%	0	6	6	2	100%
Distributor 24	0	0	3	10	< 0.5%	100%	100%	100%	100%	0	0	3	10	100%
Distributor 54	0	0	8	5	< 0.5%	100%	80%	80%	80%	0	0	6	4	80%
Distributor 12	2	9	1	0	< 0.5%	100%	100%	100%	100%	2	9	1	0	100%
Distributor 34	0	3	9	0	< 0.5%	100%	100%	100%	100%	0	3	9	0	100%
Distributor 48	0	4	8	0	< 0.5%	65%	65%	65%	65%	0	3	5	0	65%
Distributor 31	0	0	0	10	< 0.5%	100%	100%	100%	100%	0	0	0	10	100%
Distributor 38	0	2	7	0	< 0.5%	100%	100%	100%	100%	0	2	7	0	100%
Distributor 11	1	1	5	1	< 0.5%	0%	25%	75%	50%	0	0	4	1	56%
Distributor 68	0	0	2	6	< 0.5%	40%	40%	40%	40%	0	0	1	2	40%
Distributor 27	0	1	3	2	< 0.5%	100%	100%	100%	100%	0	1	3	2	100%
Distributor 45	0	1	2	3	< 0.5%	20%	20%	20%	20%	0	0	0	1	20%
Distributor 1	0	0	2	3	< 0.5%	100%	100%	100%	100%	0	0	2	3	100%
Distributor 22	0	3	2	0	< 0.5%	100%	100%	100%	100%	0	3	2	0	100%
Distributor 47	0	2	3	0	< 0.5%	100%	100%	100%	100%	0	2	3	0	100%
Distributor 53	0	0	2	3	< 0.5%	25%	25%	25%	25%	0	0	1	1	25%
Distributor 13	0	1	3	0	< 0.5%	100%	100%	100%	100%	0	1	3	0	100%
Distributor 14	0	1	2	1	< 0.5%	100%	100%	80%	75%	0	1	2	1	84%
Distributor 21	0	4	0	0	< 0.5%	100%	100%	100%	100%	0	4	0	0	100%
Distributor 59	0	3	1	0	< 0.5%	100%	100%	100%	100%	0	3	1	0	100%
Distributor 66	0	0	0	4	< 0.5%	0%	30%	33%	33%	0	0	0	1	33%
Distributor 18	0	2	0	0	< 0.5%	100%	100%	100%	100%	0	2	0	0	100%
Distributor 52	0	0	1	1	< 0.5%	100%	100%	100%	100%	0	0	1	1	100%
Distributor 44	0	0	0	1	< 0.5%	100%	100%	100%	100%	0	0	0	1	100%
Distributor 67	0	0	0	1	< 0.5%	100%	100%	100%	100%	0	0	0	1	100%
Overall	**572**	**2,062**	**1,807**	**1,217**						**294**	**1,063**	**976**	**729**	
% of Total Motors Sold through 04/05 Program	**61%**	**87%**	**83%**	**76%**	**80%**				**Free-ridership Estimate**	**51%†**	**52%†**	**54%†**	**60%†**	**54%**

* Sixty-eight of the 71 distributors in the sample could provide estimates of free ridership.

† Free-ridership estimates at the motor size level are not statistically valid and are shown for illustrative purposes only.

Table 6-7 shows the free-ridership estimates for each motor size category as well as the average estimate across all size categories. The overall free-ridership rate is 54% (weighted by the number of motors for which distributors in the sample received rebates in each size category). Note that sample sizes (number of motor distributors) within each motor size category are too small to support statistically valid estimation of free-ridership rates for individual size categories; these estimates are provided for illustrative purposes only and are combined to yield the program-level estimate of free ridership for motors.

The table also shows the NTFR ratio that was derived from the overall estimate of free ridership across all motor size categories. The NTFR ratio for all motor size categories for which the 2004/2005 Upstream Motors and HVAC Program provided incentives is 46%.

Table 6-7: Free-Ridership Estimates by Motor Size Category and Overall Estimate of NTFR Ratio

Estimate	**Motor Size**				**Overall (All Motor Sizes)**
	1 HP	**1.5 to 5 HP**	**>5 to 20 HP**	**>20 HP**	
Total rebated motors (2004/2005) represented by distributors in sample	572	2,062	1,807	1,217	5,658
"Free rider" units represented by distributors in sample (n=68)*	294	1,063	976	729	3,063
Free ridership rate	51%[†]	52%[†]	54%[†]	60%[†]	**54%**
NTFR Ratio (inverse of free ridership)					**46%**
n (number of distributors)*	33	57	62	58	68

* Sixty-eight of the 71 distributors in the sample could provide estimates of free ridership.

† Free-ridership estimates at the motor size level are not statistically valid and are shown for illustrative purposes only.

The evaluators also calculated free-ridership estimates across all motor size categories for each IOU (Table 6-8), but again, sample sizes (number of motor distributors) are too small to support statistically valid estimation of free-ridership rates at this level of detail. The IOU-level free-ridership estimates shown in the table are for illustrative purposes only.

Table 6-8: Free-Ridership Estimates by IOU - Motors

IOU	Free-Ridership Estimate	n
PG&E	44%†	43
SCE	55%†	32
SDG&E	28%†	6
Overall	**54%**	**68***

* Sixty-eight of the 71 distributors in the sample could provide estimates of free ridership.
† Free-ridership estimates at the IOU level are not statistically valid and are shown for illustrative purposes only.

6.3.2 Central Air Conditioners

Free-ridership rates for central air conditioners were calculated based on interviews with distributors who received incentives through the 2004/2005 Upstream Program for these measures. Interviewers asked CAC distributors to provide free-ridership estimates for five equipment size/efficiency categories:

- <65 kBtuh, Tier 1,
- <65 kBtuh, Tier 2,
- <65 kBtuh, Tier 3,
- 65–135 kBtuh, Tiers 2 and 3, and
- >135 kBtuh, Tiers 2 and 3.

Evaluators interviewed 21 (62%) of the total 34 CAC distributors who participated in the 2004/2005 Upstream Program. Two of the 21 CAC distributors interviewed were unable to provide free-ridership estimates. The remaining 19 CAC distributors sold approximately 77% of the total cooling tonnage for which the program provided incentives during the 2004/2005 period (as shown in the bottom row of Table 6-9).

For the 19 CAC distributors who participated in the phone interviews and were able to estimate free ridership, Column A in Table 6-9 shows the cooling tons of CAC for which the program provided incentives during the 2004/2005 program period by CAC size/efficiency category. Column B shows the distributors' self-reported free-ridership estimates within each size/efficiency category. Multiplying the number of program-discounted CAC within each size category in Column A by the appropriate free ridership estimate in Column B yields the number of "free rider CAC tonnage" (the tons of CAC that would have been sold in absence of the program incentives) in Column C. For example, the table shows that participating CAC distributors estimate that of the total 22,072 tons of <65 kBtuh Tier 1 CAC for which the program provided incentives, approximately 7,816 tons in absence of the program would have been sold. This proportion (35%) is the free-ridership estimate for the <65 kBtuh Tier 1 CAC size/efficiency category which, when combined with estimates for the other size/efficiency categories, yields the program-level estimate of free ridership for CACs (28%).

Table 6-9: Free-Ridership Calculation by CAC Size/Efficiency Category

	Column A - Tons of Rebated CAC					% of total CAC tonnage sold through 04/05 program	Column B - Self-reported Free-Ridership Percentage					Column C - "Freerider" CAC Tons					
Distributor	<65 kbtuh Tier 1	<65 kbtuh Tier 2	<65 kbtuh Tier 3	65-135 kbtuh	>135 kbtuh		<65 kbtuh Tier 1	<65 kbtuh Tier 2	<65 kbtuh Tier 3	65-135 kbtuh	>135 kbtuh	<65 kbtuh Tier 1	<65 kbtuh Tier 2	<65 kbtuh Tier 3	65-135 kbtuh	>135 kbtuh	Distribu Free-ri
Distributor 15	11,305	23,791	344	12,346	3,433	38.7%	10%	10%	10%	10%	10%	1,131	2,379	34	1,235	343	
Distributor 12	4,209	76	252	2,654	2,929	7.7%	80%	80%	80%	70%	100%	3,367	61	201	1,858	2,929	
Distributor 16	471	5,541	0	2,984	547	7.2%	50%	20%	10%	40%	40%	236	1,108	0	1,194	219	
Distributor 3	698	3,126	58	3,184	1,206	6.3%	50%	25%	0%	40%	30%	349	782	0	1,274	362	
Distributor 17	306	3,859	23	3,056	724	6.0%	23%	23%	23%	50%	50%	69	868	5	1,528	362	
Distributor 10	1,607	43	84	1,759	3,539	5.3%	10%	10%	10%	10%	10%	161	4	8	176	354	
Distributor 14	566	26	5	709	691	1.5%	100%	100%	100%	100%	100%	566	26	5	709	691	
Distributor 7	1,292	0	10	0	0	1.0%	70%	70%	70%	60%	60%	905	0	7	0	0	
Distributor 18	507	43	13	284	106	0.7%	75%	85%	85%	90%	90%	380	37	11	255	95	
Distributor 9	424	15	123	196	45	0.6%	50%	50%	50%	50%	50%	212	8	61	98	23	
Distributor 13	222	27	0	240	251	0.6%	100%	100%	100%	100%	100%	222	27	0	240	251	
Distributor 1	0	0	0	0	506	< 0.5%	100%	100%	100%	100%	100%	0	0	0	0	506	
Distributor 2	0	0	0	0	443	< 0.5%	0%	0%	0%	0%	25%	0	0	0	0	111	
Distributor 5	244	22	74	7	94	< 0.5%	10%	10%	20%	10%	10%	24	2	15	1	9	
Distributor 4	11	5	0	73	176	< 0.5%	100%	100%	100%	100%	100%	11	5	0	73	176	
Distributor 19	25	23	0	42	172	< 0.5%	10%	10%	10%	10%	10%	3	2	0	4	17	
Distributor 6	180	0	0	0	0	< 0.5%	100%	100%	100%	100%	100%	180	0	0	0	0	
Distributor 11	3	0	0	106	18	< 0.5%	50%	50%	50%	50%	50%	2	0	0	53	9	
Distributor 8	0	0	11	0	16	< 0.5%	0%	0%	0%	0%	0%	0	0	0	0	0	
Overall	22,072	36,596	997	27,641	14,895							7,816	5,309	349	8,697	6,456	
% of total CAC tonnage sold through 04/05 program	81%	93%	67%	78%	51%	**77%**					**Free-ridership estimate**	35%†	15%†	35% †	31%†	43%†	

* Nineteen of the 21 distributors in the sample could provide estimates of free ridership.

† Free-ridership estimates at the CAC size/efficiency category level are not statistically valid and are shown for illustrative purposes only.

Table 6-10 shows the free-ridership estimates for each CAC size/efficiency category as well as the average estimate across all categories. The overall free-ridership rate is 28% (weighted by the tons of CAC for which the sample distributors in the category received incentives). Sample sizes (number of motor distributors) within each CAC size/efficiency category are too small to support statistically-valid estimation for individual categories; these estimates are provided for illustrative purposes only and are combined to yield the program-level estimate of free-ridership for CACs.

The table also shows the NTFR ratio that was derived from the estimate of free ridership across all CAC size/efficiency category. Across all CAC size/efficiency categories, the NTFR ratio is estimated at 72%.

Table 6-10: Free-Ridership Estimates and NTFR Ratios – Overall and by CAC Size/Efficiency Category

Estimate	CAC Size/Efficiency					Overall (All Motor Sizes)
	<65 kBtuh Tier 1	<65 kBtuh Tier 2	<65 kBtuh Tier 3	65-135 kBtuh	>135 kBtuh	
Total rebated CAC tonnage (2004/2005) represented by distributors in sample	22,072	36,596	997	27,641	14,895	102,200
"Free rider" tonnage represented by distributors in sample (n=19)*	7,816	5,309	349	8,697	6,456	28,627
Free ridership rate	35%[†]	15%[†]	35%[†]	31%[†]	43%[†]	**28%**
NTFR Ratio (inverse of free ridership)						**72%**
n (number of distributors)	16	13	11	14	17	19

* Nineteen of the 21 distributors in the sample could provide estimates of free ridership.

† Free-ridership estimates at the motor size level are not statistically valid and are shown for illustrative purposes only.

Free-ridership estimates were also calculated across all CAC size/efficiency categories for each IOU (Table 6-11), but sample sizes (number of CAC distributors) are too small to support statistically valid estimation of free ridership rates at this level of detail. The IOU-level free ridership estimates shown in the table are thus for illustrative purposes only.

Table 6-11: Free-Ridership Estimates by IOU - CAC

IOU	Free-Ridership Estimate	n
PG&E	31%†	15
SCE	27%†	11
SDG&E	20%†	8
Overall	**28%**	**19***

* Nineteen of the 21 distributors in the sample could provide estimates of free ridership.
† Free-ridership estimates at the IOU level are not statistically valid and are shown for illustrative purposes only.

6.4 Discrete Choice Analysis

This section describes the discrete choice modeling methodology that was used to estimate net-of-free-ridership ratios and cross-program effects for the Non-residential Audit (NRA) and Express Efficiency programs. The primary goal of the net-of-free-ridership model presented here is to measure an NRA-only, rebate program-only and combined-program net-of-free-ridership ratio for lighting and HVAC equipment measures. Specifically, the objectives of the net-of-free-ridership model analysis include the following estimates.

- A net-of-free-ridership ratio for measures and practices adopted by NRA participants who were not rebated through the Express Efficiency or SPC Program. This represents the "NRA-only" net-of-free-ridership ratio.
- A net-of-free-ridership ratio for measures adopted by non-NRA customers who were rebated through the Express Efficiency or SPC program. This represents the "Rebate-only" net-of-free-ridership ratio.
- A net-of-free-ridership ratio for measures adopted by NRA participants who were also rebated by the Express Efficiency or SPC Program. This represents the portion of savings that would not have occurred in the absence of both the NRA and the rebate programs.

For different end-use categories, it is expected that a different set of factors may be influential in the purchase and equipment choice decisions. For example, the age of the existing air conditioner may influence the decision to install a new HVAC system, but have no effect on the decision to install lighting. Similarly, the NRA program may have a varying degree of impact on program awareness and equipment purchases depending upon the end-use or customer type. Therefore, three different models were generated for each end-use category to address this variation across lighting and HVAC measures.

The discrete choice modeling was completed using two stages for the linear fluorescent lighting and HVAC models. The first stage models the decision to purchase equipment while the second stage models the choice of actual equipment. A one-stage purchase decision model was used to estimate net-of-free-ridership ratios for CFLs since they are already considered energy efficient.

The final discrete choice methodologies described below are a departure from the model framework that was originally described in the final research plan for this evaluation. The research plan called for a nested logit model specification to estimate the purchase decision. Multiple variations on the nested logit model were attempted but none of these models yielded a well-specified model.[72] Since a correctly specified nested logit model was infeasible, an alternative discrete choice method was adopted which involved estimating the various decision stages separately and then combining the probability results outside the model to determine the net-of-free-ridership ratio. This approach is the same as that used in previous evaluations of the Express Efficiency Program.

The decision tree structure was also modified from the original research plan. The original research plan suggested a decision tree that had three levels: 1) receive an audit [Yes/No], 2) become aware of Express Efficiency/SPC [Yes/No], and 3) purchase equipment [Equipment options, no purchase]. It is believed that part of the difficulty with the nested logit model came from the awareness data available for the second stage.[73] Customers were surveyed several years after they participated in the program which made identifying the actual source of program awareness (NRA audit or otherwise) very difficult to determine. Participants may have also become aware of the Express Program several years prior to participating, which further compounds the difficulty of tracing the source of awareness. Despite these issues, an attempt was made to estimate lighting and HVAC models using awareness rather than purchase as the first stage. As discussed below, this resulted in models that were very sensitive to the variables included. For these reasons, the final discrete choice model omits the awareness stage and, instead, includes awareness as an explanatory variable. The result is a two-stage rather than three-stage model for both linear lighting and HVAC, and a one-stage model for CFLs.

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72 With the nested logit specification, an "inclusive value" coefficient is used to link the different stages of the model. An inclusive value coefficient estimate between 0 and 1 indicates a properly specified model. Despite attempting numerous different specifications and tree structures, the modelers were unable to get inclusive value estimates within this range. For this reason, the nested logit model specification was abandoned in favor of the sequential logit models discussed above.

