Customer Energy Efficiency Program
Measurement and Evaluation Program

EVALUATION OF PACIFIC GAS & ELECTRIC COMPANY'S 1995 NONRESIDENTIAL ENERGY EFFICIENCY INCENTIVES PROGRAM FOR COMMERCIAL SECTOR LIGHTING TECHNOLOGIES APPENDICES

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VOLUME I: ANALYSIS APPENDICES

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Appendix A
Sample Design

A. SAMPLE DESIGN

This appendix presents the sample design for the evaluation of Pacific Gas and Electric Company's (PG&E's) 1995 Nonresidential Energy Efficiency Incentive (EEI) Programs, Commercial Sector (the Commercial program). An integrated sample design was implemented for the Lighting, HVAC, and Refrigeration end uses. First, the sample design approach and resulting sample allocation are presented. This appendix then concludes with a discussion of the California Public Utilities Commission (CPUC) Evaluation and Measurement Protocols (the Protocols) requirements.

A.1 EXISTING DATA SOURCES FOR SAMPLE DESIGN

The participant tracking system for the Retrofit Express (RE), Retrofit Efficiency Options (REO), and Customized Incentives Programs is maintained as part of the PG&E Management Decision Support System (MDSS). Henceforth, the RE and REO program components are referred to as simply Retrofit. The MDSS contains program application, rebate, and technical information regarding installed measures, including measure descriptions, quantities, rebate amounts, and ex ante demand, energy and therm saving estimates. The MDSS extract used in this evaluation is consistent with data used in the PG&E Annual Earning Assessment Proceedings (AEAP) Report.

For the Retrofit and Customized Incentives programs, participation was tracked at both application and measure levels. They are linked by application code and program year. Each application can cover multiple measures and accounts, and each measure is linked to a PG&E electrical or gas service location where the measures are supposed to be installed. The account location is identified by its account number, or a unique seven-digit identification number (PG&E's control number). Unlike customer accounts, control numbers are used to identify service locations and serve as stable identifiers for linking datasets.

QC's existing PG&E commercial population files, assembled in support of prior evaluations, cover the period from January 1992 to September 1995. The billing series for October 1995 through September 1996 were extended only for customers in the analysis dataset. PG&E's billing data contain monthly energy-consumption as well as other customer information, such as customer name, service location, rate schedule, and Standard Industrial Classification (SIC) code.

A.2 SAMPLE DESIGN OVERVIEW

The objectives of the sample design were to

- Determine the optimal sample allocation for first-year gross impact analysis, based upon sample size and evaluation accuracy requirements of the Protocols and available project resources.
- Allocate sufficient sample points to meet net-to-gross (NTG) objectives.
- Reallocate available resources, wherever feasible, to focus on measures and/or program features deemed most important by PG&E staff for future program design while not compromising the overall accuracy of the evaluation.

The sample design is based upon a nested sample design approach. This approach consists of nesting samples of customer data so that the most expensive and detailed primary data can be leveraged to the population. The largest customer group includes all of the commercial customers with monthly PG&E billing data and participant tracking data who were rebated for eligible lighting, HVAC and refrigeration technologies in 1995 (the "participant population"). The smallest group is the metered (TOU loggered or end-use metered) participants, who have the most comprehensive information available. These participants have lighting logger (for the Lighting end use) or end-use metering (for the HVAC end use) data, on-site audit data, telephone survey data, participant tracking data, and billing data.

The advantage of a nested sample design is that the overlapping samples of primary data can be used to improve the accuracy of the engineering and statistical analysis for the population, rather than just for the customers for which the data are available. For example, logger and metered data are used to establish accurate measures of operating hours by key business types that are then used to improve the reliability of estimates for all customers in the survey sample.

A.3 SAMPLE SEGMENTATION

Evaluation of the Commercial program at the participant segment level allows more precise, and insightful, analyses than those undertaken at the aggregate PG&E system level. The program segmentation consists of two components: participant segmentation and technology segmentation. A key feature of the sample design is that the sampling unit is a unique customer site. Significant effort was undertaken to aggregate billing and participation records to this level.

The first step in the participant segmentation process grouped firms by business type, as defined in the MDSS. There are a total of 12 business types and 34 technology groups, as defined below. Exhibit A-1 presents the distribution of unique customer sites across the business type and technology group segmentation.

Annual energy consumption values were used to group customers into five usage/size strata based upon a Dalenius-Hodges procedure. The comparison group customers are then selected to mirror the underlying distribution of the participant target population by size and business type. (For the customers in the largest size strata, a census was attempted both for among participants and nonparticipants.)

Exhibit A-1
1995 Commercial Segmentation and Distribution of Unique Participant Sites

Technology	Business Type	Commercial												
		Office	Retail	College/Univ	School	Grocery	Restaurant	Health Care	Hotel/Motel	Warehouse	Personal Serv.	Comm. Serv.	Misc.	Total
Indoor Lighting	Halogen	47	46	8	17	2	26	10	16	9	4	24	8	217
	Compact Fluorescent Lamps	323	106	19	175	38	136	107	136	36	31	156	39	1,301
	Incandescent to Fluorescent Fixture	14	2	2	16	0	12	2	7	2	0	10	5	72
	Exit Signs	175	60	10	107	18	80	35	9	11	9	73	10	596
	Efficient Ballasts Changeouts	33	20	6	26	17	6	10	3	10	2	18	5	156
	T8 Lamps and Electronic Ballasts	728	620	33	345	229	194	187	41	135	152	271	126	3,055
	Delamp Fluorescent Fixtures	280	155	14	106	58	80	42	9	42	39	48	26	898
	High Intensity Discharge	40	42	4	30	11	2	1	2	67	14	34	82	329
	Reduced Wattage Lighting	2	1	0	1	0	0	0	0	1	1	1	0	7
	Controls	113	48	15	80	10	12	29	18	25	12	52	28	442
	Customized Lighting Measures	7	1	1	0	42	0	0	0	6	0	6	1	64
	Indoor Lighting End Use Total	890	726	43	401	294	260	215	158	208	183	379	222	3,968
HVAC	Central A/C	179	65	3	49	13	38	66	7	31	25	71	14	558
	Adjustable Speed Drives	35	27	2	2	12	0	2	2	1	9	2	2	96
	Package Terminal A/C	1	1	2	8	0	2	2	42	1	0	2	0	61
	Set-Back Thermostat	90	32	2	24	3	18	19	3	16	12	39	12	269
	Reflective Window Film	90	23	6	5	11	9	33	5	22	20	25	13	262
	Water Chillers	6	4	0	1	0	0	4	0	0	0	3	0	18
	Customized EMS	10	0	2	30	5	0	7	2	1	1	0	0	58
	Customized Controls	3	0	1	1	0	0	1	0	0	1	2	0	9
	Chiller Optimization	1	0	0	0	0	0	1	0	0	0	0	0	2
	Convert to VAV	3	0	0	1	0	0	2	0	0	0	0	0	6
	Other Customized Equipment	3	0	0	0	0	0	5	0	1	0	0	0	9
	Other HVAC Technologies	19	2	0	10	3	3	8	1	3	1	4	1	55
	HVAC End Use Total	354	123	17	114	43	53	123	59	59	57	116	34	1,149
Refrigeration	Customized Measures	1	0	0	0	61	0	0	0	1	0	0	5	68
	Standardized Measures	13	75	3	4	193	208	2	6	10	1	18	12	545
	Refrigeration End Use Total	14	75	3	4	253	208	2	6	11	1	18	17	612
Misc.	Outdoor Lighting	87	47	12	101	19	22	35	30	35	16	72	42	518
	Energy Efficient Motors	19	4	4	2	3	0	9	1	6	3	6	23	80
	Heat Recovery & Hot Water	0	0	1	0	1	1	0	1	0	1	2	0	7
	AG Pumping	1	0	0	0	0	0	0	0	0	2	1	13	17
	AG Other	0	0	0	0	0	0	0	0	1	0	0	1	2
	Cooking Equipment	4	2	0	12	29	50	1	4	2	0	3	0	107
	Non-Process Boilers	0	0	1	0	0	0	2	0	0	0	2	0	5
	Process Boilers	0	0	0	0	0	1	0	0	1	1	1	0	4
	Process	2	0	0	0	0	0	0	0	2	2	2	15	23
	Misc. End Uses Total	113	53	15	112	52	73	46	36	46	23	88	90	747
Program Total		1,231	869	61	518	544	558	336	218	289	239	528	321	5,694

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

A.4 TECHNOLOGY SEGMENTATION

Program measures are classified into technology groups through combining technologies with similar energy reduction characteristics. This grouping strengthens the analysis by creating homogenous analysis segments in terms of electricity use. The three elements of the technology segmentation are as follows:

Technology Groups consist of those measures that comprise, in the case of the Lighting end use, those specific measures that are expected to have similar energy saving characteristics. For example, all T12 to T8 retrofit measures are grouped together. The projected energy savings differences will be accounted for in the engineering estimates, yielding similar per-unit estimates.

Measure Group, the second level of segmentation, groups measures by the PG&E program measure description.

Measure, the highest level of segmentation presented, is the actual measure offered by the PG&E program.

The technology segmentation presented in Exhibit A-1 shows the highest level of segmentation, at the measure level for all end uses in the commercial sector. While the engineering analysis was conducted at the measure level, the statistical billing data analysis was conducted at a much coarser level, that is, at the technology-group level or at an even higher level of aggregation.

A.5 SAMPLE FRAME

The first step in sample design is to determine the sampling frame. In general, the sampling frame includes only those customers who are program participants, or likely targets of the program, rather than all customers in the population. It sets the stage for all data collection activities that follow, and determines the availability of billing data for the remainder of the analysis.

In this evaluation, different analyses (e.g., impact analysis, free-rider analysis, and spillover analysis) use different sampling frames, which are defined by analyzing what possible actions a customer in PG&E's service territory could have taken during the study period. This classification provides the basis for the sample design. Without this kind of control, the Statistically Adjusted Engineering (SAE) analysis change model cannot be estimated, since nonprogram-induced changes cannot be separated from changes between periods attributable to other factors, such as weather and economic trends.

A.6 PARTICIPANT SAMPLE FRAME

This section details the reduction of the eligible participant population to a sample frame suitable for impact analysis. None of the criteria used to screen the sample are believed to have adverse impacts on the sample representativeness; therefore, the screening criteria preserve the transferability of the impact results to the population.

The final participant sample frame for the Lighting and HVAC end uses consists of 2,560 commercial customers drawn from the eligible population of 5,694 program participants paid in 1995. In addition, there were 322 pretest and 78 multisite participants that were added to the 2,560 unique sites to form the final fielding sample frame. Criteria considered in the assessment of the quality of participant account billing data are as follows:

Presence of a billing rate schedule for the customer: Customers are required to have a rate schedule code for all years spanned by the billing data.

Quality of usage readings for the customer for the period of January 1993 through September 1995: Customers are required to have non-missing, non-zero usage values for all months spanned by the billing data. Customers are also required to have realistic PG&E revenues for the period. Realistic revenues are defined as revenues of at least $0.03 per kWh, but no greater than $0.25 per kWh.

Cohesion of billing data across years: The original billing data was received by year, i.e., the billing data for each calendar year was stored on a separate data tape. Data from different billing tapes was checked to ensure that the first month on each tape was immediately after the last month of the previous year's tape.

PG&E division representative deletion requests: Lists of customers in the sample frame were sent to the appropriate PG&E division representative for approval. Based upon responses from the representatives, some customers were deleted from the sample frame.

Reasonable usage across years and populated telephone numbers: Accounts are screened to ensure that the mean usage on the account for 1994 and 1995 is no more than twice (or less than half) the mean usage on the account for 1993 and 1994, respectively. Accounts are also screened to ensure they have reasonable phone numbers, and any accounts with no telephone number, or zeros in place of a number, are rejected from the sample frame.

For the Refrigeration end use, the entire participant sample was drawn for the sample frame because only 612 participant sites were available.

A.7 COMPARISON GROUP SAMPLE FRAME

The comparison group sample frame consists of 4,153 commercial customers drawn from the eligible population of 801,561 nonparticipants (Lighting and HVAC end uses) in the Commercial program. Since comparison group surveys were conducted only for customers in the commercial sector, the first step in creation of the sample frame is to limit eligibility to only those accounts having SIC codes representing commercial business activities. Note that similar screen criteria were used:

- Excessive changes in usage between 1993 and 1994 billing years: Accounts are screened to ensure that the mean usage on the account for 1994 and 1995 is no more than twice (or less than half) the mean usage on the account for 1993 and 1994, respectively.

- Geographic location of customers: Accounts are screened to insure that they fall within the geographic regions targeted for comparison group telephone survey and on-site survey data collection.

In drawing the sample frame, targets are established for each business type and usage segment, so that the sample frame distribution, by business type and usage segment, is the same as that of the surveyed program participant population. The drawing is conducted in this manner to ensure sufficient representation of each business type/usage segment combination in the sample frame and allow survey data collection in accordance with the sample design.

For the Refrigeration end use, a supplemental nonparticipant sample frame consisting 836 customers divided among small grocery (574), supermarkets (154), agricultural preparation (65), and refrigerated warehouses (43) was drawn to supplement the Lighting and HVAC comparison group.

Finally, the canvass survey sample frame of 6,000 is drawn randomly from a frame of 172,354 customers based upon geographic targets for this survey.

A.8 SAMPLE ALLOCATION APPROACH

The sample design complies with the Protocols and meets the program evaluation objectives. In this evaluation, the sampling unit is a customer site, which defines a unique service address. Applications in the MDSS database can cover more than one control number.

The final sample sizes for the telephone, on-site, lighting logger, and end-use metering are summarized in Exhibit A-2 by end-use element.

Exhibit A-2
Data Collected by Program and End Use

Program	End Use	Commercial				
		Telephone Surveys	On-Site Audits	End-Use Metering	Time-of-Use (TOU) Loggers	Combination
Custom	Lighting	18	1	0	0	0
	HVAC	58	32	0	0	0
	Refrigeration	7	16	0	1	1
Retrofit	Lighting	600	227	5	108	112
	HVAC	434	107	20	13	31
	Refrigeration	235	16	0	1	1
Total	Lighting	614	228	5	108	112
	HVAC	487	137	20	13	31
	Refrigeration	241	18	0	2	2
Total Participants (Unique Sites)		1,217	380	20	108	126
Total Nonparticipants (Unique Sites)		808	36	0	0	0
Total (Unique Sites)		2,025	416	20	108	126

Telephone Survey Sample - For each segment, the retrofit program sample design allocated the sample in proportion to the program-avoided cost by segment. This sample design concentrates sample points to segments that represent highest impact, in order to obtain the best estimate of impact for the largest portion of the population. In addition, a census was attempted for the largest customers. This sample allocation, combined with the random sampling techniques within each segment, produces a stratified random telephone survey sample representing the program-participant population (paid in 1995). A nonparticipant sample is developed based upon on the business type and usage strata distribution resulting from the participant sample allocation.

Telephone surveys were collected for a total of 2,025 customers, 1,217 of which are participants, and the remaining 808 are in the comparison group (451 as the original lighting and HVAC comparison group, 201 as the supplemental refrigeration comparison group, and 156 outside the program retrofitters found through the canvass survey).

On-site Audit Sample - Similar to the telephone survey sample, this sample was also structured to be approximately proportional to the program segment-level avoided cost estimates. A total of 416 on-site surveys were conducted for the commercial sector, with 380 participants and 36 comparison group customers.

Lighting Logger and End-Use Metering - This sample is not intended to be a random sample, nor strictly proportional to the program-avoided cost. The sample allocations were manipulated in order to assure adequate sample sizes for calibration of engineering models. A total of 108 and 20 participant sites were loggered or end-use metered.

A.9 RELATIVE PRECISION

Given a sample design, the relative precision, based upon total annual energy use, reflects the uncertainty regarding the extent to which the allocated sample sizes are large enough to control for the population variance in terms of annual energy usage. Precision for the telephone sample is calculated using the following procedure. First, the 1994 annual energy consumption is computed for all participants in the analysis dataset.

Next, five strata are constructed based on customers' annual usage using the Delanius-Hodges procedure. Exhibit A-3 presents the stratum-level sample size, sample weight, sample mean, and estimated standard errors for each end-use element. Note that since a census was attempted for the largest customers, participants with consumption greater than 10,000,000 kWh were excluded from this step. Overall, there were 73 participants in the population with usage at or above this level; 37 were successfully surveyed and included in the analysis dataset. (If these 37 were included in the variance calculation—using the surveyed sample—the oversampling of large customers would explode the variance far beyond that of the true variance in the population.)

Then, the program level mean and standard error are calculated using classic stratified sample techniques. [1] Finally, the relative precision at 90 percent confidence level is calculated as a two-tailed test.

By end-use element, the following relative precisions were achieved:

- For indoor lighting, the relative precision is 4.7 percent based upon a survey sample of 592. For the largest customers, 22 surveys were completed out of a participant population of 49.

- For HVAC, the relative precision is 6.0 percent based upon a survey sample of 473. For the largest customers, 14 surveys were completed out of a participant population of 21.

- For refrigeration, the relative precision is 4.6 percent based upon a survey sample of 240. For the largest customers, 1 survey was completed out of a participant population of 3.

[1] Cochran, W.G., *Sampling Techniques*, Third Edition, John Wiley & Sons, 1977. pp 91-95.

Exhibit A-3
Telephone Sample
Relative Precision Levels

LIGHTING

Weight	n	mean	Standard Error	Relative Prec.
52.8%	205	60,757	4,746	12.8%
24.5%	153	218,522	6,452	4.9%
11.5%	99	575,245	20,564	5.9%
6.9%	78	1,586,348	58,156	6.0%
4.3%	57	4,918,699	287,212	9.6%
100.0%				
TOTAL	592	471,990	13,460	4.7%
Usage > 10,000,000 kWh in 1994			49	
Surveyed			22	
TOTAL Surveyed = 614				

REFRIGERATION

Weight	n	mean	Standard Error	Relative Prec.
59.1%	168	45,814	2,759	9.9%
22.7%	41	227,111	13,980	10.1%
3.9%	13	631,164	50,908	13.3%
12.3%	12	1,533,060	55,581	6.0%
2.0%	6	4,068,986	339,006	13.7%
100.0%				
TOTAL	240	372,375	10,401	4.6%
Usage > 10,000,000 kWh in 1994			3	
Surveyed			1	
TOTAL Surveyed = 241				

HVAC

Weight	n	mean	Standard Error	Relative Prec.
53.9%	231	51,141	3,357	10.8%
19.5%	96	211,135	8,474	6.6%
10.7%	58	610,891	28,876	7.8%
10.1%	51	1,654,388	79,836	7.9%
5.7%	37	4,660,035	327,280	11.6%
100.0%				
TOTAL	473	566,376	20,647	6.0%
Usage > 10,000,000 kWh in 1994			21	
Surveyed			14	
TOTAL Surveyed = 487				

It follows that the 808 surveys that comprise the comparison group sample yield a relative precision of at least that obtained by the corresponding participant samples. Since the expected precision is based upon the annual energy usage, this does not imply that these levels of precision can be obtained for the impact analysis.

A.10 DEMONSTRATION OF PROTOCOL COMPLIANCE

A.10.1 Sampling Procedures Adopted

The sample design follows the rules established by the CPUC in the January 1995 revisions to the "Protocols and Procedures for the Verification of Costs, Benefits and Shareholder Earning from Demand Side Management Programs." Recent revisions to the Protocols—a draft dated 6/27/95—were incorporated wherever appropriate. The purpose of this section of the report is to identify compliance with these Protocols, with respect to the 1995 Commercial Sector Program Evaluation activities.

A.10.2 Sample Definitions

The following definitions are provided to introduce the primary segments targeted—both a participant sample and a comparison group—to ensure experiment control:

Participants - According to Table 5, part C, paragraph 1 of the Protocols, participants are defined as "those who received utility financial assistance to install a measure or group of measures during the program year."

Comparison Group - A control group is defined as a group of customers that represents what would have happened in the absence of the program. According to Table 5, part D, paragraphs 3 & 4, the comparison groups include both "customers who installed applicable measures" and "customers who did not install applicable measures," with no preference for either group (i.e., random or stratified random sample). This sample is therefore representative of the population, excluding only program participants during the evaluation year.

A.10.3 Overall Sampling Procedures

The commercial customer samples are driven by a primary data collection activity; in this case, the telephone surveys serve as the primary site-specific data collection elements that contribute to the analysis dataset. The commercial telephone sample was drawn to achieve a stratified random sample and optimally distribute the allocated sample points.

A.10.4 Detailed Protocol Sample Requirement

The commercial participant and comparison group samples are designed to meet the Protocol requirements in terms of analysis dataset sample size, precision of the results, availability of pre- and post-billing data contributing to the analysis dataset, and in ensuring cost-effective use of measured data.

Analysis Dataset Sample for Commercial Participants: The Protocols require that a program with more than 450 participants has a randomly drawn sample sufficiently large to achieve minimum energy use precision of ±10 percent at the 90 percent confidence level, and at least 450 contributing points in the analysis dataset. *(This was the requirement at the time of the sample design; this requirement was relaxed to 350 subsequent to the completion of the data collection activities conducted for this evaluation.)*

Data collection protocols are met regarding minimum analysis dataset size, if primary site-specific data are collected on-site, as per Table 5, part C, paragraph 4 of the Protocols. Data collection efforts are further strengthened during on-site activities through the installation of lighting loggers. These devices record specific fixture operating profiles during the monitoring period, and serve to calibrate self-reported lighting operating schedules. Data collected in this way follows the participant protocol recommendations set forth in Table C-4, paragraph 1 of the Protocols.

As discussed earlier, the sample collected for the commercial section, all end uses achieve a relative precision of at least 6 percent at a 90 percent confidence level, well below the 10 percent required by the Protocols, Table 5, part C, paragraph 4. Each participant chosen for the telephone sample is required to have at least nine months of post-installation billing data, and 12 months of pre-installation data, as per the Protocols, Table 5, part D, paragraphs 2 and 1, respectively.

Analysis Dataset Sample for Commercial Comparison Group - The Protocols require that the comparison group sample "be drawn using the same criteria for participants," as per Table 5, part C, paragraph 6.

The analysis dataset meets the sample size requirement in Table 5, part C, paragraph 3. The calculated relative precision meets the precision requirement in Table 5, part C, paragraph 4. The commercial comparison group telephone sample is drawn based upon the similar distribution of participant sample, in terms of their business types and annual usage.

To ensure compliance with comparison group protocols, the telephone survey sample frame is drawn to meet the billing data requirements of Table 5, part D, paragraphs 3 and 4 of the Protocols. All customers in the analysis dataset have billing data from January 1991 to September 1996, which ensures an adequate pre- and post-installation billing periods for customers who installed applicable measures between 1993 and 1995.

Appendix B
Engineering Detailed Computational Methods

B. ENGINEERING DETAILED COMPUTATIONAL METHODS

The technical approach and engineering results that support realized gross impacts in the 1995 Pacific Gas and Electric Company (PG&E) Nonresidential Energy Efficiency Incentive (EEI) Program, Commercial Lighting Technologies Evaluation (Commercial Lighting Evaluation) are presented in this section. The purpose of a presentation of the engineering computations is to provide detailed intermediate results that either verify or contradict the methods used to generate program design demand and energy impact estimates. Results are presented to ensure that future program design and evaluation activities will benefit from the engineering parameters generated during the 1995 program evaluation effort.

B.1 APPENDIX B STRUCTURE

This appendix is structured as follows:

The appendix begins with a presentation of the general approach used to generate both evaluation results and program design estimates. The purpose of a presentation of the engineering approach is to:

- Summarize and define each of the lighting end-use impact components that were used to generate final impact results
- Demonstrate key differences between the evaluation methods and those used to derive program design estimates
- Provide engineering results and discuss the data sources and methods used to derive each parameter

Next, program design estimate methods that were used to generate impacts for the majority of the 1995 program applications are introduced. This discussion focuses on the methods used to derive impacts for the Retrofit Express (RE) Program.

An analysis approach is then presented that estimates program lighting impacts using an hourly impact model.

Then, detailed derivations are presented for several key engineering parameters, including business type-specific operating schedules, technology- and business type-dependent operating factors, and heating and cooling system impacts caused by changes in heat gain from the lighting system.

Next, engineering results are presented.

- First, the frequency of observed lamp burn-out is explored to highlight the importance of including these adjustments in all future program design estimates.
- Then, evaluation estimates of annual fixture hours of operation are compared against ex ante assumptions, yielding results by business type and technology group.
- Next, evaluation estimates of summer on-peak coincident diversified operating factor (CDOF) are presented, yielding significant results by business type and technology group.

- Lastly, evaluation estimate results are presented for heating (energy and therm) and cooling (energy and demand) impacts caused by the retrofit of standard-efficiency lighting systems with high-efficiency systems offered under the program.

Then, the methods are described that were used to both classify and analyze 1995 program impacts for lighting retrofits installed under the Customized Incentives Program.

Finally, to summarize the engineering effort, RE-selected hourly impact profiles are presented by daytype, business type, and time-of-use (TOU) costing period for selected RE lighting measures.

B.2 OVERVIEW OF THE EVALUATION APPROACH

This overview of the engineering approach addresses the generic methodology used to estimate impacts for the majority of the lighting retrofits covered under the RE and Customized Incentives programs, and the data sources contributing to these estimates of energy, therm, and demand impact. More specifically, the following are addressed as follows:

First, lighting end-use parameters, which contribute to energy, therm, and demand impact estimates, are introduced using the impact decomposition approach.

Then, data sources that contributed to each component of impact are then discussed. This introduction focuses on the accuracy of these contributing data elements, and the concept of the nested sample design that was used to transfer accurate data elements.

B.2.1 Introduction to the Impact Decomposition Approach

The general lighting model used to estimate most of the impacts under the RE and Customized Incentives programs was founded on the decomposition of lighting impacts into manageable engineering parameters. The impact decomposition approach was used to estimate unadjusted engineering impacts (UEIs) over a specified period of time—by daytype/hour—and is defined as follows:

$$UEI_t = [(\Delta UOL \times U \times OF_t) \times T_l \times [1+HVAC]$$

Where

ΔUOL = the technology level change in connected kW associated with a particular measure.

U = the number of measure units installed for a particular application.

OF_t = the operating factor which describes the percentage of full load used by a group of fixtures during a prescribed period of time, t.

T = the time interval for which an impact is estimated; for most measures, the OF term is the engineering parameter that changes significantly over time. Time intervals for lighting estimates were single hours, segmented by hours "on" (open operating factor) and hours "off" (closed operating factor) schedules.[1]

[1] Although there are periods of time when lights are generally considered off, many lights are either accidentally or purposely left on during these periods. The effective hours of lighting operation captured during these off periods were applied using the operating factor term (the probability that lights operate during a particular time interval).

HVAC = the component of impact associated with both the net savings due to cooling (demand or energy) and the net increase due to heating (energy or therm).

The process of analyzing each contributing element in this relationship with respect to time dependency is referred to in this approach as engineering model calibration. Premise-specific estimates were calibrated to either business type segment-level results, technology group segment-level results, or both. Calibration of the lighting end-use engineering parameters yielded typical lighting hourly load shapes by daytype and season.

Note that neither program design demand nor energy impact estimates include claimed credits for the indirect HVAC impacts associated with a reduction in internal heat gain (as a result of an efficient lighting retrofit).

B.2.2 Data Sources and the Nested Sample Design

Data sources used in the engineering analysis are mapped to specific analysis objectives in Exhibit B-1. Note that the impact approach used several data sources to collect similar engineering parameters. The purpose of gathering like information from several sources was to ensure calibration of engineering parameters using the most accurate data gathered.

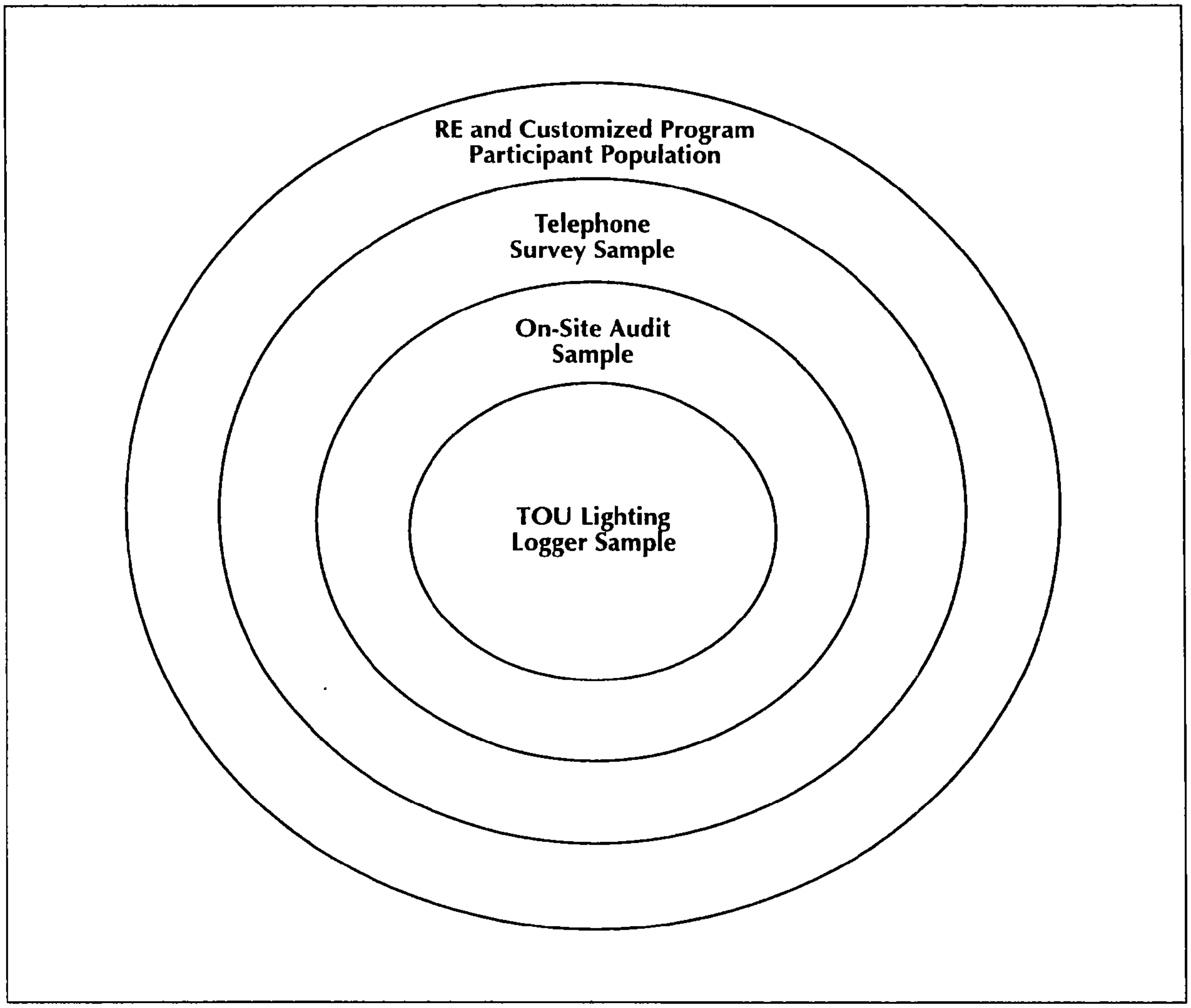
Exhibit B-1
Engineering Analysis Data Sources

Data Sources / Impact Analysis Objectives		Telephone Survey		On-Site Audit		Metering
	MDSS Database	Lighting Participant	Program Nonparticipant	Lighting Participant	Program Nonparticipant	TOU Metering
Unit Operating Load/Impact						
Old Wattage	●					
New Wattage	●					
Impact (UOI)	●					
Hours of Operation						
Operating Factor (OF)				●	●	●
Operating Hours (OH)		●	●	●	●	●
Measure Installation						
Unit Installed (U)	●			●		
Retention				●		
Burned-Out Lamps				●	●	
Interactions						
Cooling Savings		●				
Heating Penalty		●				

Resource constraints required that the most accurate, and therefore valuable, analytical data were gathered at a relatively small sample of sites, and that these data were then transferred to a larger sample of participants using leveraging techniques whenever possible.

Exhibit B-2 depicts the nested sample design that was used to generate the most accurate estimate of engineering parameters, given certain constraints imposed by limited resources.

Exhibit B-2
Schematic of the Commercial Lighting Program
Nested Data Collection Design



A good example of this calibration process using the nested sample design involves the use of logger information to calibrate on-site self-report lighting schedules, and likewise, the use of calibrated on-site self-report lighting schedules to calibrate the telephone sample self-report lighting schedules. Details regarding the derivation of calibrated operating schedules are presented in *Section B.5.1* of this appendix.

B.3 PROGRAM DESIGN IMPACT ESTIMATE METHODS

B.3.1 Overview

The methods implemented to achieve 1995 Lighting RE program design impacts are introduced in this section.[2] The gross program design impacts that were generated using these methods are recorded in the Management Decision Support System (MDSS) database and are also referred to in this report and appendix as the ex ante impact estimates. These methods are introduced at this early stage in the engineering approach to enable the direct comparisons between evaluation and program design engineering parameters that appear throughout the remainder of this section. In this section, engineering parameters that were used to generate ex ante impact estimates are defined, including the following:

ΔUOL -- Measure-specific, per-unit noncoincident demand impacts (the difference in fixture connected load pre- and post-retrofit) were used as inputs to both the energy and demand impact estimates.

CDF -- A Coincident Diversity Factor (CDF) is described, a parameter that serves to diversify noncoincident demand impact estimates.

Annual Hours of Operation -- Annual hours of operation, defined by business type and measure segment, were used to generate annual energy impact estimates.

Results are presented following this overview of the program design methods; these results are based on an effort to reproduce program design estimates. The methods described in this section were applied and yielded several important discrepancies between the intended application of these impact methods and the gross impacts stored in the MDSS.

B.3.2 Noncoincident Demand Impact Calculations

All lighting estimates require the use of pre- and post-retrofit fixture connected loads or, more typically, the change in fixture connected load. This engineering parameter represents the ΔUOL term in the impact decomposition approach. This change in lighting system connected load is referred to as the noncoincident demand impact, which is defined for each RE measure using the following formula:

$$kW_{NCP} = kW_E - kW_R \qquad (1)$$

Where

kW_{NCP} = Per-unit noncoincident demand impact by measure

kW_E = Per-unit existing measure demand

kW_R = Per-unit retrofit measure demand

Exhibit B-3 provides a summary of the assumed change in connected load for the measures installed according to the 1995 Lighting RE document cited above. This difference in connected

[2] These methodologies are described in an October Advice Filing titled "1995 Lighting Retrofit Express Program", submitted by Darrell Hall and Sam Cohen; Advice Filing 1867-G/1481-E.

load is based upon both the measure definition specified under the Lighting RE program (and typical customer installations for each measure), and an assumed existing system that represents a typical customer configuration prior to retrofit.

Also provided in Exhibit B-3 are the specific CDFs and coincident demand impacts, and nonsegment-specific annual energy impacts used to generate program design estimates. These terms are described in detail in the following two subsections.

The RE connected load figures were carried over into the evaluation analyses of program savings, though they were modified wherever possible for lamp burn-out rates in both the new and existing systems. Typical lamp burn-out rates were determined for specific technology groups, based upon data gathered during on-site audit activities. Burned-out lamp rates and methodologies are presented in an upcoming section of this appendix.

Design estimates are based upon an assumed existing fixture. As PG&E retains few records (hard copy application records for the Customized Incentives Program only) of the removed fixtures, an assumed pre-retrofit (existing) fixture was developed for each RE measure. The difference in connected load is based upon both the measure definition specified under the lighting RE program (and typical installations for each measure), and an assumed existing system that represents a typical customer configuration prior to retrofit.

Exhibit B-3
Fixture Assumptions Used to Generate RE Commercial Lighting Program Design (Ex Ante) Estimates

Measure Group Description	Application Year	MDSS Measure Code	Per-Unit NC Impact (Watts)	Coincident Diversity Factor	Per-Unit Peak Demand Impact (Watts)	Per-Unit Annual Energy Impact* (kWh)
Halogen						
< 45 watts	1994	L60	30.0	0.67	†	60
< 50 watts	1995	L173	30.0	0.67	†	60
> 50 watts	1994, 1995	L61	50.0	0.67	†	150 / 105
Compact Fluorescent Lamps						
Screw In CF						
5-13 watts	1994	L62	45.0	0.67	30.2	
14-26 watts	1994	L63	45.0	0.67	30.2	
Screw In CF- Reusable ballast						
5-13 watts	1994, 1995	L64	45.0	0.67	30.2	
14-26 watts	1994, 1995	L65	45.0	0.67	30.2	
Hard Wired CF						
5-13 watts	1994, 1995	L66	45.0	0.67	30.2	
14-26 watts	1994, 1995	L67	45.0	0.67	30.2	
27-50 watts	1994, 1995	L68	52.0	0.67	34.8	
Incandescent to Fluorescent Fixture						
With Energy Saving Ballast & T12 Lamps	1993, 1994	L7	212.0	0.67	142.0	
With Electronic Ballast & T8 Lamps	1993 - 1995	L8	240.0	0.67	160.8	
Exit Signs						
Incand. to Compact Fluorescents	1993 - 1995	L5, L110	29.0	1.00	29.0	254
Incand. to LED or Electroluminescent Retrofit	1993 - 1995	L6	33.0	1.00	33.0	289
Efficient Ballasts Changeouts						
Electronic Ballasts						
2 Lamp Electronic Ballast	1993 - 1995	L14	19.0	0.67	12.7	
3 Lamp Electronic Ballast	1993 - 1995	L15	29.0	0.67	19.4	
4 Lamp Electronic Ballast	1993 - 1995	L16	38.0	0.67	25.5	
T8 Lamps and Electronic Ballasts						
New Fixtures						
2'-1 U Tube or 2 lamps	1994, 1995	L69	21.0	0.67	14.1	
2'-2 U Tubes or 4 lamps	1994, 1995	L70	43.0	0.67	28.8	
2'-3 U Tubes or 6 lamps	1994, 1995	L71	78.0	0.67	52.3	
4'-1 lamp	1994, 1995	L72	22.0	0.67	14.7	
4'-2 lamps	1994, 1995	L73	22.0	0.67	14.7	
4'-3 lamps	1994, 1995	L74	37.0	0.67	24.8	
4'-2 lamps or 8'-1 lamps	1995	L160	22.0	0.67	14.7	
4'-4 lamps or 8'-2 lamps	1994, 1995	L75	45.0	0.67	30.2	
Fixture Modif.- Replace Lamps and Ballasts						
Replace Lamps & Ballasts - 2' Fixture	1993 - 1995	L21	10.5	0.67	7.0	
Replace Lamps & Ballasts - 3' Fixture	1993 - 1995	L22	13.0	0.67	8.7	
Replace Lamps & Ballasts - 4' Fixture	1993 - 1995	L23	11.8	0.67	7.9	
Replace Lamps & Ballasts - 8' Fixture	1993 - 1995	L24	22.5	0.67	15.1	
Delamp Fluorescent Fixtures						
Fixture Modif.- Delamp and Reflector						
Removal - 2' Lamps & Ballasts	1993 - 1995	L17	32.0	0.67	21.4	
Removal - 3' Lamps	1993 - 1995	L18	43.0	0.67	28.8	
Removal - 4' Lamps	1993 - 1995	L19	46.0	0.67	30.8	
Removal - 8' Lamps	1993 - 1995	L20	96.0	0.67	64.3	
High Output T8 & T10 Conversion w/ Delamp						
T10 & Energy Saving Ballast	1994	L76	31.0	0.67	20.8	
T10 or T8 & Electronic Ballast	1994, 1995	L77	65.0	0.67	43.6	
High Intensity Discharge						
Interior Compact HPS from Incand.						
0-35 watts HPS	1994, 1995	L78	107	0.67	71.7	
36-70 watts HPS	1994, 1995	L79	112	0.67	75.0	
71-100 watts HPS	1994, 1995	L80	155	0.67	103.9	

Exhibit B-3 (Continued)
Fixture Assumptions Used to Generate RE Commercial Lighting Program Design (Ex Ante) Estimates

Measure Group Description	Application Year	MDSS Measure Code	Per-Unit NC Impact (Watts)	Coincident Diversity Factor	Per-Unit Peak Demand Impact (Watts)	Per-Unit Annual Energy Impact* (kWh)
Interior Standard MH from Merc. Vapor						
101-175 watts MH	1993 - 1995	L26	240	0.67	160.8	
176 watts & greater MH	1993	L37		0.67	0.0	
176-250 watts MH	1994, 1995	L27	528	0.67	353.8	
251-400 watts MH	1994, 1995	L81	620	0.67	415.4	
Reduced Wattage Lighting						
4' T-8 Lamp Replacement	1993	L13	11	0.67	7.4	
4' Energy Saving Lamp Replacement	1992	L112	7	0.67	4.7	
Controls						
Time Clocks	1993 - 1995	L31	352	NA	0.0	439
Occupancy Sensors						
351-1000 watts controlled	1993	L33	704	NA	212.0	824
Wall Mounted	1994, 1995	L82	264	NA	62.0	277
Ceiling Mounted	1994, 1995	L83	704	NA	212.0	824
Bypass/Delay	1993, 1994	L35	352	NA	106.0	412
Photocell	1993 - 1995	L36	352	NA	0.0	99

* Most ex ante (MDSS) energy impacts vary as a function of business type.
† Halogen fixture, ex ante peak demand impacts vary by business type.

B.3.3 Coincident Demand Impact Calculations

To estimate the ex ante coincident demand impacts, engineering estimates of noncoincident demand impact from equation (1) are multiplied by a CDF which was developed based upon PG&E load research data, as part of the Commercial End-Use Metering Project performed by Regional Economic Research (RER). CDF[3] is mathematically defined as:

CDF = Coincidence Factor x Diversity Factor

Where

Coincidence Factor is the ratio of the measure demand reduction at system peak and the noncoincident demand impact

and

Diversity Factor is the probability that a given measure is on at the time of system peak

The value of CDF for most lighting end-use program design estimates is 0.67. Hence, coincident demand impacts are typically estimated as follows:

Coincident Demand Impact $= 0.67 \times kW_{NCP}$

As shown in Exhibit B-3, the CDF does vary for certain measures, specifically exit lights, while for other measures, peak demand impacts are not calculated using a CDF. Evaluation methods used business type-specific schedules in conjunction with business type and technology group operating factors to generate program impacts at the hourly level, as discussed in *Section B.4*.

[3] According to page NRR-37 of the 1993 Retrofit Express Nonresidential Retrofit Program Advice Filing.

B.3.4 Annual Energy Impact Calculations

Per-unit ex ante energy impacts are typically calculated based upon the product of the per-unit noncoincident demand impact and industry group annual hours of fixture operation, as shown in the following equation:

$$kWh_{ANNUAL} = kW_{NCP} \times hrs \quad (2)$$

Where

kWh_{ANNUAL} = Per-unit annual energy impact by measure

hrs = Annual hours that a given measure operates in business type z

B.3.5 Annual Hours of Operation by Business Type

Annual hours of fixture operation are based upon results from a PG&E study (HBRS and Customized Incentives 1992) and negotiations regarding impact estimates, according to a 1991 PG&E Advice Filing with the CPUC. Hours of operation vary by business type, except in cases where all sectors share identical estimates for hours of operation, such as exit lighting. Exhibit B-4 provides assumed hours of operation for various business types, as specified in the majority of the program design estimates. Refer to Exhibit B-3 for additional information regarding measures that are assumed to have the same energy impacts, independent of business type.

Exhibit B-4
Annual Fixture Operating Assumptions Used to Generate Retrofit Express Commercial Lighting Program Design Estimates

Business Type	Annual Operating Hours
Office	3,400
Retail	4,700
College/Univ	3,500
School	2,100
Grocery	7,000
Restaurant	4,800
Health Care	4,000
Hotel/Motel	4,000
Warehouse	4,000
Personal Service	4,000
Community Service	4,000
Misc.	4,000

The evaluation results do not use the operating hours specified in the program design methodology, yielding instead to customer schedules derived using self-reported telephone survey responses, on-site schedule group responses, and lighting logger data to calibrate those responses. Again, unique customer lighting profiles were generated at the hourly level by daytype and season, in order to accurately estimate impacts according to PG&E-specified TOU periods. This methodology ensured consistency between hourly impacts and energy impacts, where energy is derived by simply adding across specific hours.

B.3.6 Reproduction of Program Design Estimates

In an attempt to verify both the methods used to generate program design impacts and the impact estimates stored in the MDSS, Lighting RE program ex ante impacts were reproduced. Although the methods applied in the MDSS were generally found to be correct, in several instances differences were found between the reproduced values and those stored in the MDSS. Further investigation showed that for specific cases impact estimates in the MDSS were calculated incorrectly. Those particular instances are summarized below.

L1,L36, L38 Energy – Energy impact estimates for halogen measures were underestimated. The cause of this error appears to be related to double-counting the effect of measure life on energy impact estimates. Impact reduction due to the relatively short measure life of halogen technologies is already accounted for by the MDSS variable PKWH1.

L1,L36, L38 Energy – For demand impact estimates, measure life (PPJ_LIF1) provides the probability of measure burnout during the course of a year—assuming the measure would not be replaced—which is consistent with the Advice filing methods. However, applying these probabilities to the PKWH1 impacts is incorrect since this variable has already been adjusted for halogen measure life.

Other Records -- Another 11 MDSS records underpredict energy and demand impacts by roughly 10-30 percent. All of these observations fall within the university and other business types and affect L6, L17, L21-L23, L67, L72, L73, and L75. There does not appear to be any clear pattern surrounding these errors.

L14, L15, L16 -- To reproduce MDSS estimates for efficient ballasts, an assumption was made that PNUMPUR1 contains the number of ballasts installed. While this is accurate with respect to 1994 and 1995 application forms, this contradicts the 1993 application form (in which rebates are issued based upon the number of lamps affected, not ballasts installed).

B.4 EVALUATION APPROACH

To satisfy the PG&E requirements for impact estimates by Time-of-Use (TOU) costing periods, all impact estimates were generated hourly. Engineering estimates that were used as inputs to the SAE were estimated using operating schedules that were developed within each business type.

To estimate energy impacts for each hour, business type operating schedules were developed by daytype and hour and expressed as numeric values between 0 and 1, where 1 indicates that the probability of being open is 100 percent, and 0 represents a closed premise. Impacts use distinct operating factors by daytype for both closed periods and open periods. Additionally, operating factors were derived by business type and technology group. To estimate hourly energy impacts, fixture noncoincident demand connected loads are used along with the applicable schedule and operating factors, according to the following equation:

$$UEI_{ijzdh} = \Delta UOL_i \times U_{ij} \times \left[(PO_{jdh} \times OOF_{izd}) + ((1 - PO_{jdh}) \times COF_{izd})\right] \times \left[1 + HVAC_{ij}\right]$$

Where

UEI_{ijzdh} is the unadjusted engineering impact for measure i, customer j, business type z, daytype d, and hour h.

ΔUOL_i is the change in connected load for technology measure i.

U_{ij} is the number of units of technology type i installed by customer j.

PO_{jdh} is the schedule defined probability that customer j will be open on daytype d during the hour h.

OOF_{izd} is the open-period operating factor which describes the percentage of full load (during normal business hours) used by a group of fixtures of type i, in business type z, during daytype d.

COF_{izd} is the closed-period operating factor which describes the percentage of full load (during non-business hours) used by a group of fixtures of type i, in business type z, during daytype d.

$HVAC_{ij}$ is the contribution of impact caused by both heating and cooling interaction for technology measure i, installed by customer j.

Energy impacts for each measure/daytype/hour were derived and applied to the 1995 calendar year, yielding demand profiles which encompassed all 8,760 hours in a year.

In addition, hourly HVAC interactive therm impacts were calculated using methods that are described in detail in *Sections B.5.3.4* and *B.5.3.5* of this appendix.

B.5 DETAILED ENGINEERING DERIVATIONS

B.5.1 Business Type Operating Schedule Derivation

Calibrated operating schedules for each business type were developed using data gathered from lighting loggers, on-site audits, and participant and nonparticipant telephone surveys. The following discussion provides details of the analysis steps used in the calibration process of operating schedules:

Loggers were installed to measure operating schedules within schedule groups at a selected number of audit sites. During the monitoring period, each logger stores a continuous date- and time-stamped record of lights being turned on or turned off. These continuous data were then transferred into a useful format for analytical purposes using the following steps:

- Each 15-minute interval during the monitoring period was assigned a value between 1 and 0 that specifies the percentage of time during the 15-minute interval that a particular light operated. These 15-minute values were then aggregated to hourly results.

- Then, for each logger, hourly mean values were generated by daytype (weekday, Saturday, and Sunday) for the duration of the monitoring period. This yielded an hourly/daytype operating factor (the percentage of time the lights were on) for the fixture monitored.

- In order to derive operating schedules from the logger data, it was necessary to set criteria for open and closed periods. The criteria used to determine the time of transition from open-period to closed-period was set at half the difference between the maximum hour-specific observation and the minimum hour-specific observation for a given daytype.

Customer self-reported operating schedules were developed, at the schedule group level, for every premise in the audit sample.

- For analytical purposes, self-reported schedule group profiles are represented as hourly numerical values. Generally these consist of 1s (schedule group fixtures are on) and 0s (schedule group fixtures are off), though "shoulder" hours (when the schedule group fixtures transition from on to off) may have intermediate values. These values represent the probability for any given hour of the day that lights are operating, according to the on-site contact.

- Operating schedules were developed for each of the three daytypes (weekday, Saturday, and Sunday).

Next, the self-reported operating schedules for each audited premise were adjusted, at the schedule group level, to correct for bias detected by measurements within the logger sample. This bias was determined through an analysis of the nested lighting logger sample (that falls within the audit sample). Logger data and self-reported operating schedules were compared hourly, to detect bias in the self-report open-period to closed-period transitions using the following sequence of steps:

- Operating schedules for loggers and schedule groups within a particular business type were independently combined using a weighted mean calculation. Weights were applied based upon the total "equivalent" retrofit connected load for a given technology.
  - For retrofitted fixtures in a particular schedule group, the weight is simply based upon the connected load of the fixture.
  - For existing fixtures in a particular schedule group, however, the weight is based upon the equivalent connected load of a retrofit fixture that would replace the existing technology under PG&E's Lighting program (i.e., an existing 60 watt incandescent bulb would have the equivalent weight of a 15 watt compact fluorescent bulb).

- Then, adjustments were developed (by business type) to the self-reported schedule group open-period to closed-period transitions, based upon measured differences detected in the logger sample.

- Lastly, all schedule group self-reports from the audit sample were adjusted to correct for the business type mean bias detected within the logger sample. Schedules were adjusted by moving the self-report periods of transition (both open period to closed period and closed period to open period).

- In general, the results of these analyses showed that customer self-reports were highly accurate. In the absence of well behaved business type results, either unadjusted customer self-reports were used or overall segment-independent results were used to adjust the customer self-reports.

