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Summary of California DSM Impact Evaluation Studies

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EXECUTIVE SUMMARY

Over the past several years, four of the largest California utilities have completed more than 50 evaluation studies designed to measure the energy and demand impacts of their demand-side management (DSM) programs. The four utilities include: Pacific Gas and Electric Company (PG&E), San Diego Gas and Electric Company (SDG&E), Southern California Edison (SCE), and Southern California Gas Company (SoCalGas). These utilities, along with eight additional organizations, comprise the California Demand Side Management Measurement Advisory Committee (CADMAC) which was established by the California Public Utilities Commission to oversee the DSM measurement and evaluation activities of these utilities.[1]

The objective of this report is to summarize the results of these DSM evaluation studies in order to describe what DSM has achieved in California, to assess how well these achievements were forecast, and to compare the effectiveness of different types of DSM programs. The CADMAC supported the analysis and the U.S. Department of Energy funded publication of the report.

The studies reviewed for this report represent a major, multi-million dollar undertaking by the four utilities. While the depth and rigor of these evaluations varied tremendously, the studies generally involved state-of-the-art evaluation methods and extensive data collection and analysis. Many of the study reports were multi-volume, with separate sub-studies focusing on particular issues, such as net-to-gross analysis and the validity of various engineering assumptions. In some cases, multiple methodologies were employed to converge on the savings estimates. Overall, the effort expended to evaluate these programs will pay dividends in California and throughout the nation, in terms of advances in evaluation methods and lessons learned about the performance of a wide array of DSM activities.

This report documents the sizable investment made by the California utilities in their 1990-92 DSM programs. Between 1990 and 1992, the four utilities spent $772 million on energy-efficiency/conservation programs.[2] The utilities operated two types of programs: (1) resource programs that typically earn the utilities financial incentives based on the savings achieved, and (2) equity/services programs that generally are operated for performance-adder incentives. Resource programs are intended to provide a reliable, cost-effective alternative to supply-side resources. They include a variety of retrofit incentive and new construction programs. Equity/services programs are

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1 The remaining members of CADMAC are the California Manufacturers Association, Toward Utility Rate Normalization, California Energy Commission, Natural Resources Defense Council, California Institute for Energy Efficiency, California Public Utilities Commission, National Association of Energy Service Companies, and Residential Energy Services Companies' United Effort.

2 In addition, the four utilities spent $114 million on measurement and evaluation activities between 1990 and 1992 and earned shareholder incentives of $156 million, neither of which are reflected in the above total. The four utilities also spent additional funds on information, load management, load retention, and load building programs which are not reflected in the above total.

implemented for equity or educational purposes. They include residential direct assistance programs for low-income households, which are viewed as equity programs, and programs that provide energy management services such as energy audits, for which savings are difficult to estimate. Between 1990 and 1992, the four utilities spent 51% of their DSM expenditures on resource programs and 49% on equity/services programs.

Each utility had a unique profile of investments in different types of programs, with SDG&E investing the greatest share (73%) of its total DSM expenditures in resource programs. In contrast, PG&E and SCE spent a large proportion of their total DSM budgets delivering energy management services. Another profile is provided by SoCalGas, which dedicated 47% of its total DSM expenditures to residential direct assistance programs. Altogether, the programs described in the 50 impact studies served more than 800,000 participants annually between 1990 and 1992. Thus, an impressive number of customers (approximately 2,400,000) benefited from California's DSM programs over the three-year study period.

Based on the measure penetration rates itemized in these impact studies, the four California utilities have had a significant impact on the purchase and installation of energy-efficient equipment and materials in the State. Undoubtedly this has been responsible for generating region-wide consumer demand for DSM products and for strengthening the wholesale and retail infrastructures that promote their distribution beyond the immediate participants in DSM programs. Few of the 50 impact evaluations reviewed in this report attempted to quantify these market transformation benefits.

The evaluation studies summarized in this report do not address the total impacts of all DSM programs implemented during the 1990-92 period, but only those specific programs and years actually addressed by the studies. Therefore, the estimates of DSM participants, measures installed, and savings compiled in this report are substantially less than the total achievements of the four utilities in all years.

Compiling the total savings estimates reported by the individual evaluation studies was complicated by the significant variation in the way savings were estimated and reported across the studies. Specifically, the reported savings:

- varied by time frame
- were aggregated at many different levels
- varied by unit of measurement
- resulted from a variety of estimation and evaluation methodologies.

For these reasons, it was difficult to summarize total savings across all of the evaluation studies.

This report also summarizes realization rates from the evaluation studies reviewed. Realization rates are defined as *ex-post* net savings estimates divided by *ex-ante* net savings estimates where both estimates have been adjusted for free-ridership.[3] *Ex-ante* savings estimates are preliminary estimates of program impacts developed by the utilities and based usually on engineering calculations. *Ex-post* savings estimates are based on formal post-implementation evaluation studies. Realization rates are summarized for 158 programs and program segments.

The distribution of realization rates is shown in Figure ES.1. The median realization rate for all 158 programs and program segments is 0.86 and the mean is 1.12. Four realization rates (ranging from 5.59 to 14.54) were found to be more than 3 standard deviations above the mean. (No values were more than 3 standard deviations below the mean.) Removal of these four outliers results in the same median of 0.86 but reduces the mean to 0.93. Overall, these results suggest that the forecasts of energy savings were reasonably accurate, and that most of the DSM programs were cost-effective since they generally were designed to produce benefit-cost ratios of at least 1.2. Further, these results suggest that the California DSM programs operating between 1990 and 1992 have outperformed typical programs from the 1980's, which often fell short of their expected savings by 30% to 70%

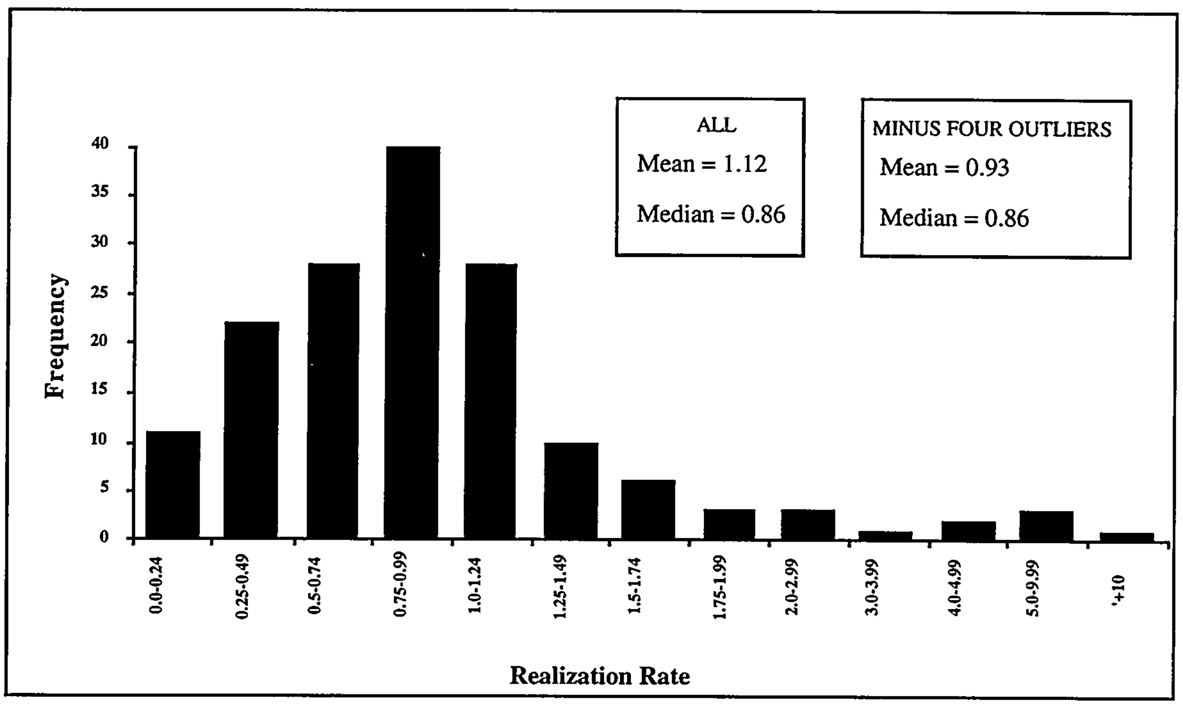

Figure ES.1 Distribution of Realization Rates (N=158)

[3] In some cases the numerator is an ex-post estimate of gross savings because the impact study did not present net savings or assumed a net-to-gross ratio of 100%. The ex-ante savings estimates are assumed to be net savings (unless explicitly noted in the studies). However, limited documentation was provided on the calculation of the ex-ante savings estimates. Thus, it cannot be stated with certainty which realization rates are net and which are gross.

(Hirst, et al., 1989; Sebold and Fox, 1985; Brown and White, 1992). However, it was not possible to discern how much the improved performance resulted from greater actual energy savings versus improved forecasting (i.e., *ex-ante* estimation of savings).

In general, commercial, industrial, and agricultural (C/I/A) realization rates were higher than residential realization rates. The mean realization rate for all C/I/A programs and program segments is 1.26. Removal of the four highest realization rates (which are all C/I/A) reduces this mean to 0.96. The mean realization rate for all residential programs and program segments is 0.88.

The realization rates presented in this report are unweighted. That is, each program or program segment realization rate (total of 158) has the same weight in the calculation of means. If the realization rates were weighted by energy savings, the mean would be expected to be greater. This is because the C/I/A programs have higher realization rates and tend to have higher savings than the residential programs, yet in the unweighted calculation all are counted equally. Thus, the overall mean of 1.12 (0.93 without the four highest outliers) could be viewed as a conservative calculation of the ratio of actual savings to anticipated savings.

The difference between the mean and median values reflects the skewed distribution of realization rates. Nearly one quarter (22%) of the programs delivered less than 50% of their *ex-ante* savings estimates, while 10% exceeded 150% of their *ex-ante* savings estimates. The implementation of initiatives to narrow the range of realization rates should be a major thrust of resource planners and program managers in the four California utilities. The impact of different *ex-ante* estimation procedures warrants further examination in this regard. The *ex-ante* estimates of savings for similar DSM measures across utilities and across programs in the same utility were found to be wide ranging and a possible source of systematic bias in the realization rates. In particular, higher-than-average *ex-ante* estimates of savings for a particular measure generally were associated with lower-than-average realization rates.

Table ES.1 reports mean and median realization rates by sector and by program type. The means, particularly in the C/I/A retrofit incentive area, are affected by a few very high observations (See Figure ES.1). Some studies reported several savings estimates (e.g., by market segment or measure type), rather than an overall program value. Hence, some studies had a greater influence on the statistics reported in Table ES.1 than other studies, because they contributed several realization rate observations.

By comparing the realization rates reported in the various impact studies, it is possible to suggest features of the DSM programs, the *ex-ante* estimates of savings, and the evaluation methods that may cause realization rates to vary. In the residential sector, higher realization rates were associated with retrofit incentive programs, calibrated engineering models, relatively low *ex-ante*

Table ES.1 Summary of Realization Rates by Sector and Program Type

	Mean	Median	Number of Programs or Segments
TOTAL	1.12	0.86	158
Sector:			
Residential	0.88	0.69	60
Commercial/Industrial/Agricultural (C/I/A)	1.26*	0.91	98
Resource Programs:			
TOTAL	1.36	0.86	83
Residential retrofit incentives	1.18	1.06	17
C/I/A retrofit incentives	1.54	0.91	52
Residential new construction	0.78	0.70	8
C/I/A new construction	1.16	0.66	6
Equity/Services Programs:			
TOTAL	0.85	0.86	75
Residential direct assistance	0.68	0.53	26
Residential energy management services	1.00	0.59	9
C/I/A energy management services	0.92	0.95	40

* This mean becomes 0.96 if the four highest realization rates (ranging from 5.59 to 14.54) are removed from the calculation.

estimates of savings, and evaluations that fail to discount savings for free riders, rebound effects, and imperfect measure retention. Among the non-residential programs, higher realization rates were associated with commercial sector programs and *ex-post* evaluation methods that involve simplified engineering models and conditional demand analysis.