73 Multiple different nested logit specifications were attempted without the awareness stage, and none of these alternatives yielded valid results, indicating that there were additional problems with using the nested logit model in this application beyond just the problems relating to accurately measuring the source and timing of program awareness.

Data Sources

The data used for discrete choice modeling are a combination of NRA, Express Efficiency, and SPC program tracking and survey data. The sample is divided by equipment end use, and then further separated into three groups for the net-of-free-ridership calculation: customers who participated in the NRA program only, customers who participated in the Express Efficiency or SPC programs only, and customers who participated in both the NRA and a rebate program.

Estimation of Cost, Savings, and Rebates

A requirement of the conditional logit specification is that information must be included in the model for all of the choices in the choice set and not just for the option which is actually selected by the customer. As a result, data on equipment characteristics are needed for all the non-chosen equipment alternatives as well as for the equipment option actually chosen. The method used to calculate these parameters for the non-chosen equipment alternatives is described below. For those customers who installed high-efficiency equipment within the Express Efficiency/SPC program, the cost, savings, and rebate data from the tracking system (if available) are used in the model.

For those customers who installed high efficiency equipment outside of the Express Efficiency program (or are participants who did not have this information stored in the tracking system), installation costs are determined either from cost data contained in the DEER database or program tracking data for those measures that could be easily matched by description. The per-unit costs are multiplied by the reported quantities installed to determine the total cost of the retrofit. When survey responses did not include information on the number of units installed, an estimate was developed from the tracking data based on the average number of units installed by business size and measure type. Data on per unit energy savings for each measure were also collected from the DEER database. These savings were assigned to each measure based on climate zone and building vintage and then multiplied by the actual or estimated number of units installed to get total energy savings for that customer.

For the non-chosen equipment options, cost, savings, and rebate information is assigned similarly based on customer size, climate zone, and other information collected from customer surveys. Costs and savings per unit are taken from the DEER database and rebates are pulled from Express/SPC tracking data. These are then multiplied by the estimated average quantities installed for each business size and measure type. If a person was unaware of the Express/SPC program, the rebate amount is automatically set to zero for all high-efficiency equipment options. The costs, savings, and rebate calculations are summarized as follows.

- *Actual Equipment Option Chosen – In Program.* Uses the reported cost, savings, rebate, and quantity information from Express/SPC tracking data. If this information is not available in the tracking data, estimates were developed based on average values for that measure from other customers in the same size category.
- *Actual Equipment Option Chosen – Outside Program.* Costs and savings are calculated using the reported number of units installed and equipment cost/savings information contained in the DEER database. Where applicable, rebates are calculated using reported quantities installed and known Express rebate amounts.
- *Non-Chosen Equipment Alternative.* Costs-Savings and rebates are estimated for each business size and measure using actual and reported information from tracking and survey data. For those unaware of the rebate program, rebate is set to zero for all program qualifying equipment options.

The remainder of this section presents detailed information on the discrete choice models developed for linear lighting, HVAC, and CFLs.

<u>Linear Fluorescent Lighting Model (Linear Lighting)</u>

The decision to purchase high efficiency lighting is modeled here as two separate probabilities. The probability of purchasing any given equipment option A can be expressed as the product of two separate probabilities: the probability that the customer purchases equipment is multiplied by the probability that equipment option A is chosen given that a purchase is made, which can be expressed as:

$$Prob(Purchase\ \&\ Equip\ A) = Prob(Purchase) \times Prob(Equip\ A \mid Purchase)$$

The two-stage model adopted for this analysis estimates both of the right-hand side probabilities separately. The first stage of the model estimates the probability that a customer purchases equipment and is referred to as the purchase probability. The second stage of the model estimates the type of equipment chosen given that the customer makes a purchase and is referred to as the equipment choice probability. The product of the purchase probability and the equipment choice probability is the total probability and reflects the probability that any one equipment option is purchased, given the decision to purchase equipment. Once estimated, the model is used to determine the probability of purchasing high-efficiency equipment in the absence of the program. This is simulated by setting both the audit and rebate program awareness variables to zero in both stages of model.

An attempt was made to run this model using program awareness (rather than purchase) as the first stage. This specification of the model was extremely sensitive to the variables included, with resulting net-of-free-ridership ratios ranging from 1 to 99% across two different plausible versions of the model. Because of this sensitivity, the purchase decision was used as the first stage instead, as this yielded more stable results across specifications.

The net-of-free-ridership ratio is calculated using the total probability of purchasing high-efficiency equipment both with and without the existence of the programs (NRA and Express Efficiency/SPC). Details of the net-of-free-ridership ratio calculations are covered later in this section.

Characteristics of the sample used to estimate both stages of the lighting model are shown in Table 6-12.

Table 6-12: Linear Lighting Model Sample

Group	Sample Size
Initial Sample	5,999
Observations dropped for Express participants with no rebate data	17
Observations dropped for missing data or for having multiple installations	85
Observations dropped for customers who were not eligible to purchase linear lighting	3,770
Final Sample	2,127
Express/SPC Participants	602
NRA Participants	277
Cross Program Participants	88
Nonparticipants	1,160

Stage 1: Lighting Purchase Model Specification

The purchase model is specified as a logit model with a dependent variable PURCHASE having a value of either zero or one. In this application, customers are given a value of one if they purchased fluorescent lighting equipment and zero if they did not. The purchase model specification is defined as:

$$PURCHASE = \alpha + \beta' X + \gamma' Y + \theta' Z + \varepsilon$$

Variable definitions are given in Table 6-13. The explanatory variables in array X contain information on audit and rebate program awareness that capture the effect of the energy efficiency programs. Customer characteristics such as knowledge of energy efficiency and information-seeking behavior are contained in group Y. Variable group Z contains variables indicating building type and type of lighting. The error term ε is assumed to be distributed logistic consistent with the logit model specification.

The variables AWARENESS and AUDIT are designed to capture the effect of the audit and rebate program on the decision to make a purchase. For AWARENESS, customers are given a value of one if they indicated they were aware of the retrofit program before they selected their lighting equipment. If they became aware of the program after or at the same time they selected the equipment, they are given a value of zero for AWARENESS. This definition of awareness is used to take into account that the process of shopping for equipment will result in some customers becoming aware of the energy efficiency program. When awareness is set to zero to simulate the absence of the program, only those who started shopping after they became aware of the program will be affected since it is assumed that the program influenced them to shop for new equipment. This definition of program awareness avoids the problem of having program awareness affect those customers who were already looking for equipment when they became aware of the program.

Using this restricted definition of awareness, 70% of purchasers were aware of the energy efficiency program at the time they selected their equipment. For those who did not make any purchases, 27% were aware of the program. For the entire sample, 43% of the customers were coded as being aware of the energy efficiency program.

The specification for the logit model used to estimate the linear lighting purchase decision is expressed as follows:

$$PURCHASE = \beta' BLDTYPE + \beta' BLDSIZE + \beta' AUDIT + \beta' AWARE + \\ + \beta' OWN + \beta' INFOSEEK + \varepsilon$$

where

BLDTYPE	=	Vector of dummy variables indicating building type
BLDSIZE	=	Vector of dummy variables indicating building size
AUDIT	=	Audit received through the NRA program
AWARE	=	Aware of the Express/SPC program
OWN	=	Participant owns building
INFOSEEK	=	Participant is an efficiency information seeker based on survey responses
β	=	Coefficients to be estimates
ε	=	Random error term assumed logistically distributed.

Table 6-13: Linear Lighting Purchase Model Variable Definitions

Variable Name	Units	Variable Type	Description
Very_Small	0,1	Z	Very small customer
Small	0,1	Z	Small customer
Medium	0,1	Z	Medium customer
Large	0,1	Z	Large customer
Office	0,1	Z	Office building
Retail	0,1	Z	Retail building
Industrial	0,1	Z	Industrial building
School	0,1	Z	School
Grocery	0,1	Z	Grocery Store
Restaurant	0,1	Z	Restaurant
HealthCare	0,1	Z	Health care facility
Hotel	0,1	Z	Hotel
Warehouse	0,1	Z	Warehouse
Community	0,1	Z	Community building
Awareness	0,1	X	Aware of rebate program prior to purchase
Audit	0,1	X	Customer received an audit through NRA
Own	0,1	Y	Customer owns building
Infoseek	0,1	Y	Customer actively looks for information on energy efficiency

For both the purchase and equipment choice models, several different model alternatives were explored in addition to the final model specifications presented here. The different models indicated the net-of-free-ridership results are generally sensitive to the model specification used. This is likely due in part to the various correlations and interactions across variables (e.g., awareness and audit, building type and lighting, awareness, etc.). The final model specification was chosen as it included variables for the major factors thought to influence both the purchase and equipment choice decision and the estimation results had the expected signs for most of the variables used. These models also omitted some variables (such as rebates) that are highly correlated with variables already included in the model (i.e., savings, which is used to calculate the rebate amount).

Lighting Purchase Model Estimation Results

The estimation results from the purchase model are given in Table 6-14. A likelihood ratio test yields a test statistic of over 971 with 18 degrees of freedom, indicating that the model specification overall has significant explanatory power. The building size variables (VERY_SMALL, SMALL, MEDIUM, LARGE) take the place of an intercept in the model and all are negative and significant. Based on the building type variables, office, retail, school, restaurant, hotel, and warehouse buildings all have statistically significant coefficient estimates. Among these, warehouse facilities and schools are more likely to make a lighting purchase.

As expected, program awareness (AWARENESS) has a strong positive effect on the decision to purchase lighting equipment. The audit program variable (AUDIT) is also positive as expected and statistically significant. Some of the influence of this variable may be captured in the AWARENESS coefficient. Finally, customers who own their own building (OWN) or have actively sought information on energy efficiency (INFOSEEK) are also more likely to make a lighting purchase.

Table 6-14: Linear Lighting Purchase Model Estimation Results

Variable Name	Coefficient Estimate	Standard Error	Significance Level
Very_Small	-2.23	0.20	< 1%
Small	-2.61	0.20	< 1%
Medium	-2.47	0.21	< 1%
Large	-2.33	0.24	< 1%
Office	0.38	0.19	4%
Retail	0.51	0.20	1%
Industrial	-0.078	0.19	68%
School	0.56	0.24	2%
Grocery	0.15	0.35	68%
Restaurant	-0.53	0.30	7%
HealthCare	0.046	0.30	88%
Hotel	-1.81	0.54	< 1%
Warehouse	0.65	0.27	2%
Community	-0.40	0.23	8%
Awareness	1.75	0.12	< 1%
Audit	0.36	0.14	< 1%
Own	0.098	0.12	42%
Infoseek	0.078	0.13	55%

The estimated model parameters are used to calculate the probability of equipment purchase. With the logit model, the probability of purchasing is given by:

$$PROB_{PURCHASE} = \frac{\exp(Q)}{1 + \exp(Q)}$$

$$Where\ Q = \alpha + \beta' X + \gamma' Y + \theta' Z + \varepsilon$$

The probability of making an equipment purchase in absence of the program is calculated by removing the effect of the rebate and NRA programs from the purchase decision model. This is done by setting AWARENESS and AUDIT equal to zero to reflect the absence of both programs. The probability of making a purchase is then recalculated using the logistic density function given above. All other variable values remain the same, as they are not expected to change in absence of the program.

Stage 2: Lighting Equipment Choice Model Specification

The second stage of the model estimates the probability that a specific type of equipment option is chosen given that a linear lighting purchase is made. The choice set for the equipment choice model contains two different fluorescent lighting options: T5/T8s or T10/T12s. In the logit model, customers are given a value of one for the dependent variable for the option they actually chose and a zero for the remaining non-chosen alternative.

The equipment choice model specification is expressed as follows:

$$EQUIPCHOICE = \beta' BLDTYPE + \beta' BLDSIZE + \beta' COST + \beta' SAVINGS + \beta' CINDEX + \beta' AWARE + \varepsilon$$

where

BLDTYPE	=	Vector of dummy variables indicating building type
BLDSIZE	=	Vector of dummy variables indicating building size
COST	=	Total job cost
SAVINGS	=	Annual kWh savings expected from equipment
CINDEX	=	$(Cost - Rebate)/Cost$
AWARENESS	=	Aware of the Express/SPC program
β	=	Coefficients to be estimates
ε	=	Random error term assumed logistically distributed.

The explanatory variables used in the equipment choice model are described in Table 6-15. In this stage of the model, awareness is defined in the same way as stage one: the customer is considered aware of the rebate program (AWARENESS = 1) if they became aware of the program before selecting the lighting equipment.

The variable CINDEX gives the fraction of the cost of the equipment which is paid by the customer and is defined by the cost of the equipment minus any rebate divided by the cost of the equipment. The CINDEX variable indicates that share of the project cost which is not covered by the program rebate. For those who did not purchase equipment or were unaware of the program when the equipment was selected, the expected rebate is zero. This results in a CINDEX value of one since the customer pays the entire cost of the measure. Similarly, for those who made a purchase and are aware of the program, the expected rebate is nonzero and CINDEX takes on a value less than one. For standard efficiency lighting equipment, CINDEX takes a value of one since a rebate is not available for this equipment. Although cost and rebate information is combined into one variable called CINDEX, COST is also included in the model to pick up any effects specifically relating to the total cost of the lighting retrofit, which is not captured in the CINDEX ratio.

A characteristic of the conditional logit specification is that variables that do not vary over choices will drop out of the model. For instance, firmographic variables such as size do not vary across the equipment options and, therefore, cannot be included in the model. One way to avoid this problem is to interact firmographic variables with choice specific dummy variables. This method is used in this application to allow for firm specific variables such as size, building type, and program awareness to influence equipment choice. The variables for building type, customer size, and awareness are all variables interacted with a dummy variable for the high-efficiency equipment options and zero values for the standard-efficiency option in this stage.

Table 6-15: Linear Fluorescent Equipment Choice Model Variable Definitions

Variable Name	Units	Description
Very_Small	0,1	Very small customer (interacted with equip options)
Small	0,1	Small customer (interacted with equip options)
Medium	0,1	Medium customer (interacted with equip options)
Large	0,1	Large customer (interacted with equip options)
Office	0,1	Office building (interacted with equip options)
Retail	0,1	Retail building (interacted with equip options)
Industrial	0,1	Industrial building (interacted with equip options)
Savings	kWh	Annual kWh savings expected from equipment
Cost	dollars	Total job cost of lighting equipment
Cindex	ratio	(Cost-Rebate)/Cost
Awareness	0,1	Awareness of rebate program (interacted with equip options)

Lighting Equipment Choice Model Estimation Results

The estimation results for the equipment choice model are given in Table 6-16. In general, the estimation results conform to expectations. The coefficient estimate on CINDEX is negative, indicating that the greater portion of the installation cost a customer must pay out-of-pocket, the less attractive the equipment option. As expected, the estimate for SAVINGS is positive, while the estimate for COST is negative.

The remaining variables are all interacted with a dummy variable indicating a high-efficiency equipment option. The coefficient estimate on AWARENESS is positive, indicating those who are aware of the rebate program are more likely to purchase high-efficiency equipment. The coefficient estimates for MEDIUM and LARGE are negative and increasing in magnitude, indicating a slight tendency for larger firms to purchase standard efficiency equipment. The remaining variables indicate business type. All three (OFFICE, RETAIL, INDUSTRIAL) have negative coefficient estimates, indicating these customers are less likely to choose T8s.

Table 6-16: Linear Fluorescent Equipment Choice Model Estimation Results

Variable Name	Coefficient Estimate	Standard Error	Significance Level
Very_Small	1.15	9.89	91%
Small	17.23	1,939	99%
Medium	-2.81	42.87	95%
Large	-3.43	52.99	95%
Office	-0.78	0.75	30%
Retail	-0.62	0.78	43%
Industrial	-0.65	0.74	38%
Savings	0.00024	0.0022	91%
Cost	-0.00045	0.0041	91%
Cindex	-7.96	36.60	83%
Awareness	0.91	6.68	89%

Using the coefficient estimates from the purchase model, the probability of choosing any particular equipment option is calculated. Using the conditional logit density function, the probability of selecting equipment option *j* is given by:

$$PROB_{EQUIP\,j} = \frac{\exp(\beta' X_j)}{\sum \exp(\beta' X)}$$

where $\beta' X_j$ is the product of the variables and coefficient estimates used in the equipment choice model for equipment option *j*, and the denominator is the sum of $\beta' X$ across the two equipment options in the choice set.