Then, premise level schedules were developed for all audited sites using weighted schedule group calculations (based on the retrofit "equivalent" connected load weights described above).

Next, these premise level schedules were compared with the telephone survey-reported operating schedules for each audited site. This analysis allowed for the development of a business type specific bias for the telephone survey, which was applied, where possible, to the telephone sample.

Mean (unweighted) operating profiles were generated at the business type level using data from participant and nonparticipant telephone surveys. Nonparticipant telephone data were used to increase the telephone survey sample size.

Lastly, calibrated operating schedules for each daytype were developed by business type.

- The bias detected in customer telephone-based schedules (measured within the audit-calibrated telephone sample) was applied, where possible, to the larger sample of participant and nonparticipant telephone survey mean business type results.

- In the absence of well behaved business type results, either unadjusted customer telephone survey responses were used or overall segment-independent results were used to adjust the customer survey responses.

These business type adjusted fixture operating profiles were used to generate final evaluation impacts for the entire MDSS sample. These profiles incorporate two distinct calibration steps, bias in on-site self-reported schedules bias in telephone survey self-reported schedules. These calibration steps are grounded on the most accurate information gathered in this research effort, lighting logger data. The final derived schedules represent, at a business type level, the probability that a particular customer will operate their lighting system for a given hour and daytype.

B.5.2 Business Type and Technology Group Operating Factors

Operating factors, the percentage of lights operating during a specified time interval, were generated by business type, technology group, and daytype for facility open and closed periods. The data sources contributing to these estimates were taken primarily from two sources: lamp counts performed at the time of each audit, and lighting logger data used in conjunction with the calibrated schedule group profiles. Open-period operating factors were developed first, and then closed-period operating factors were developed.

B.5.2.1 Open-Period Operating Factors

An open-period operating factor (OOF), is applied hourly in the impact calculation to the probability that a particular business type is open (see B.5.1 for details regarding operating schedules). The steps that were implemented to derive operating factors are presented below.

Preliminary weekday OOFs were developed using lamp counts that were recorded during each on-site audit. Since on-site audits were conducted during normal weekday facility business hours, the lamp counts represent business type- and technology-specific instantaneous weekday OOFs. A table of the preliminary weekday OOFs used to develop impacts can be found in Exhibit B-5. The following steps were used to develop preliminary weekday OOFs:

- Counts of on and off lamps, for both existing and retrofit lamps, were cataloged. Existing lamp counts were used to enhance the sample size for the retrofit technology-specific operating factors.

- An average OOF (weighted by retrofit "equivalent" connected load), was then calculated for each business type and technology group. In order to develop retrofit technology-specific operating factors, existing lamp technologies were mapped to an equivalent retrofit technology (that would replace the existing technology under PG&E's Lighting program).

- A unique OOF was developed for exit signs, using lamp counts from all business types, since continuous operation of exit sign lights is mandatory across business types.

- Schools, with reduced student occupancy in the summer months, prompted the development of two separate weekday OOFs for the analysis period.
    - Instead of technology specific operating factors, an OOF for weekdays prior to June 1, and an OOF for weekdays after June 1, were developed that incorporated all technology groups.

- The audit sample size for the college/university business type was too small for the development of similar OOFs.

- Weighted mean values were also generated for each technology group across all business types (which were used to derive business type/technology group results where sample sizes did not support a finer segment level result).

Exhibit B-5
Preliminary Weekday OOFs by Technology Group and Business Type

	Technology Group									
	Halogen		Standard Fluorescent		Compact Fluorescent		High Intensity Discharge		All Technology Groups	
Business Type	**OF**	**Sample Size**	**OF**	**Sample Size**	**OF**	**Sample Size**	**OF**	**Sample Size**	**OF**	**Sample Size**
College/University	-	-	-	-	-	-	-	-	0.85	1
Community Service	0.93	5	**0.71**	16	**0.44**	14	0.86	5	-	-
Grocery	0.00	1	**0.75**	15	**0.91**	8	0.00	1	-	-
Health Care/Hospital	-	0	**0.76**	16	**0.57**	13	0.74	3	-	-
Hotel/Motel	-	0	0.86	2	0.27	3	-	0	-	-
Misc. Commercial	-	0	0.65	5	1.00	2	0.97	4	-	-
Office	**0.90**	8	**0.92**	65	**0.90**	41	**0.86**	7	-	-
Personal Service	-	0	0.68	4	0.14	1	0.00	1	-	-
Restaurant	1.00	2	**0.75**	10	**0.51**	8	1.00	1	-	-
Retail	**0.97**	6	**0.88**	39	**0.99**	24	**0.89**	10	-	-
School, post-June 1	-	-	-	-	-	-	-	-	**0.43***	9
School, pre-June 1	-	-	-	-	-	-	-	-	**0.83***	17
Warehouse	0.32	2	**0.92**	16	0.51	5	**0.99**	10	-	-
All Business Types	**0.92**	24	**0.87**	216	**0.76**	134	**0.86**	47	-	-

Note: A single open-period operating factor of 0.99 was developed for exit signs which incorporates all business type samples.
Bolded values (with sample sizes of 6 or greater) were used to derive segment-specific final open-period operating factors estimates.
* Operating factors were developed based upon both audits conducted before and after June1 in order to independently capture lighting system operating factors for the summer season.

Using business type and technology specific values, final OOFs were developed for use in evaluation estimates. A table of the final weekday OOFs used to develop impacts can be found in Exhibit B-6. The following detail the criteria used to determine final weekday OOFs:

- Specific OOFs for a given business type and technology group were used if the audit sample size was greater than six. If, however, the audit sample size for a given business type and technology group was less than six, then the technology group mean OOF, weighted across all business types, was used.

- School OOFs for the given analysis period were applied across all technology groups, (with the exception of exit signs).

- The OOF developed for exit signs was applied to all business types.

Exhibit B-6
Final Weekday OOFs by Technology Group and Business Type

	Technology Group				
Business Type	**Halogen**	**Standard Fluorescent**	**Compact Fluorescent**	**High Intensity Discharge**	**Exit Signs**
College/University	0.92	0.87	0.76	0.86	0.99
Community Service	0.92	0.71	0.44	0.86	0.99
Grocery	0.92	0.75	0.91	0.86	0.99
Health Care/Hospital	0.92	0.76	0.57	0.86	0.99
Hotel/Motel	0.92	0.87	0.76	0.86	0.99
Misc. Commercial	0.92	0.87	0.76	0.86	0.99
Office	0.90	0.92	0.90	0.86	0.99
Personal Service	0.92	0.87	0.76	0.86	0.99
Restaurant	0.92	0.75	0.51	0.86	0.99
Retail	0.97	0.88	0.99	0.89	0.99
School, post-June 1	0.43	0.43	0.43	0.43	0.99
School, pre-June 1	0.83	0.83	0.83	0.83	0.99
Warehouse	0.92	0.92	0.76	0.99	0.99

It was also necessary to produce both Saturday and Sunday OOFs with no supporting lamp count data. To support Saturday and Sunday OOFs, logger data were used in the following way:

First, Saturday and Sunday OOFs were developed (both by business type and as a weighted mean across all business types).

Next, weekday OOFs were estimated, (both by business type and weighted across all business types), for two logger sample subsets; those which contained both weekday and Saturday open-period values, and those which contained both weekday and Sunday open-period values.

Then, using the subset weekday OOFs developed above, a ratio of Saturday or Sunday OOFs to the subset weekday OOFs was developed for both Saturday and Sunday (both by business type and as a weighted mean across all business types).

Finally, for both Saturday and Sunday, this ratio was applied to the lamp count-derived weekday OOFs for each business type and technology group (see above for details regarding the lamp count-derived weekday OOFs).

The following equation was used to derive Saturday OOFs (Sunday OOFs were derived using the same equation, with different inputs):

$$OOF_{sat} = OOF_{wkd} \times (LOOF_{sat})/(LOOF_{wkd})$$

Where

OOF_{sat} = adjusted Saturday OOF for a particular business type and technology group.

OOF_{wkd} = lamp count-derived weekday OOF for a particular business type and technology group.

$LOOF_{sat}$ = logger-derived Saturday OOF for a particular business type.

$LOOF_{wkd}$ = weekday OOF developed using the Saturday subset logger sample for a particular business type.

Exhibit B-7 presents sample values used to derive Saturday and Sunday OOFs for the office business type, as well as the subset weekday OOFs developed across all business types. Using values from Exhibit B-7 and the weekday OOF for office halogen lamps (see Exhibit B-6) the following representative calculation is performed to derive a business-type and technology group-specific Sunday OOF:

$$OOF_{sun} = OOF_{wkd} \times (LOOF_{sun})/(LOOF_{wkd})$$

$$OOF_{sun} = 0.90 \times (0.42/0.76)$$

$$= 0.50$$

Exhibit B-7
Example of Logger Derived OOFs
For Use in the Development of Saturday and Sunday OOFs

Business Type	Daytype	Logger Data Sample Size	Operating Factors	Restricted Sample Weekday OF*
Office	Weekday	58	0.80	
	Saturday	26	0.39	0.80
	Sunday	10	0.42	0.76
All Business Types	Weekday	168	0.77	
	Saturday	93	0.63	0.83
	Sunday	66	0.69	0.77

* Unrestricted weekday OFs were derived using a subset of the total logger sample; those that contained both weekday and Saturday open-period OFs and those that contained both weekday and Sunday open-period OFs.

Final Saturday and Sunday OOFs were developed by business type and technology group. A table of the final weekend OOFs used to develop impacts can be found in Exhibit B-8. The following detail the criteria used to determine final weekend OOFs:

- Logger-derived business type-specific values were used if the subset sample size was greater than six for a given OOF. If, however, a given logger subset sample size was equal to or smaller than six then a mean OOF, weighted across all business types, was used.

- The weekday exit sign OOF was applied across all business type segments and daytypes, since the continuous operation of exit sign lights is mandatory.

Exhibit B-8
Final Weekend OOFs by Technology Group and Business Type

Business Type	Halogen	Standard Fluorescent	Compact Fluorescent	High Intensity Discharge	Exit Signs
	Technology Group				
		DAYTYPE: SATURDAY			
College/University	0.70	0.67	0.58	0.66	0.99
Community Service	0.70	0.54	0.34	0.66	0.99
Grocery	0.87	0.71	0.87	0.82	0.99
Health Care/Hospital	0.43	0.36	0.27	0.41	0.99
Hotel/Motel	0.70	0.67	0.58	0.66	0.99
Misc. Commercial	0.70	0.67	0.58	0.66	0.99
Office	0.43	0.44	0.43	0.41	0.99
Personal Service	0.70	0.67	0.58	0.66	0.99
Restaurant	0.89	0.74	0.50	0.84	0.99
Retail	0.90	0.82	0.92	0.83	0.99
School, post-June 1	0.33	0.33	0.33	0.33	0.99
School, pre-June 1	0.64	0.64	0.64	0.64	0.99
Warehouse	0.70	0.70	0.58	0.76	0.99
		DAYTYPE: SUNDAY			
College/University	0.82	0.78	0.67	0.77	0.99
Community Service	1.00*	1.00*	0.67	1.00*	0.99
Grocery	0.82	0.67	0.82	0.78	0.99
Health Care/Hospital	0.57	0.47	0.36	0.54	0.99
Hotel/Motel	0.82	0.78	0.67	0.77	0.99
Misc. Commercial	0.82	0.78	0.67	0.77	0.99
Office	0.50	0.51	0.50	0.48	0.99
Personal Service	0.82	0.78	0.67	0.77	0.99
Restaurant	0.88	0.73	0.49	0.83	0.99
Retail	0.93	0.85	0.95	0.86	0.99
School, post-June 1	0.38	0.38	0.38	0.38	0.99
School, pre-June 1	0.74	0.74	0.74	0.74	0.99
Warehouse	0.82	0.82	0.67	0.88	0.99

* The methods used to derive Sunday open-period operating factors (OOFs) yielded values greater than one in several particular instances. In such instances, OOFs were set equal to 1.00.

A comparison by business type of OOFs that were generated using lamp counts with those generated using logger data was performed. These comparisons strongly support the operating factors generated for weekdays using lamp counts, which, in turn, support the operating factors generated using logger profiles.

B.5.2.1 Closed-Period Operating Factors

A closed-period operating factor (COF), is applied hourly in the impact calculation to one minus the probability that a given facility is open (see *Section B.5.1* for details regarding operating schedules). The steps that were implemented to derive COFs are very similar to those used to derive Saturday and Sunday OOFs. The following discuss any discrepancies and emphasize key steps used to develop COFs:

Business type-specific COFs were developed for weekday, Saturday, and Sunday daytypes using logger data from all technology groups (both by business type and as a weighted mean across all business types), since lamp count data are unavailable for closed-period hours. In order to enhance the logger sample size, COFs were developed across all technology groups.

- With the exception of exit signs, this method was applied for all business types and technologies.
- Since the continuous operation of exit sign lights is mandatory across business types and operating schedules, the exit sign COF was equal to the lamp count-derived OOF for exit signs.

Final business type-specific weekday COFs were developed for use in the impact calculations. Exhibit B-9 displays the final weekday COFs used to develop impacts. Some key points regarding weekday COFs are presented below:

- Since COFs were developed at a business type level, the same COF was applied to all technology groups within a business type.
- It should be noted that a single COF was developed for schools (as compared to the two OOFs that were developed), since school COFs do not change with relation to student occupancy.
- Business type-specific COFs were used if the sample size was greater than six for a given business type. If, however, the sample size for a given business type was equal to or smaller than six, then a mean weighted COF was used.

Exhibit B-9
Final Weekday COFs by Technology Group and Business Type

	Technology Group				
Business Type	**Halogen**	**Standard Fluorescent**	**Compact Fluorescent**	**High Intensity Discharge**	**Exit Signs**
College/University	0.18	0.18	0.18	0.18	0.99
Community Service	0.08	0.08	0.08	0.08	0.99
Grocery	0.20	0.20	0.20	0.20	0.99
Health Care/Hospital	0.24	0.24	0.24	0.24	0.99
Hotel/Motel	0.18	0.18	0.18	0.18	0.99
Misc. Commercial	0.18	0.18	0.18	0.18	0.99
Office	0.23	0.23	0.23	0.23	0.99
Personal Service	0.18	0.18	0.18	0.18	0.99
Restaurant	0.12	0.12	0.12	0.12	0.99
Retail	0.22	0.22	0.22	0.22	0.99
School	0.09	0.09	0.09	0.09	0.99
Warehouse	0.07	0.07	0.07	0.07	0.99

Saturday and Sunday COFs were developed in much the same way that Saturday and Sunday OOFs factors were developed (see above). However, instead of a the logger subset ratio being applied to the weekday lamp count-derived operating factors, the logger subset ratio was applied to the weekday COF developed using the total logger sample. The following equation was used to derive Saturday COFs (Sunday COFs were derived using the same equation, with different inputs):

$COF_{sat} = LCOF_{twkd} \times (LCOF_{sat})/(LCOF_{swkd})$

Where

COF_{sat}	=	adjusted Saturday COF for a particular business type.
$LCOF_{twkd}$	=	weekday COF, derived using the total logger sample for a particular business type.
$LCOF_{sat}$	=	logger-derived Saturday COF for a particular business type.
$LCOF_{swkd}$	=	weekday COF developed using the Saturday subset logger sample for a particular business type.

Final business type-specific Saturday and Sunday COFs were developed for use in the impact calculations. The same criteria used in the development of weekday COFs was applied. Exhibit B-10 displays the final Saturday and Sunday COFs used to develop impacts.

Exhibit B-10
Final Weekend COFs by Technology Group and Business Type

	Technology Group				
Business Type	**Halogen**	**Standard Fluorescent**	**Compact Fluorescent**	**High Intensity Discharge**	**Exit Signs**
		DAYTYPE: SATURDAY			
College/University	0.15	0.15	0.15	0.15	0.99
Community Service	0.14	0.14	0.14	0.14	0.99
Grocery	0.26	0.26	0.26	0.26	0.99
Health Care/Hospital	0.18	0.18	0.18	0.18	0.99
Hotel/Motel	0.15	0.15	0.15	0.15	0.99
Misc. Commercial	0.15	0.15	0.15	0.15	0.99
Office	0.17	0.17	0.17	0.17	0.99
Personal Service	0.15	0.15	0.15	0.15	0.99
Restaurant	0.18	0.18	0.18	0.18	0.99
Retail	0.21	0.21	0.21	0.21	0.99
School	0.04	0.04	0.04	0.04	0.99
Warehouse	0.01	0.01	0.01	0.01	0.99
		DAYTYPE: SUNDAY			
College/University	0.15	0.15	0.15	0.15	0.99
Community Service	0.10	0.10	0.10	0.10	0.99
Grocery	0.25	0.25	0.25	0.25	0.99
Health Care/Hospital	0.23	0.23	0.23	0.23	0.99
Hotel/Motel	0.15	0.15	0.15	0.15	0.99
Misc. Commercial	0.15	0.15	0.15	0.15	0.99
Office	0.17	0.17	0.17	0.17	0.99
Personal Service	0.15	0.15	0.15	0.15	0.99
Restaurant	0.16	0.16	0.16	0.16	0.99
Retail	0.19	0.19	0.19	0.19	0.99
School	0.03	0.03	0.03	0.03	0.99
Warehouse	0.03	0.03	0.03	0.03	0.99

B.5.3 HVAC Interactive Effects

B.5.3.1 Introduction to HVAC Interactive Effects

In addition to the direct effects of lighting retrofits on premise energy and demand, the contribution of impact caused by cooling and heating system use is described in this section. Internal gains affect both the air-conditioning and heating loads in buildings, and thus HVAC equipment run-time and consumption. Lighting retrofits modify the heat gain in buildings, and thus heating system and air-conditioner usage. When high-efficiency lighting systems replace standard-efficiency systems, cooling loads are decreased while heating loads increase. This section presents the method used to quantify those impacts.

Of the engineering data sources used to develop the HVAC interactive analysis of energy and demand, as identified by shading in Exhibit B-11, survey responses and calibration data gathered on-site were the most important.

Exhibit B-11
Data Sources Contributing to Heating and Cooling Interactive Estimates

Data Sources / Impact Analysis Objectives		Telephone Survey		On-Site Audit		Metering
	MDSS Database	Lighting Participant	Program Nonparticipant	Lighting Participant	Program Nonparticipant	TOU Metering
Unit Operating Load/Impact						
Old Wattage	●					
New Wattage	●					
Impact (UOI)	●					
Hours of Operation						
Operating Factor (OF)				●	●	●
Operating Hours (OH)		●	●	●	●	●
Measure Installation						
Unit Installed (U)	●			●		
Retention				●		
Burned-Out Lamps				●	●	
Interactions						
Cooling Savings		●				
Heating Penalty		●				

The interactive effects of HVAC appliances were estimated using methods developed by ASHRAE, and published in an *ASHRAE Journal*[4] article. This article explores HVAC energy usage as a function of energy-efficient lighting design, and estimates potential savings and penalties resulting from efficient technology retrofits.

This section includes a thorough overview of the steps required to implement interactive adjustments to lighting technology-level impacts. Flowcharts are used to depict key decisions that must be made for each contributing customer, and equations are supplied that were used to estimate the interactive benefits (savings) and costs (penalties) for each lighting participant.

[4] Rundquist, R., *et al.* 1993. "Calculating Lighting and HVAC Interactions", ASHRAE Journal, November 1993, pages 28-37.

B.5.3.2 Cooling Energy Equations

The algorithm that was used to estimate cooling energy interactive savings is presented in Exhibit B-12. To estimate the annual cooling energy contribution from the HVAC system, three new terms are introduced in addition to those already required to estimate the lighting technology-only contribution.

Exhibit B-12
Gross Annual Cooling Energy Impact Algorithm

$$COOLSAV_j = \left[HGANNUAL_j \times \frac{1}{MCOP_j} \times HVAC_{PERCENTj} \right] \times \left[\sum_{t=1}^{Tj} \Delta\, kWh_{tjz} \right]$$

Where

$COOLSAV_j$ = Annual HVAC savings resulting from lighting reduction for premise j

$HGANNUAL_j$ = Annual fraction of internal heat gain removed mechanically for premise j

$MCOP_j$ = Marginal coefficient of performance of cooling equipment for premise j

$HVAC_{PERCENTj}$ = The percentage of premise j's facility that is conditioned

$\Delta\, kWh_{tj}$ = Technology t annual energy savings for premise j, a member of industry group z

Tj = The number of lighting technologies installed in premise j

The first term, HGANNUALj, describes the fraction of heat gain removed mechanically from the building, as defined in the ASHRAE method Table 1 (from the ASHRAE article, appended to this report).

- The fraction of heat gain removed mechanically is a function of building size, and whether or not the building is served by an economizer (a device that uses outside air rather than mechanically chilled air to cool buildings when the outside temperature is sufficiently low). The reduced heat gain caused by an energy-efficient lighting retrofit will only benefit the cooling system energy use when lighting waste heat is mechanically cooled.

- Additionally, the fraction of heat gain that is mechanically cooled is always less than one, because of outdoor air ventilation (including the use of economizers), exhaust fans (that mechanically remove heat), and building envelope infiltration.

- Table 1 inputs are weather normalized for various locations throughout the United States, including three cities within PG&E's service territory. Santa Barbara, San Francisco, and Sacramento were used as proxies for each participant site.

The second term, MCOPj, defines the marginal cooling system efficiency, a variable describing the efficiency (including all auxiliaries, and supply and return fans) applicable to the incremental cooling load. A default system efficiency is supplied by the ASHRAE method for estimates that involve the retrofit of lighting systems. The MCOP term serves as a conversion constant in the HVAC energy equation, producing an estimate of electricity consumption needed to mechanically cool lighting waste heat.

The third term, $HVAC_{PERCENTj}$, defines the percentage of conditioned space within each facility (a proxy for the percentage of each retrofit installed within a conditioned space). Although this term is not explicitly defined in the ASHRAE method, accounting for this parameter improves the accuracy of the ASHRAE approach.

Next, the methods used to determine the cooling interactive terms used in the ASHRAE method are described in greater detail.

B.5.3.3 Application of the ASHRAE Cooling Energy Method

Exhibit B-13 introduces the decision-making processes leading to the calculation of annual cooling energy impacts. This exhibit illustrates several key points.

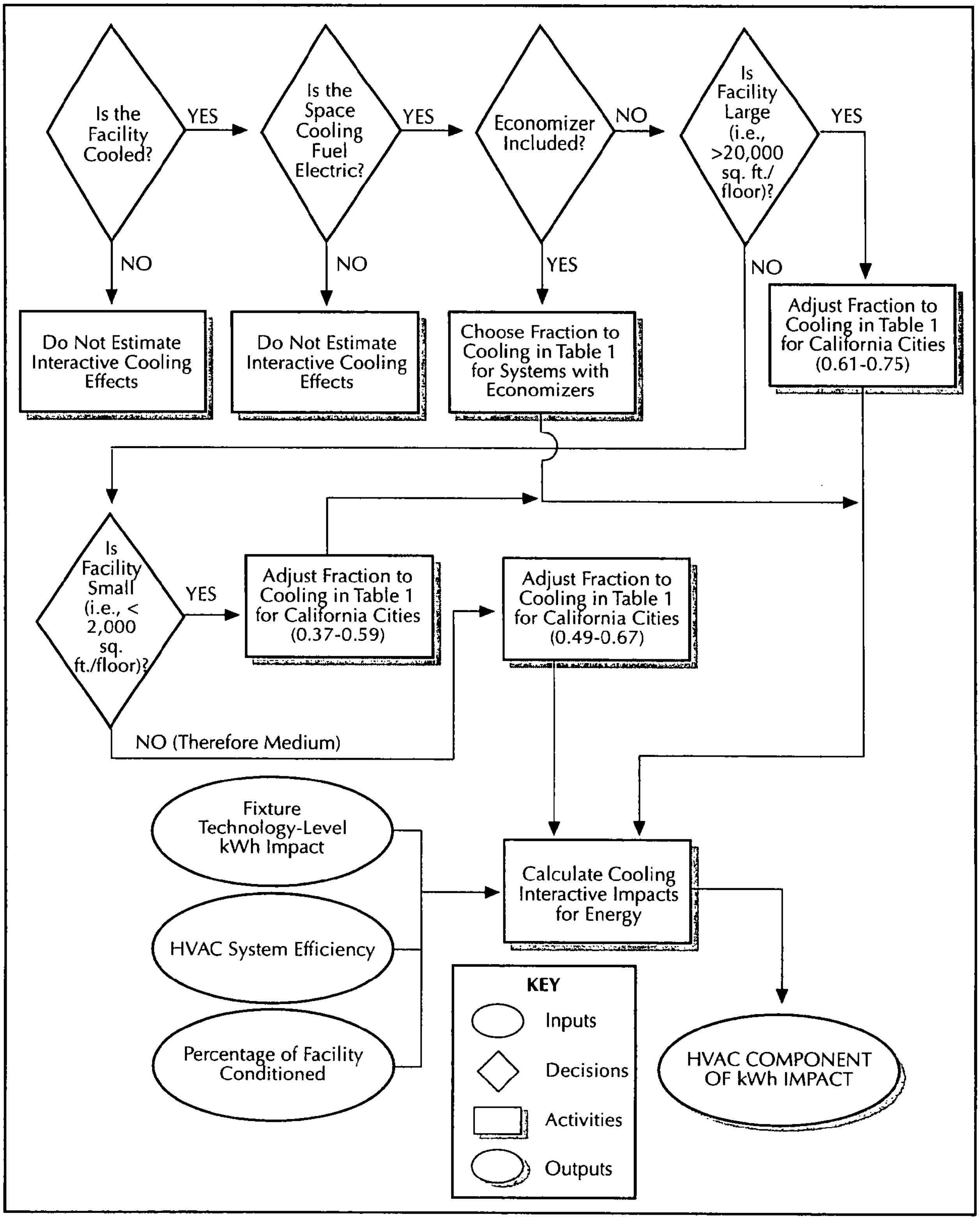
First, cooling impacts were estimated only for premises with cooling systems.

Second, engineering impacts were estimated only for sites served by electric-powered cooling systems. Engineering impacts were estimated in two ways.

- For premises served by HVAC systems that included an economizer mode, ASHRAE article Table 1 HGANNUALj values were selected.

- For premises without economizers, values for HGANNUALj were calculated based upon the building size per floor.

Exhibit B-13
Determining the Cooling Interactive Contribution to Energy Impacts



Buildings are classified into three size categories: large, medium, and small, with relatively large to small values of HGANNUALj, respectively. Premises served by economizers have the smallest relative values of HGANNUALj, thus implying that less lighting system heat is mechanically cooled on an annual basis when economizers are present.

ASHRAE HVAC impacts are achieved by multiplying the heat gain fraction removed mechanically (HGANNUALj) and the marginal coefficient of performance (MCOPj) with annual fixture-level energy impacts for indoor lighting systems, on a per-premise basis. Additionally, the percentage of each facility that is conditioned is applied to each ASHRAE HVAC impact, serving as a proxy for the percentage of each retrofit installed within conditioned space. The resulting cooling energy savings are used as inputs to the SAE analyses, along with both technology-level impacts and heating penalty estimates (as described below).

B.5.3.4 Heating Energy Equations

To estimate the annual heating energy or therm penalty associated with an electric or gas heating system, four new terms are introduced, in addition to those already required to estimate the lighting technology-only impacts and HVAC cooling interactive impacts. The algorithm presented in Exhibit B-14 was used to estimate heating energy and therm interactive penalties, and includes the following distinctive terms:

HVAC interactive heating estimates include a term that describes the fraction of internal heat gain contributing to the building heating loads (HLANNUALj), as defined in the ASHRAE publication, Table 1. The following points must be considered:

- Because a lighting system efficiency upgrade typically results in reduced internal gains, more heat is needed from the HVAC system to meet building losses.
- This input is weather normalized for various locations throughout the United States, including three cities located within PG&E's service territory. A particular city is used as a proxy for each participant site.

The contribution to the heating system is also influenced by the dimensions of each building. The fraction of each retrofit on the exterior 15-foot perimeter, PERIMETERj, is used to define the fraction of fixture heat contributing to the annual heating load. The internal "core" zones are always assumed to require cooling, never heating.

HVAC interactive estimates also include a term that describes the electric heating system efficiency (HPCOPj), which depends upon the system type, specifically, whether heat pump or resistance heat. Resistance heaters are assumed to have an HPCOP of 1.0, while heat pump systems are assumed to have a HPCOP of 1.5.

THERMC describes both the kWh to therm conversion constant and an assumed seasonal efficiency for a typical gas appliance.

Exhibit B-14
Gross Annual Heating Energy and Therm Impact Algorithm

To estimate heating impacts for customers with electric heating systems:

$$ELECPEN_j = \left[HLANNUAL_j \; x \; PERIMETER_j \; x \; \frac{1}{HPCOP_j} \times HVAC_{PERCENTj} \right] x \left[\sum_{t=1}^{T_j} \Delta \, kWh_{tjz} \right]$$

Where

$ELECPEN_j$	= Annual HVAC electric penalty resulting from a lighting retrofit for premise j
$HLANNUAL_j$	= Annual fraction of internal heat gain contributing to the building heating load for premise j
$PERIMETER_j$	= Fraction of lighting retrofit on the perimeter area for premise j
$HPCOP_j$	= Heat pump coefficient of performance of heating equipment for premise j
$HVAC_{PERCENTj}$	= The percent of premise j's facility that is conditioned
ΔkWh_{tj}	= Technology t annual energy savings for premise j, a member of industry group z
T_j	= The number of lighting technologies installed in premise j

To estimate heating impacts for customers with gas heating systems:

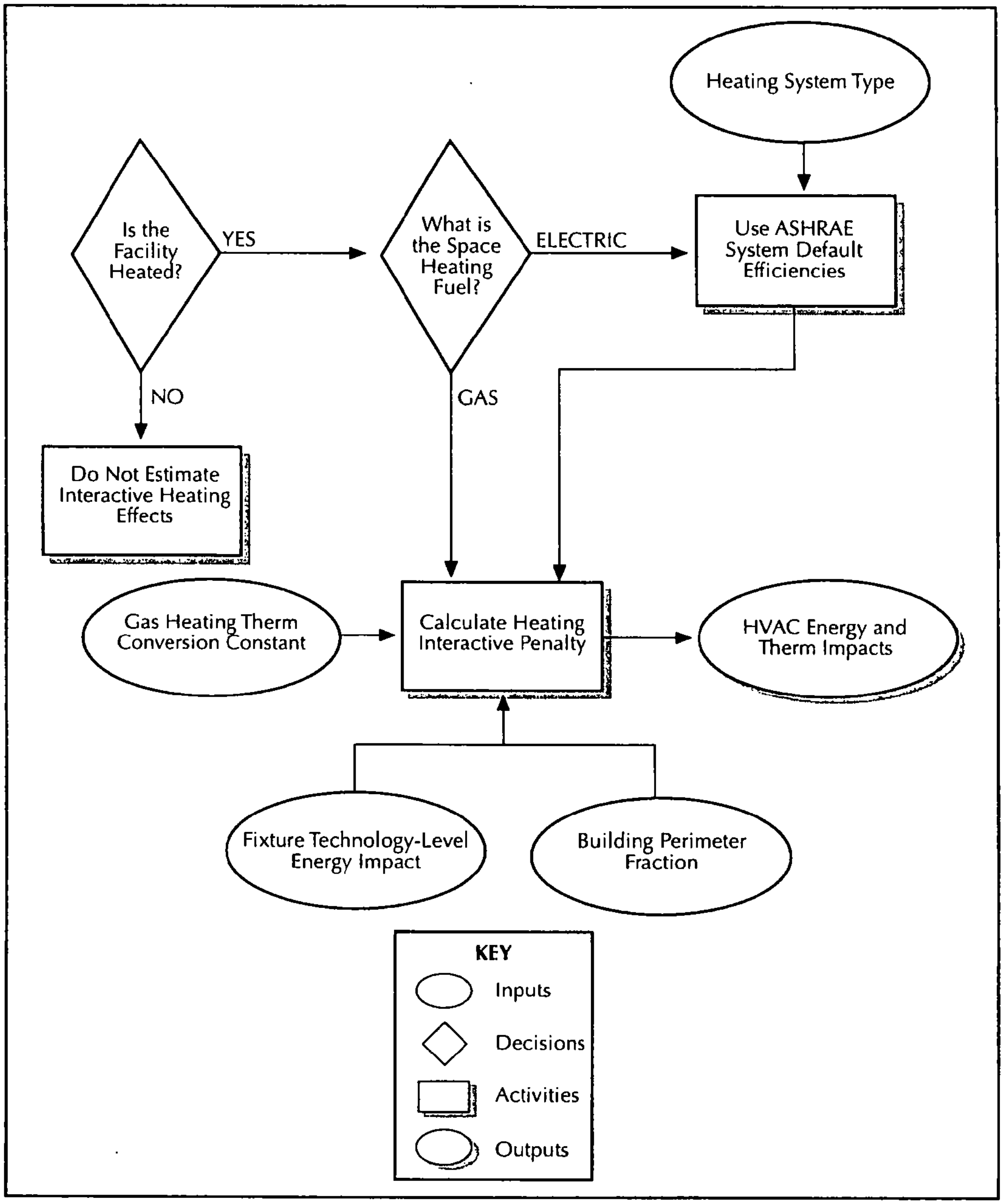
$$GASPEN_j = \left[HLANNUAL_j \; x \; PERIMETER_j \; x \; THRMC \times HVAC_{PERCENTj} \right] x \left[\sum_{t=1}^{T_j} \Delta \, kWh_{tjz} \right]$$

Where

$GASPEN_j$	= Annual HVAC gas penalty resulting from a lighting retrofit for premise j
THRMC	= Therm conversion constant from the ASHRAE method

Next the logic used to determine heating interactive estimates (according to the ASHRAE method) are described in greater detail.

Exhibit B-15
Determining the Heating Interactive Contribution to Energy and Therm Impacts



B.5.3.5 Application of the ASHRAE Heating Energy Method

As described earlier, the efficient lighting technologies installed under the Lighting program caused a reduction in internal heat gains in buildings, and a related increase in the energy required to heat internal spaces. The flow chart shown in Exhibit B-15 establishes the general decisions used to estimate heating impacts using the ASHRAE method. To apply the ASHRAE method, the heating system fuel must be know and, if electric, whether or not the system is a heat pump.

Next, the methods are presented that were used to determine the distribution of annual cooling impacts and heating penalties among each hour in the year.

B.5.3.6 Hourly HVAC Impacts

Impact results for this study are required by costing period (related to TOU customer rates). Since the ASHRAE impacts predict a reduction in cooling energy use and increased heating energy use on an annual basis, a methodology was developed to distribute the annual impacts determined using the ASHRAE method to each customer on an hourly basis. This section describes this method.

The distribution of impacts to each hour of the day was accomplished while maintaining several key constraints.

- HVAC impacts were applied during selected days in proportion to hourly lighting system impacts.
- Cooling impacts were applied to selected days as a function of summed daily temperature.
- Heating impacts were applied to selected days as a function of summed daily temperature.
- HVAC impacts for any given hour were applied based upon mechanical system efficiency parameters supported by the ASHRAE method.

Details regarding the methodology are described below, with special consideration surrounding the constraints described above.

In applying both cooling and heating impacts, certain parameters introduced in exhibits B-11 and B-13 specify the fraction of annual fixture heat gain that must be either mechanically cooled or mechanically heated.

For cooling impacts, the term HGANNUALj x $HVAC_{PERCENTj}$ describes the customer-specific fraction of fixture heat gain that requires cooling, and for heating impacts, HLANNUALj x PERIMETERj x $HVAC_{PERCENTj}$ describes the customer-specific fraction of fixture heat gain that contributes to annual heating loads.

The method used to distribute HVAC impacts over each hour of the year uses the above intermediate results to identify the number of days per year that HVAC impacts are applied. To select specific days (to which HVAC impacts are applied), all days in a year were ranked according to summed daily temperatures, for each of three applicable weather tapes, WYEC Santa Barbara, San Francisco, and Sacramento. Dry bulb temperatures were used for this procedure.

For cooling impacts, the selected days to which impacts were applied (on an hourly basis) are those days with the highest summed daily temperatures. The number of days applied per customer is always HGANNUALj x $HVAC_{PERCENTj}$ x 365. Hourly impacts for applicable measures were generated using the following formula:

$$HVAC_{ijzdhs} = \frac{UEI_{ijzdh}}{MCOP_{j}}$$

Likewise, for electric and gas heating impacts, the selected days to which impacts were applied (on an hourly basis) are those days with the lowest summed daily temperatures. The number of days applied per customer is always HLANNUALj x PERIMETERj x $HVAC_{PERCENTj}$ x 365.

Hourly electric heating impacts for applicable measures were generated using the following formula:

$$HVAC_{ijzdhs} = \frac{UEI_{ijzdhs}}{HPCOP_j}$$

Hourly gas heating impacts for applicable measures were generated using the following formula:

$$HVAC_{ijzdhs} = UEI_{ijzdhs} \times THRMC$$

B.5.3.7 HVAC Demand

The distribution of hourly estimates of HVAC impact during the summer on-peak period and system peak hour, vary day-to-day with changes in fixture operating schedule and outdoor temperature. To arrive at a single program figure for any particular business type and lighting technology segment, mean values were calculated for the peak hour across the entire summer on-peak period, thus providing a diversified estimate of HVAC impact.

This concludes the derivation of HVAC interactive engineering parameters. In the next section of this appendix, intermediate engineering results are presented.

B.6 EVALUATION RESULTS

B.6.1 Overview

In this section detailed engineering results are presented for parameters that contributed to the unadjusted evaluation gross impact estimates.

B.6.2 Burned-Out Lamp Rates

When retrofit Lighting programs are implemented, existing burned-out lamps are often replaced. For those particular lamps, the first year impacts yield an increase in energy use, though the program saves energy across all observations. In addition, some new fixtures will fail a short time after installation, resulting in a decrease in energy use for those particular fixtures. In an effort to quantify these impacts, burned-out lamps were counted during the on-site audits (in addition to the total number of lamps observed). All such counts were categorized as either retrofit technologies or existing technologies, to allow separate analysis of the pre- and post-retrofit burned-out lamp rates.

Total lamp counts yielded significant burned-out lamp results in four fixture categories, as provided in Exhibit B-16 below:

Exhibit B-16
Observed Burned-Out Lamp Rates

Pre- or Post-Retrofit	Technology Group	Observed Burned-Out Lamp Rate
Pre-Retrofit	Incandescent	2.10%
Pre-Retrofit	Standard Fluorescent	1.98%
Post-Retrofit	Compact Fluorescent	1.39%
Post-Retrofit	Standard Fluorescent	0.51%

These burned-out lamp observations were applied to the pre- and post-retrofit connected load assumptions based upon the following rules:

- Burned-out lamp rates were only applied within the RE Lighting program because of the diversity of measures installed under the Customized Incentives Lighting program.
- Burned-out lamp rates were only applied to measures where both the pre- and post-retrofit technologies had supporting burned-out lamp data, never just pre- or just post-retrofit fixture loads.

The following equation was used to incorporate burn-out rates within the estimated change in pre- to post-retrofit connected load:

$$kW_{NCP} = \left[(1 - BO_E) \times kW_E\right] - \left[(1 - BO_R) \times kW_R\right]$$

Where

BO_E = Estimated burn-out rate for the existing measure system

BO_R = Estimated burn-out rate for the retrofit measure system

B.6.3 Hours of Fixture Operation by Business Type and Technology Group

Exhibit B-17 presents a summary of the annual hours of fixture operation applied in generating RE energy impacts in the commercial sector.

Exhibit B-17
Commercial Sector Annual Fixture Hours of Operation By Business Type and Technology Group

Program & Technology Group \ Business Type	Office	Retail	College/ University	School	Grocery	Restaurant	Health Care	Hotel/Motel	Warehouse	Personal Service	Community Service	Misc.
	Commercial Sector Hours of Fixture Operation											
Retrofit Express Program												
Compact Fluorescent	4,000	5,200	3,900	2,300	5,700	3,400	3,200	5,400	3,300	3,700	2,000	3,900
Standard Fluorescent	4,100	4,700	4,300	2,300	4,800	4,600	4,000	5,900	3,900	4,100	2,800	4,200
High Intensity Discharge	3,900	4,700	2,700	2,300	5,400	5,500	4,400	6,200	4,100	4,100	3,100	4,300
Halogen	4,000	5,100	4,600	2,300	5,700	5,700	4,600	6,600	3,900	4,700	3,400	4,500
Exit Signs	8,700	8,700	8,700	8,700	8,700	8,700	8,700	8,700	8,700	8,700	8,700	8,700
Business Type Mean	4,100	4,700	4,100	2,300	4,800	4,400	3,900	5,600	4,000	4,100	2,700	4,200

The hours, presented by business type and technology group, show the annual hours of fixture operation that were applied to all participants in this study. However, this is a result based upon evaluation data from the sample of customers selected for this study. Because of the relatively small sample sizes contributing to this evaluation, it is not recommended that the results be transferred to other participant samples. However, business type results (also shown in Exhibit B-17), are supported by large enough samples to allow transfer to other participant samples.

The annual fixture operating figures presented here are based upon the combined application of customer operating schedules by daytype, and open- and COFs developed by daytype, business type and technology group.

B.6.4 Coincident Diversified Operating Factors by Business Type and Technology Group

Exhibit B-18 presents a summary of the commercial sector peak-hour coincident diversified operating factors (CDOFs). These represent, for a given business type and technology group, the percentage of connected load use estimated for the peak hour on a mean basis across the summer on-peak period. This term incorporates diversity as a function of both customer operating schedules, and weekday OOFs and COFs that were developed by business type and technology group. These terms are presented for the purpose of providing PG&E with detailed customer retrofit performance during the critical on-peak hour.

Exhibit B-18
Commercial Sector Summer On-Peak CDOFs

Program & Technology Group \ Business Type	Office	Retail	College/ University	School	Grocery	Restaurant	Health Care	Hotel/Motel	Warehouse	Personal Service	Community Service	Misc.
	Commercial Sector Summer On-Peak CDF Results											
Retrofit Express Program												
Compact Fluorescent	0.83	0.96	0.70	0.38	0.84	0.49	0.54	0.67	0.73	0.68	0.32	0.72
Standard Fluorescent	0.85	0.86	0.80	0.38	0.70	0.69	0.72	0.76	0.86	0.80	0.48	0.83
High Intensity Discharge	0.83	0.87	0.51	0.38	0.80	0.81	0.81	0.76	0.93	0.78	0.55	0.80
Halogen	0.83	0.95	0.86	0.38	0.85	0.87	0.87	0.81	0.86	0.88	0.64	0.85
Exit Signs	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99
Business Type Mean	0.85	0.87	0.76	0.38	0.71	0.66	0.70	0.70	0.90	0.79	0.48	0.81

The coincident diversified operating factors, presented by business type and technology group, show the CDOFs that were applied to all participants in this study. However, this is a result based upon evaluation data from the sample of customers selected for this study. Because of the relatively small sample sizes contributing to this evaluation, it is not recommended that the results be transferred to other participant samples. However, business type results (also shown in Exhibit B-18), are supported by large enough samples to allow transfer to other participant samples.

B.6.5 HVAC Impact Results

Exhibit B-19 presents commercial sector mean HVAC energy, therm, and summer on-peak demand adjustment factors by business type that describe the ratio of total fixture and HVAC impact to fixture-only impact. Therm impacts are negative, as there is a net increase in heating gas usage caused by lighting retrofits. These adjustments could be applied by business type to future estimates of technology-only lighting impacts, yielding estimates of total impacts that include the HVAC component.

Exhibit B-19
Commercial Sector HVAC Adjustments

	Indoor Lighting HVAC Adjustments		
Business Type	**Energy Adjustment (kWh)**	**Demand Adjustment (kW)**	**Therm* Adjustment (therm/GWh)**
Office	1.19	1.26	-0.39
Retail	1.13	1.22	-0.26
College/Univ	1.10	1.11	-0.11
School	1.18	1.23	-0.43
Grocery	1.14	1.26	-0.09
Restaurant	1.16	1.26	-0.46
Health Care	1.24	1.30	-0.19
Hotel/Motel	1.11	1.20	-0.05
Warehouse	1.06	1.07	-0.06
Personal Service	1.06	1.07	-0.07
Community Service	1.23	1.31	-0.35
Misc.	1.06	1.09	-0.08

* Therm impacts represent the impact in annual therm usage per gigawatt hour of impact in annual energy use (them/GWh).

B.6.6 Customized Incentives Methodology

The Customized Incentives Lighting impacts were estimated using the following steps:

First, hard copy application forms for Customized Incentives Lighting program participants were obtained from PG&E, providing a critical source of information used to derive program impacts. Key engineering data from the forms were entered into a database to classify each impact by technology group, and to generate information regarding the retrofit system installed and the existing system removed.

Then, using the hard copy application forms and MDSS data, impacts were classified according to technology group. This was necessary because Customized Incentives Lighting measures are often not categorized in the MDSS.

Next, for each measure retrofit, a change in fixture connected load was determined.

- Data were taken from hard copy application forms when available.
- If hard copy application forms were not available, the approximate change in connected load was determined using the MDSS demand impact (using the PKW1 variable).

Finally, impacts were developed using the determined change in connected load, the categorized measure, and business type-specific schedule information.

Analysis of the Customized Incentives Lighting participants revealed that some of the items retrofit did not fit into a category associated with the RE Lighting measures, as described in the following cases:

Studio lights: MDSS energy estimates were used and applied evenly to every hour of the year.

EMS system: Energy estimates, taken either from the application forms or the MDSS, were used, and simply applied evenly to every hour of the year.

EMS system to control anti-sweat devices for supermarket refrigerator case doors: Impacts which resulted from the limiting the run-time of anti-sweat devices were tracked in the MDSS under the Lighting program, even though these impacts are associated with refrigeration retrofits.

B.7 INDOOR IMPACT PROFILES BY BUSINESS TYPE AND COSTING PERIOD

To conclude this engineering appendix, hourly/daytype unadjusted gross energy profiles are presented for selected business types, by costing period, for all indoor lighting technologies installed under the RE Lighting program. Exhibits B-20 - B-43, which follow, provide a graphical representation of the distribution profiles of the summer energy impacts developed for this study.