More information and knowledge would have been gained from this review of California's recent impact evaluations if similar types of programs had been evaluated using similar methodologies and if consistent reporting formats had been employed. The California state-wide measurement protocols will promote more consistent reporting of savings in future evaluation studies and thus facilitate the statewide aggregation of savings and comparative analysis. In general, such greater consistency will result in the following benefits:

- improvement in the transferability of savings estimates across utilities (so that the number and frequency of evaluation might be reduced),

- greater ability to identify effective program features (so that programs can be redesigned to maximize performance), and
- aggregations of energy savings estimates, participation levels, realization rates, and other key statistics across utilities (to help state level DSM planning and forecasting).

Finally, any future effort to summarize and synthesize lessons learned from California impact studies should involve the analysis of a wider range of data. In particular, it should include (a) calculation of a total energy savings estimate appropriate for weighting each realization rate,[4] (b) analysis of procedures used to generate *ex-ante* estimates of energy savings, and (c) compilation of utility statistics such as the numbers of customers by sector which would facilitate comparisons of the relative market penetration of each utility's DSM programs.

Appendix A to this report contains a bibliography of the evaluation and related studies summarized, while Appendix B describes the evaluation methodologies employed in the 50 studies. Appendix C contains detailed tables of evaluation results.

4 For instance, if a realization rate is calculated by comparing the ex-post and ex-ante savings of a particular retrofit measure, then it would be necessary to know how many of these measures were installed to calculate the total energy savings associated with the realization rate. Alternatively, if a realization rate is calculated for a particular market segment, it would be necessary to know the number of participants in that segment to calculate the total energy savings and thereby weight the realization rate.

ABSTRACT

Over the past several years, four of the largest investor-owned California utilities have completed more than 50 evaluation studies designed to measure the energy and demand impacts of their demand-side management (DSM) programs. These four are: Pacific Gas and Electric (PG&E), Southern California Edison (SCE), Southern California Gas (SoCalGas), and San Diego Gas and Electric (SDG&E). These studies covered residential, commercial, industrial, and agricultural DSM programs and provided a wealth of information on program impacts. The objective of this report is to summarize the results of these DSM evaluation studies in order to describe what DSM has achieved in California, to assess how well these achievements were forecast, and to compare the effectiveness of different types of DSM programs.

This report documents the sizable investment made by the California utilities in their 1990-92 DSM programs. Between 1990 and 1992, the four utilities spent $772 million on energy-efficiency/conservation programs. Over this three-year period, the four utilities operated two types of programs: (1) resource programs that typically earned the utilities financial incentives based on the savings achieved, and (2) equity/services programs that generally were operated for performance-adder incentives. Resource programs are intended to provide a reliable, cost-effective alternative to supply-side resources. The four utilities spent 51% of their DSM expenditures on resource programs and 49% on equity/services programs.

This report also summarizes the realization rates extimated by the 50+ evaluation studies. Realization rates are defined as *ex-post* net savings estimates divided by *ex-ante* net savings estimates. Realization rates are summarized for 158 programs and program segments. The median realization rate for these 158 programs and program segments is 0.86 and the mean is 1.12. Removal of four positive outliers results in the same median of 0.86 but reduces the mean to 0.93. Overall, these results suggest that the forecasts of energy savings were reasonably accurate and that most of the DSM programs were cost-effective, since the programs generally were designed to produce benefit-cost ratios of at least 1.2. In general, realization rates were higher for commercial, industrial, and agricultural programs than for residential programs. In the residential sector, higher realization rates were associated with retrofit incentive programs, calibrated engineering models, relatively low *ex-ante* estimates of savings, and evaluations that fail to discount savings for free riders, rebound effects, and imperfect measure retention. Among the non-residential programs, higher realization rates were associated with commercial sector programs and *ex-post* evaluation methods that involve simplified engineering models and conditional demand analysis.

ACKNOWLEDGMENTS

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1. INTRODUCTION

1.1 BACKGROUND

Since the late 1980's, the four largest California investor-owned utilities have initiated and expanded various demand-side management (DSM) programs designed to produce energy and capacity savings and to provide comprehensive services to their customers. This commitment to energy efficiency was encouraged by the establishment of financial incentives for the utilities to acquire demand-side resources. The four utilities include:

- Pacific Gas and Electric Company (PG&E),
- San Diego Gas and Electric Company (SDG&E),
- Southern California Edison (SCE), and
- Southern California Gas Company (SoCalGas).

Over the past several years, each of the four utilities has conducted or sponsored formal evaluation studies designed to retrospectively evaluate the energy (gas and electric) and electrical demand impacts achieved by DSM programs that operated between 1990 and 1992. This effort yielded more than 50 evaluation studies, which are listed by utility and program in Table 1.1.[1] Altogether, these studies assess the impacts of a cumulative investment of nearly one billion dollars by the four utilities in DSM programs. This figure does not reflect the total DSM investment by the four utilities since the evaluation studies listed in Table 1.1 do not cover all of the DSM programs undertaken by the utilities over this period.

These four utilities, along with nine additional organizations, comprise the California Demand Side Management Measurement Advisory Committee (CADMAC).[2] CADMAC was established by the California Public Utilities Commission (CPUC) to oversee the DSM measurement and evaluation activities of these utilities. CADMAC commissioned this report.

1.2 OBJECTIVES OF REPORT

The evaluation studies produced by the four utilities contain much detailed information related to the measurement of energy and demand impacts of the utilities' DSM programs. Many of the studies are multi-volume and examine the impact issues from several methodological perspectives. (The individual evaluation studies are listed in Table 1.1). The objective of this report is to

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1 These studies are publicly available through the respective utilities.

2 The remaining members of CADMAC are the California Manufacturers Association, Toward Utility Rate Normalization, California Energy Commission, Natural Resources Defense Council, California Institute for Energy Efficiency, California Public Utilities Commission, National Association of Energy Service Companies, and Residential Energy Services Companies' United Effort.

Table 1.1 Impact Evaluation Studies Summarized in This Report*

Utility	Year(s)	Program(s) Covered
PG&E	1991-1992	Ceiling Insulation Rebate
PG&E	1991	Energy Saver Showerhead Coupon
PG&E	1992	Residential Compact Fluorescent Lighting
PG&E	1991-1992	Residential New Construction
PG&E	1991	Energy Partner
PG&E	1991-1992	Targeted Customer Appliance
PG&E	1991	Residential Energy Savings Plan
PG&E	1991	Commercial, Industrial, and Agricultural Direct Rebate--Phase I
PG&E	1991	Commercial, Industrial, and Agricultural Direct Rebate--Phase II
PG&E	1991	Commercial New Construction
PG&E	1991	Commercial, Industrial, and Agricultural Direct Rebate
PG&E	1991-1992	CIA Retrofit Rebate
PG&E	1990-1992	Non-Residential New Construction
PG&E	1990-1992	Non-Residential Energy Management Services
PG&E	1990-1991	Custom Rebates--On-Site Validation
SDG&E	1991	Low-Flow Showerhead
SDG&E	1991	Appliance Efficiency--Residential Compact Fluorescent Lighting
SDG&E	1991	Residential High Efficiency Refrigerator
SDG&E	1990-1991	Appliance Efficiency--Low-Flow Showerheads
SDG&E	1992	Appliance Efficiency--Compact Fluorescents
SDG&E	1991-1992	Residential Energy Management Services--Audits
SDG&E	1992	Residential Direct Assistance
SDG&E	1985-1989	Non-Residential Audits
SDG&E	1990-1991	Commercial/Industrial Lighting Retrofit
SDG&E	1991-1992	Commercial/Industrial Efficiency Incentives--Lighting Retrofits
SDG&E	1991-1992	Commercial/Industrial Efficiency Incentives--Lighting Retrofit
SDG&E	1990-1991	Agricultural Energy Management Services

* See Appendix A for complete citations.

Table 1.1 Impact Evaluation Studies Summarized in This Report (cont'd)*

Utility	Year(s)	Program(s) Covered
SCE	1990-1992	Residential Appliance Efficiency Incentives
SCE	1990	Residential Appliance Efficiency Incentives
SCE	1990	Residential Energy Management Services
SCE	1990-1991	Customer Assistance
SCE	1990	Welcome Home Appliance Usage
SCE	1991	Welcome Home Appliance Usage
SCE	1990	Energy Management Services & Hardware Rebate
SCE	1990	Energy Management Services & Hardware Rebate
SCE	1990	Energy Management Services & Hardware Rebate
SCE	1990	Energy Management Services & Hardware Rebate
SCE	1990	Energy Management Services & Hardware Rebate
SCE	1990	Energy Management Services & Hardware Rebate
SCE	1990	Energy Management Services & Hardware Rebate
SCE	1990	Energy Management Services & Hardware Rebate
SCE	1990	Energy Management Services & Hardware Rebate
SCE	1990-1992	Commercial New Construction Incentives
SoCalGas	1990-1992	Residential Conservation
SoCalGas	1990-1992	Direct Assistance: Appliance Repair and Replacement
SoCalGas	1990-1991	Residential New Construction
SoCalGas	1990-1992	Commercial Demand-Side Management
SoCalGas	1990-1992	Industrial Demand-Side Management
SoCalGas	1990-1992	Commercial New Construction
SoCalGas	1990	Residential Energy Management Services

* See Appendix A for complete citations.

summarize the results of these DSM evaluation studies in order to describe what DSM has achieved in California, to assess how well these achievements were forecast, and to compare the effectiveness of different types of DSM programs. The main emphasis is on summarization.

In defining their programs, and in annual reporting of program status, the individual utilities formulated preliminary estimates of program impacts. These estimates are known as *ex-ante* impact estimates. In most cases, they are based on engineering calculations. The formal evaluation studies, summarized in this report, estimate impacts based on post-implementation measurement and/or estimates of key parameters. Thus, the impact evaluation studies summarized in this report produced *ex-post* impact estimates. A key objective of this report is to compare the *ex-ante* and *ex-post* impact estimates of the four utilities' DSM programs. This was accomplished by formulating "realization rates," which are the ratio of the *ex-post* to the *ex-ante* estimates.

1.3 ORGANIZATION OF REPORT

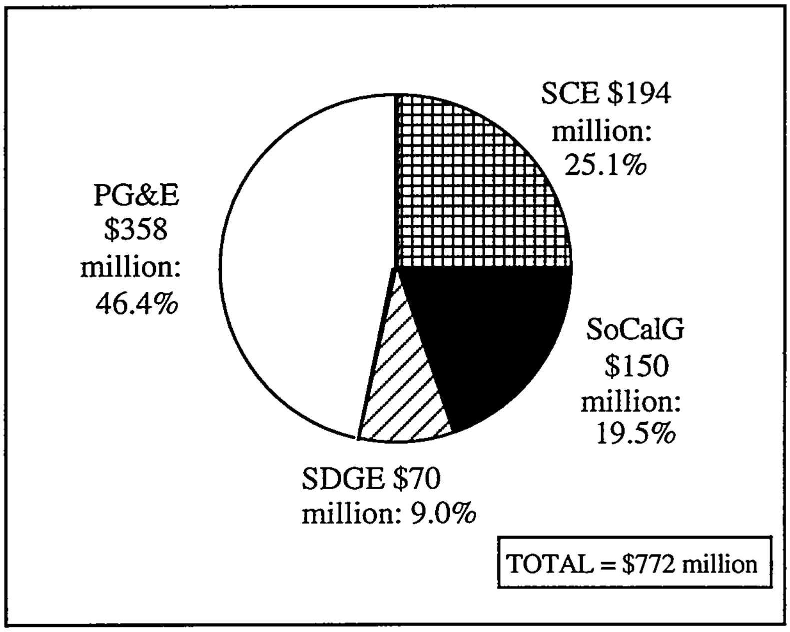
This report is organized into seven chapters and four appendices. Chapter 2 provides an overview of the California utility DSM programs which are the subject of the evaluation studies. The programs are summarized in terms of extent of DSM investment, program participation, and the installation of DSM measures. Chapter 3 provides a summary of *ex-post* program impact estimates to the extent they are reported at the programmatic level. Three measures of impact are summarized. These include net electrical savings (mWh or kWh), net electrical demand savings (MW or kW), and net gas savings (therms). Chapter 4 provides a similar summary of impact estimates, but at the participant and/or measure level for selected measure types. Chapter 5 compares *ex-post* and *ex-ante* impact estimates based on a summary of realization rates achieved. Finally, Chapter 6 provides brief conclusions. Chapter 7 contains references.

