SOUTHERN CALIFORNIA
EDISON

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1994 Commercial CFL Evaluation
First Year Impact Evaluation Report
Study ID # 561

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Southern California Edison

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FIRST YEAR LOAD IMPACT EVALUATION, FEBRUARY 1996, STUDY ID NO. 561

Designated Unit of Measurement: LOAD IMPACTS PER REBATED LAMP
ENDUSE: LIGHTING- CFLs

				5. A. 90% CONFIDENCE LEVEL				5. B. 80% CONFIDENCE LEVEL			
				LOWER BOUND	UPPER BOUND	LOWER BOUND	UPPER BOUND	LOWER BOUND	UPPER BOUND	LOWER BOUND	UPPER BOUND
1. Average Participant Group and Average Comparison Group		PART GRP	COMP GRP	PART GRP	PART GRP	COMP GRP	COMP GRP	PART GRP	PART GRP	COMP GRP	COMP GRP
A. Pre-install usage:	Pre-install kW	OPTIONAL	OPTIONAL	OPTIONAL	OPTIONAL	OPTIONAL	OPTIONAL	OPTIONAL	OPTIONAL	OPTIONAL	OPTIONAL
	Pre-install kWh	OPTIONAL	OPTIONAL	OPTIONAL	OPTIONAL	OPTIONAL	OPTIONAL	OPTIONAL	OPTIONAL	OPTIONAL	OPTIONAL
	Base kW	OPTIONAL	OPTIONAL	OPTIONAL	OPTIONAL	OPTIONAL	OPTIONAL	OPTIONAL	OPTIONAL	OPTIONAL	OPTIONAL
	Base kWh	OPTIONAL	OPTIONAL	OPTIONAL	OPTIONAL	OPTIONAL	OPTIONAL	OPTIONAL	OPTIONAL	OPTIONAL	OPTIONAL
	Base kW/ designated unit of measurement	OPTIONAL	OPTIONAL	OPTIONAL	OPTIONAL	OPTIONAL	OPTIONAL	OPTIONAL	OPTIONAL	OPTIONAL	OPTIONAL
	Base kWh/ designated unit of measurement	OPTIONAL	OPTIONAL	OPTIONAL	OPTIONAL	OPTIONAL	OPTIONAL	OPTIONAL	OPTIONAL	OPTIONAL	OPTIONAL
B. Impact year usage:	Impact Yr kW	OPTIONAL	OPTIONAL	OPTIONAL	OPTIONAL	OPTIONAL	OPTIONAL	OPTIONAL	OPTIONAL	OPTIONAL	OPTIONAL
	Impact Yr kWh	OPTIONAL	OPTIONAL	OPTIONAL	OPTIONAL	OPTIONAL	OPTIONAL	OPTIONAL	OPTIONAL	OPTIONAL	OPTIONAL
	Impact Yr kW/designated unit	OPTIONAL	OPTIONAL	OPTIONAL	OPTIONAL	OPTIONAL	OPTIONAL	OPTIONAL	OPTIONAL	OPTIONAL	OPTIONAL
	Impact Yr kWh/designated unit	OPTIONAL	OPTIONAL	OPTIONAL	OPTIONAL	OPTIONAL	OPTIONAL	OPTIONAL	OPTIONAL	OPTIONAL	OPTIONAL
2. Average Net and Gross End Use Load Impacts		AVG GROSS	AVG NET	AVG GROSS	AVG GROSS	AVG NET	AVG NET	AVG GROSS	AVG GROSS	AVG NET	AVG NET
	A. i. Load Impacts - MW	5.3	4.0	2.4	8.2	1.8	6.1	3.1	7.5	2.3	5.7
	A. ii. Load Impacts - GWH	39.8	29.9	28.52	51.1	21.4	38.3	37.6	42.0	28.2	31.5
	B. i. Load Impacts/designated unit - kW	0.0166	0.0125	0.0075	0.0255	0.0057	0.0191	0.0095	0.0235	0.0071	0.0176
	B. ii. Load Impacts/designated unit - kWh	123.9	92.9	88.8	159.1	66.6	119.3	117.0	130.9	87.7	98.2
	C. i. a. % change in usage - Part Grp - kW	OPTIONAL	OPTIONAL	OPTIONAL	OPTIONAL	OPTIONAL	OPTIONAL	OPTIONAL	OPTIONAL	OPTIONAL	OPTIONAL
	C. i. b. % change in usage - Part Grp - kWh	OPTIONAL	OPTIONAL	OPTIONAL	OPTIONAL	OPTIONAL	OPTIONAL	OPTIONAL	OPTIONAL	OPTIONAL	OPTIONAL
	C. ii. a. % change in usage - Comp Grp - kW	OPTIONAL	OPTIONAL	OPTIONAL	OPTIONAL	OPTIONAL	OPTIONAL	OPTIONAL	OPTIONAL	OPTIONAL	OPTIONAL
	C. ii. b. % change in usage - Comp Grp - kWh	OPTIONAL	OPTIONAL	OPTIONAL	OPTIONAL	OPTIONAL	OPTIONAL	OPTIONAL	OPTIONAL	OPTIONAL	OPTIONAL
D. Realization Rate:	D.A. i. Load Impacts - kW, realization rate	0.30	0.27	0.14	0.55	0.10	0.41	0.17	0.51	0.13	0.38
	D.A. ii. Load Impacts - kWh, realization rate	0.69	0.61	0.50	1.05	0.37	0.79	0.66	0.86	0.49	0.65
	D.B. i. Load Impacts/designated unit - kW, real rate	0.30	0.27	0.14	0.55	0.10	0.41	0.17	0.51	0.13	0.38
	D.B. ii. Load Impacts/designated unit - kWh, real rate	0.69	0.61	0.50	1.05	0.37	0.79	0.66	0.86	0.49	0.65
3. Net-to-Gross Ratios		RATIO		RATIO	RATIO			RATIO	RATIO		
	A. i. Average Load Impacts - kW	0.75		NA	NA			NA	NA		
	A. ii. Average Load Impacts - kWh	0.75		NA	NA			NA	NA		
	B. i. Avg Load Impacts/designated unit of measurement - kW	0.75		NA	NA			NA	NA		
	B. ii. Avg Load Impacts/designated unit of measurement - kWh	0.75		NA	NA			NA	NA		
	C. i. Avg Load Impacts based on % chg in usage in Impact year relative to Base usage in Impact year - kW	OPTIONAL		OPTIONAL	OPTIONAL			OPTIONAL	OPTIONAL		
	C. ii. Avg Load Impacts based on % chg in usage in Impact year relative to Base usage in Impact year - kWh	OPTIONAL		OPTIONAL	OPTIONAL			OPTIONAL	OPTIONAL		
4. Designated Unit Intermediate Data		PART GRP	COMP GRP	PART GRP	PART GRP	COMP GRP	COMP GRP	PART GRP	PART GRP	COMP GRP	COMP GRP
	A. Pre-install average value	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	B. Post-install average value	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
6. Measure Count Data		NUMBER	INC COST								
	A. Number of measures installed by participants in Part Group	55,413									
	B. Number of measures installed by all program participants in the 12 months of the program year	289,841									
	C. Number of measures installed by Comp Group	NA									
7. Market Segment Data											
	Number of Participants	17 manuf.									