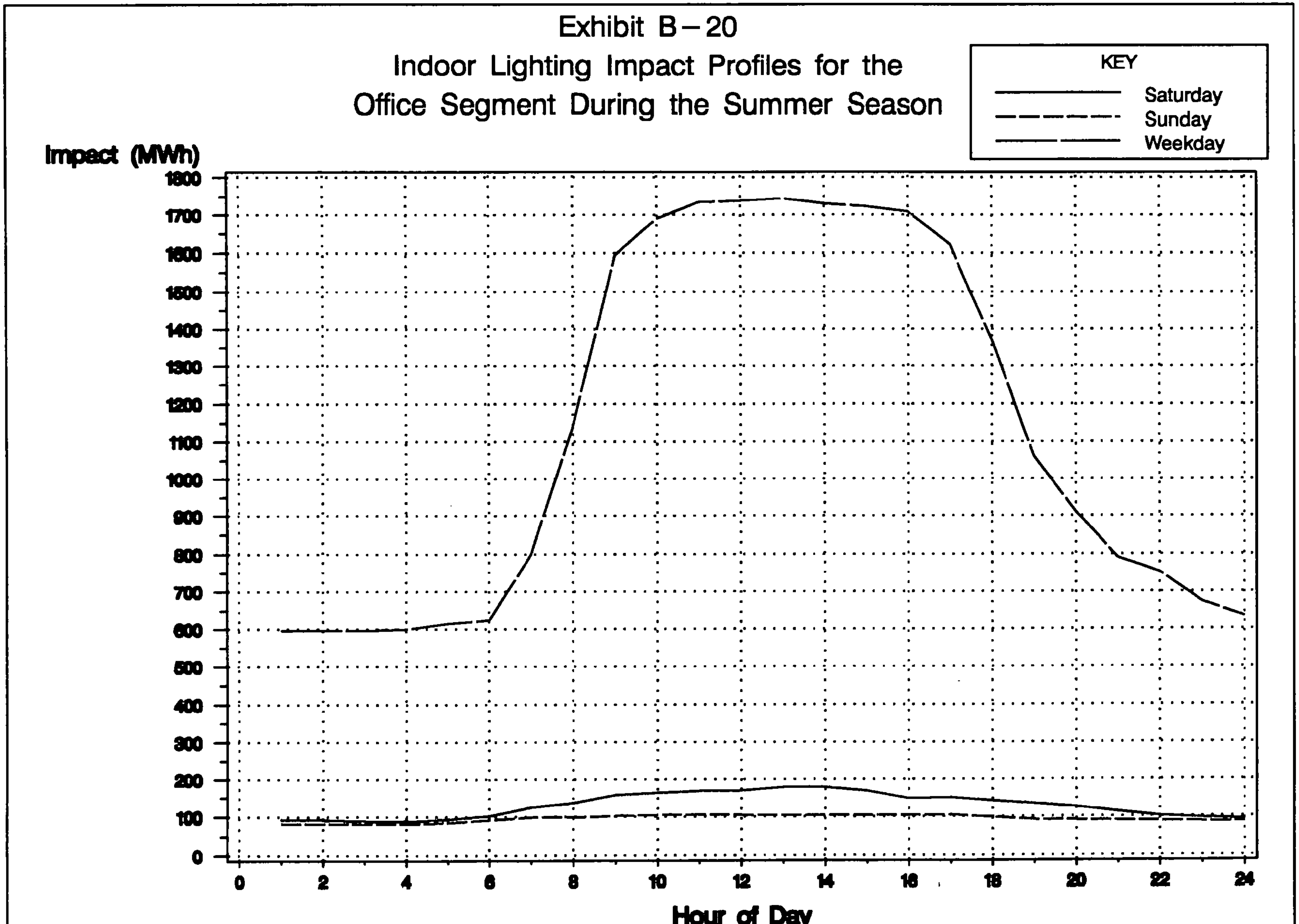


Exhibit B-20
Indoor Lighting Impact Profiles for the
Office Segment During the Summer Season
KEY
Saturday
Sunday
Weekday
Impact (MWh)
1800
1700
1600
1500
1400
1300
1200
1100
1000
900
800
700
600
500
400
300
200
100
0
0
2
4
6
8
10
12
14
16
18
20
22
24
Hour of Day

Exhibit B-21

Indoor Lighting Impact Profiles for the Retail Segment During the Summer Season

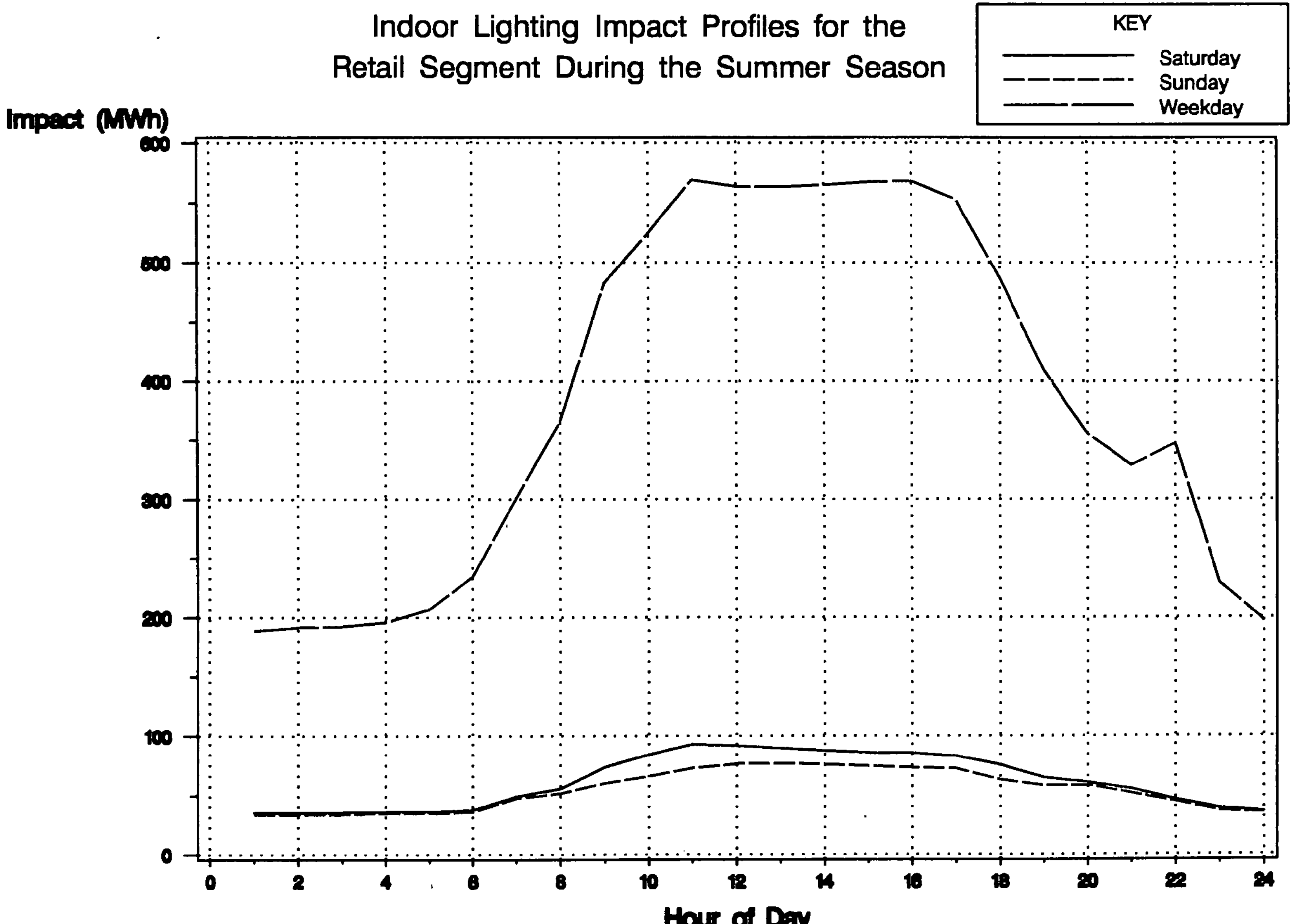


Exhibit B-22

Indoor Lighting Impact Profiles for the Col/Univ Segment During the Summer Season

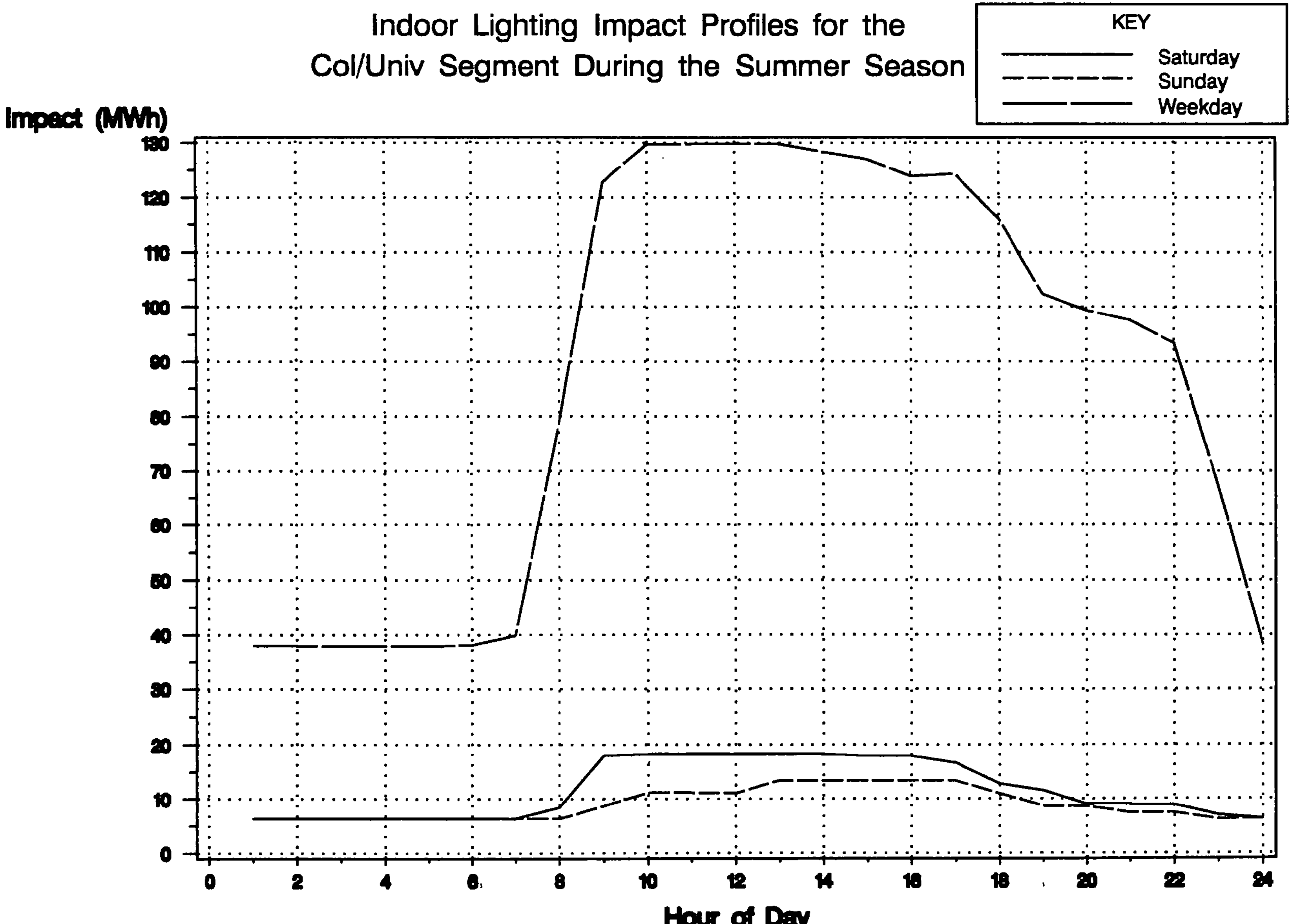


Exhibit B–23

Indoor Lighting Impact Profiles for the School Segment During the Summer Season

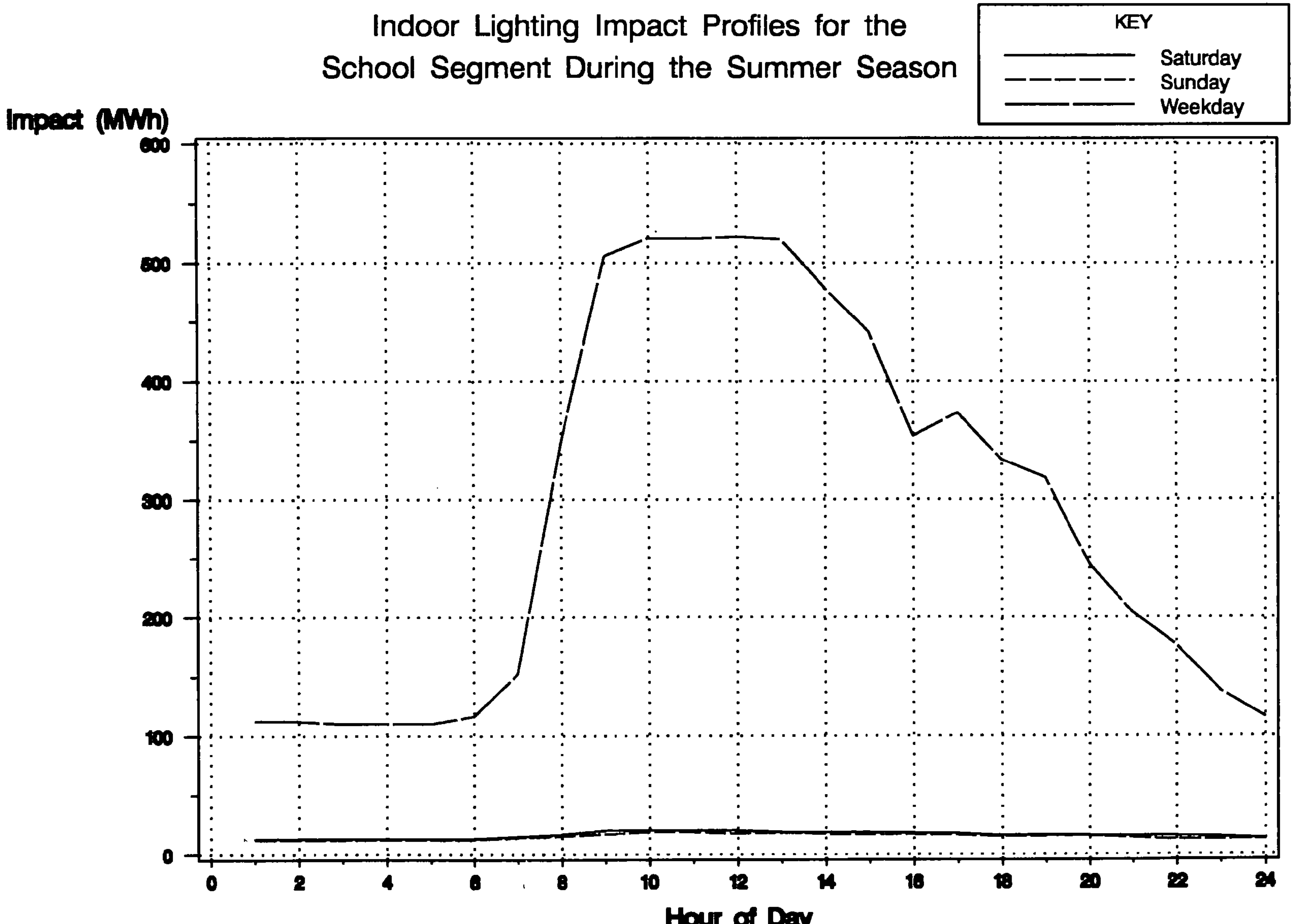


Exhibit B – 24

Indoor Lighting Impact Profiles for the Grocery Segment During the Summer Season

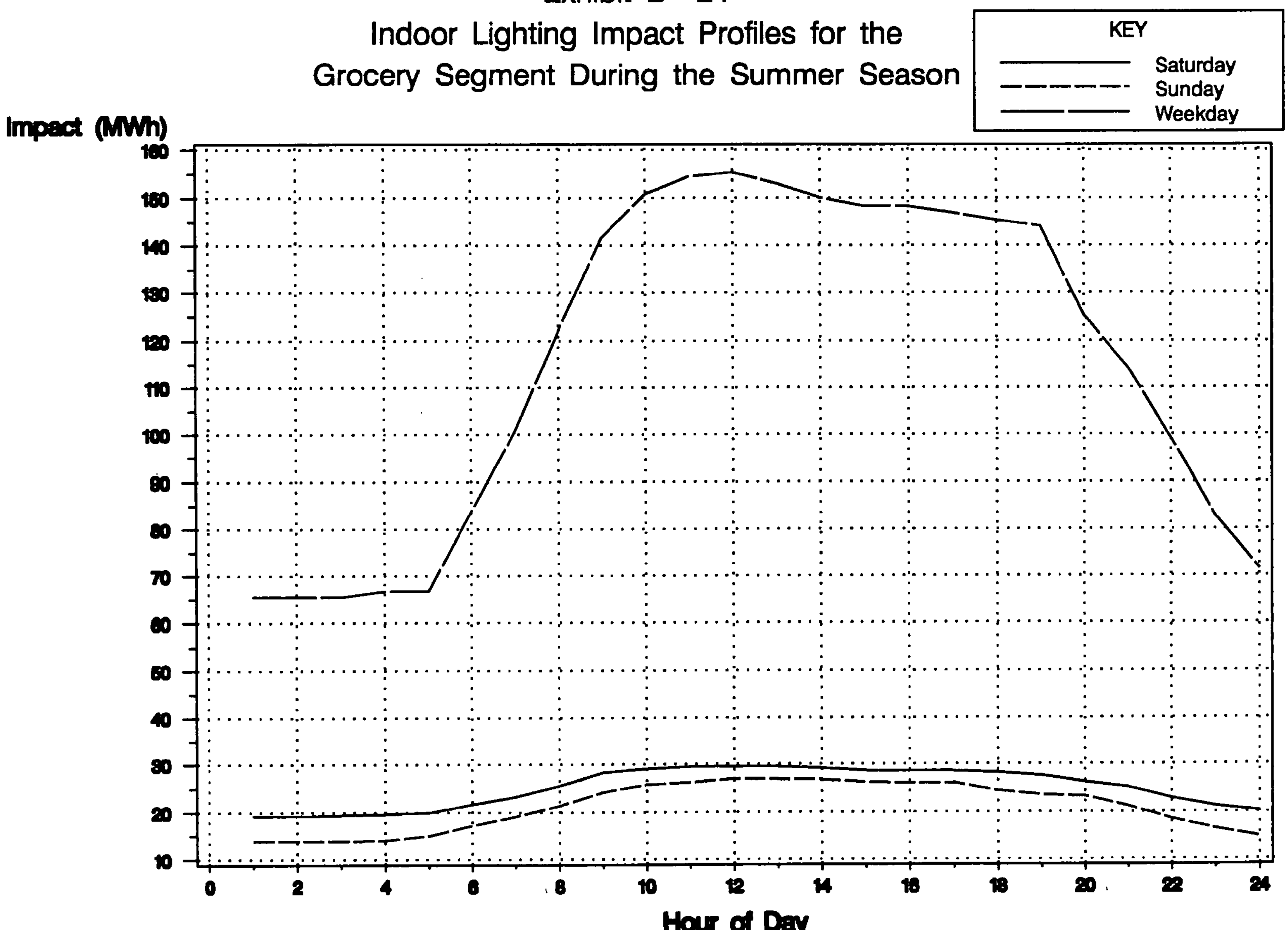


Exhibit B-25

Indoor Lighting Impact Profiles for the Restaurant Segment During the Summer Season

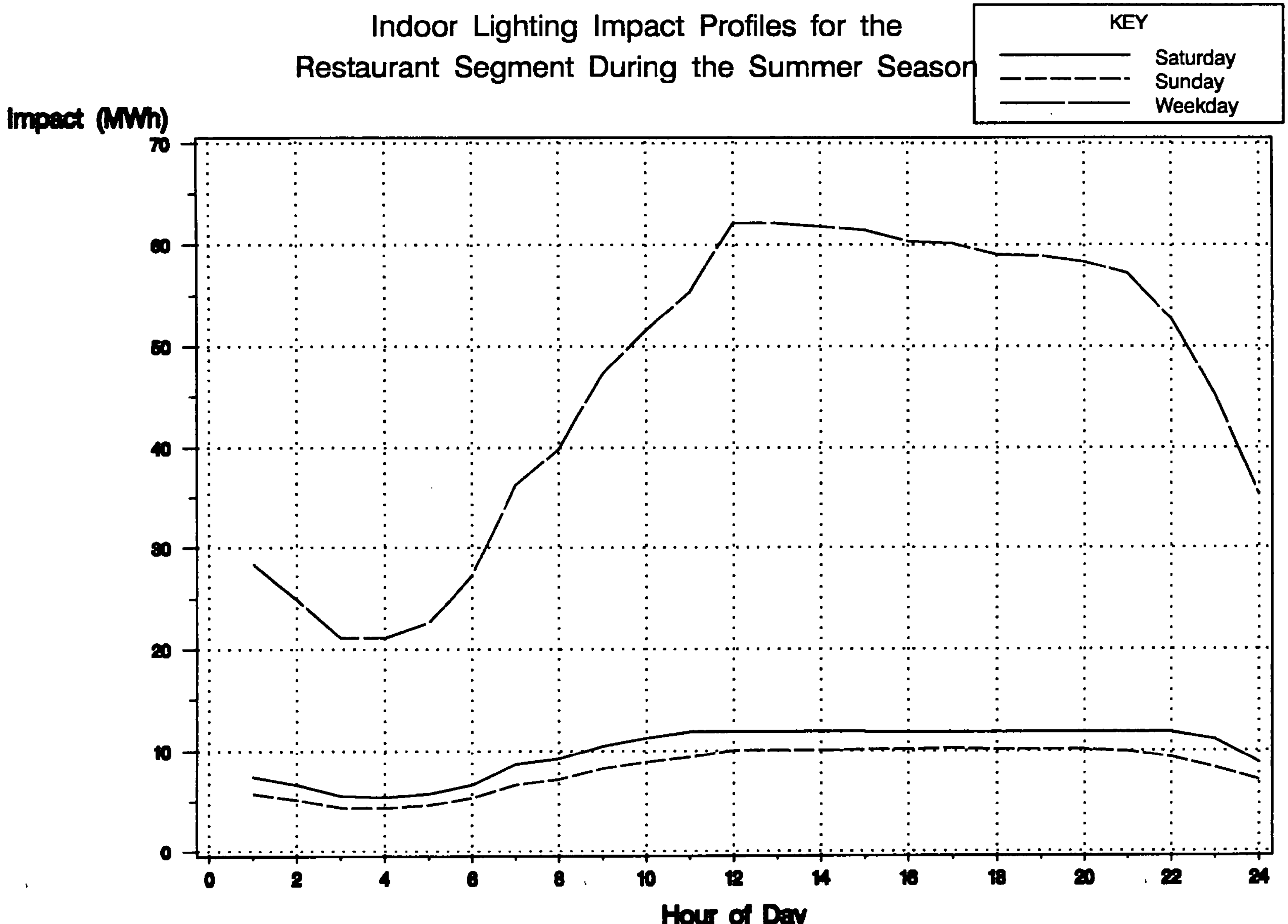
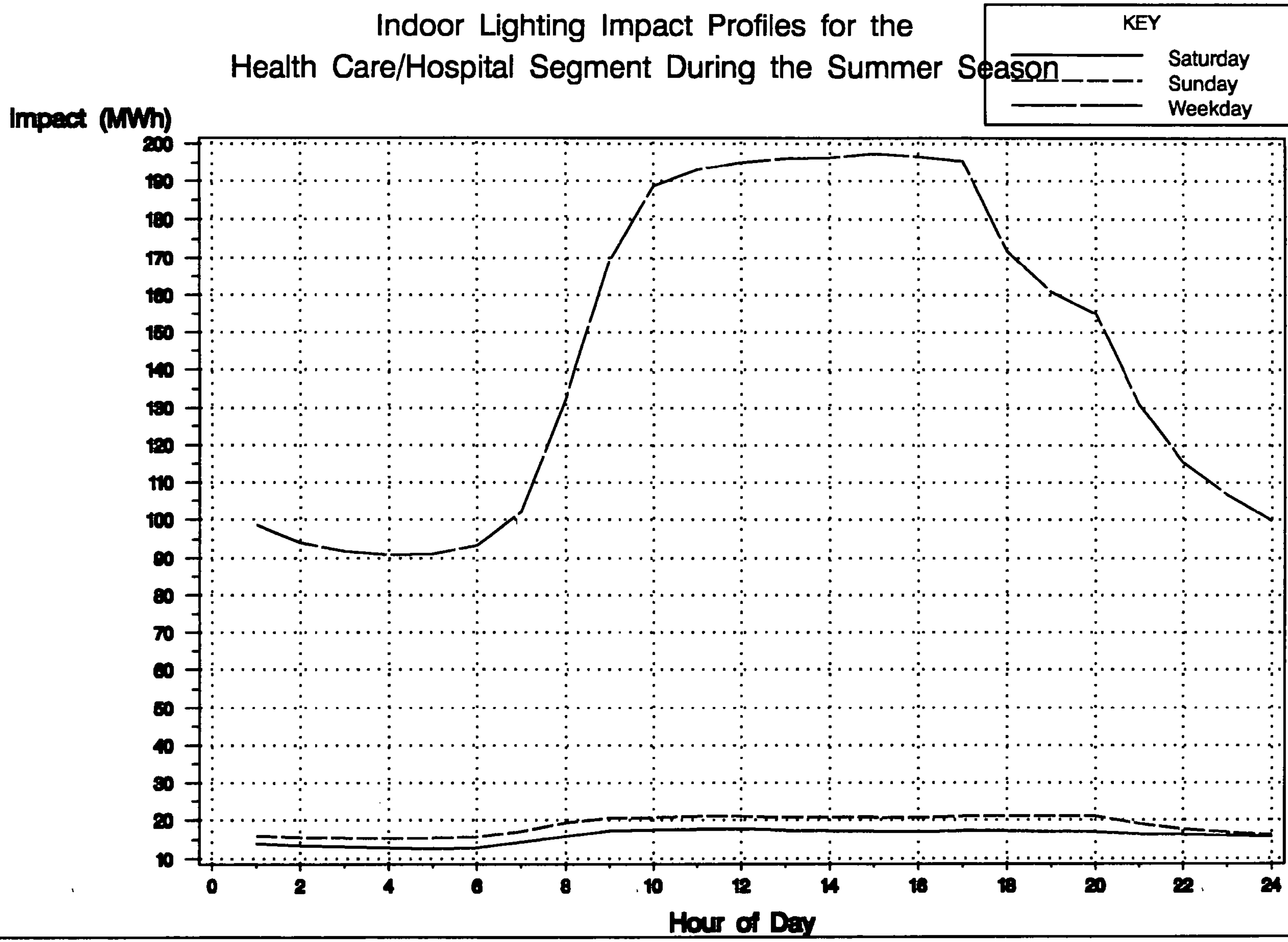


Exhibit B-26
Indoor Lighting Impact Profiles for the
Health Care/Hospital Segment During the Summer Season



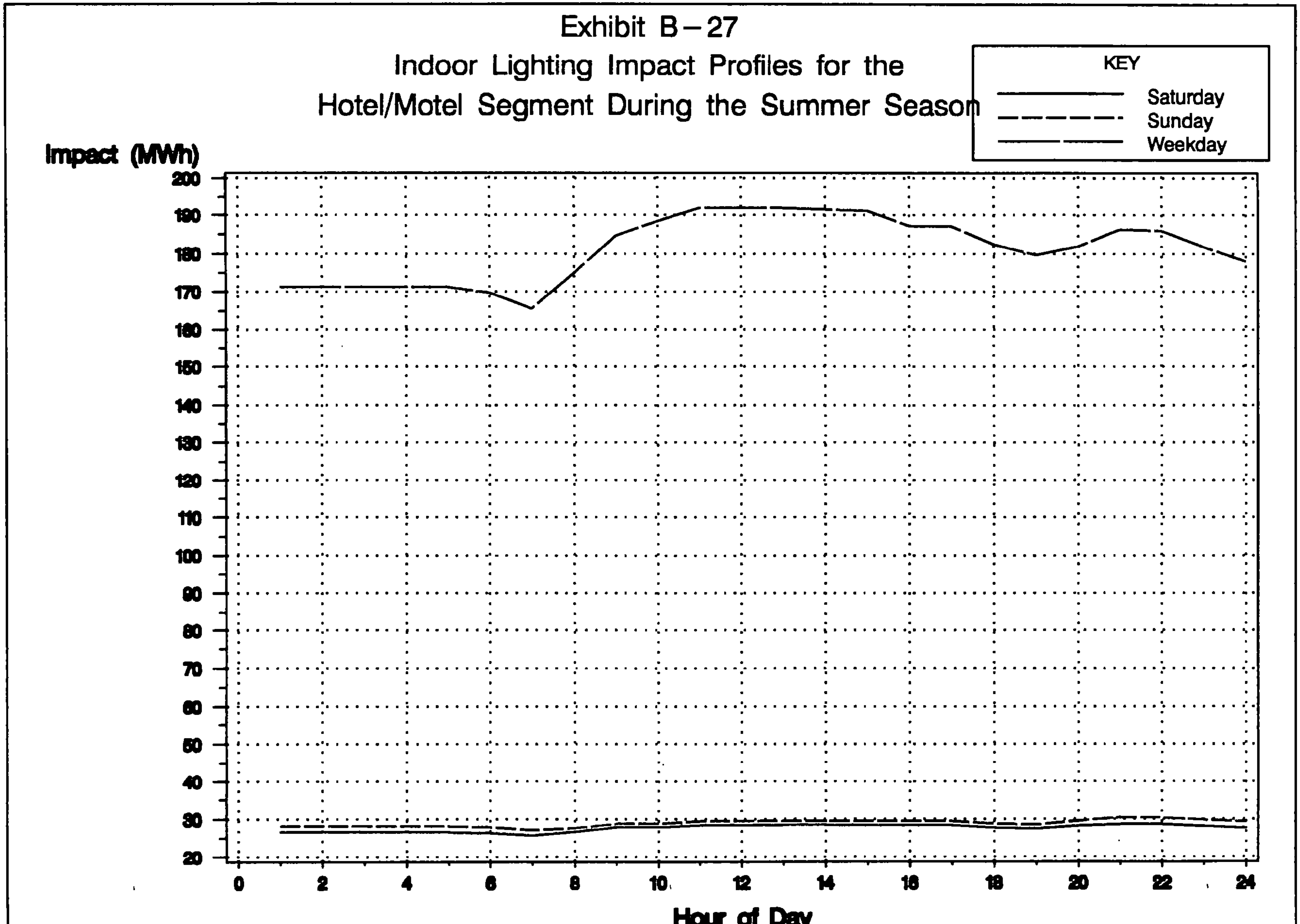


Exhibit B-27
Indoor Lighting Impact Profiles for the
Hotel/Motel Segment During the Summer Season
KEY
Saturday
Sunday
Weekday
Impact (MWh)
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
0
2
4
6
8
10
12
14
16
18
20
22
24
Hour of Day

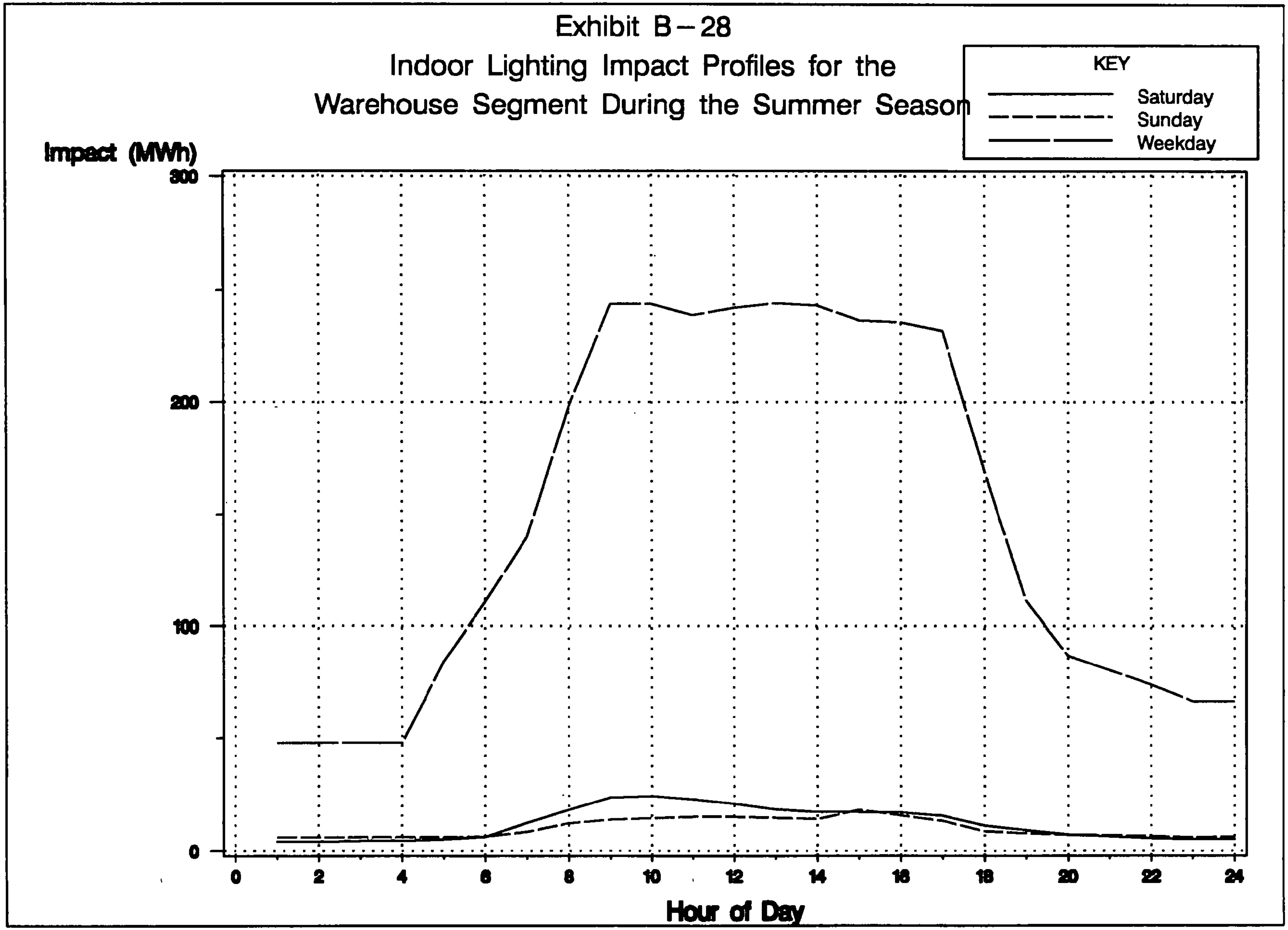


Exhibit B-28
Indoor Lighting Impact Profiles for the
Warehouse Segment During the Summer Season
KEY
Saturday
Sunday
Weekday
Impact (MWh)
300
200
100
0
0
2
4
6
8
10
12
14
16
18
20
22
24
Hour of Day

Exhibit B-29

Indoor Lighting Impact Profiles for the Personal Service Segment During the Summer Season

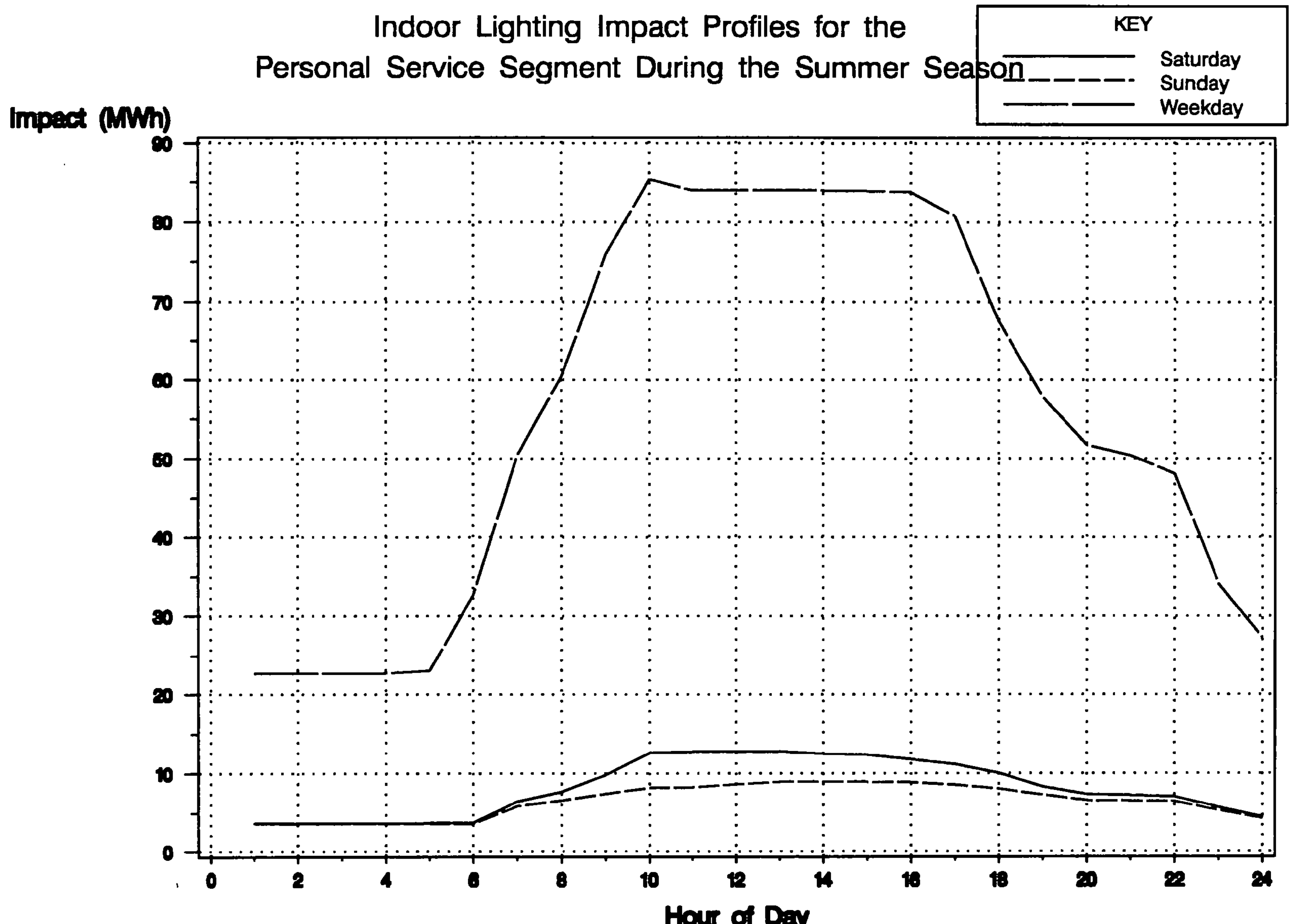


Exhibit B-30

Indoor Lighting Impact Profiles for the Community Service Segment During the Summer Season

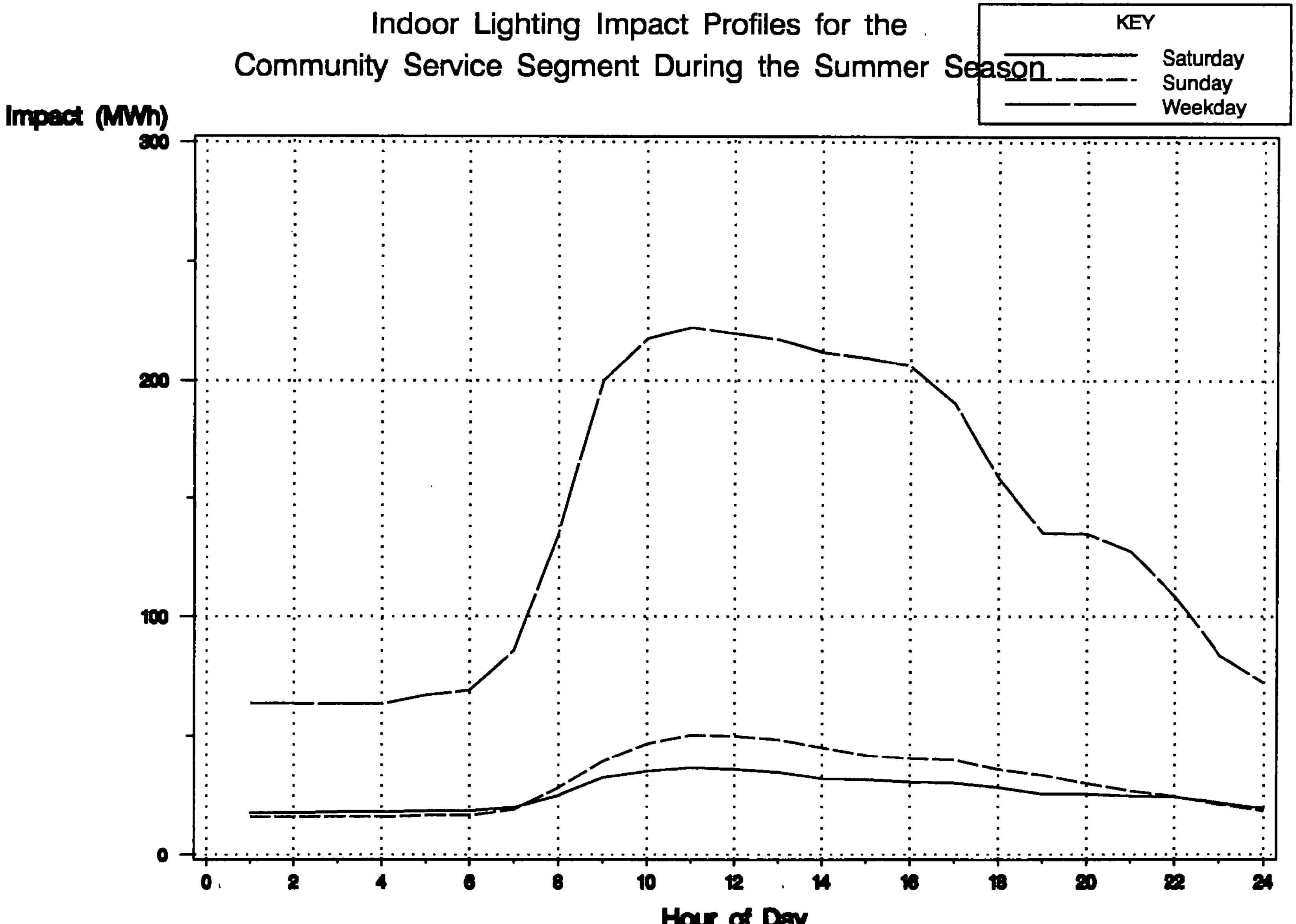
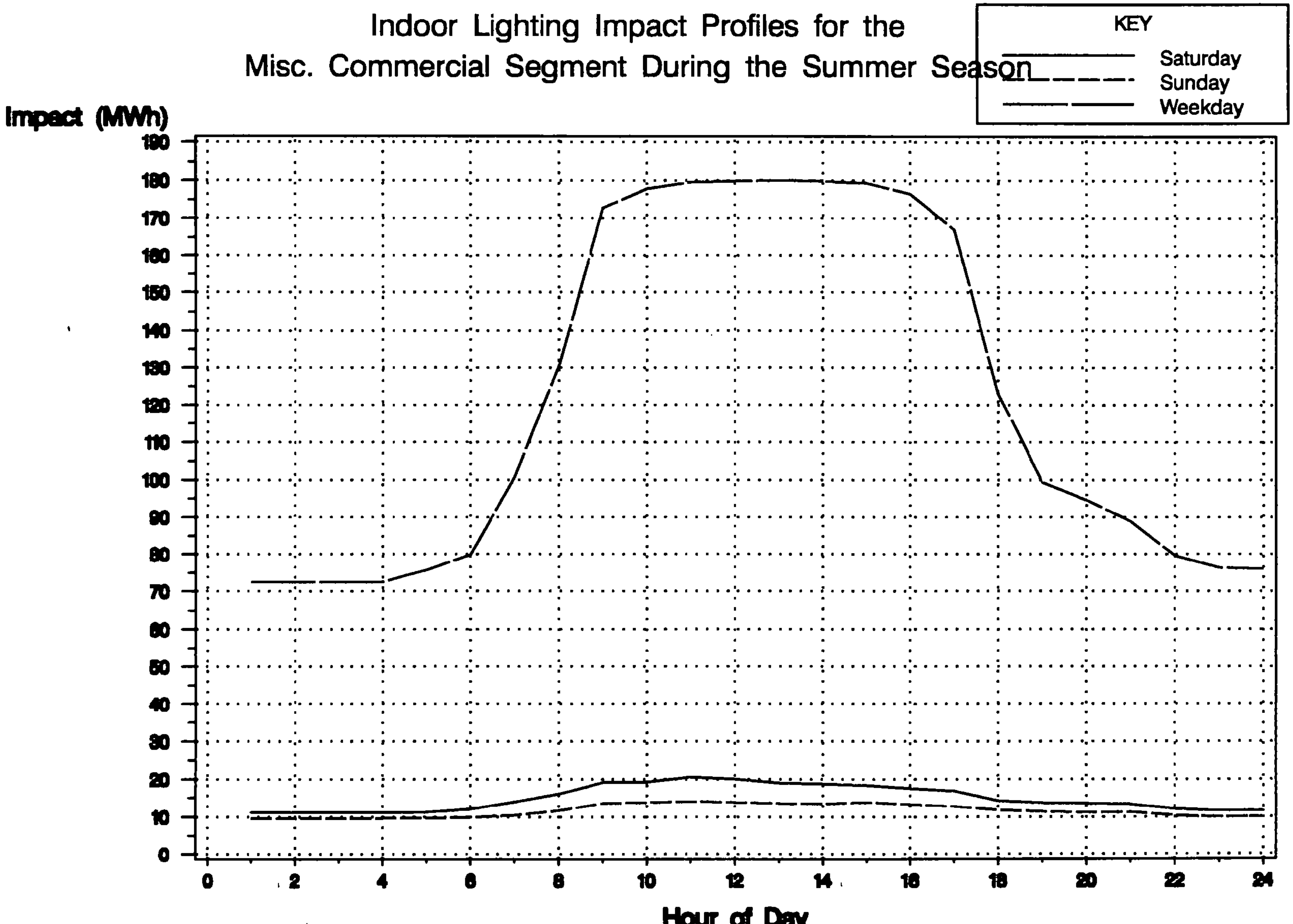


Exhibit B-31

Indoor Lighting Impact Profiles for the Misc. Commercial Segment During the Summer Season



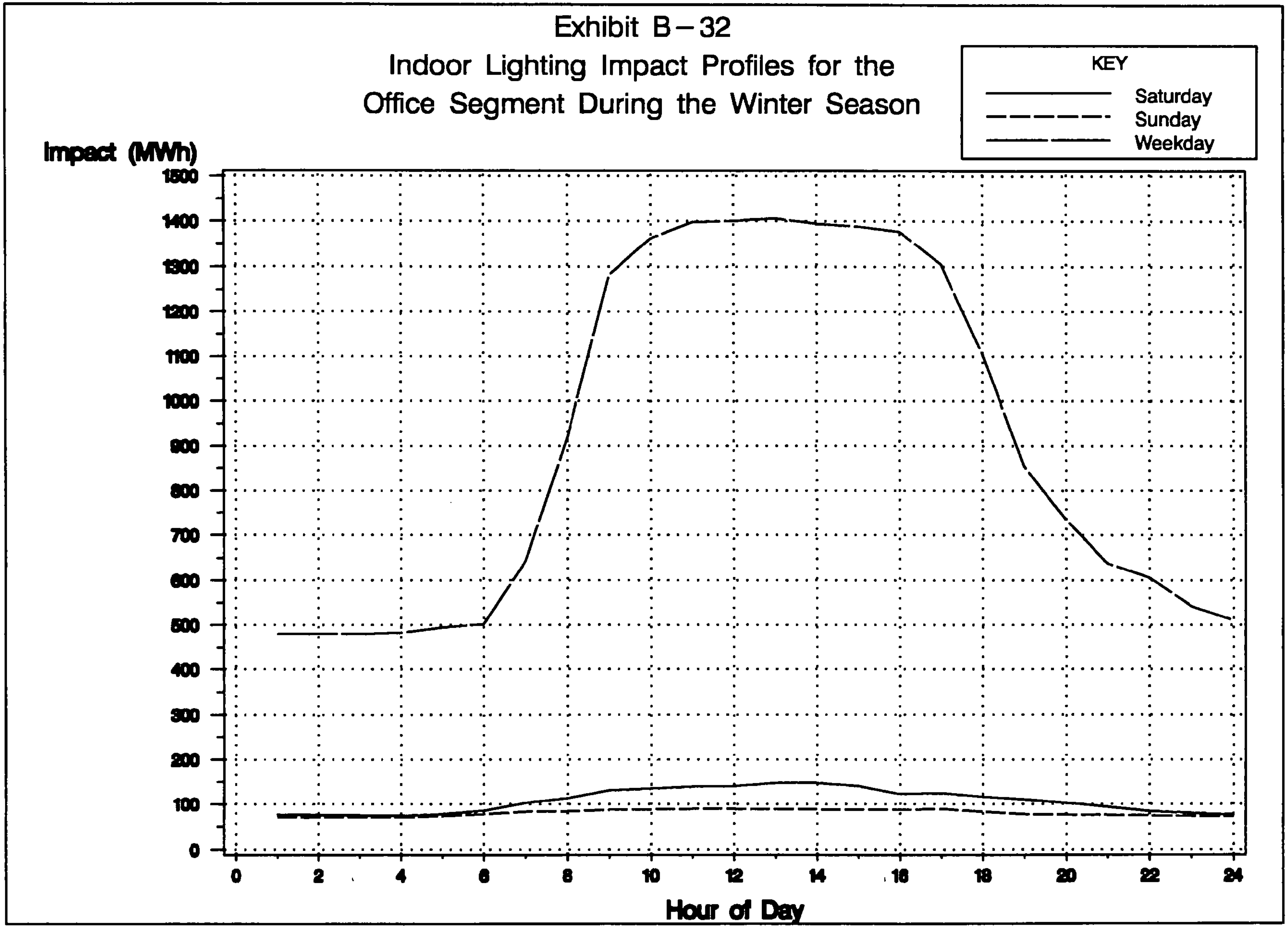


Exhibit B-32
Indoor Lighting Impact Profiles for the
Office Segment During the Winter Season
KEY
Saturday
Sunday
Weekday
Impact (MWh)
1500
1400
1300
1200
1100
1000
900
800
700
600
500
400
300
200
100
0
0
2
4
6
8
10
12
14
16
18
20
22
24
Hour of Day

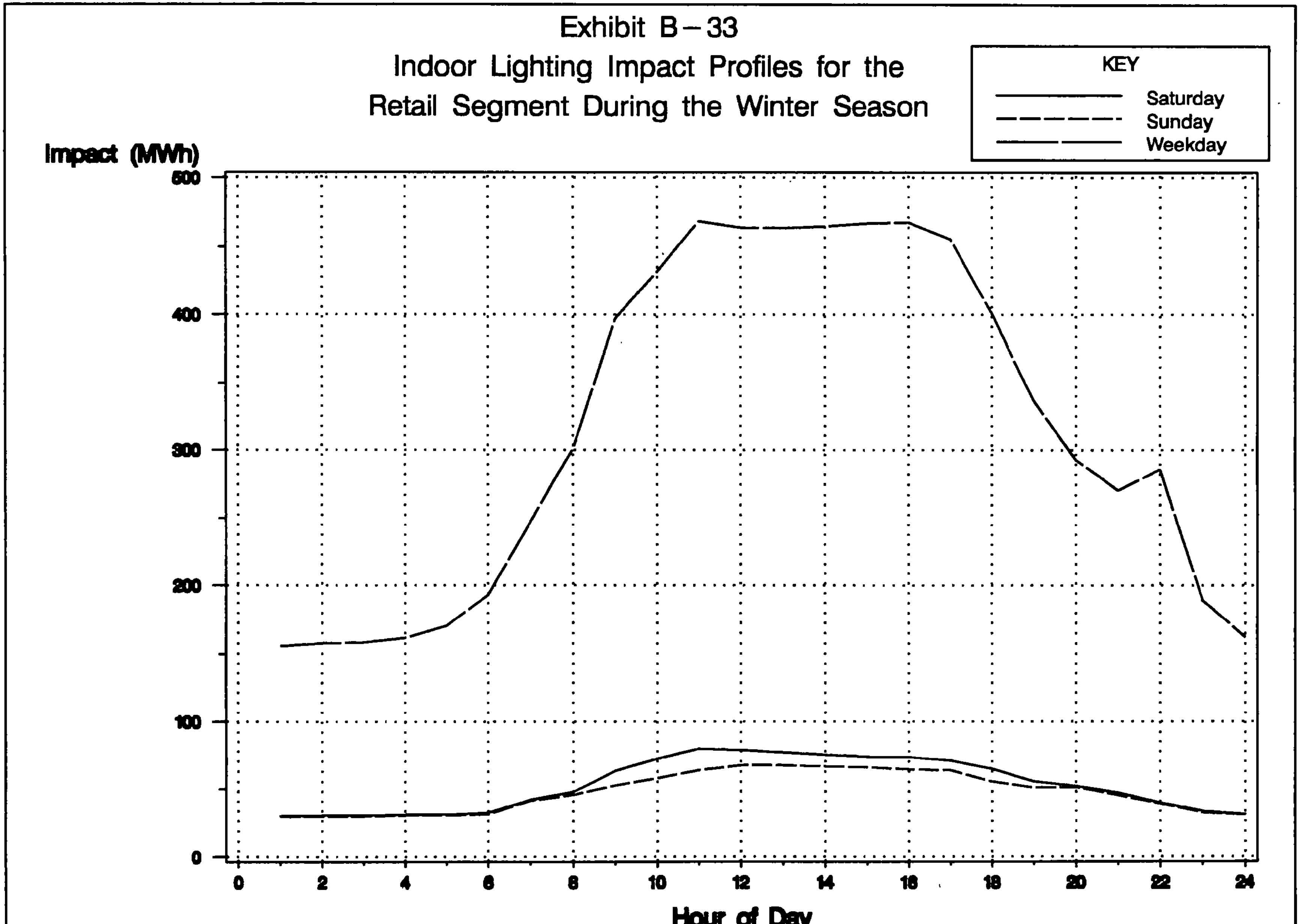


Exhibit B-33
Indoor Lighting Impact Profiles for the
Retail Segment During the Winter Season
KEY
Saturday
Sunday
Weekday
Impact (MWh)
500
400
300
200
100
0
0
2
4
6
8
10
12
14
16
18
20
22
24
Hour of Day

