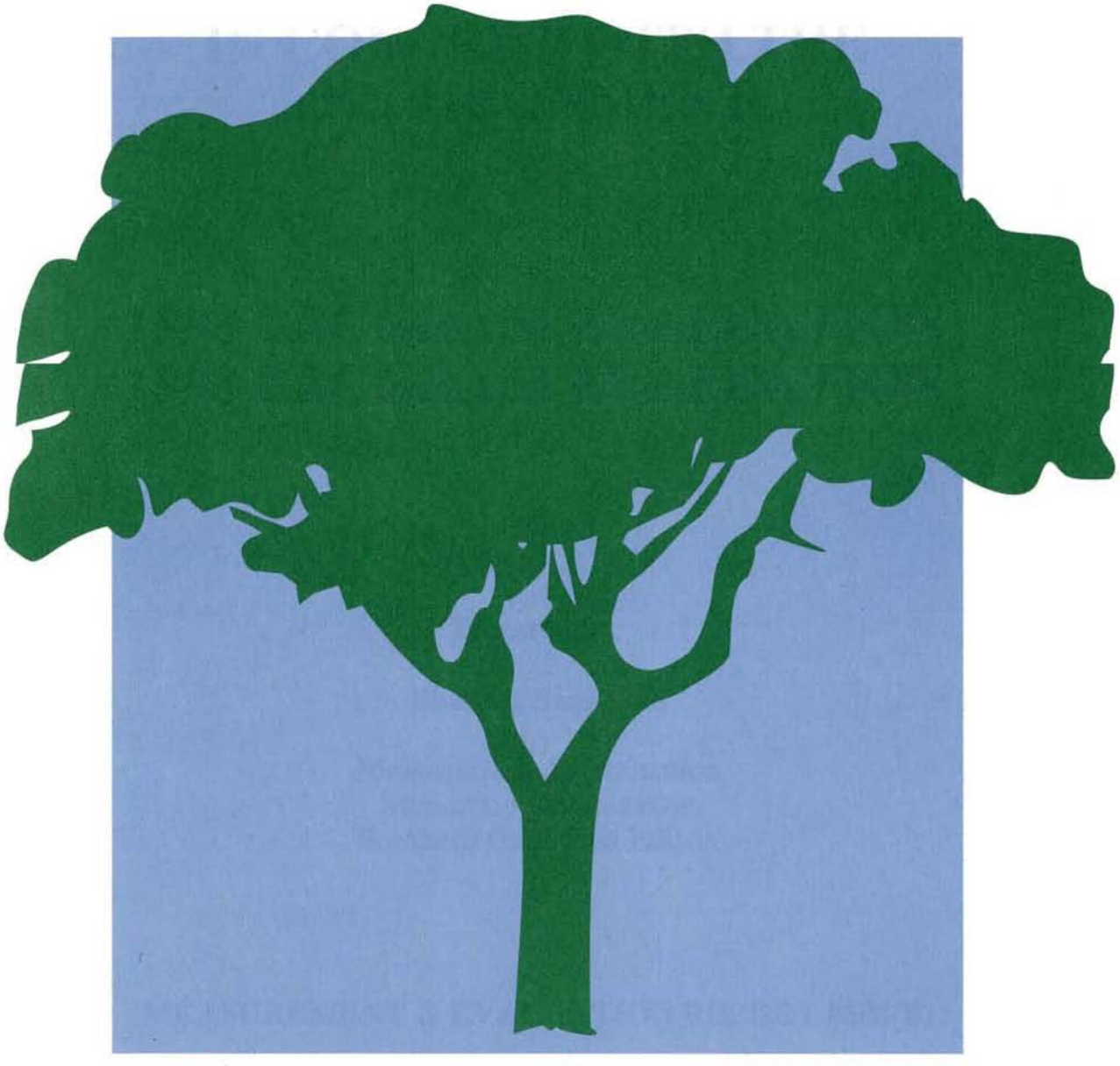
Southern California Edison

Impact Evaluation Study Report

program year 1993



In Concert With The Environment®

SOUTHERN CALIFORNIA EDISON

IN CONCERT WITH THE ENVIRONMENT

1993 PROGRAM EVALUATION
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MEASUREMENT & EVALUATION REPORT #508(B)

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IN CONCERT WITH THE ENVIRONMENT