The report includes four appendices. Appendix A contains a bibliography with citations for each of the impact evaluation studies and annual DSM reports reviewed as part of this report. Appendix B provides an abbreviated overview of the impact evaluation methodologies which have been employed in the impact evaluation studies reviewed as part of this report. Appendix C contains detailed tables of evaluation results.

2. OVERVIEW OF DSM PROGRAMS

2.1 OVERVIEW OF UTILITIES AND THEIR DSM EXPENDITURES

Between 1990 and 1992, Pacific Gas and Electric Company, Southern California Edison Company, Southern California Gas Company, and San Diego Gas and Electric Company spent $772 million on energy-efficiency/conservation programs (Division of Ratepayer Advocates, California Public Utilities Commission, 1993).[1] The magnitude of DSM investments varies widely across the four utilities (Figure 2.1). Almost half ($358 million) of this total was expended by PG&E, the largest of the four investor-owned utilities and the country's leading utility in terms of DSM expenditures in 1992 (Hirst, 1994). Less than 10 percent ($70 million) was spent by SDG&E, the smallest of the four utilities. However, the magnitude of the SDG&E investment is still large by national standards. According to Hirst (1994), only twelve electric utilities spent more than SDG&E on DSM in 1992.



Source: Division of Ratepayer Advocates, California Public Utilities Commission, 1993

Figure 2.1 Total Energy-Efficiency/Conservation Expenditures (in Millions of Dollars): 1990-92

[1] In addition, the four utilities spent $114 million on measurement and evaluation activities between 1990 and 1992 and earned shareholder incentives of $156 million between 1990 and 1992, neither of which are reflected in the above total. The four utilities also spent additional funds on information, load management, load retention, and load building programs which are not reflected in the above total.

When calculated as a percent of operating revenues, these conservation expenditures are quite consistent across the four utilities (Table 2.1). Based on the findings of Schlegel, et al. (1993), SCE spent the smallest proportion (1.1%) of its operating revenues on DSM conservation expenditures between 1990 and 1992. At the other end of the spectrum, SoCalGas spent 1.7% of its operating revenues on DSM conservation expenditures.

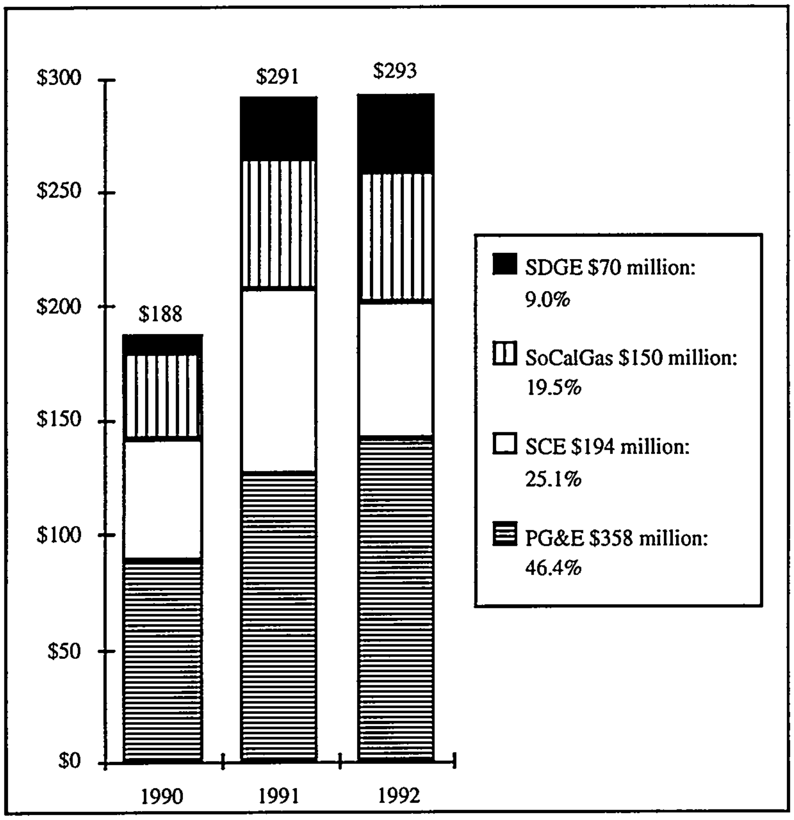
Table 2.1 DSM Conservation Expenditures as a Percent of Operating Revenues

	1990	1991	1992	Averages
PG&E				
Electric	0.9	1.3	1.7	1.3
Gas	1.3	1.4	1.5	1.4
SCE	0.8	1.2	1.3	1.1
SoCalGas	1.2	2.0	1.9	1.7
SDG&E				
Electric	0.6	1.8	2.1	1.5
Gas	0.3	1.2	1.7	1.1
Averages	0.9	1.5	1.7	1.4

Source: Schlegel, et al. (1993), Figures 3-15, 3-21, 3-36, and 3-30.

As Table 2.1 and Figure 2.2 show, DSM expenditures grew rapidly between 1990 and 1991 and leveled off somewhat between 1991 and 1992. The establishment of DSM shareholder incentives for each of the four utilities was a major contributor to this observed increase in utility DSM activities. These shareholder incentives resulted in approximately $100 million in after-tax earnings for the four utilities over the three-year period (Schlegel, *et al.*, 1993).

The increase in DSM expenditures between 1990 and 1992 represents the second period of growth in DSM activities in California. In the early 1980's, California experienced a significant rise in demand-side investments, spurred by regulatory pressures. This was followed by a period of decline in DSM expenditures between 1985 and 1988, corresponding with decreased regulatory interest in DSM. As a result of the growth between 1989 and 1992, three of the four utilities (PG&E, SCE, and SDG&E) have now nearly reached or exceeded the high levels of investment in DSM experienced at the end of the earlier growth period. SoCalGas is the one exception. It has experienced only modest increases in its DSM expenditures in recent years, and by 1992-93, was spending less than half of the amount it had invested annually in DSM between 1983 and 1985. This is due to generally lower gas prices than in the 1980's and the consequent significant reduction in DSM budgets which can be justified by SoCalGas based on benefit-cost criteria.



Source: Division of Ratepayer Advocates, California Public Utilities Commission, 1993

Figure 2.2 Total Energy-Efficiency/Conservation Expenditures (in Millions of Dollars): 1990-92

2.2 DSM EXPENDITURES BY SECTOR AND PROGRAM TYPE

The four investor-owned California utilities operate DSM programs that serve the residential, commercial, industrial, and agricultural sectors. These programs can be divided into two types: (1) resource programs that typically earn the utilities shared-savings incentives, and (2) equity/services programs that generally are operated for performance-adder incentives.

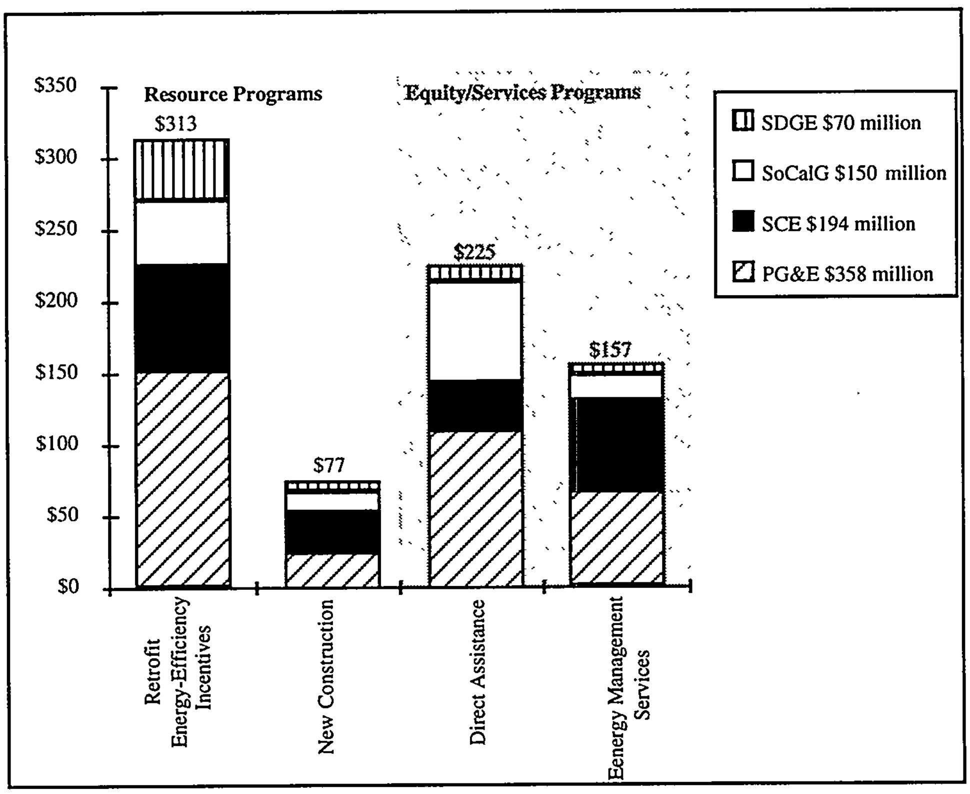
Resource programs include a variety of retrofit incentive and new construction programs. These programs are intended to be viable, cost-effective alternatives to supply-side options for which the utilities are eligible to earn shared-savings incentives.

Equity/services programs include residential direct assistance programs for low-income households, which are viewed as equity programs. Most of the utilities are eligible to earn performance-adder incentives for operating these programs. DSM programs that provide energy management services such as energy audits of buildings and industrial processes also fall into the equity/services category. The savings of these programs are difficult to measure, even though they may be significant. Utility incentives are therefore based on performance-adders and not shared-savings. Many of the equity and services programs are mandated by the CPUC, while the resource programs are not.

Reflecting these various programmatic differences, the CPUC employs the following classification scheme for DSM programs:

- retrofit energy-efficiency incentives (residential and commercial/industrial/ agricultural - C/I/A),
- residential direct assistance,
- new construction (residential and C/I/A), and
- energy management services (residential and C/I/A).

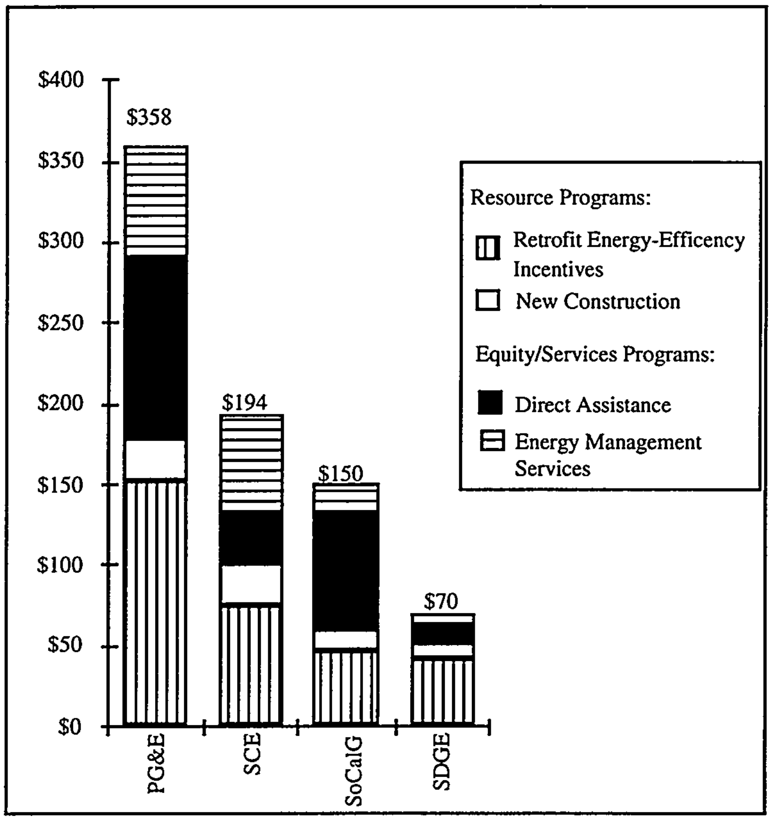
Figure 2.3 indicates that retrofit energy-efficiency incentive programs account for the largest percentage of DSM expenditures of the four types of programs, totaling $313 million or 41 percent of the total. Residential direct assistance programs account for the next largest percentage, with $225 million (29 percent). Energy management services are a close third, with $157 million (20 percent). Finally, new construction programs represent the smallest type, with only $77 million, or 10% of the total expenditure.