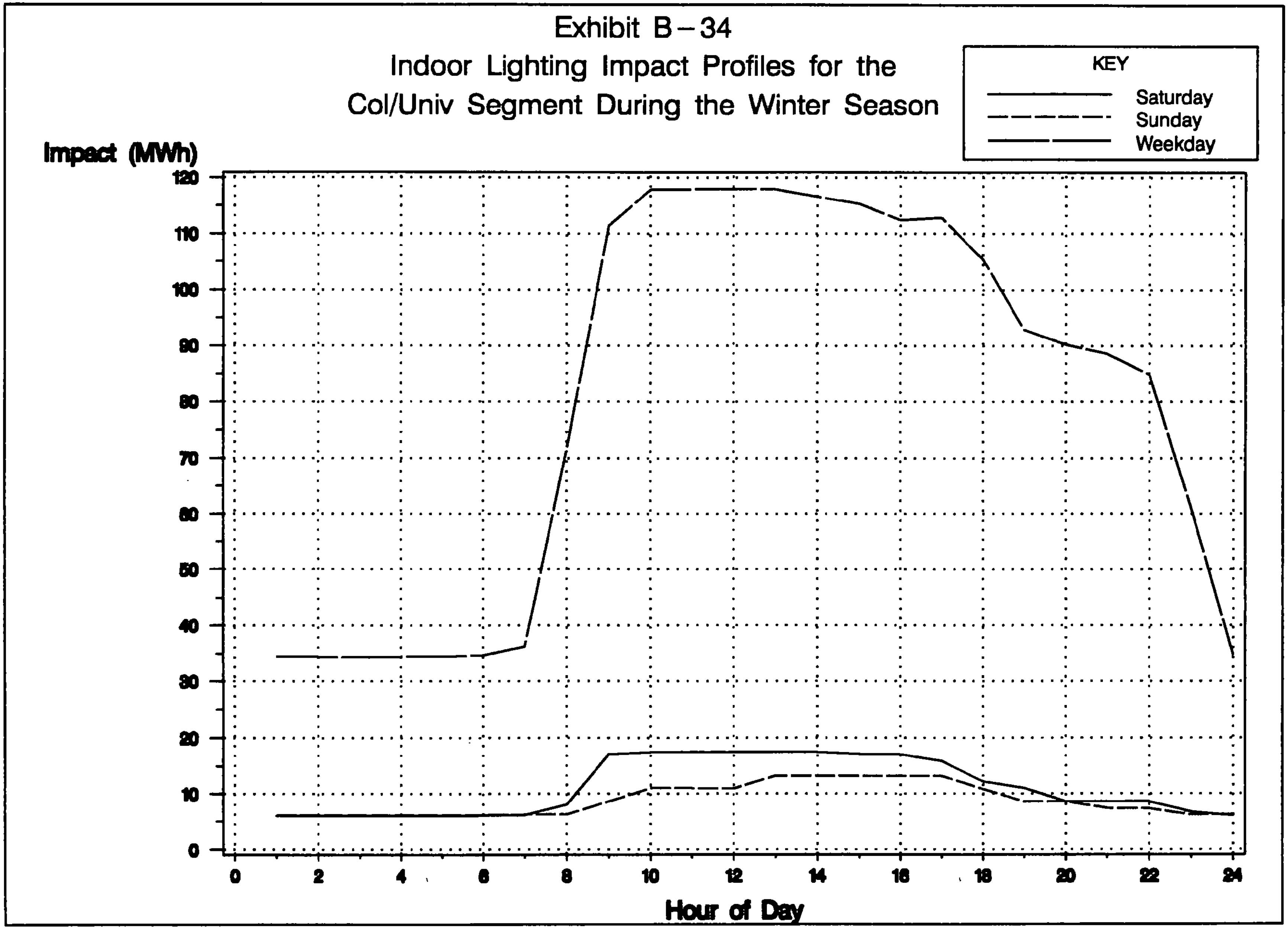
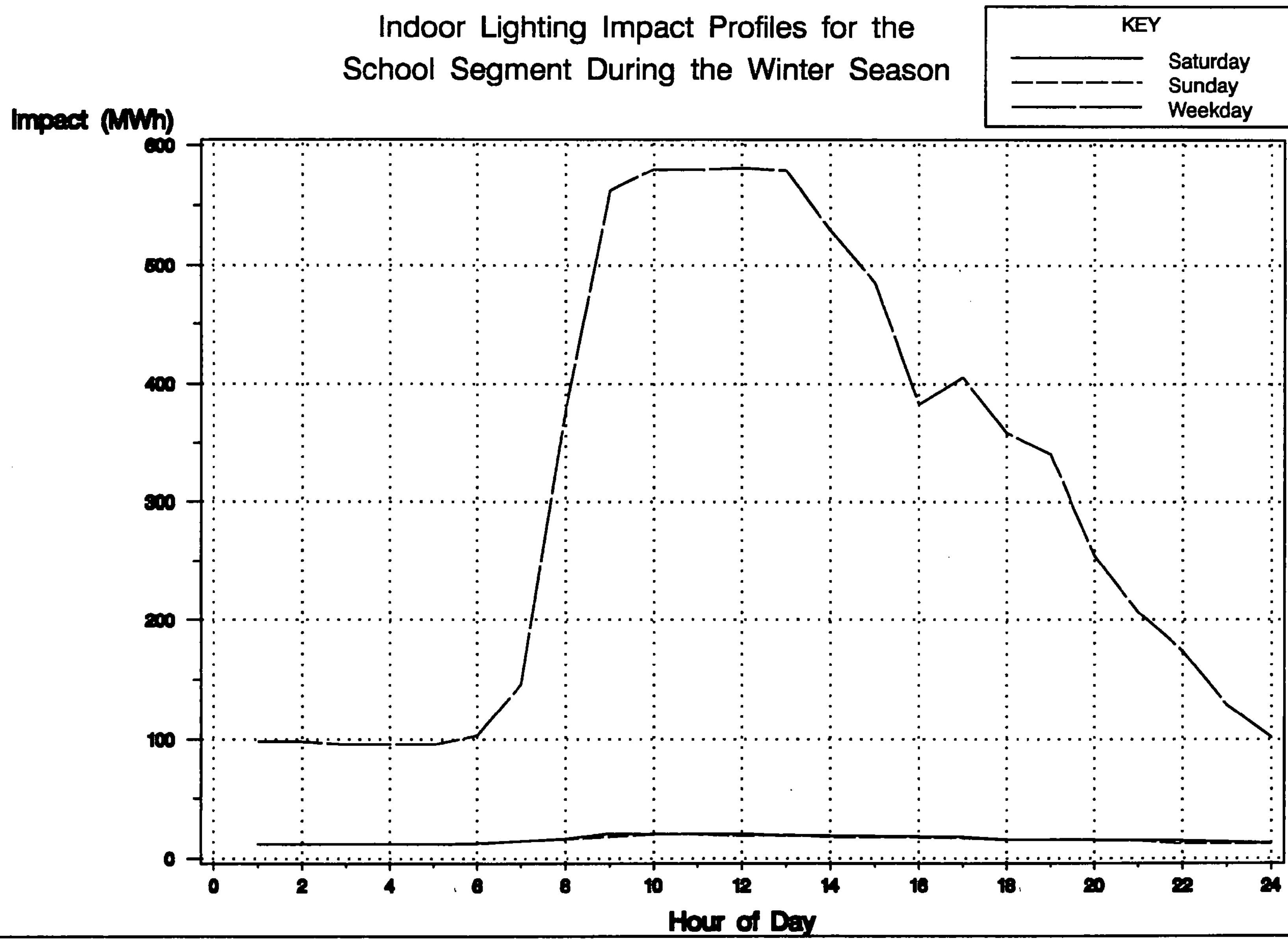


Exhibit B-34
Indoor Lighting Impact Profiles for the
Col/Univ Segment During the Winter Season
KEY
Saturday
Sunday
Weekday
Impact (MWh)
0
10
20
30
40
50
60
70
80
90
100
110
120
0
2
4
6
8
10
12
14
16
18
20
22
24
Hour of Day

Exhibit B-35
Indoor Lighting Impact Profiles for the School Segment During the Winter Season



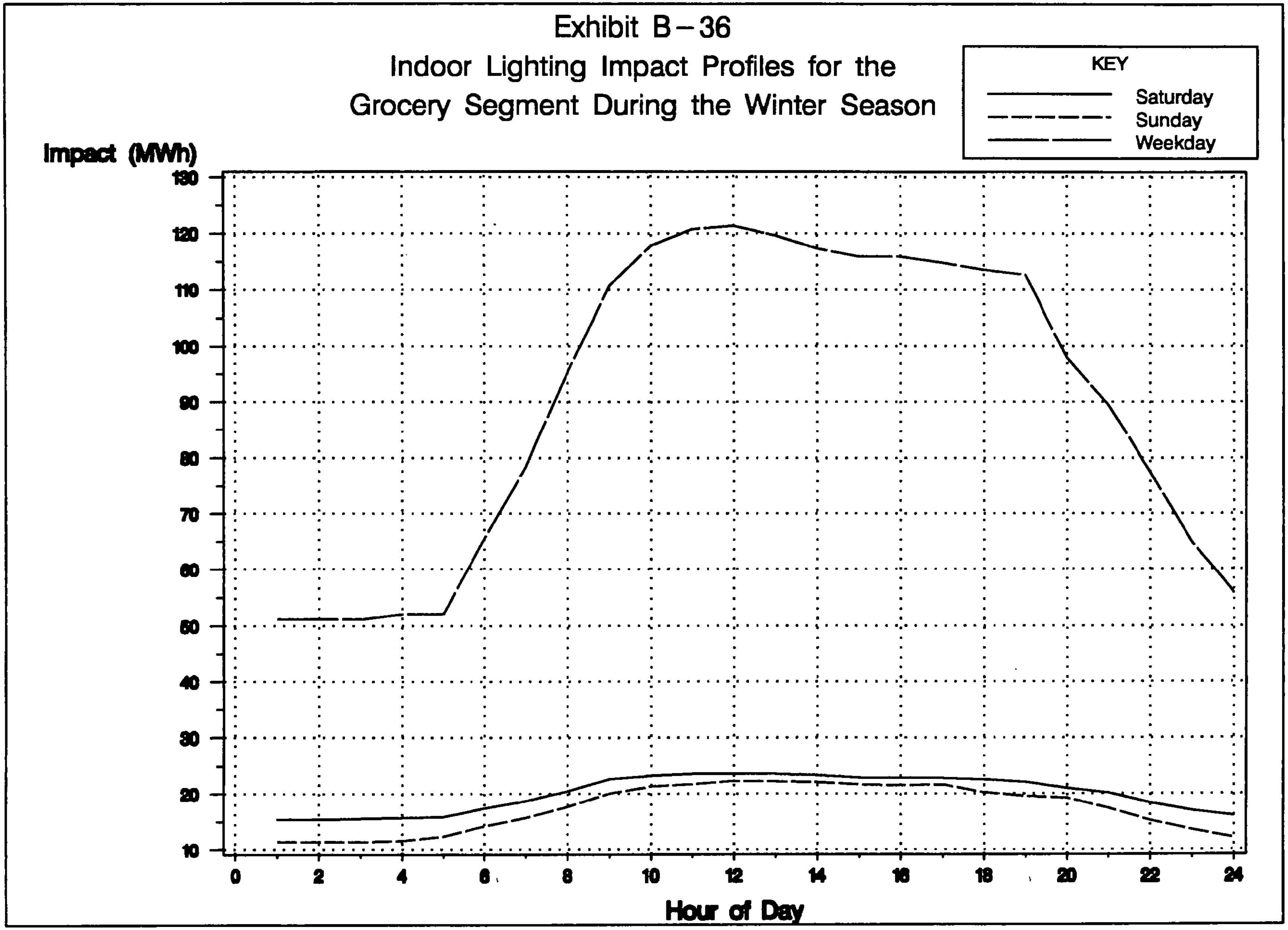


Exhibit B-36
Indoor Lighting Impact Profiles for the
Grocery Segment During the Winter Season
KEY
Saturday
Sunday
Weekday
Impact (MWh)
130
120
110
100
90
80
70
60
50
40
30
20
10
0
2
4
6
8
10
12
14
16
18
20
22
24
Hour of Day

Exhibit B-37

Indoor Lighting Impact Profiles for the Restaurant Segment During the Winter Season

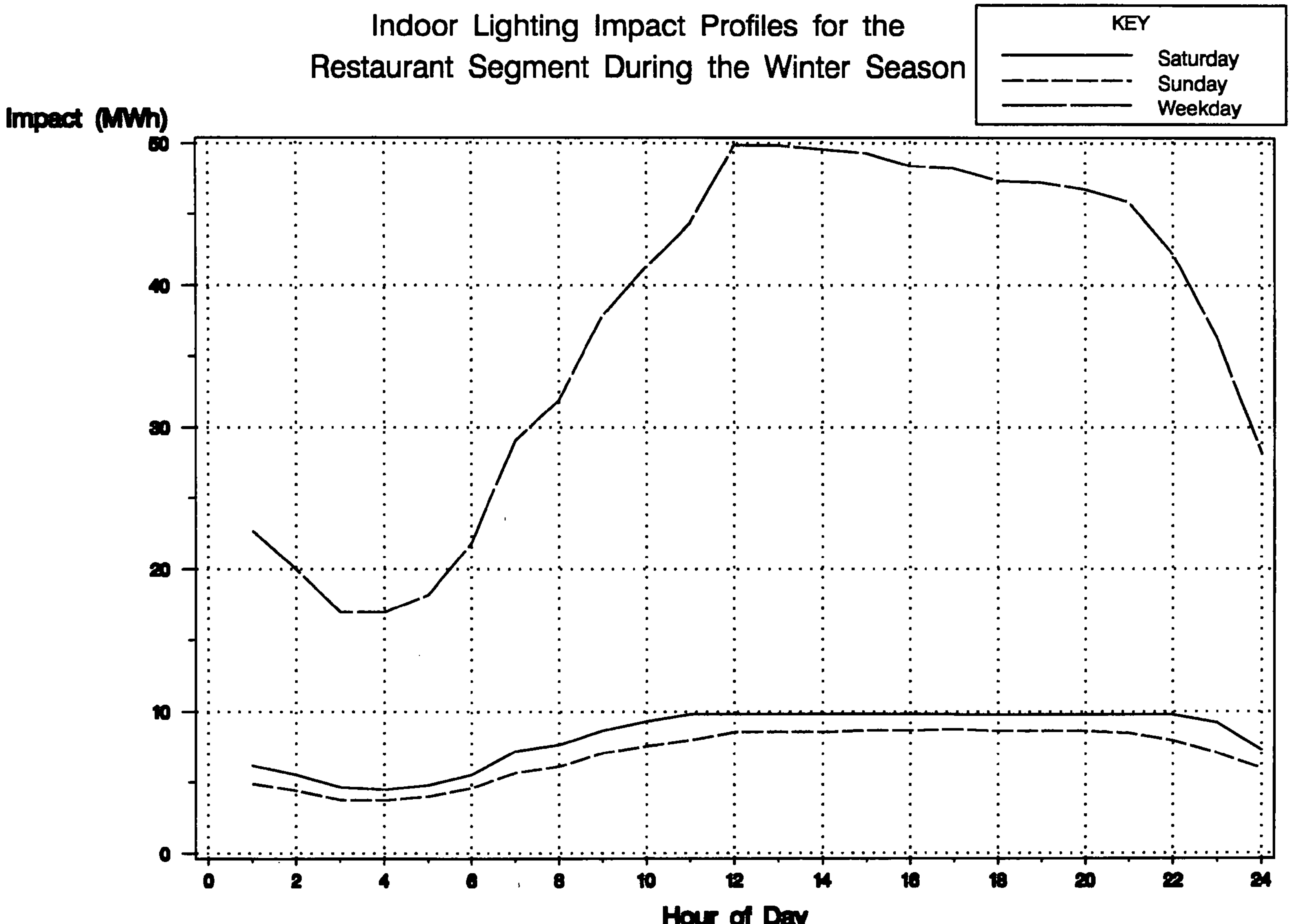
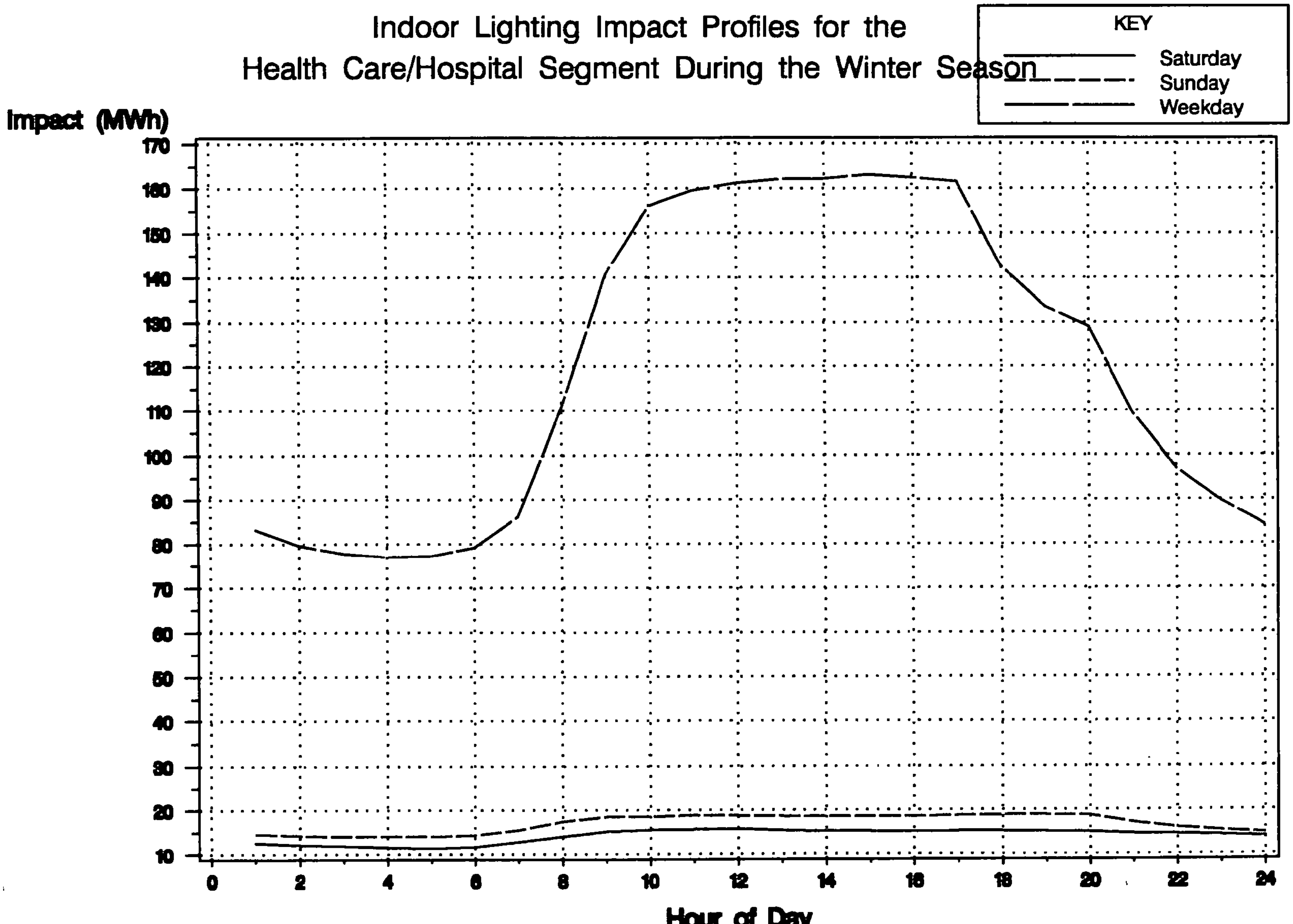


Exhibit B-38

Indoor Lighting Impact Profiles for the Health Care/Hospital Segment During the Winter Season



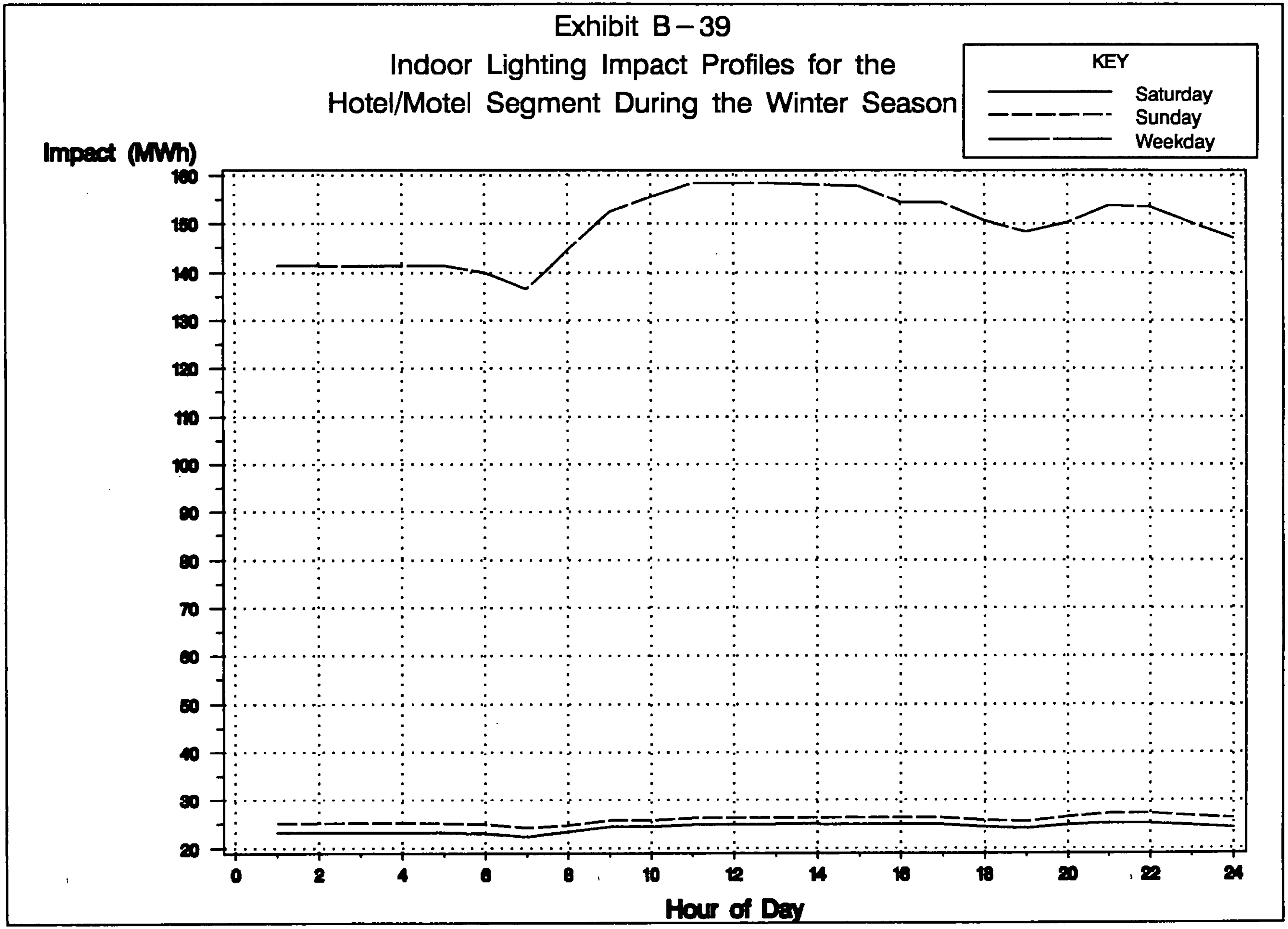
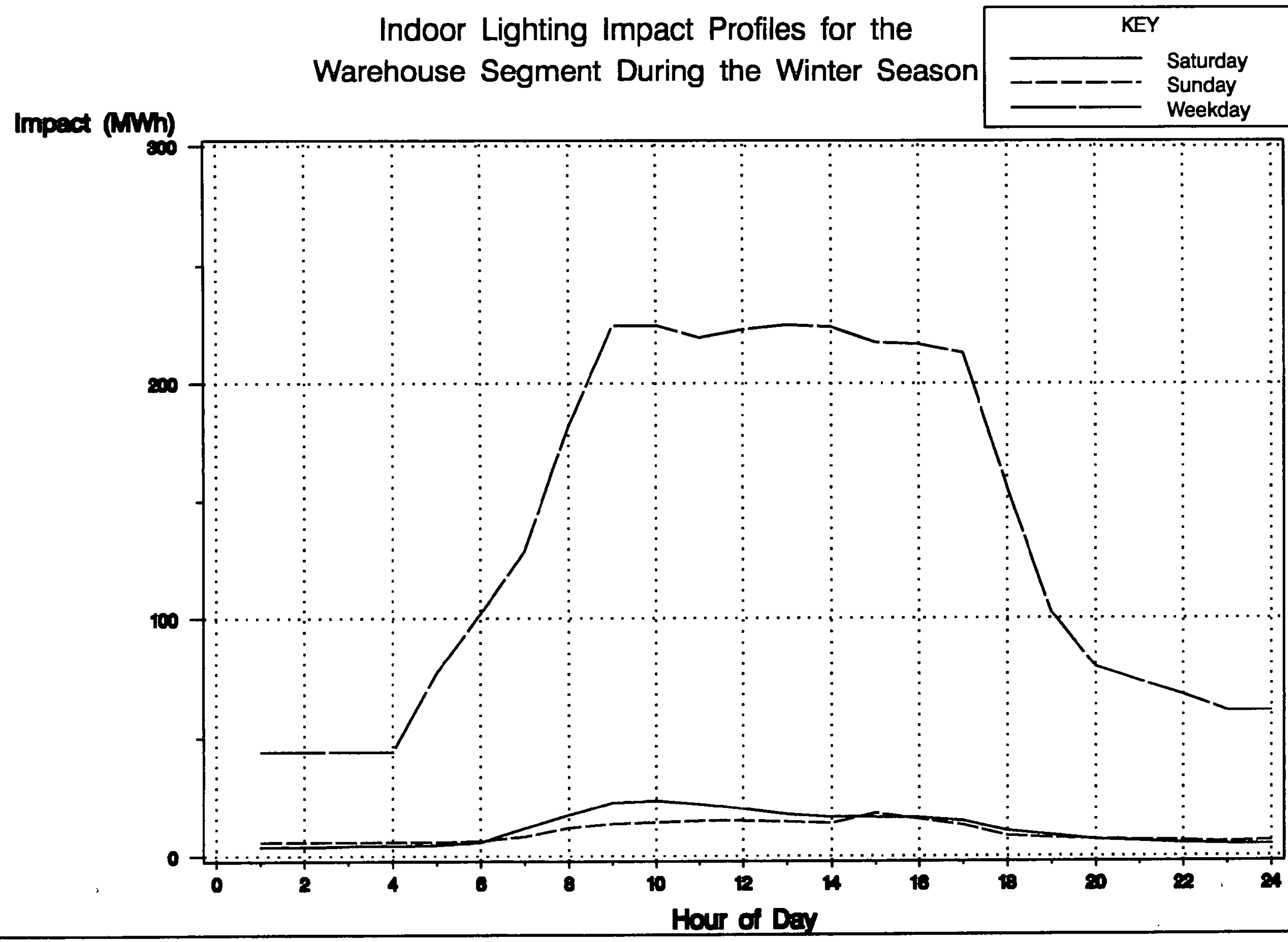


Exhibit B – 39
Indoor Lighting Impact Profiles for the
Hotel/Motel Segment During the Winter Season
KEY
Saturday
Sunday
Weekday
Impact (MWh)
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
0
2
4
6
8
10
12
14
16
18
20
22
24
Hour of Day

Exhibit B – 40

Indoor Lighting Impact Profiles for the Warehouse Segment During the Winter Season



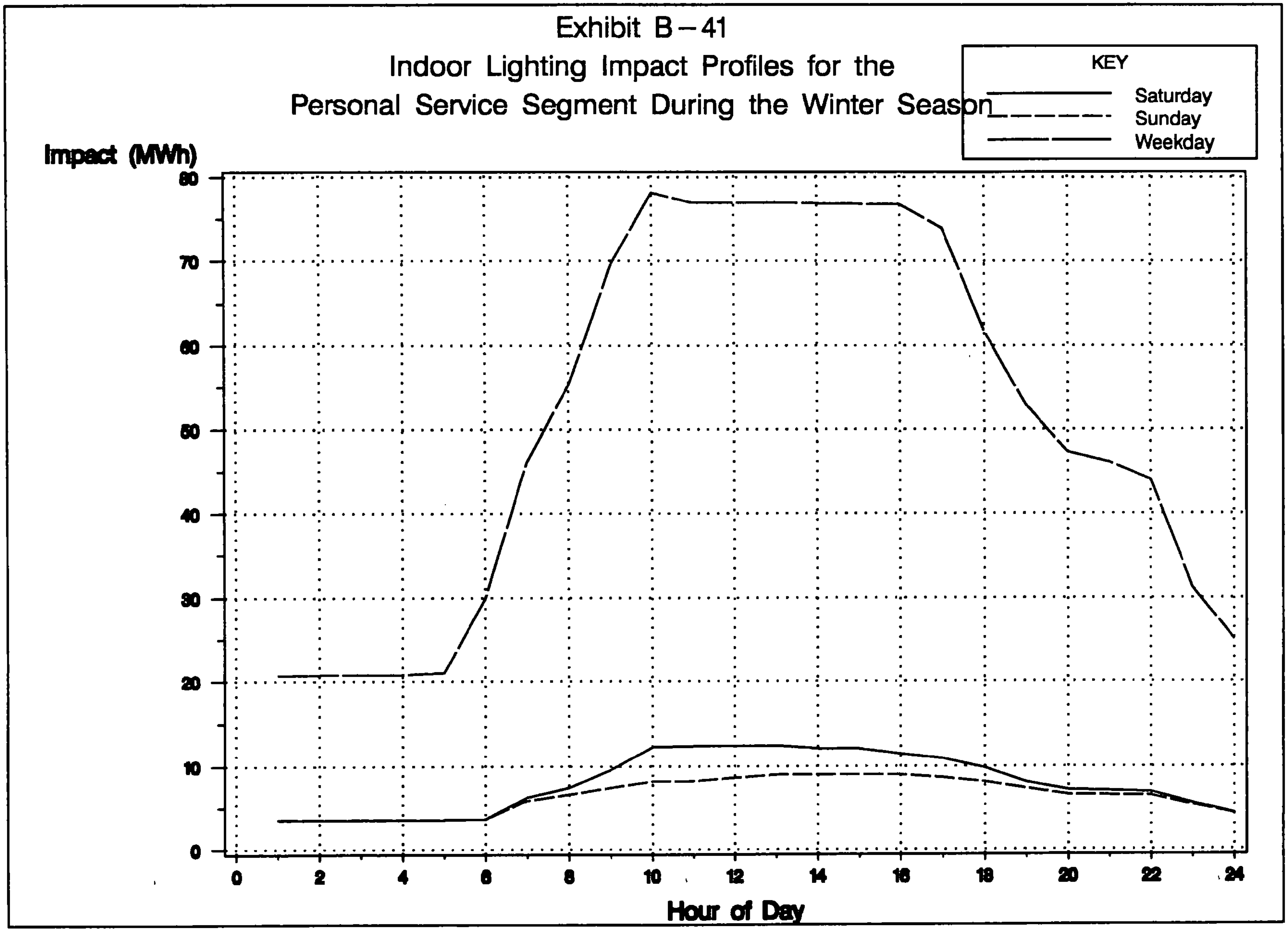
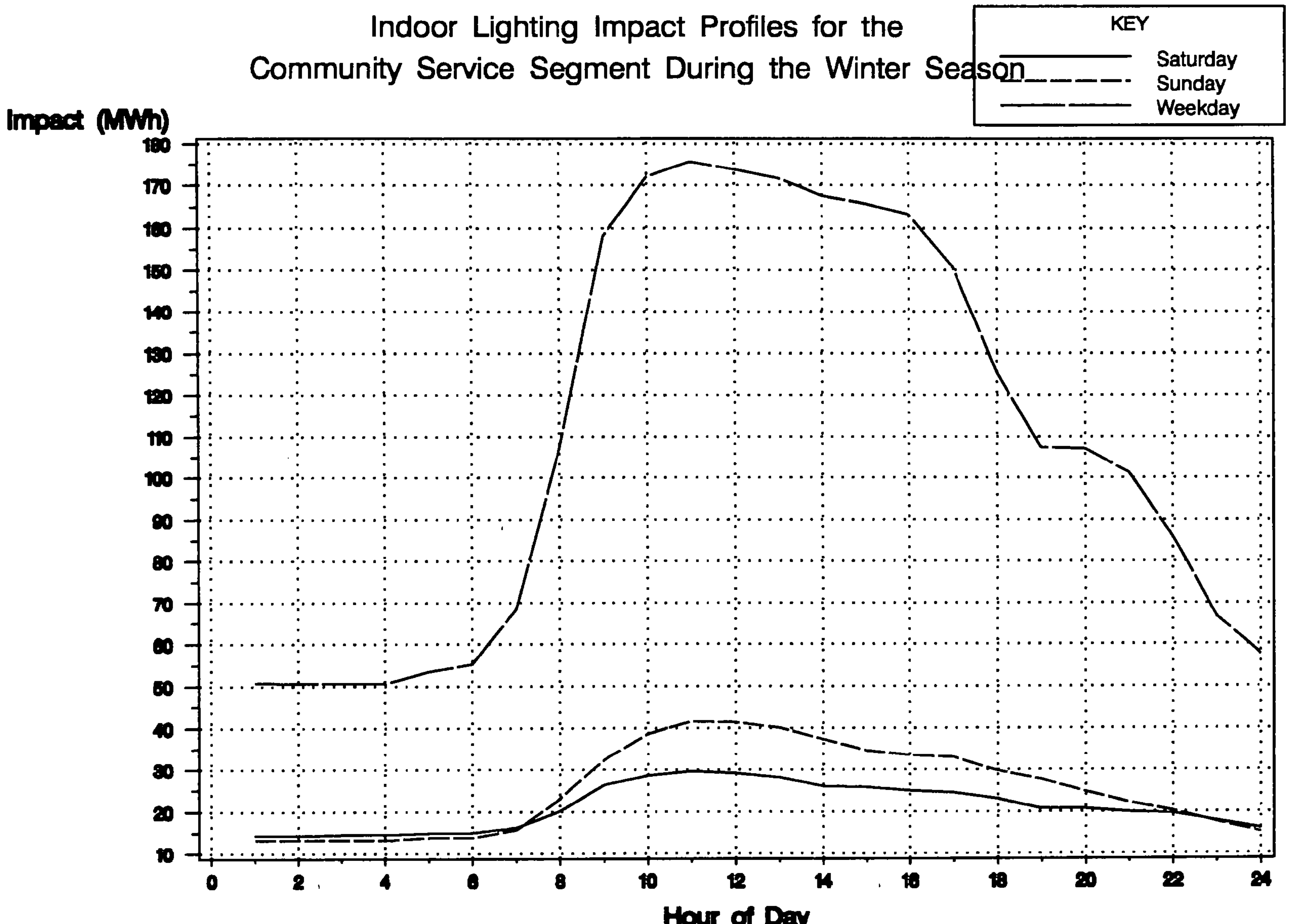


Exhibit B – 41
Indoor Lighting Impact Profiles for the
Personal Service Segment During the Winter Season
KEY
Saturday
Sunday
Weekday
Impact (MWh)
0
10
20
30
40
50
60
70
80
0
2
4
6
8
10
12
14
16
18
20
22
24
Hour of Day

Exhibit B-42

Indoor Lighting Impact Profiles for the Community Service Segment During the Winter Season



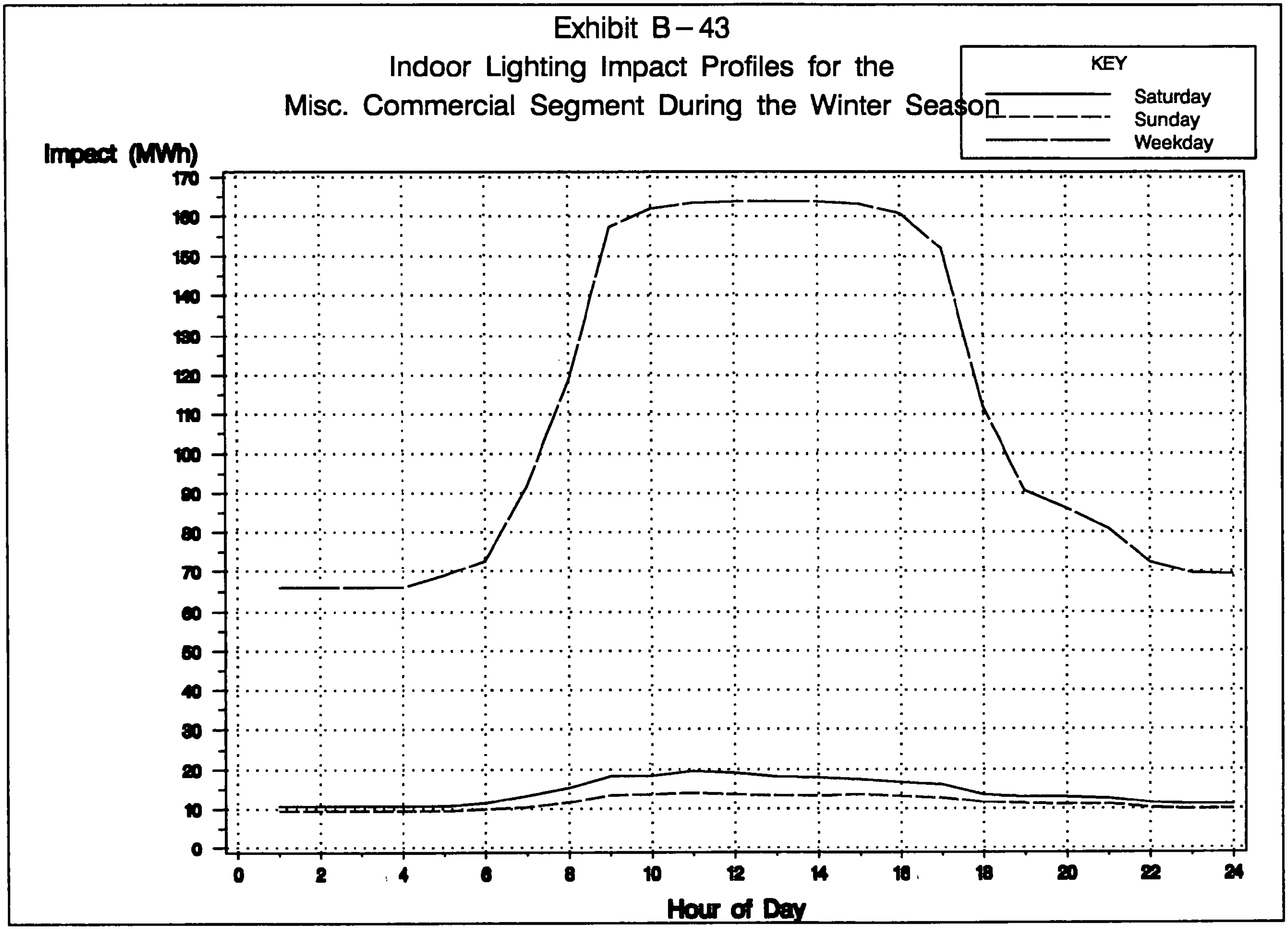


Exhibit B-43
Indoor Lighting Impact Profiles for the
Misc. Commercial Segment During the Winter Season
KEY
Saturday
Sunday
Weekday
Impact (MWh)
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
0
2
4
6
8
10
12
14
16
18
20
22
24
Hour of Day

Appendix C
Billing Regression Analysis

C. BILLING REGRESSION ANALYSIS

This appendix documents the detailed analytical steps undertaken in the billing regression analysis of Pacific Gas and Electric Company's (PG&E's) 1995 Nonresidential Retrofit Program for the Commercial Sector (the Commercial Program). Both net and gross billing analysis models were implemented, however, the net model was unable to provide statistically valid results due to problems of multi-colinearity. This appendix begins with a discussion of the analysis periods and data sources used in the billing regression analysis. Then, the results of the data censoring that was applied to the billing analysis sample are provided. Next, the gross billing analysis regression model specification and SAE coefficients are presented, along with the relative precision calculations. Finally, the net billing analysis regression model specification and results are presented.

C.1 OVERVIEW

The key objective of the billing analysis is to determine the first-year program energy impacts. A statistical analysis is employed to model the differences of customers' energy usage between pre- and post-installation periods. The model is specified using actual customer billing data and independent variables that explain changes in customers' energy usage, including engineering estimates of program participation. This statistically adjusted engineering (SAE) analysis is consistent with the requirements of the Load Impact Regression Model (LIRM) defined in the California Public Utilities Commission's (CPUC's) Measurement and Evaluation Protocols (the Protocols).

The results of the billing regression analysis are estimated as ratios, termed "SAE coefficients," of realized impacts to engineering impact estimates. Realized impacts represent the fractions of the engineering estimates actually "observed" or "detected" in the statistical analysis of actual billing data. The SAE coefficients estimated in the billing analysis regression models are relative to the results of the evaluation-based engineering estimates, not the PG&E Program ex ante estimates. The SAE coefficients, the estimation of which is the topic of this appendix, are then used to estimate program impacts and realization rates relative to the ex ante estimates.

As discussed below, the billing regression analysis was conducted on a sample of telephone surveyed participants and nonparticipants. Because many Commercial Program participants installed measures under multiple end uses, one integrated billing analysis approach was used to model the Lighting, HVAC and Refrigeration end uses.

C.2 DATA SOURCES FOR BILLING REGRESSION ANALYSIS

The billing regression analysis for the 1995 Commercial Program Evaluation uses data from five primary data sources: the PG&E Management Decision Support System (MDSS) tracking database, the billing database, the telephone survey data, the engineering estimates of changes of usage between the pre- and post-installation periods, and the weather data tapes from PG&E's load research weather sites. A summary of the data elements used in the regression analysis are presented below.

C.2.1 Program Participant Tracking System

The participant tracking system for the Retrofit Express (RE), Retrofit Efficiency Options (REO) and Customized Incentives Programs was maintained as part of the MDSS. It contains program applications, rebate and technical information about installed measures, including measure description, quantity, rebate amount, and ex ante demand, ad energy and therm savings estimates. The MDSS database is linked to the billing database and other program databases through PG&E's customers control numbers.

C.2.2 PG&E Billing Data

For this evaluation, the PG&E billing data were obtained from two different data sources within PG&E. The original nonresidential billing dataset contains monthly energy usage for all nonresidential accounts in PG&E's service territory, and was used in the sample design as described in *Appendix A: Sample Design*. The billing histories contained in this data base only run through September 1995.

The second billing dataset, which consists only of customer accounts in the surveyed dataset, was later obtained from PG&E Load Data Services. This billing dataset contains bill readings that run through September 1996, and was therefore used in the billing regression analysis. In addition, the billing series from this database is the PG&E pro-rated monthly usage data, a series calculated by PG&E for each calendar month, from January 1992 to September 1996.

C.2.3 Weather Data

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

C.2.4 Telephone Survey Data

All available telephone surveys (except for the Canvass surveys, which do not collect detailed information regarding changes that have occurred at the premise) collected as part of the evaluation for the Commercial Sector Program were used in the billing regression analysis. Four telephone survey samples totaling 1,217 participants and 652 nonparticipants were collected for the Commercial Sector Evaluation. The 1,217 participant surveys included 614 Lighting participants, 487 HVAC participants, and 241 Refrigeration participants. Because of the significant levels of cross-over among participants across the Commercial Program end uses, one integrated billing regression model was developed to evaluate all three Commercial Program end uses.

The data collected in the telephone survey supplies information on energy-related changes at each site for the billing period covered by the billing regression analysis. For a detailed discussion of the telephone survey sample design and the final sample distribution, see *Appendix A: Sample Design*.

C.2.5 Engineering Estimates

Engineering estimates of savings were estimated for each of the 1,217 participants. Separate estimates were calculated for every measure installed under the Commercial Sector Program. The engineering estimates were calculated based on expected savings from the pre-installation technology to the post-installation technology. For some technologies, such as Central A/Cs installed in the HVAC program, the savings estimates will differ from the impact estimates. This is due to the impacts being calculated relative to a baseline efficiency, compared to the savings estimates which are based on a pre-existing unit's efficiency. *Appendix B: Engineering Detailed Computational Methods* discusses the calculation of the savings estimates used in the billing analysis in greater detail.

For all measures, customer-specific engineering estimates were used in the SAE billing regression model, except for some Customized Incentive measures. For customers with EMS and "Other HVAC" Customized Incentive measures who were not on-site audited, the impact estimates supporting the application were used as the engineering estimates for the SAE analysis. From the engineering analysis based on the on-site audited measures, it was determined that the application's energy estimate was reasonable and accurate for all but one EMS application (which was not part of the SAE analysis).

For the "Other HVAC" Customized Incentive measures, the measures can be so unique and the impact estimates so dependent on building characteristics and other equipment installed at the facility, that it is very difficult to estimate an impact without performing an on-site audit. However, the level of documentation provided along with the applications was sufficient to allow for an assessment of the quality of the impact calculations made. A review of the applications associated with the "Other HVAC" Customized Incentive measures indicated that the applications provided the best data for use in the SAE analysis. In other words, performing an engineering analysis based solely on the application, without an on-site audit, would result in reverting to the application's estimate.

C.3 DATA AGGREGATION AND ANALYSIS DATASET DEVELOPMENT

Because many measures installed under the Commercial Program affected multiple customer accounts within a unique site, the billing analysis had to be performed at the site level. Therefore, all account level data had to be aggregated up to the site level. In PG&E's billing data, an array of variables are defined to track a customer. These include the following:

- Control number, which is the finest level of aggregation, and is usually unique to a meter.
- Premise number, which is used to define a unique site, but can sometimes contain multiple buildings. The premise number may map to many control numbers, but a control number maps to a unique premise number.
- Corporation number, which is used to define a unique corporation, which can map to many premise numbers. A premise number maps to a unique corporation number.

Of the three, the premise number serves as the best indicator of a unique site. However, there are some premise numbers that contain multiple sites. To address this issue, service address was also used to help identify a unique site. If there was more than one service address for a premise number, it was broken out into multiple sites. Therefore, a unique site was defined as all of the control numbers within a unique combination of service address,[1] premise number, and corporation number. A unique Site ID was created based on this combination of address, premise, and corporation to serve as the key variable for linking data.

The billing data was provided at the control number level. Therefore, the monthly billing data was aggregated to the Site ID level. A concern with aggregating to the Site ID level is that there may be control numbers associated with a different premise number, service address, or corporation number that are in the same physical site and are being affected by the installed measures. If this is

[1] Because of potential data entry errors in the billing system, or inconsistencies in tracking service addresses in the billing system, only the first eight characters of the service address were used. Generally, this would contain the numeric portion of the address and the first few characters of the street name. For the large majority of records in the billing system, premise number and service address were unique.

the case, the billing analysis will have the effect of underestimating the impacts. This a topic that will be discussed further in the *Data Censoring* section below.

The telephone surveys were sampled at the Site ID level, and all questions were phrased to ask about all of the control numbers associated with the Site ID.

The engineering estimates of change were also aggregated to the Site ID level. However, prior to aggregating to the Site ID level, the installation dates for each individual measure were analyzed to ensure that only the impacts occurring within the billing analysis periods were being aggregated. The selection of analysis periods is discussed in the next section.

All data elements mentioned above were linked to the final analysis database by Site ID. Exhibits C-1 through C-4 below provide the sample frame that was available for the billing analysis for each end use (Lighting, HVAC, and Refrigeration) and also for nonparticipants. The sample sizes are provided by business type and technology (for participants). The values presented are the unique number of the Site IDs within a given segment.

Exhibit C-1
Billing Analysis Sample Frame
Pre-Censoring
Indoor Lighting End-Use Technologies

	Business Type												
Program and Technology Group	**Office**	**Retail**	**College/ University**	**School**	**Grocery**	**Restaurant**	**Health Care**	**Hotel/Motel**	**Warehouse**	**Personal Service**	**Community Service**	**Misc.**	**Total**
Retrofit Express Program													
Compact Fluorescent	61	29	4	57	9	11	19	17	6	3	17	3	236
Incandescent to Fluorescent	5	-	-	4	-	1	-	2	2	-	2	-	16
Efficient Ballast	8	7	2	7	4	-	2	-	2	-	1	1	34
T8 Lamps and Electronic Ballasts	154	68	8	115	30	17	29	8	25	8	33	9	504
Optical Reflectors w/ Fluor. Delamp	75	32	5	34	13	11	10	1	10	5	7	4	207
High Intensity Discharge	8	7	2	13	1	1	-	1	15	5	5	7	65
Halogen	13	4	2	8	-	2	1	1	1	-	6	1	39
Exit Signs	38	12	3	29	2	5	5	1	2	1	7	1	106
Controls	28	2	3	34	1	1	5	2	4	1	6	5	92
Retrofit Express Total	177	80	9	120	42	27	33	21	34	14	42	15	614
Customized Incentives Program													
Compact Fluorescent													
Standard Fluorescent													
High Intensity Discharge													
Halogen													
Exit Signs													
Controls													
Other													
Customized Incentives Total	5	1	0	0	10	0	0	0	1	0	1	0	18
Total	177	80	9	120	42	27	33	21	34	14	42	15	614

Exhibit C-2
Billing Analysis Sample Frame
Pre-Censoring
HVAC End-Use Technologies

Program and Technology Group	Business Type												
	Office	Retail	College/ University	School	Grocery	Restaurant	Health Care	Hotel/Motel	Warehouse	Personal Service	Community Service	Misc.	Total
Retrofit Express Program													
Central A/C	93	32	1	30	4	12	24	3	8	5	27	5	244
Variable Speed Drive HVAC Fan	16	11	1	2	-	-	-	1	-	-	-	1	32
Package Terminal A/C	2	-	-	7	-	2	-	15	-	-	-	-	26
Programmable Thermostat	53	12	-	14	-	7	7	2	3	3	15	1	117
Reflective Window Film	44	9	1	3	3	2	12	4	5	2	10	2	97
Water Chiller	1	1	-	1	-	-	1	-	-	-	2	-	6
Other RE Measures	1	1	-	1	1	1	1	-	-	-	1	-	7
Retrofit Express Total	170	52	3	49	8	19	37	23	13	8	40	7	429
Retrofit Efficiency Options Program													
Variable Frequency Drive	1	-	1	-	-	-	-	-	-	-	-	-	2
Water Chiller	-	-	-	1	-	-	2	-	-	-	1	-	4
CAV to VAV	1	-	-	-	-	-	-	-	-	-	-	-	1
Cooling Tower	-	-	-	1	-	-	-	-	-	-	-	-	1
Retrofit Efficiency Options Total	2	-	1	1	-	-	2	-	-	-	1	-	7
Customized Incentives Program													
HVAC Variable Speed Drive	2	1	-	-	1	-	-	-	-	-	1	-	5
High Efficiency Chiller	1	-	-	-	-	-	-	-	-	-	-	-	1
Energy Management System	8	-	2	17	1	-	2	1	1	-	-	-	32
Other CI Measures	9	-	1	4	-	-	5	-	2	-	1	1	23
Customized Incentives Total	20	1	3	20	2	-	6	1	2	-	2	1	58
Total	190	53	6	68	10	19	43	24	15	8	43	8	487

Exhibit C-3
Billing Analysis Sample Frame
Pre-Censoring
Refrigeration End-Use Technologies

	Business Type												
Program and Technology	Office	Retail	College/ University	School	Grocery	Restaurant	Health Care	Hotel/Motel	Warehouse	Personal Service	Community Service	Misc.	Total
Retrofit Express Program													
Refrigeration Load Reduction													
Low Temperature Glass/Acrylic Door	-	-	-	-	-	-	-	-	-	-	-	-	-
Heatless Door	-	-	-	-	2	-	-	-	-	-	-	-	2
Cooler/Freezer Door Gaskets	-	1	-	-	11	3	-	-	-	1	-	-	16
Auto Closer for Cooler/Freezer	-	1	-	-	2	1	-	1	-	1	-	-	6
Medium Temperature Case w/ Door	1	-	-	-	6	2	-	-	-	-	-	-	9
Strip Curtains for Walk-in	1	1	-	-	8	5	-	-	6	-	1	-	22
Low Temperature Case w/ Door	-	-	-	-	3	1	-	-	-	-	-	-	4
Night Covers for Display Cases	-	1	-	-	21	1	-	-	-	-	-	-	23
Compressor Upgrades													
Mechanical Subcooler	-	-	-	-	1	-	-	-	-	-	-	-	1
Multiplex Comprssor System	-	-	-	-	1	-	-	-	-	-	-	-	1
Adjustable Speed Drive	-	-	-	-	-	-	-	-	1	-	-	-	1
Floating Head Pressure Controls	-	-	-	-	-	-	-	-	-	-	-	-	-
Condenser Upgrades													
Oversized Air-Cooled Condenser	-	-	-	-	1	-	-	-	-	-	-	-	1
Oversized Evaporative Condenser	-	-	-	-	-	-	-	-	1	-	-	1	2
Evaporator Upgrades													
Walk-in Cooler PSC Evaporator Motor	-	-	-	-	1	-	-	-	-	-	-	-	1
Display PSC Evaporator Motor	-	-	-	-	2	-	-	-	-	-	-	-	2
Other													
Anti-Sweat Heater Control	-	-	-	-	1	-	-	-	-	-	-	-	1
Suction Line Insulation	1	-	-	-	1	-	-	-	1	-	-	-	3
Display Case Electronic Ballast	-	1	-	-	4	-	-	-	1	-	-	-	6
Non-Electric Condensate Evaporator	3	4	1	2	17	120	-	1	1	3	12	1	165
Retrofit Express Total	5	8	1	2	63	128	-	1	8	4	13	2	235
Customized Incentives Program													
Compressor Upgrades													
Floating Head Pressure Controls	-	-	-	-	-	-	-	-	-	-	-	-	-
Booster Desuperheaters	-	-	-	-	-	-	-	-	-	-	-	-	-
Condenser Upgrades													
Oversized Condensers	-	-	-	-	-	-	-	-	-	-	-	-	-
Other													
Refrigeration EMS	-	1	-	-	2	-	-	-		-	-	1	4
Refrigeration Add/Change	1	-	-	-	-	-	-	-	-	-	-	1	2
Refrigeration Other	-	1	-	-		-	-	-	1	-	-	-	2
Customized Incentives Total	1	1	-	-	2	-	-	-	1	-	-	2	7
Total	6	8	1	2	64	128	-	1	10	4	13	3	241

Exhibit C-4
Billing Analysis Sample Frame
Pre-Censoring
Nonparticipants

Program and Technology Group	Business Type												
	Office	Retail	College/ University	School	Grocery	Restaurant	Health Care	Hotel/Motel	Warehouse	Personal Service	Community Service	Misc.	Total
Total	75	130	2	28	190	35	28	16	58	6	34	50	652

C.4 ANALYSIS PERIODS

When the billing regression analysis is used to model the change of consumption attributable to the program measures, the first step is to isolate the pre- and post-installation periods for each customer in the analysis database so that the impact of these measures can be verified.