TABLE 7: DOCUMENTATION OF PROTOCOLS FOR DATA QUALITY AND PROCESSING

A. OVERVIEW INFORMATION

1. Study Title and Study ID: Southern California Edison 1994 Commercial CFL Program Impact Evaluation. Study ID #561
2. Program, Program Year or Years, and Program Description: 1994 Commercial Compact Fluorescent Lamp Program. This program provided financial incentives directly to CFL manufacturers to sell compact fluorescent equipment in Southern California Edison territory at discounted prices. In all, approximately 320,000 units were distributed under this program.
3. End-Uses and/or Measures Covered: Compact fluorescent fixtures, lamp assemblies, and bulbs.
4. Method(s) and Model(s) Used: The methodology employed in this report consists of the use of an engineering model to compute kWh energy impacts and kW load impacts, based on product tracking, manufacturer, distributor, and end-user interviews, on-site inspections of in-use and in-stock program product, and TOU light logger metering for selected lighting segments.
5. Program Participants: Program participants included manufacturers, primary and secondary distributors, as well as product end-users who purchased discounted CFL equipment within Edison territory.
6. Analysis of Sample Size: The sample used for this study was the population of 16 participating CFL manufacturers, 151 distributors, and 617 end-user customers reported in the program tracking database. In addition, distributors were asked to identify additional end-user customers that may have not been reported in program records. 203 on-site inspections were conducted from an end-user survey population of 205 respondents. TOU light logger data was obtained for 101 lighting segments found at 26 end-user locations.

B. DATABASE MANAGEMENT

1. Flow Chart Illustrating Relationships between Data Elements: See Figure A-1, Structure of Program Participants Data
2. Specific Data Sources: Edison program tracking records, telephone books, and commercial sources for company names, addresses, and telephone numbers. Additional end-user customers identified by distributor survey respondents.
3. Data Attrition Process: See page 9 of the report.
4. Internal/Organizational Data Quality Checks and Procedures: Data entry operations were subject to visual review and double-punch verification for key identifying variables and quantities.
5. Summary of the Data Collected but Not Used: None.

C. SAMPLING

1. Sampling Procedures and Protocols: The sample consisted of all manufacturers, distributors, and end-users identified in program tracking records.
2. Survey Information: The appendix provides copies of the survey instruments for manufacturer and distributor telephone surveys as well as on-site inspection data collection forms.
3. Statistical Descriptions: Not applicable.

D. DATA SCREENING AND ANALYSIS

1. Procedures Used for Treatment of Outliers, Missing Data Points, and Weather Adjustment: Seasonal adjustments were based on an estimate of annual Los Angeles daylight hours obtained from U.S. Naval Observatory data.
2. Controlling for the Effects of Background Variables: Not applicable.
3. Procedures Used to Screen Data: Not applicable.
4. Regression Statistics: Not applicable.
5. Specification: **a.** Not applicable. **b.** Not applicable. **c.** Not applicable. **d.** Not applicable. **e.** Not applicable.
6. Error in Measuring Variables: TOU metering: Cycles that occurred on the day of installation or day of removal were excluded for purposes of analysis.
7. Autocorrelation: Not applicable.
8. Heteroskedasticity: Not applicable.
9. Collinearity: Not applicable.
10. Influential Data Points: Not applicable.
11. Missing Data: Estimates of product wattage distributions were adjusted to reflect overall program product wattage distributions. Product sale invoices with missing quantities were excluded from the installation percentage calculations. Installation rates were capped at 100 percent using the assumption that, if more bulbs were found than predicted (by invoice records), then all qualifying program product was installed.
12. Precision: Precision was calculated using propagation of error techniques for the formulas which determine energy and load savings. Energy savings have been estimated at 39.8 GWH plus or minus 11.3 GWH at the 90 percent confidence level. Load savings have been estimated at 5.3 MW plus or minus 2.9 MW at the 90 percent confidence level.