1993 PROGRAM EVALUATION

I. EXECUTIVE SUMMARY

This report presents an impact evaluation of a Southern California Edison (SCE) conservation education program for students in high school. The program, entitled "In Concert with the Environment" (ICWE) , was implemented as a pilot program during the year 1993. This study seeks to determine how effective the pilot program was in terms of its impact on the electricity usage of participating students' households. The approach utilizes an analysis of actual energy consumption changes as a result of participation in the program.

During the program year 1993, about 2,772 students in grades 9-12 participated in the program . Of these, we were able to match 1,253 participants with SCE's billing records database. The matching was based on customer name, addresses, and where available in the program data, the account numbers. A non-participant sample was also used in the study to arrive at the net impact of the program. This sample of non-participants came from a separate impact study simultaneously conducted for Edison's residential mail audits program entitled 1993 Energy Use Profile Program Impact Study. The non-participant sample consists of 1,369 customers. Although there are differences between participants and non-participants in terms of climate zone and the presence of teenagers, we controlled for these differences in the regression analysis. The pre-and post-program energy usage analysis used the billing histories between January 1992 and December 1994. The methodology used to arrive at energy impacts of the program is a variation of Conditional Demand Analysis (CDA) that uses a 12-month change formulation. The regression analysis results can be used to calculate program impacts using the difference of differences method outlined in Table 5 of the California

Measurement and Evaluation Protocols. The analysis controlled for basic changes in cooling, space heating, and water heating usage as well as changes in consumption in other end uses.

We found that, in general, energy use was higher for households in Edison's less moderate weather zones (zones 9 and 10) and having teenagers among their occupants. Next we tried to test whether the participants in the program exhibit any other tendencies in consumption apart from the non-participants after controlling for the weather zone and the presence of teenagers. We found that after controlling for the presence of appliances and whether or not they owned the home, the consumption of participants went down by 1.8% per square foot from 1992 to 1994. The net impact of the program is summarized in the following table.

TABLE 1

	kWh EX POST ESTIMATE per square foot per month	kWh EX POST ESTIMATE per year	kWh EX ANTE ESTIMATE per year
Net Impact Estimate	0.018245	0.018245 * 1546.16† *12 = 333.97	125.00
One Standard Error Confidence Band** for net impact estimate	0.018245 +/- 0.01001724 upper 0.02826224 lower 0.00822776	upper bound = 431.44 lower bound = 245.58	

† Average Square footage of house for participants = 1546.16

** The One Standard Error Confidence Band is used to provide a statistical statement about the range of values likely to contain the true parameter.

II. INTRODUCTION

SCE contracted with EcoGroup, Inc. to implement the In Concert with the Environment (ICWE) Program in selected ninth to twelfth grade classrooms in its franchise territory. The program was implemented as a pilot in 1993. During the pilot program year 2,772 students participated in the program.

SCE conducted a billing analysis study to determine the energy impacts of the 1993 pilot program. The evaluation study goal was to identify and document energy savings (kWh) associated with the ICWE program participation, by determining the influence of the program on the participant household energy usage (focusing on electricity consumption).

PROGRAM DESCRIPTION

The ICWE program is designed to educate secondary school students and their households about energy efficiency, resource management and the positive environmental results from wise energy use. The program encourages participation by all household members. The student is asked to investigate the many ways his or her household uses energy. The program is an energy and environmental awareness package provided by EcoGroup, Inc. In the ICWE package, the secondary school teachers are responsible to introduce the program to the students. Student handbooks and energy use surveys are given out to students. The student completes the survey at home with the help of other family members. Next the student processes the data through a sophisticated computer program and extracts an individualized EcoWatt Benefit Report. This report incorporates specific recommendations based on the household's actual energy consumption. The student shares this report with his or her family.