In accordance with the Protocols, participants are defined by the "paid date" instead of "installation date." Therefore, all customers actually installed measures in 1992, 1993, 1994 or 1995, with 1995 installations accounting for approximately two-thirds of total installations.

C.4.1 Selection of Installation Date

Although installation date is a field in the MDSS it is rarely collected (only 2 percent of the time). Because the "paid date" can be off by as much as 3 years from the installation date, another approach was developed to estimate installation date. For 68 percent of the MDSS records, a pre- and post-installation inspection date was collected. From these two variables, an interval containing the installation date could be determined. Another date field in the MDSS that is populated 100 percent of the time is the date the application was received by PG&E. This date always occurs after the pre-installation inspection date (when populated) and rarely exceeds the post-installation inspection date (when populated) by more than a month (6 percent). In fact, the application received date and post-installation inspection date are within a month of each other 78 percent of the time. Therefore, the application received date was used as a proxy for the installation date.

In addition, the telephone survey asked every participant to estimate the installation date. If the installation date provided through the self reported survey fell between the pre- and post-installation inspection dates, the customer reported date was used over the application received date.

C.4.2 Selection of Analysis Periods

Billing data were available from January 1992 through September 1996. To maximize the number of post installation months, a post period of October 1995 through September 1996 was used. Because the majority of installations occurred during 1995, the only feasible pre-periods were October 1992 through September 1993 and October 1993 through September 1994. Survey data gathered change information dating back from the beginning of 1993. Therefore, both pre-installation periods could be used. However, the further back the pre-installation period is chosen, the more likely there are to be changes that have occurred at the site. To minimize the number of changes that have occurred outside the program between the pre- and post-installation periods (and to minimize the errors associated with self-reported changes and dates the changes occurred), the October 1993 through September 1994 pre-installation period was selected.

The only disadvantage to selecting the more recent pre-installation period is that some participants may have actually installed the participating measure during or before the pre-installation period. There were no rebated Lighting or Refrigeration installations, and only 18 rebated HVAC installations (2 percent of HVAC) in the analysis sample that occurred prior to the pre-installation period. In addition, only 2 percent of the rebated Lighting and Refrigeration installations, and 8 percent of the rebated HVAC installations occurred during the pre-installation period.

For installations that occurred prior to the pre-installation period, the engineering impact is set to zero. For installation that occurred during either the pre- or post-installation period, the engineering impact is only aggregated over the months for which there is an impact that should be realized.

Exhibits C-5 through C-7 provide the cumulative participation by month for the participants that are part of the billing analysis sample frame.

Exhibit C-5
Commercial Lighting Rebated Technologies
By Estimated Installation Date

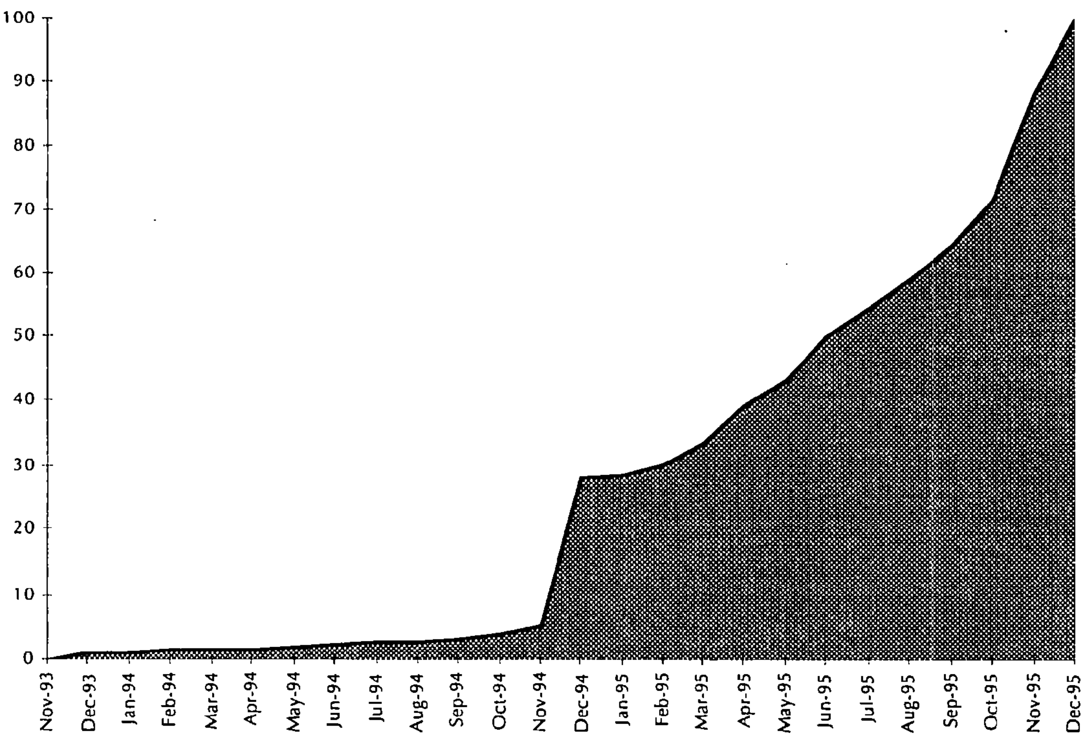


Exhibit C-6
Commercial HVAC Rebated Technologies
By Estimated Installation Date

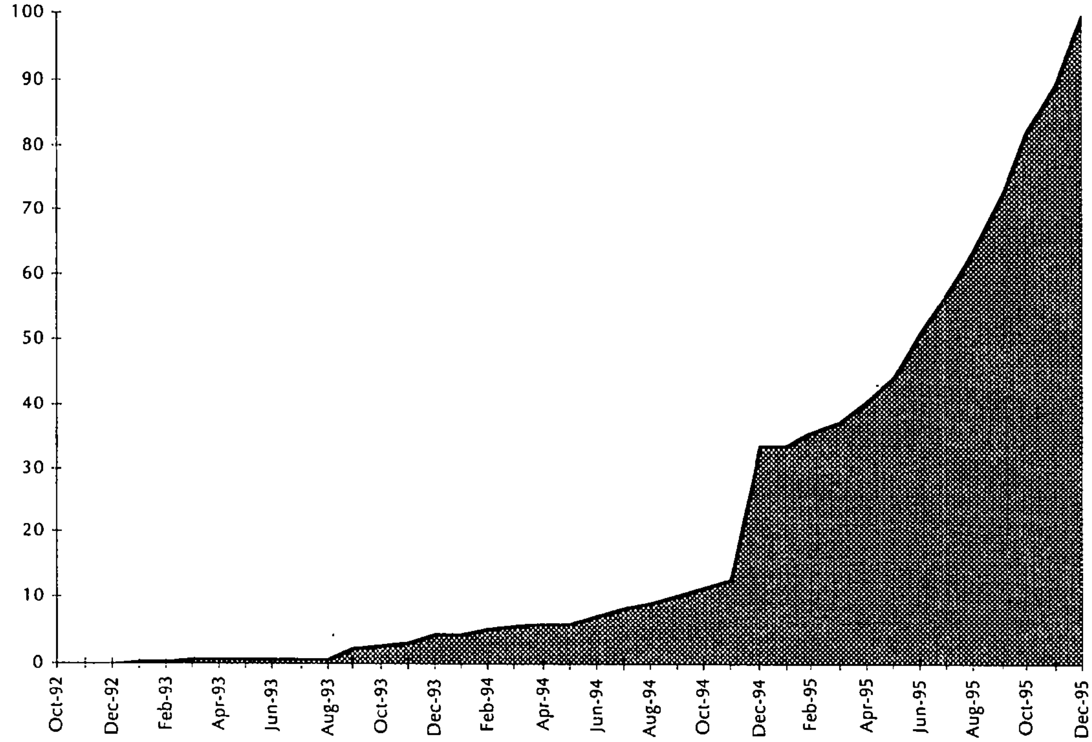
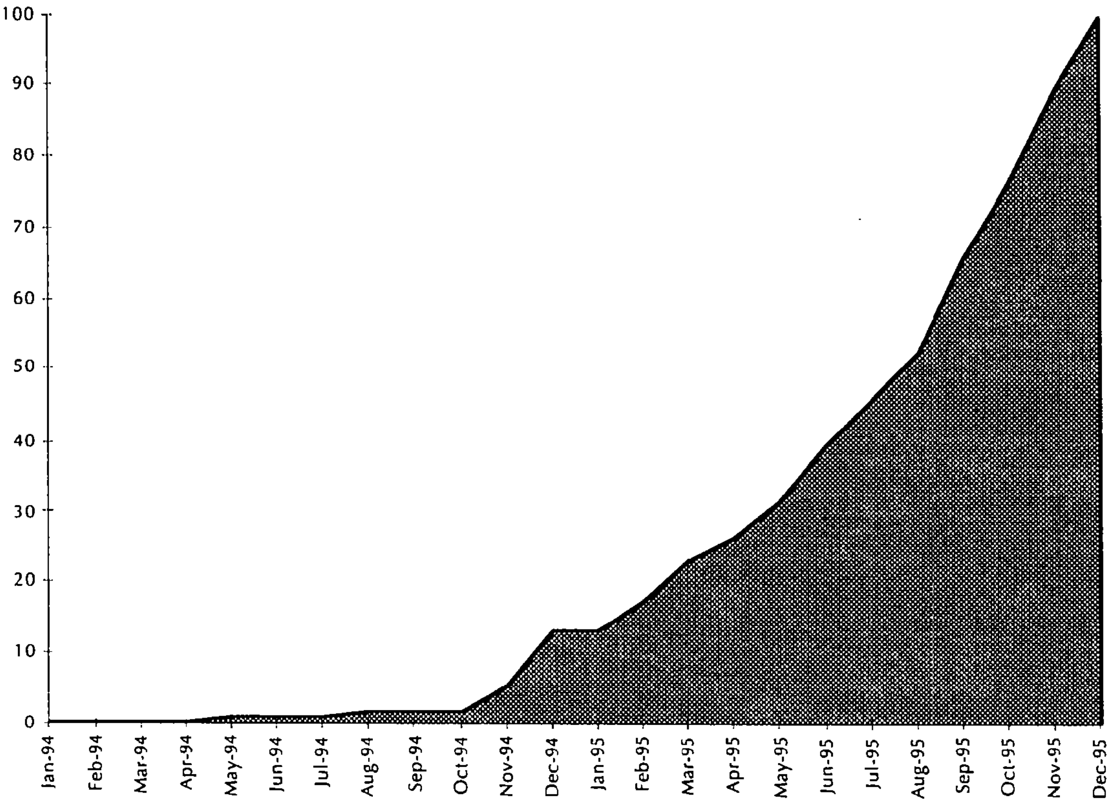


Exhibit C-7
Commercial Refrigeration Rebated Technologies
By Estimated Installation Date



C.5 DATA CENSORING

Three types of data censoring screens were applied to the billing analysis sample frame to remove customers that have invalid billing data, that may not have had their bill properly aggregated to the Site ID level, or that were extremely large users.

C.5.1 Invalid Usage

For customers to be included in the final billing analysis, customers had to have billing data that met the following three criteria.

The pre- and post-installation annual bills had to have been comprised of at least six non-zero monthly bills. If there were seven or more monthly bills with zero energy, the customer was removed from the analysis. If there were between one and six monthly bills with zero energy, the remaining months were prorated to an annual estimate.

The pre-installation annual bill could not be more than three times or less than one third of the post-installation bill. If this occurred, the customer was removed from the analysis.

The pre-installation annual bill could not be more than twice or less than one half the post-installation bill, unless the telephone survey responses indicated that the customer had a change at the site that may have caused an increase or decrease in usage, respectively. For example, if a customer doubled their usage and reported an increase in square footage, or an increase in employees, or an additional measure installed, the customer remained in the sample. However, if the customer reported no changes, or only changes that would indicate a decrease in usage, such as a removal of a measure, then the customer was removed from the analysis.

Exhibit C-8 presents the number of participants and nonparticipants that were deleted for each of the above criteria. Note that only 22 nonparticipants were deleted, whereas 123 participants were deleted. This is due to the fact that the nonparticipants were pre-screened to have relatively valid billing data prior to being selected into the nonparticipant survey sample frame. The participants, however, were often a census and no pre-screening was done on their billing data prior to being selected into the participant survey sample frame. Of the 123 participants, 87 were deleted due to the zero bill criteria.

Exhibit C-8
Distribution of Customers Removed from Billing Analysis
By Data Censoring Criteria
Customers with Invalid Billing Data

Participant or Nonparticipant	Zero Monthly Bills >6?	Usage Doubled or Cut in Half, No Corresponding Change at Site?	Usage Tripled or Cut to a Third?	Number Removed From Analysis
NP	NO	NO	YES	4
NP	NO	YES	YES	3
NP	YES	NO	NO	3
NP	YES	NO	YES	3
NP	YES	YES	NO	1
NP	YES	YES	YES	8
TOTAL				22
P	NO	NO	YES	17
P	NO	NO	YES	3
P	NO	YES	NO	2
P	NO	YES	YES	7
P	NO	YES	YES	6
P	NO	YES	YES	1
P	YES	NO	NO	2
P	YES	NO	NO	8
P	YES	NO	YES	5
P	YES	NO	YES	2
P	YES	YES	NO	5
P	YES	YES	NO	5
P	YES	YES	NO	1
P	YES	YES	YES	38
P	YES	YES	YES	21
TOTAL				123

C.5.2 Large Customers

Customers whose annual post-installation energy consumption exceeded three million kWh were excluded from the billing analysis. Customers of this size were deleted for a number of reasons.

First, there were 98 participants dropped for this reason, compared to only 10 nonparticipants. This indicated that the nonparticipants would not provide a good control for this group of participants. Very large customers are more likely to participate because they are more aware of the program, since they have more contact with PG&E representatives. Therefore, it is difficult to find a sample of nonparticipants that adequately represents these customers.

Large customers installing measures that provide relatively low levels of savings are particularly problematic in billing analyses of this type. It is very difficult to detect an annual impact even as large as 10,000 kWh in a customer's bill which exceeds 10 million kWh, for example. In addition, large customers are more likely to have made changes at the site, which could significantly affect their energy usage. If the model does not adequately capture all of these changes (possibly due to the unique nature of the change, or an error in the self-reported survey responses) it is likely that the coefficient on the program *energy* impact may reflect the change. While this is true of all customers, regardless of size, it is more of a concern for larger customers because the magnitude of their changes can have significant influence over the results of the model.

C.5.3 Aggregation to Site ID Level

As mentioned above, one concern with aggregating to the Site ID level is that there may be control numbers associated with a different premise number, service address, or corporation number that are in the same physical site and are being affected by the installed measures. If this is the case, the billing analysis will have the effect of underestimating the impacts. Therefore, a comparison was made between the engineering energy impact and the pre- and post-installation bills to identify any customers where this problem of bill aggregation may exist.

There were 148 participants that were identified as having total Commercial Sector Program energy impacts that were either more than 50 percent of their pre-installation usage or more than 100 percent of their post-installation usage. These 148 participants were further analyzed to determine whether the impact was large relative to usage because of a problem in aggregating the bill, or if the engineering estimates were just over-estimated, in which case the customer would not be removed from the billing analysis.

Three criteria were used to determine if there was a problem with aggregating the bill for these 148 participants. If a participant failed any of these criteria, the customer was removed from the analysis on the basis that the bills were not properly aggregated and the entire impact will not be detected in an analysis of the customer's billing data.

If the customer's annual kWh per square foot was in the bottom tenth percentile of all participants, the customer was removed.

If the customer's annual kWh per employee was in the bottom tenth percentile of all participants, the customer was removed.

The first billing data pull, which consisted of every nonresidential customer in PG&E's service territory over the period of January 1992 to September 1995, was compared to the second data pull, which is being used for the billing analysis. Customer bills from the first billing data pull were aggregated to the Site ID level in the same way described above. These annual aggregated bills were compared to the aggregated bills used in the analysis. If the aggregated bills from the first data pull were more than 50 percent larger than the bills being used in the billing analysis, the customer was removed. This would indicate that either not all of the control numbers that link to a site were provided in the second data pull or, more likely, since 1995 (when the first billing data was pulled and when the customer participated) there has been customer turnover at the site, and there are now additional premise numbers that no longer link to one unique site.

As a results of these three criteria, 102 of the 148 premises were removed. Of the 102 removed customers, 45 failed the invalid usage data screening checks as well. Therefore, only 57 premises were removed solely on these data screening criteria alone.

Exhibit C-9 presents the number of participants that were removed from the analysis for each of the above criteria.

Exhibit C-9
Distribution of Customers Removed from Billing Analysis
By Data Censoring Criteria
Customers with Billing Aggregation Problems

Low Usage per Sqft?	Low Usage Per Employee?	Low Usage Relative to 1995 Billing Data Pull?	Number of Participants Removed
YES	NO	NO	3
YES	YES	NO	1
YES	YES	YES	1
NO	NO	YES	5
NO	YES	NO	1
NO	YES	YES	2
YES	NO	NO	27
YES	NO	YES	11
YES	YES	NO	9
YES	YES	YES	7
NO	NO	YES	1
NO	YES	NO	2
NO	YES	YES	1
YES	NO	NO	12
YES	NO	YES	2
YES	YES	NO	11
YES	YES	YES	6
TOTAL			102

C.5.4 Other Censoring

In addition to all of the above censoring, three other participants were removed from the analysis for the following reasons. One customer was removed from the analysis because the customer was noted as a "Z-Customer" in the MDSS. PG&E does not claim impacts on "Z-Coded" customers.

Another site had a retrofit performed that will affect a neighboring customer's utility bill. The refrigeration equipment (compressors and condensers) serving the participant are maintained and operated by a nonparticipant. The participant buys liquid ammonia from the nonparticipant via lines running under an adjacent road (driveway) and suction gas is returned to the nonparticipant following use. The impacts of this retrofit (which affect ice production) will be realized by the manufacturer of the liquid ammonia product, a nonparticipant. Therefore, the participating customer was removed from the analysis.

Finally, two other customers were identified as having added the rebated measure installed under the Commercial Program, causing a net increase in energy from the pre- to post-installation period. One of these customers was previously identified as being a large customer and deleted. Therefore, only one extra customer was removed.

Exhibit C-10 summarizes the total number of participants and nonparticipants that were removed from the billing analysis. Exhibits C-11 to C-14 present the final sample sizes used in the billing analysis by business type and technology for participants and by business type for nonparticipants.

Exhibit C-10
Distribution of Customers Removed from Billing Analysis
By Data Censoring Criteria

Participant or Nonparticipant	Zero Monthly Bills >6?	Usage Doubled or Cut in Half, No Corresponding Change at Site?	Usage Tripled or Cut to a Third?	PG&E's Z-Coded Customer?	Impact Affects NP Site?	Rebated Measure Increases Usage?	Large Customer?	Bill Not Aggregated Properly?	Number Removed From Analysis
NP	NO	NO	NO	NO	NO	NO	YES	NO	10
NP	NO	NO	YES	NO	NO	NO	NO	NO	4
NP	NO	YES	YES	NO	NO	NO	NO	NO	3
NP	YES	NO	NO	NO	NO	NO	NO	NO	3
NP	YES	NO	YES	NO	NO	NO	NO	NO	3
NP	YES	YES	NO	NO	NO	NO	NO	NO	1
NP	YES	YES	YES	NO	NO	NO	NO	NO	8
TOTAL									32
P	NO	NO	NO	NO	NO	NO	NO	YES	57
P	NO	NO	NO	NO	NO	NO	YES	NO	98
P	NO	NO	NO	NO	NO	YES	YES	NO	1
P	NO	NO	NO	NO	NO	YES	NO	NO	1
P	NO	NO	NO	NO	YES	NO	NO	NO	1
P	NO	NO	NO	YES	NO	NO	NO	NO	1
P	NO	NO	YES	NO	NO	NO	NO	NO	17
P	NO	NO	YES	NO	NO	NO	NO	YES	3
P	NO	YES	NO	NO	NO	NO	NO	NO	2
P	NO	YES	YES	NO	NO	NO	NO	NO	7
P	NO	YES	YES	NO	NO	NO	NO	YES	6
P	NO	YES	YES	NO	NO	NO	YES	NO	1
P	YES	NO	NO	NO	NO	NO	NO	NO	2
P	YES	NO	NO	NO	NO	NO	NO	YES	8
P	YES	NO	YES	NO	NO	NO	NO	NO	5
P	YES	NO	YES	NO	NO	NO	NO	YES	2
P	YES	YES	NO	NO	NO	NO	NO	NO	5
P	YES	YES	NO	NO	NO	NO	NO	YES	5
P	YES	YES	NO	NO	NO	NO	YES	NO	1
P	YES	YES	YES	NO	NO	NO	NO	NO	38
P	YES	YES	YES	NO	NO	NO	NO	YES	21
TOTAL									282

Exhibit C-11
Billing Analysis Sample Used
Post-Censoring
Indoor Lighting End-Use Technologies

Program and Technology Group	Business Type												
	Office	Retail	College/ University	School	Grocery	Restaurant	Health Care	Hotel/Motel	Warehouse	Personal Service	Community Service	Misc.	Total
Retrofit Express Program													
Compact Fluorescent	46	20	2	47	8	10	15	13	5	3	12	2	183
Incandescent to Fluorescent	5	0	0	3	0	1	0	1	0	0	1	0	11
Efficient Ballast	5	7	1	4	4	0	1	0	1	0	1	0	24
T8 Lamps and Electronic Ballasts	109	53	2	95	29	13	25	6	16	8	22	6	384
Optical Reflectors w/ Fluor. Delamp	60	24	2	26	12	10	8	1	5	5	4	2	159
High Intensity Discharge	3	5	1	10	0	0	0	1	10	4	2	5	41
Halogen	8	3	1	7	1	2	1	1	1	0	5	1	31
Exit Signs	29	10	1	22	2	5	4	0	2	1	5	1	82
Controls	14	1	0	25	0	1	3	2	2	1	4	4	57
Retrofit Express Total	123	61	3	99	40	22	27	16	20	13	30	10	464
Customized Incentives Program													
Compact Fluorescent	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Standard Fluorescent	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
High Intensity Discharge	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Halogen	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Exit Signs	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Controls	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Other	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Customized Incentives Total	5	0	0	0	9	0	0	0	1	0	0	0	15
Total	123	61	3	99	40	22	27	16	20	13	30	10	464

Exhibit C-12
Billing Analysis Sample Used
Post-Censoring
HVAC End-Use Technologies

Program and Technology Group	Business Type												
	Office	Retail	College/ University	School	Grocery	Restaurant	Health Care	Hotel/Motel	Warehouse	Personal Service	Community Service	Misc.	Total
Retrofit Express Program													
Central A/C	75	26	-	24	4	10	20	3	8	4	19	5	198
Variable Speed Drive HVAC Fan	12	10	-	2	-	-	-	-	-	-	-	1	25
Package Terminal A/C	2	-	-	7	-	2	-	13	-	-	-	-	24
Programmable Thermostat	36	10	-	13	-	6	7	2	2	2	10	1	89
Reflective Window Film	34	9	-	3	3	2	7	3	3	2	8	2	76
Water Chiller	-	1	-	1	-	-	-	-	-	-	2	-	4
Other RE Measures	-	1	-	-	1	1	-	-	-	-	-	-	3
Retrofit Express Total	131	45	-	41	8	17	27	19	11	7	30	7	343
Retrofit Efficiency Options Program													
Variable Frequency Drive	-	-	-	-	-	-	-	-	-	-	-	-	-
Water Chiller	-	-	-	1	-	-	-	-	-	-	-	-	1
CAV to VAV	-	-	-	-	-	-	-	-	-	-	-	-	-
Cooling Tower	-	-	-	1	-	-	-	-	-	-	-	-	1
Retrofit Efficiency Options Total	-	-	-	1	-	-	-	-	-	-	-	-	1
Customized Incentives Program													
HVAC Variable Speed Drive	1	-	-	-	1	-	-	-	-	-	-	-	2
High Efficiency Chiller	-	-	-	-	-	-	-	-	-	-	-	-	-
Energy Management System	4	-	-	14	1	-	-	-	1	-	-	-	20
Other CI Measures	2	-	1	1	-	-	-	-	1	-	-	-	5
Customized Incentives Total	7	-	1	15	2	-	-	-	1	-	-	-	26
Total	138	45	1	55	10	17	27	19	12	7	30	7	368

Exhibit C-13
Billing Analysis Sample Used
Post-Censoring
Refrigeration End-Use Technologies

Program and Technology	Business Type												
	Office	Retail	College/ University	School	Grocery	Restaurant	Health Care	Hotel/Motel	Warehouse	Personal Service	Community Service	Misc.	Total
Retrofit Express Program													
Refrigeration Load Reduction													
Low Temperature Glass/Acrylic Door	-	-	-	-	-	-	-	-	-	-	-	-	-
Heatless Door	-	-	-	-	2	-	-	-	-	-	-	-	2
Cooler/Freezer Door Gaskets	-	1	-	-	11	3	-	-	-	1	-	-	16
Auto Closer for Cooler/Freezer	-	1	-	-	2	1	-	1	-	1	-	-	6
Medium Temperature Case w/ Door	-	-	-	-	6	1	-	-	-	-	-	-	7
Strip Curtains for Walk-in	1	1	-	-	7	5	-	-	1	-	1	-	16
Low Temperature Case w/ Door	-	-	-	-	3	1	-	-	-	-	-	-	4
Night Covers for Display Cases	-	1	-	-	21	1	-	-	-	-	-	-	23
Compressor Upgrades													
Mechanical Subcooler	-	-	-	-	1	-	-	-	-	-	-	-	1
Multiplex Comprssor System	-	-	-	-	1	-	-	-	-	-	-	-	1
Adjustable Speed Drive	-	-	-	-	-	-	-	-	-	-	-	-	-
Floating Head Pressure Controls	-	-	-	-	-	-	-	-	-	-	-	-	-
Condenser Upgrades													
Oversized Air-Cooled Condenser	-	-	-	-	1	-	-	-	-	-	-	-	1
Oversized Evaporative Condenser	-	-	-	-	-	-	-	-	-	-	-	-	-
Evaporator Upgrades													
Walk-in Cooler PSC Evaporator Motor	-	-	-	-	1	-	-	-	-	-	-	-	1
Display PSC Evaporator Motor	-	-	-	-	2	-	-	-	-	-	-	-	2
Other													
Anti-Sweat Heater Control	-	-	-	-	1	-	-	-	-	-	-	-	1
Suction Line Insulation	1	-	-	-	1	-	-	-	-	-	-	-	2
Display Case Electronic Ballast	-	1	-	-	4	-	-	-	-	-	-	-	5
Non-Electric Condensate Evaporator	3	3	1	2	11	87	-	1	1	3	9	-	121
Retrofit Express Total	4	7	1	2	56	94	-	1	2	4	10	-	181
Customized Incentives Program													
Compressor Upgrades													
Floating Head Pressure Controls	-	-	-	-	-	-	-	-	-	-	-	-	-
Booster Desuperheaters	-	-	-	-	-	-	-	-	-	-	-	-	-
Condenser Upgrades													
Oversized Condensers	-	-	-	-	-	-	-	-	-	-	-	-	-
Other													
Refrigeration EMS	-	-	-	-	2	-	-	-	-	-	-	-	2
Refrigeration Add/Change	1	-	-	-	-	-	-	-	-	-	-	-	1
Refrigeration Other	-	-	-	-	-	-	-	-	-	-	-	-	-
Customized Incentives Total	1	-	-	-	2	-	-	-	-	-	-	-	3
Total	5	7	1	2	57	94	-	1	2	4	10	-	183

Exhibit C-14
Billing Analysis Sample Used
Post-Censoring
Nonparticipants

Program and Technology Group	Business Type												
	Office	Retail	College/ University	School	Grocery	Restaurant	Health Care	Hotel/Motel	Warehouse	Personal Service	Community Service	Misc.	Total
Total	74	124	1	26	185	34	27	15	53	6	31	44	620

C.6 MODEL SPECIFICATION

The billing regression analysis for the Commercial Program Evaluation used two different multivariate regression models under an integrated framework of providing unbiased and robust model estimates in the commercial sector. The key feature of the approach is that it employs a simultaneous equation approach to account for both the year-to-year and cross-sectional variation in a manner that consistently and efficiently isolates program impacts.

A baseline model is initially estimated using only the comparison group sample. This model estimates a relationship that is then used to forecast the post-installation-year energy consumption for participants as a function of pre-installation year usage. In this way, baseline energy usage is forecasted for participants by assuming that their usage will change, on average, in the same way that usage did for the comparison group.

The resulting SAE coefficients are used to adjust the engineering estimates of expected annual energy impacts for the entire participant population. These impacts are presented in *Section 4* and are used to compute program realization rates.

C.6.1 Baseline Model

The baseline model explains post-installation energy usage as a function of the pre-installation energy usage, weather changes, and customer self-reports of factors that could affect energy usage. In order to isolate the program impact from the energy usage changes, only the comparison group is used to fit this model. The baseline model has the following functional form:

$$kWh_{post,i} = \sum_j (\alpha_j + \beta_j kWh_{pre,i}) + \gamma(\Delta CDD_i) * kWh_{pre,i} + \phi(\Delta HDD_i) * Elec_i * kWh_{pre,i} + \sum_k \eta_k Chg_{i,k} + \varepsilon$$

Where

$kWh_{post,i}$ and $kWh_{pre,i}$ are customer i's annualized energy usage for the post- and pre-installation periods, respectively;

ΔCDD_i and ΔHDD_i are the annual change of cooling and heating degree days (base 65°F) between the post-installation year and pre-installation year;

$Elec_i$ is an indicator variable (0/1) for the ith customer, which equals 1 if the customer has electric heating;

$Chg_{i,k}$ are the customer self-reported change variables from the survey data, including adding, replacing, or removing equipment associated with major end uses, changes in number of employees and square footage;

α_j is the indicator variable (0/1) for the jth business type, which equals 1 if the customer is in that business type and 0 otherwise;

β, γ and ϕ are the estimated slopes on their respective independent variables. Separate slopes on pre-usage are estimated by business type; and,

ε is the random error term of the model.

For each customer in the analysis dataset, a post-installation predicted usage value is calculated using the parameters of the baseline models estimated for the 1994 to 1996 analysis period. They both take the same functional form with different segment-level intercept series (α_j) and slopes (β, γ and ϕ):

$$k\hat{W}h_{post,i} = F_{pre}(kWh_{pre}, \Delta CDD, \Delta HDD) = \sum_j (\alpha_j + \beta_j kWh_{pre,i}) + \gamma(\Delta CDD_i) * kWh_{pre,i} + \phi(\Delta HDD_i) * Elec_i * kWh_{pre,i}$$

Exhibit C-15 summarizes the final baseline model results that were estimated using 620 customers, as discussed in the *Data Censoring* section. Exhibit C-15 summaries the independent variables used in the baseline model, together with the t-statistics and the sample sizes available for each parameter estimate used to predict the post-period usage. The final functional relation is estimated as follows:

Baseline Model (1994 to 1996):

$$\begin{aligned} k\hat{W}h_{96,i} = {} & -40834 * OFF\_LG + 1349 * OFF\_SM - 19849 * RET\_LG - 120 * RET\_SM \\ & +942 * SCHOOLS + 5378 * GROCERY + 8461 * SUPERMKT + 4756 * REST \\ & +10964 * HEALTH + 2403 * HOTEL + 4167 * WAREHOUS + 675 * PERSONAL \\ & +4795 * COMMUN + 37895 * MISCBT \\ & +1.13 * OFF\_LG4 + 0.91 * OFF\_SM4 + 0.99 * RET\_LG4 + 1.00 * RET\_SM4 \\ & +1.00 * SCHOOLS4 + 0.98 * GROCERY4 + 0.98 * SUPERMKT4 + 0.99 * REST4 \\ & +0.99 * COLLEGE4 + 0.94 * HEALTH4 + 1.02 * HOTEL4 + 1.04 * WAREHOUS4 \\ & +0.94 * PERSONAL4 + 0.95 * COMMUN4 + 0.95 * MISCBT4 \\ & +0.0000456 * CDD_{96-94,i} * kWh_{94,i} + 0.0000324 * HDD_{96-94,i} * kWh_{94,i} \end{aligned}$$

Exhibit C-15
Billing Regression Analysis Final Baseline Model Outputs

Parameter Descriptions	Analysis Variable Name	Units	Parameter Estimate	t-Statistic	Sample Size
Intercepts					
Large Office	OFF_LG	(0,1)	-40834	0.99	19
Small Office	OFF_SM	(0,1)	1349	0.07	55
Large Retail	RET_LG	(0,1)	19849	0.44	22
Small Retail	RET_SM	(0,1)	-121	0.01	102
Schools	SCHOOLS	(0,1)	942	0.04	26
Grocery	GROCERY	(0,1)	5378	0.33	127
Supermarket	SUPERMKT	(0,1)	8461	0.30	58
Restaruant	REST	(0,1)	4756	0.19	34
College/University	COLLEGE	(0,1)	0	-	1
Health Care	HEALTH	(0,1)	10964	0.50	27
Hotel/Motel	HOTEL	(0,1)	2403	0.07	15
Warehouse	WAREHOUS	(0,1)	4167	0.19	53
Personal Service	PERSONAL	(0,1)	675	0.01	6
Community Service	COMMUN	(0,1)	4795	0.25	31
Miscellaneous	MISCBT	(0,1)	37895	1.95	44
Pre Usage					
Large Office	OFF_LG4	kWh	1.13	27.16	19
Small Office	OFF_SM4	kWh	0.91	7.39	55
Large Retail	RET_LG4	kWh	0.99	26.44	22
Small Retail	RET_SM4	kWh	1.00	9.48	102
Schools	SCHOOLS4	kWh	1.00	33.42	26
Grocery	GROCERY4	kWh	0.98	8.90	127
Supermarket	SUPERMKT4	kWh	0.98	38.46	58
Restaruant	REST4	kWh	0.99	10.94	34
College/University	COLLEGE4	kWh	0.99	3.36	1
Health Care	HEALTH4	kWh	0.94	28.61	27
Hotel/Motel	HOTEL4	kWh	1.02	9.50	15
Warehouse	WAREHOUS4	kWh	1.04	53.01	53
Personal Service	PERSONAL4	kWh	0.94	4.37	6
Community Service	COMMUN4	kWh	0.95	25.30	31
Miscellaneous	MISCBT4	kWh	0.95	35.82	44
Weather Variables					
Change in HDD	HDD9694	HDD*kWh	0.0000324	1.06	620
Change in CDD	CDD9694	CDD*kWh	0.0000456	0.78	620

C.6.2 SAE Model

Using the predicted post-installation usage values estimated in the baseline model, a simultaneous equation model is specified to estimate the SAE coefficients on energy impact. The SAE simultaneous system can be described as follows:

$$kWh_{96,i} - F_{94}(kWh_{94}, \Delta CDD\ \Delta HDD) = \sum_m \beta_m^{'} Eng_m + \sum_k \eta_k^{'} Chg_{i,k} + \mu_i$$

The difference between predicted and actual usage in 1996 was used as the dependent variable in a SAE model. Based upon the estimated participation month, the pro-rated engineering estimates and change variables were used to explain the deviation of the actual usage from the predicted usage. As discussed above, the predicted usage is estimated using only the comparison group to forecast the 1996 usage as a function of 1994 usage and change of cooling and heating degree days from 1994 to 1996. This usage prediction presents what would have happened in the absence of the program.

C.7 BILLING REGRESSION ANALYSIS RESULTS

The coefficients of the engineering impact, termed the SAE coefficients, are used to calculate the ex post gross energy impacts. Independent realization rates are estimated to provide PG&E with business type- and technology group-level results. Exhibit C-16 summarizes the final SAE model results that were estimated using 935 participants, as discussed in the *Data Censoring* section. Exhibit C-16 summaries the independent variables used in the SAE model, together with the t-statistics and the sample sizes available for each parameter estimate.

Exhibit C-16
Billing Regression Analysis Final Model Outputs

Parameter Descriptions	Units	Parameter Estimate	t-Statistic	Sample Size
SAE Coefficients				
Lighting End Use				
Office Flourescents	kWh	-1.00	14.67	116
Other Flourescents	kWh	-0.68	7.41	261
Controls	kWh	-1.38	2.09	57
Warehouse HIDs	kWh	0.02	0.07	10
School HIDS	kWh	0.11	0.30	10
Other RE Lighting	kWh	-1.26	2.15	119
Custom Lighting	kWh	-0.51	3.07	15
HVAC End Use				
Central A/Cs	kWh	-2.07	3.67	184
ASDs	kWh	-1.90	6.75	27
Chillers	kWh	-1.58	2.39	5
EMS	kWh	-1.03	8.38	20
Other Custom HVAC	kWh	-0.65	4.76	5
Office Thermostats	kWh	0.05	1.06	36
Other RE/REO HVAC	kWh	-0.90	2.89	153
Refrigeration				
Custom Refrigeration	kWh	-0.75	2.00	3
RE/REO Refrigeration	kWh	-0.53	1.98	181
Other End Uses	kWh			
Other	kWh	-1.71	2.90	62
Change Variables	kWh			
Cooling System Replacement	(0,1)*kWh	-0.03	0.70	10
Lighting System Replacement	(0,1)*kWh	-0.08	4.17	48
Change in Employees	(±1,0)*kWh	0.01	0.64	57
Square Foot Change	± sqft	4.42	2.37	27
Heating System Replacement	(0,1)*kWh	-0.07	0.04	4
Other Equipment Change	(0,1)*kWh	0.03	1.17	42
Remove Equipment	(0,1)*kWh	0.08	0.64	2
Refrigeration Replacement	(0,1)*kWh	0.00	0.01	3
Add Equipement	(0,1)*kWh	0.11	0.49	11
Other Additions	(0,1)*kWh	0.14	12.41	375

The dependent variable is the difference between the actual and predicted 1996 usage using the 1994 baseline model.

SAE coefficients are calculated for 16 different combinations of business type and measure. Primarily those measures that have broad participation and relatively high expected impacts were supported by separate SAE coefficients. In addition, a separate SAE coefficient was calculated for other Commercial Program measures outside Lighting, HVAC, and Refrigeration.

Attempts were made to estimate the SAE coefficients at a finer level of segmentation, but generally either one of two problems were encountered. First, available sample sizes were too small to support a finer level of segmentation. Second, certain parameters were correlated with each other and needed to be combined into a single parameter (a standard econometric solution to solving the problem of colinearity). For example, it was determined that there was a high incidence of compact and standard fluorescent installations at the same site in office buildings. Therefore, there was enough correlation between the compact and fluorescent engineering estimates to warrant combining the two estimates into a single fluorescent estimate in the model.

All but three of the SAE coefficients are significant at the 95 percent confidence level (t-statistics greater than 1.96). In addition, all of the statistically significant SAE coefficients were the correct sign, and therefore were used in the calculation of the final ex post energy calculations. The three SAE coefficients that were not significant at the 95 percent confidence interval (HIDs in warehouses and schools, and thermostats in offices) were not used in the final ex post energy calculations. Because each of the insignificant SAE coefficients were also the wrong sign, they were set to zero. Therefore, no energy impacts are being claimed for these three segments.

All the of the HVAC technologies are represented in the SAE billing analysis, except for REO Variable Frequency Drives (VFD), REO CAV to VAV, and Customized Incentive Chillers, as shown in Exhibit C-12. Although these measures represent only ten percent of the energy impact, an approach needed to be developed for adjusting the engineering energy impact estimate for these measures.

The REO VFD measure is very similar to those installed under the RE and Customized Incentive programs, and the engineering estimate is calculated using the same approach. Therefore, engineering energy impact estimate for the REO VFD measure was adjusted by the SAE coefficient estimated for the RE and Customized Incentive measures.

Three approaches were considered for adjusting the engineering energy impact estimate for the REO CAV to VAV measure: (1) applying the Other RE HVAC SAE coefficient, (2) applying the Other Custom HVAC SAE coefficient, or (3) leaving the engineering estimate unadjusted. Because the REO CAV to VAV measure is usually installed in large businesses, typical of those installing Customized Incentive measures, the Other Custom HVAC SAE coefficient was used to adjust the engineering energy impact estimate for the REO CAV to VAV measure. This is also the most conservative approach since the SAE coefficient is only 0.65.

The engineering energy impact for Chillers was estimated differently for Customized Incentive applications than for RE and REO applications, due to the different types of businesses that install these measures. Therefore, the engineering energy impact estimate for Customized Incentive Chillers was left unadjusted, which is conservative compared to the alternative approach of applying the 1.58 SAE coefficient estimated for the RE and REO applications.

The SAE coefficient of 0.65 for Other Custom HVAC measures is based on a sample size of only five sites, compared to the 43 unique sites that installed "Other" Customized Incentive HVAC measures in 1995. In addition, these five sites represent only seven percent of the total ex ante energy impact contributed by these 43 sites. Also, one third of the customers installing "Other" Customized Incentive HVAC measures have usage over 3 million kWh per year, which are not represented in the SAE analysis.

The larger customers (usage over 3 million kWh per year), however, are very well represented in the on-site audit sample, for which calibrated engineering energy impacts were estimated. Sixteen sites, which represent 53 percent of the total ex ante energy impact, were on-site audited, one of which was included in the SAE billing analysis. The ratio of the engineering energy impact estimate to the ex ante estimate is 0.79 for the on-site audit sample. This can be directly compared to the SAE coefficient, because ex ante estimates were used as the engineering energy impact estimates for the billing analysis, as mentioned above.

Three approaches were considered for estimating the ex post gross energy impact for the "Other" Customized Incentive HVAC measures:

- The SAE coefficient of 0.65 could be applied to the ex ante estimate of gross energy impact for the population.

- The 0.79 ratio of engineering energy engineering energy impact estimate to the ex ante estimate from the on-site audit sample could be applied to the ex ante estimate of gross energy impact for the population.

- The SAE coefficient of 0.65 could be applied to the ex ante estimate of gross energy impact for the population that is most similar to the SAE sample, and the 0.79 ratio of engineering energy engineering energy impact estimate to the ex ante estimate could be applied to the population most similar to the on-site audit sample.

The approach of applying the SAE coefficient to the ex ante estimate of gross energy impact for the population, which is the most conservative method, was chosen for two reasons. First, the SAE coefficient provides a statistically adjusted result that is significant at the 95 percent confidence level. Second, the 0.79 ratio based on the on-site audit is very sensitive to a few individual on-site results. For example, the ratio of the engineering to ex ante estimate is 1.51 for the site with the largest energy impact. If the engineering estimate was set equal to the ex ante estimate for this customer, the overall ratio for all on-sites would be 0.64. Conversely, if the site with the second largest energy impact, which has a ratio of 0.41, had an engineering estimate set equal to the ex ant estimate, the overall ratio would be 0.95.

The SAE coefficient of 0.75 for Customized Incentive Refrigeration measures is based on a sample size of only three sites, compared to the 53 unique sites that installed Customized Incentive Refrigeration measures in 1995. Adjusting the engineering estimates of energy impact by 0.75 for all Customized Incentive measures should be considered conservative because it is likely that a sample size of three may not be representative of the population. An alternative approach would be to adjust only those measures that are similar to the three represented in the billing analysis, and leave the remaining measures unadjusted. It was found that the ratio of the engineering energy to the ex ante gross energy estimate was 98 percent over all 53 unique sites, and 94 percent for the three sites used in the SAE analysis. Because the ratio for the SAE sample is similar to the population's ratio and because the SAE coefficient was statistically significant at the 95 percent confidence level, the conservative approach of adjusting all Customized Incentive Refrigeration measures by 0.75 was chosen.

Impact estimates from the MDSS for other end uses were included in the model for customers that installed measures outside the Lighting, HVAC, and Refrigeration end uses. Although this result is statistically significant and the correct sign, it is not recommended that this value be used because the sample may not be representative of the population of participants installing these measures.

The majority of the change variables that were included in the model were not statistically significant at the 95 percent confidence level. Most of the parameter estimates are the correct sign, and those that are not have very low t-statistics. All but one variable, was determined solely on telephone survey responses. The change variable termed "other additions" was determined by comparing the predicted estimate of post-installation usage, based on the baseline model, to the actual post-installation usage. If the predicted usage is less than the actual post-installation usage, it is likely that some change occurred at the premise that would cause the usage to increase. An analysis of these customers revealed that two thirds of them indicated through the telephone survey that some change did occur at the premise. However, almost half of these customers did not provide a date for when the change occurred. Therefore, the "other additions" variable was created in an attempt to capture other changes that would cause usage to increase, which were not explained by the other independent variables in the model.

The final SAE coefficients for the Lighting, HVAC, and Refrigeration end uses are provided in Exhibits C-17 through C-19, respectively. The SAE coefficients are multiplied by the evaluation estimates of gross energy impact to calculate the gross ex post energy impacts.