The equipment choice probability is calculated both with and in absence of the program utilizing the same method applied to the purchase probability. To simulate the absence of the program, AWARENESS is set to zero and CINDEX is set to one for all of the lighting equipment options in the equipment choice stage.

The total probability of choosing high-efficiency equipment option *j* is then the product of the purchase probability and the equipment choice probability for option *j*:

$$PROB_{TOTAL} = PROB_{PURCHASE} \times PROB_{EQUIP\ j}$$

The total probability is then calculated with and without the program variables as described above. The change in the total probability with and without the program variables is used to calculate the net-of-free-ridership ratio and is discussed in more detail at the end of this section.

HVAC Purchase Model

The HVAC purchase model has the same underlying theory as the lighting purchase model. The probability of purchasing any given equipment option A is expressed as the product of the probability of making any equipment purchase and probability of choosing equipment option A given that some purchase is being made:

$$Prob(Purchase\ \&\ Equip\ A) = Prob(Purchase) \times Prob(Equip\ A \mid Purchase)$$

A similar two-stage model is used to estimate both of the right-hand side probabilities separately. As before, the first stage of the model estimates the probability that a customer makes an HVAC purchase and is referred to as the purchase probability. The second stage of the model estimates the type of equipment chosen given that the customer is making a purchase and is referred to as the equipment choice probability. The product of the purchase probability and the equipment choice probability is the total probability and reflects the probability that any one equipment option will be purchased. Once estimated, the model is used to determine the probability of purchasing high-efficiency equipment in the absence of the programs. This is simulated by setting both the audit and rebate program awareness variables to zero in both stages of model. Both stages of the model are estimated using population weights developed from the survey sample size and the respective participant and nonparticipant population sizes.

As with the lighting model, we attempted to run this model using program awareness (rather than purchase) as the first stage. This specification of the model was also very sensitive to the variables included, with resulting net-of-free-ridership ratios ranging from 18 to 66% across two different similar and equally plausible versions of the model. Because of this sensitivity, we used the purchase decision as the first stage since this yielded more stable results across specifications.

Characteristics of the sample used to estimate both stages of the HVAC model are shown in Table 6-17.

Table 6-17: HVAC Model Sample

Group	Sample Size
Initial Sample	2,603
Observations dropped for PTAC purchasers	64
Observations dropped for missing data	79
Final Sample	2,460
Express/SPC Participants	49
NRA Participants	647
Cross Program Participants	74
Nonparticipants	1,690

Stage 1: HVAC Purchase Model Specification

The HVAC purchase model is specified as a logit model with a dependent variable having a value of one if an HVAC purchase is made and zero otherwise. The basic model structure for the purchase stage is as follows:

$$PURCHASE = \alpha + \beta' X + \gamma' Y + \theta' Z + \varepsilon$$

The HVAC model is estimated for split and package unit purchases only, as the other equipment options had very small sample sizes and did not produce reasonable results when included in the model. For this reason, only split and package units were used for the HVAC model.

Variable definitions are given in Table 6-18. The explanatory variables X contain information on audit and rebate program awareness that capture the effect of the energy efficiency programs. Customer characteristics such as knowledge of energy efficiency and information seeking behavior are contained in group Y. Variable group Z contains variables indicating building type and size. The error term ε is assumed to be distributed logistic consistent with the logit model specification.

The variable AUDIT is included to capture the effect of the audit program on the probability of being aware of the rebate program. For AUDIT, customers are given a value of one if they received an audit through the NRA program, otherwise they are assigned a zero value.

Table 6-18: HVAC Purchase Model Variable Definitions

Variable Name	Units	Variable Type	Description
Very_small	0,1	Z	Very small customer
Small	0,1	Z	Small customer
Medium	0,1	Z	Medium customer
Large	0,1	Z	Large customer
Office	0,1	Z	Office building
Retail	0,1	Z	Retail building
Industrial	0,1	Z	Industrial building
School	0,1	Z	School
Grocery	0,1	Z	Grocery Store
Restaurant	0,1	Z	Restaurant
HealthCare	0,1	Z	Health care facility
Hotel	0,1	Z	Hotel
Warehouse	0,1	Z	Warehouse
Community	0,1	Z	Community building
Awareness	0,1	X	Aware of rebate program prior to purchase
Audit	0,1	X	Customer received an audit through NRA
Benefits	0,1	Y	Customer receives benefits of energy savings (pays own utility bills)
EE_Import	0,1	Y	Customer indicates that energy efficiency is important to their business

HVAC Purchase Model Estimation Results

The estimation results for the HVAC purchase model are given in Table 6-19. The model was weighted to the population based on the survey sample sizes and the respective participant and nonparticipant population sizes. A likelihood ratio test (calculated with these sample weights included) yields a test statistic of over 821,851 with 18 degrees of freedom, which is well above the critical value at any of the conventional levels of significance. As expected, AUDIT and AWARENESS have positive and significant effects on the decision to make an HVAC purchase. Business size indicators (VERY_SMALL, SMALL, MEDIUM, LARGE) serve as intercepts in the model and are all negative and significant. Among the building types, grocery stores and schools are more likely to make an HVAC purchase. Offices and warehouses also had positive and significant coefficient estimates; however, the magnitude of these coefficients is smaller. Those customers who receive the benefits of energy savings (BENEFITS), meaning they pay their own utility bills, had a negative and significant estimate. This indicates that customers who have their utility bills paid by a third party (such as a corporate office) are still likely to make an HVAC purchase. Those customers who also indicated energy efficiency was important to them (EE_IMPORT) also were more likely to make a new HVAC purchase.

Table 6-19: HVAC Purchase Model Estimation Results

Variable Name	Coefficient Estimate	Standard Error	Significance Level
Very_small	-3.49	0.02	< 1%
Small	-3.39	0.02	< 1%
Medium	-2.67	0.03	< 1%
Large	-2.59	0.03	< 1%
Office	0.04	0.02	1%
Retail	-1.29	0.03	< 1%
Industrial	-0.83	0.03	< 1%
School	0.76	0.03	< 1%
Grocery	1.26	0.03	< 1%
Restaurant	-0.74	0.04	< 1%
HealthCare	-0.82	0.03	< 1%
Hotel	-2.02	0.13	< 1%
Warehouse	0.06	0.03	3%
Community	-0.25	0.03	< 1%
Awareness	0.27	0.02	< 1%
Audit	0.36	0.02	< 1%
Benefits	-0.12	0.01	< 1%
EE_Import	0.52	0.01	< 1%

The estimated model parameters are used to calculate the purchase probability. With the logit model, the probability of making an HVAC purchase is given by the following expression:

$$PROB_{PURCHASE} = \frac{\exp(Q)}{1+\exp(Q)}$$

$$Where\ Q = \alpha + \beta' X + \gamma' Y + \theta' Z + \varepsilon$$

The probability of an HVAC purchase in absence of the program is calculated by removing the effect of the audit and Express/SPC programs from the purchase model. This is done by setting AUDIT and AWARENESS equal to zero. The purchase probability is then recalculated using the logistic density function given above. All other variable values remain the same as they are not expected to change in absence of the program.

Stage 2: HVAC Equipment Choice Model Specification

The second stage of the model is devoted to estimating the probability that a specific type of equipment option is chosen given that an HVAC purchase is being made. This second stage of the model is specified as a conditional logit and is described below.

The choice set for the equipment choice model includes two options: a high efficiency split or package system and a standard-efficiency split or package system. In the logit model, customers are given a value of one for the dependent variable for the option they actually chose and a zero for the non-chosen alternative.

The equipment choice model specification is expressed as:

$$EQUIPCHOICE = \beta' COST + \beta' SAVINGS + \beta' CINDEX + \varepsilon$$

where

COST	=	Total job cost
SAVINGS	=	Annual kWh savings expected from equipment
CINDEX	=	$(Cost - Rebate)/Cost$
β	=	Coefficients to be estimates
ε	=	Random error term assumed logistically distributed.

The explanatory variables used in the equipment choice model are described in Table 6-20.

Because of the small sample sizes for the HVAC group, we were unable to include choice-specific variables in the equipment choice model as was done in the lighting equipment choice model. We attempted to include these variables, but results became widely divergent depending on which variables were used. Consequently, only those variables that varied across the HVAC equipment options were used in the HVAC equipment choice model.

Cost and rebate information is combined into one variable called CINDEX. As stated previously in the linear fluorescent lighting model, the variable COST is also included to pick up any effects of the total equipment cost on equipment choice not already covered by CINDEX.

For those who were unaware of the rebate program when the equipment was selected, the expected rebate is zero. This results in a CINDEX value of one since the customer pays the entire cost of the measure. Similarly, for those who made a purchase and are aware of the program, the expected rebate is nonzero and CINDEX takes on a value less than one. For the standard efficiency equipment choice, CINDEX takes a value of one since a rebate is not available for this equipment.

Table 6-20: HVAC Equipment Choice Model Variable Definitions

Variable Name	Units	Description
Cost	dollars	Total job cost of lighting equipment
Savings	kWh	Annual amount of kWh savings expected from equipment
Cindex	ratio	(Cost-Rebate)/Cost

HVAC Equipment Choice Model Estimation Results

The estimation results for the equipment choice model are given in Table 6-21. In general, the estimation results conform to expectations. The coefficient estimate on CINDEX is negative and significant, indicating that the greater portion of the installation cost a customer must pay out-of-pocket, the less attractive the equipment option. The estimate for SAVINGS is positive and COST is negative, as would be expected, and both are statistically significant.

Table 6-21: Equipment Choice Model Estimation Results

Variable Name	Coefficient Estimate	Standard Error	Significance Level
Cost	-0.000026	0.000004	< 1%
Savings	0.000017	0.000002	< 1%
Cindex	-7.790650	0.208550	< 1%

Using the coefficient estimates from the awareness model, the probability of choosing any particular equipment option is calculated. Using the conditional logit density function, the probability of selecting equipment option *j* is expressed as:

$$PROB_{EQUIP\,j} = \frac{\exp(\beta' X_j)}{\sum \exp(\beta' X)}$$

where $\beta' X_j$ is the product of the variables and coefficient estimates used in the equipment choice model for equipment option *j*, and the denominator is the sum of $\beta' X$ across the two equipment options in the choice set. To simulate the absence of the audit and rebate programs, CINDEX is set to one for all of the HVAC equipment options.

The total probability of choosing high-efficiency equipment option *j* is then the product of the purchase probability and the equipment choice probability for option *j* is expressed as:

$$PROB_{TOTAL} = PROB_{PURCHASE} \times PROB_{EQUIP\ j}$$

The total probability is then calculated with and without the program variables as described above. The change in the total probability with and without the program variables is used to calculate the net-of-free-ridership ratio and is discussed in more detail at the end of this section.

CFL Model

A one-stage discrete choice model of the decision to purchase CFLs was used to determine the probability of choosing high-efficiency equipment, specifically CFLs, over standard efficiency, incandescent bulbs in this case. The CFL model was weighted to the population using weights developed from the survey sample sizes for participants and nonparticipants and the corresponding population numbers. Once estimated, the model is used to determine the probability of purchasing high-efficiency equipment in the absence of the program. This is simulated by setting both the audit and rebate program awareness variables to zero in the model. Several model specifications were explored and the final specification drops those customers who had abnormally large CFL installations (more than 1000 CFLs) as these outlier observations were having a disproportionate influence over the estimation results.

Characteristics of the sample used to estimate both stages of the HVAC model are shown in Table 6-22.

Table 6-22: CFL Model Sample

Group	Sample Size
Initial Sample	5,999
Observations dropped for Express participants with no rebate data	8
Observations dropped for missing data or having multiple installations	83
Observations dropped for large jobs (> 1000 CFLs)	14
Observations dropped for customers who were not eligible to purchase CFLs	4,332
Final Sample	1,562
Express/SPC Participants	568
NRA Participants	133
Cross Program Participants	110
Nonparticipants	751

Stage 1: CFL Purchase Model Specification

The purchase model is specified as a logit model with a dependent variable having a value of either zero or one. In this application, customers are given a value of one if they purchased CFLs and zero if they did not. The purchase model specification is defined as:

$$PURCHASE = \alpha + \beta' X + \gamma' Y + \theta' Z + \varepsilon$$

The CFL model variable definitions are given in Table 6-23. The explanatory variables X contain information on audit and rebate program awareness that capture the effect of the energy efficiency programs. Customer characteristics such as knowledge of energy efficiency and information seeking behavior are contained in group Y. Variable group Z contains variables indicating building type and type of lighting. The error term ε is assumed to be distributed logistic consistent with the logit model specification.

The variable definitions and rationale for using them in the CFL model is the same as for the linear lighting and HVAC models. The variables AWARENESS and AUDIT are specified to capture the effect of the audit and rebate programs on the decision to make a purchase. Customers are given a value of one for AWARENESS if they indicated they were aware of the retrofit program before they selected their lighting equipment. If they became aware of the program after or at the same time they selected the equipment, they are given a value of zero for AWARENESS. This definition of awareness is used to take into account that the process of shopping for equipment will result in some customers becoming aware of the energy efficiency program. When awareness is set to zero to simulate the absence of the program, only those who started shopping after they became aware of the program will be affected since it is assumed the program influenced them to shop for new equipment.

Using this definition of awareness, 86% of CFL purchasers were aware of the energy efficiency program at the time they selected their equipment. For those who did not make any purchases, 30% were aware of the program. For the entire sample, 50% of the customers were aware of the energy efficiency program.

Table 6-23: CFL Purchase Model Variable Definitions

Variable Name	Units	Variable Type	Description
Office	0,1	Z	Office building
Retail	0,1	Z	Retail building
Industrial	0,1	Z	Industrial building
School	0,1	Z	School
Grocery	0,1	Z	Grocery
Restaurant	0,1	Z	Restaurant
HealthCare	0,1	Z	Health care facility
Warehouse	0,1	Z	Warehouse
Very_Small	0,1	Y	Very small customer
Small	0,1	Y	Small customer
Medium	0,1	Y	Medium customer
Large	0,1	Y	Large customer
Net_cost	0,1	X	Cost- Rebate
EEimport	0,1	Y	Customer indicates that energy efficiency is important to their business
Infoseek	0,1	Y	Customer actively looks for information on energy efficiency
Awareness	0,1	X	Aware of rebate program prior to purchase
Audit	0,1	X	Audit received through the NRA program
Aware_other	0,1	Y	Aware of other energy efficiency programs
Benefits	0,1	Y	Customer receives benefits of energy savings (pays own utility bills)

CFL Purchase Model Estimation Results

The estimation results from the CFL purchase model are given in Table 6-24. A likelihood ratio test yields a test statistic of over 278,440 with 19 degrees of freedom, which is well above the critical value and indicates the model has significant explanatory power. As expected, program awareness (AWARENESS) has a positive effect on the decision to purchase CFLs. Receiving an audit also has a positive effect on the CFL purchase decision and is also statistically significant. Based on the building type coefficient estimates, industrial is the building type that was most likely to make a CFL purchase. All of the other variables except GROCERY, including the building type and customer size variables, were all statistically significant in this model. The customer size variables are all negative with the estimate for small size having the largest magnitude. Finally, the NET_COST variable (reflecting CFL cost net of the program incentive) is positive and statistically significant.

Table 6-24: CFL Purchase Model Estimation Results

Variable Name	Coefficient Estimate	Standard Error	Significance Level
Office	0.11	0.024	< 1%
Retail	0.089	0.025	< 1%
Industrial	0.46	0.03	< 1%
School	0.25	0.044	< 1%
Grocery	0.021	0.086	81%
Restaurant	-1.07	0.031	< 1%
HealthCare	-1.12	0.043	< 1%
Warehouse	0.93	0.031	< 1%
Very_Small	-3.47	0.027	< 1%
Small	-4.35	0.031	< 1%
Medium	-3.41	0.043	< 1%
Large	-3.94	0.060	< 1%
Net_cost	0.00011	0.0000089	< 1%
EEimport	-0.076	0.017	< 1%
Infoseek	-0.15	0.017	< 1%
Awareness	1.60	0.018	< 1%
Audit	2.15	0.019	< 1%
Aware_other	0.70	0.021	< 1%
Benefits	0.39	0.017	< 1%

The estimated model parameters are used to calculate the probability of purchase. With the logit model, the probability of purchasing is given by the following expression:

$$PROB_{PURCHASE} = \frac{\exp(Q)}{1 + \exp(Q)}$$

where

$$Q = \alpha + \beta' X + \gamma' Y + \theta' Z + \varepsilon$$

The probability of making an equipment purchase in absence of the program is calculated by removing the effect of the energy efficiency program from the purchase decision model. This is done by setting AWARENESS and AUDIT equal to zero and adding back the rebate amount to the NETCOST variable. The probability of making a purchase is then recalculated using the logistic density function given above using the new variable values that simulate the absence of the program. All other variable values remain the same as they are not expected to change in absence of the program.