Source: Division of Ratepayer Advocates, California Public Utilities Commission, 1993

Figure 2.3 Total Energy-Efficiency/Conservation Expenditures by Program Type (in Millions of Dollars): 1990-92

Figure 2.4 shows the allocation of each utility's DSM expenditures across the four types of programs. These expenditure profiles exhibit several noteworthy differences. In particular, PG&E and SCE spent high proportions of their total DSM budgets on energy management services programs. SoCalGas, in turn, dedicated a large proportion of its total DSM expenditures to its residential direct assistance programs. All three of these utilities spent a sizable share of their DSM expenditures on equity/services programs, ranging from 48% for SCE to 60% for SoCalGas. SDG&E provides a different profile, with 60 percent of its DSM expenditures going to retrofit energy-efficiency incentive programs. Altogether, SDG&E spent only 27% of its DSM expenditures on equity/services.



Source: Division of Ratepayer Advocates, California Public Utilities Commission, 1993

Figure 2.4 Total Energy-Efficiency/Conservation Expenditures by Utility (in Millions of Dollars): 1990-92

2.3 OVERVIEW OF PROGRAM PARTICIPATION LEVELS

The impact studies shown in Table 1.1 provide a basis for describing the magnitude of the California DSM activities in terms of program participation levels (described in this section) and numbers of measures distributed (described in section 2.4). The impact studies do not report participant or measure penetration levels for every DSM program, nor do all the impact studies cover all three years.[2] As a result, the data presented in the following figures should be viewed as illustrative and not as a complete inventory.

Altogether, the four types of residential DSM programs shown in Figure 2.5 for which evaluation studies were submitted served more than 800,000 households. Altogether, an estimated 2,400,000 customers benefited from California's DSM programs over the three-year period. Although there may be some duplication in these totals--as when a household first has an audit and then participates in a retrofit incentive program--the numbers are nevertheless impressive. Table C.1 in Appendix C lists the programs and annual numbers of participants that constitute the totals reported in Figure 2.5.

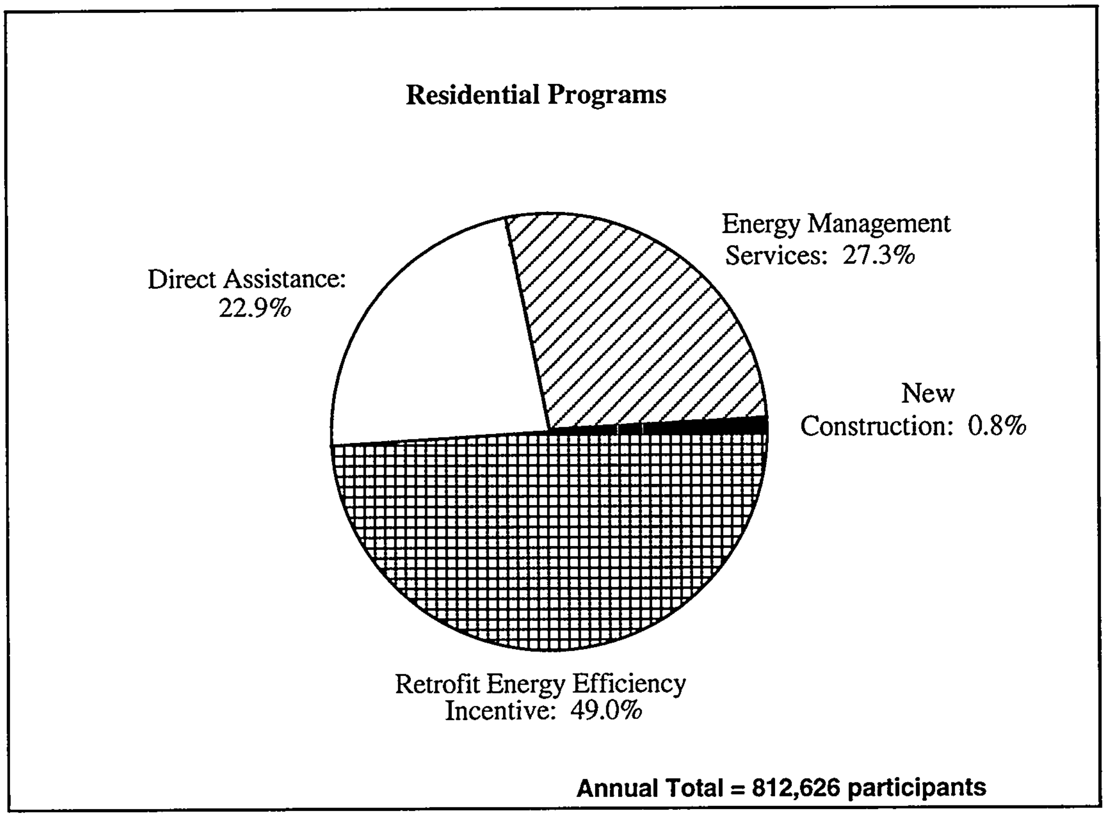


Figure 2.5 Annual Number of Participants in Residential Programs Covered by Evaluation Studies

Impact evaluations of 11 residential retrofit energy-efficiency incentive programs were conducted, spanning all four utilities. Included among these programs are residential weatherization, ceiling insulation, appliance efficiency, compact fluorescent, and low-flow showerhead programs.

2 The data on numbers of participants are annualized, so that comparisons can be made across impact studies that cover different time periods. For example, 21,976 households participated in PG&E's Ceiling Insulation Rebate Program during 1991 and 1992. The annualized participation level reported in this chapter, therefore, is 10,988.

These eleven programs served almost 400,000 participants on an annual basis during the 1990-92 time frame (Figure 2.5). The compact fluorescent lighting programs account for approximately half of these participants. Programs offering incentives for the purchase of energy-efficient central air-conditioning units and refrigerator replacements account for the largest share of the remaining participants.

Each of the four utilities operated a residential energy management services program between 1990 and 1992. Altogether, approximately 222,000 households participated in the programs covered by evaluation studies each year, receiving home audits, energy information, and/or low-cost measures such as low-flow showerheads or compact fluorescent lamps. The largest of these programs is operated by SCE, which accounts for nearly half of these participants.

As noted previously, residential direct assistance programs account for 29% of the total expenditures of the four utilities on energy-efficiency/conservation programs. Based on participation levels for seven of these programs, nearly 186,000 low-income households (representing 23% of the number of residential participants) participated in these seven programs each year between 1990 and 1992. These programs range from relamping efforts (which accounted for 59,874 of SCE's participants each year) to more substantial home weatherization and appliance repair and replacement programs, which served most of the remaining participants.

Several of the utilities also operate residential new construction programs that provide financial incentives and technical assistance to builders to construct homes that exceed Title 24 standards. Participants in the three programs with impact studies served approximately 6,900 participants each year. These numbers are small, as are the expenditures on these DSM programs, partly because of the depressed home construction industry that characterized the national economy during this period.

Figure 2.6 summarizes the annual levels of participation in the C/I/A programs covered by the impact studies. The annual total is 61,000 participants, suggesting a three-year total of 183,000. Table C.2 in Appendix C lists the levels of participation by program.

The definition of program "participants" is complicated for many C/I/A programs. For example, one customer may be responsible for many audits or several retrofit "projects" located at more than one site. At the other extreme, several customers may be part of a single commercial building new construction project. Since information was not always available on participation levels using identical units, Figure 2.6 is a compilation of different units. (See Table C.2 for further details.) The number of units have been annualized based on the reporting period, to give a mean number of units delivered per year. Some of these figures are derived by extrapolating sample results over a utility customer base.

C/I/A energy management services programs operated by the four utilities served approximately one-fourth as many participants annually (totaling 52,000) as their residential EMS program counterparts. As with the residential EMS programs, SCE delivered energy management services to the largest number of C/I/A participants -- accounting for approximately half of the total. At the other extreme, SDG&E had fewer than 1,000 participants in their C/I/A EMS programs.

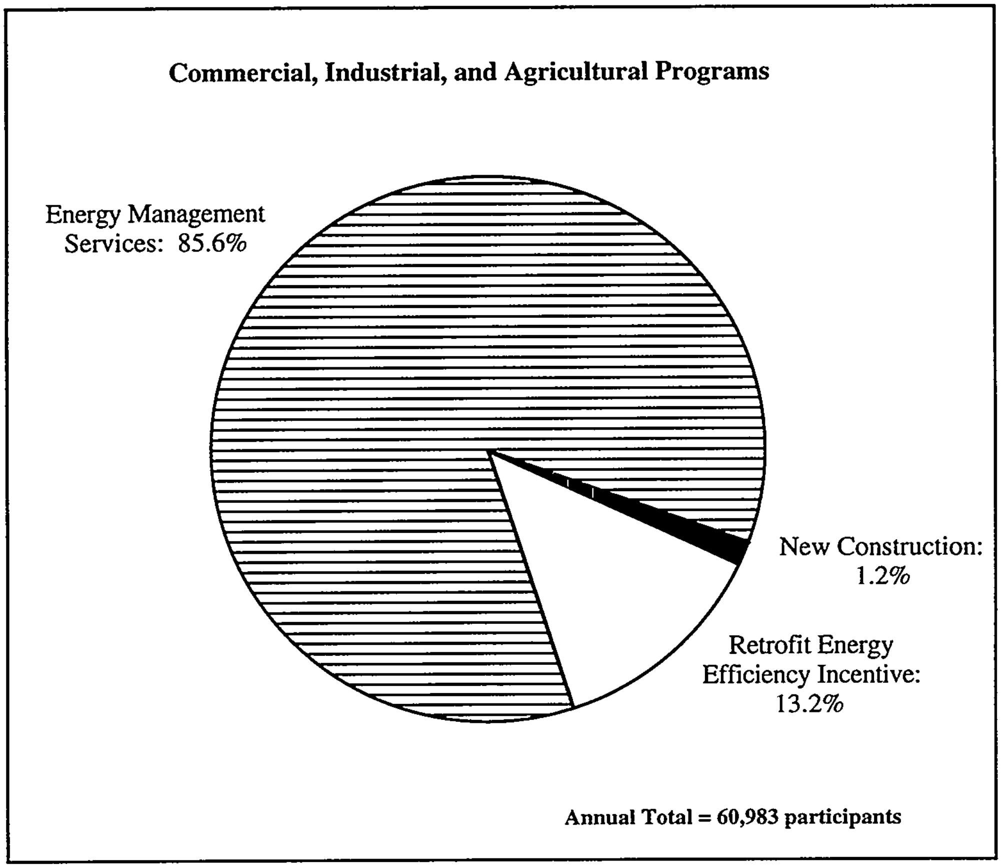


Figure 2.6 Annual Number of Participants in C/I/A Programs Covered by Evaluation Studies

Levels of participation in C/I/A new construction programs are much smaller than in C/I/A retrofit and energy management services programs, reflecting the lower level of utility expenditures dedicated to these programs. The number of participants in C/I/A new construction programs operated by three of the four utilities, per year, ranged from 57 in PG&E's program to 584 in SCE's program. The energy-efficiency technologies promoted by these programs include high-efficiency lighting, glazing, daylighting controls, motors, adjustable speed drives, and high-efficiency cooling, refrigeration, and cooking equipment.

Based on the numbers of participants in programs covered by impact evaluation studies itemized in Figures 2.5 and 2.6, the four California utilities served nearly 900,000 participants annually between 1990 and 1992, or more than 2,600,000 participants over the three years. Since a participant may take advantage of two or more of a utility's programs, the unduplicated number of participants may be somewhat less. Nevertheless, these figures indicate that an impressive number of customers have benefited from California's DSM programs.

2.4 INSTALLATION LEVELS FOR SELECTED MEASURES

In addition to comparing the levels of DSM expenditures and the numbers of DSM program participants across utilities, it is possible to compare the numbers of DSM measures distributed for a small subset of residential measures: compact fluorescent lamps, low-flow showerheads, and refrigerator replacements.