ANALYSIS DATASET

The study is based on a dataset of the students' home energy use survey responses gathered for SCE through EcoGroup, Inc. The survey instrument is provided in Appendix A. During the pilot program year 1993, 2772 students participated in the program. This population of students and hence the participant households was screened for availability of electricity usage history for the period January 1992 through December 1994 by matching the last names and addresses of the students with Edison's billing records. This process produced a sample of 1,253 good matches. Each household was also assigned a weather station based on its zip code in order to get the weather data from SCE's weather database.

The non-participant sample from the 1993 Energy Use Profile Impact Study (Measurement and Evaluation Study #508(A)) was used as a non-participant sample for the current study. Using such a sample enabled us to get more detailed information on the characteristics of households not exposed to the program. Although there are differences between participants and non-participants in terms of climate zone and teenage occupants in the house, we controlled for such differences in the regression procedure. We found that in some cases these distinctions are not statistically significant while in others they are.

In the following pages we will first discuss the methodology used for the analysis including a short review of the difference of differences Approach to net impact measurement. Next we will specify the model used for the regression procedure. Finally we will present results of the regression analysis and draw conclusions.

III. ANALYSIS METHODOLOGY

The evaluation goal was to estimate the energy savings of the 1993 In Concert with the Environment Program. To achieve this goal, we analyzed the changes in monthly electricity usage for the sample of participants and non-participants between the years 1992 and 1994. The analysis is based on a form of Conditional Demand Model that would yield an estimate of net energy savings. In Table 5 of the California Measurement and Evaluation Protocols, there is a suggestion for measuring net load impacts of DSM programs. This measurement method has come to be known as the "difference of differences (DOD) Approach" to net impact measurement. In this section, we review the simple analytics of the DOD method. The DOD method rests on the assumption that changes in a *comparison group* consumption level, properly corrected, can be used as a proxy for the consumption changes we would observe for *participant* customers in the absence of the program. Given this orientation, the *net* program impact can be computed by simply subtracting the participants' change in consumption from the comparison group's change in consumption. Using the DOD method, the comparison group is generally understood to consist of energy customers who did not participate in the program.

The DOD method can be carried out using regression methods as well as simple comparisons. Here we discuss only regression methods in order to show the relationship between the underlying structure of the demand relationships and the DOD impact estimation. Within the regression approach, however, there are several forms that can yield DOD impact estimates. We start with a simple symbolic form of the DOD impact calculations.

THE DOD NET IMPACT CALCULATIONS

The impact calculations for the DOD method require estimates of participant and comparison group usage levels in the base period and in the program year. The DOD net impact calculation can be written as follows:

1) $NI = \Delta L_p - \Delta L_c$

2) $\Delta Lc = LcBase - LcProg$

3) $\Delta Lp = LpBase - LpProg$

The definitions of terms in the above equations are presented below.

Definitions Of Variables In Equations 1 Through 3

Variable	Definition
NI	The DOD estimate of net program impact
ΔLc	The gross impact of the program for the comparison group
ΔLp	The gross impact of the program for the participant group
Lc_{Base}	The comparison group load in the base period
Lc_{Prog}	The comparison group load in the program period
Lp_{Base}	The program group load in the base period
Lp_{Prog}	The program group load in the program period

Given this basic structure of the DOD approach, we next show the DOD calculations in the context of a *Difference Model* of energy consumption.

A LOAD DIFFERENCE MODEL

We can model the change in load, at the customer level, from a base period to the program period (base period minus program period loads)[1] as follows.