Exhibit C-17
Commercial Indoor Lighting Gross Energy Impact SAE Coefficients By Business Type and Technology Group

Business Type / Program and Technology Group	SAE Coefficients											
	Office	**Retail**	**College/ University**	**School**	**Grocery**	**Restaurant**	**Health Care**	**Hotel/Motel**	**Warehouse**	**Personal Service**	**Community Service**	**Misc.**	**Total**
Retrofit Express Program													
Compact Fluorescent	1.00	0.68	0.68	0.68	0.68	0.68	0.68	0.68	0.68	0.68	0.68	0.68	
Incandescent to Fluorescent	1.00	0.68	0.68	0.68	0.68	0.68	0.68	0.68	0.68	0.68	0.68	0.68	
Efficient Ballast	1.00	0.68	0.68	0.68	0.68	0.68	0.68	0.68	0.68	0.68	0.68	0.68	
T8 Lamps and Electronic Ballasts	1.00	0.68	0.68	0.68	0.68	0.68	0.68	0.68	0.68	0.68	0.68	0.68	
Optical Reflectors w/ Fluor. Delamp	1.00	0.68	0.68	0.68	0.68	0.68	0.68	0.68	0.68	0.68	0.68	0.68	
High Intensity Discharge	1.26	1.26	1.26	0.00	1.26	1.26	1.26	1.26	0.00	1.26	1.26	1.26	
Halogen	1.26	1.26	1.26	1.26	1.26	1.26	1.26	1.26	1.26	1.26	1.26	1.26	
Exit Signs	1.26	1.26	1.26	1.26	1.26	1.26	1.26	1.26	1.26	1.26	1.26	1.26	
Controls	1.38	1.38	1.38	1.38	1.38	1.38	1.38	1.38	1.38	1.38	1.38	1.38	
Retrofit Express Total													
Customized Incentives Program													
Compact Fluorescent	0.51	0.51	0.51	0.51	0.51	0.51	0.51	0.51	0.51	0.51	0.51	0.51	
Standard Fluorescent	0.51	0.51	0.51	0.51	0.51	0.51	0.51	0.51	0.51	0.51	0.51	0.51	
High Intensity Discharge	0.51	0.51	0.51	0.51	0.51	0.51	0.51	0.51	0.51	0.51	0.51	0.51	
Halogen	0.51	0.51	0.51	0.51	0.51	0.51	0.51	0.51	0.51	0.51	0.51	0.51	
Exit Signs	0.51	0.51	0.51	0.51	0.51	0.51	0.51	0.51	0.51	0.51	0.51	0.51	
Controls	0.51	0.51	0.51	0.51	0.51	0.51	0.51	0.51	0.51	0.51	0.51	0.51	
Other	0.51	0.51	0.51	0.51	0.51	0.51	0.51	0.51	0.51	0.51	0.51	0.51	
Customized Incentives Total													
Total													

Exhibit C-18
Commercial HVAC Gross Energy Impact SAE Coefficients
By Business Type and Technology Group

Business Type / Program and Technology Group	SAE Coefficients												
	Office	Retail	College/ University	School	Grocery	Restaurant	Health Care	Hotel/Motel	Warehouse	Personal Service	Community Service	Misc.	Total
Retrofit Express Program													
Central A/C	2.069	2.069	2.069	2.069	2.069	2.069	2.069	2.069	2.069	2.069	2.069	2.069	
Variable Speed Drive HVAC Fan	1.901	1.901	1.901	1.901	1.901	1.901	1.901	1.901	1.901	1.901	1.901	1.901	
Package Terminal A/C	0.898	0.898	0.898	0.898	0.898	0.898	0.898	0.898	0.898	0.898	0.898	0.898	
Programmable Thermostat	0.000	0.898	0.898	0.898	0.898	0.898	0.898	0.898	0.898	0.898	0.898	0.898	
Reflective Window Film	0.898	0.898	0.898	0.898	0.898	0.898	0.898	0.898	0.898	0.898	0.898	0.898	
Water Chiller	1.582	1.582	1.582	1.582	1.582	1.582	1.582	1.582	1.582	1.582	1.582	1.582	
Other Measures	0.898	0.898	0.898	0.898	0.898	0.898	0.898	0.898	0.898	0.898	0.898	0.898	
Retrofit Express Total													
Retrofit Efficiency Options Program													
Variable Frequency Drive	1.901	1.901	1.901	1.901	1.901	1.901	1.901	1.901	1.901	1.901	1.901	1.901	
Water Chiller	1.582	1.582	1.582	1.582	1.582	1.582	1.582	1.582	1.582	1.582	1.582	1.582	
CAV to VAV	0.653	0.653	0.653	0.653	0.653	0.653	0.653	0.653	0.653	0.653	0.653	0.653	
Cooling Tower	0.898	0.898	0.898	0.898	0.898	0.898	0.898	0.898	0.898	0.898	0.898	0.898	
Retrofit Efficiency Options Total													
Customized Incentives Program													
HVAC Variable Speed Drive	1.901	1.901	1.901	1.901	1.901	1.901	1.901	1.901	1.901	1.901	1.901	1.901	
High Efficiency Chiller	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	
Energy Management System	1.026	1.026	1.026	1.026	1.026	1.026	1.026	1.026	1.026	1.026	1.026	1.026	
Other Measures	0.653	0.653	0.653	0.653	0.653	0.653	0.653	0.653	0.653	0.653	0.653	0.653	
Customized Incentives Total													
Total													

Exhibit C-19
Commercial Refrigeration Gross Energy Impact SAE Coefficients By Business Type and Technology Group

Business Type / Program and Technology	SAE Coefficients												
	Office	Retail	College/ University	School	Grocery	Restaurant	Health Care	Hotel/Motel	Warehouse	Personal Service	Community Service	Misc.	Total
Retrofit Express Program													
Refrigeration Load Reduction													
Low Temperature Glass/Acrylic Door	0.526	0.526	0.526	0.526	0.526	0.526	0.526	0.526	0.526	0.526	0.526	0.526	
Heatless Door	0.526	0.526	0.526	0.526	0.526	0.526	0.526	0.526	0.526	0.526	0.526	0.526	
Cooler/Freezer Door Gaskets	0.526	0.526	0.526	0.526	0.526	0.526	0.526	0.526	0.526	0.526	0.526	0.526	
Auto Closer for Cooler/Freezer	0.526	0.526	0.526	0.526	0.526	0.526	0.526	0.526	0.526	0.526	0.526	0.526	
Medium Temperature Case w/ Door	0.526	0.526	0.526	0.526	0.526	0.526	0.526	0.526	0.526	0.526	0.526	0.526	
Strip Curtains for Walk-in	0.526	0.526	0.526	0.526	0.526	0.526	0.526	0.526	0.526	0.526	0.526	0.526	
Low Temperature Case w/ Door	0.526	0.526	0.526	0.526	0.526	0.526	0.526	0.526	0.526	0.526	0.526	0.526	
Night Covers for Display Cases	0.526	0.526	0.526	0.526	0.526	0.526	0.526	0.526	0.526	0.526	0.526	0.526	
Compressor Upgrades													
Mechanical Subcooler	0.526	0.526	0.526	0.526	0.526	0.526	0.526	0.526	0.526	0.526	0.526	0.526	
Multiplex Comprssor System	0.526	0.526	0.526	0.526	0.526	0.526	0.526	0.526	0.526	0.526	0.526	0.526	
Adjustable Speed Drive	0.526	0.526	0.526	0.526	0.526	0.526	0.526	0.526	0.526	0.526	0.526	0.526	
Floating Head Pressure Controls	0.526	0.526	0.526	0.526	0.526	0.526	0.526	0.526	0.526	0.526	0.526	0.526	
Condenser Upgrades													
Oversized Air-Cooled Condenser	0.526	0.526	0.526	0.526	0.526	0.526	0.526	0.526	0.526	0.526	0.526	0.526	
Oversized Evaporative Condenser	0.526	0.526	0.526	0.526	0.526	0.526	0.526	0.526	0.526	0.526	0.526	0.526	
Evaporator Upgrades													
Walk-in Cooler PSC Evaporator Motor	0.526	0.526	0.526	0.526	0.526	0.526	0.526	0.526	0.526	0.526	0.526	0.526	
Display PSC Evaporator Motor	0.526	0.526	0.526	0.526	0.526	0.526	0.526	0.526	0.526	0.526	0.526	0.526	
Other													
Anti-Sweat Heater Control	0.526	0.526	0.526	0.526	0.526	0.526	0.526	0.526	0.526	0.526	0.526	0.526	
Suction Line Insulation	0.526	0.526	0.526	0.526	0.526	0.526	0.526	0.526	0.526	0.526	0.526	0.526	
Display Case Electronic Ballast	0.526	0.526	0.526	0.526	0.526	0.526	0.526	0.526	0.526	0.526	0.526	0.526	
Non-Electric Condensate Evaporator	0.526	0.526	0.526	0.526	0.526	0.526	0.526	0.526	0.526	0.526	0.526	0.526	
Retrofit Express Total													
Customized Incentives Program													
Compressor Upgrades													
Floating Head Pressure Controls	0.753	0.753	0.753	0.753	0.753	0.753	0.753	0.753	0.753	0.753	0.753	0.753	
Booster Desuperheaters	0.753	0.753	0.753	0.753	0.753	0.753	0.753	0.753	0.753	0.753	0.753	0.753	
Condenser Upgrades													
Oversized Condensers	0.753	0.753	0.753	0.753	0.753	0.753	0.753	0.753	0.753	0.753	0.753	0.753	
Other													
Refrigeration EMS	0.753	0.753	0.753	0.753	0.753	0.753	0.753	0.753	0.753	0.753	0.753	0.753	
Refrigeration Add/Change	0.753	0.753	0.753	0.753	0.753	0.753	0.753	0.753	0.753	0.753	0.753	0.753	
Refrigeration Other	0.753	0.753	0.753	0.753	0.753	0.753	0.753	0.753	0.753	0.753	0.753	0.753	
Customized Incentives Total													
Total													

C.7.1 Relative Precision Calculation

Relative precision at 90 percent and 80 percent confidence levels for the adjusted gross energy impact estimates are calculated for each of the SAE analysis segments. As mentioned above, there are a total of sixteen analysis segments that were explicitly modeled, and the relative precision estimates based upon the model output are presented in Exhibit C-20 below. In order to calculate the total program level adjusted gross impact and relative precision, the segment-level results were weighted by their unadjusted engineering energy impact estimates in the following equations.

$$\text{Total Adjusted Energy Impact} = \Sigma_i \beta_i \text{Eng}_i$$

Where β_i and Eng_i are the SAE coefficients and unadjusted engineering impact estimates for segment i, respectively. The program level standard error can be estimated as:[2]

$$\text{StdErr} = \sqrt{\sum_i (CV_i * \beta_i * \text{Eng}_i)^2}$$

Where $CVi = (std(\beta i)/\beta i)$ is the coefficient of variation in segment i, estimated in the billing regression model. Finally, the relative precision at 90 percent and 80 percent confidence levels were calculated as

$$RP = \frac{t * \text{StdErr}}{\text{Total Adj. Energy Impact}}$$

Where t equals 1.645 and 1.282 for the 90 percent and 80 percent confidence levels, respectively.

[2] This procedure assumes that the samples in different segments are independent and can be treated as strata in a stratified sampling.

Exhibit C-20
Relative Precision Calculation

SAE Analysis Level	Engineering Gross Energy Impact Estimate (MWh)	SAE Coefficient	t-Statistic	Relative Precision at 80%	Relative Precision at 90%
Lighting End Use					
Office Flourescents	51,455	1.00	14.67	9%	11%
Other Flourescents	76,591	0.68	7.41	17%	22%
Controls	5,318	1.38	2.09	61%	79%
Warehouse HIDs	4,306	0.00	-	-	-
School HIDS	815	0.00	-	-	-
Other RE Lighting	17,534	1.26	2.15	60%	77%
Customized Incentives Lighting	10,242	0.51	3.07	42%	54%
Total	166,261	0.83		13%	16%
HVAC End Use					
Central A/Cs	878	2.07	3.67	35%	45%
ASDs	8,971	1.90	6.75	19%	24%
Chillers	2,966	1.58	2.39	54%	69%
EMS	10,290	1.03	8.38	15%	20%
Other Customized Incentives HVAC	18,668	0.65	4.76	27%	35%
Office Thermostats	1,332	0.00	-	-	-
Other RE/REO HVAC	6,087	0.90	2.89	44%	57%
Total	49,192	1.03		12%	15%
Refrigeration					
Customized Incentives Refrigeration	18,206	0.75	2.00	64%	82%
RE/REO Refrigeration	8,566	0.53	1.98	65%	83%
Total	26,772	0.68		51%	65%

C.8 NET BILLING ANALYSIS

In addition to conducting a billing analysis to estimate gross energy impacts, a net billing analysis was performed, with the objective of estimating SAE coefficients that could be applied to gross engineering estimates to calculate net energy impact. The net billing analysis model specification differs from the gross billing analysis model, which used two different multivariate regression models (a baseline model using a control group and an SAE model using participants). Instead, the net billing analysis model runs one integrated model combining both the participants and nonparticipants.

A disadvantage of combining both participants and nonparticipants into one model of net energy savings is that the resulting sample is not random. In particular, participants self-select into the program and therefore may not be randomly distributed. As a result, there are certain unobserved characteristics that influence the decision to participate. If these characteristics are not accounted for in the model, the net savings model could produce biased coefficient estimates.

One solution to this problem is to include an Inverse Mills Ratio in the model to correct for self-selection. This method was developed by Heckman (1976, 1979[3]) and is used by others (Goldberg and Train, 1996[4]) to address the problem of self-selection into energy retrofit programs. The Mills Ratio technique assumes that the unobserved factors that are influencing participation are distributed normally. The influence of these unobserved factors on participation can be approximated by a Mills Ratio which itself is distributed normally. Using the Mills Ratio corrects for the self-selection bias in the net savings regression as the unobserved factors affecting participation are now controlled for in the model. As a result, standard regression techniques should produce unbiased coefficient estimates.

Goldberg and Train (1996) develop the technique of using an additional Mills Ratio in the savings regression to account for the possibility that participation is correlated with the size of energy savings. The second Mills Ratio is interacted with a measure of energy savings, which allows the amount of net savings to vary with participation. The rationale for the second term is that those customers who have potentially large savings are more likely to participate in the program. Consequently, the unobserved factors that are influencing participation are also affecting the amount of savings. The additional Mills Ratio accounts for the fact that amount of savings will be correlated with participation.

To correct for self-selection, a probit model of program participation is estimated separately for each of the Lighting, HVAC, and Refrigeration retrofit programs. Upon estimation, the parameters of the participation model are then used to calculate an Inverse Mills Ratio for both participants and nonparticipants. This Mills Ratio is then included in the net savings regression that combines both participants and nonparticipants. If the Mills Ratio controls for those unobserved factors that determine participation, and the other model assumptions are met, then the net savings model can then be estimated as if participation in the program is randomly determined.

Using the Inverse Mills Ratio to correct for selection relies on several assumptions. First, the net savings due to the program, whether expressed as naturally occurring savings or a net-to-gross ratio, must be normally distributed. In addition, the Mills Ratio must not be highly correlated with the other independent variables used in the net billing regression. In this application, both of these assumptions are found to be violated. Net savings due to the program is biased upward toward large customers and is not distributed normally. The Mills Ratio term used in the net savings regression is also found to be highly correlated with other independent variables, which introduces multi-collinearity into the model. As a result of these violations, the regression analysis using the Mills Ratio technique does not yield reliable estimates in this application. A description of the methods used for this application are given in the following sections. *Section C.8.1* describes the data and variables used for the probit participation model and *Section C.8.2* gives the estimation results. *Section C.8.3* describes how the Inverse Mills Ratio is used in the Net Billing Model and *Section C.8.4* gives the estimation results from the Net Billing Model.

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[3] Heckman, J. 'The Common Structure of Statistical Models of Truncation, Sample Selection and Limited Dependent Variables and a Simple Estimator for Such Models.", Annals of Economic and Social Measurement, Vol. 5, pp. 475-492, 1976.

Heckman, J. "Sample Selection Bias as a Specification Error." Econometrica, Vol. 47, pp. 153-161, 1979.

[4] Goldberg, Miriam and Kenneth Train. 'Net Savings Estimation: An analysis of Regression and Discrete Choice Approaches', prepared for the CADMAC Subcommittee on Base Efficiency by Xenergy, Inc. Madison, WI, March 1996.

C.8.1 Probit Model of Participation

The first stage of calculating the Mills Ratio is to develop a probit model of program participation. The probit model is a discrete choice model with a dependent variable of either zero or one reflecting whether or not an event occurred. In this case, individuals received a value of one if they participated in the retrofit program and a zero otherwise. The sample includes all 1,217 participants and 652 nonparticipants, and includes information obtained from the telephone surveys as well as billing data. All of these 1,869 survey respondents were used to estimate the participation probit for each program. Of the 1,869, 614 are participants in the Lighting program, 487 are participants in the HVAC program, and 241 are participants in the Refrigeration program. For those customers with missing information, an average value is assigned based on both building type and program participation.

For each of the three retrofit programs, the participation model specification is the same:

$$\text{Participation} = \alpha + \beta' X + \gamma' Y + \vartheta' Z + \varepsilon$$

A description of the explanatory variables is given in Exhibit C-21. The dependent variable PARTICIPATION has a value of one if the customer participated in the 1995 Retrofit program and a zero if they did not participate. The independent variables used are those characteristics that are likely to influence program participation. The first set of variables (X) used in the participation probit describe the customer's business activity. These consist of indicator variables for various building types. The second group of variables (Y) reflect the building characteristics. These include customer size and energy use as well as recent changes in high energy equipment. The third group of variables (Z) contain information on participation in other PG&E programs. Finally, the error term (ε) is assumed to be normally distributed for the probit specification.

Exhibit C-21
Explanatory Variables Description

Variable Name	Units	Variable Type	Description
ADDLIGHT	0,1	Y	Customer added light equipment since 1/93
AVGUSE	Kwh	Y	Average monthly electricity use over 1992-1994
ADDCOOL	0,1	Y	Customer added cooling equipment since 1/93
ADDREF	0,1	Y	Customer added refrigeration equipment since 1/93
ARCOOL	0,1	Y	Cooling equipment was added and removed since 1/93
ARLIGHT	0,1	Y	Lighting equipment was added and removed since 1/93
ARREF	0,1	Y	Refrigeration equipment was added and removed since 1/93
CCHGPGE	0,1	Y	Cooling change was part of a PG&E program
LCHGPGE	0,1	Y	Lighting change was part of a PG&E program
COLLEGE	0,1	X	College
COMMSERV	0,1	X	Community service building
GROCERY	0,1	X	Grocery
HEALTH	0,1	X	Health Care Building
HOTEL	0,1	X	Hotel
MISCCOM	0,1	X	Miscellanious commercial building
OFFICE	0,1	X	Office building
PERSONAL	0,1	X	Personal service building
RESTRNT	0,1	X	Restaurant
SCHOOL	0,1	X	School
RETAIL	0,1	X	Retail Building
WAREHSE	0,1	X	Warehouse
MEDCUST	0,1	Y	Medium sized customer, based on electricty use
LARGCUST	0,1	Y	Large sized customer, based on electricity use
LIGHT95	0,1	Y	Lighting change done in 1995 or later
COOL95	0,1	Y	Cooling change done in 1995 or later
HEAT95	0,1	Y	Heating change done in 1995 or later
OTHER95	0,1	Y	Other equipment change done in 1995 or later
GASHEAT	0,1	Y	Customer has gas heating
ELECHEAT	0,1	Y	Customer has electric heating
DUALHEAT	0,1	Y	Customer has dual heating
HAWARE	0,1	Z	Customer is an HVAC part and became aware of the PG&E program either before or at the same time the new equipment was selected
LAWARE	0,1	Z	Customer is an lighting part and became aware of the PG&E program either before or at the same time the new equipment was selected

C.8.2 Probit Estimation Results

The results of the probit estimation for each program are given in Exhibits C-22, C-23, and C-24.

Exhibit C-22
Lighting Program Probit Estimation Results

Variable Name	Coefficient Estimate	Standard Error	Significance Level
ADDLIGHT	-0.21	0.17	22%
AVGUSE	0.00	0.00	1%
ADDCOOL	0.02	0.17	91%
ADDREF	-0.25	0.26	34%
ARCOOL	0.08	0.15	58%
ARLIGHT	-1.02	0.17	1%
ARREF	-0.34	0.27	22%
CCHGPGE	0.47	0.28	10%
LCHGPGE	-0.13	0.20	51%
COLLEGE	-0.36	0.31	24%
COMMSERV	-0.10	0.14	50%
GROCERY	-1.51	0.13	10%
HEALTH	-0.65	0.17	16%
HOTEL	-0.29	0.21	1%
MISCCOM	-1.17	0.15	8%
OFFICE	-0.22	0.12	2%
PERSONAL	-0.45	0.20	1%
RESTRNT	-1.17	0.14	1%
SCHOOL	-0.52	0.13	1%
RETAIL	-0.66	0.13	2%
WAREHSE	-0.39	0.17	2%
MEDCUST	0.41	0.08	1%
LARGCUST	0.58	0.10	1%
LIGHT95	-0.11	0.24	66%
COOL95	0.10	0.27	70%
HEAT95	0.34	0.27	21%
OTHER95	-0.36	0.25	14%
GASHEAT	0.18	0.10	6%
ELECHEAT	-0.06	0.11	60%
DUALHEAT	0.14	0.29	63%
HAWARE	-0.65	0.09	1%

Exhibit C-23
HVAC Program Probit Estimation Results

Variable Name	Coefficient Estimate	Standard Error	Significance Level
ADDLIGHT	0.13	0.24	59%
AVGUSE	0.00	0.00	3%
ADDCOOL	-0.33	0.26	20%
ADDREF	-0.09	0.46	84%
ARCOOL	-0.71	0.26	1%
ARLIGHT	0.07	0.20	73%
ARREF	-0.30	0.53	58%
CCHGPGE	1.33	0.44	1%
LCHGPGE	0.56	0.24	2%
COLLEGE	-1.12	0.48	2%
COMMSERV	-0.50	0.23	3%
GROCERY	-2.16	0.24	1%
HEALTH	-0.37	0.24	11%
HOTEL	-0.39	0.3	19%
MISCCOM	-1.74	0.26	1%
OFFICE	-0.24	0.19	20%
PERSONAL	-0.70	0.29	2%
RESTRNT	-1.43	0.22	1%
SCHOOL	-0.70	0.20	1%
RETAIL	-1.07	0.21	1%
WAREHSE	-0.81	0.26	1%
MEDCUST	-0.13	0.12	25%
LARGCUST	-0.11	0.15	46%
LIGHT95	0.31	0.28	26%
COOL95	-0.63	0.55	25%
HEAT95	-0.26	0.44	56%
OTHER95	-0.11	0.36	75%
GASHEAT	0.62	0.16	1%
ELECHEAT	0.40	0.18	3%
DUALHEAT	0.33	0.43	45%
LAWARE	-0.79	0.12	1%

Exhibit C-24
Refrigeration Program Probit Estimation Results

Variable Name	Coefficient Estimate	Standard Error	Significance Level
ADDLIGHT	-0.08	0.32	80%
AVGUSE	0.00	0.00	62%
ADDCOOL	-0.06	0.33	86%
ADDREF	-0.16	0.27	56%
ARCOOL	-0.51	0.34	13%
ARLIGHT	-0.29	0.26	27%
ARREF	0.44	0.24	7%
CCHGPGE	0.66	0.62	29%
LCHGPGE	0.39	0.30	20%
COLLEGE	-0.66	0.60	23%
COMMSERV	-1.52	0.42	1%
GROCERY	-0.38	0.14	1%
HEALTH	-6.56	0.83	99%
HOTEL	-1.00	0.44	2%
MISCCOM	-1.00	0.23	1%
OFFICE	-1.09	0.24	1%
PERSONAL	-1.81	0.67	1%
RESTRNT	0.80	0.16	1%
SCHOOL	-0.85	0.23	1%
RETAIL	-0.90	0.21	1%
WAREHSE	-0.50	0.27	7%
MEDCUST	-0.33	0.14	2%
LARGCUST	-0.35	0.15	2%
LIGHT95	0.77	0.30	1%
COOL95	0.81	0.40	4%
HEAT95	0.21	0.41	60%
OTHER95	-0.32	0.52	54%
GASHEAT	-0.28	0.13	4%
ELECHEAT	-0.33	0.16	4%
DUALHEAT	0.16	0.46	73%
LAWARE	-0.86	0.21	1%
HAWARE	-1.48	0.36	1%

In general, the estimation results conform to expectations. For the Lighting probit, customer size as reflected by energy use has a positive impact on program participation. In addition, those customers with gas heating and with a recent cooling equipment change are also more likely to participate. All of the building type variables have negative coefficient estimates, which reflects the fact that each building type has more nonparticipants than participants included in the sample. Finally, recent additions and removals in lighting equipment as well as changes in HVAC equipment have a negative effect on program participation.

For the HVAC probit, large customers based on average monthly electricity use tend to participate in the program. Recent changes in lighting and cooling due to PG&E programs also have a positive impact on program participation. As with the lighting model, all of the building types have negative coefficient estimates.

For the Refrigeration model, smaller customers tend to participate more relative to the medium- and large-sized customers. In addition, restaurants are more likely to participate in the program while other business types are less likely to participate. Recent changes in cooling and lighting equipment also tend to increase participation.

Upon estimation, the coefficient estimates are used to calculate the Inverse Mills Ratio for use in the net savings regression. The product of all of the independent variables and respective coefficient estimates are used in the following calculation

$$\text{Mills Ratio} = \phi(Q)/\Phi(Q) \quad \text{(for participants)}$$

$$= -\phi(Q)/\Phi(-Q) \quad \text{(for nonparticipants)}$$

$$Q = \alpha + \beta'X + \gamma'Y + \vartheta'Z$$

where ϕ is the standard normal probability density function and Φ is the standard normal cumulative density function. Again, this Mills Ratio is used as a measure of the influence that unobserved factors have on program participation. In the following sections, the Mills Ratio is included in the net billing regression as an additional explanatory variable to correct for the problem of self-selection into the Lighting program.

C.8.3 Net Billing Model

The net billing regression analysis for the Commercial Program Evaluation uses a model specification similar to the baseline model used in the gross billing analysis, with three significant differences.

- Both participants and nonparticipants are used in the model.
- The engineering impact estimates are included as independent variables in the model. For nonparticipants, these values are all zero.
- The Mills Ratio is entered into the model in two ways. First, the three Mills Ratios, corresponding to each end use, are included as independent variables. Second, the three Mills Ratios are interacted with the total engineering impact estimate for each corresponding end use.

The resulting SAE coefficients on the energy impacts are then used to adjust the engineering estimates of expected annual energy impacts for the entire participant population to estimate the net ex post energy impacts. The net billing analysis model has the following functional form:

$$kWh_{post,i} = \sum_j (\alpha_j + \beta_j kWh_{pre,i}) + \gamma(\Delta CDD_i) * kWh_{pre,i} + \phi(\Delta HDD_i) * Elec_i * kWh_{pre,i} + \sum_k \eta_k Chg_{i,k}$$
$$+ \sum_m (\rho_m Eng_{m,i}) + \delta_1 Mills_{light,i} + \delta_2 Mills_{HVAC,i} + \delta_3 Mills_{refrig,i} + \delta_4 Mills_{light,i} * Eng_{light,i} + \delta_5 Mills_{HVAC,i} Eng_{HVAC,i}$$
$$+ \delta_6 Mills_{refrig,i} Eng_{refrig,i} + \varepsilon$$

Where

$kWh_{post,i}$ and $kWh_{pre,i}$ are customer i's annualized energy usage for the post- and pre-installation periods, respectively;

ΔCDD_i and ΔHDD_i are the annual change of cooling and heating degree days (base 65°F) between the post-installation year and pre-installation year;

$Elec_i$ is an indicator variable (0/1) for the ith customer, which equals 1 if the customer has electric heating;

$Chg_{i,k}$ are the customer self-reported change variables from the survey data, including adding, replacing, or removing equipment associated with major end uses, changes in number of employees and square footage;

$Eng_{m,i}$ are the engineering impact estimates for technology m, customer i;

$Mills_{light,i}$ is the Mills Ratio for the Lighting end use for customer i;

$Mills_{HVAC,i}$ is the Mills Ratio for the HVAC end use for customer i;

$Mills_{refrig,i}$ is the Mills Ratio for the Refrigeration end use for customer I;

$Eng_{light,i}$ is the engineering estimate for all Lighting technologies for customer i;

$Eng_{HVAC,i}$ is the engineering estimate for all HVAC technologies for customer i;

$Eng_{refrig,i}$ is the engineering estimate for all Refrigeration technologies for customer i;

α_j is the indicator variable (0/1) for the jth business type, which equals 1 if the customer is in that business type and 0 otherwise;

β, γ and ϕ are the estimated slopes on their respective independent variables. Separate slopes on pre-usage are estimated by business type; and,

ρ_m are the SAE coefficients for the engineering impact estimates for technology m;

δ are the coefficients on the individual Mills ratios, and on the Mills ratios interacted with the engineering energy impacts;

ε is the random error term of the model.

This model was run with the same set of 620 nonparticipants and 935 participants that were used in the gross billing analysis model. The results of the model are presented below. The parameter estimates, t-statistics and sample sizes are presented for all of the SAE coefficients and Mills ratios.

Exhibit C-25
Net Billing Regression Analysis Final Model Outputs

Parameter Descriptions	Units	Parameter Estimate	t-Statistic	Sample Size
SAE Coefficients				
Lighting End Use				
Office Flourescents	kWh	-0.35	0.75	116
Other Flourescents	kWh	-0.70	1.40	261
Controls	kWh	-0.60	0.83	57
Warehouse HIDs	kWh	0.08	0.14	10
School HIDS	kWh	0.13	0.23	10
Other RE Lighting	kWh	-0.05	0.07	119
Customized Incentives Lighting	kWh	-0.47	0.92	15
HVAC End Use				
Central A/Cs	kWh	-3.64	3.41	184
ASDs	kWh	-2.53	2.40	27
Chillers	kWh	-1.85	1.76	5
EMS	kWh	-2.20	3.17	20
Other Customized Incentives HVAC	kWh	-1.31	1.60	5
Office Thermostats	kWh	-0.83	0.85	36
Other RE/REO HVAC	kWh	-1.70	1.75	153
Refrigeration				
Customized Incentives Refrigeration	kWh	5.78	2.08	3
RE/REO Refrigeration	kWh	4.72	2.02	181
Other End Uses	kWh			
Other	kWh	-2.18	3.94	62
Mills Ratios				
Single Mills				
Lighting	unitless	-3083	1.18	1555
HVAC	unitless	2980	1.08	1555
Refrigeration	unitless	4051	1.00	1555
Double Mills, Interacted with Impact				
Lighting	kWh	0.07	0.33	464
HVAC	kWh	0.54	1.56	368
Refrigeration	kWh	-1.92	2.21	183

It was found that there was a significant problem of multi-collinearity with the net billing model. The double Mills ratios (the Mills ratio interacted with the engineering energy impacts) were found to be extremely highly correlated with the corresponding engineering energy impacts. Exhibit C-26 below presents the correlation of estimates between the double Mills and the engineering energy impacts.

Exhibit C-26
Correlation Between Double Mills Ratios and Energy Impact Estimates

	Double Mills Ratios		
Parameter Descriptions	**Lighting**	**HVAC**	**Refrigeration**
Engineering Energy Impact Estimates			
Lighting End Use			
Office Flourescents	-0.99	-0.06	-0.014
Other Flourescents	-0.98	-0.11	-0.0132
Controls	-0.50	-0.04	-0.0121
Warehouse HIDs	-0.91	-0.07	-0.0137
School HIDS	-0.78	-0.06	-0.0109
Other RE Lighting	-0.65	-0.09	-0.01
Customized Incentives Lighting	-0.95	-0.06	-0.0061
HVAC End Use			
Central A/Cs	-0.06	-0.85	-0.0035
ASDs	-0.12	-0.96	-0.008
Chillers	-0.05	-0.81	-0.004
EMS	-0.08	-0.98	-0.008
Other Customized Incentives HVAC	-0.10	-0.99	-0.0075
Office Thermostats	-0.05	-0.87	-0.0054
Other RE/REO HVAC	-0.09	-0.95	-0.0066
Refrigeration			
Customized Incentives Refrigeration	-0.01	0.00	-0.9916
RE/REO Refrigeration	-0.01	-0.01	-0.9936
Other End Uses			
Other	0.07	-0.02	-0.003

As a result of the multi-collinearity problem, the majority of the SAE coefficients in the net billing model are insignificant at the 95 percent confidence level. In addition, the high correlation between the double Mills Ratios and the engineering impact estimates results in relatively meaningless parameter estimates. For example, because the HVAC double Mills Ratio is 99 percent negatively correlated with the "other Custom HVAC" energy impact estimate, the SAE coefficient on the energy impact will tend to become more negative as the parameter estimate on the Mills Ratio becomes more positive. Therefore, because of the positive parameter estimate of 0.54 on the HVAC double Mills Ratio, we see the SAE coefficient on the "other Custom HVAC" energy impact being driven down to a value of -1.31 (from -.65 in the gross billing analysis). This would indicate a net ex post impact estimate that is twice as large as the gross ex post impact estimate. Conversely, the negative parameter on the Refrigeration double Mills Ratio is causing the SAE coefficient on the refrigeration energy impacts to become positive.

A number of alternative model specifications were implemented, however all suffered from the problem of multi-collinearity. Therefore, the results of the net billing analysis were not incorporated into the final net ex post energy impact estimates. *Appendix D* discusses the results of the net to gross analysis that was conducted to estimate the final net ex post energy impact estimates.

Appendix D
Net-to-Gross Analysis

D. NET-TO-GROSS METHOD

In this appendix, the methods used to derive net-to-gross (NTG) results for the evaluation of PG&E's 1995 Nonresidential Energy Efficiency Incentive (EEI) Programs is presented. After a brief discussion of data sources, estimates of free-ridership and spillover from participant self-reports are discussed, followed by more sophisticated statistical modeling techniques that were used to estimate program net effects..

D.1 DATA SOURCES

Data used in the NTG analysis include 597 telephone surveys from Lighting end use participants surveyed from April 1996 through August 1996, and 451 telephone surveys from Lighting end use nonparticipants surveyed from June through August 1996. Other data used in this analysis include 156 telephone surveys from canvass nonparticipants and 634 canvass nonparticipants who were "thanked and terminated" because they had not made an equipment retrofit or installation. The canvass nonparticipants were surveyed from June 1996 through July 1996.

D.2 SELF-REPORT-BASED ESTIMATES OF FREE-RIDERSHIP

The RE and Customized Incentives participants surveyed installed or adopted the following technology groups. (Participants who installed multiple technologies may be included in more than one technology group.)

Technology Group	N
T-8: New and Replacements	491
Compact Fluorescents	232
Delamp Fluorescent Fixtures	202
Exit Signs	104
Controls	91
HID Fixtures	62
Halogen	36
Electronic Ballasts	32
Incandescent-to-fluorescent Conversion	16
Reduced Wattage Lighting	2
Custom	17

Because free-ridership often varies by technology, results were calculated for each technology group. However, caution should be employed in interpreting the analysis results, given the small group sizes for some technology groups.

D.2.1 Methods for Scoring Free-Ridership

Multiple methods were used in scoring free-ridership. The methods used vary slightly from each other and elaborate on the technique described in the work plan. All of them use participant responses to survey questions regarding the timing of and reasons for equipment replacement actions. The complete text of the participant surveys may be found in *Appendix S-1*.

Six methods were used in this analysis. Each is described below.

Method 1 is the method described in the work plan. If the customer indicated that he had not been shopping for new lighting before becoming aware of the program, he was scored initially as a net participant. A customer was then classified as a free-rider if he (1) stated that he would have installed high-efficiency lighting within the year and had already selected the lighting equipment; and (2) stated that he would have purchased high-efficiency lighting equipment if the program had not existed.

To be classified as a free-rider under *Method 2*; a customer must have: (1) stated that he became aware of the program *after* making an equipment selection; (2) stated that he had already decided to purchase high-efficiency equipment before becoming aware of the program; and (3) stated that he would have purchased high-efficiency equipment if the program had not existed. As a consistency check, if a customer indicated that he would not have replaced lighting equipment (an unprompted response), free-ridership was scored as "0" for the site.

With *Method 3,* if the customer stated that he would have purchased high-efficiency equipment if the program had not existed, he was scored as a free-rider. Additional questions were used to "override" this preliminary assignment.

Method 4 is identical to Method 3 except deferred free-riders[1] are assigned a NTG ratio value of "0.5."

Method 5 is similar to Method 1, except that additional questions are used to validate results.

Method 6 is similar to Methods 1 and 5, except that customers citing information and referral services associated with the program as the most important factor in deciding to install the equipment were scored as net participants. An opportunity to revert to free-ridership status was also allowed with this method.

D.2.2 Free-Ridership Results

NTG results weighted by avoided cost (AC) and calculated by subtracting the free-ridership rates obtained through each of the methods described above are presented in Exhibit D-1. Results are presented overall and by segment.

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

Exhibit D-1
NTG Weighted by Avoided Cost

	RE Measures					
	T-8: New and Replacements	Delamp Fluorescent Fixtures	HID Fixtures	Compact Fluorescents	Controls	Exit Signs
N	491	202	62	232	91	104
% Avoided Cost	67.65%	15.28%	7.30%	2.88%	1.33%	1.05%
Method 1	0.911	0.903	0.732	0.876	0.962	0.925
Method 2	0.942	0.999	0.984	0.963	0.975	0.978
Method 3	0.856	0.945	0.967	0.775	0.804	0.975
Method 4	0.843	0.899	0.843	0.740	0.801	0.928
Method 5	0.868	0.910	0.754	0.874	0.962	0.914
Method 6	0.865	0.900	0.732	0.871	0.962	0.913

	RE Measures (Cont.)					
	Incandescent-to-Fluorescent Conversion	Electronic Ballasts	Halogen	Reduced Wattage Lighting	Custom	Overall
N	16	32	36	2	17	1285
% Avoided Cost	0.57%	0.42%	0.04%	0.02%	3.46%	100%
Method 1	1.00	0.994	0.649	1.00	0.783	0.890
Method 2	1.00	0.995	0.953	1.00	1.00	0.967
Method 3	1.00	0.990	0.847	1.00	1.00	0.897
Method 4	0.948	0.988	0.741	1.00	0.891	0.861
Method 5	1.00	0.993	0.649	1.00	0.783	0.871
Method 6	1.00	0.993	0.649	1.00	0.783	0.866

Overall, weighted NTG results range from a low of 0.86 for Method 4 to a high of 0.97 for Method 2. This method generates the highest NTG ratios because of the final condition that must be met in order to be scored as a free-rider (i.e., most customers reported that they would not have replaced equipment without the program and hence were scored as net participants). Results obtained using Method 1 (initially proposed in the workplan) were consistent with those from the other methods, and the Method 1 result of 0.89 overall NTG was used as the basis for subsequent adjustment for spillover.

D.3 SELF-REPORT-BASED ESTIMATES OF SPILLOVER

Lighting spillover can be defined as lighting efficiency improvements implemented outside the program but influenced by the program. Preliminary estimates of lighting spillover rates were generated by analyzing responses to a combination of questions asked of 597 participants and 1,241 nonparticipants.

D.3.1 Methods for Scoring Spillover

The integrated approach used to estimate lighting spillover is summarized below.

All surveyed respondents were asked if they had installed lighting equipment outside the program since January 1993. Participants who answered "yes" to the first question were asked if these changes were made after participating in the program. Nonparticipants, and participants who said the changes were made after participation, were asked if they made the equipment changes through a PG&E program.

Participants who passed the first two screening questions and had not changed out lighting equipment through a PG&E program, and nonparticipants who passed the first two screening questions and were aware of the program at the time of equipment purchase, were asked how influential the program was in their decision. Those who said that the program had influenced their decision[2] were included in the estimate of program spillover.

Survey-based estimates were applied to the lighting participant population and the lighting nonparticipant population along with estimates of impact per site, resulting in a final spillover impact.

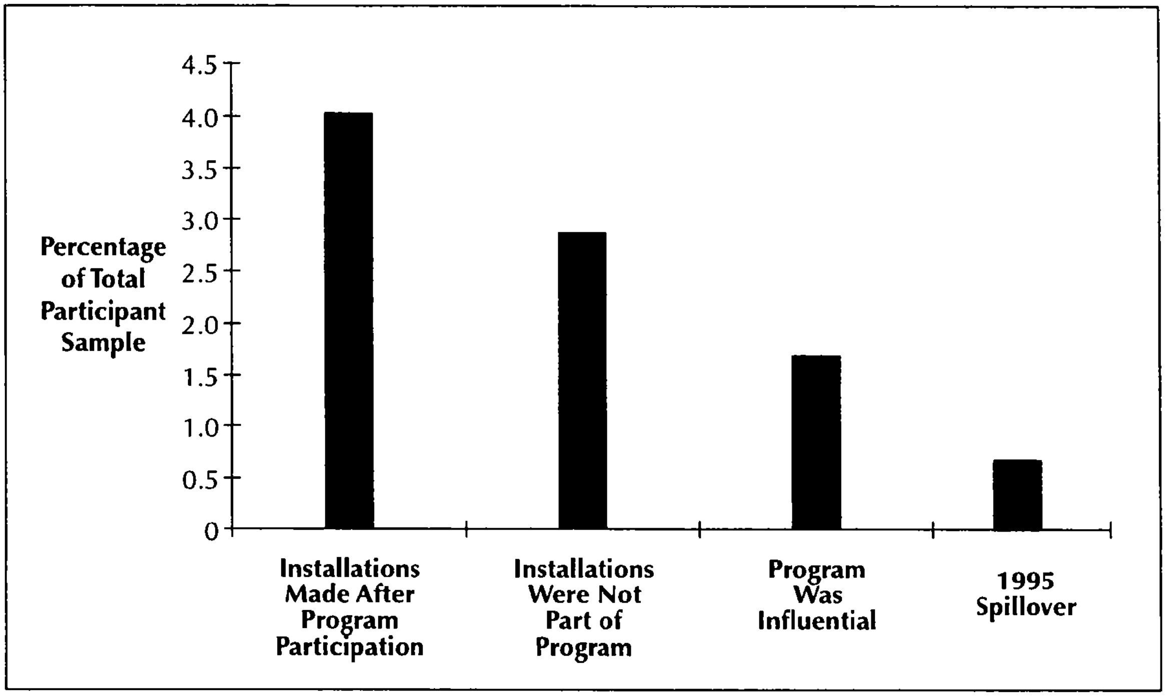
It should be noted that this analysis provides a preliminary indication of spillover rates and more in-depth analysis is required to quantify spillover impacts.

[2] "To what extent did participating in the program influence your additional equipment selection?" Values of 2, 3, 4, and 5 (slightly influential to very influential) were considered to demonstrate program influence on the purchase.

D.3.2 Spillover Result— Participants

Results of the sequential analysis of survey responses to estimate a participant spillover rate of 0.67 percent are illustrated in Exhibit D-2.

Exhibit D-2
Lighting Spillover Indicators
Program Participants

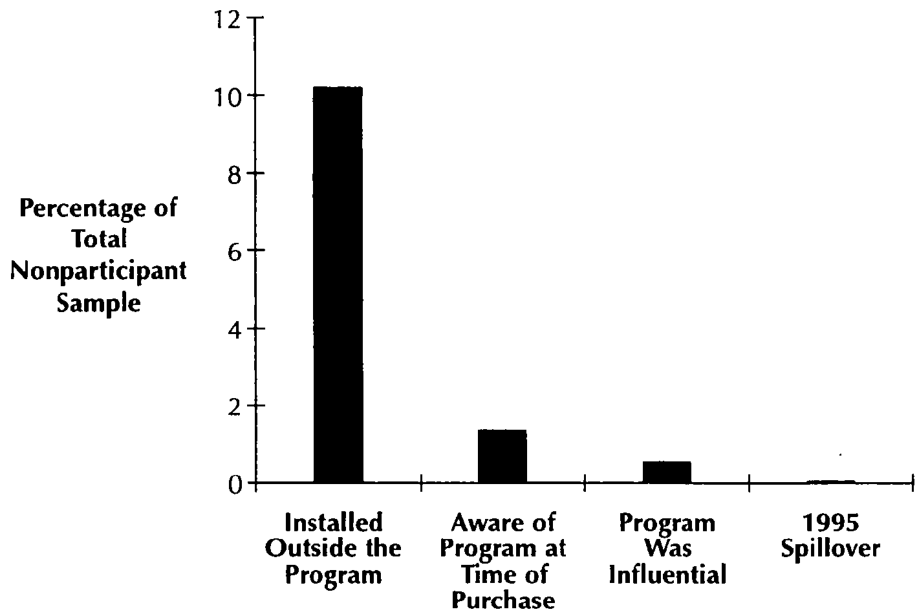


Forty-eight surveyed participants (8 percent of the total participant sample) reported that since January 1993 they had added lighting equipment. Fifty percent of those participants who added equipment (4 percent of the total participant sample) added the equipment after participating in the program. Thirty-five percent (2.85 percent of the total participant sample) did not install the equipment through the program. Ten of these respondents (1.68 percent of the total participant sample) reported that the program influenced their additional lighting equipment installations. Of these 10, 4 installed additional lighting equipment in 1995. Four of 597 participants yields an initial unweighted spillover rate of 0.67 percent for 1995.

D.3.3 Spillover Results—Nonparticipants

Results of the sequential analysis of survey responses to estimate a nonparticipant spillover rate of 0.08 percent are illustrated in Exhibit D-3.

Exhibit D-3
Lighting Spillover Indicators
Program Nonparticipants



One hundred seventy-nine of 1,241 program nonparticipants reported making lighting changes outside the program, of which 126 respondents confirmed their installations were not done through the program. Seventeen respondents (1 percent of the total nonparticipant sample) reported they were aware of the program before they purchased the equipment. Of these 17, 6 respondents reported that their knowledge of the program influenced their equipment selection. One of these 6 respondents installed lighting equipment in 1995. One of 1,241 nonparticipants yields an unweighted spillover estimate of 0.08 percent for 1995.

Because the levels of self-reported spillover are so low and based on such a small number of responses, it was decided not to apply a correction for either participant or nonparticipant spillover. One minus the self-reported rate of free-ridership (1 - 0.11 = 0.89) was therefore used as the self-reported NTG ratio for the Lighting program.

D.4 OVERVIEW OF DISCRETE CHOICE METHOD

A discrete choice logit model is used to estimate both a net-to-gross ratio and the free ridership rate associated with PG&E's Commercial Lighting Energy Efficiency Incentive (EEI) Program (the Lighting program). The decision to purchase high-efficiency equipment is explained in the logit model by the cost and savings of the equipment, any rebate offered by the Lighting program, awareness of the Lighting program, and other customer characteristics. In this application, the high-efficiency equipment examined is fluorescent lighting.[3] Once estimated, the model can be used to determine the probability of purchasing high-efficiency equipment in the absence of the Lighting program. This is simulated by setting both the rebate and program awareness variables to zero in the logit purchase model.

The net-to-gross ratio is calculated using the probability of purchasing high-efficiency equipment both with and without the existence of the retrofit program. The expected impact with the program is the probability of choosing high-efficiency equipment multiplied by the energy impact of the equipment. Similarly, the expected energy impact in absence of the Lighting program is the probability of purchasing high-efficiency equipment without the program multiplied by the energy impact of the equipment. The net-to-gross ratio is the net savings due to the program divided by the expected energy that results from having the program. As discussed below, this method is also used to determine free ridership rates and nonparticipant spillover.

The data used to estimate the logit model of high-efficiency purchases is described in *Section D.4.1*. The logit model specification and variable definitions are given in *Section D.4.3*. The estimation results are discussed in *Section D.4.4* and the net-to-gross ratios are calculated in *Section D.4.5*.

D.4.1 Data Sources for the Net-to-Gross Analysis

The data used for the net-to-gross analysis are a combination of telephone survey information and the program information contained in the MDSS dataset. The sample is divided into both a high-efficiency equipment purchase group and a group of customers that maintain the current lighting system. Those that bought high-efficiency fluorescent lighting equipment either in or outside of the retrofit program are considered purchasers. Those that maintain their current lighting equipment or that purchased standard efficiency lighting equipment comprise the nonpurchase group.

The sample used to estimate the logit model contains information on 1,369 customers. Of these, 819 did not make any lighting equipment purchases. For high-efficiency equipment purchases, 504 customers purchased 1,455 separate lighting measures within the retrofit program while 23 customers purchased 56 separate measures outside the program. For standard equipment, 23 customers purchased 29 different measures. This results in a sample of 848 observations for those did not purchase high-efficiency equipment and a sample of 1,511 observations where high-efficiency equipment was purchased.

D.4.2 Estimating Lighting Equipment Economic Variables

For those customers that installed high-efficiency equipment within the Lighting program, the reported cost, savings, and rebate data is used in the model. For those customers who installed

[3] Other lighting technologies such as compact fluorescents and HIDs did not have enough data to estimate additional logit purchase models. However, the fluorescent lighting measures account for the majority of the lighting retrofits, over 70 percent of the energy impacts from the Lighting program.

high-efficiency equipment outside of the Lighting program, the costs are determined from vendor prices of equipment multiplied by the number of reported fixtures installed. Energy savings is calculated by multiplying the noncoincident demand savings for a given technology by the electricity rate, number of fixtures installed, and the operating hours for that customer.

For those customers who maintain their current lighting equipment, cost, savings and rebate information for high-efficiency equipment needs to be estimated. This is done by using the cost and savings information from customers that purchased high-efficiency equipment outside of the Lighting program. Since these installations are typically smaller than those within the program, it is believed that they provide a better representation of the costs and savings that the nonparticipating customers would actually face when deciding whether or not to purchase high-efficiency equipment. The costs and savings information for the high-efficiency measures adopted outside the Lighting program are averaged by building type and then assigned by building type to those that did not purchase high-efficiency equipment.

Since customers that installed high-efficiency equipment outside the program did not receive rebates, this group cannot be used to assign rebates to the group maintaining the current lighting system. The program participant cost and rebate information is used to determine rebate amounts for customers that did not purchase high-efficiency equipment. For those that purchased inside the program, the ratio of rebate amount to the cost of the measure is calculated. The ratio is then averaged by building type for the program participants and assigned by building type to those that did not purchase high-efficiency equipment. The ratio is then multiplied by the costs assigned to the maintain current system group to obtain a rebate amount.

The costs, savings, and rebate information for each group is summarized below:

High-Efficiency Equipment Installed Inside the Program: Uses the reported cost, savings, and rebate information.

High-Efficiency Equipment Installed Outside the Program: Costs are calculated from vendor prices of equipment and reported number of fixtures installed. Savings are determined by the product of number of fixtures, operating hours, electricity rate, and noncoincident demand savings.

Maintain Current System: Cost and savings data for high-efficiency equipment is assigned by building type from the average cost and savings of high-efficiency measures installed outside the Lighting program. Rebate amounts are estimated using the average ratio of rebate to costs from those installations done within the program. The ratio is assigned by building type and multiplied by the estimated cost to get an estimated rebate.

Other missing data resulted from missing information from survey responses. Rather than estimate the model using mean or median values for those with missing information, these observations were dropped from the final sample.

D.4.3 Logit Purchase Model Specification

The logit model is a discrete choice model with a dependent variable of either zero or one. In this application, customers are given a value of one if they purchased high-efficiency fluorescent lighting either in or outside the program and a zero if they purchased standard equipment or did not make any fluorescent lighting purchase. The logit model specification is defined as:

$$\text{PURCHASE} = \alpha + \beta' X + \gamma' Y + \vartheta' Z + \varepsilon$$

Exhibit D-4
Definitions for Variables Used in the Logit High-Efficiency Equipment Purchase Model

Variable Name	Variable Units	Variable Type	Description
INTERCPT	1.00		
PAYBACK	years	X	Years for installation payback given by (cost - rebate) / savings
AWARE	0,1	X	Aware of the Lighting Program
ADDCOOL	0,1	Y	Added cooling equipment since 1/93
ADDHEAT	0,1	Y	Added heating equipment since 1/93
ARCOOL	0,1	Y	Added and removed cooling equipment since 1/93
ARHEAT	0,1	Y	Added and removed heating equipment since 1/93
COLLEGE	0,1	Z	College
COMMSERV	0,1	Z	Community service building
SIZE	Square feet	Y	Size of facility
AVGUSE	Kwh	Y	Average monthly electric use over 1992-1994
ELECHEAT	0,1	Y	Customer has electric heat
GASHEAT	0,1	Y	Customer has gas heat
GROCERY	0,1	Z	Grocery
HEALTH	0,1	Z	Health
HEAT95	0,1	Y	Heating equipment change occured in 1995 or later
HOTEL	0,1	Z	Hotel
LARGCUST	0,1	Y	Large sized customer based on electricity use
OFFICE	0,1	Z	Office Building
OTHER95	0,1	Y	Other change in energy use occured in 1995 or later
WAREHSE	0,1	Z	Warehouse
SMALCUST	0,1	Y	Small sized customer based on electricity use
RETAIL	0,1	Z	Retail
RESTRNT	0,1	Z	Restaurant

Variable definitions are given in Exhibit D-4. The explanatory variables X contain information on rebate and program awareness that capture the effect of the Lighting program. Building characteristics such as size, energy use, and changes to high energy equipment are contained in Y. Variable group Z contains variables indicating building type. The error term ε is assumed to be distributed logistic consistent with the logit model specification.