Based on the impact evaluation studies reviewed, compact fluorescent lamps would appear to be the DSM measure that was distributed to the greatest number of customers between 1990 and 1992. In particular, the annualized numbers shown in Figure 2.7 indicate more than 775,000 lamps were distributed each year by the three utilities that deliver electric services: PG&E, SCE, and SDG&E. Between 200,000 and 300,000 lamps were distributed annually by each of these utilities under programs for which impact evaluation studies were submitted. The average number of compact fluorescent lamps delivered per household ranged across programs from 1.0 to 4.6.

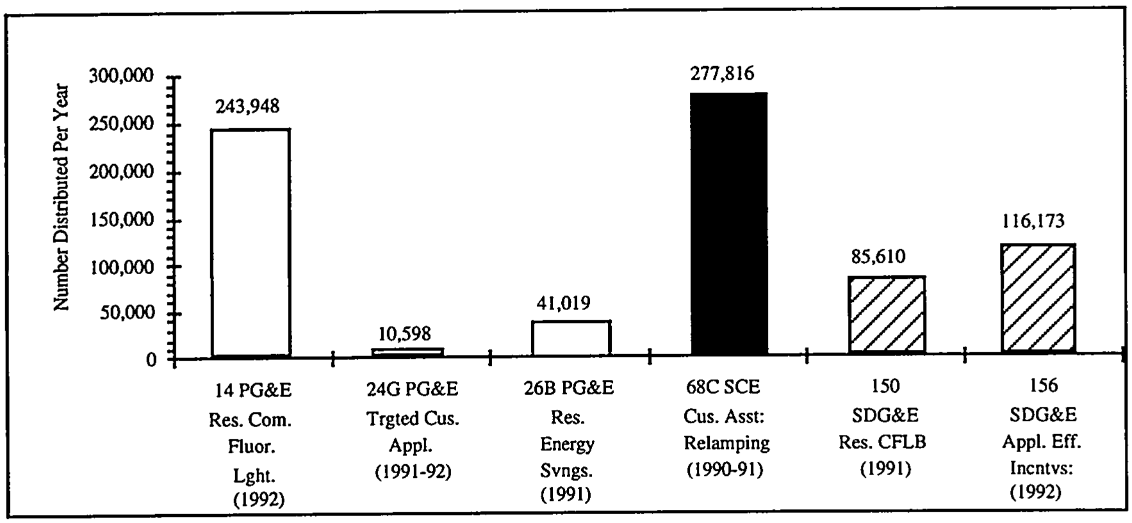


Figure 2.7 Number of Compact Fluorescent Lamps Distributed for Programs Covered by Evaluation Studies

All four utilities operated one or more programs that included the distribution of low-flow showerheads. However, data on numbers of measures installed are available for only two utilities: PG&E and SDG&E. The numbers reported in Figure 2.8 suggest that these utilities distributed more than 120,000 low-flow showerheads on an annual basis during the three-year study period under programs for which impact evaluation studies were submitted.

Refrigerator replacements are a feature of the DSM programs operated by three of the four utilities (specifically, those that provide electric services). The three programs listed in Figure 2.9 for which evaluation studies were submitted contributed to the purchase of nearly 123,000 energy-efficient refrigerators each year between 1990 and 1992.

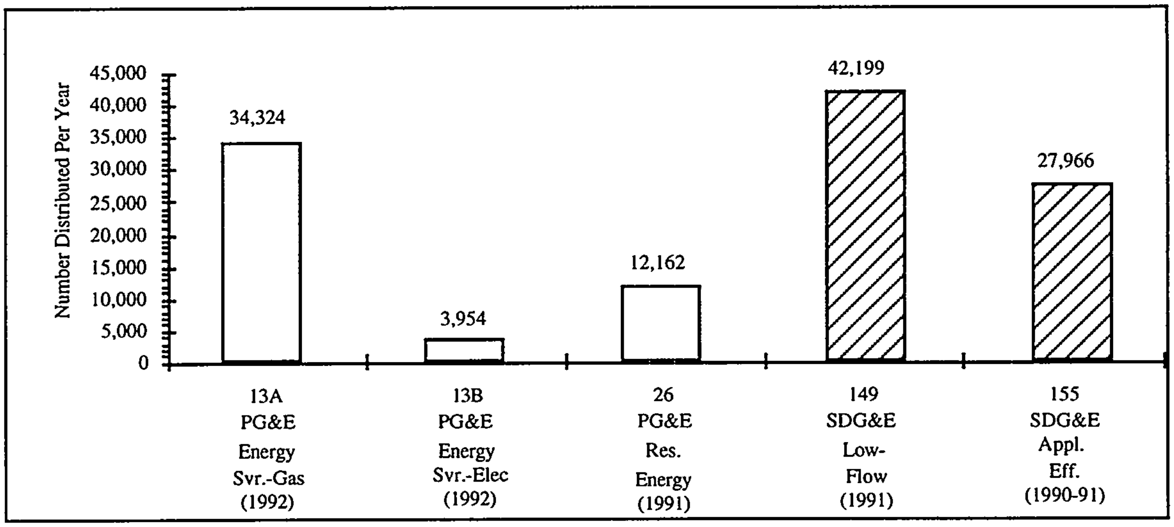


Figure 2.8 Number of Low-Flow Showerheads Distributed Under Programs Covered by Evaluation Studies

Based on the measure penetration rates itemized in Figures 2.7 through 2.9, the four California utilities have had a significant impact on the purchase and installation of energy-efficient equipment and materials in the State. Undoubtedly this has been responsible for generating region-wide consumer demand for DSM products and for strengthening the wholesale and retail infrastructures that promote their distribution beyond the immediate participants in DSM programs. None of the 50 impact evaluations reviewed here attempted to monetize these market transformation benefits.

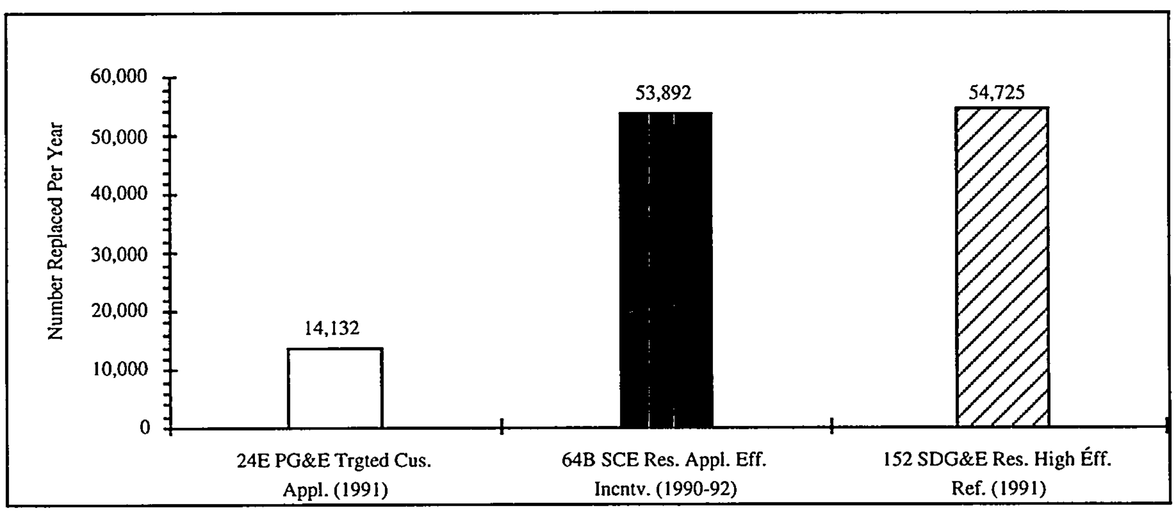


Figure 2.9 Number of Refrigerator Replacements Under Programs Covered by Evaluation Studies

This chapter has documented the sizable investment made by California utilities in their 1990-92 energy-efficiency/conservation programs. It also highlights the variability in the magnitudes and types of DSM investments made by each utility.

- PG&E invested $358 million on DSM programs, with a higher-than-average percentage going to residential direct assistance programs (42%), which served approximately 76,000 low-income households each year. Of the four utilities, PG&E invested the lowest percentage of its DSM expenditures (7%) in new construction programs.

- SCE spent a particularly high percentage (31%) of its $194 million DSM investment providing energy management services. These programs benefited 110,000 households and more than 25,000 commercial, industrial, and agricultural participants each year.

- SoCalGas spent only 13% of its $150 million DSM budget on energy management services. Its DSM emphasis was on residential direct assistance programs, which consumed 47% of its budget and provided appliance repair and replacement services to 31,000 low-income households each year.

- SDG&E spent 60% of its $70 million DSM expenditures on retrofit energy-efficiency incentives. This investment contributed to the purchase of nearly 55,000 high-efficiency refrigerators and more than 70,000 low-flow showerheads each year.

The emphasis of each utility on different types of DSM programs and energy end uses can be explained in part by the type of energy distributed by each utility: natural gas only (SoCalGas), electricity only (SCE), or both fuels (PG&E and SDG&E). Two obvious examples are compact fluorescent and refrigerator replacement programs which are part of the DSM portfolios of the three utilities that offer electric services, but are not operated by SoCalGas. Other explanations for the diverse approaches must lie in characteristics of the customer base, climate, and perhaps the resource planning process. It is possible that by sharing the results of DSM impact evaluations, a trend toward greater convergence on the most successful types of programs and end uses will emerge.

3. SUMMARY OF *EX-POST* PROGRAM IMPACT ESTIMATES FOR SELECTED PROGRAMS

3.1 INTRODUCTION

This chapter, along with Chapter 4, summarizes energy and demand savings as reported in the individual utility evaluations studied. This chapter summarizes estimated savings at the programmatic level (where available), while Chapter 4 summarizes savings reported at the participant or measure level. The focus is on net electrical energy savings (mWh or kWh), net electrical demand savings (MW or kW), and net gas savings (therms).

Before describing our results, it is important to note the constraints of this analysis. Because of the significant variation in the ways savings were estimated and reported, it is difficult to systematically compare estimates of savings on the same dimensions or to aggregate savings. Some of the sources of this problem are described below.

- The savings reported vary by time frame. Some studies reported savings for a single year, while others reported savings for multiple years or parts of years. Where possible, the authors attempted to annualize the savings, if this could be done with a reasonable degree of confidence. If not, the savings are reported for the period covered by the study.

- Savings were reported at many different levels of aggregation. Some savings were reported for the program as a whole. In other cases, savings were reported on a per measure basis (e.g., per refrigerator replaced). In other cases, savings were reported on a per participant basis. In some cases, savings were reported by end-use measure class (e.g., lighting as a measure class category in commercial buildings as opposed to per fixture). Savings were also sometimes reported on a per building or per average building basis.

- Savings are reported in a variety of different units of measurement. Some studies reported savings on a megawatt hour per year basis. In other cases, average monthly kilowatt hours were reported. In yet another variant, watts per measure saved by a program were reported in one study, and a separate study then estimated the number of hours each measure was used. The combination of studies would thus provide estimated watt-hour savings.

- Consistent savings estimation approaches were not used across the four utilities, or even within single utilities. Evaluation methods also vary by sector and program type. For instance, significantly different approaches were employed to estimate savings for residential programs versus commercial, industrial, and agricultural programs. Although the use of different methods is often appropriate, it does complicate comparisons. These differences also may create systematic biases in the estimation of savings.

- Finally, the ways savings were reported tended to vary by the evaluation method employed. Conditional demand analysis, for example, often reported results in terms of units such as average monthly kilowatt hours, while building simulation modeling would report estimated savings per building, or per average building, disaggregated to measure classes.

Wherever possible, the authors attempted to normalize the reported savings through simple calculations. In each case, the authors attempted to carefully label the savings as reported in the individual studies.

The programs themselves, even those that appear similar on the surface, are also highly diverse in design and delivery. This can account for significant variation in the reported savings. The fact that different program savings are reported on the same graphic is simply a presentational convenience, and is not meant to indicate the programs are comparable.

Since the completion of most of the studies summarized in this report, Protocols and Procedures for the Verification of Costs, Benefits, and Shareholder Earnings from Demand-Side Management Programs were developed by the four utilities, the California Energy Commission (CEC), the California Public Utilities Commission (CPUC) - Division of Ratepayer Advocates, and the Natural Resources Defense Council (NRDC). These Protocols (revised July 21, 1994) were adopted by CPUC Decision 93-05-063, and thus will govern all future DSM program evaluations beginning January 1, 1994.