4) $\Delta L = b(\Delta FM) + c(\Delta FT) + Prog\ Effect$

Definition of Variables in Equation 4

Variable	Definition
ΔL	The average load change at the customer level from the base period to the program period
ΔFM	The average change in a modeled factor that varies over time and that would be included in the model (e.g. weather). The change is taken from the base period to the program period
ΔFT	The average change in a factor that varies over time but would be modeled as a function of time rather than as an explicit variable (e.g. changes in consumer attitudes about conservation). The change is taken from the base period to the program period
Prog Effect	The effect of the program on the load (may be modeled as an SAE term, a function of other characteristics of the customer, or in other ways).

Note that if FT is a simple linear trend term (say, FT equals calendar months) then the term c(ΔFT) would be an equation intercept. Alternatively, if FT is viewed as a trend polynomial or an interaction trend term, then the c(ΔFT) term(s) would *not* reduce to a simple equation intercept.

For the participants the equation (4) will be

(5) $\Delta L_p = b(\Delta FM_p) + c(\Delta FT_p) + Prog\ Effect_{prog}$

where subscript 'p' is for participants and 'prog' indicates the program existence.

[1] In the regression equation of Section IV, the change is taken as the program period minus the base period. The interpretation of the results is the same except that all the signs of the coefficients are reversed.

Similarly equation (4) for the comparison group become:

(6) $\Delta Lc = b(\Delta FM_c) + c(\Delta FT_c)$

where subscript 'c' denotes the comparison group.

Once equation (4) is estimated, we would evaluate the gross savings estimates for participants using the average characteristics of the participants (floorspace, weather, etc.). To compute the net program impact we would take account of an important measurement objective (Table 5, objective 2.a):viz., *"to measure the level and type of change in load at a comparable level of service*[2]. To comply with this protocol objective in measuring the participant effects, after estimating equation (4) we would proceed to calculate the change in the load for the non-participant comparison group corrected for the participant level of service (equation 6 calculated using participant characteristics).

We would then calculate the net impact by subtracting the gross impact for the participants (equation 5) from the corrected gross impact for the non-participants (equation 6 with participant characteristics). Thus:

(7) $NI = \Delta L_p - \Delta L_c$

or

(8) $NI = [\, b(\Delta FMp) + c(\Delta FTp) + Prog\ Effect_{prog}] - [b(\Delta FMp) + c(\Delta FTp)\,]$

Canceling the appropriate terms, we have

(9) $NI = Prog\ Effect_{prog}$

Thus, the estimated Prog Effect term in the load equation is the estimate of the net program impact.

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[2]California M & E Protocols, Table 5, Objective 2.a.

IV. MODEL SPECIFICATIONS

To apply the logic of the DOD approach we use the following formulation of the conditional demand model.

$$\Delta kWh_{it} = \beta o + \beta_1, COOL\_DEL + \beta_2 HEAT\_DEL + \beta_3 WTHT\_DEL + \beta_4 ZT + \beta_5 ZTCOOL + \beta_6 ZTHEAT + \beta_7 ZTWTHT + \beta_8 ZTSQFT + \beta_9 SQRFT\_Q + \beta_{10} SQPPART + \beta_{11} OWN + \beta_{12} OWNSQ + \beta_{13} OWNZTSQ + \varepsilon_{it}$$

Where

ΔkWh_{it} = 12-month change in average electricity consumption in period t (the impact year) from the equivalent period in the base year for i-th household.

The explanatory variables have the following meaning:

COOL_DEL = Appliance stock $_{Cooling}$ * ΔCDD * Square foot where ΔCDD is the 12-month change in cooling degree days in period t (the impact year) from the equivalent period in the base year.

HEAT_DEL = Appliance stock $_{Space\ heating}$ * ΔHDD * Square foot where ΔHDD is the 12-month change in heating degree days in period t (the impact year) from the equivalent period in the base year .

WTHT_DEL = Appliance stock $_{Water\ heating}$ * Number of occupants

ZT = Dummy variable for Zone 9 and 10 * Dummy variable for presence of teenagers in the household.