The variables AWARE and PAYBACK are specified to capture the effect of the lighting retrofit program on high-efficiency equipment purchases. For AWARE, all program participants are coded as a being aware and have a value of one. For those outside the program, customers are coded as being aware if they participated in the lighting program with a different technology, or if they indicated in the telephone survey that they were aware of the program. For those maintaining the current lighting system, 28 percent reported being aware of the program. For high-efficiency measures done outside the Lighting program, 46 percent were performed by customers aware of the Lighting program.

The rebate amount is contained in the variable PAYBACK, which is the cost of the measure minus the rebate divided by the yearly dollar savings due to the technology. The payback value reflects the number or years of savings required to equal the initial net cost of the equipment. Since the majority of the technologies have an expected life of around 16 years, the PAYBACK variable was capped at a maximum value of 16. This avoids the problem of using a payback measure that is longer than the estimated life of the equipment.[4]

D.4.4 Logit Model Estimation Results

A likelihood ratio test gives a test statistic of over 1600 with 23 degrees of freedom, which is well above the critical value at any of the conventional levels of significance. This indicates that the model has significant explanatory power. As shown in Exhibit 3, the estimated probabilities of purchasing high-efficiency equipment is high for program participants, which conforms to *a priori* expectations. Other measures of predictive power such as Somers' D and the Goodman-Kruskal Gamma test both give values above 0.8, which also indicates good predictive power of the model.

The coefficient estimates are given in Exhibit D-5. As expected, program awareness has a strong positive effect on whether to purchase high-efficiency equipment. The coefficient estimate for PAYBACK is also positive, which suggests that program participants may have higher payback periods than nonparticipants. This is not surprising since those that choose not to participate may have more stringent payback criteria. Office, retail, college, community service, and warehouses are the business types most likely to purchase high-efficiency lighting.

[4] Less than two percent had payback periods of more than 16 years. For the entire sample, the average payback period was 3.4 years.

Exhibit D-5
Logit Estimation Results

Variable Name	Coefficient Estimate	Standard Error	Significance Level
INTERCPT	-3.60	0.35	1%
PAYBACK	0.22	0.04	1%
AWARE	4.93	0.22	1%
ADDCOOL	0.45	0.32	16%
ADDHEAT	-0.06	0.43	90%
ARCOOL	0.18	0.29	53%
ARHEAT	-0.21	0.34	54%
COLLEGE	1.11	0.59	6%
COMMSERV	0.62	0.27	2%
SIZE	0.00	0.00	3%
AVGUSE	0.00	0.00	3%
ELECHEAT	-0.48	0.24	4%
GASHEAT	0.00	0.20	100%
GROCERY	-0.27	0.30	37%
HEALTH	0.44	0.30	13%
HEAT95	1.00	0.61	10%
HOTEL	-1.18	0.43	1%
LARGCUST	-0.17	0.20	39%
OFFICE	0.49	0.22	2%
OTHER95	-0.51	0.51	32%
WAREHSE	0.96	0.36	1%
SMALCUST	-0.84	0.17	1%
RETAIL	0.46	0.25	6%
RESTRNT	-0.16	0.35	64%

The estimated model parameters are used to calculate the probability of purchasing high-efficiency fluorescent lighting. With the logit model, the probability of purchasing is given by:

PURCHASE = exp (Q) / 1 + exp (Q)

where $Q = \alpha + \beta' X + \gamma Y + \vartheta' Z + \varepsilon$

The estimated probabilities for each group are given in Exhibit D-6.

Exhibit D-6
Estimated Probabilities of Purchasing High-Efficiency Fluorescent Lighting

Group	Estimated Probability: With Program	Estimated Probability: In Absence of Program
Maintain Current System	0.25	0.05
Install Standard Efficiency	0.41	0.05
High Efficiency Outside the Program	0.46	0.08
High Efficiency in the Program	0.87	0.14

As expected, Lighting program participants have a high probability of purchasing high-efficiency equipment with an estimated purchase probability of 87 percent. Conversely, those that are maintaining their current lighting system have a relatively low estimated probability of purchasing high-efficiency equipment at 25 percent.

The probability of a high-efficiency equipment purchase is estimated by removing the effect of the Lighting program from the model. This is done by setting AWARE equal to zero and setting the rebate equal to zero in the PAYBACK variable and then recalculating the purchase probability 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.

The new probabilities of a high-efficiency purchase in absence of the Lighting program are also given in Exhibit D-6. In the absence of the Lighting program, the probability of purchasing high-efficiency equipment drops from 87 percent to 14 percent. This suggests that most of those who purchased high-efficiency equipment would not have done so without the Lighting program. The Lighting program also decreases the probability that those outside the program will purchase high-efficiency equipment. For those purchasing high-efficiency outside the program, removing the program decreases the probability of a high-efficiency purchase from 46 percent to 8 percent.

D.4.5 Net-to-Gross Ratio Calculations

Given the estimated probabilities of purchasing high-efficiency equipment with and without the retrofit program, the model can be used to determine net energy savings resulting from the program. For those that participated in the Lighting program, the expected energy savings is given by:

$$\text{EXPECTED IMPACT}_W^{HEIN} = P_W^{HEIN} * \text{IMPACT}$$

where P_W^{HEIN} = Probability of a high-efficiency purchase made by a program participant with the existence of the Lighting program

IMPACT = Energy impact of the high-efficiency equipment adopted

For those who purchase high-efficiency equipment outside the Lighting program, the expected savings is calculated in the same manner:

$$\text{EXPECTED IMPACT}_W^{HEOUT} = P_W^{HEOUT} * \text{IMPACT}$$

where P_W^{HEOUT} = Probability of a high-efficiency purchase for a customer outside of the program with the existence of the Lighting program

The calculations for expected energy impacts in the absence of the program follow the same format. For program participants and those purchasing high-efficiency equipment outside the program, the expected energy savings without the program is given by:

$$\text{EXPECTED IMPACT}_{WO}^{HEIN} = P_{WO}^{HEIN} * \text{IMPACT}$$

$$\text{EXPECTED IMPACT}_{WO}^{HEOUT} = P_{WO}^{HEOUT} * \text{IMPACT}$$

where P_{WO}^{HEIN} = Probability of a high-efficiency purchase made by a program participant without the Lighting program

P_{WO}^{HEOUT} = Probability of a high-efficiency purchase for a customer outside of the program without the Lighting program

D.4.6 Net -to-Gross Ratio

The expected savings for both groups of high-efficiency purchasers with and without the Lighting program is used to calculate the net energy savings due to the Lighting program as well as a net-to-gross ratio. The expected energy savings are given for each group in Exhibit D-7. To calculate the net-to-gross ratio, the net energy savings for each group is weighted up to the population. For program participants, the weight reflects the total energy impact from fluorescent lighting due to the retrofit program represented in the sample. For those that did high-efficiency outside the program but also participated in the Lighting program in some other fashion, the weight assigned is the same assigned to the program participants. If the customer purchased high-efficiency equipment outside the program and did not participate in the lighting program in any way, the weight assigned reflects the number of similar customers in the non-participant population.

Exhibit D-7
Estimated Energy Impacts and Net-to-Gross Ratios

	Annual GWh		
Group	**With Program**	**In Absence of Program**	**Net Impact**
Maintain Current System	777.49	141.71	635.78
Install Standard Efficiency	55.12	6.03	49.09
High Efficiency in the Program	85.17	8.27	76.9
High Efficiency Outside the Program	15.26	3.05	12.21

Estimated Net-To-Gross Ratio	
Program Participants Only	0.9
With Nonparticipation Spillover	1.05

To calculate the net-to-gross ratio, the net savings is divided by the expected energy savings with the program. For program participants the net-to-gross ratio (NTG) is:

$$NTG^{HEIN} = (EXPECTED\ IMPACT_{W}^{HEIN} - EXPECTED\ IMPACT_{WO}^{HEIN}) \ / \ EXPECTED\ IMPACT_{W}^{HEIN}$$

$$= (85.17 - 8.27) / 85.17$$

$$= 0.90$$

The level of free ridership among program participants is one minus the net-to-gross ratio, or 0.10. This means that 10 percent of the estimated program impact among participants would have been achieved without the Lighting program.

This method is also used to incorporate the spillover effect that the program has on those installing high-efficiency equipment outside the Lighting program. The above formula is modified to take into account the net savings for those installing high-efficiency outside the Lighting program both with and in absence of the program. The net-to-gross ratio including spillover is the sum of the net savings from those installing high-efficiency equipment both inside and outside the Lighting program, divided by the total expected savings due to the program.

$$NTG^{HEIN + HEOUT} = (NET\ IMPACT^{HEIN} + NET\ IMPACT^{HEOUT}) \ / \ EXPECTED\ IMPACT_{W}^{HEIN}$$

$$= (76.91 + 12.13) / 85.17$$

$$= 1.05$$

where $NET\ IMPACT^{HEIN} = EXPECTED\ IMPACT_{W}^{HEIN} - EXPECTED\ IMPACT_{WO}^{HEIN}$

$$NET\ IMPACT^{HEOUT} = EXPECTED\ IMPACT_{W}^{HEOUT} - EXPECTED\ IMPACT_{WO}^{HEOUT}$$

The net-to-gross ratio estimate of 1.05 can be decomposed to the 90 percent of the Lighting program impact that is expected from the program participants as well as an additional 15 percent expected from spillover from those customers installing outside the Lighting program.

D.5 Summary of Final Net-to-Gross Adjustments

The final net-to-gross ratios applied to the ex post gross impacts are derived from a combination of both methods described above. For the fluorescent technologies (efficient ballasts, T8 lamps and electronic ballasts, and optical reflectors with fluorescent delamping) the results of the logit model are applied. This includes an adjustment for free ridership and spillover. It is important to also note that the adjustment for free ridership is almost identical for both the logit model results and the self report results.

For the remaining technologies, since no logit model was estimated, the self report results are applied. This should be considered a very consevative approach because no spillover is included in the net-to-gross adjustment for these segments.

Exhibit D-8 below summarizes the final net-to-gross adjustments that were applied to the ex post gross impacts as described in *Section 4*. Because the net-to-gross adjustments are estimated at the technology level, the totals presented in Exhibit D-8 are weighted by the ex post gross energy impacts. The totals will differ slightly when weighted by demand and therm, which are presented in the executive summary in Exhibits 1-3 and 1-4.

Exhibit D-8
Summary of Final Net-to-Gross Adjustments

Program and Technology Group / Business Type	NTG Adjustment		
	Free Ridership (1-FR)	Spillover	NTG Ratio
Retrofit Express Program			
Compact Fluorescent	0.88	0.00	0.88
Incandescent to Fluorescent	1.00	0.00	1.00
Efficient Ballast	0.90	0.14	1.05
T8 Lamps and Electronic Ballasts	0.90	0.14	1.05
Optical Reflectors w/ Fluor. Delamp	0.90	0.14	1.05
High Intensity Discharge	0.73	0.00	0.73
Halogen	0.65	0.00	0.65
Exit Signs	0.93	0.00	0.93
Controls	0.96	0.00	0.96
Retrofit Express Total*	0.88	0.10	0.98
Customized Incentives Program			
Compact Fluorescent	0.78	0.00	0.78
Standard Fluorescent	0.78	0.00	0.78
High Intensity Discharge	0.78	0.00	0.78
Halogen	0.78	0.00	0.78
Exit Signs	0.78	0.00	0.78
Controls	0.78	0.00	0.78
Other	0.78	0.00	0.78
Customized Incentives Total*	0.78	0.00	0.78
Total*	0.88	0.09	0.97

*** Weighted by ex post gross kWh.**

Appendix E
Results Tables

Commercial Indoor Lighting Ex Ante Gross Energy Impacts
By Business Type and Technology Group

Business Type / Program and Technology Group	MDSS Gross Energy Impacts (kWh)												
	Office	Retail	College/Univ	School	Grocery	Restaurant	Health Care	Hotel/Motel	Warehouse	Personal Service	Community Service	Misc.	Total
Retrofit Express Program													
Compact Fluorescent	1,505,151	570,340	506,204	712,162	281,519	645,788	1,075,604	5,165,604	145,864	80,248	1,209,652	281,344	12,179,480
Incandescent to Fluorescent	109,249	5,640	17,640	156,744	----	32,256	35,520	312,048	27,360	-----	161,792	388,576	1,246,825
Efficient Ballast	135,815	327,666	13,919	96,360	203,742	6,734	14,820	608	61,908	3,800	85,060	9,500	959,932
T8 Lamps and Electronic Ballasts	21,640,423	11,475,110	2,074,542	7,896,491	6,698,055	933,439	3,571,552	948,930	2,063,964	1,693,960	5,045,606	1,598,998	65,641,070
Optical Reflectors w/ Fluor. Delamp	16,165,837	4,452,936	821,962	2,954,207	1,732,836	896,551	2,049,304	314,632	1,200,560	694,144	1,743,200	503,584	33,529,753
High Intensity Discharge	2,621,626	2,459,374	441,224	690,986	308,952	43,656	2,480	7,616	4,067,148	569,356	1,775,156	3,330,924	16,318,498
Halogen	150,768	164,364	76,410	49,860	2,280	52,320	14,370	118,830	34,680	16,560	105,960	42,900	829,302
Exit Signs	1,131,436	66,458	159,246	376,833	22,027	71,548	225,184	44,001	54,680	27,843	305,664	37,974	2,522,894
Controls	2,104,752	101,168	136,876	1,052,234	11,104	14,249	531,029	141,165	173,742	88,176	433,049	54,496	4,842,039
Retrofit Express Total	45,565,056	19,623,056	4,248,024	13,985,877	9,260,515	2,696,541	7,519,863	7,053,434	7,829,906	3,174,087	10,865,139	6,248,296	138,069,793
Customized Incentives Program													
Compact Fluorescent	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Standard Fluorescent	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
High Intensity Discharge	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Halogen	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Exit Signs	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Controls	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Other	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Customized Incentives Total	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	10,772,306
Total	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	148,842,099

Commercial Indoor Lighting Ex Ante Net Energy Impacts
By Business Type and Technology Group

Business Type / Program and Technology Group	MDSS Net Energy Impacts (kWh)												
	Office	Retail	College/Univ	School	Grocery	Restaurant	Health Care	Hotel/Motel	Warehouse	Personal Service	Community Service	Misc.	Total
Retrofit Express Program													
Compact Fluorescent	1,158,966	439,162	389,777	548,365	216,770	497,257	828,215	3,977,515	112,315	61,791	931,432	216,635	9,378,199
Incandescent to Fluorescent	84,122	4,343	13,583	120,693	----	24,837	27,350	240,277	21,067	----	124,580	299,204	960,055
Efficient Ballast	104,578	252,303	10,718	74,197	156,881	5,185	11,411	468	47,669	2,926	65,496	7,315	739,148
T8 Lamps and Electronic Ballasts	16,663,125	8,835,834	1,597,398	6,080,298	5,157,502	718,748	2,750,095	730,676	1,589,252	1,304,349	3,885,117	1,231,228	50,543,623
Optical Reflectors w/ Fluor. Delamp	12,447,694	3,428,761	632,911	2,274,739	1,334,284	690,344	1,577,964	242,267	924,431	534,491	1,342,264	387,760	25,817,909
High Intensity Discharge	2,018,652	1,893,718	339,742	532,059	237,893	33,615	1,910	5,864	3,131,704	438,404	1,366,870	2,564,811	12,565,243
Halogen	116,091	126,560	58,836	38,392	1,756	40,286	11,065	91,499	26,704	12,751	81,589	33,033	638,563
Exit Signs	871,206	51,173	122,619	290,161	16,961	55,092	173,392	33,881	42,104	21,439	235,361	29,240	1,942,628
Controls	1,620,659	77,899	105,395	810,220	8,550	10,972	408,892	108,697	133,782	67,896	333,447	41,962	3,728,370
Retrofit Express Total	35,085,092	15,109,753	3,270,978	10,769,125	7,130,596	2,076,337	5,790,294	5,431,144	6,029,028	2,444,047	8,366,156	4,811,188	106,313,738
Customized Incentives Program													
Compact Fluorescent	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Standard Fluorescent	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
High Intensity Discharge	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Halogen	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Exit Signs	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Controls	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Other	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Customized Incentives Total	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	8,079,230
Total	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	114,392,967

Commercial Indoor Lighting Unadjusted Engineering Energy Impacts
By Business Type and Technology Group

Business Type / Program and Technology Group	First Year Gross Unadjusted Energy Impacts (kWh)												
	Office	Retail	College/Univ	School	Grocery	Restaurant	Health Care	Hotel/Motel	Warehouse	Personal Service	Community Service	Misc.	Total
Retrofit Express Program													
Compact Fluorescent	1,941,996	689,063	560,893	812,133	251,617	500,698	942,977	7,455,882	120,065	73,391	641,125	280,505	14,270,345
Incandescent to Fluorescent	142,745	6,214	22,271	180,624	—	35,114	38,418	517,501	26,271	—	130,679	386,717	1,486,551
Efficient Ballast	151,271	370,661	14,983	86,843	146,001	6,983	15,236	960	58,548	3,152	57,911	9,943	922,493
T8 Lamps and Electronic Ballasts	27,950,796	12,422,596	2,546,318	8,940,403	4,908,670	965,783	3,832,424	1,375,691	1,869,938	1,713,943	3,751,103	1,686,712	71,964,376
Optical Reflectors w/ Fluor. Delamp	21,268,655	4,904,187	1,035,712	3,410,862	1,313,097	938,873	2,231,728	525,179	1,165,240	729,795	1,336,000	543,001	39,402,328
High Intensity Discharge	3,390,777	2,793,509	354,745	815,217	269,599	56,144	3,030	12,819	4,306,110	593,760	1,513,614	3,721,021	17,830,345
Halogen	278,643	575,946	157,593	43,381	12,275	202,313	33,582	405,919	62,181	32,818	184,463	85,943	2,075,058
Exit Signs	1,250,199	73,830	159,322	402,648	24,774	79,697	246,419	47,363	55,856	28,130	342,095	39,311	2,749,645
Controls	2,348,686	113,504	141,322	1,135,446	12,610	16,030	586,855	153,453	179,244	89,970	483,968	56,968	5,318,055
Retrofit Express Total	58,723,768	21,949,510	4,993,159	15,827,557	6,938,643	2,801,636	7,930,668	10,494,765	7,843,452	3,264,959	8,440,957	6,810,121	156,019,197
Customized Incentives Program													
Compact Fluorescent	73,125	—	—	—	11,819	—	—	—	—	—	—	—	84,944
Standard Fluorescent	753,641	—	—	—	2,111,203	—	—	—	467,493	—	—	—	3,332,338
High Intensity Discharge	—	21,437	90,482	—	354,102	—	—	—	537,336	—	64,803	—	1,068,161
Halogen	2,692	—	—	—	—	—	—	—	—	—	—	—	2,692
Exit Signs	8,729	—	—	—	—	—	—	—	—	—	—	—	8,729
Controls	531,948	—	—	—	3,898,176	—	—	—	56,313	—	162,158	—	4,648,595
Other	—	—	—	—	421,726	—	—	—	223,183	—	440,525	11,506	1,096,940
Customized Incentives Total	1,370,137	21,437	90,482	0	6,797,026	0	0	0	1,284,325	0	667,486	11,506	10,242,399
Total	60,093,905	21,970,948	5,083,641	15,827,557	13,735,669	2,801,636	7,930,668	10,494,765	9,127,777	3,264,959	9,108,444	6,821,627	166,261,596

Commercial Indoor Lighting Gross Energy Impact SAE Coefficients By Business Type and Technology Group

Business Type / Program and Technology Group	SAE Coefficients												
	Office	Retail	College/Univ	School	Grocery	Restaurant	Health Care	Hotel/Motel	Warehouse	Personal Service	Community Service	Misc.	Total
Retrofit Express Program													
Compact Fluorescent	1.00	0.68	0.68	0.68	0.68	0.68	0.68	0.68	0.68	0.68	0.68	0.68	[redacted]
Incandescent to Fluorescent	1.00	0.68	0.68	0.68	0.68	0.68	0.68	0.68	0.68	0.68	0.68	0.68	[redacted]
Efficient Ballast	1.00	0.68	0.68	0.68	0.68	0.68	0.68	0.68	0.68	0.68	0.68	0.68	[redacted]
T8 Lamps and Electronic Ballasts	1.00	0.68	0.68	0.68	0.68	0.68	0.68	0.68	0.68	0.68	0.68	0.68	[redacted]
Optical Reflectors w/ Fluor. Delamp	1.00	0.68	0.68	0.68	0.68	0.68	0.68	0.68	0.68	0.68	0.68	0.68	[redacted]
High Intensity Discharge	1.26	1.26	1.26	0.00	1.26	1.26	1.26	1.26	0.00	1.26	1.26	1.26	[redacted]
Halogen	1.26	1.26	1.26	1.26	1.26	1.26	1.26	1.26	1.26	1.26	1.26	1.26	[redacted]
Exit Signs	1.26	1.26	1.26	1.26	1.26	1.26	1.26	1.26	1.26	1.26	1.26	1.26	[redacted]
Controls	1.38	1.38	1.38	1.38	1.38	1.38	1.38	1.38	1.38	1.38	1.38	1.38	[redacted]
Retrofit Express Total	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Customized Incentives Program													
Compact Fluorescent	0.51	0.51	0.51	0.51	0.51	0.51	0.51	0.51	0.51	0.51	0.51	0.51	[redacted]
Standard Fluorescent	0.51	0.51	0.51	0.51	0.51	0.51	0.51	0.51	0.51	0.51	0.51	0.51	[redacted]
High Intensity Discharge	0.51	0.51	0.51	0.51	0.51	0.51	0.51	0.51	0.51	0.51	0.51	0.51	[redacted]
Halogen	0.51	0.51	0.51	0.51	0.51	0.51	0.51	0.51	0.51	0.51	0.51	0.51	[redacted]
Exit Signs	0.51	0.51	0.51	0.51	0.51	0.51	0.51	0.51	0.51	0.51	0.51	0.51	[redacted]
Controls	0.51	0.51	0.51	0.51	0.51	0.51	0.51	0.51	0.51	0.51	0.51	0.51	[redacted]
Other	0.51	0.51	0.51	0.51	0.51	0.51	0.51	0.51	0.51	0.51	0.51	0.51	[redacted]
Customized Incentives Total	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Total	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]

Commercial Indoor Lighting Ex Post Gross Energy Impacts
By Business Type and Technology Group

Program and Technology Group \ Business Type	First Year Cross Energy Impacts (kWh)												
	Office	Retail	College/Univ	School	Grocery	Restaurant	Health Care	Hotel/Motel	Warehouse	Personal Service	Community Service	Misc.	Total
Retrofit Express Program													
Compact Fluorescent	1,939,701	466,620	379,826	549,961	170,390	339,063	638,566	5,048,981	81,305	49,699	434,158	189,953	10,288,224
Incandescent to Fluorescent	142,576	4,208	15,081	122,315	----	23,779	26,016	350,442	17,790	---	88,493	261,877	1,052,576
Efficient Ballast	151,093	251,004	10,146	58,809	98,869	4,729	10,318	650	39,648	2,134	39,216	6,733	673,349
T8 Lamps and Electronic Ballasts	27,917,758	8,412,346	1,724,318	6,054,271	3,324,058	654,010	2,595,244	931,592	1,266,286	1,160,649	2,540,175	1,142,209	57,722,919
Optical Reflectors w/ Fluor. Delamp	21,243,516	3,321,022	701,364	2,309,771	889,205	635,787	1,511,284	355,641	789,078	494,203	904,714	367,710	33,523,294
High Intensity Discharge	4,287,990	3,532,683	448,612	0	340,936	71,000	3,832	16,211	0	750,871	1,914,122	4,705,618	16,071,876
Halogen	352,373	728,344	199,293	54,860	15,523	255,846	42,468	513,326	78,634	41,502	233,272	108,684	2,624,127
Exit Signs	1,581,007	93,366	201,480	509,190	31,329	100,786	311,622	59,896	70,636	35,574	432,615	49,713	3,477,212
Controls	3,235,982	156,384	194,711	1,564,399	17,374	22,085	808,560	211,425	246,960	123,959	666,804	78,490	7,327,131
Retrofit Express Total	60,851,995	16,965,978	3,874,832	11,223,576	4,887,683	2,107,085	5,947,909	7,488,163	2,590,338	2,658,592	7,253,569	6,910,988	132,760,708
Customized Incentives Program													
Compact Fluorescent	37,452	----	---	----	6,053	---	----	----	---	---	----	----	43,505
Standard Fluorescent	385,988	----	---	----	1,081,282	----	----	---	239,433	----	----	---	1,706,703
High Intensity Discharge	---	10,980	46,342	---	181,358	----	---	---	275,204	---	33,190	----	547,074
Halogen	1,379	---	----	---	----	----	---	---	---	---	---	----	1,379
Exit Signs	4,471	---	---	---	---	----	---	---	----	---	----	----	4,471
Controls	272,445	----	----	---	1,996,505	---	----	----	28,841	---	83,051	---	2,380,843
Other	----	----	----	---	215,993	----	---	---	114,306	---	225,621	5,893	561,813
Customized Incentives Total	701,735	10,980	46,342	0	3,481,192	0	0	0	657,785	0	341,862	5,893	5,245,788
Total	61,553,729	16,976,958	3,921,174	11,223,576	8,368,875	2,107,085	5,947,909	7,488,163	3,248,123	2,658,592	7,595,432	6,916,880	138,006,496

Commercial Indoor Lighting Net-to-Gross Adjustments
By Business Type and Technology Group

Business Type / Program and Technology Group	Net-to-Gross Adjustments												
	Office	Retail	College/Univ	School	Grocery	Restaurant	Health Care	Hotel/Motel	Warehouse	Personal Service	Community Service	Misc.	Total
Retrofit Express Program													
Compact Fluorescent	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	[redacted]
Incandescent to Fluorescent	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	[redacted]
Efficient Ballast	1.05	1.05	1.05	1.05	1.05	1.05	1.05	1.05	1.05	1.05	1.05	1.05	[redacted]
T8 Lamps and Electronic Ballasts	1.05	1.05	1.05	1.05	1.05	1.05	1.05	1.05	1.05	1.05	1.05	1.05	[redacted]
Optical Reflectors w/ Fluor. Delamp	1.05	1.05	1.05	1.05	1.05	1.05	1.05	1.05	1.05	1.05	1.05	1.05	[redacted]
High Intensity Discharge	0.73	0.73	0.73	0.73	0.73	0.73	0.73	0.73	0.73	0.73	0.73	0.73	[redacted]
Halogen	0.65	0.65	0.65	0.65	0.65	0.65	0.65	0.65	0.65	0.65	0.65	0.65	[redacted]
Exit Signs	0.93	0.93	0.93	0.93	0.93	0.93	0.93	0.93	0.93	0.93	0.93	0.93	[redacted]
Controls	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	[redacted]
Retrofit Express Total	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Customized Incentives Program													
Compact Fluorescent	0.78	0.78	0.78	0.78	0.78	0.78	0.78	0.78	0.78	0.78	0.78	0.78	[redacted]
Standard Fluorescent	0.78	0.78	0.78	0.78	0.78	0.78	0.78	0.78	0.78	0.78	0.78	0.78	[redacted]
High Intensity Discharge	0.78	0.78	0.78	0.78	0.78	0.78	0.78	0.78	0.78	0.78	0.78	0.78	[redacted]
Halogen	0.78	0.78	0.78	0.78	0.78	0.78	0.78	0.78	0.78	0.78	0.78	0.78	[redacted]
Exit Signs	0.78	0.78	0.78	0.78	0.78	0.78	0.78	0.78	0.78	0.78	0.78	0.78	[redacted]
Controls	0.78	0.78	0.78	0.78	0.78	0.78	0.78	0.78	0.78	0.78	0.78	0.78	[redacted]
Other	0.78	0.78	0.78	0.78	0.78	0.78	0.78	0.78	0.78	0.78	0.78	0.78	[redacted]
Customized Incentives Total	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Total	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]

Commercial Indoor Lighting Ex Post Net Energy Impacts
By Business Type and Technology Group

Business Type / Program and Technology Group	First Year Net Energy Impacts (kWh)												
	Office	Retail	College/Univ	School	Grocery	Restaurant	Health Care	Hotel/Motel	Warehouse	Personal Service	Community Service	Misc.	Total
Retrofit Express Program													
Compact Fluorescent	1,699,178	408,760	332,728	481,766	149,262	297,020	559,384	4,422,908	71,224	43,536	380,322	166,398	9,012,484
Incandescent to Fluorescent	142,576	4,208	15,081	122,315	----	23,779	26,016	350,442	17,790	----	88,493	261,877	1,052,576
Efficient Ballast	157,953	262,402	10,607	61,479	103,359	4,944	10,786	679	41,448	2,231	40,997	7,039	703,924
T8 Lamps and Electronic Ballasts	29,185,433	8,794,329	1,802,615	6,329,181	3,474,995	683,707	2,713,088	973,893	1,323,785	1,213,352	2,655,518	1,194,074	60,343,971
Optical Reflectors w/ Fluor. Delamp	22,208,130	3,471,821	733,212	2,414,652	929,581	664,656	1,579,907	371,790	824,908	516,644	945,794	384,407	35,045,503
High Intensity Discharge	3,138,809	2,585,924	328,384	0	249,565	51,972	2,805	11,866	0	549,638	1,401,137	3,444,513	11,764,613
Halogen	228,690	472,695	129,341	35,604	10,074	166,044	27,562	333,149	51,034	26,935	151,394	70,536	1,703,058
Exit Signs	1,462,431	86,364	186,369	471,001	28,979	93,227	288,250	55,403	65,339	32,906	400,169	45,984	3,216,421
Controls	3,113,014	150,441	187,312	1,504,952	16,714	21,246	777,834	203,391	237,576	119,248	641,465	75,507	7,048,700
Retrofit Express Total	61,336,215	16,236,945	3,725,648	11,420,949	4,962,529	2,006,594	5,985,632	6,723,521	2,633,103	2,504,489	6,705,290	5,650,336	129,891,251
Customized Incentives Program													
Compact Fluorescent	29,325	----	----	----	4,740	----	----	----	----	----	----	----	34,065
Standard Fluorescent	302,228	----	----	----	846,644	----	----	----	187,476	----	----	----	1,336,349
High Intensity Discharge	----	8,597	36,286	----	142,004	----	----	----	215,485	----	25,988	----	428,359
Halogen	1,080	----	----	----	----	----	----	----	----	----	----	----	1,080
Exit Signs	3,501	----	----	----	----	----	----	----	----	----	----	----	3,501
Controls	213,324	----	----	----	1,563,264	----	----	----	22,583	----	65,029	----	1,864,200
Other	----	----	----	----	169,122	----	----	----	89,502	----	176,661	4,614	439,900
Customized Incentives Total	549,458	8,597	36,286	0	2,725,773	0	0	0	515,046	0	267,678	4,614	4,107,452
Total	61,885,674	16,245,541	3,761,934	11,420,949	7,688,302	2,006,594	5,985,632	6,723,521	3,148,148	2,504,489	6,972,969	5,654,950	133,998,703

Commercial Indoor Lighting Gross Energy Impact Realization Rates
By Business Type and Technology Group

Business Type / Program and Technology Group	Gross Energy Impact Realization Rates												
	Office	Retail	College/Univ	School	Grocery	Restaurant	Health Care	Hotel/Motel	Warehouse	Personal Service	Community Service	Misc.	Total
Retrofit Express Program													
Compact Fluorescent	1.29	0.82	0.75	0.77	0.61	0.53	0.59	0.98	0.56	0.62	0.36	0.68	0.84
Incandescent to Fluorescent	1.31	0.75	0.85	0.78	-----	0.74	0.73	1.12	0.65	-----	0.55	0.67	0.84
Efficient Ballast	1.11	0.77	0.73	0.61	0.49	0.70	0.70	1.07	0.64	0.56	0.46	0.71	0.70
T8 Lamps and Electronic Ballasts	1.29	0.73	0.83	0.77	0.50	0.70	0.73	0.98	0.61	0.69	0.50	0.71	0.88
Optical Reflectors w/ Fluor. Delamp	1.31	0.75	0.85	0.78	0.51	0.71	0.74	1.13	0.66	0.71	0.52	0.73	1.00
High Intensity Discharge	1.64	1.44	1.02	0.00	1.10	1.63	1.55	2.13	0.00	1.32	1.08	1.41	0.98
Halogen	2.34	4.43	2.61	1.10	6.81	4.89	2.96	4.32	2.27	2.51	2.20	2.53	3.16
Exit Signs	1.40	1.40	1.27	1.35	1.42	1.41	1.38	1.36	1.29	1.28	1.42	1.31	1.38
Controls	1.54	1.55	1.42	1.49	1.56	1.55	1.52	1.50	1.42	1.41	1.54	1.44	1.51
Retrofit Express Total	1.34	0.86	0.91	0.80	0.53	0.78	0.79	1.06	0.33	0.84	0.67	1.11	0.96
Customized Incentives Program													
Compact Fluorescent	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Standard Fluorescent	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
High Intensity Discharge	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Halogen	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Exit Signs	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Controls	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Other	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Customized Incentives Total	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	0.49
Total	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	0.93

Commercial Indoor Lighting Net Energy Impact Realization Rates
By Business Type and Technology Group

Business Type / Program and Technology Group	Net Energy Impact Realization Rates												
	Office	Retail	College/Univ	School	Grocery	Restaurant	Health Care	Hotel/Motel	Warehouse	Personal Service	Community Service	Misc.	Total
Retrofit Express Program													
Compact Fluorescent	1.47	0.93	0.85	0.88	0.69	0.60	0.68	1.11	0.63	0.70	0.41	0.77	0.96
Incandescent to Fluorescent	1.69	0.97	1.11	1.01	-----	0.96	0.95	1.46	0.84	-----	0.71	0.88	1.10
Efficient Ballast	1.51	1.04	0.99	0.83	0.66	0.95	0.95	1.45	0.87	0.76	0.63	0.96	0.95
T8 Lamps and Electronic Ballasts	1.75	1.00	1.13	1.04	0.67	0.95	0.99	1.33	0.83	0.93	0.68	0.97	1.19
Optical Reflectors w/ Fluor. Delamp	1.78	1.01	1.16	1.06	0.70	0.96	1.00	1.53	0.89	0.97	0.70	0.99	1.36
High Intensity Discharge	1.55	1.37	0.97	0.00	1.05	1.55	1.47	2.02	0.00	1.25	1.03	1.34	0.94
Halogen	1.97	3.73	2.20	0.93	5.74	4.12	2.49	3.64	1.91	2.11	1.86	2.14	2.67
Exit Signs	1.68	1.69	1.52	1.62	1.71	1.69	1.66	1.64	1.55	1.53	1.70	1.57	1.66
Controls	1.92	1.93	1.78	1.86	1.95	1.94	1.90	1.87	1.78	1.76	1.92	1.80	1.89
Retrofit Express Total	1.75	1.07	1.14	1.06	0.70	0.97	1.03	1.24	0.44	1.02	0.80	1.17	1.22
Customized Incentives Program													
Compact Fluorescent	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Standard Fluorescent	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
High Intensity Discharge	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Halogen	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Exit Signs	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Controls	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Other	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Customized Incentives Total	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	0.51
Total	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	1.17

Commercial Indoor Lighting Ex Ante Gross Demand Impacts By Business Type and Technology Group*

Business Type / Program and Technology Group	MDSS Gross Demand Impacts (kW)												
	Office	Retail	College/Univ	School	Grocery	Restaurant	Health Care	Hotel/Motel	Warehouse	Personal Service	Community Service	Misc.	Total
Retrofit Express Program													
Compact Fluorescent	295	81	96	225	27	90	180	862	24	13	202	47	2,142
Incandescent to Fluorescent	22	1	3	50	-----	5	6	52	5	-----	27	65	235
Efficient Ballast	27	47	3	31	20	1	2	0	10	1	14	2	158
T8 Lamps and Electronic Ballasts	4,272	1,643	399	2,533	638	131	598	160	346	284	846	268	12,119
Optical Reflectors w/ Fluor. Delamp	3,209	635	158	943	166	125	344	53	201	117	293	85	6,329
High Intensity Discharge	516	351	84	220	30	6	0	1	681	95	297	557	2,840
Halogen	36	39	18	12	1	12	3	28	8	4	25	10	195
Exit Signs	129	8	18	43	3	8	26	5	6	3	35	4	288
Controls	519	23	33	264	2	2	130	32	38	22	102	11	1,179
Retrofit Express Total	9,024	2,828	813	4,322	885	380	1,290	1,193	1,320	539	1,841	1,049	25,486
Customized Incentives Program													
Compact Fluorescent	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Standard Fluorescent	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
High Intensity Discharge	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Halogen	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Exit Signs	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Controls	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Other	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Customized Incentives Total	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	1,168
Total	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	26,654

* Summer On-Peak demand impacts are defined for weekdays during the hour 3:00 PM - 4:00 PM, May 1 - October 31.

Commercial Indoor Lighting Ex Ante Net Demand Impacts*
By Business Type and Technology Group

Business Type / Program and Technology Group	MDSS Net Demand Impacts (kW)												
	Office	Retail	College/Univ	School	Grocery	Restaurant	Health Care	Hotel/Motel	Warehouse	Personal Service	Community Service	Misc.	Total
Retrofit Express Program													
Compact Fluorescent	227	63	74	173	21	69	138	663	19	10	155	36	1,650
Incandescent to Fluorescent	17	1	3	39	-----	3	5	40	4	-----	21	50	181
Efficient Ballast	21	36	2	24	15	1	2	0	8	0	11	1	122
T8 Lamps and Electronic Ballasts	3,289	1,265	307	1,950	492	101	461	123	267	219	651	207	9,331
Optical Reflectors w/ Fluor. Delamp	2,471	489	121	726	128	97	265	41	155	90	226	65	4,874
High Intensity Discharge	397	270	65	170	23	5	0	1	524	73	229	429	2,187
Halogen	27	30	14	9	0	9	3	22	6	3	19	8	150
Exit Signs	99	6	14	33	2	6	20	4	5	2	27	3	222
Controls	399	18	26	204	1	2	100	25	30	17	79	9	908
Retrofit Express Total	6,948	2,178	626	3,328	681	293	993	919	1,017	415	1,418	808	19,624
Customized Incentives Program													
Compact Fluorescent	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Standard Fluorescent	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
High Intensity Discharge	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Halogen	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Exit Signs	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Controls	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Other	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Customized Incentives Total	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	876
Total	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	20,501

* Summer On-Peak demand impacts are defined for weekdays during the hour 3:00 PM - 4:00 PM, May 1 - October 31.

Commercial Indoor Lighting Ex Post Gross Demand Impacts*
By Business Type and Technology Group

Business Type / Program and Technology Group	First Year Gross Demand Impacts (kW)												
	Office	Retail	College/Univ	School	Grocery	Restaurant	Health Care	Hotel/Motel	Warehouse	Personal Service	Community Service	Misc.	Total
Retrofit Express Program													
Compact Fluorescent	437	138	106	142	41	79	172	996	27	14	113	54	2,320
Incandescent to Fluorescent	32	1	4	32	-----	6	8	69	6	-----	26	88	271
Efficient Ballast	34	73	3	15	24	1	3	0	13	1	11	2	179
T8 Lamps and Electronic Ballasts	6,334	2,436	490	1,560	796	160	752	202	427	343	714	339	14,552
Optical Reflectors w/ Fluor. Delamp	4,820	968	201	595	212	156	444	70	270	141	259	109	8,244
High Intensity Discharge	781	554	69	142	44	9	1	2	999	116	298	718	3,732
Halogen	63	115	31	8	2	34	7	54	14	6	38	17	388
Exit Signs	156	9	19	49	3	10	31	6	7	3	43	5	339
Controls	292	14	17	138	2	2	73	19	21	11	61	7	655
Retrofit Express Total	12,948	4,308	938	2,679	1,124	457	1,490	1,418	1,784	635	1,563	1,338	30,682
Customized Incentives Program													
Compact Fluorescent	17	-----	-----	-----	2	-----	-----	-----	-----	-----	-----	-----	18
Standard Fluorescent	171	-----	-----	-----	348	-----	-----	-----	108	-----	-----	-----	627
High Intensity Discharge	-----	4	17	-----	58	-----	-----	-----	125	-----	13	-----	217
Halogen	1	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	1
Exit Signs	1	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	1
Controls	66	-----	-----	-----	491	-----	-----	-----	7	-----	20	-----	584
Other	-----	-----	-----	-----	53	-----	-----	-----	26	-----	55	1	136
Customized Incentives Total	255	4	17	0	952	0	0	0	266	0	88	1	1,585
Total	13,204	4,312	956	2,679	2,076	457	1,490	1,418	2,050	635	1,651	1,339	32,267

* Summer On-Peak demand impacts are defined for weekdays during the hour 3:00 PM - 4:00 PM, May 1 - October 31.

Commercial Indoor Lighting Ex Post Net Demand Impacts*
By Business Type and Technology Group

Business Type / Program and Technology Group	First Year Demand Impacts (kW)												
	Office	Retail	College/Univ	School	Grocery	Restaurant	Health Care	Hotel/Motel	Warehouse	Personal Service	Community Service	Misc.	Total
Retrofit Express Program													
Compact Fluorescent	383	121	93	124	36	69	151	873	24	12	99	47	2,032
Incandescent to Fluorescent	32	1	4	32	-----	6	8	69	6	-----	26	88	271
Efficient Ballast	36	76	3	16	25	1	3	0	14	1	11	2	187
T8 Lamps and Electronic Ballasts	6,621	2,547	512	1,630	832	168	786	212	447	359	747	354	15,213
Optical Reflectors w/ Fluor. Delamp	5,039	1,012	210	622	222	163	464	73	282	147	270	114	8,618
High Intensity Discharge	571	406	50	104	32	7	0	1	732	85	218	526	2,732
Halogen	41	75	20	5	1	22	4	35	9	4	25	11	252
Exit Signs	144	8	17	45	3	9	28	5	6	3	40	4	314
Controls	281	13	16	132	2	2	70	18	20	10	58	6	630
Retrofit Express Total	13,148	4,259	926	2,710	1,153	447	1,515	1,286	1,539	621	1,495	1,153	30,251
Customized Incentives Program													
Compact Fluorescent	13	-----	-----	-----	2	-----	-----	-----	-----	-----	-----	-----	14
Standard Fluorescent	134	-----	-----	-----	273	-----	-----	-----	85	-----	-----	-----	491
High Intensity Discharge	-----	3	14	-----	45	-----	-----	-----	98	-----	10	-----	170
Halogen	0	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	0
Exit Signs	1	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	1
Controls	52	-----	-----	-----	385	-----	-----	-----	5	-----	16	-----	458
Other	-----	-----	-----	-----	42	-----	-----	-----	20	-----	43	1	106
Customized Incentives Total	200	3	14	0	746	0	0	0	208	0	69	1	1,241
Total	13,348	4,262	939	2,710	1,898	447	1,515	1,286	1,747	621	1,564	1,154	31,492

* Summer On-Peak demand impacts are defined for weekdays during the hour 3:00 PM - 4:00 PM, May 1 - October 31.

Commercial Indoor Lighting Gross Demand Impact Realization Rates*
By Business Type and Technology Group

Business Type / Program and Technology Group	Gross Demand Impact Realization Rates												
	Office	Retail	College/Univ	School	Grocery	Restaurant	Health Care	Hotel/Motel	Warehouse	Personal Service	Community Service	Misc.	Total
Retrofit Express Program													
Compact Fluorescent	1.48	1.70	1.10	0.63	1.54	0.88	0.96	1.16	1.11	1.04	0.56	1.14	1.08
Incandescent to Fluorescent	1.50	1.51	1.26	0.63	-----	1.28	1.26	1.31	1.33	-----	0.96	1.34	1.15
Efficient Ballast	1.28	1.54	1.07	0.49	1.18	1.22	1.20	1.22	1.25	0.98	0.75	1.18	1.13
T8 Lamps and Electronic Ballasts	1.48	1.48	1.23	0.62	1.25	1.23	1.26	1.27	1.23	1.21	0.84	1.26	1.20
Optical Reflectors w/ Fluor. Delamp	1.50	1.52	1.28	0.63	1.28	1.24	1.29	1.32	1.34	1.21	0.88	1.29	1.30
High Intensity Discharge	1.51	1.58	0.82	0.65	1.49	1.49	1.47	1.34	1.47	1.22	1.00	1.29	1.31
Halogen	1.77	2.98	1.67	0.64	3.92	2.76	2.04	1.91	1.77	1.69	1.54	1.71	1.99
Exit Signs	1.20	1.20	1.04	1.13	1.24	1.22	1.20	1.17	1.05	1.04	1.23	1.07	1.18
Controls	0.56	0.61	0.50	0.52	0.98	0.86	0.56	0.59	0.54	0.48	0.60	0.60	0.56
Retrofit Express Total	1.43	1.52	1.15	0.62	1.27	1.20	1.16	1.19	1.35	1.18	0.85	1.27	1.20
Customized Incentives Program													
Compact Fluorescent	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Standard Fluorescent	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
High Intensity Discharge	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Halogen	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Exit Signs	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Controls	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Other	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Customized Incentives Total	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	1.36
Total	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	1.21

* Summer On-Peak demand impacts are defined for weekdays during the hour 3:00 PM - 4:00 PM, May 1 - October 31.

Commercial Indoor Lighting Demand Net Impact Realization Rates*
By Business Type and Technology Group

Business Type / Program and Technology Group	Commercial Sector Net RR												
	Office	Retail	College/Univ	School	Grocery	Restaurant	Health Care	Hotel/Motel	Warehouse	Personal Service	Community Service	Misc.	Total
Retrofit Express Program													
Compact Fluorescent	1.68	1.93	1.25	0.72	1.75	1.00	1.09	1.32	1.26	1.19	0.64	1.30	1.23
Incandescent to Fluorescent	1.95	1.97	1.64	0.82	-----	1.66	1.64	1.71	1.72	-----	1.25	1.75	1.50
Efficient Ballast	1.73	2.09	1.45	0.67	1.61	1.66	1.63	1.66	1.70	1.33	1.02	1.60	1.54
T8 Lamps and Electronic Ballasts	2.01	2.01	1.66	0.84	1.69	1.66	1.71	1.72	1.67	1.64	1.15	1.72	1.63
Optical Reflectors w/ Fluor. Delamp	2.04	2.07	1.73	0.86	1.74	1.69	1.75	1.79	1.82	1.64	1.20	1.76	1.77
High Intensity Discharge	1.44	1.50	0.78	0.61	1.42	1.41	1.39	1.27	1.40	1.16	0.95	1.22	1.25
Halogen	1.49	2.51	1.41	0.54	3.30	2.33	1.72	1.61	1.49	1.43	1.30	1.44	1.68
Exit Signs	1.45	1.44	1.24	1.36	1.49	1.46	1.44	1.40	1.26	1.25	1.48	1.29	1.42
Controls	0.70	0.76	0.63	0.65	1.23	1.08	0.71	0.74	0.68	0.60	0.74	0.75	0.69
Retrofit Express Total	1.89	1.96	1.48	0.81	1.69	1.53	1.53	1.40	1.51	1.50	1.05	1.43	1.54
Customized Incentives Program													
Compact Fluorescent	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Standard Fluorescent	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
High Intensity Discharge	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Halogen	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Exit Signs	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Controls	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Other	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Customized Incentives Total	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	1.42
Total	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	1.54

* Summer On-Peak demand impacts are defined for weekdays during the hour 3:00 PM - 4:00 PM, May 1 - October 31.

Commercial Indoor Lighting Ex Post Gross Therm Impacts
By Business Type and Technology Group

Business Type / Program and Technology Group	First Year Gross Impacts (Therm)												
	Office	Retail	College/Univ	School	Grocery	Restaurant	Health Care	Hotel/Motel	Warehouse	Personal Service	Community Service	Misc.	Total
Retrofit Express Program													
Compact Fluorescent	-640	-158	-54	-300	-21	-199	-146	-345	-7	-5	-180	-21	-2,075
Incandescent to Fluorescent	-47	-1	-2	-67	-----	-14	-6	-24	-2	-----	-37	-29	-230
Efficient Ballast	-50	-85	-1	-32	-12	-3	-2	0	-4	0	-16	-1	-207
T8 Lamps and Electronic Ballasts	-9,232	-2,849	-244	-3,301	-411	-383	-598	-65	-115	-114	-1,064	-127	-18,502
Optical Reflectors w/ Fluor. Delamp	-7,023	-1,126	-99	-1,260	-110	-373	-349	-24	-71	-48	-382	-41	-10,906
High Intensity Discharge	-1,130	-642	-39	-301	-23	-22	0	-1	-264	-39	-429	-279	-3,168
Halogen	-92	-132	-15	-16	-1	-80	-5	-19	-4	-2	-53	-6	-426
Exit Signs	-361	-17	-13	-127	-2	-32	-36	-2	-3	-2	-97	-3	-695
Controls	-679	-26	-12	-358	-1	-6	-85	-7	-11	-6	-137	-4	-1,331
Retrofit Express Total	-19,253	-5,037	-480	-5,761	-581	-1,112	-1,227	-486	-481	-216	-2,396	-511	-37,540
Customized Incentives Program													
Compact Fluorescent	-24	-----	-----	-----	-1	-----	-----	-----	-----	-----	-----	-----	-25
Standard Fluorescent	-249	-----	-----	-----	-177	-----	-----	-----	-29	-----	-----	-----	-454
High Intensity Discharge	-----	-5	-9	-----	-30	-----	-----	-----	-33	-----	-18	-----	-94
Halogen	-1	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-1
Exit Signs	-3	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-3
Controls	-154	-----	-----	-----	-317	-----	-----	-----	-3	-----	-46	-----	-520
Other	-----	-----	-----	-----	-34	-----	-----	-----	-14	-----	-125	-1	-174
Customized Incentives Total	-430	-5	-9	0	-559	0	0	0	-79	0	-189	-1	-1,272
Total	-19,683	-5,042	-489	-5,761	-1,140	-1,112	-1,227	-486	-559	-216	-2,586	-512	-38,812

Commercial Indoor Lighting Ex Post Net Therm Impacts
By Business Type and Technology Group

Business Type / Program and Technology Group	First Year Net Impacts (Therm)												
	Office	Retail	College/Univ	School	Grocery	Restaurant	Health Care	Hotel/Motel	Warehouse	Personal Service	Community Service	Misc.	Total
Retrofit Express Program													
Compact Fluorescent	-560	-139	-47	-263	-19	-174	-128	-302	-6	-4	-158	-18	-1,818
Incandescent to Fluorescent	-47	-1	-2	-67	-----	-14	-6	-24	-2	-----	-37	-29	-230
Efficient Ballast	-52	-89	-2	-34	-13	-3	-2	0	-4	0	-17	-1	-216
T8 Lamps and Electronic Ballasts	-9,651	-2,979	-255	-3,451	-430	-401	-625	-68	-120	-119	-1,112	-133	-19,343
Optical Reflectors w/ Fluor. Delamp	-7,342	-1,178	-104	-1,317	-115	-390	-364	-25	-75	-50	-399	-43	-11,401
High Intensity Discharge	-827	-470	-28	-220	-17	-16	0	0	-193	-29	-314	-204	-2,319
Halogen	-60	-86	-10	-10	-1	-52	-3	-12	-2	-1	-34	-4	-276
Exit Signs	-334	-15	-12	-117	-2	-30	-33	-2	-3	-2	-90	-3	-643
Controls	-653	-25	-11	-344	-1	-6	-82	-6	-10	-6	-132	-4	-1,281
Retrofit Express Total	-19,526	-4,981	-472	-5,823	-596	-1,085	-1,244	-440	-416	-211	-2,294	-439	-37,526
Customized Incentives Program													
Compact Fluorescent	-19	-----	-----	-----	-1	-----	-----	-----	-----	-----	-----	-----	-20
Standard Fluorescent	-195	-----	-----	-----	-139	-----	-----	-----	-22	-----	-----	-----	-356
High Intensity Discharge	-----	-4	-7	-----	-23	-----	-----	-----	-26	-----	-14	-----	-74
Halogen	-1	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-1
Exit Signs	-2	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-2
Controls	-120	-----	-----	-----	-248	-----	-----	-----	-3	-----	-36	-----	-407
Other	-----	-----	-----	-----	-27	-----	-----	-----	-11	-----	-98	-1	-136
Customized Incentives Total	-337	-4	-7	0	-438	0	0	0	-62	0	-148	-1	-996
Total	-19,863	-4,985	-479	-5,823	-1,034	-1,085	-1,244	-440	-477	-211	-2,443	-440	-38,522

Commercial Indoor Lighting
Mapping of Technology to PG&E's Measure Code

Business Type / Program and Technology Group	PG&E Measure Classification / Measure Code
Retrofit Express Program	
Compact Fluorescent	L2 - L4, L56 - L59, L62 - L68
Incandescent to Fluorescent	L7 & L8
Efficient Ballast	L14 - L16, L114
T8 Lamps and Electronic Ballasts	L9 - L12, L21 - L24, L69 - L75, L117 - L124, L160, L13, L112
Optical Reflectors w/ Fluor. Delamp	L17 - L20, L76 - L77
High Intensity Discharge	L25, L78 - L80, L26, L27, L37, L81
Halogen	L1, L60, L61, L173
Exit Signs	L5, L6, L110
Controls	L31 - L36, L82 - L83
Customized Incentives Program	
Compact Fluorescent	*
Standard Fluorescent	*
High Intensity Discharge	*
Halogen	*
Exit Signs	*
Controls	*
Other	*

* The MDSS does not track Customized Incentives measures by the results classification shown.