The Protocols were designed to apply consistent and rigorous measurement and evaluation procedures to the DSM programs operated by the four utilities. They contain explicit and detailed guidelines for conducting impact evaluations and reporting impact evaluation results. Specifically, Tables 6 and 11 and Appendix E of the Protocols address reporting of impact measurement study results in a consistent manner. Adherence to these Protocols by the four utilities will greatly facilitate future comparison and aggregation efforts of the type attempted in this report, and may be expected to mitigate many of the aggregation problems encountered in this report. The evaluation studies summarized in this report were prepared prior to the adoption of the Protocols.

3.2 RESIDENTIAL PROGRAMS

This section summarizes savings where they were reported at the program level. Not all of the studies reported program level savings. Some studies only reported per measure savings. Therefore, the figures in this chapter do not present the total savings achieved, but only the portion of savings reported at the program level. Chapter 4 summarizes savings reported at the per measure level.

Figure 3.1 summarizes residential program level electricity savings as reported in the 50 studies. For those studies reporting program level savings, a total of 124.6 GWh of savings were reported. Sixty-nine percent of these savings derived from retrofit incentive programs while 25% came from direct assistance programs. Table C.3 in Appendix C contains the study level details underlying the program level electricity savings reported in Figure 3.1.

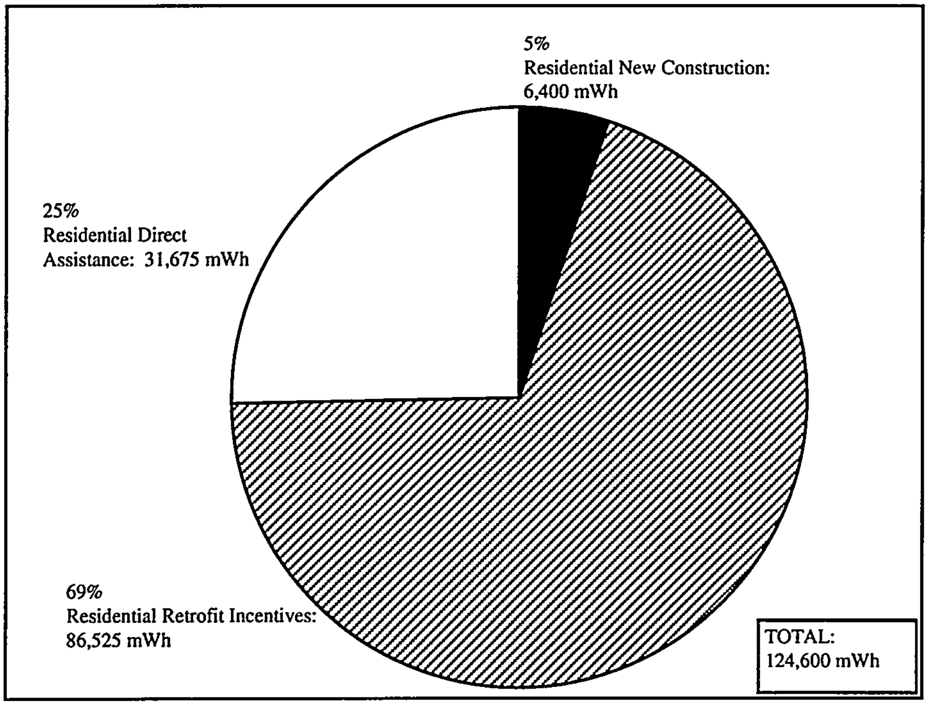


Figure 3.1 Summary of Residential Program Level mWh Savings Reported in Nine Evaluation Studies

Based on these impact studies of residential programs, Southern California Edison's Residential Appliance Efficiency Program (Study No. 64) accounts for the largest program-wide electricity savings with a total of 53,341 megawatt hours of savings between 1990 and 1992. SCE also accounts for the program with the second largest electricity savings--24,381 megawatt hours--which resulted from the Customer Assistance Relamping Program in 1990-91 (Study No. 68). According to the impact studies, the third largest program in terms of electricity savings was PG&E's Residential Compact Fluorescent Program (Study No. 13). It saved 13,807 megawatt hours in a single year (1992). Thus, two of the three programs that saved the most electricity according to the impact studies were compact fluorescent lighting programs.

Figure 3.2 shows the distribution of program-level mWh savings (exclusive of new construction) by end-use. Sixty one percent of these savings derive from appliance efficiency programs, while 36% came from lighting programs.

Figure 3.3 summarizes residential gas savings for those studies reporting savings at the program level. A total of 8,853 kilotherms of gas savings were reported. The largest portion, 65%, came from retrofit incentive programs. The balance was split approximately equally between direct assistance and energy management services. Table C.4 in Appendix C provides supporting detail on the studies underlying Figure 3.3.

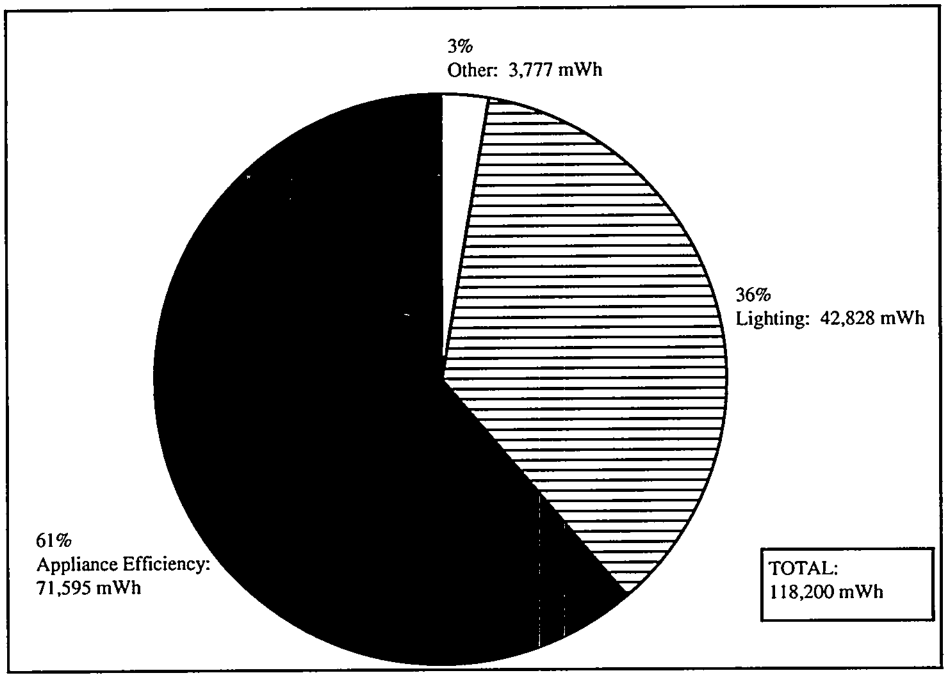


Figure 3.2 Summary of Residential Program Level mWh Savings By End-Use Category Reported in Nine Evaluation Studies (Excludes New Construction)

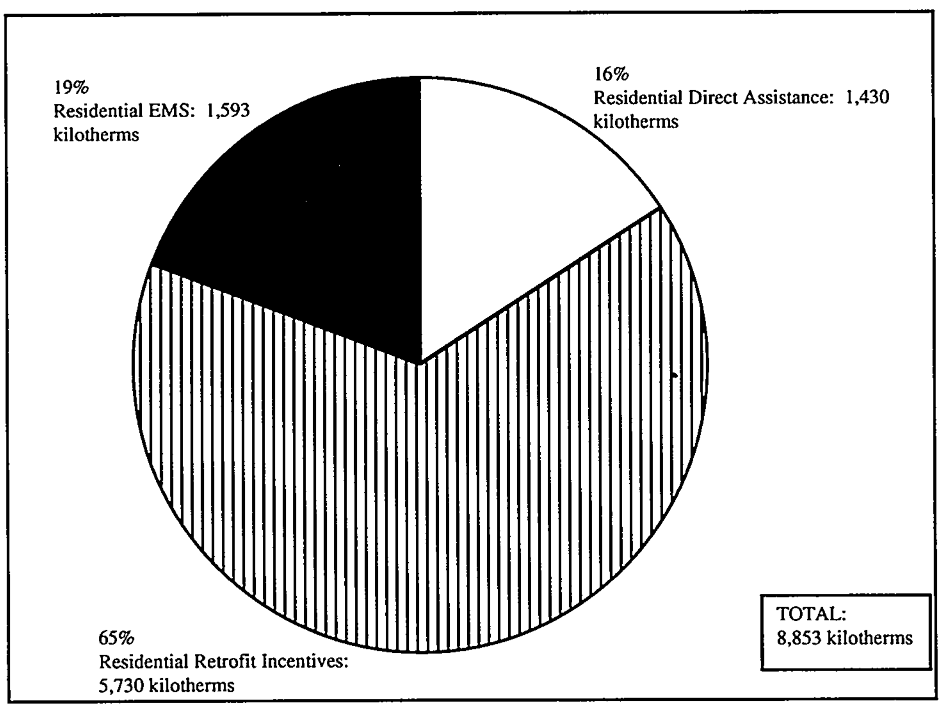


Figure 3.3 Summary of Residential Program Level Gas Savings Reported in Nine Evaluation Studies

Southern California Gas' Residential Conservation Program (Study No. 129) reported the largest savings among these programs, totaling 2,559 kilotherms during 1990-92. This was followed closely by SoCalGas's Residential EMS Program with 1,693 kilotherms in 1990 (Study No. 195). The residential program with the largest estimated savings is PG&E's Ceiling Insulation Rebate Program (Study No. 12), which produced an estimated savings of 714 kilotherms during the 1991-92 period.

3.3 COMMERCIAL, INDUSTRIAL, AND AGRICULTURAL PROGRAMS

This section summarizes the savings estimates for commercial, industrial, and agricultural (C/I/A) programs, where they were reported at the program level. Figure 3.4 summarizes net electrical energy savings. Compared to the residential programs reviewed above (Figure 3.1), the C/I/A programs saved an order of magnitude more electricity than the residential programs. (Seven non-residential evaluation studies reported program-wide energy savings as compared to nine residential evaluation studies.)

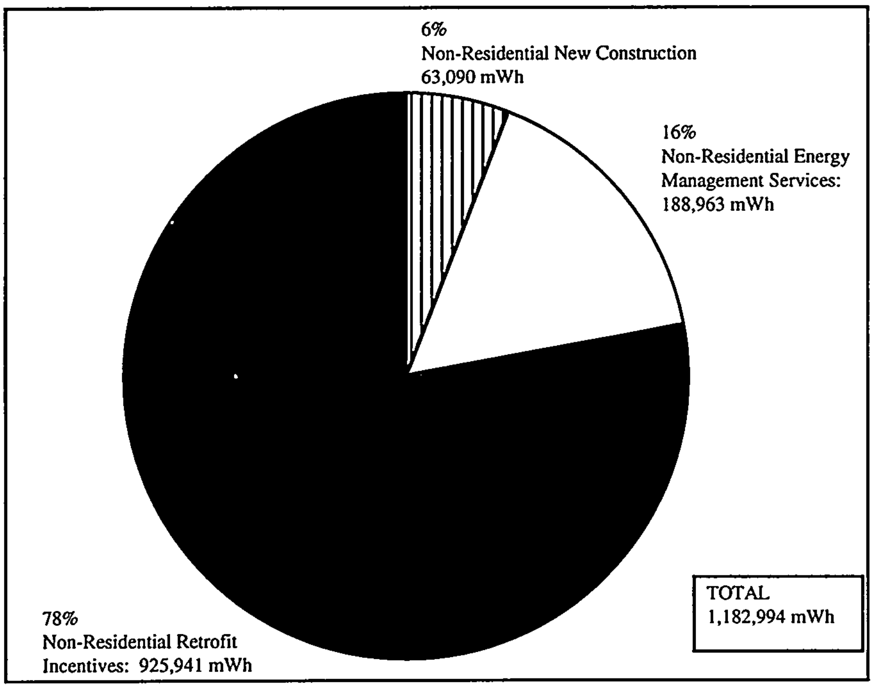


Figure 3.4 Summary of Program-Level Non-Residential mWh Savings Reported in Seven Evaluation Studies

A total of 1,182,994 mWh of non-residential electricity savings were reported, with 78% of these savings deriving from non-residential retrofit incentive programs. Non-residential energy management services accounted for 16% of the savings while new construction accounted for 6% of the reported savings.