E. DATA INTERPRETATION AND APPLICATION

Because a manufacturers discount program does not produce complete end-user detail an engineering model estimation was used to estimate savings based on units that could be identified through diligent field work and tracking of program product from distributors to end-users.

REQUEST FOR RETROACTIVE WAIVER 1994 PILOT COMMERCIAL CFL PROGRAM

Southern California Edison
Request for Retroactive Waiver
1994 Pilot Commercial Compact Fluorescent Lamp Program

(Approved by CADMAC on February 21, 1996)

Program Background

In 1994 Southern California Edison implemented a Pilot Compact Fluorescent Lamp program designed to substantially increase the availability and distribution of CFL technology in the commercial sector. The program paid incentives to manufacturers of CFL bulbs who agreed to lower sales prices to distributors and direct purchase customers. In contrast to conventional DSM rebate programs, the program stimulated demand for CFLs by paying incentives to manufacturers rather than directly to the end-user. Evaluators can observe purchasers of product, but purchasers don't know they received subsidies and don't make conscious decisions to participate. No advertising campaigns accompanied the program.

Parameter

Table C-4 of the Protocols, specifying end-use consumption and load impact model and comparison group sample.

Protocol Requirements.

1. The current protocols for commercial EEI programs require the use of conditional demand analysis or calibrated engineering modeling procedures that rely on billing data analysis to determine load impacts.

2. The Protocols further require site-specific survey data be collected from a comparison group composed of individual nonparticipants to determine the extent to which measure adoption (and savings) would have occurred in the absence of the DSM program.

Waiver Alternative

1. Allow the use of a Simplified Engineering model to calculate gross energy savings. Installation rates, wattage reductions, hours of operation, and time-of-use duty cycles among participants will be verified and measured with on-site inspection surveys and light-sensitive data loggers.

2. Allow the use of (a) manufacturer sales and shipment data to reflect market activity/measure adoption in the absence of the program, or (b) base the net-to-gross value on a default assumption of .75 in the event that method (a) proves unsuccessful.

Rationale

We are requesting that a Simplified Engineering model be used to estimate the energy impacts as a function of bulbs installed, hours of operation and per unit watts per hour savings for typical bulbs installed. We believe that this method will produce gross impact estimates with higher precision than a billing analysis that attempts to search for the impact of installing relatively few measures per site in the premise billing record, where unexplained variance is likely to overwhelm the energy impact. A precedent for the adoption of this method has been established in the current residential lighting protocols (Table C-3a).

Quantifying programs designed to have widespread effects on a regional market requires a comparison market and tracking of sales trends in that market. In this situation the Protocols for Commercial EEI Programs, which call for a "*comparison group*" may not be appropriate.

As an alternative, we will attempt obtaining 1992-1995 sales trend data from participating and nonparticipating CFL manufacturers for both the Southern California and out-of-state regional markets (which have had no recent lighting programs). The difference in the growth in sales or installations between the two areas is taken as the impact of the program. Net-to-gross will also be calculated by observing differences in these trends. Similar approaches have been applied to several programs, including Wisconsin Electric's dealer-incentive lighting program (1991), BC Hydro's motor program (1993), commercial lighting programs of NYSEG (1993), and is currently being employed by the CADMAC statewide refrigerator studies subcommittee.

The proposed analysis is difficult, at best. Obtaining manufacturer cooperation for the release of sensitive information, tracking warehouse shipments to specific regional markets by selective products, and finding a comparable market to Southern California without an incentive program are all barriers to successful trend analysis. If we are unsuccessful in obtaining satisfactory trend data for these areas, we are further requesting a waiver of the Protocols for this evaluation. As an alternative, we request using the default assumption of

.75 net-to-gross ratio approved for miscellaneous incentive programs (Table C-9), or a lower ratio agreed upon by Edison and the CEC.

1994 Program Summary

Pilot Commercial Compact Fluorescent Lamp Program
1994 Preliminary Results

Measure Count	320,000
Administrative Cost	$428,000
Incentive Cost	$1,983,600
Total Program Cost	$2,412,000
Participant Cost	$4,227,000
kWh Saved	41,958,760
kW Reduced	13,208

EXECUTIVE SUMMARY

This research study performs an engineering analysis to update the first-year savings impacts for Edison's 1994 Commercial CFL Lighting Program. The evaluation tracked purchases from manufacturer to distributor to end-user customers and then evaluated installation rates, hours of operation, per unit/hour savings, coincidence of operation with system peak and considered net-to-gross ratio.

KEY FINDINGS

Impacts

- Gross energy savings are estimated at 39.8 GWH, this is 70 percent of earlier estimates.
- Load savings are estimated at 5.3 MW, which is 28 percent of earlier estimates.
- Net-to-Gross has been negotiated to be 75 percent for both outdoor bulbs (*55% of total*) according to the CPUC evaluation protocols and for the remaining indoor-use bulbs based on a CADMAC waiver. This compares to 85 percent originally used in the tracking system.
- Energy savings are lower than expected because installation rates are less than 100 percent. Hours of operation are actually somewhat higher than anticipated and watt/unit-hour savings are essentially what was expected.
- Load impacts are substantially lower because most bulbs were used in outdoor applications and those are not in operation during system peak.
- Net-to-gross is lower than expected due in-part to negotiated .75 ratio for the majority of bulbs which are used in outdoor applications.