Net-of-Free-Ridership Calculation

Once both the purchase probability and the equipment choice probability are estimated, the two probabilities are multiplied together to determine the total probability that an individual equipment option is selected, given a purchase is made. This total probability is calculated twice. First, the total probability is calculated using the original values for the program variables AUDIT, AWARENESS, and CINDEX (or NETCOST). This gives the total probability with the existence of the program. Next, the total probability is calculated in absence of the program. This is done by setting AUDIT and AWARE equal to zero and CINDEX equal to one to reflect the absence of rebates. If the model uses the NETCOST variable (as in the HVAC and CFL models), the value is adjusted adding back in the rebate amount so that NETCOST reflects the full cost of the installation without any program incentive.

The estimated net-of-free-ridership ratios are based on the probability of purchasing high efficiency measures with and without the program.

$$NTG = \frac{PROB^{W}_{TOTAL\,j} - PROB^{WO}_{TOTAL\,j}}{P^{W}_{TOTAL\,j}}$$

Where

$PROB^{W}_{TOTAL_j}$ = Probability of choosing option *j* with the rebate program.

$PROB^{WO}_{TOTAL\,j}$ = Probability of choosing option *j* in the absence of the rebate program.

The estimated net-of-free-ridership impacts are weighted up to the population based on the survey sample sizes. Participants are weighted to reflect either the NRA or Express Efficiency/SPC participant population. Nonparticipants are assigned weights based on the nonparticipant population represented in the sample. For NRA participants, weights were assigned based on size, utility, and type of audit. Weights for Express/SPC participants and all nonparticipants were assigned based on size and utility.

The resulting net-of-free-ridership ratios using this calculation are shown in Table 6-25.

Table 6-25: Estimated NTFR Ratios

Measure Type	NRA Participants	Express Participants	Cross-program Participants
CFLs	0.88	0.77	0.93
T5/T8s	0.79	0.76	0.80
Split and Packaged A/C	0.44	0.58	0.60

6.5 Conclusions and Recommendations

The results of the Express Program self-report (both participant and upstream) and discrete choice analyses are presented in Table 6-26.

Table 6-26: Estimated NTFR Ratios for Express Program Measures – Self-Report versus Discrete

Measure Type	Self-Report Express Participants	Self-Report Upstream	Discrete Choice Express Participants
Lighting			
CFLs	81%		77%
T8_T5s	78%		76%
LED Exit Signs	77%		
Occupancy Sensors	78%		
HVAC			
Programmable Thermostats	76%		
PTACs	74%		
Reflective Window Film	59%		
Splt/Packgd A/C Systems	N/A	72%	58%
Refrigeration			
Curtains	46%		
Door Gaskets	76%		
Motors	N/A	46%	

There were only three measures for which both the discrete choice and self-report analyses were completed – CFLs, T8s and split and packaged A/Cs. A description follows of how a final NTFR ratio was developed for measures that had multiple estimates of NTFR ratios.

For CFLs, the self-report value for free ridership was a bit lower than the discrete choice analysis result, 0.19 versus 0.23 (or NTFRs of 0.81 and 0.77). However, we are concerned that the discrete choice result may be biased (providing a higher free-ridership value), because it is not properly accounting for the effects of the upstream CFL lighting program which has been in place for the past several years. The upstream CFL lighting program has been focused on the residential sector, providing rebates at the retailer and manufacturer level, driving down prices significantly. It is expected that commercial customers (or their vendors) are purchasing some of these discounted lamps and installing them in their business. The discrete choice model is not able to account for this, as many customers are not aware if they received discounted bulbs (especially if a vendor installed them). Therefore, there are likely some nonparticipants in the model that are CFL adopters who received discounted bulbs through the upstream program.[74] One would expect the number of these adopters to have decreased if the upstream program was not in place. The higher number of nonparticipant adopters will likely have the affect of increasing the baseline likelihood of adopting CFLs, which will, in turn, dampen the affects of the rebate and awareness on the model. Because of this, using the self-report value for free ridership is recommended.

For T8s, the self-report and discrete choice analyses validated each other with nearly the same result, a free-ridership value of 0.22 for self-report and 0.24 for discrete choice (or NTFR ratio of 0.78 and 0.76). Because the two values are so close, we recommend averaging the two values for a NTFR ratio of 0.77.

For A/Cs, the self report NTFR ratio was higher at 72%, compared to a value of 58% based on the discrete choice approach. However, the discrete choice analysis for A/Cs could also suffer from the similar upstream issues faced by CFLs. The tracking data do not always identify the end user receiving the A/C, and it is possible that customers who are surveyed may not be aware they received an upstream discounted unit. Therefore, it is possible that the NTFRR based on the discrete choice analysis for A/Cs may be biased downwards. Furthermore, we are relying on the customer's self-report to tell us if the nonparticipating A/C adoptions are high efficiency or standard efficiency. It may be difficult for respondents to understand this difference, and customers may think of their standard unit being high efficiency because it is more efficient than their old unit. If there is a bias in the nonparticipant respondent's ability to accurately report the efficiency of a recently purchased A/C, it would have an effect on the model results. If nonparticipants over-reported their efficiency, it would likely have the effect of overstating free ridership as it increases the baseline likelihood of purchasing high-efficiency equipment. Because of these issues, we recommend using the upstream self report result of 72%.

Table 6-27 presents the final NTFR ratios recommended. Upstream and downstream results are presented separately, so that an overall downstream Express Efficiency NTFR ratio (and overall downstream HVAC value) can be presented. We felt that if these values are used for future planning and analysis, it would be important to separate out the two delivery mechanisms.

Self report results were also generated for all other measures not included in the measure-specific table below, but were grouped into the following categories due to small sample sizes: other lighting, other HVAC, other refrigeration, other water heating and miscellaneous

74 In 2004-05, the residential upstream lighting program rebated on the order of 20 million CFLs. This compares to only 1 million bulbs under Express. Therefore, if just 5% of the upstream bulbs went to nonresidential customers, there would be as many upstream CFLs in nonresidential as there are downstream through Express.

other. These values are not presented in the table below as they are generally based on small sample sizes and are not measure specific. However, these values were used to develop the overall NTFR presented below. In order to develop net ex post savings, the NTFR ratios were applied consistently to all measures within each of these "other" categories. However we do not recommend using these "other" category NTFR ratios outside of this evaluation as they were not developed at the measure specific level.

Table 6-27: Final Estimated NTFR Ratios

	Downstream NTFR Ratio	Upstream NTFR Ratio
Overall Express	75%	
Lighting		
CFLs	81%	
T8_T5s	78%	
LED Exit Signs	77%	
Occupancy Sensors	78%	
HVAC		
Programmable Thermostats	76%	
PTACs	74%	
Reflective Window Film	59%	
Splt/Packgd A/C Systems		72%
Refrigeration		
Curtains	46%	
Door Gaskets	76%	
Motors		46%

It is interesting to note the free-ridership values have not changed dramatically for lighting overall, since the evaluation of PG&E's pre-1998 Retrofit Express Program, which was the precursor to the Statewide Express Efficiency program. As part of the evaluation, both self-report and discrete choice analyses were conducted. For T8s, self-reported free-ridership was found to be 0.22 (screw-in CFLs were not rebated at that time). It is important to note in the pre-1998 program, the average size of a participant was larger than those typically participating in 2004-05. In the more recent years, programs have targeted smaller, harder to reach customers. During the 1990s, measures such as T-8s were not as saturated and were still considered more "emerging." Therefore, it is not surprising that free-ridership values nearly 10 years ago have not changed dramatically, as products have matured and the target market has focused on harder to reach markets.

HVAC is more difficult to compare, which was also evaluated as part of the PG&E's pre-1998 Retrofit Express Program. At that time, split and packaged A/C systems were rebated downstream, instead of upstream. And instead of programmable thermostats, set-back thermostats were rebated. For A/Cs, the self-reported value for free ridership was 0.68 and the discrete choice value was 0.27 (again this was a downstream program). For set-back thermostats, only a self-report analysis was done, resulting in a free-ridership value of 0.39.

7

Overall Savings Analysis

The overall savings analysis presents the ex post net first year and lifetime savings and the first year and overall realization rates for the 2004-05 California Statewide Express Efficiency and Upstream HVAC and Motors programs. Sections 4 and 5 presented the impact evaluations for each of the programs while Section 6 presented the net-of-free-ridership analysis. The results from these three sections are synthesized here to arrive at the final estimates of ex post net program savings and overall program realization rates.[75] First, the inputs used in the calculation of ex post net savings are presented. The results section follows with tables showing the first year and lifetime savings and first year and overall realization rates for the Express and Upstream programs by IOU and funding source.

7.1 Input Tables

The inputs to the calculation of ex post net energy and demand savings and program realization rates include: on-site verification realization rates for lighting and non-lighting measures in Express (not for the Upstream program, however, since onsite verification was not carried out), engineering and billing analysis realization rates, ex ante and ex post net-of-free-ridership ratios, and ex ante and ex post expected useful life (EUL) estimates.

7.1.1 On-Site Verification Realization Rates

The following two tables present the on-site verification realization rates. Table 7-1 presents the verification realization rates for CFLs, T8/T5s, and high bays by facility type. Table 7-2 shows the verification rates for other lighting and non-lighting measures. These verification rates are applied across all the California IOUs. For measures that were not verified during onsite visits, a verification realization rate of 1 is assumed.

[75] Program realization rates for energy savings are taken as the ratio of ex post net energy savings and ex ante gross energy savings.

Table 7-1: On-Site Verification Rates for Lighting Measure Types

Facility Type	Verification Rate		
	CFL	T8	High Bay T5
College/University	0.95	1.00	0.46
Community Service	0.77	1.00	0.98
Grocery	0.67	0.93	1.00
Health Care/Hospital	0.92	0.98	1.00*
Hotel/Motel	0.92	1.00*	1.00*
Misc. Commercial	0.81	0.86	0.79
Office	0.77	0.93	0.99
Personal Service	0.67	1.00	1.00
Restaurant	0.78	0.99	1.00*
Retail	0.93	0.96	0.99
School	0.44	0.99	1.00

* A verification rate of 1 is assumed when none were verified on-site.

Table 7-2: On-Site Verification Rates for Other Lighting and Non-Lighting Measure Types

End Use	Measure Group	Verification Rate
Agriculture	Ag Process	1.00*
Agriculture	Efficient Irrigation	1.00*
Agriculture	Greenhouse Heat Curtain	1.00
Agriculture	Infrared Film for Greenhouses	1.00
Food Service	Ice Machine	1.00*
Food Service	Insulated Holding Cabinet	1.00*
Food Service	Pressureless Steamer	1.00*
Refrigeration	Anti-Sweat Heater Controls	0.78
Refrigeration	Auto Closer	1.00
Refrigeration	Chillers	1.00*
Refrigeration	Cooler/Freezer Door Gaskets	0.86
Refrigeration	Efficient Condenser - Air Cooled	1.00*
Refrigeration	Efficient Condenser – Evap. Cooled	1.00*
Refrigeration	Efficient Condenser - Multiplex	1.00*
Refrigeration	Efficient Evaporator Fan Motors - ECM	1.00*
Refrigeration	Efficient Evaporator Fan Motors - PSC	1.00*
Refrigeration	Evaporator Fan Controller	1.00*
Refrigeration	Glass Doors - Low Temp	1.00*

Table 7-2: (cont'd.) On-Site Verification Rates for Other Lighting and Non-Lighting Measure Types

End Use	Measure Group	Verification Rate
Refrigeration	Glass Doors - Med Temp	1.00*
Refrigeration	HE Low Temp Reach-in Display Case with Special Doors	1.00*
Refrigeration	New Refrigeration Case With Doors - Low Temp	1.00
Refrigeration	New Refrigeration Case With Doors - Med Temp	0.97
Refrigeration	Night Covers	1.03
Refrigeration	Refrigerator	1.00*
Refrigeration	Special Doors with Low/No ASH Controls	1.00*
Refrigeration	Strip Curtains for Walk-ins	1.23
Refrigeration	Suction Line Insulation	1.00*
Refrigeration	Vending Machine Controller	1.00*
Retro Commissioning	Retro Commissioning	1.00*
Water Heating	Boiler, Water	1.00
Water Heating	Clothes Washer	0.92
Water Heating	Commercial Pool Heater	1.00*
Water Heating	Economizer	1.00*
Water Heating	Gas Storage Water Heater	1.00*
Water Heating	Instantaneous Water Heater - Gas	1.00*
Water Heating	Pipe Insulation	1.00
Water Heating	Space Heating Boilers	1.00*
Water Heating	Spray Nozzle	1.00*
Water Heating	Steam Boiler, Process	1.00*
Water Heating	Tank Insulation	0.99
Water Heating	Water Boiler, Process	1.00
Lighting-Other	Lighting-Other	0.90
Motors	Motors	1.00*
HVAC	Packaged A/C	1.00*
HVAC	Cool Roofs	1.01
HVAC	Evaporative Coolers	1.00*
HVAC	Refrigerant Charge Adjustment	1.00*
HVAC	VSD - AHU	1.37
HVAC	Window Film	1.05
HVAC	Programmable Thermostats	0.93
HVAC	PTAC	1.00*

* A verification rate of 1 is assumed when none were verified on-site.

7.1.2 Engineering Realization Rates

The engineering realization rates for measures rebated through the Express and Upstream programs are presented in Table 7-3 and Table 7-4. Table 7-3 shows the kWh engineering realization rates for CFLs, T8/T5s, and high bays by facility type and IOU. Table 7-4 provides the kWh and therm engineering realization rates for non-lighting measures by utility. For measures that were not audited during onsite visits, an engineering realization rate of 1 is assumed.