PG&E's Commercial, Industrial, and Agricultural Retrofit Rebate Program for the period 1991-92 (Study No. 43) reported over 663,000 megawatt hours of savings for the 1991-92 period. Its Commercial, Industrial, and Agricultural Customized Rebate Program saved over 208,000 megawatt hours between 1990 and 1991, and its Nonresidential Energy Management Services Program saved 177,000 megawatt hours over the same period. In contrast, recall that Southern California Edison's Residential Appliance Efficiency Program (Study No. 64) is the residential program with the largest program-wide savings, totaling 53,341 megawatt hours of savings between 1990 and 1992.

Figure 3.5 summarizes non-residential electrical demand (MW) savings reported at the program level. (NOTE: Very few residential programs reported MW demand savings.) A total of 225.7 MW of demand savings were reported for non-residential programs at the program level. The largest share, 64%, again derived from non-residential retrofit incentive programs. As with the estimates of energy savings, PG&E's Commercial, Industrial, and Agricultural Retrofit Rebate Program accounts for the largest estimated demand savings among the impact studies, totaling 110.5 MW (Study No. 43) for the 1991-92 period. Table C.5 in Appendix C contains study details which underlie the values reported in Figures 3.4 and 3.5.

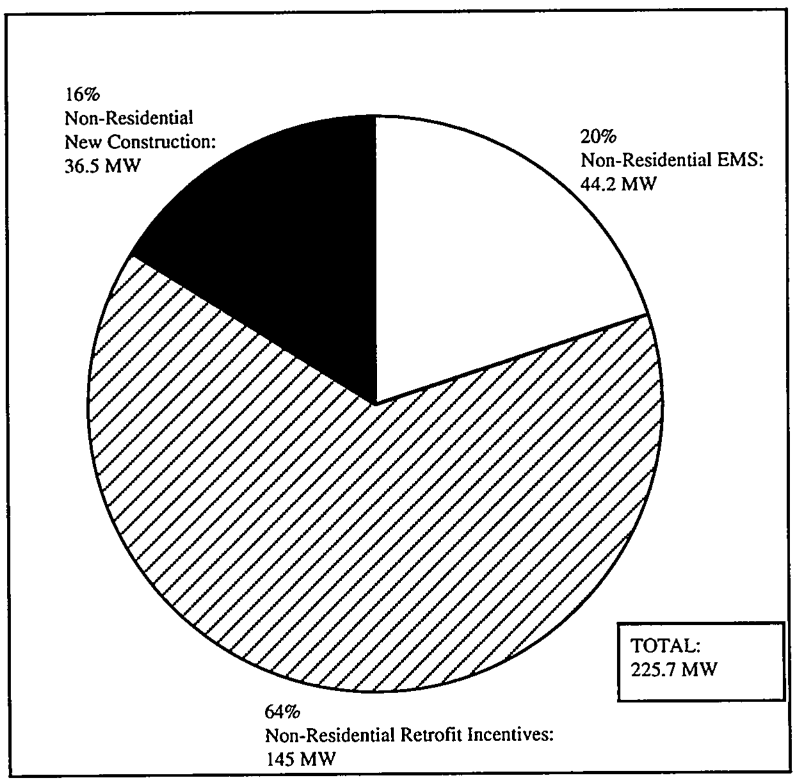


Figure 3.5 Summary of Program-Level Non-Residential MW Savings Reported in Six Evaluation Studies

Only two studies reported non-residential program-level gas savings. A total of 2,712 kilotherms of gas savings were reported by these two studies. The largest of these programs, in terms of gas savings, was PG&E's Nonresidential Energy Management Services Program, which reported 2,572 kilotherms of savings between 1990 and 1992. Details may be found in Table C.6 in Appendix C.

In summary, the aggregate program-level savings as reported by the impact studies are shown in Table 3.1 The table shows that electricity savings from C/I/A programs are an order of magnitude higher than electricity savings from the residential programs for those studies reporting program-level savings. However, a majority of the estimated gas savings resulted from residential programs. In aggregate, over 1.3 million mWh of electricity savings were reported, and 11,565 kilotherms of gas energy savings. Chapter 4 will focus on summarizing evaluation studies which presented measure-level savings estimates.

Table 3.1 Summary of Reported Program-Level Savings*

	Residential Programs	Commercial/Industrial/ Agricultural Programs	Total
mWh	118,200	1,182,994	1,301,194
MW	---	225.6	225.6
Kilotherms	8,853	2,712	11,565

* Savings reflect only those reported at the program level in the studies reviewed. Many studies did not report program-level savings (e.g., only per measure savings were reported). These are not reflected in the above totals.

4. SUMMARY OF *EX-POST* PROGRAM IMPACT ESTIMATES FOR SELECTED MEASURES

Chapter 3 summarized savings as reported at the programmatic level, that is, megawatt hour, megawatt, and kilotherm savings were aggregated to the whole program. Many of the evaluation studies also reported savings on a per measure or per participant basis, in addition to the aggregated programmatic savings. Other evaluation studies only reported savings at the measure or participant level. This chapter provides a summary of savings reported for selected measures or measure categories.

4.1 RESIDENTIAL MEASURES

As examples of measure savings reported in the residential sector, savings for refrigerator, residential lighting, and low-flow showerhead measures are summarized. In all cases, *ex-post* net savings are reported.

Figure 4.1 summarizes the net kWh savings of three programs that promoted energy-efficient refrigerators. As can be seen in Figure 4.1, the range of residential refrigerator-related annual savings vary widely, from 90 kWh to 392 kWh per refrigerator. (See Table C.7 in Appendix C for more details on the studies in Figure 4.1.) These wide ranges reflect some combination of differences in program design characteristics (e.g., refrigerator replacement versus early retirement programs) and evaluation methods. Readers are cautioned against direct comparison of these figures due to the large degree of variation in the program designs and time periods covered. For example, studies 152 and 64B cover programs which provided incentives to purchase refrigerators with greater energy efficiency. On the other hand, the PG&E program (Study No. 24) offered early retirement of refrigerators and refrigerator repair.

Figure 4.2 provides similar comparisons for residential lighting measures. (See Table C.8 in Appendix C for details on the studies in Figure 4.2.) Again, a wide variation of net kilowatt hour savings per lamp is reported (34 kilowatt hours to 128 kilowatt hours), reflecting some combination of differences in program design and implementation features (e.g., the number of lamps installed per home) and evaluation methods.

Further discussion of these two measures (energy-efficient refrigerators and compact fluorescent lamps) appears in chapter 5, where their varying realization rates are analyzed.

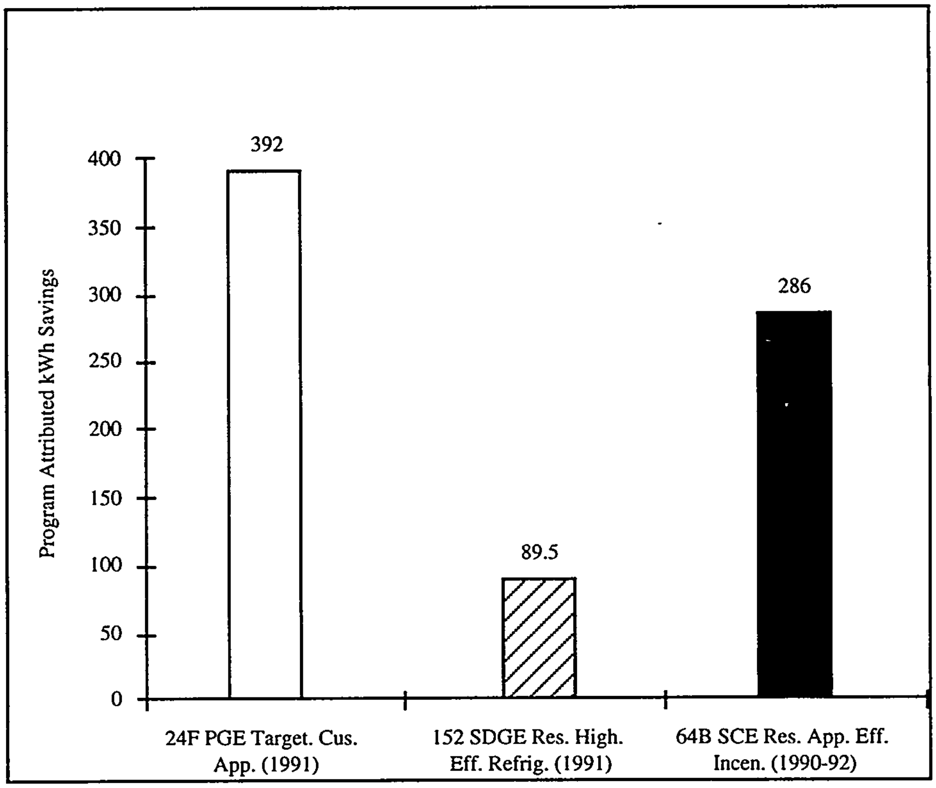


Figure 4.1 Savings Reported per Refrigerator Replaced

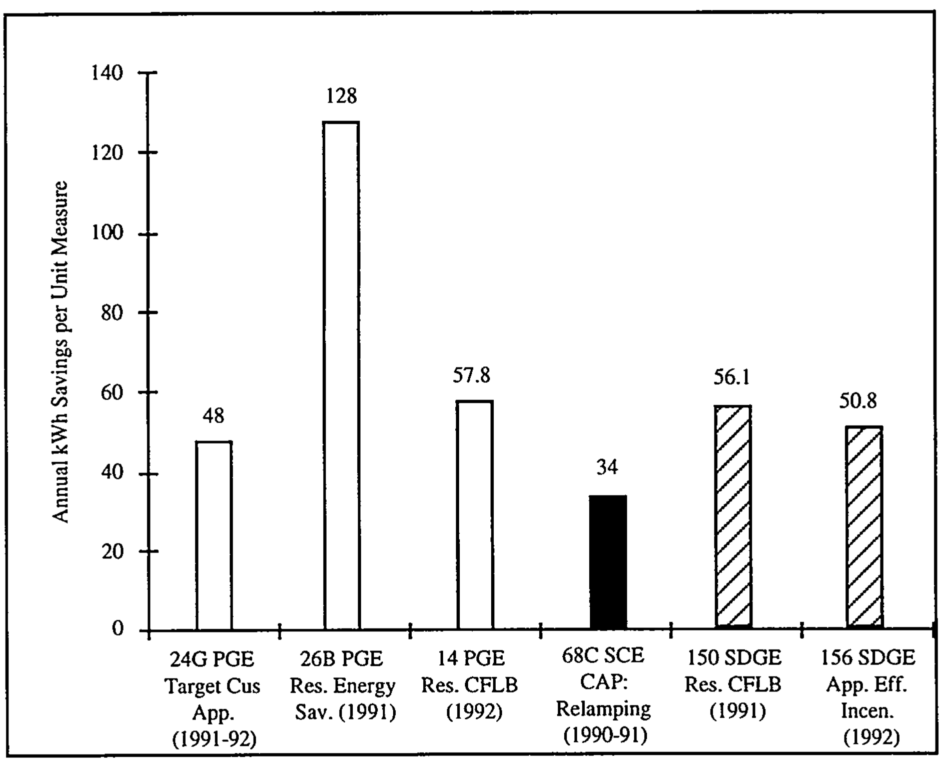


Figure 4.2 Savings Reported per Residential CFLB

4.2 COMMERCIAL, INDUSTRIAL, AND AGRICULTURAL MEASURES

Ex-post estimates of impacts are available for only a few of the C/I/A measures covered by the evaluation reports studied here. These measure-specific estimates are discussed below.

The measure level savings reported by Southern California Edison for its 1990 Energy Management Services and Hardware Rebate Program are illustrated in Figures 4.3 and 4.4. (See Table C.9 in Appendix C for study details.) Figure 4.3 reports estimated annual gross kilowatt hour savings for the indicated measure category.[1] Of the common measures selected for presentation in this report, lighting reflectors and HVAC energy management systems reported the largest gross annual savings at 96,960 kilowatt hours and 90,276 kilowatt hours respectively. Similarly, of the selected measures compared for demand savings, lighting reflectors again delivered the largest gross demand savings (19 kW) followed by indoor lighting systems at 14.5 kW (see Figure 4.4).