Participants

- Distributors confirmed that the program had a upward impact on CFL sales, but indicated a general upward trend was already being experienced.
- Manufacturers indicated that demand is increasing for CFL products in the commercial sector. Results of the trend survey identify an increase in demand during the program year.

Further Research

- Market transformation programs are easier to administer, but more challenging to evaluate due to less direct tracking of the energy saving devices.
- Net-to-gross ratios can be difficult to evaluate where strong background trends are present.

1994 Commercial CFL First Year Impact Evaluation

INTRODUCTION

This research study performs a first-year impact evaluation of Southern California Edison's 1994 Commercial CFL Program. This program promoted the adoption of energy-saving compact fluorescent lamps and fixtures by supplying financial incentives to manufacturers. Manufacturers in turn agreed to sell promotional units at discounted prices only to Edison's customers. Over 320,000 bulbs and fixtures were distributed under the program.

First-year impacts are calculated by updating tracking system impact estimates using survey research and metering to determine installation rate, hours of operation, energy savings per unit and net-to-gross ratio. A simplified engineering model is used to revise gross energy savings estimates.

PROGRAM DESCRIPTION

The 1994 Commercial CFL Program was designed to achieve both energy efficiency improvements and minimize the cost of program administration per CPUC instructions. Manufacturer subsidies were chosen to transform the market via price reductions with small transaction costs for program tracking and administration. Sixteen manufacturers participated in the program, with the top 5 manufacturers accounting for 80 percent of the bulbs and fixtures. Program alternatives which would require dealing directly with numerous end-users were rejected because they would have been of limited success and very costly to administer.

The rebates averaged $6.20 per bulb on the 321,000 units distributed. Specific model rebates were based on a formula that considered bulb, ballast, and fixture. This rebate represents about 25 percent of unit cost and resulted in substantial acquisition cost savings to purchasers.

Manufacturers were allotted fixed quantities of selected bulbs eligible for promotional pricing and were required to earn the rebate over a 16 week performance period. Manufacturers were required to provide invoices showing in-period sales to distributors in Edison's service territory and were responsible for distributor's returning Tag Data forms which tracked product to end-user purchases. Manufacturers were required to label units "Special Low Price Made Possible by Southern California Edison and Manufacturer; No Further Rebates or Incentives Apply." They were also instructed to make assurances that the product would only be resold to end-users in the service territory. Unearned rebates were realloted to other manufacturers.

Manufacturers sold to qualified distributors and to large end-user customers. Distributors in-turn sold to end-users or other distributors or contractors who in turn would sell to end-users. The manufacturer invoice and freight company proof of delivery documents were required paperwork to process the rebates. Distributors and final resellers were to provide CFL Tag documents to show sale of the product to qualified end-users in the service territory. Edison tracked the posted units in its General Journal and made energy savings estimates and load impact estimates based on information about the distributed units.

RESEARCH OBJECTIVES

The goal of this study is to update overall kWh energy impacts and kW load impacts of the commercial CFL program. In accordance with CPUC evaluation protocols, the study will:

- Update tracking system estimates
- Measure installation rates in territory and the commercial sector
- Determine baseline wattage of bulbs replaced
- Estimate watts per bulb unit impacts
- Determine hours of operation
- Assess coincidence of energy savings with system peak.

EVALUATION METHODOLOGY

This evaluation used a simplified engineering model to update the first-year program impact estimates, which were originally forecasted by the program tracking system. The study gathered physical data about installation, removal, hours of use, and equipment the CFLs replaced in order to calculate energy saved and load reduction produced.

Decision Sciences analyzed the available data to create samples of distributors and end-user. Surveys were then conducted to identify additional end-user purchasers and understand distributor experiences with the program. End-users were surveyed to estimate unit installation rate in the proper business sector within the service territory. Surveys were followed with on-site inspections by engineers who evaluated bulb location, equipment replaced and rates of retention. Depending on the type of lighting controls, selected locations were metered using time of use light loggers to refine hours of operation estimates. This new information was combined with tracking system estimates to update gross program savings.

Manufacturer and distributor surveys were used to try to estimate a net-to-gross ratio for this market transformation program. Due to the nature of this market transformation

program an exemption to the Evaluation Protocol's requirement for a control group had been requested as all firms in the territory were eligible to purchase promotional units.

The following section describes available data sources, the data collection process, and the methodology used to analyze the data.

Data Sources

Program administration tracked the program using a database which had several references and data tables. For example, one data table tracked 492 manufacturers' invoices to distributors and another tracked manufacturer name and address reference information. This was the information used to administer the program, authorize rebate payments to manufacturers, and track energy and load savings. These files were made available to Decision Sciences for use in developing sampling frames for the surveys and inspections conducted for this study. The files included:

1. General Journal - Program Tracking Spreadsheet
2. Manufacturer's Reference File - contact information
3. Distributor's Reference File - contact information
4. Manufacturer to Distributor Invoice File
5. Manufacturer to Direct Customer Invoice File
6. Distributor to Customer Tag File
7. Edison Distributor Inspection Record File
8. Eligible Bulb Characteristics File
9. Testimony Workbook Exhibits

Data Collection

The data collection process included three different surveys, on-site inspections and installation and removal of time-of-use light loggers:

Survey Fieldwork
- *distributor*
- *end-user*
- *manufacturer*

On-site Inspections

On-off lighting loggers

The end-user survey and inspection was used to determine percent installed, hours of operation, actual watts saved per unit per hour and coincidence of usage with system peak. Light loggers were used to monitor hours of operation for an average period of 21 days where usage was uncertain (*e.g., in hotel rooms*). Lighting on circuits connected to timers or light sensors was typically not metered, if its operation was predictable and verified during the inspection.