Table 7-3: Engineering Realization Rates for Lighting Measures

Measure Group	Facility Type	PGE KWh	SCE KWh	SDGE KWh
Lighting-T-8/T-5, Elec Bal, Delamp	College/University	0.69	0.76	0.67
Lighting-T-8/T-5, Elec Bal, Delamp	Community Service	0.73	0.87	0.77
Lighting-T-8/T-5, Elec Bal, Delamp	Grocery	0.78	1.26	1.11
Lighting-T-8/T-5, Elec Bal, Delamp	Health Care/Hospital	0.57	0.73	0.64
Lighting-T-8/T-5, Elec Bal, Delamp	Hotel/Motel	1.00	1.54	1.35
Lighting-T-8/T-5, Elec Bal, Delamp	Misc. Commercial	0.73	0.87	0.77
Lighting-T-8/T-5, Elec Bal, Delamp	Office	0.50	0.57	0.50
Lighting-T-8/T-5, Elec Bal, Delamp	Personal Service	0.73	0.87	0.77
Lighting-T-8/T-5, Elec Bal, Delamp	Restaurant	0.84	1.09	0.96
Lighting-T-8/T-5, Elec Bal, Delamp	Retail	0.55	0.67	0.59
Lighting-T-8/T-5, Elec Bal, Delamp	School	1.25	0.76	0.67
Lighting-T-8/T-5, Elec Bal, Delamp	Warehouse	0.66	0.61	0.53
High Bay T5	College/University	0.69	0.76	0.67
High Bay T5	Community Service	0.73	0.87	0.77
High Bay T5	Grocery	0.78	1.26	1.11
High Bay T5	Health Care/Hospital	0.57	0.73	0.64
High Bay T5	Hotel/Motel	1.00	1.54	1.35
High Bay T5	Misc. Commercial	0.73	0.87	0.77
High Bay T5	Office	0.50	0.57	0.50
High Bay T5	Personal Service	0.73	0.87	0.77
High Bay T5	Restaurant	0.84	1.09	0.96
High Bay T5	Retail	0.55	0.67	0.59
High Bay T5	School	1.25	0.76	0.67
High Bay T5	Warehouse	0.66	0.61	0.53
Lighting-CFL	College/University	0.71	0.79	0.69
Lighting-CFL	Community Service	0.76	0.90	0.79
Lighting-CFL	Grocery	0.44	0.71	0.62
Lighting-CFL	Health Care/Hospital	0.58	0.74	0.65
Lighting-CFL	Hotel/Motel	0.72	1.11	0.98

Table 7-3: (cont'd.) Engineering Realization Rates for Lighting Measures

Measure Group	Facility Type	PGE KWh	SCE KWh	SDGE KWh
Lighting-CFL	Misc. Commercial	0.76	0.90	0.79
Lighting-CFL	Office	0.54	0.62	0.54
Lighting-CFL	Personal Service	0.76	0.90	0.79
Lighting-CFL	Restaurant	1.15	1.50	1.32
Lighting-CFL	Retail	0.80	0.97	0.86
Lighting-CFL	School	1.29	0.79	0.69
Lighting-CFL	Warehouse	1.00	0.92	0.81
Lighting-Other	All	1.00	1.00	1.00

Table 7-4: Engineering Realization Rates for Non-Lighting Measures

End Use	Measure Group	PGE KWh	SCE KWh	SDGE KWh	PGE Therm	SCG Therm	SDGE Therm
Agriculture	Ag Process	1.00	1.00	1.00			
Agriculture	Efficient Irrigation	1.00	1.00	1.00			
Agriculture	Greenhouse Heat Curtain				0.85	0.85	0.85
Agriculture	Infrared Film for Greenhouses				1.00	1.00	1.00
Food Service	Ice Machine	1.00	1.00	1.00			
Food Service	Insulated Holding Cabinet	1.00	1.00	1.00			
Food Service	Pressureless Steamer	1.00	1.00	1.00			
Refrigeration	Anti-Sweat Heater Controls	0.98	0.98	0.98			
Refrigeration	Auto Closer	0.76	0.76	0.76			
Refrigeration	Chillers	1.00	1.00	1.00			
Refrigeration	Cooler/Freezer Door Gaskets	0.89	0.89	0.89			
Refrigeration	Efficient Condenser - Air Cooled	1.00	1.00	1.00			
Refrigeration	Efficient Condenser - Evap Cooled	1.00	1.00	1.00			
Refrigeration	Efficient Condenser - Multiplex	1.00	1.00	1.00			
Refrigeration	Efficient Evaporator Fan Motors - ECM	1.00	1.00	1.00			
Refrigeration	Efficient Evaporator Fan Motors - PSC	1.00	1.00	1.00			
Refrigeration	Evaporator Fan Controller	1.00	1.00	1.00			
Refrigeration	Glass Doors - Low Temp	1.00	1.00	1.00			
Refrigeration	Glass Doors - Med Temp	1.00	1.00	1.00			
Refrigeration	HE Low Temp Reach-in Display Case with Special Doors	1.00	1.00	1.00			
Refrigeration	New Refrigeration Case With Doors - Low Temp	1.10	1.10	1.10			

Table 7-4: (cont'd.) Engineering Realization Rates for Non-Lighting Measures

End Use	Measure Group	PGE KWh	SCE KWh	SDGE KWh	PGE Therm	SCG Therm	SDGE Therm
Refrigeration	New Refrigeration Case With Doors - Med Temp	1.10	1.10	1.10			
Refrigeration	Night Covers	1.77	1.77	1.77			
Refrigeration	Refrigeration	1.00	1.00	1.00			
Refrigeration	Special Doors with Low/No ASH Controls	0.98	0.98	0.98			
Refrigeration	Strip Curtains for Walk-ins	0.32	0.32	0.32			
Refrigeration	Suction Line Insulation	1.00	1.00	1.00			
Refrigeration	Vending Machine Controller	1.00	1.00	1.00			
Retro Commissioning	Retro Commissioning	1.00	1.00	1.00	1.00	1.00	1.00
Water Heating	Boiler, Water				1.43	1.43	1.43
Water Heating	Clothes Washer	1.17	1.17	1.17	1.17	1.17	1.17
Water Heating	Commercial Pool Heater				1.00	1.00	1.00
Water Heating	Economizer	1.00	1.00	1.00			
Water Heating	Gas Storage Water Heater				1.00	1.00	1.00
Water Heating	Instantaneous Water Heater - Gas				1.00	1.00	1.00
Water Heating	Pipe Insulation				1.00	1.00	1.00
Water Heating	Space Heating Boilers				1.00	1.00	1.00
Water Heating	Spray Nozzle				1.00	1.00	1.00
Water Heating	Steam Boiler, Process				1.00	1.00	1.00
Water Heating	Tank Insulation				2.01	2.01	2.01
Water Heating	Water Boiler, Process				0.76	0.76	0.76
HVAC-A/Cs	Packaged A/C	0.92	0.56	0.65			
HVAC-A/Cs	PTAC	1.00	1.00	1.00			
HVAC-Other	Cool Roofs	1.00	1.00	1.00	1.00	1.00	1.00
HVAC-Other	Evaporative Coolers	1.00	1.00	1.00	1.00	1.00	1.00
HVAC-Other	Refrigerant Charge Adjustment	1.00	1.00	1.00	1.00	1.00	1.00
HVAC-Other	VSD - AHU	1.00	1.00	1.00	1.00	1.00	1.00
HVAC-Other	Window Film	0.82	0.82	0.82	1.00	1.00	1.00
HVAC-Other	Programmable Thermostats	0.02	0.02	0.02	0.02	0.02	0.02
Motors	0-10 hp Motor	0.41	0.37	0.27	0.48	0.41	0.28
Motors	100-149 hp Motor	0.16	0.12	0.10	0.13	0.14	0.07
Motors	11-25 hp Motor	0.41	0.37	0.27	0.48	0.41	0.28
Motors	150-249 hp Motor	0.16	0.12	0.10	0.13	0.14	0.07
Motors	26-99hp Motor	0.13	0.10	0.09	0.13	0.10	0.07

7.1.3 Billing Analysis Realization Rates

The billing analysis realization rates for select measures are presented in Table 7-5. Billing realization rates were used to adjust savings for lighting, programmable thermostats, strip curtains, and other refrigeration measures by facility type. If no billing analysis realization rate is presented for a measure or measure group, it is assumed to equal one in the estimation of ex post net energy and demand savings.

Table 7-5: Billing Analysis Realization Rates by Measure Group and Facility Type

Measure Group	Facility Type	Realization Rate
Lighting	College/University	0.63
Lighting	Community Service	0.83
Lighting	Grocery	0.63
Lighting	Health Care/Hospital	0.63
Lighting	Hotel/Motel	0.09
Lighting	Misc. Commercial	0.63
Lighting	Office	0.51
Lighting	Personal Service	0.63
Lighting	Restaurant	1*
Lighting	Retail	1.69
Lighting	School	0.63
Lighting	Warehouse	0.63
HVAC-Programmable Thermostats	Hotel/Motel	12.15
HVAC-Programmable Thermostats	All Other Building Types	1*
Refrigeration – All except Strip Curtains	All	0.95
Refrigeration - Strip Curtains for Walk-ins	All	1*

* These represent the realization rates used in the estimation of ex post net energy and demand savings and may differ from the results presented in the billing analysis. Billing analysis realization rates of 1 were assumed when the estimated coefficients were not significant at the 85% confidence interval. Also note that in the billing analysis, the estimated coefficients are negative, but are presented as positive realization rates here.

NTFR RatiosTable 7-6 provides the ex ante and ex post net-of-free-ridership ratios used in the calculation of ex ante and ex post gross and net savings for both the Express and Upstream programs. Note that for some measure groups, the IOUs relied upon different ex ante net-of-free-ridership ratios. However, ex post NTFR ratios were applied uniformly across all of the California IOUs.

Table 7-6: Ex Ante and Ex Post Net-of-Free-Ridership Ratios

End Use	Measure Group	PGE Ex-Ante	SCE Ex-Ante	SCG Ex-Ante	SDGE Ex-Ante	Ex-Post
Agriculture	*Ag Process**	0.96	0.96	0	0.96	*0.57*
Agriculture	*Efficient Irrigation**	0.96	0.96	0	0.96	*0.57*
Agriculture	*Greenhouse Heat Curtain**	0.96	0	0.96	0.96	*0.57*
Agriculture	*Infrared Film for Greenhouses**	0.96	0	0.96	0.96	*0.57*
Food Service	*Ice Machine**	0.96	0.96	0	0.96	*0.57*
Food Service	*Insulated Holding Cabinet**	0.96	0.96	0	0.96	*0.57*
Food Service	*Pressureless Steamer**	0.96	0.96	0	0.96	*0.57*
HVAC-A/Cs	PTAC	0.96	0.96	0	0.96	0.74
HVAC-A/Cs	Packaged A/C	0.96	0.96	0	0.8	0.72
HVAC-Other	*Cool Roofs**	0.96	0.96	0	0.96	*0.59*
HVAC-Other	*Evaporative Coolers**	0.96	0.96	0	0.96	*0.59*
HVAC-Other	Programmable Thermostats	0.96	0.96	0.96	0.96	0.76
HVAC-Other	*Refrigerant Charge Adjustment**	0.96	0.96	0.96	0.96	*0.59*
HVAC-Other	*VSD – AHU**	0.96	0.96		0.96	*0.59*
HVAC-Other	Window Film	0.96	0.96		0.96	0.59
Lighting-CFL	CFL	0.96	0.96		0.96	0.81
Lighting-Other	*Ceramic Metal Halide**	0.96	0.96		0.96	*0.75*
Lighting-Other	*Induction Fixture**	0.96	0.96		0.96	*0.75*
Lighting-Other	*LED Exit Sign**	0.96	0.96		0.96	*0.77*
Lighting-Other	*LED Signs**	0.96	0.96		0.96	*0.75*
Lighting-Other	*Lighting**	0.96	0.96		0.96	*0.75*
Lighting-Other	*Metal Halide Ext – IncanBase**	0.96	0.96		0.96	*0.75*
Lighting-Other	*Metal Halide Ext – MVBase**	0.96	0.96		0.96	*0.75*
Lighting-Other	*Metal Halide Int – IncanBase**	0.96	0.96		0.96	*0.75*
Lighting-Other	*Metal Halide Int – MVBase**	0.96	0.96		0.96	*0.75*
Lighting-Other	Occ-Sensor - Ceiling	0.96	0.96		0.96	0.78
Lighting-Other	Occ-Sensor - High Bay	0.96	0.96		0.96	0.78
Lighting-Other	Occ-Sensor - Plug Load	0.96	0.96		0.96	0.78

* Self report results were generated for all other measures not included in the Table 6-27, but were grouped into the following categories due to small sample sizes: other lighting, other HVAC, other refrigeration, other water heating and miscellaneous other. These values are not presented in Table 6-27 as they are generally based on small sample sizes and are not measure specific. We do not recommend using these "other" category NTFR ratios outside of this evaluation as they were not developed at the measure specific level. See Section 6.5 for more detail on how the NTFR values were assigned.

Table 7-6: (cont'd.) Ex Ante and Ex Post Net-of-Free-Ridership Ratios

End Use	Measure Group	PGE Ex-Ante	SCE Ex-Ante	SCG Ex-Ante	SDGE Ex-Ante	Ex-Post
Lighting-Other	Occ-Sensor - Wall box	0.96	0.96		0.96	0.78
Lighting-Other	*Photocells**	0.96	0.96		0.96	*0.75*
Lighting-Other	*Pulse Start Metal Halide**	0.96	0.96		0.96	*0.75*
Lighting-Other	*Time Clock**	0.96	0.96		0.96	*0.75*
Lighting-T-8/T-5, Elec Bal, Delamp	Delamp	0.96	0.96		0.96	0.78
Lighting-T-8/T-5, Elec Bal, Delamp	Electronic Ballast	0.96	0.96		0.96	0.78
Lighting-T-8/T-5, Elec Bal, Delamp	Electronic Ballast, Dimming	0.96	0.96		0.96	0.78
Lighting-T-8/T-5, Elec Bal, Delamp	High Bay T5	0.96	0.96		0.96	0.78
Lighting-T-8/T-5, Elec Bal, Delamp	Misc - Lighting	0.96	0.96		0.96	0.78
Lighting-T-8/T-5, Elec Bal, Delamp	T8 El Ballast	0.96	0.96		0.96	0.78
Motors	Motors	0.96	0.96		0.8	0.46
Refrigeration	*Anti-Sweat Heater Controls**	0.96	0.96		0.96	*0.29*
Refrigeration	*Auto Closer**	0.96	0.96		0.96	*0.29*
Refrigeration	*Chillers**	0.96	0.96		0.96	*0.29*
Refrigeration	Cooler/Freezer Door Gaskets	0.96	0.96		0.96	0.76
Refrigeration	*Efficient Condenser - Air Cooled**	0.96	0.96		0.96	*0.29*
Refrigeration	*Efficient Condenser - Evap Cooled**	0.96	0.96		0.96	*0.29*
Refrigeration	*Efficient Condenser – Multiplex**	0.96	0.96		0.96	*0.29*
Refrigeration	*Efficient Evaporator Fan Motors – ECM**	0.96	0.96		0.96	*0.29*
Refrigeration	*Efficient Evaporator Fan Motors – PSC**	0.96	0.96		0.96	*0.29*
Refrigeration	*Evaporator Fan Controller**	0.96	0.96		0.96	*0.29*
Refrigeration	*Glass Doors - Low Temp**	0.96	0.96		0.96	*0.29*
Refrigeration	*Glass Doors - Med Temp**	0.96	0.96		0.96	*0.29*

* Self report results were generated for all other measures not included in the Table 6-27, but were grouped into the following categories due to small sample sizes: other lighting, other HVAC, other refrigeration, other water heating and miscellaneous other. These values are not presented in Table 6-27 as they are generally based on small sample sizes and are not measure specific. We do not recommend using these "other" category NTFR ratios outside of this evaluation as they were not developed at the measure specific level. See Section 6.5 for more detail on how the NTFR values were assigned.

Table 7-6: (cont'd.) Ex Ante and Ex Post Net-of-Free-Ridership Ratios

End Use	Measure Group	PGE Ex-Ante	SCE Ex-Ante	SCG Ex-Ante	SDGE Ex-Ante	Ex-Post
Refrigeration	*HE Low Temp Reach-in Display Case with Special Doors**	0.96	0.96		0.96	*0.29*
Refrigeration	*New Refrigeration Case With Doors - Low Temp**	0.96	0.96		0.96	*0.29*
Refrigeration	*New Refrigeration Case With Doors - Low Temp**	0.96	0.96		0.96	*0.29*
Refrigeration	*New Refrigeration Case With Doors - Med Temp**	0.96	0.96		0.96	*0.29*
Refrigeration	*Night Covers**	0.96	0.96		0.96	*0.29*
Refrigeration	*Refrigerator**	0.96	0.96	0.96	0.96	*0.29*
Refrigeration	*Special Doors with Low/No ASH Controls**	0.96	0.96	0	0.96	*0.29*
Refrigeration	Strip Curtains for Walk-ins	0.96	0.96	0	0.96	0.46
Refrigeration	*Suction Line Insulation**	0.96	0.96	0	0.96	*0.29*
Refrigeration	*Vending Machine Controller**	0.96	0.96	0	0.96	*0.29*
Retro Commissioning	*Retro Commissioning**	0.96	0.96	0.96	0.96	*0.75*
Water Heating	*Boiler, Water**	0.96	0	0.96	0.96	*0.46*
Water Heating	*Clothes Washer**	0.96	0	0.96	0.96	*0.46*
Water Heating	*Commercial Pool Heater**	0.96	0	0.96	0.96	*0.46*
Water Heating	*Economizer**	0.96	0.96	0.96	0.96	*0.46*
Water Heating	*Gas Storage Water Heater**	0.96	0	0.96	0.96	*0.46*
Water Heating	*Instantaneous Water Heater – Gas**	0.96	0	0.96	0.96	*0.46*
Water Heating	*Pipe Insulation**	0.96	0	0.96	0.96	*0.46*
Water Heating	*Space Heating Boilers**	0.96	0	0.96	0.96	*0.46*
Water Heating	*Spray Nozzle**	0.96	0	0.96	0.96	*0.46*
Water Heating	*Steam Boiler, Process**	0.96	0	0.96	0.96	*0.46*
Water Heating	*Tank Insulation**	0.96	0	0.96	0.96	*0.46*
Water Heating	*Water Boiler, Process**	0.96	0	0.96	0.96	*0.46*

* Self report results were generated for all other measures not included in the Table 6-27, but were grouped into the following categories due to small sample sizes: other lighting, other HVAC, other refrigeration, other water heating and miscellaneous other. These values are not presented in Table 6-27 as they are generally based on small sample sizes and are not measure specific. We do not recommend using these "other" category NTFR ratios outside of this evaluation as they were not developed at the measure specific level. See Section 6.5 for more detail on how the NTFR values were assigned.