ZTCOOL	=	ZT * COOL_DEL
ZTHEAT	=	ZT * HEAT_DEL
ZTWTHT	=	ZT * WTHT_DEL
ZTSQFT	=	ZT * Square foot (i.e., household's conditioned floor space)
SQRFT_Q	=	Square foot
SQPPART	=	Square foot * Participation Dummy variable
OWN	=	Dummy variable for owning the house
OWNSQ	=	OWN * SQRFT_Q
OWNZTSQ	=	OWN * Dummy for Zone 9/10 households * Dummy for teenage occupants * SQRFT_Q
ε_{it}	=	A random error term

The coefficients in the regression equation, carry the following meaning:

β_0	=	Intercept
β_1	=	Basic consumption for cooling
β_2	=	Basic consumption for space heating
β_3	=	Basic consumption for water heating
β_4	=	Consumption for household in SCE weather zone 9 and 10 and who have teenagers living in the house (hereon called ZT households)
β_5	=	Incremental consumption for ZT households for cooling
β_6	=	Incremental consumption for ZT households for electric space heating
β_7	=	Incremental consumption for ZT households for electric water heating

β_8 = Effect of house size on a ZT households energy consumption

β_9 = Effect of house size on the general household's energy consumption

β_{10} = Incremental effect per square foot of participation in the program on energy consumption

β_{11} = Effect of ownership of house on energy consumption

β_{12} = Incremental effect of size of the house on energy consumption

β_{13} = Incremental effect of house size and ownership on ZT households' energy consumption

The right hand side variables that appear in the above regression equation can be seen to be tied with the Load Difference Model as shown in equation 4. Variables such as COOL-DEL, HEAT-DEL, WTHT_DEL, ZTCOOL, ZTHEAT, ZTWTHT are the factors modeled as changing over time with changes in weather conditions. The effect of the program on the load here is modeled as a function of characteristics of the customer and is represented by the variable SQPPART. Hence β_{10} is the parameter of interest in the analysis that will give us an estimate to compute the net program impact.

REGRESSION RESULTS

Table II shows the results of the regression analysis.

THE CONDITIONAL DEMAND MODEL REGRESSION RESULTS

TABLE II.

VARIABLE CATEGORY *DEPENDENT VARIABLE:* **ΔkWh** **Electricity consumption in month t in 1994 minus the consumption in equivalent month in the year 1992**	n = 32,464 R^2 = 0.0391 Adj R^2=0.0387		
INDEPENDENT VARIABLES:	**Regression Coefficients**	**Standard Error**	**T-Ratio**
INTERCEPT	**23.211593**	**12.58536547**	**1.844**
COOL_DEL ***Factors affecting proxy for cooling load*** **Appliance stock $_{Cooling}$ * ΔCDD * Square ft** **where ΔCDD is the cooling degree days in month t in 1994 minus the cooling degree days in equivalent month in the year 1992**	**0.000837**	**0.00007858**	**10.648**
HEAT_DEL ***Factors affecting proxy for Space heating load*** **Appliance stock $_{Elec.\ Space\ heating}$ * ΔHDD * Square ft** **where ΔHDD is the heating degree days in month t in 1994 minus the heating degree days in equivalent month in the year 1992**	**0.001048**	**0.00011833**	**8.858**

TABLE II. (CONT.)

VARIABLE CATEGORY *DEPENDENT VARIABLE:* ΔkWh	n = 32,464 R^2 = 0.0391 Adj R^2=0.0387		
INDEPENDENT VARIABLES:	Regression Coefficients	Standard Error	T-Ratio
WTHT_DEL *Factors affecting proxy for Elec water heating load* Appliance stock Elec water heating * number of occupants	-13.398902	4.49243206	-2.983
ZT Dummy variable Zone 9/10 * Du y variable teenage occupants	0.111986	10.26408436	0.011
ZT COOL ZT * COOL_DEL	-0.00000951	0.00009624	-0.099
ZT HEAT ZT * HEAT_DEL	0.000358	0.00022658	1.578
ZTWTHT ZT * WTHT_DEL	58.838429	5.79383315	10.155
ZTSQFT ZT * Square Ft.	0.096330	0.01069784	9.005
SQRFT_Q Square Ft (size of house)	0.004654	0.01053708	0.442
SQPPART SQRFT_Q * Dummy variable participation	-0.018245	0.00500862	-3.643

TABLE II. (CONT.)