Analysts decided to follow these administrative documents forward to find end-user customers for interview rather than to conduct a more general survey of the entire market. This was a market transformation program available to the entire market, but purchases were quite concentrated with a few customers who individually bought thousands of bulbs each. A general survey of Edison's 300,000 commercial customers would be an inefficient way to find many purchaser's of promotional bulbs, particularly these large customers. Survey responses would also be suspect given a simultaneous residential program which may have had a number of bulbs diverted to the nonresidential sector. Respondents would not necessarily be able to differentiate the two program sources.

The program had a mechanism to track bulbs to their final customer, the Tag Form[1]. This was to ensure that program rules were met which required bulbs eventually be sold to Edison customers. That path could be quite complicated and the Tag Forms only tracked about one-fifth of program bulbs to their destination. Some sales had four or more parties involved, for example, manufacturer sent the product to a qualified distributor who in turn

[1] The promotional bulbs were even specially labeled by the manufacturers, but the prospect of having to get permission to look for the promotional bulb labels in general customers' ceilings proved an unattractive research approach.

provided the product to a contractor or secondary distributor who sold the product to an end-user customer. Unfortunately this type of multiple distribution chain was difficult to track because not all parties completed the required forms. In fact, complaints were often received about the amount of required paperwork during the course of our distributor interviews.

Decision Sciences analyzed these files to develop a frame of end-users for the surveys and on-site inspections. Due to the fact that, customers and distributors can have multiple invoices, but only one interview can be conducted per party, the invoices were reduced to a list of unique customers. The remaining list of interview candidates included 617 customers, 151 distributors and 16 manufacturers.

Distributor surveys covered topics of program induced changes in behavior, including stocking and product recommendation patterns both during the program year and at the present time. Questions were asked about what type of trends and behaviors were either observed or anticipated now that the program has ended. These questions were designed to estimate a net-to-gross ratio and assess spillover effects. Referrals were also requested and obtained for additional end-user customers of the promotional bulbs.

No formal samples were selected as these frames were small enough that virtually everyone was contacted in order to conduct customer interviews. The Decision Sciences CATI system randomized the interviews to avoid any sample fieldwork bias in case the survey totals had been obtained prior to exhausting the candidate list.

Interviews were eventually conducted with 205 end-user customers. On-site inspections were then completed at 203 sites and 101 segments at 26 sites were monitored with light loggers. Some 212 interviews were conducted with primary and secondary distributors and 16 manufacturers were contacted, of which 9 manufacturers provided some form of sales trend data. Data were keyed either during the interview process or after the inspection forms were returned and then entered into SAS databases.

ANALYSIS METHODOLOGY

Energy Savings

First-year annual gross energy savings (watts) for these bulbs is given by the engineering relationship

*Savings = Net Bulbs * Hours * Watts Saved Per Unit*

Where net bulbs are the average number of bulbs installed throughout the year which produce savings. That is, these bulbs should not be replacements for bulbs of the same type nor net additions to the lighting stock at the site[1]. Hours of operation are annual hours in use. Watts saved per unit hour are the difference between the bulbs replaced and the bulbs installed.

The number of fixtures and lamps installed in the service territory was updated from initial tracking database counts using on-site inspection information about percent installed, type of unit replaced and failure/removal rate.

Hours of operations estimates were updated using both customer responses, metering data, and time of sunrise/sunset information. Special facilities such as schools and colleges were reviewed to make sure their seasonal operation is properly reflected in hours of operation reported. Baseline wattage data or assumptions were updated as well as confirming the CFL wattage of the bulbs replaced using inspection data.

The analysis was done at the watt category level and used tracking system totals to weight the results. This introduces some level of control into a sample that is otherwise an unknown with regard to its being representative or not. These watt categories also tend to control for the type of lighting application and its location.

Load Savings

Load savings at the system peak are given by the formula:

*Load Impacts = Net Bulbs * Watts Saved / Unit * Coincidence Factor*

[1] Alternative consistent approaches which count all bulbs and match watts, including an initial zero for units additions are possible. This is the procedure we used consistently for the measurement of net bulbs installed and watts saved per unit hour.

Net bulbs and *watts saved* per *unit* are calculated as above for energy savings. The *coincidence factor* is calculated using hours of operation data to determine whether the bulbs are in operation during the afternoon system peak.

Net-to-gross

Net-to-gross percentages are updated using the qualitative data provided by manufacturers and distributors during interview. For bulbs installed outdoors, the Evaluation Protocols stipulates that an assumed net-to-gross ratio of .75 be used.