7.1.4 Expected Useful Life

Table 7-7 presents the ex ante and ex post EULs used in the calculation of ex ante and ex post gross and net savings for both the Express and Upstream programs. The ex ante and ex post EULs are equal to each other except for in the case of CFLs. Based on the results of the EUL retention analysis for CFLs presented in Section 4, the ex post EUL for this measure is set equal to 4 years. Note that for some measure groups, the IOUs relied upon different ex ante EULs. For this reason, the ex ante and ex post EULs for each measure group are presented by IOU.

Table 7-7: Ex Ante and Ex Post EULs by IOU

End Use	Measure Group	PGE Ex Ante	PGE Ex Post	SCE Ex Ante	SCE Ex Post	SCG Ex Ante	SCG Ex Post	SDGE Ex Ante	SDGE Ex Post
Agriculture	Ag Process	8	8	5	5	0	0	8	8
Agriculture	Efficient Irrigation	20	20	20	20	0	0	20	20
Agriculture	Greenhouse Heat Curtain	5	5	0	0	5	5	5	5
Agriculture	Infrared Film for Greenhouses	4	4	0	0	4	4	5	5
Food Service	Ice Machine	12	12	12	12	0	0	12	12
Food Service	Insulated Holding Cabinet	12	12	12	12	0	0	12	12
Food Service	Pressure less Steamer	12	12	12	12	0	0	12	12
HVAC-A/Cs	PTAC	15	15	15	15	0	0	15	15
HVAC-A/Cs	Packaged A/C	15	15	15	15	0	0	15	15
HVAC-Other	Cool Roofs	15	15	15	15	0	0	15	15
HVAC-Other	Evaporative Coolers	15	15	15	15	0	0	15	15
HVAC-Other	Programmable Thermostats	11	11	11	11	11	11	11	11
HVAC-Other	Refrigerant Charge Adjustment	10	10	0	0	0	0	0	0
HVAC-Other	VSD - AHU	15	15	15	15	0	0	15	15
HVAC-Other	Window Film	10	10	10	10	0	0	10	10
Lighting-CFL	CFL Lamps	8	4	8	4	0	0	8	4
Lighting-CFL	CFL Fixture	16	16	16	16	0	0	16	16
Lighting-Other	Ceramic Metal Halide	16	16	16	16	0	0	16	16
Lighting-Other	Induction Fixture	16	16	16	16	0	0	16	16
Lighting-Other	LED Exit Sign	16	16	16	16	0	0	16	16
Lighting-Other	LED Signs	16	16	16	16	0	0	16	16
Lighting-Other	Lighting	16	16	16	16	0	0	16	16
Lighting-Other	Metal Halide Ext - IncanBase	16	16	16	16	0	0	16	16

Table 7-7 (cont'd.): Ex Ante and Ex Post EULs by IOU

End Use	Measure Group	PGE Ex Ante	PGE Ex Post	SCE Ex Ante	SCE Ex Post	SCG Ex Ante	SCG Ex Post	SDGE Ex Ante	SDGE Ex Post
Lighting-Other	Metal Halide Ext - MVBase	16	16	16	16	0	0	16	16
Lighting-Other	Metal Halide Int - IncanBase	16	16	16	16	0	0	16	16
Lighting-Other	Metal Halide Int - MVBase	16	16	16	16	0	0	16	16
Lighting-Other	Occ-Sensor - Ceiling	8	8	8	8	0	0	8	8
Lighting-Other	Occ-Sensor - High Bay	8	8	8	8	0	0	8	8
Lighting-Other	Occ-Sensor - Plug Load	8	8	8	8	0	0	8	8
Lighting-Other	Occ-Sensor - Wall box	8	8	8	8	0	0	8	8
Lighting-Other	Photocells	8	8	8	8	0	0	8	8
Lighting-Other	Pulse Start Metal Halide	16	16	10	10	0	0	16	16
Lighting-Other	Time Clock	8	8	8	8	0	0	8	8
Lighting-T-8/T-5, Elec Bal, Delamp	Delamp	16	16	16	16	0	0	16	16
Lighting-T-8/T-5, Elec Bal, Delamp	Electronic Ballast	16	16	16	16	0	0	16	16
Lighting-T-8/T-5, Elec Bal, Delamp	Electronic Ballast, Dimming	16	16	16	16	0	0	16	16
Lighting-T-8/T-5, Elec Bal, Delamp	High Bay T5	16	16	16	16	0	0	16	16
Lighting-T-8/T-5, Elec Bal, Delamp	Misc - Lighting	16	16	16	16	0	0	16	16
Lighting-T-8/T-5, Elec Bal, Delamp	T8 El Ballast	16	16	16	16	0	0	16	16
Motors	Motors	15	15	8	8	0	0	15	15
Refrigeration	Anti-Sweat Heater Controls	12	12	8	8	0	0	12	12
Refrigeration	Auto Closer	8	8	8	8	0	0	8	8
Refrigeration	Chillers	12	12	12	12	0	0	12	12

Table 7-7 (cont'd.): Ex Ante and Ex Post EULs by IOU

End Use	Measure Group	PGE Ex Ante	PGE Ex Post	SCE Ex Ante	SCE Ex Post	SCG Ex Ante	SCG Ex Post	SDGE Ex Ante	SDGE Ex Post
Refrigeration	Cooler/Freezer Door Gaskets	4	4	4	4	0	0	4	4
Refrigeration	Efficient Condenser - Air Cooled	16	16	16	16	0	0	16	16
Refrigeration	Efficient Condenser - Evap Cooled	16	16	16	16	0	0	16	16
Refrigeration	Efficient Condenser - Multiplex	16	16	12	12	0	0	16	16
Refrigeration	Efficient Evaporator Fan Motors - ECM	16	16	16	16	0	0	16	16
Refrigeration	Efficient Evaporator Fan Motors - PSC	16	16	16	16	0	0	16	16
Refrigeration	Evaporator Fan Controller	5	5	5	5	0	0	5	5
Refrigeration	Glass Doors - Low Temp	12	12	12	12	0	0	12	12
Refrigeration	Glass Doors - Med Temp	12	12	12	12	0	0	12	12
Refrigeration	HE Low Temp Reach-in Display Case with Special Doors	16	16	12	12	0	0	16	16
Refrigeration	New Refrigeration Case With Doors - Low Temp	16	16	16	16	0	0	16	16
Refrigeration	New Refrigeration Case With Doors - Med Temp	16	16	16	16	0	0	16	16
Refrigeration	Night Covers	5	5	5	5	0	0	5	5
Refrigeration	Refrigerator	20	20	0	0	0	0	0	0
Refrigeration	Special Doors with Low/No ASH Controls	16	16	12	12	0	0	16	16
Refrigeration	Strip Curtains for Walk-ins	4	4	4	4	0	0	4	4
Refrigeration	Suction Line Insulation	11	11	11	11	0	0	11	11
Refrigeration	Vending Machine Controller	3	3	15	15	0	0	3	3
Retro Commis-sioning	Retro Commissioning	15	15	0	0	0	0	0	0

Table 7-7 (cont'd.): Ex Ante and Ex Post EULs by IOU

End Use	Measure Group	PGE Ex Ante	PGE Ex Post	SCE Ex Ante	SCE Ex Post	SCG Ex Ante	SCG Ex Post	SDGE Ex Ante	SDGE Ex Post
Water Heating	Boiler, Water	20	20	0	0	20	20	20	20
Water Heating	Clothes Washer	10	10	0	0	10	10	10	10
Water Heating	Commercial Pool Heater	5	5	0	0	5	5	5	5
Water Heating	Economizer	20	20	0	0	0	0	0	0
Water Heating	Gas Storage Water Heater	15	15	0	0	15	15	15	15
Water Heating	Instantaneous Water Heater - Gas	15	15	0	0	15	15	20	20
Water Heating	Pipe Insulation	20	20	0	0	20	20	11	11
Water Heating	Space Heating Boilers	20	20	0	0	20	20	20	20
Water Heating	Spray Nozzle	5	5	0	0	5	5	5	5
Water Heating	Steam Boiler, Process	20	20	0	0	20	20	20	20
Water Heating	Tank Insulation	20	20	0	0	13	13	11	11
Water Heating	Water Boiler, Process	20	20	0	0	20	20	20	20

7.2 Results

Table 7-8 through Table 7-17 show the Express Efficiency and Upstream HVAC and Motors program ex post net energy and demand savings by utility and funding source. Year 1 savings along with lifetime savings are presented in each of the tables. Table 7-18 and Table 7-19 present the first year and overall program realization rates, where the program realization rate is equal to the ratio of ex post net savings to ex ante gross savings.

Table 7-8: PG&E Program Energy Impact Reporting for 2004-2005 Programs – Express PGC (1133-04)

Year	Calendar Year	Gross Program-Projected MWh Savings	Net Evaluation Confirmed Program MWh Savings	Gross Program-Projected Peak MW Savings	Evaluation Projected Net Peak MW Savings	Gross Program-Projected Therm Savings	Net Evaluation Confirmed Program Therm Savings
1	2004	82,233	30,316	13.3	9.0	3,915,866	138,013
2	2005	219,253	76,043	30.4	20.6	8,589,628	294,061
3	2006	219,253	76,043	30.4	20.6	8,589,628	294,061
4	2007	218,676	75,884	30.4	20.6	8,589,628	294,061
5	2008	216,021	62,901	30.2	17.2	8,568,208	281,852
6	2009	206,164	41,795	29.0	11.0	8,485,109	240,663
7	2010	205,537	41,490	29.0	11.0	8,433,721	216,028
8	2011	205,537	41,490	29.0	11.0	8,433,721	216,028
9	2012	168,947	38,905	21.6	9.2	8,433,721	216,028
10	2013	108,198	35,375	11.0	7.5	8,433,721	216,028
11	2014	106,680	34,642	10.8	7.3	8,424,190	210,890
12	2015	91,040	33,401	10.5	7.2	4,656,119	151,995
13	2016	54,368	28,530	10.5	7.2	144,716	87,094
14	2017	54,318	28,516	10.5	7.2	144,716	87,094
15	2018	54,318	28,516	10.5	7.2	144,716	87,094
16	2019	52,351	27,334	9.8	6.7	136,083	83,123
17	2020	27,026	14,863	5.0	3.5	130,377	80,498
18	2021	359	205	0.1	0.1	130,377	80,498
19	2022	359	205	0.1	0.1	130,377	80,498
20	2023	359	205	0.1	0.1	130,377	80,498
TOTAL	**2004-2023**	**2,290,998**	**716,660**			**94,645,003**	**3,436,108**

Table 7-9: PG&E Program Energy Impact Reporting for 2004-2005 Programs – Express Procurement (1503-04)

Year	Calendar Year	Gross Program-Projected MWh Savings	Net Evaluation Confirmed Program MWh Savings	Gross Program-Projected Peak MW Savings	Evaluation Projected Net Peak MW Savings	Gross Program-Projected Therm Savings	Net Evaluation Confirmed Program Therm Savings
1	2004	29,443	11,802	5.4	3.6	-	-
2	2005	225,787	72,425	33.4	22.4	8,980	6,735
3	2006	225,787	72,425	33.4	22.4	8,980	6,735
4	2007	225,751	72,415	33.4	22.4	8,980	6,735
5	2008	224,007	66,327	33.3	20.9	8,980	6,735
6	2009	201,218	47,714	30.7	12.9	8,980	6,735
7	2010	200,528	47,376	30.7	12.9	8,980	6,735
8	2011	200,528	47,376	30.7	12.9	8,980	6,735
9	2012	181,875	45,335	27.3	12.1	8,980	6,735
10	2013	97,629	35,309	13.1	8.6	8,980	6,735
11	2014	97,629	35,309	13.1	8.6	8,980	6,735
12	2015	94,272	33,653	12.2	8.1	8,980	6,735
13	2016	67,970	29,025	12.2	8.1	8,980	6,735
14	2017	67,393	28,819	12.0	8.0	8,980	6,735
15	2018	67,393	28,819	12.0	8.0	8,980	6,735
16	2019	67,393	28,819	12.0	8.0	8,980	6,735
17	2020	52,070	21,230	9.4	6.2	-	-
18	2021	1,311	501	0.3	0.1	-	-
19	2022	1,311	501	0.3	0.1	-	-
20	2023	1,311	501	0.3	0.1	-	-
TOTAL	**2004-2023**	**2,330,607**	**725,681**			**134,700**	**101,025**

Table 7-10: SCE Program Energy Impact Reporting for 2004-2005 Programs – Express PGC (1243-04)

Year	Calendar Year	Gross Program-Projected MWh Savings	Net Evaluation Confirmed Program MWh Savings	Gross Program-Projected Peak MW Savings	Evaluation Projected Net Peak MW Savings	Gross Program-Projected Therm Savings	Net Evaluation Confirmed Program Therm Savings
1	2004	87,177	39,946	19.3	13.3	-	-
2	2005	175,351	76,797	34.6	23.8	-	-
3	2006	175,351	76,797	34.6	23.8	-	-
4	2007	175,351	76,797	34.6	23.8	-	-
5	2008	172,380	60,466	34.1	18.0	-	-
6	2009	169,302	48,305	33.7	13.7	-	-
7	2010	169,295	48,302	33.7	13.7	-	-
8	2011	169,295	48,302	33.7	13.7	-	-
9	2012	127,902	45,233	23.3	12.0	-	-
10	2013	94,391	42,400	16.2	11.2	-	-
11	2014	93,381	41,830	16.0	11.0	-	-
12	2015	88,706	40,686	15.7	10.9	-	-
13	2016	69,891	37,622	15.5	10.8	-	-
14	2017	68,752	37,239	15.3	10.7	-	-
15	2018	68,752	37,239	15.3	10.7	-	-
16	2019	65,479	35,296	14.8	10.4	-	-
17	2020	31,809	17,880	7.5	5.2	-	-
18	2021	1,604	915	0.9	0.5	-	-
19	2022	1,604	915	0.9	0.5	-	-
20	2023	1,604	915	0.9	0.5	-	-
TOTAL	**2004-2023**	**2,007,378**	**813,878**			**-**	**-**

Table 7-11: SCE Program Energy Impact Reporting for 2004-2005 Programs – Express Procurement (1178-04)

Year	Calendar Year	Gross Program-Projected MWh Savings	Net Evaluation Confirmed Program MWh Savings	Gross Program-Projected Peak MW Savings	Evaluation Projected Net Peak MW Savings	Gross Program-Projected Therm Savings	Net Evaluation Confirmed Program Therm Savings
1	2004	54,824	23,484	11.7	8.2	-	-
2	2005	124,465	50,375	22.6	15.4	-	-
3	2006	124,465	50,375	22.6	15.4	-	-
4	2007	124,465	50,375	22.6	15.4	-	-
5	2008	123,867	42,946	22.5	11.9	-	-
6	2009	120,932	36,642	22.1	9.8	-	-
7	2010	120,914	36,633	22.1	9.8	-	-
8	2011	120,914	36,633	22.1	9.8	-	-
9	2012	94,884	34,933	16.5	9.4	-	-
10	2013	68,350	27,821	10.8	7.3	-	-
11	2014	67,728	27,517	10.7	7.2	-	-
12	2015	64,211	26,987	10.6	7.2	-	-
13	2016	54,200	25,730	10.6	7.1	-	-
14	2017	53,796	25,617	10.5	7.1	-	-
15	2018	53,796	25,617	10.5	7.1	-	-
16	2019	53,167	25,221	10.3	7.0	-	-
17	2020	30,314	12,443	5.3	3.4	-	-
18	2021	1,901	1,084	1.1	0.6	-	-
19	2022	1,901	1,084	1.1	0.6	-	-
20	2023	1,901	1,084	1.1	0.6	-	-
TOTAL	**2004-2023**	**1,460,995**	**562,599**			**-**	**-**

Table 7-12: SCG Program Energy Impact Reporting for 2004-2005 Programs – Express PGC (1251-04)