Appendix F
Summary of Gross Program Impacts by Costing Period

F. SUMMARY OF GROSS PROGRAM IMPACTS BY COSTING PERIOD

Unadjusted program gross demand and energy impacts are summarized by time-of-use (TOU) costing periods in Exhibit F-1, yielding important H-factor information in support of Pacific Gas and Electric Company's (PG&E's) cost-effectiveness calculations. The following hours were selected from the PG&E costing periods when generating demand figures:

- Summer on-peak is defined as the weekday hour 3:00 PM to 4:00 PM.
- Summer partial-peak is defined as the weekday hour 11:00 AM to noon.
- Summer off-peak is defined as the weekday hour 7:30 AM to 8:30 AM. To estimate this impact for this hour, a mean impact was generated using the hours 7:00 AM to 8:00 AM, and 8:00 AM to 9:00 AM.
- Winter partial-peak is defined as the weekday hour 5:00 PM to 6:00 PM.
- Winter off-peak is defined as the weekday hour 7:30 AM to 8:30 AM. To estimate this impact for this hour, a mean impact was generated using the hours 7:00 AM to 8:00 AM, and 8:00 AM to 9:00 AM.

The results presented in Exhibit F-1 were generated using evaluation program impact estimates for every hour in a year (8,760 hours). In general, the estimates provided are based upon only those specific hours that comprise a particular row (or costing period) in the exhibit. Whether demand or energy, the impacts presented reflect all contributing hours during that period, either as a mean or summed, respectively. The following describes in greater detail how each column in the exhibit was calculated using evaluation impact results.

Program gross unadjusted kW impacts are presented in the first column for a single specified hour of the day. In all cases, the hour specified occurs on a weekday. Each impact is the mean impact for a particular hour of the day, across all contributing days and customers. To achieve this, customer- or measure-specific mean estimates were taken across all contributing days; these intermediate mean estimates were then summed across all contributing customers and/or measures.

The second column, the kW adjustment factor, is the ratio of each program demand impact (column 1 kW savings) to the summer on-peak demand estimate.

The third column, kWh savings, is the sum of all hourly impacts during each costing period for all applicable daytypes. Note that some costing periods only contain weekdays, while others include both weekdays and weekends. The sum of all contributing rows is equal to the annual program impact.

The fourth column, kWh adjustment factor, is the ratio of each program energy impact (column 3, "kWh savings") to annual total energy savings.

Exhibit F-1
Gross Demand and Energy Savings by Costing Period
For Commercial Indoor Lighting Measures

PG&E Cost Period	Time-of-Use Impact Distribution			
	Program kW Savings Coincident with System Max in Period	kW Adjustment Factor	kWh Savings	kWh Adjustment Factor
Summer On-Peak: May 1 to Oct. 31 12:00 PM - 6:00 PM Weekdays	27,513	1.00	21,574,469	0.14
Summer Partial Peak: May 1 to Oct. 31 8:30 AM - 12:00 PM & 6:00 PM - 9:30 PM Weekdays	29,086	1.06	21,079,966	0.14
Summer Off-Peak: May to Oct. 31 9:30 PM - 8:30 AM	23,534	0.86	34,056,171	0.22
Winter Partial Peak: Nov. 1 to April 31 8:30 AM - 9:30 PM Weekdays	23,442	0.85	42,160,968	0.28
Winter Off-Peak: Nov. 1 to April 31 9:30 PM - 8:30 AM Other	24,095	0.88	33,468,126	0.22

Appendix G
Protocol Tables 6 & 7

G. PROTOCOL TABLES 6 AND 7

1995 COMMERCIAL ENERGY EFFICIENCY INCENTIVES PROGRAM EVALUATION OF LIGHTING TECHNOLOGIES

PG&E STUDY ID #324

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

Table 6 Assumptions

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

- Items 1.A, 1.B, 2.C, 3.C: The change model of estimates did not require an evaluation of base usage for these technologies.
- Item 2.B: The per-unit gross and net impacts required by the Protocols specify two terms in the denominator, square footage and hour of fixture operation. The interpretation of these terms are:
    - Square footage estimates of the lighted area were derived using survey responses for post-retrofit total facility square footage. This is the total area, not just the retrofit area.
    - Hours of fixture operation were defined using survey self-report values of weekday, Saturday, and Sunday hours of operation. Pre- and post- hours of operation were assumed to be the same for most retrofits.
- Item 2.B: The per-unit constant of 129,633,595 (Sq. Ft. 1000 hours of operation used in the denominator) was taken directly from Table E-3 of the Technical Appendix of the Annual Summary Report on Demand Side Management Programs in 1995 and 1996, revised in December 1996.
- Items 6 and 7: The number of measures reported are the purchased number in the MDSS. As such, they reflect a variety of units of measure, including lamps, fixtures, ballasts, time clocks, photocells, sensors, etc.

The Table 7 synopsis of analytical methods applied follows Items 1 through 7 of Protocol Table 6.

Protocol Table 6
Items 1-5
PG&E Lighting Study ID #324

Item Number	Table Item: Description	Estimate	Relative Precision: 90% Confidence	Relative Precision: 80% Confidence
1.A†	Pre-installation usage, Base usage, and Base usage per designated unit of measurement.	N/A	N/A	N/A
1.B†	Impact Year usage, Impact year usage per designated unit of measurement.	N/A	N/A	N/A
2.A	Gross Peak kW (Demand) Impacts	32,267	26%	21%
	Gross kWh (Energy) Impacts	138,006,496	16%	13%
	Gross thm (Therm) Impacts	-38,812	26%	21%
	Net Peak kW (Demand) Impacts	31,492	27%	21%
	Net kWh (Energy) Impacts	133,998,703	16%	13%
	Net thm (Therm) Impacts	-38,522	27%	21%
2.B	Per designated unit* Gross Demand Impacts	0.00025	26%	21%
	Per designated unit* Gross Energy Impacts	1.06	16%	13%
	Per designated unit Gross Therm Impacts	-0.00030	26%	21%
	Per designated unit* Net Demand Impacts	0.00024	27%	21%
	Per designated unit* Net Energy Impacts	1.03	16%	13%
	Per designated unit Net Therm Impacts	-0.00030	27%	21%
2.C†	Percent change in usage (relative to base usage) of the participant group and comparison group.	N/A	N/A	N/A
2.D	Gross Demand Realization Rate	1.36	26%	21%
	Gross Energy Realization Rate	0.49	16%	13%
	Gross Therm Realization Rate §	N/A	N/A	N/A
	Net Demand Realization Rate	1.42	27%	21%
	Net Energy Realization Rate	0.51	16%	13%
	Net Therm Realization Rate §	N/A	N/A	N/A
3.A	Net-to-Gross ratio based on Avg. Load Impacts	0.97	1%	1%
3.B	Net-to-Gross ratio based on Avg. Load Impacts per designated unit* of measurement.	0.97	1%	1%
3.C†	Net-to-Gross ratio based on Avg. Load Impacts as a percent change from base usage	N/A	N/A	N/A
4.A	Pre-installation Avg. (mean) Sq. Foot (participant group)	47,343	13.3%	10.4%
	Pre-installation Avg. (mean) Sq. Foot (comparison group)	25,230	25.5%	19.9%
	Pre-installation Avg. Hours of Operation¥ (participant group)	4,215	3.4%	2.6%
	Pre-installation Avg. Hours of Operation¥ (comparison group)	4,184	3.1%	2.4%
4.B	Post-installation Avg. (mean) Sq. Foot (participant group)	48,138	13.5%	10.5%
	Post-installation Avg. (mean) Sq. Foot (comparison group)	25,934	26.6%	20.7%
	Post-installation Avg. Hours of Operation¥ (participant group)	4,215	3.4%	2.6%
	Post-installation Avg. Hours of Operation¥ (comparison group)	4,184	3.1%	2.4%

† The change model estimates of impact did not require an evaluation of base usage.
* The per designated unit used Sq. Ft. 1000 hours of operation.
¥ Hours of operation are based purely upon survey self-report. It is assumed that pre- and post-retrofit operation schedules are the same for most estimates.
§ There were no Ex Ante therm calculations for this end use.

Protocol Table 6
Item 6: Lighting Measure Count Data
PG&E Study ID #324

	Number of Measures Paid in 1995		
Program and Technology Group Description	**All Participants (Item 6.B)**	**Participant Sample (Item 6.A)**	**Comparison Group (Item 6.C)**
Retrofit Express Program			
Compact Fluorescent	70,162	13,387	3,019
Incandescent to Fluorescent	1,501	692	257
Efficient Ballast	10,866	3,516	7,984
T8 Lamps and Electronic Ballasts	1,360,090	519,179	28,541
Optical Reflectors w/ Fluor. Delamp	192,007	80,369	3,464
High Intensity Discharge	7,609	2,520	439
Halogen	8,876	1,439	117
Exit Signs	9,496	2,532	189
Controls	8,936	2,910	60
Total for Retrofit Express:	**1,669,543**	**626,544**	**44,070**
Customized Incentives Program			
Other	66	19	
Total for Customized Incentives:	**66**	**19**	**0**
TOTAL:	**1,669,609**	**626,563**	**44,070**

Protocol Table 6
Item 7.A: Lighting Market Segment Data by Business Type
PG&E Study ID # 324

Business Type	Indoor Lighting # of Part.	Indoor Lighting % of Part.
Office	885	22%
Retail	726	18%
Col/Univ	42	1%
School	400	10%
Grocery	294	7%
Restaurant	260	7%
Health Care/Hospital	214	5%
Hotel/Motel	158	4%
Warehouse	208	5%
Personal Service	183	5%
Community Service	377	10%
Misc. Commercial	220	6%
TOTAL:	**3967**	**100%**

Protocol Table 6
Item 7.B: Lighting Market Segment Data by 3-Digit SIC Code
PG&E Study ID # 324

Industry (3-Digit SIC Code)	Lighting # of Part.	Lighting % of Part.
821	400	10%
652	365	9%
581	260	7%
541	228	6%
701	145	4%
866	136	3%
554	103	3%
566	90	2%
594	87	2%
753	87	2%
422	81	2%
799	65	2%
533	57	1%
650	57	1%
653	55	1%
603	51	1%
721	51	1%
633	45	1%
919	44	1%
922	43	1%
801	42	1%
802	42	1%
832	42	1%
805	41	1%
599	37	1%
602	35	1%
822	35	1%
531	34	1%
571	34	1%
737	31	1%
072	30	1%
551	30	1%
553	30	1%
593	30	1%
525	29	1%
806	29	1%
864	29	1%
508	27	1%
562	25	1%
592	24	1%
514	22	1%
836	22	1%
546	20	1%
723	20	1%
421	19	0%
431	19	0%

Protocol Table 6
Item 7.B: Lighting Market Segment Data by 3-Digit SIC Code
PG&E Study ID # 324

	Lighting	
Industry (3-Digit SIC Code)	# of Part.	% of Part.
519	18	0%
823	17	0%
871	17	0%
873	17	0%
495	16	0%
521	16	0%
641	16	0%
738	16	0%
769	16	0%
784	16	0%
074	15	0%
481	15	0%
506	15	0%
573	15	0%
809	15	0%
651	14	0%
835	14	0%
507	13	0%
804	13	0%
811	13	0%
458	12	0%
509	12	0%
913	12	0%
569	11	0%
591	11	0%
921	11	0%
542	10	0%
565	10	0%
572	10	0%
872	10	0%
473	9	0%
501	9	0%
504	9	0%
702	9	0%
733	9	0%
841	9	0%
561	8	0%
703	8	0%
807	8	0%
002	7	0%
472	7	0%
549	6	0%
735	6	0%
752	6	0%
839	6	0%
971	6	0%

Protocol Table 6
Item 7.B: Lighting Market Segment Data by 3-Digit SIC Code
PG&E Study ID # 324

	Lighting	
Industry (3-Digit SIC Code)	# of Part.	% of Part.
449	5	0%
523	5	0%
526	5	0%
539	5	0%
762	5	0%
793	5	0%
833	5	0%
962	5	0%
078	4	0%
518	4	0%
543	4	0%
560	4	0%
564	4	0%
606	4	0%
662	4	0%
704	4	0%
722	4	0%
736	4	0%
754	4	0%
824	4	0%
411	3	0%
415	3	0%
483	3	0%
498	3	0%
503	3	0%
511	3	0%
596	3	0%
655	3	0%
672	3	0%
724	3	0%
751	3	0%
781	3	0%
829	3	0%
861	3	0%
944	3	0%
951	3	0%
076	2	0%
423	2	0%
451	2	0%
484	2	0%
540	2	0%
552	2	0%
556	2	0%
631	2	0%
632	2	0%
636	2	0%

Protocol Table 6
Item 7.B: Lighting Market Segment Data
by 3-Digit SIC Code
PG&E Study ID # 324

Industry (3-Digit SIC Code)	Lighting	
	# of Part.	% of Part.
729	2	0%
731	2	0%
734	2	0%
783	2	0%
792	2	0%
808	2	0%
842	2	0%
863	2	0%
869	2	0%
941	2	0%
964	2	0%
413	1	0%
417	1	0%
493	1	0%
502	1	0%
505	1	0%
512	1	0%
516	1	0%
517	1	0%
555	1	0%
557	1	0%
559	1	0%
563	1	0%
614	1	0%
616	1	0%
621	1	0%
726	1	0%
732	1	0%
791	1	0%
794	1	0%
830	1	0%
931	1	0%
943	1	0%
953	1	0%
075	0	0%
478	0	0%
492	0	0%
544	0	0%
598	0	0%
609	0	0%
615	0	0%
725	0	0%
782	0	0%
862	0	0%
874	0	0%
TOTAL:	**3967**	**100%**

PROTOCOL TABLE 7

1995 COMMERCIAL ENERGY EFFICIENCY INCENTIVES PROGRAM EVALUATION OF LIGHTING TECHNOLOGIES PG&E STUDY ID #324

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

A. OVERVIEW INFORMATION

1. Study Title and Study ID Number

Study Title: Evaluation of PG&E's 1995 Nonresidential Enegy Efficiency Incentives (EEI) Program for Commercial Sector Lighting Technologies.

Study ID Number: 324

2. Program, Program Year and Program Description

Program: PG&E Nonresidential EEI Program, Commercial Sector.

Program Year: Rebates Received in the 1995 Calendar Year.

Program Description:

The Nonresidential EEI Program offered by PG&E has two components: the Retrofit Express (RE) Program and the Customized Incentive Program.

The RE Program offers fixed rebates to PG&E's customers that install specific gas or electric energy-efficient equipment in their facilities. The RE Program covers most common energy-saving measures: lighting, air conditioning, refrigeration/food service, and motors. To receive a rebate, the customer is required to submit proof of purchase along with the application. This Program is primarily marketed to small and medium commercial, industrial, and agricultural customers. The maximum total rebate amount of the RE Program is $300,000 per account. This includes participation in any combination of the lighting, air conditioning, refrigeration/food service, and motor program options.

The Customized Incentives Program offers financial incentives to customers who undertake large or complex projects that save gas or electricity. These customers must submit calculations for the projected first year energy savings, along with an application, prior to the start of the customers' installation of high-efficiency equipment. The maximum total incentive amount for the Customized Program is $500,000 per account. The minimum qualifying incentive amount is $2,500 per project.

3. End Uses and/or Measures Covered

End Use Covered: Indoor Lighting Technologies.

Measures Covered: For the list of RE Program measures covered in this evaluation, see *Appendix B,* Exhibit B-3. Customized Incentives Program measures generally map into related technology categories.

4. Methods and Models Used

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

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

or

= {[(Operating Impact) x (Operating Factor)] x [1+HVAC]} x (SAE Realization Rate) x (Net-to-Gross)

or

= $\{[(\Delta UOL \times U) \times (OF_t \times T)] \times [1+HVAC]\} \times$ (SAE Realization Rate) x (Net-to-Gross)

Operating impact – The technology level change in connected kW associated with a particular measure, which is defined as the load impact coincident with a specific hour, given that the equipment is operating. This approach relies on the engineering analysis to simulate operating equipment performance independent of premise size and customer behavioral factors. This term captures the per-unit difference in connected load between program installed (retrofit) high efficiency lighting measures and the existing equipment (ΔUOL), the number of units installed (U), and includes an adjustment for the probability of lamp burnout for both the retrofit and existing fixture. A detailed discussion of the operating impact calculation can be found in the *Section 3.2.1,* (under the subheading *Engineering Connected Load Estimates).*

Operating factor -- The percentage of full load (OF_t) used by a group of fixtures during a prescribed time period (T). This term reflects both the equipment's operating schedule and the percentage of lights operating (which is dependent upon whether the schedule reflects an open- or closed-period). The schedule was estimated at a high level of precision using lighting logger data in conjunction with on-site audits and telephone surveys. The open- and closed-period probability of fixture operation was estimated using both on-site audit lamp counts and lighting logger data. A detailed discussion of the operating factor approach can be found in *Section 3.2.1,* (under the subheading *Engineering Operating Schedule and Operating Factor Estimates).*

HVAC Interaction – The component of lighting impact associated with an interaction between the HVAC system and reduced internal gains. A detailed discussion of the HVAC interaction approach can be found in *Section 3.2.1,* (under the subheading *Engineering HVAC Interactive Estimates).*

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

Net-to-Gross – The net-to-gross (NTG) ratio adjusts the program baseline derived from estimates of free-ridership and spillover associated with the program. Two approaches were used to capture the NTG effect: (1) a discrete choice model used to estimate free ridership and spillover effects and (2) the NTG ratio calculation based on survey self report using a representative nonparticipant sample to account for naturally occurring conservation. The NTG analysis approach is presented in detail in *Section-3.4*.

5. Participant and Comparison Group Definition

Participant

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

Comparison Group

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

6. Analysis Sample Size

The final analysis dataset has 2,025 observations based upon 2,025 telephone survey completes (of which 614 were lighting end-use participants, and the remaining 1,411 served as a comparison group for that sample). In addition, 228 on-site audits were conducted at lighting end-use participant sites, which included the installation of lighting loggers at 108 of these sites. The distribution of the sample by business type and technology is presented in *Appendix A, Section A-3*.

B. DATABASE MANAGEMENT

1. Data Description and Flow Chart

The Evaluation of PG&E Commercial Lighting Technologies was based on a nested sample design approach (see *Section 3.1.1*). The main feature of this approach is that it consists of four groups of customers subsetted according to the availability of detailed evaluation data (within each group). The largest customer group included all of the commercial customers who received rebates for eligible lighting technologies in 1995 (the "participant population") with monthly PG&E billing data and participant tracking data. The smallest group included the participants with the most comprehensive information available -- lighting logger data, on-site audit data, telephone survey, participant tracking data, and billing data. A similar nested sample design was also implemented for the comparison group, the exception being that logger data were not collected for the comparison group. The advantage of the nested sample design was that it yielded overlapping samples which were used to compute bias in many of the intermediate engineering parameters derived.

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

2. Key Data Elements and Sources

A complete list of data elements and their sources can be found in *Section 3.1.1* and *Appendix C.* The key analysis data elements and their sources are listed below:

Program Participant Tracking System. The participant tracking system for the RE and Customized Incentives programs was maintained as part of the PG&E MDSS. It contains program application, rebate, and technical information about installed measures, including measure description, quantity, rebate amount, and ex ante demand, energy, and therm saving estimates.

PG&E Billing Data. Initially, the PG&E billing data were obtained from two PG&E data sources. The original nonresidential billing dataset contains monthly energy usage for all nonresidential accounts in PG&E's service territory, and was used in the sample design as described in *Appendix A.* The billing histories contained in this database only run through September 1995.

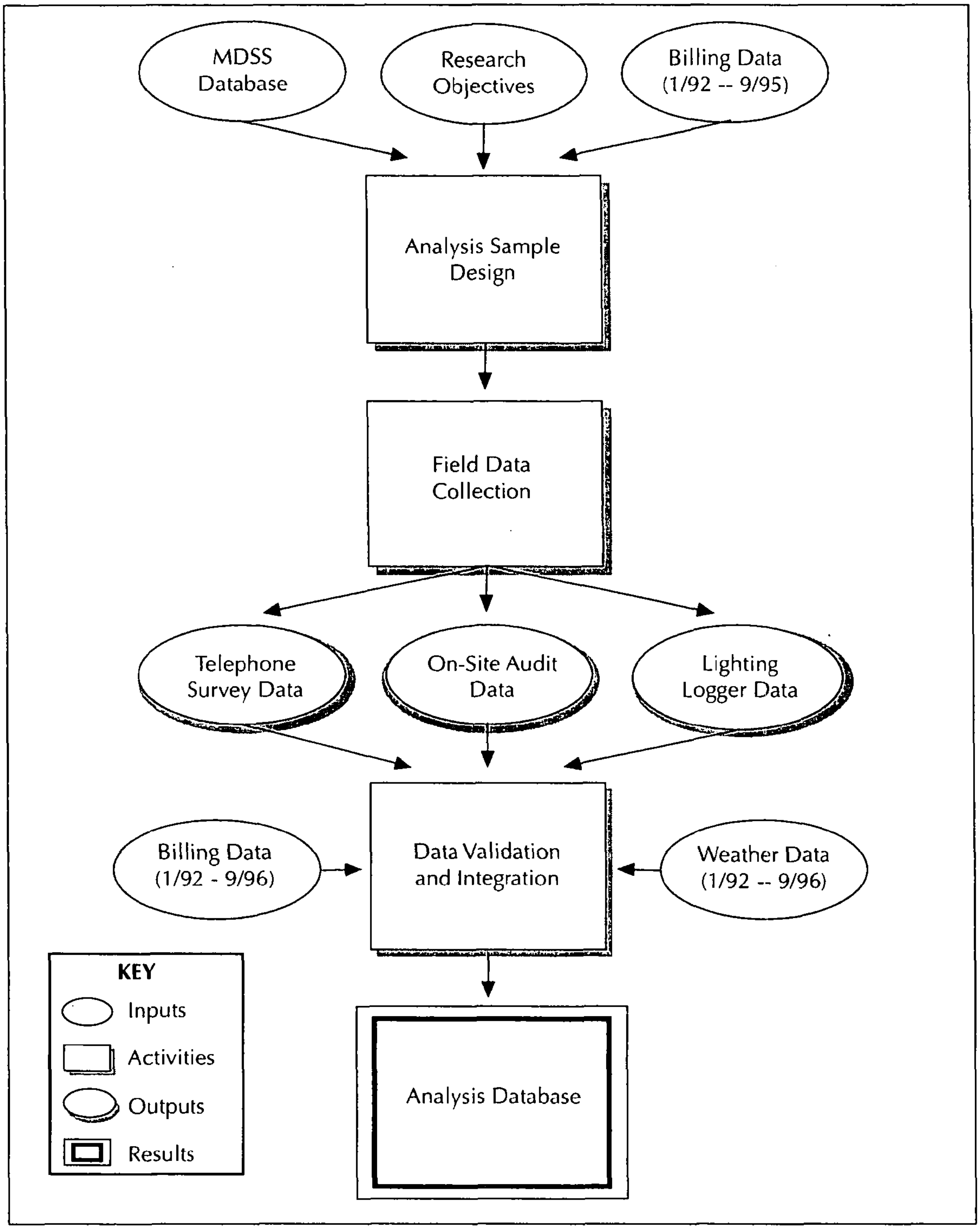
The second billing dataset, which consists only of customer accounts in the surveyed dataset, was later obtained from PG&E's Load Data Services.[1] This billing dataset contains bill readings that run through September 1996, and was therefore used in the billing regression analysis. In addition, the billing series from this database is the PG&E pro-rated monthly usage data, a series calculated by PG&E for each calendar month, from January 1992 to September 1996.

Telephone Survey Data. Two telephone survey samples (614 participants and 1,411 comparison group customers) were collected as part of this evaluation. They were designed to be representative of the population of each business type. The telephone survey supplies information on customer decision-making, equipment operating characteristics, equipment stocks, and energy-related changes at each site for the billing period covered by the statistical billing analysis.

On-Site Audit Data. On-site audit data were collected as part of this evaluation for both the participant and comparison group. The on-site audit is designed to support the telephone sample for the largest participation segments. This sample contributes site-specific equipment details, and better estimates of operating hours and operating factors. There were a total of 228 participant on-site audits conducted for this lighting end-use evaluation, and 36 nonparticipants in a comparison group sample.

[1] A preliminary analysis has concluded that the monthly usage and bill read date information in these two datasets is consistent.

Exhibit A
Analysis Database Development



Lighting Logger Data. The lighting logger data collected for the Evaluation provides operating factor profiles which were used to minimize modeling error in the engineering algorithms. The lighting logger sample was designed to best support the estimate of lighting technology and customer sectors with the highest projected impact. A total of 108 lighting loggers were installed within the sample of the 228 on-site audited lighting participant sites.

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

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

3. *Data Attrition Process*

All data elements mentioned above were first validated and then merged together to form the final analysis dataset. Records with out-of-range or questionable data were either deleted or flagged to ensure that only those records with sufficient data, both in terms of data quality and representativeness, were used in the analysis. The key data attrition decisions are summarized in *Appendix C, Section 5.*

4. *Internal Data Quality Procedures*

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

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

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

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

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

5. Unused Data Elements

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

C. SAMPLING

1. Sampling Procedures and Protocols

The sample design for the Commercial Lighting Evaluation was based upon analysis of 1995 program participation data and PG&E billing data. The goal of the sample design was to achieve the most efficient utilization of project resources in order to estimate the first-year gross and net impacts in a manner that met the sample size and evaluation accuracy requirements defined by the Protocols.

The telephone survey sample was selected based upon the stratified random sampling techniques for both participant and comparison group. The objective of stratification is to improve the overall reliability of estimates by restricting the sample to reasonably homogeneous segments, while at the same time ensuring that sufficient representation of the population is preserved. The sample segmentation is developed across two dimensions: business types and technology groups.

The customer segment is defined primarily by the business types, which were determined based upon the MDSS database (for participants), and the Second Standard Industrial Classification (SIC2) code—which represents building activity—from the billing dataset (for the comparison group). Within each business type, the annual energy consumption is used as a proxy to group customers into usage bins, and sample points are selected to reflect the underlying distribution of the participant population.

Technology segmentation is important because the use of electricity, and therefore the program impacts, varies by program measure. Therefore, by grouping together common technologies, the variation in impacts is reduced, which, in turn, results in more accurate estimates of the SAE realization rates. For example, all T12 to T8 retrofit measures are grouped together, despite the fact that some installations are new fixtures, while others are retrofits, and different measures have different levels of projected energy impacts. These factors are directly accounted for in the engineering estimates. That is, the engineering estimates account for interparticipant variation so that what is assumed is that the fraction of the expected impact is stable within a segment, rather than the level of the impact. This assumption is the basis for SAE models.

Twelve business types and nine technology groups were defined and used in the sample design and sample allocation for the RE program. For each business type and technology combination, the sample was allocated in proportion to avoided costs. The purpose of this weighting scheme is to identify which technologies and/or business types account for the greatest impact on the program's resource and shareholder values.

Given the low participation in the Customized Incentives program, all hard copy application forms were reviewed and a census was attempted for all eligible participants.

The sampling unit for both participant and comparison groups was defined as customer premise. A premise is defined as all billing accounts that correspond to the same location and customer. The final participant sample frame consists of 2,560 premises drawn from the eligible population of 5,694 program participants who were paid in 1995 from both the RE and Customized Incentives programs.

The comparison group sample frame consists of 4,153 customers drawn from the eligible population of 172,354 commercial customers that satisfied all of the screening criteria used in construction of the sample frame. In drawing the sample frame, targets are established for each business type and usage segment, so that the sample frame distribution, by business type and usage segment, is the same as that of the participant population.

The process of reduction to the eligible sample involved the elimination of customers that had 1) moved during the period of interest; or 2) had billing records with significant missing data. Customers were further screened to identify those who had high-quality data for each month, for all three years of the analysis window.

Finally, the achieved samples and their distributions can be found in *Appendix A*. Based on the total energy usage, the samples relative precision was estimated to be 4.7 percent at the 90 percent level. The procedures used in the relative precision calculation and a summary of how the Evaluation sample design meets the Protocols' requirement in terms of sample size and relative precision are presented in *Appendix A*.

2. Survey Information

Telephone survey instruments are presented in the *Survey Appendix , Section S-1* (for participants) and *Section S-2* (for comparison group customers). Participant and comparison group customer's survey response frequencies are presented in *Section S-9*. Finally, reasons for refusals are presented in *Section S-10*.

On-site audit instruments are presented in the *Survey Appendix , Section S4*.

3. Statistical Descriptions

As mentioned above, a complete set of participant and comparison group customer response frequencies are presented in *Survey Appendix S-9*. In addition, statistics on usage and engineering impact variables that were used in the billing data regression models are also presented in *Appendix C*.

D. DATA SCREENING AND ANALYSIS

A detailed discussion of the billing data regression data analysis is presented in *Appendix C*. The statistical billing model described in this section incorporates analysis for three distinct end uses, lighting, HVAC and refrigeration (for Study ID's 324, 326 and 330, respectively). Specific procedures and modeling issues are discussed below.

1. Outliers, Missing Data and Weather Adjustment

Three types of data censoring screens were applied to the billing analysis sample frame to remove customers that have invalid billing data, that may not have had their bill properly aggregated to the Site ID level, or that were extremely large users.

Invalid Usage

For customers to be included in the final billing analysis, customers had to have billing data that met the following three criteria.

The pre- and post-installation annual bills had to have been comprised of at least six non-zero monthly bills. If there were seven or more monthly bills with zero energy, the customer was removed from the analysis. If there were between one and six monthly bills with zero energy, the remaining months were prorated to an annual estimate.

The pre-installation annual bill could not be more than three times or less than one third of the post-installation bill. If this occurred, the customer was removed from the analysis.

The pre-installation annual bill could not be more than twice or less than one half the post-installation bill, unless the telephone survey responses indicated that the customer had a change at the site that may have caused an increase or decrease in usage, respectively. For example, if a customer doubled their usage and reported an increase in square footage, or an increase in employees, or an additional measure installed, the customer remained in the sample. However, if the customer reported no changes, or only changes that would indicate a decrease in usage, such as a removal of a measure, then the customer was removed from the analysis.

Appendix C presents the number of participants and nonparticipants that were deleted for each of the above criteria. Note that only 22 nonparticipants were deleted, whereas 123 participants were deleted. This is due to the fact that the nonparticipants were pre-screened to have relatively valid billing data prior to being selected into the nonparticipant survey sample frame. The participants, however, were often a census and no pre-screening was done on their billing data prior to being selected into the participant survey sample frame. Of the 123 participants, 87 were deleted due to the zero bill criteria.

Large Customers

Customers whose annual post-installation energy consumption exceeded three million kWh were excluded from the billing analysis. Customers of this size were deleted for a number of reasons. First, there were 98 participants dropped for this reason, compared to only 10 nonparticipants. This indicated that the nonparticipants would not provide a good control for this group of participants. Very large customers are more likely to participate because they are more aware of the program, since they have more contact with PG&E representatives. Therefore, it is difficult to find a sample of nonparticipants that adequately represents these customers.

Large customers installing measures that provide relatively low levels of savings are particularly problematic in billing analyses of this type. It is very difficult to detect an annual impact even as large as 10,000 kWh in a customer's bill which exceeds 10 million kWh, for example. In addition, large customers are more likely to have made changes at the site, which could significantly affect their energy usage. If the model does not adequately capture all of these changes (possibly due to the unique nature of the change, or an error in the self-reported survey responses) it is likely that the coefficient on the program *energy* impact may reflect the change. While this is true of all customers, regardless of size, it is more of a concern for larger customers because the magnitude of their changes can have significant influence over the results of the model.

Aggregation to Site ID Level

As mentioned above, one concern with aggregating to the Site ID level is that there may be control numbers associated with a different premise number, service address, or corporation number that are in the same physical site and are being affected by the installed measures. If this is the case, the billing analysis will have the effect of underestimating the impacts. Therefore, a comparison was made between the engineering energy impact and the pre- and post-installation bills to identify any customers where this problem of bill aggregation may exist.

There were 148 participants that were identified as having total Commercial Sector Program energy impacts that were either more than 50 percent of their pre-installation usage or more than 100 percent of their post-installation usage. These 148 participants were further analyzed to determine whether the impact was large relative to usage because of a problem in aggregating the bill, or if the engineering estimates were just over-estimated, in which case the customer would not be removed from the billing analysis.

Three criteria were used to determine if there was a problem with aggregating the bill for these 148 participants. If a participant failed any of these criteria, the customer was removed from the analysis on the basis that the bills were not properly aggregated and the entire impact would not be detected in an analysis of the customer's billing data.

If the customer's annual kWh per square foot was in the bottom tenth percentile of all participants, the customer was removed.

If the customer's annual kWh per employee was in the bottom tenth percentile of all participants, the customer was removed.

The first billing data pull, which consisted of every nonresidential customer in PG&E's service territory over the period of January 1992 to September 1995, was compared to the second data pull, which is being used for the billing analysis. Customer bills from the first billing data pull were aggregated to the Site ID level in the same way described above. These annual aggregated bills were compared to the aggregated bills used in the analysis. If the aggregated bills from the first data pull were more than 50 percent larger than the bills being used in the billing analysis, the customer was removed. This would indicate that either not all of the control numbers that link to a site were provided in the second data pull or, more likely, since 1995 (when the first billing data was pulled and when the customer participated) there has been customer turnover at the site, and there are now additional premise numbers that no longer link to one unique site.

As a results of these three criteria, 102 of the 148 premises were removed. Of the 102 removed customers, 45 failed the invalid usage data screening checks as well. Therefore, only 57 premises were removed solely on these data screening criteria alone.

Appendix C presents the number of participants that were removed from the analysis for each of the above criteria.

Other Censoring

In addition to all of the above censoring, three other participants were removed from the analysis for the following reasons:

One customer was removed from the analysis because the customer was noted as a "Z-Customer" in the MDSS. PG&E does not claim impacts on "Z-Coded" customers.

Another site had a retrofit performed that will affect a neighboring customer's utility bill. The refrigeration equipment (compressors and condensers) serving the participant are maintained and operated by a nonparticipant. The participant buys liquid ammonia from the nonparticipant via lines running under an adjacent road (driveway) and suction gas is returned to the nonparticipant following use. The impacts of this retrofit (which affect ice production) will be realized by the manufacturer of the liquid ammonia product, a nonparticipant. Therefore, the participating customer was removed from the analysis.

Finally, two other customers were identified as having added the rebated measure installed under the Commercial Program, causing a net increase in energy from the pre- to post-installation period. One of these customers was previously identified as being a large customer and deleted. Therefore, only one extra customer was removed.

Appendix C summarizes all of these data screening criteria and provides the pre- and post-censoring sample sizes by technology and business type.

2. Background Variables

Background variables, such as interest rates, unemployment rates and other economic factors, were not explicitly modeled in the final model. However, the effect of these factors was explicitly accounted for when a cross-sectional time series model was used with a comparison group. This is based on the assumption that the comparison group was equally impacted by the same set of background variables.

3. Data Screen Process

As explained in *Appendix C*, the final model was fitted in two steps. The first step is to estimate a baseline model to develop the relationship between the pre-installation year usage and the post-installation year usage, followed by an SAE model to estimate the SAE realization rates based on the engineering estimates of program impacts. Section 1 above describes in detail all of the data screening criteria. *Appendix C* also details the number of customers that were screened for each criteria.

4. Regression Statistics

The billing regression analysis for the lighting program uses two different multivariate regression models under an integrated framework of providing unbiased and robust model estimates in the commercial sector. The key feature of our approach is that it employs a simultaneous equation approach to account for both the year-to-year and cross-sectional variations in a manner that consistently and efficiently isolates program impacts.

A baseline model is initially estimated using only the comparison group sample. This model estimates a relationship that is then used to forecast the post-installation-year energy consumption for both participants and the comparison group, as a function of pre-installation-year usage. In this way, baseline energy usage is forecasted for participants by assuming that their usage will change, on average, in the same way that usage did for the comparison group. The outputs of the baseline model are presented in *Appendix C*.

The estimated SAE realization rates are used to adjust the engineering estimates of expected annual energy impacts for the entire participant population. The regression statistics for the final SAE model are presented in the following exhibits and a more detailed discussion can be found in *Appendix C*.

Exhibit B
Final SAE Model Output

Parameter Descriptions	Units	Parameter Estimate	t-Statistic	Sample Size
SAE Coefficients				
Lighting End Use				
Office Flourescents	kWh	-1.00	14.67	116
Other Flourescents	kWh	-0.68	7.41	261
Controls	kWh	-1.38	2.09	57
Warehouse HIDs	kWh	0.02	0.07	10
School HIDS	kWh	0.11	0.30	10
Other RE Lighting	kWh	-1.26	2.15	119
Custom Lighting	kWh	-0.51	3.07	15
HVAC End Use				
Central A/Cs	kWh	-2.07	3.67	184
ASDs	kWh	-1.90	6.75	27
Chillers	kWh	-1.58	2.39	5
EMS	kWh	-1.03	8.38	20
Other Custom HVAC	kWh	-0.65	4.76	5
Office Thermostats	kWh	0.05	1.06	36
Other RE/REO HVAC	kWh	-0.90	2.89	153
Refrigeration				
Custom Refrigeration	kWh	-0.75	2.00	3
RE/REO Refrigeration	kWh	-0.53	1.98	181
Other End Uses	kWh			
Other	kWh	-1.71	2.90	62
Change Variables	kWh			
Cooling System Replacement	(0,1)*kWh	-0.03	0.70	10
Lighting System Replacement	(0,1)*kWh	-0.08	4.17	48
Change in Employees	(±1,0)*kWh	0.01	0.64	57
Square Foot Change	± sqft	4.42	2.37	27
Heating System Replacement	(0,1)*kWh	-0.07	0.04	4
Other Equipment Change	(0,1)*kWh	0.03	1.17	42
Remove Equipment	(0,1)*kWh	0.08	0.64	2
Refrigeration Replacement	(0,1)*kWh	0.00	0.01	3
Add Equipement	(0,1)*kWh	0.11	0.49	11
Other Additions	(0,1)*kWh	0.14	12.41	375

The dependent variable is the difference between the actual and predicted 1996 usage using the 1994 baseline model.

SAE coefficients were calculated for 16 different combinations of business type and measure. Primarily those measures that have broad participation and relatively high expected impacts were supported by separate SAE coefficients. In addition, a separate SAE coefficient was calculated for other Commercial Program measures outside Lighting, HVAC, and Refrigeration.

Attempts were made to estimate the SAE coefficients at a finer level of segmentation, but generally either one of two problems were encountered. First, available sample sizes were too small to support a finer level of segmentation. Second, certain parameters were correlated with each other and needed to be combined into a single parameter (a standard econometric solution to solving the problem of colinearity). For example, it was determined that there was a high incidence of compact and standard fluorescent installations at the same site in office buildings. Therefore, there was enough correlation between the compact and fluorescent engineering estimates to warrant combining the two estimates into a single fluorescent estimate in the model.

All but three of the SAE coefficients are significant at the 95 percent confidence level (t-statistics greater than 1.96). In addition, all of the statistically significant SAE coefficients were the correct sign, and therefore were used in the calculation of the final ex post energy calculations. The three SAE coefficients that were not significant at the 95 percent confidence interval (HIDs in warehouses and schools, and thermostats in offices) were not used in the final ex post energy calculations. Because each of the insignificant SAE coefficients were also the wrong sign, they were set to zero. Therefore, no energy impacts are being claimed for these three segments.

All of the HVAC technologies are represented in the SAE billing analysis, except for REO Variable Frequency Drives (VFD), REO CAV to VAV, and Customized Incentive. Although these measures represent only ten percent of the energy impact, an approach needed to be developed for adjusting the engineering energy impact estimate for these measures.

- The REO VFD measure is very similar to those installed under the RE and Customized Incentive programs, and the engineering estimate is calculated using the same approach. Therefore, engineering energy impact estimate for the REO VFD measure was adjusted by the SAE coefficient estimated for the RE and Customized Incentive measures.

- Three approaches were considered for adjusting the engineering energy impact estimate for the REO CAV to VAV measure: (1) applying the Other RE HVAC SAE coefficient, (2) applying the Other Custom HVAC SAE coefficient, or (3) leaving the engineering estimate unadjusted. Because the REO CAV to VAV measure is usually installed in large businesses, typical of those installing Customized Incentive measures, the Other Custom HVAC SAE coefficient was used to adjust the engineering energy impact estimate for the REO CAV to VAV measure. This is also the most conservative approach since the SAE coefficient is only 0.65.

- The engineering energy impact for Chillers was estimated differently for Customized Incentive applications than for RE and REO applications, due to the different types of businesses that install these measures. Therefore, the engineering energy impact estimate for Customized Incentive Chillers was left unadjusted, which is conservative compared to the alternative approach of applying the 1.58 SAE coefficient estimated for the RE and REO applications.

The SAE coefficient of 0.65 for Other Custom HVAC measures is based on a sample size of only five sites, compared to the 43 unique sites that installed "Other" Customized Incentive HVAC measures in 1995. In addition, these five sites represent only seven percent of the total ex ante energy impact contributed by these 43 sites. Also, one third of the customers installing "Other" Customized Incentive HVAC measures have usage over 3 million kWh per year, which are not represented in the SAE analysis.

The larger customers (usage over 3 million kWh per year), however, are very well represented in the on-site audit sample, for which calibrated engineering energy impacts were estimated. Sixteen sites, which represent 53 percent of the total ex ante energy impact, were on-site audited, one of which was included in the SAE billing analysis. The ratio of the engineering energy impact estimate to the ex ante estimate is 0.79 for the on-site audit sample. This can be directly compared to the SAE coefficient, because ex ante estimates were used as the engineering energy impact estimates for the billing analysis, as mentioned above.

Three approaches were considered for estimating the ex post gross energy impact for the "Other" Customized Incentive HVAC measures:

- The SAE coefficient of 0.65 could be applied to the ex ante estimate of gross energy impact for the population.
- The 0.79 ratio of engineering energy engineering energy impact estimate to the ex ante estimate from the on-site audit sample could be applied to the ex ante estimate of gross energy impact for the population.
- The SAE coefficient of 0.65 could be applied to the ex ante estimate of gross energy impact for the population that is most similar to the SAE sample, and the 0.79 ratio of engineering energy engineering energy impact estimate to the ex ante estimate could be applied to the population most similar to the on-site audit sample.

The approach of applying the SAE coefficient to the ex ante estimate of gross energy impact for the population, which is the most conservative method, was chosen for two reasons. First, the SAE coefficient provides a statistically adjusted result that is significant at the 95 percent confidence level. Second, the 0.79 ratio based on the on-site audit is very sensitive to a few individual on-site results. For example, the ratio of the engineering to ex ante estimate is 1.51 for the site with the largest energy impact. If the engineering estimate was set equal to the ex ante estimate for this customer, the overall ratio for all on-sites would be 0.64. Conversely, if the site with the second largest energy impact, which has a ratio of 0.41, had an engineering estimate set equal to the ex ant estimate, the overall ratio would be 0.95.

The SAE coefficient of 0.75 for Customized Incentive Refrigeration measures is based on a sample size of only three sites, compared to the 53 unique sites that installed Customized Incentive Refrigeration measures in 1995. Adjusting the engineering estimates of energy impact by 0.75 for all Customized Incentive measures should be considered conservative because it is likely that a sample size of three may not be representative of the population. An alternative approach would be to adjust only those measures that are similar to the three represented in the billing analysis, and leave the remaining measures unadjusted. It was found that the ratio of the engineering energy to the ex ante gross energy estimate was 98 percent over all 53 unique sites, and 94 percent for the three sites used in the SAE analysis. Because the ratio for the SAE sample is similar to the population's ratio and because the SAE coefficient was statistically significant at the 95 percent confidence level, the conservative approach of adjusting all Customized Incentive Refrigeration measures by 0.75 was chosen.

Impact estimates from the MDSS for other end uses were included in the model for customers that installed measures outside the Lighting, HVAC, and Refrigeration end uses. Although this result is statistically significant and the correct sign, it is not recommended that this value be used because the sample may not be representative of the population of participants installing these measures.

The majority of the change variables that were included in the model were not statistically significant at the 95 percent confidence level. Most of the parameter estimates are the correct sign, and those that are not have very low t-statistics. All but one variable, was determined solely on telephone survey responses. The change variable termed "other additions" was determined by comparing the predicted estimate of post-installation usage, based on the baseline model, to the actual post-installation usage. If the predicted usage is less than the actual post-installation usage, it is likely that some change occurred at the premise that would cause the usage to increase. An analysis of these customers revealed that two thirds of them indicated through the telephone survey that some change did occur at the premise. However, almost half of these customers did not provide a date for when the change occurred. Therefore, the "other additions" variable was created in an attempt to capture other changes that would cause usage to increase, which were not explained by the other independent variables in the model.

5. Model Specification

The model specifications are presented in *Appendix C*. Specific model specification issues are further discussed below:

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

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

Self-selection. Self-selection is not treated explicitly in the billing regression analysis. The reasons for excluding such a correction is based on the following considerations: (1) the objective of the billing regression analysis is to estimate the program gross energy impacts, where self-selection bias is believed to have a limited effect on the regression result (when both cross-sectional and time series data are used), and (2) the existing self-selection correction procedures all have serious flaws in their underlying assumptions. For example, the Mills ratio approach was attempted, but resulted in serious multi-collinearity problems between the double inverse Mills ratio variable and the engineering estimates of impact.

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

Net Impact. As mentioned in the Self-selection section, a net billing model was implemented using the double inverse Mills ratio approach, but resulted in problems with multi-colinearity that were uncorrectable. Therefore, a gross billing analysis model was used and adjusted by a net-to-gross ratio using discrete choice and self report methods.

6. Measurement Errors

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

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

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

7. Autocorrelation

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

8. Heteroskdasticity

See discussion above.

9. Collinearity

See discussion above.

10. Influential Data Points

See discussion above.

11. Missing Data

See discussion above.

12. Precision

The precision calculation for the gross SAE realization rates are presented in *Section 3*. Relative precision's for net estimates were calculated using the following procedure:

- First, NTG ratios, N_i, were computed for all technology groups that were represented in the telephone survey.
- Then, the program level NTG and program level standard error for the NTG were calculated using the classic stratified sample techniques. The program level NTG was a weighted average of technology level NTG values with adjusted gross impacts per technology group providing the weights.[2] The functional relation can be best described in the following equations:

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

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

2 Technology groups with no standard errors were excluded from this calculation.

where

N = Net-to-Gross Value

i = Technology Group

w = Weight

- Then, the relative precision[3] for the program NTG value for energy was calculated and combined with the relative precision of the gross energy impact to yield an overall relative precision for the net energy impacts:

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

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

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

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

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

E. DATA INTERPRETATION AND APPLICATION

The program net-to-gross analysis was conducted based on a discrete choice analysis and on survey self-report. For a detailed NTG analysis discussion, see *Appendix D.*

Self Report Method

The self-report method used to score free-ridership uses participant responses to survey questions regarding the timing of and reasons for equipment replacement actions. The complete text of the participant surveys may be found in *Survey Appendix S-1.* Questions used for the self-report analysis are summarized in *Appendix D.*

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

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

The net-to-gross ratio using the self-report method relied only on free ridership and did not include any estimate of spillover. This conservative approach was used for all lighting technologies except for fluorescent lighting, which used the discrete choice method described below.

Discrete Choice Method

A discrete choice logit model is used to estimate both a net-to-gross ratio and the free ridership rate associated with PG&E's Commercial Lighting EEI Program (the Lighting program). The decision to purchase high-efficiency equipment is explained in the logit model by the cost and savings of the equipment, any rebate offered by the Lighting program, awareness of the Lighting program, and other customer characteristics. In this application, the high-efficiency equipment examined is fluorescent lighting.[4] Once estimated, the model can be used to determine the probability of purchasing high-efficiency equipment in the absence of the Lighting program. This is simulated by setting both the rebate and program awareness variables to zero in the logit purchase model.

The net-to-gross ratio is calculated using the probability of purchasing high-efficiency equipment both with and without the existence of the retrofit program. The expected impact with the program is the probability of choosing high-efficiency equipment multiplied by the energy impact of the equipment. Similarly, the expected energy impact in absence of the Lighting program is the probability of purchasing high-efficiency equipment without the program multiplied by the energy impact of the equipment. The net-to-gross ratio is the net savings due to the program divided by the expected energy that results from having the program. As discussed in *Appendix D*, this method is also used to determine free ridership rates and nonparticipant spillover.

[4] Other lighting technologies such as compact fluorescents and HIDs did not have enough data to estimate additional logit purchase models. However, the fluorescent lighting measures account for the majority of the lighting retrofits, over 70 percent of the energy impacts from the Lighting program.