IMPACT EVALUATION FINDINGS

Program Product Tracking System

Program tracking began with units tracked in the General Journal system which accounts for rebates paid to manufacturers by bulb model. The General Journal summarizes invoices to the bulb model level and estimates detailed program savings based on specific unit characteristics and number of units shipped. Summary counts and savings assumptions are shown in the table below:

Table 1 - Tracking File Summary

Number of Units	321,058
Hours of Operation	3,272
Average Watts Saved/Unit-Hour	54.5
Net to Gross Ratio	0.85
kWh Energy Saving/Year	
Gross	57.3 GWH
Net	48.7 GWH
Total kW Load Saving	
Gross	17.5 MW
Net	14.8 MW

The program distributed 321,000 bulbs with an estimated hours of operation of 3,272 for all bulbs. The weighted average of unit savings was 54.5 watts per hour and an assumed net-to-gross ratio of .85. Gross energy savings were estimated to be 57.3 GWH and gross Load Savings were estimated at 17.5 MW. Net savings for these energy and load figures are simply .85 multiplied times the gross estimate. Implicit in these tracking system numbers is a 100 percent installation rate and a 100 percent coincident operation with peak rate, assuming the net-to-gross ratio applies only to free-ridership. Perhaps the

tracking system savings model was intentionally made simple, but it is important to recognize that the new first-year impact estimates developed here will reflect both installation rates and coincident operation with peak. Both percentages will necessarily adjust savings estimates downward.

The analysis uses ratio estimates to update the original tracking system data, leveraging the detailed and complete accounting offered by the General Journal. For example, if the tracking system assumed watts saved per unit-hour was 55 and our analysis discovers 53 watts is a better estimate, we revised the estimated total using the ratio 53/55=.964. The analysis was done by subcategory to control for differences in the samples available to do one analysis or another. A readily available breakdown from the tracking system is manufacturer's wattage category.

Table 2 - Units and Savings by Watt Category

Manufacturer Watt Category	Number of Units	Percent	Watts/Unit Savings	GWH/Year Savings	MW Load Savings
4-13	168,223	52.40%	39	21.46	6.6
14-20	54,930	17.10%	55.5	9.97	3
21-45	97,056	30.20%	80.3	25.51	7.8
45+	849	0.30%	122	0.34	0.1
Total	**321,058**	**100.00%**	**54.5**	**57.28**	**17.5**

As Table 2 indicates 52.4 percent of the bulbs were in the 4-13 watt size class, 17.1 percent were in the 14-20 watt size class and another 30.2 percent were in the 21-45 watt class. Expected watts/unit-hr savings were 39, 55.5, and 80.3 watts for these bulb classes, respectively. The expected larger unit savings for the 21-45 watt class lead to larger energy estimates than the 4-13 watt class despite the smaller number of bulbs.

Percent Installed

Several factors were considered in determining the number of program bulbs which actually produce energy savings, as follows:

- Percent installed *(in service territory and sector)*
- Percent producing savings
- Percent removed or failing

Some units might be purchased, but not installed to take advantage of the special promotional pricing for eventual use in the future. Others, might be diverted to other sectors or areas against the rules specified by the program.

To produce savings the CFLs must replace less efficient lighting not just replace existing CFLs at attractive prices. CFL that are new lighting do not produce savings, and their additional energy use can not be attributed to the program either. We estimate the rate of replacement and additions from our on-site inspection data by bulb type.

Units which were removed as inadequate or failed in operation also don't produce savings. Here, we estimate the rate of failure/removal and assess the number of units remaining at mid-year when half the removals would have occurred, assuming a uniform rate of removal.

Table 3 - Net Unit Installations by Watt Category

Watt Category	Number	Percent Installed	Installed Units	Replaced/ Additions	Units w/Energy Savings	Failed/ Removed	Net Mid-Year Units
4-13	168,223	97.10%	163,345	10.50%	146,275	3.70%	143,569
14-20	54,930	75.70%	41,582	0.40%	41,416	11.00%	39,138
21-45	97,056	86.70%	84,148	0.40%	83,786	7.00%	80,853
45+	849	90.30%	767	100.00%	0		0
Total	**321,058**	**90.30%**	**289,841**	**6.30%**	**271,476**	**5.80%**	**263,560**

Table 3 summarizes our calculation of units installed and producing savings. Overall, we estimate that 90 percent of the bulbs promoted were installed. Smaller purchase sites were more likely to divert or keep the units in storage for future use, but larger sites with thousands of bulbs purchased had high installation rates. Most of the failure to install was due to end-user holding on to the bulb for future use, but perhaps one-fifth of the failure to install was due to diversion of the product for other uses. We calculate the rate of diversion as the percent of all bulbs that were not found at the end-user site or when the customer reported no recollection of the CFL purchase. The respondent would often indicate that the bulbs were diverted to other areas (e.g. Hawaii) or for other uses. The rest of the uninstalled bulbs remain on shelves for future use.

We looked for shipments outside of Edison's service territory by matching ZIP codes on TAG file forms. We found no forms with sales and ZIPs out of scope, but remember that the TAG forms only account for 20 percent of total promotional units. We also looked for units

used in other sectors besides those already counted in the diversion adjustments as part of the installation rate. We found no evidence of use in other sectors, as long as we define the common areas in multi-family buildings as non-residential.

Some 6.3 percent of the bulbs replaced existing CFL bulbs of the same type or were new additions. Ninety percent were used as replacements, while the other 10 percent was used for additions to the stock. We don't count either type of unit as producing energy savings.

Another 5.8 percent of the bulbs had failed or were removed by the end of 1995. We have deducted half this percent from the units counted as producing savings. The highest failure/removal rate was for 14-20 watt units, the units which are most often located in ceiling fixtures.

Overall, we estimate that 263,560 bulbs were installed and producing savings in the service territory and nonresidential sector. That is 82 percent of the promotional total explains the major reduction in program savings estimates.

Business and Lighting Applications

As Table 4 indicates, nearly 60 percent of the tracked units were installed in hotels. This is consistent with the marketing efforts that took place during the program, particularly in the Palm Springs area. Common multi-family housing areas which accounted for 20.4 percent were the next most frequent business activity, followed by a single large egg producer at 10.2 percent and restaurants at 7.3 percent. All other business activities accounted for only 4 percent of all tracked bulbs.