Year	Calendar Year	Gross Program-Projected MWh Savings	Net Evaluation Confirmed Program MWh Savings	Gross Program-Projected Peak MW Savings	Evaluation Projected Net Peak MW Savings	Gross Program-Projected Therm Savings	Net Evaluation Confirmed Program Therm Savings
1	2004	113	-	-	-	4,894,000	2,053,761
2	2005	113	-	-	-	7,387,931	3,352,114
3	2006	113	-	-	-	7,387,931	3,352,114
4	2007	113	-	-	-	7,387,931	3,352,114
5	2008	113	-	-	-	7,283,772	3,292,743
6	2009	113	-	-	-	5,497,677	2,425,922
7	2010	113	-	-	-	4,661,903	2,022,039
8	2011	113	-	-	-	4,661,903	2,022,039
9	2012	113	-	-	-	4,661,903	2,022,039
10	2013	113	-	-	-	4,661,903	2,022,039
11	2014	113	-	-	-	4,173,958	1,758,987
12	2015	-	-	-	-	2,844,227	1,616,725
13	2016	-	-	-	-	2,810,169	1,616,235
14	2017	-	-	-	-	2,616,043	1,436,520
15	2018	-	-	-	-	2,555,348	1,380,331
16	2019	-	-	-	-	2,413,908	1,315,268
17	2020	-	-	-	-	2,294,206	1,260,205
18	2021	-	-	-	-	2,294,206	1,260,205
19	2022	-	-	-	-	2,294,206	1,260,205
20	2023	-	-	-	-	2,294,206	1,260,205
TOTAL	**2004-2023**	**1,248**	**-**			**85,077,332**	**40,081,811**

Table 7-13: SDG&E Program Energy Impact Reporting for 2004-2005 Programs – Express PGC (1344-04)

Year	Calendar Year	Gross Program-Projected MWh Savings	Net Evaluation Confirmed Program MWh Savings	Gross Program-Projected Peak MW Savings	Evaluation Projected Net Peak MW Savings	Gross Program-Projected Therm Savings	Net Evaluation Confirmed Program Therm Savings
1	2004	32,723	15,236	5.1	3.5	316,402	156,502
2	2005	66,309	28,033	10.4	7.1	532,416	269,354
3	2006	66,309	28,033	10.4	7.1	532,416	269,354
4	2007	66,178	27,997	10.4	7.1	532,416	269,354
5	2008	65,676	21,241	10.3	5.4	532,416	269,354
6	2009	65,188	12,543	10.2	2.7	275,265	142,915
7	2010	65,188	12,543	10.2	2.7	143,167	77,580
8	2011	65,188	12,543	10.2	2.7	143,167	77,580
9	2012	49,438	11,504	7.7	2.5	143,167	77,580
10	2013	25,986	11,298	3.8	2.4	143,167	77,580
11	2014	25,351	10,991	3.7	2.4	106,533	57,831
12	2015	24,493	10,832	3.7	2.4	75,111	40,891
13	2016	23,014	10,528	3.6	2.4	73,656	40,222
14	2017	21,964	10,240	3.6	2.3	73,656	40,222
15	2018	21,964	10,240	3.6	2.3	73,656	40,222
16	2019	20,854	9,576	3.4	2.2	72,119	39,515
17	2020	6,973	3,180	1.2	0.8	56,789	32,463
18	2021	-	-	-	-	56,789	32,463
19	2022	-	-	-	-	56,789	32,463
20	2023	-	-	-	-	56,789	32,463
TOTAL	**2004-2023**	**712,795**	**246,560**			**3,995,889**	**2,075,907**

Table 7-14: PG&E Program Energy Impact Reporting for 2004-2005 Programs – Upstream PGC (1120-04)

Year	Calendar Year	Gross Program-Projected MWh Savings	Net Evaluation Confirmed Program MWh Savings	Gross Program-Projected Peak MW Savings	Evaluation Projected Net Peak MW Savings	Gross Program-Projected Therm Savings	Net Evaluation Confirmed Program Therm Savings
1	2004	3,724	1,895	2.0	0.9	-	-
2	2005	11,579	5,593	6.0	2.7	-	-
3	2006	11,579	5,593	6.0	2.7	-	-
4	2007	11,579	5,593	6.0	2.7	-	-
5	2008	11,579	5,593	6.0	2.7	-	-
6	2009	11,579	5,593	6.0	2.7	-	-
7	2010	11,579	5,593	6.0	2.7	-	-
8	2011	11,579	5,593	6.0	2.7	-	-
9	2012	11,579	5,593	6.0	2.7	-	-
10	2013	11,579	5,593	6.0	2.7	-	-
11	2014	11,579	5,593	6.0	2.7	-	-
12	2015	11,579	5,593	6.0	2.7	-	-
13	2016	11,579	5,593	6.0	2.7	-	-
14	2017	11,579	5,593	6.0	2.7	-	-
15	2018	11,579	5,593	6.0	2.7	-	-
16	2019	7,855	3,698	4.0	1.8	-	-
17	2020	-	-	-	-	-	-
18	2021	-	-	-	-	-	-
19	2022	-	-	-	-	-	-
20	2023	-	-	-	-	-	-
TOTAL	**2004-2023**	**173,687**	**83,901**			**-**	**-**

Table 7-15: PG&E Program Energy Impact Reporting for 2004-2005 Programs – Upstream Procurement (1508-04)

Year	Calendar Year	Gross Program-Projected MWh Savings	Net Evaluation Confirmed Program MWh Savings	Gross Program-Projected Peak MW Savings	Evaluation Projected Net Peak MW Savings	Gross Program-Projected Therm Savings	Net Evaluation Confirmed Program Therm Savings
1	2004	4,039	2,100	2.1	1.0	-	-
2	2005	15,538	7,960	8.3	3.8	-	-
3	2006	15,538	7,960	8.3	3.8	-	-
4	2007	15,538	7,960	8.3	3.8	-	-
5	2008	15,538	7,960	8.3	3.8	-	-
6	2009	15,538	7,960	8.3	3.8	-	-
7	2010	15,538	7,960	8.3	3.8	-	-
8	2011	15,538	7,960	8.3	3.8	-	-
9	2012	15,538	7,960	8.3	3.8	-	-
10	2013	15,538	7,960	8.3	3.8	-	-
11	2014	15,538	7,960	8.3	3.8	-	-
12	2015	15,538	7,960	8.3	3.8	-	-
13	2016	15,538	7,960	8.3	3.8	-	-
14	2017	15,538	7,960	8.3	3.8	-	-
15	2018	15,538	7,960	8.3	3.8	-	-
16	2019	11,500	5,860	6.2	2.8	-	-
17	2020	-	-	-	-	-	-
18	2021	-	-	-	-	-	-
19	2022	-	-	-	-	-	-
20	2023	-	-	-	-	-	-
TOTAL	**2004-2023**	**233,077**	**119,398**			**-**	**-**

Table 7-16: SCE Program Energy Impact Reporting for 2004-2005 Programs – Upstream Procurement (1179-04)

Year	Calendar Year	Gross Program-Projected MWh Savings	Net Evaluation Confirmed Program MWh Savings	Gross Program-Projected Peak MW Savings	Evaluation Projected Net Peak MW Savings	Gross Program-Projected Therm Savings	Net Evaluation Confirmed Program Therm Savings
1	2004	11,076	3,787	4.1	1.7	-	-
2	2005	39,256	13,891	14.8	6.3	-	-
3	2006	39,256	13,891	14.8	6.3	-	-
4	2007	39,256	13,891	14.8	6.3	-	-
5	2008	39,256	13,891	14.8	6.3	-	-
6	2009	39,256	13,891	14.8	6.3	-	-
7	2010	39,256	13,891	14.8	6.3	-	-
8	2011	39,256	13,891	14.8	6.3	-	-
9	2012	39,059	13,857	14.8	6.3	-	-
10	2013	38,710	13,798	14.7	6.3	-	-
11	2014	38,710	13,798	14.7	6.3	-	-
12	2015	38,710	13,798	14.7	6.3	-	-
13	2016	38,710	13,798	14.7	6.3	-	-
14	2017	38,710	13,798	14.7	6.3	-	-
15	2018	38,710	13,798	14.7	6.3	-	-
16	2019	29,703	10,176	11.0	4.6	-	-
17	2020	3,442	236	0.7	0.0	-	-
18	2021	-	-	-	-	-	-
19	2022	-	-	-	-	-	-
20	2023	-	-	-	-	-	-
TOTAL	**2004-2023**	**590,331**	**208,082**			**-**	**-**

Table 7-17: SDG&E Program Energy Impact Reporting for 2004-2005 Programs – Upstream Procurement (1334-04)

Year	Calendar Year	Gross Program-Projected MWh Savings	Net Evaluation Confirmed Program MWh Savings	Gross Program-Projected Peak MW Savings	Evaluation Projected Net Peak MW Savings	Gross Program-Projected Therm Savings	Net Evaluation Confirmed Program Therm Savings
1	2004	3,104	941	1.6	0.7	-	-
2	2005	6,028	2,073	3.4	1.5	-	-
3	2006	6,028	2,073	3.4	1.5	-	-
4	2007	6,028	2,073	3.4	1.5	-	-
5	2008	6,028	2,073	3.4	1.5	-	-
6	2009	6,028	2,073	3.4	1.5	-	-
7	2010	6,028	2,073	3.4	1.5	-	-
8	2011	6,028	2,073	3.4	1.5	-	-
9	2012	6,028	2,073	3.4	1.5	-	-
10	2013	6,028	2,073	3.4	1.5	-	-
11	2014	6,028	2,073	3.4	1.5	-	-
12	2015	6,028	2,073	3.4	1.5	-	-
13	2016	6,028	2,073	3.4	1.5	-	-
14	2017	6,028	2,073	3.4	1.5	-	-
15	2018	6,028	2,073	3.4	1.5	-	-
16	2019	2,924	1,132	1.8	0.8	-	-
17	2020	-	-	-	-	-	-
18	2021	-	-	-	-	-	-
19	2022	-	-	-	-	-	-
20	2023	-	-	-	-	-	-
TOTAL	**2004-2023**	**90,424**	**31,096**			**-**	**-**

Table 7-18: Express and Upstream Program Realization Rates by IOU and Funding Source – Realization Rates for First Year Savings

Utility	Program	Funding Source	Program #	First Year Realization Rate		
				kWh	kW	Therms
SCE	Express	PGC	1243-04	43.8%	68.8%	-
SCE	Express	Procurement	1178-04	40.5%	68.0%	-
PG&E	Express	PGC	1133-04	34.7%	67.7%	3.4%
PG&E	Express	Procurement	1503-04	32.1%	67.1%	75.0%
SCG	Express	PGC	1251-04	-	-	45.4%
SDG&E	Express	PGC	1344-04	42.3%	68.7%	50.6%
SCE	Upstream	Procurement	1179-04	35.4%	42.4%	-
PG&E	Upstream	PGC	1120-04	48.3%	44.6%	-
PG&E	Upstream	Procurement	1508-04	51.2%	45.4%	-
SDG&E	Upstream	Procurement	1334-04	34.4%	43.9%	-

Table 7-19: Express and Upstream Program Realization Rates by IOU and Funding Source – Realization Rates for Lifetime Savings

Utility	Program	Funding Source	Program #	Overall Realization Rate	
				kWh	Therms
SCE	Express	PGC	1243-04	40.5%	-
SCE	Express	Procurement	1178-04	38.5%	-
PG&E	Express	PGC	1133-04	31.3%	3.6%
PG&E	Express	Procurement	1503-04	31.1%	75.0%
SCG	Express	PGC	1251-04	-	47.1%
SDG&E	Express	PGC	1344-04	34.6%	52.0%
SCE	Upstream	Procurement	1179-04	35.2%	-
PG&E	Upstream	PGC	1120-04	48.3%	-
PG&E	Upstream	Procurement	1508-04	51.2%	-
SDG&E	Upstream	Procurement	1334-04	34.4%	-

8

Conclusions and Recommendations

This final section highlights the findings and recommendations from the impact evaluation of the 2004-05 Statewide Express Efficiency program (hereafter referred to as the "Express program") and the Upstream HVAC/Motors program (referred to as the "Upstream program"). The Express program is a business prescriptive retrofit program funded by California utility customers and administered under the auspices of the California Public Utilities Commission (CPUC). Express Efficiency is run on a consistent, statewide basis by the four investor-owned utilities (IOUs): Pacific Gas and Electric Company (PG&E), San Diego Gas and Electric Company (SDG&E), Southern California Edison Company (SCE) and Southern California Gas Company (SCG). The Express program offers financial incentives (rebates) to qualifying customers for installing selected energy-efficient technologies. The Upstream program is offered by the three electric IOUs and seeks to change distributors' stocking practices by encouraging manufacturers and distributors to maintain sufficient inventories of high efficiency air conditioning (AC) equipment and motors so that they are available at the time the customer is making the buying decision, typically upon failure of existing equipment. Incentives are paid to participants upon proof that a qualifying model has been delivered.

This evaluation of the 2004-05 Express and Upstream programs offers both retrospective examination and prospective guidance in shaping current rebate programs for small and medium-sized nonresidential customers, and it meets the objectives set forth by the CPUC in Decision R.01-08-028 for measurement and evaluation (M&E) studies, as well as those provided in the California Evaluation Framework[76].

The impact evaluation of the 2004-05 Express and Upstream programs addresses several objectives. The following study: (1) verifies energy savings, (2) calculates ex post savings, (3) conducts a net-of-free-ridership analysis, and (4) estimates the overall energy and demand savings of the programs. A process evaluation of the Express and Upstream programs was also completed and results from this study are presented in a separate report.

Below are the key findings and recommendations that were a result of this study.

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8.1 Program Activity and Participation

8.1.1 IOU Claimed Savings Versus Targets

As in past years, performance targets for the 2004-05 program years were set in terms of energy, demand, and therm savings. Specifically, the statewide net ex ante savings accomplishments reported by the IOUs for the two-year program cycle for Express were approximately 778.4 GWh, 126 MW, and 15.9 million therms. As reported by the IOUs, the statewide program almost met its kWh target, exceeded its therm target by an impressive 75%, and fell short of meeting its kW target by approximately 20%. SCG and PG&E outperformed SCE and SDG&E in reaching or surpassing their target net ex ante energy savings, though SCE was extremely close to meeting its target.

8.1.2 Comparison of Savings Between Filings and Program Tracking

The total energy, demand, and therm savings across the Energy Efficiency filings and the program tracking databases align very closely. Demand savings were also closely aligned for the upstream HVAC and Motors and downstream Express Efficiency programs with the slight exception of SCE's demand savings reported for its Upstream HVAC/Motors program. Therm savings are only reported for the downstream Express program since there were no therm savings from the Upstream program. The therm savings were closely aligned for PG&E and SCG, with a less than 2% difference in reported accomplishments for SDG&E.

8.1.3 HTR Participation

When the goals are compared to the IOU-reported hard-to-reach (HTR) accomplishments, all of the IOUs with the exception of SCE met or surpassed their targets. Only 37% of SCE's Express program participants were HTR when its goal was 40%. However, Itron's estimates of HTR participation for each of the IOUs indicated that all four IOUs exceeded their HTR targets.

8.1.4 Historical Participation Trends in Customer Size

In 2003, about half of all Express applications were submitted by very small customers.[77] During the 2004 and 2005 program years, there was a significant increase in large customer participation. The participation of very small customers decreased to less than a third as a percent of applications submitted in 2004 and decreased slightly further in 2005. Overall, there is a slight trend towards medium and large customers and away from very small customers submitting applications to the Express program.

[77] Very small customers are defined as those with demand less than 20kW.

8.1.5 Historically Dominant Measures

Lighting has historically dominated the program (especially in 2002 and 2003); however, during the last program cycle, there was a noticeable shift away from lighting measures and towards HVAC measures in the percentage of applications and rebate dollars paid during the 2004-05 program cycle. For example, there was a drop in the percentage of CFL rebated applications from 54% in 2003 to just below 20% in 2005, and an increase in HVAC applications rebate from 13% in 2003 to 45% in 2005.

8.1.6 Business Type Trends

Business type trends again follow the changes that have occurred with program eligibility and incentives. In 2002, rebates to smaller customers were emphasized which led many miscellaneous commercial establishments to participate (e.g., personal services and community services). In 2003, participation was fairly even across all of the business categories.[78] In program years 2004 and 2005, more than a third of the total participants were from the other business types, while the participation of the retail category decreased further.