VARIABLE CATEGORY ***DEPENDENT VARIABLE:*** **ΔkWh**	n = 32,464 R^2 = 0.0391 Adj R^2=0.0387		
INDEPENDENT VARIABLES:	Regression Coefficients	Standard Error	T-Ratio
OWN **Dummy variable Own house**	**40.932572**	**11.55972846**	**3.541**
OWNSQ **OWN * SQRFT_Q**	**-0.018516**	**0.01006791**	**-1.839**
OWNZTSQ **OWN * SQRFT_Q * ZT**	**-0.093905**	**0.00770580**	**-12.186**

The regression results show that on average the change in consumption in 1994 is 23 kWh/month if all the variables on the right hand side of the equation are set to zero. The regression analysis establishes the following results.

- The bigger the scale of the house interaction with the change in degree days and the presence of cooling or electric space heating, the larger the change in consumption.
- The larger the number of occupants interaction with presence of electric water heating, the smaller the change in consumption.
- If we control SCE's weather zone 9 and zone 10 households along with existence of teenage occupants in the house from which our participants are drawn, we find that this population's change in consumption is not significantly different from the rest of the population.
- We tested to see if the zone 9/10 teenage occupants households differ also for the three major end uses considered but found no significant difference for cooling and space heating except for electric water heating. We found that the effect on change in consumption tended to be larger than the rest of the population.
- We found that the effect of size (i.e., conditioned floor space) of the house for these zone 9/10 teenage occupants households was also significantly greater that the rest of the population.
- In attempting to control for factors related to the house size, such as lighting and multiple ownership of particular appliances, we used the square footage of the house and tested for the effect of size of the house on changes in energy consumption. We found the size of the house in itself to be statistically insignificant in the general population (t ratio = 0.442).

- We tested to see whether the effect of participation or changes in consumption is size-related. We found that the bigger the size of the participant house, the more negative is the impact on change in consumption. This estimated effect is the net estimate of the average impact per square foot of a participant's house. It is net in the sense that it is the extra change over and above the non-participant group.
- We found that ownership of house in itself had a significant positive impact on changes in consumption, probably through greater appliance stocks associated with household ownership.
- After taking home ownership into account, we tested to see whether the house size effect is sensitive to whether or not the households own their home. We found that for home owners, the bigger the size of the house, the smaller the change in consumption. The t ratio for this effect was, however, relatively low (t=-1.8). The same tendency was observed for Zone 9/10 households with teenage occupants.

V. CONCLUSION

We tested for the effect on changes in consumption due to changes in factors such as cooling degree days, heating degree days, square footage and the number of occupants in the house. In addition to this we controlled for different weather zones to which the participants and non-participants households belong and also for the ownership status of the house. After accounting for all these factors, we estimated 0.018245 kWh/ sq. ft. savings impact for the participants of the program. Given this statistically significant estimate we estimate the annual impact to be 384.58 Kwh. Taking one standard error confidence band, the range is estimated to be between 431 kWh and 246 kWh. The summary table of results from Section I is repeated here:

TABLE 1

	kWh EX POST ESTIMATE per square foot per month	kWh EX POST ESTIMATE per year	kWh EX ANTE ESTIMATE per year
Net Impact Estimate	0.018245	0.018245 * 1546.16† *12 333.97	125.00
One Standard Error Confidence Band** for net impact estimate	0.018245±0.01001724 upper 0.02826224 lower 0.00822776	upper bound=431.44 lower bound=245.58	

† Average Square footage of house for participants = 1546.16

** The One Standard Error Confidence Band is used to provide a statistical statement about the range of values likely to contain the true parameter.