Table 4 - Percent Installed: Type of Business by Watt Category

Business Activity	Percent of Bulbs
Hotels	58.50%
Multi-Family	20.40%
Egg Producer	10.20%
Restaurants	7.30%
All Others	3.60%
Total	**100.00%**

The tracked sample necessarily emphasizes the largest customers, the ones most likely to fill out the required paperwork. Nevertheless, these customers accounted for over 60,000 bulbs and fixtures, about 20 percent of the total program. We are assuming that their

experience (*installation, usage, savings*) within bulb type are representative of the larger population.

As Table 5 indicates 53 percent of the bulbs were installed in indoor fixtures. As can be observed, the smaller lamps were most likely to be installed in outdoor locations. While larger watt lamps were generally installed indoors.

Table 5 - Percent Installed Indoors and Outdoors by Watt Category

Manufacturer Watt Category	Indoors (%)	Outdoors (%)
4-13	23%	77%
14-20	82%	18%
21-45	95%	5%
45+	100%	0%
Total	**53%**	**47%**

Additional tabulations by (1) fixture type and (2) installation were also calculated. The tabulations by fixture type indicated that the 4-13 watt bulbs were installed in outdoor applications. The 14-20 watt bulbs were most frequently used (59.6%) in ceiling fixtures and 21+ watt bulbs were most frequently (58.0%) used in table lamps.

While tabulations by installation location showed that 55 percent of the bulbs were installed along walkways and in parking areas. Nine percent were installed in hallways or stairs, 1 percent in bathrooms and the remaining 34 percent in the principal rooms of a business (*e.g., hotel room, restaurant dining room, office, etc.*)

Hours of Operation

Hours of operation were evaluated four ways: (1) the inspector asked the site representative about the hours the bulbs were operated by segment, (2) the inspector verified operation of sensors and timers when they were used to control time of use activity. (3) when bulbs were switched, time of use loggers were installed where allowed to measure typical activity. These loggers were used to monitor during the months of December and January, and (4) when no data was available, except the information that the unit was controlled by daylight sensor, the number of hours of darkness in Los Angeles

(4,326) was used based on sunrise/sunset times from U.S. Naval Observatory. When both metering and reported hours of operation data were available they were averaged[1].

Table 6 - Hours of Use Comparison

Watt Category	Measured	Tracking	Ratio (M/T)
4-13	4,581	3,272	1.4
14-20	2,512	3,272	0.77
21-45	1,675	3,272	0.51
45+	785	3,272	0.24
Total	**3,338**	**3,272**	**1.02**

Table 6 indicates that the number of hours of operation was greater than expected, 3,272 hours for the smaller wattage bulbs which tended to be used for outdoor lighting overnight. Hours of operation was 40 percent longer for the smaller wattage bulb and 50 percent less than expected for the larger 21-45 watt bulbs used in rooms. Weighted by units in the population the measures duration is about 2 percent longer than the tracking system assumption, but note the interaction between savings and the ratios by watt category in the section below.

The metering also gave us some insight about how often the CFLs are typically cycled during the day. During our metering which averaged 21 days per site, units were cycled on and off 2.2 times per day on average. But some units were cycled 15 times or more per day, which should not be recommended because of its negative effect on the duty cycle of the CFL.

Energy Savings Per Unit

Energy savings per unit is measured by bulb wattage as above. The reported wattage replaced in each segment is subtracted from CFL wattage to estimate savings per unit hour. When a range of wattage was reported a midpoint was selected.

[1] Note that while a few segments had metering and reported hours of use matching exactly, the unit weighted ratio of metered hours of use to reported was 16 percent for the 14 segments with hours measured both ways.

Table 7 - Watts per Unit-Hour Savings Comparison

Watt Category	Measured	Tracking	Ratio (M/T)
4-13	42.3	39.0	1.08
14-20	54.7	55.5	0.99
21-45	48.5	80.3	0.61
45+	52.0	122.0	0.43
Total	**46.4**	**54.5**	**0.85**

The watts saved per unit-hour was observed to be greater for the 4-13 watt and 14-20 watt bulb categories. As can be observed from Table 7, savings were 40 percent lower than expected for the larger bulbs, which also had lower than expected hours of use. Using tracking system bulb weights, hours of use is about 85 percent of what was specified when preparing tracking system estimates.

COINCIDENCE WITH SYSTEM PEAK

Load impacts are measured according to the load savings that can be expected at the time of the system peak. Here, we measure the percent of the bulbs by bulb category which are operating at 3 PM. As Table 8 indicates 43.8 percent of bulbs are operating during that time. This is 60 percent less than anticipated by the tracking system, due in large part to the large percentage of bulbs used outdoors for night time use only.

Table 8 - Operation Coincident with System Peak - 3 p.m. Weekdays

Watt Category	Percent Operating
4-13	17.4
14-20	53.0
21-45	76.9
45+	--
Total	**43.8**

Load impacts will need to be revised downward significantly. We doubt that program planners anticipated that these bulbs would be used predominantly in outdoor lighting applications.

REVISED GROSS SAVINGS ESTIMATES

Combining the revised net units producing savings, watts per unit savings, hours of operation and coincidence with peak numbers we estimate that first-year energy savings were 39.8 GWH (70 percent of the tracking system estimate) and load savings of 5.3 MW (28 percent of the tracking system estimate).