8.1.7 Summary of Program

Compared to 2002 and 2003, the 2004 program year showed a rise in the number of applications submitted, total rebate dollars paid, and in the total program budget. The energy savings in 2004 fall between the savings totals achieved in 2002 and 2003 while in 2005, Express Efficiency had the largest program budget and yielded the highest energy savings over the past six-year history. The installed energy savings in 2004 followed by a sharp rise in 2005 could be explained by the fact that the Express program was run for a two-year cycle, thus allowing the utilities to evaluate their accomplishments at the end of 2004 and revise program strategies, funding, and program marketing to improve program performance in the following year.

[78] The business type categories are Office, Miscellaneous Commercial, Retail, Restaurant/Grocery, and Other. It is important to note that over half of the Other business type is comprised of records in the program tracking data for which we were unable to obtain valid SIC/NAICS codes to create the business type classification.

Table 8-1: Historical Express Efficiency Summary

Program Year	Unique Sites	Unique Applications	Rebate Dollars (mil$)	Net Ex Ante Energy Savings (GWh)	Total Program Budgets (mil$)
2000	25,745	27,606	$28.6	296.7	$39.0
2001	10,681	11,072	$30.9	467.0	$45.6
2002	8,400	9,628	$12.9	318.7	$20.1
2003	9,342	9,573	$12.7	278.5	$21.4
2004	10,625	15,762	$19.4	295.6	$37.8
2005	14,129	23,707	$30.1	551.3	$46.3

8.2 Express Efficiency Gross Impact Evaluation

The gross impact evaluation of the Express Efficiency program included onsite verification of rebated qualifying equipment; a lighting logger analysis for CFL, T8, and high bay fluorescent fixtures; an engineering analysis using IOU workpapers and onsite engineering audit data; a billing analysis; and an EUL retention study of CFLs.

8.2.1 Onsite Verification

Lighting Measures

Itron visited 286 sites and verified 24 lighting measures; grouped into four categories—CFLs; high bay fixtures; other linear fluorescent fixtures and delamping; and other measures. Overall, between 80% and 87% of the measures were verified across these four categories.

Non-Lighting Measures

Itron visited 130 sites across 18 different non-lighting measure categories for verification purposes. Overall, at least 90% of the measures were verified for each category with the exception of door gaskets (86% verified) and anti-sweat heater controls (78% verified).

8.2.2 Lighting Logger Analysis

Four hundred and eighty-five lighting loggers were installed for approximately two months at 217 sites that had installed CFLs, T-8s, and high bay linear fluorescent fixtures. Overall, CFLs were estimated to operate for approximately 3,016 hours per year, T8s for 3,098 hours per year, and high bay fixtures for 5,298 hours per year. Overall, this resulted in a reduction of operating hours for CFLs and T8s. The effect of applying these operating hours was a reduction in kWh savings of 14% for CFLs overall, and a reduction of 27% to linear fluorescents overall (combined T8 and high bay fixtures).

8.2.3 Engineering Analysis

There are several dozens of individual measures offered under the Express program. Ninety-five percent of the program savings in terms of kW, kWh, and therms come from 22 specific measures. An in-depth engineering analysis was completed for these 22 high impact measures. The data sources include 250 lighting logger sites, 130 engineering on-sites, the participant surveys, and existing data sources such as the participant tracking data, CEUS data, DEER data, or CIS data. For most of the measures subject to an in-depth engineering review, the review results in either an updated algorithm or updated parameters that can be used to enhance the existing algorithm results to better represent the 2004-05 participant population.

For non-lighting measures, most ex post engineering savings estimates ranged from 80% to 120% of the ex ante estimate. Two measures were found to have significantly lower realized savings: programmable thermostats were found to save just over 2 % of the ex ante value, and strip curtains were found to save only a third of the ex ante value. Conversely, significantly more savings were found for tank insulation (201% of ex ante) and boilers (143% of ex ante).

For the remaining measures that comprise approximately 5% of savings, a cursory engineering review that primarily was comprised of a review of the IOUs' technical work papers was completed. Although no ex post engineering savings estimates are developed for these low priority measures, the cursory review does identify potential issues with some of these measures and highlights measures where future research could be conducted to enhance the ex ante estimates. The cursory reviews are provided in Appendix I.

8.2.4 Billing Analysis

For the billing analysis, a statistically adjusted engineering (SAE) model was implemented for lighting, HVAC, refrigeration measures[79], and strip curtains by facility type. The billing analysis is specified using customer billing data for 544 participants, along with independent variables gathered during the telephone survey, customer-tracking data that indicate the timing of the Express Efficiency measure installation, and energy impacts associated with measures installed under the Express Efficiency program. Engineering estimates of savings derived from the lighting logger and engineering analyses discussed above were used as inputs into the billing model. The results of the billing regression analysis are estimated as ratios, termed "SAE coefficients," of realized impacts to the engineering energy impact estimates. These realized impacts represent the fraction of the engineering estimate actually observed or detected in the statistical analysis of the billing data.

[79] Since a billing analysis realization rate was estimated specifically for strip curtains, the rate for refrigeration measures in general excludes strip curtains.

Lighting Results

The following realization rates for lighting measures were statistically significant at the 85% confidence level for six segments: 51% for offices, 169% for retail, 82% for community services, 52% for industrial, 63% for other and only 9% for hotel/motel. The resulting realization rate for restaurants was 99% but insignificant. Therefore, we did not apply the restaurant realization rate, and instead simply utilized the adjusted engineering estimates based on the lighting logger data. These estimated lighting realization rates apply to CFLs, T8 measures, and other lighting. Other lighting was largely made up of lighting sensors, and, to a smaller extent, high bay lighting.

Programmable Thermostat Results

The estimated realization rate for programmable thermostats in hotels was 1,215%. However, this realization rate applies to the engineering ex ante estimates of savings which were only 2.4% of the utility ex ante estimates. The application of the billing realization rate to the engineering estimate implies that the observed bill savings for programmable thermostats are 29% of the utility ex ante estimate in the hotel segment. The realization rates for all other segments were not statistically different from zero. For these segments, we utilized the adjusted engineering estimates, which are only 2.4% of the utility ex ante estimates.

Refrigeration Results

The estimated realization rate for strip curtains is approximately zero and is statistically insignificant. Therefore, we relied on the results of the engineering analysis, which are only 32% of the utility work paper value. The estimated realization rate for all other refrigeration measures was 95% and the estimated coefficient was statistically significant.

8.2.5 CFL EUL Analysis

An effective useful life analysis was conducted utilizing survey data collected on 250 customers that installed CFLs as part of the 2002 and 2003 Express Efficiency Program. Based on this empirical data, a four year measure life was recommended for screw-in CFLs. This is half of the eight year ex ante EUL.

8.2.6 Express Gross Impact Evaluation Recommendations

Verification

Verification of lighting measures indicted that more than 10% of the lighting could not be verified onsite. We recommend that the IOU inspection process be reviewed and consider, if not already in place, a higher level of inspections for first time vendors, 100% inspection on all “large” applications (e.g., over $2,500 in rebate) and a random sample of 10-20% of all other applications (similar to PG&E). This will likely cover a majority of the measures installed with respect to energy savings and rebates paid, but only require a minority of the sites visited. Furthermore, 100% inspection should be performed on vendors that have failed a significant number of previous inspections. For example, each month an inspection report could be generated that identifies all vendors that had failures that exceeded a certain threshold (e.g., more than 20% failed during the month). For the following month, all applications submitted by that vendor should be inspected until the vendor’s failure rate falls below the threshold for an entire month (or two consecutive months). The IOUs sometimes penalize vendors that require follow-up inspections for applications that fail initial inspections. Also consider increasing penalties for vendors that have required follow-up inspections on multiple applications (increase the penalty as the number of follow-up inspections increase).

Furthermore, the program evaluation and measurements of energy savings could be enhanced if the program prescribes the collection of pre-existing wattage information from participants. Also, pre-installation inspections would benefit the program by reducing the number of installations that are not program qualifying replacements, such as replacing CFLs with CFLs.

Engineering and Billing Analysis

Engineering analysis was only able to realize 2% of the programmable thermostat savings and 32% of the strip curtain savings. Billing analysis realization rates were statistically significant for lighting in most facility types, thermostats for hotel/motels, and other refrigeration measures. It was not, however statistically significant for lighting in restaurants, HVAC and strip curtains in all facility types, and programmable thermostats for schools and all other facility types. Therefore, the IOUs should consider the cost-effectiveness of offering these measures given the overall low level of realized savings.

Appendices I and J provide the engineering workpaper reviews for all measures offered under the 2004-05 Express program along with recommendation for changes or future research.

EUL Analysis

The EUL for CFLs was estimated to be four years, or half the ex ante value. We recommend using the four year value going forward, but also feel a more comprehensive study on the CFL EUL is warranted. Future EM&V work should consider building retention panels for future EUL analysis based on on-site visits, and tagging measures that have been verified onsite for easier identification in future years.

Because of the relationship between on-time cycles and measure life, Itron does not recommend varying the EUL by business type to correspond to variations in operating hours by business type. For example, if the annual operating hours for a specific business type were half of the average, it would be incorrect to assume the EUL would double. This is due to the fact that if the annual operating hours were half that of the average, then the average on-time cycle length would also likely be reduced significantly, thereby reducing the measure life.

Lighting Logger Analysis

We recommend a more comprehensive lighting logger study be performed for CFLs and linear fluorescent fixtures, with increased sample sizes such that reliable segment level average annual operating hour results can be developed for a handful of key market segments.

8.3 Upstream HVAC and Motors Gross Impact Evaluation

An ex post engineering savings analysis was conducted for the upstream HVAC and Motors program measures. Each analysis relied on a sample of end use metered data that was used to develop estimates of savings for a few key segments of the participant population. A total of 42 metered HVAC sites and 32 metered Motors sites were used in each analysis. The metered results for these segments were leveraged off of segment specific DEER results to estimate ex post savings values for the entire participant population. Overall, these analyses resulted in a reduction of savings for HVAC measures by 27% for kWh, and a reduction of 36% for kW. For motors measures, only 17% of the kWh and 18% of the kW savings were realized through this analysis.

Recommendations

Motors. For motors, we recommend that baseline assumptions used in the IOU workpapers for motors be revised and correspond to federal minimum (EPAct) standards, as opposed to being based on the rewind efficiency. Furthermore, we recommend that a more comprehensive metering analysis be conducted for greater than 20HP motors to develop load factor, coincident diversity factor and operating hour estimates. Otherwise DEER values should be used.

HVAC. For central air conditioning, we recommend that either a more comprehensive metering analysis be conducted across more climate zones to develop equipment full load hour and coincident diversity factor estimates for use in the engineering algorithms, or that DEER or adjusted DEER (per Section 5) results be used.

8.4 Net-of-Free-Ridership (NTFR) Analysis

8.4.1 NTFR Analysis Methodologies

A net-of-free-ridership (NTFR) analysis was conducted for all Express and Upstream measures, based on three different methodologies. In California, the NTFR ratio is defined as one minus free ridership, so no benefits are provided for spillover. A self report analysis based on participant survey data was conducted for all Express measures. A self report analysis based on upstream market actor survey data was conducted for all Upstream measures. Finally, a discrete choice analysis based on participant and nonparticipant surveys was conducted for CFLs, T-8s and upstream ACs.

8.4.2 Results

The final results utilized the self report results, with the exception of T-8s, which were an average of discrete choice and self report results. Overall, the NTFR ratio for Express measures was 75%. NTRF ratios were developed for key measures including:

- CFLs at 81%,
- T-8s at 78%,
- LED exit signs at 77%,
- Occupancy sensors at 78%,
- Programmable thermostats at 76%,
- PTACs at 74%,
- Strip curtains at 76%; and
- Door gaskets at 76%.

For the Upstream measures, split and packaged ACs had a NTFR ratio of 72% and motors had a NTFR ratio of 46%.

Recommendations

As mentioned, the NTFR ratios calculated are defined as one minus free ridership. We recommend that these free ridership rates be used for future program planning. As the definition of NTFR may change over time, we do not recommend using these NTFR ratios, rather just the resulting component of NTFR, which is free ridership.

We also recommend that discrete choice analysis for lighting measures be limited to measures that are offered only downstream, as it is difficult to determine with a high level of certainty if customers are upstream participants or not. Furthermore, if discrete choice analysis is utilized for central air conditioning, it is important to determine with a high level of certainty the efficiency of the units being installed by nonparticipants in the model. Using mailers has not proven to be effective, so on-site visits may be necessary.

8.5 Overall Savings Results

The following tables provide the first year and lifetime savings and the first year and overall realization rates of the Express and Upstream programs by IOU and funding source. These estimates were calculated using the following inputs: ex post energy savings, onsite verification realization rates, engineering realization rates, billing analysis realization rates, ex post NTFR ratios, and ex post EULs. The input values used to develop these tables can be found in Section 7.

Table 8-2: Express and Upstream Program Realization Rates by IOU and Funding Source – Total First Year Net Ex-Post Savings

Utility	Program	Funding Source	Program #	Total First Year Savings		
				MWh	MW	Therms
SCE	Express	PGC	1243-04	76,797	23.8	-
SCE	Express	Procurement	1178-04	50,375	15.4	-
PG&E	Express	PGC	1133-04	76,043	20.6	294,061
PG&E	Express	Procurement	1503-04	72,425	22.4	6,735
SCG	Express	PGC	1251-04	-	-	3,352,114
SDG&E	Express	PGC	1344-04	28,033	7.1	269,354
SCE	Upstream	Procurement	1179-04	13,891	6.3	-
PG&E	Upstream	PGC	1120-04	5,593	2.7	-
PG&E	Upstream	Procurement	1508-04	7,960	3.8	-
SDG&E	Upstream	Procurement	1334-04	2,073	1.5	-

Table 8-3: Express and Upstream Program Realization Rates by IOU and Funding Source – Realization Rates for First Year Savings

Utility	Program	Funding Source	Program #	First Year Realization Rate		
				MWh	MW	Therms
SCE	Express	PGC	1243-04	43.8%	68.8%	-
SCE	Express	Procurement	1178-04	40.5%	68.0%	-
PG&E	Express	PGC	1133-04	34.7%	67.7%	3.4%
PG&E	Express	Procurement	1503-04	32.1%	67.1%	75.0%
SCG	Express	PGC	1251-04	-	-	45.4%
SDG&E	Express	PGC	1344-04	42.3%	68.7%	50.6%
SCE	Upstream	Procurement	1179-04	35.4%	42.4%	-
PG&E	Upstream	PGC	1120-04	48.3%	44.6%	-
PG&E	Upstream	Procurement	1508-04	51.2%	45.4%	-
SDG&E	Upstream	Procurement	1334-04	34.4%	43.9%	-

Table 8-4: Express and Upstream Program Realization Rates by IOU and Funding Source – Total Lifetime Net Ex-Post Savings

Utility	Program	Funding Source	Program #	Total Lifetime Savings	
				MWh	Therms
SCE	Express	PGC	1243-04	813,878	-
SCE	Express	Procurement	1178-04	562,599	-
PG&E	Express	PGC	1133-04	716,660	3,436,108
PG&E	Express	Procurement	1503-04	725,681	101,025
SCG	Express	PGC	1251-04	-	40,081,811
SDG&E	Express	PGC	1344-04	246,560	2,075,907
SCE	Upstream	Procurement	1179-04	208,082	-
PG&E	Upstream	PGC	1120-04	83,901	-
PG&E	Upstream	Procurement	1508-04	119,398	-
SDG&E	Upstream	Procurement	1334-04	31,096	-

Table 8-5: Express and Upstream Program Realization Rates by IOU and Funding Source – Realization Rates for Lifetime Savings

Utility	Program	Funding Source	Program #	Overall Realization Rate	
				MWh	Therms
SCE	Express	PGC	1243-04	40.5%	-
SCE	Express	Procurement	1178-04	38.5%	-
PG&E	Express	PGC	1133-04	31.3%	3.6%
PG&E	Express	Procurement	1503-04	31.1%	75.0%
SCG	Express	PGC	1251-04	0.0%	47.1%
SDG&E	Express	PGC	1344-04	34.6%	52.0%
SCE	Upstream	Procurement	1179-04	35.2%	-
PG&E	Upstream	PGC	1120-04	48.3%	-
PG&E	Upstream	Procurement	1508-04	51.2%	-
SDG&E	Upstream	Procurement	1334-04	34.4%	-