Table 9 - Gross Energy and Load Savings Estimates

Watt Category	Net Units with Savings	Hours of Operation	Watts Saved Unit Hours	GWH Energy Savings Year	Coincidence with Peak	MW Load Savings
4-13	143,569	4,581	42.3	27.8	17.4%	1.1
14-20	39,138	2,512	54.7	5.4	53.0%	1.1
21-45	80,853	1,675	48.6	6.6	79.6%	3.0
45+	-	785	52.0	-		-
Total	**263,560**	**3,382**	**46.5**	**39.8**	**43.1%**	**5.3**

Table 9 - Gross Energy and Load Savings Estimates summarizes revisions to the tracking system numbers. Net units with savings were combined with revised hours of operation and energy savings per unit hour estimates to revise total energy savings. Net units, watts saved per unit and coincidence with peak were combined to produce revise load savings estimates.

NET-TO-GROSS ISSUES

As previously mentioned, net-to-gross adjustments have been fixed at .75 by agreement of CADMAC based on Edison's waiver request (*see front matter*). In addition, the research conducted for this project involved two survey efforts that included questions about trends in the Commercial CFL market. These questions were asked of all distributors and program participant CFL manufacturers.

Distributor Survey

The distributor survey was primarily used to identify additional end-user customers beyond those captured by the program participant database for the purpose of conducting end-user on-site inspections. In addition, these telephone interviews were used as an occasion to ask about the effects of Edison's commercial CFL program. Pretest interviews indicated that distributor respondents were not able or in some cases, willing to quote annual sales volume data for CFL commercial applications, so the Distributor Survey was

designed to ask a number of general questions about the direction of sales and the importance of program discounts.

Table 10 - Did you notice a change CFL in sales between 1994 and 1995?

Response	Percent
Had better sales in 1994	25.8
Had better sales in 1995	38.8
No difference in sales between '94 and '95	35.4

Table 10 presents distributor respondents answers to the question that asked for observations about sales change between 1994 (*the program year*) and 1995. Note that more respondents report CFL sales were higher in 1995 than in 1994, but that 35 percent indicate that there was no difference between these two years. Table 11 reports the results of a follow-up question asked of those who reported a "drop off" in sales. Here we observe that over 60 percent attribute the decline to the lack of a 1995 program.

Table 11 - Was the drop in sales the result of no similar CFL program in 1995?

Response	Percent
Yes, discounting encourages sales	62.2
No, decline is due to product, not rebate	9.4
No, industry slow down	25.4
No, CFL price is too high	3.0

Other responses to this question included mentions of changing building codes and increased end-user knowledge of CFL product advantages as important drivers of demand in the commercial sector.

Table 12 reports that distributor respondents believe that demand for commercial CFLs is price sensitive. Over eighty percent report that the market for commercial CFL is "somewhat" or "very" price sensitive. Other responses to this question included mentions of changing building codes and increased end-user knowledge of CFL product advantages as important drivers of demand in the commercial sector.

Table 12 - How price sensitive is the demand for CFLs?

Response	Percent
Very sensitive	69.0
Somewhat sensitive	18.6
Not sensitive	12.3

Table 13 summarizes distributor respondents' opinion that Edison's program discounts did play a significant role in stimulating demand for commercial CFL products.

Table 13 - What role did discounting play?

Response	Percent
Helpful / stimulated sales	86.2
No role/not much of a role	13.8

Manufacturer Survey

The manufacturer survey was fielded as an overnight express mailout and express return package. Each of sixteen program participant manufacturers were provided with a trend data collection form along with letters of introduction from Edison and an explanation from Decision Sciences. Copies of these materials are included in the Appendix to this report. These surveys were sent to particular individuals identified by the manufacturers during exploratory telephone calls as the persons authorized and best qualified to respond to our request for sales trend data. Of the sixteen outbound surveys, we received usable responses from nine of the participant manufacturers. These responses are summarized in Table 14 below. We observe that of the nine respondents, seven provided commercial sales estimates for the calendar year, 1993 and all nine provided sales estimates for the calendar year 1995. We believe that conducting this survey at the beginning of 1996 increased the respondents' ability to cite annual Commercial CFL sales values. Note that the center column of Table 14 contains actual Edison territory program CFL unit volumes for the nine

responding manufacturers[1]. The volumes shown for the adjacent years have been computed from the percentage estimates provided by the manufacturer respondents.

Table 14 - Program Year Adjacent Commercial CFL Volume Estimates

Respondent Manufacturer	Estimated Commercial CFL Volume 1993	1994	1995
1	3,225	6,450	1,613
2	4,197	5,246	5,771
3	5,109	6,386	6,386
4	5,200	6,500	8,125
5	2,469	2,469	2,469
6	3,099	3,874	4,261
7	na	10,050	14,372
8	na	4,750	8,408
9	31,545	74,050	45,059
Unit Sales	54,844	119,775	96,463
Adjusted Percentage	52%	100%	81%

The adjusted percentages in the bottom row of Table 14 show that manufacturers who report data for both 1993 and 1994 report that their 1993 sales were 52 percent of program year sales. Similarly, those manufacturers who report data for 1995 indicate that their commercial CFL sales were 81 percent of program year commercial CFL sales. While we would caution against using these limited estimates alone to identify the magnitude of program effects, these results are consistent with manufacturer, distributor and end-user self-reported judgments that Edison's commercial CFL program produced increased demand for qualifying products.

[1] Manufacturers' names are here represented by the numbers to comply with our promise of respondent anonymity.