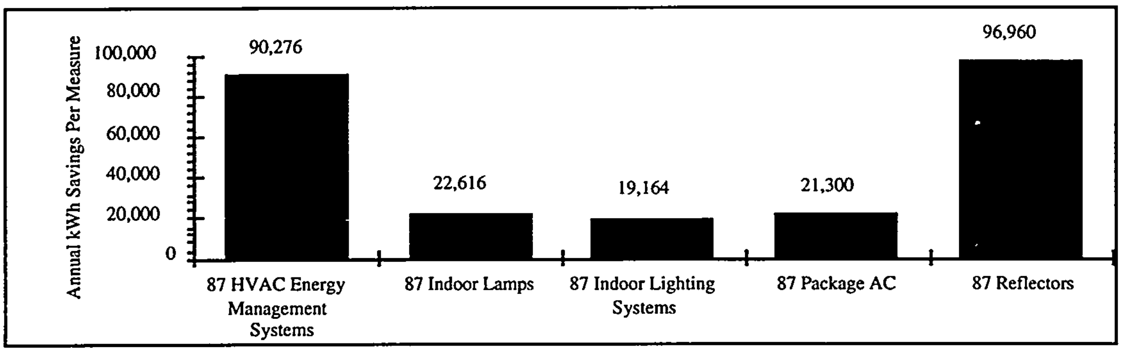


Figure 4.3 Annual kWh Savings Reported by C/I/A Measure Class

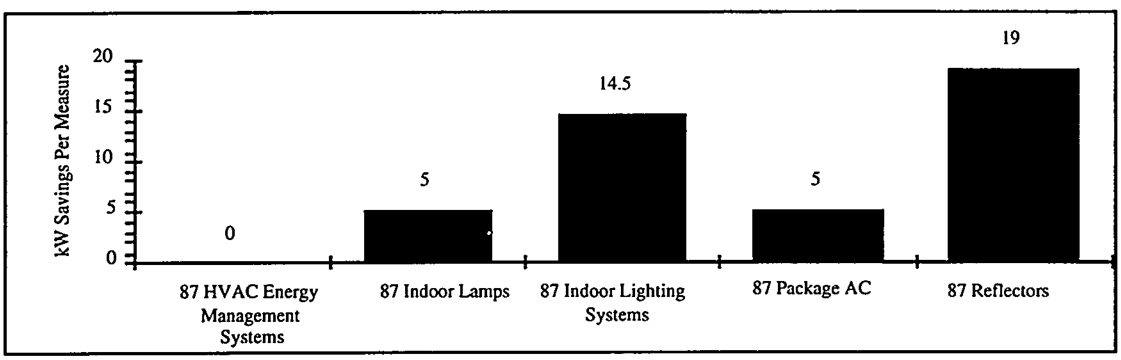


Figure 4.4 kW Savings Reported by C/I/A Measure Class

Figure 4.5 summarizes net annual gas savings per unit for selected measure types in the commercial, industrial, and agricultural sector. (See Table C.10 in Appendix C.) These results are

[1] The study reports gross savings estimates for each measure category and then applies a blanket net-to-gross ratio to all per measure gross savings. The applicable net-to-gross ratios for combined rebate and energy management services programs are 93% for HVAC, 57% for lighting, and 63% for other hardware.

reported by Southern California Gas across two studies (Study No. 137, High Efficiency Commercial Equipment and Study No. 139, Industrial Demand Side Management) for a full range of program measures. Only selected measures are illustrated in Figure 2.5. The figure demonstrates that the largest net gas savings among the commercial measures derived from high-efficiency air conditioning at 17,201 annual net therm savings per unit. (On a program-level basis, however, high efficiency boilers yielded the highest net savings at over 1.9 million therms per year.) In the industrial sector, Southern California Gas reports that of the selected measures analyzed in this report, industrial furnaces deliver the greatest net annual gas savings at 3,053 therms per unit followed by industrial boilers at 1,611 annual therms per unit. Savings covered the program years 1990-92.

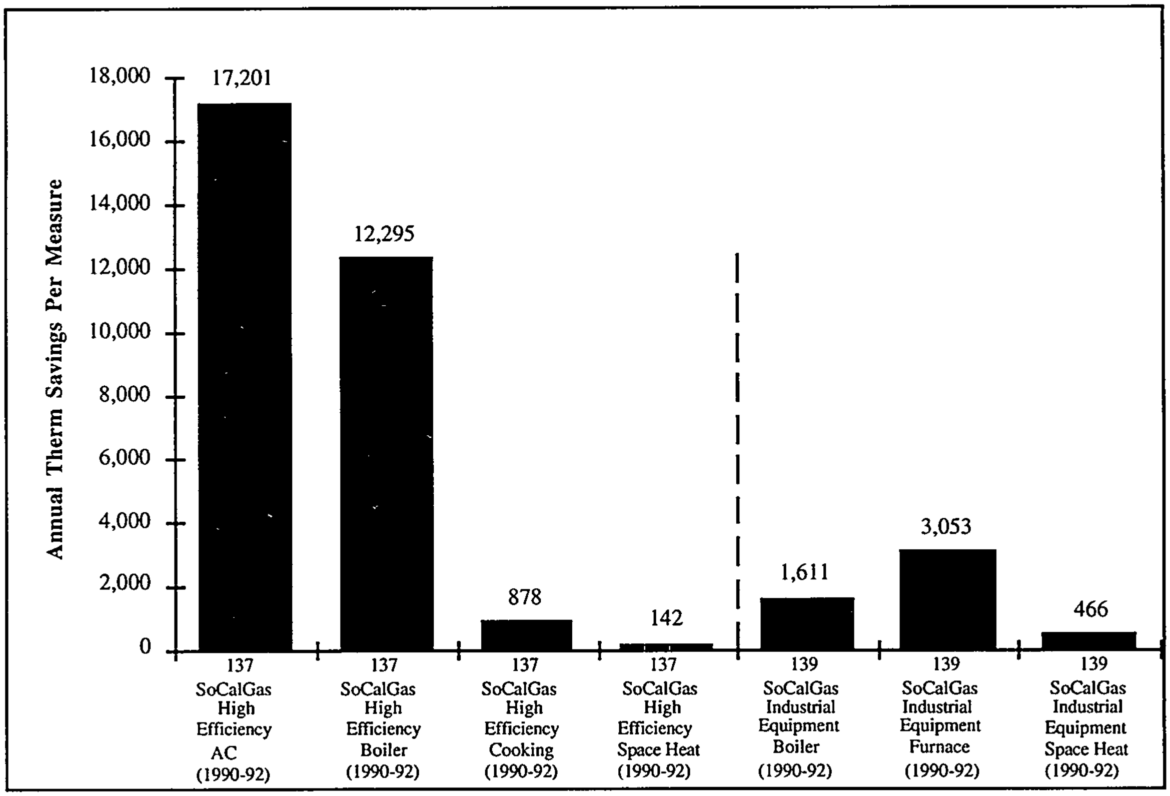


Figure 4.5 Annual Gas Savings Reported by C/I/A Measure Class (Therms)

5. COMPARISON OF *EX-POST* AND *EX-ANTE* IMPACT ESTIMATES

This chapter assesses the relationship between *ex-ante* and *ex-post* estimates of energy savings. A primary purpose of the DSM impact evaluations described in this report is to determine whether or not any systematic biases exist in the *ex-ante* estimates of program savings. Do the anticipated savings tend to be larger or smaller than the savings subsequently achieved by the programs? Identification of systematic biases in the *ex-ante* estimates can lead to improvements in program design, more effective resource planning assumptions, and incentive payments that better reflect program benefits.

The realization rate is used as the main method of assessing bias. As a general rule, realization rates are calculated as the *ex-post* estimate of net savings divided by the *ex-ante* estimate of net savings.[1] There are a few exceptions to this rule, however, as when the numerator of the realization rate is an *ex-post* estimate of gross savings because the impact study did not present net savings or because the net-to-gross ratio is assumed to be 100%. In these cases, the denominator of the realization rate is usually an *ex-ante* estimate of gross savings. In still other exceptions the nature of the *ex-ante* estimate (i.e., net or gross) is unknown. Thus, the nature of all of the realization rates cannot be characterized with certainty.

Realization rates are influenced by numerous factors. First, external events such as economic conditions within a utility's service territory may cause a program to save more or less energy than planned. Economic growth, for instance, may increase the hours of operation of a commercial or industrial establishment, thereby increasing the energy saved by the installation of energy-efficient equipment. Alternatively, the demand for energy-efficient products could increase independent of the utility program. This could increase the percentage of free riders served by a program, thereby decreasing the energy savings attributable to the utility's DSM efforts.

Second, the methods used to predict the energy savings of a program (i.e., the *ex-ante* estimation procedure) may introduce biases in the calculation of realization rates. For instance, simple engineering calculations of *ex-ante* energy savings have often overestimated the energy savings generated by DSM programs (Keating and Nadel, 1991; Brown and White, 1992). An overestimation of the *ex ante* savings can cause the realization rate to fall below 1.0. Unfortunately, it

[1] Net savings refer to the program impacts over-and-above naturally occurring conservation. They can be smaller than gross savings to the extent that some participants would have purchased and installed new energy conservation measures even without the program (i.e., free ridership). Net savings can also be larger than gross impacts to the extent that the program induces additional marketing by trade allies or additional customer investments in conservation measures outside of the program (i.e., market transformation). Many of the impact studies estimated the impacts of free ridership, but only a few of them attempted to estimate the market transformation impacts of California's DSM programs. As a result, in all of the impact studies reviewed, net savings never exceeded gross savings.

was not possible to characterize the type of method used to produce *ex-ante* estimates of energy savings in order to explore this potential source of bias.

Finally, the methods used to estimate the energy savings of a program (e.g., the *ex-post* estimation procedure) may introduce biases in the calculation of realization rates. For instance, if the *ex-post* estimation procedure does not include an adjustment for free ridership, then the realization rate may be upwardly biased. Alternatively, if free drivers are counted as free riders, the bias is reversed. Similarly, *ex-post* estimation procedures that rely on engineering calculations can produce higher estimates than methods based on analysis of utility bills (Brown et al., 1991). The evaluation methods used to generate *ex-post* estimates of energy savings are examined in Section 5.5 as a potential source of bias.

We begin by describing the realization rates of all the programs and program segments studied, and compare these across utilities (Section 5.1) Attention then turns to an analysis of realization rates by sector (Section 5.2) and program type (Section 5.3). After describing the realization rates that resulted from different evaluation methods (Section 5.4), the chapter ends by focusing on the realization rates associated with three specific DSM measures (Section 5.5). As the chapter moves from an aggregate level of analysis to a focused assessment of specific measures, greater explanation of variations in realization rates is possible.

5.1 REALIZATION RATES IN AGGREGATE

The realization rates associated with 158 programs and program segments are examined in this section. PG&E programs account for almost half of these rates (Table 5.1), which is consistent with the fact that they spent 46% of the DSM expenditures of these four utilities during the 1990-92 period. SDG&E, on the other hand, accounts for 18% of the realization rates, while they spent only 9% of the DSM expenditures.

Table 5.1 Realization Rates by Utility

	Mean	Median	Number of Programs or Segments
All programs and program segments	1.12	0.86	158
All programs/segments minus 4 highest outliers	0.93	0.86	154
PG&E	0.99	0.83	73
SCE	0.80	0.87	24
SoCalG	1.78	0.66	32
SDG&E	0.99	0.95	29

The lack of correspondence between each utility's percentage of DSM expenditures versus their percentage of realization rates underscores the fact that the 158 realization rates are not normalized in any sense. One value may represent a large program and may cover multiple years of program operation while another realization rate may represent a component of a smaller program and only a single year. Weighting of the realization rates by their *ex-post* estimates of net savings was beyond the scope of this study, but could represent a valuable addition to the analysis in future efforts of this type.[2]

The distribution of realization rates is shown in Figure 5.1. The median realization rate for all programs and program segments is 0.86, and the mean is 1.12.[3] Applying a statistical test for outliers, we note that the four highest realization rates are more than three standard deviations from the mean. If we do not include the four highest realization rates (ranging from 5.59 to 14.54), the median remains at 0.86, but the mean realization rate drops to 0.93.

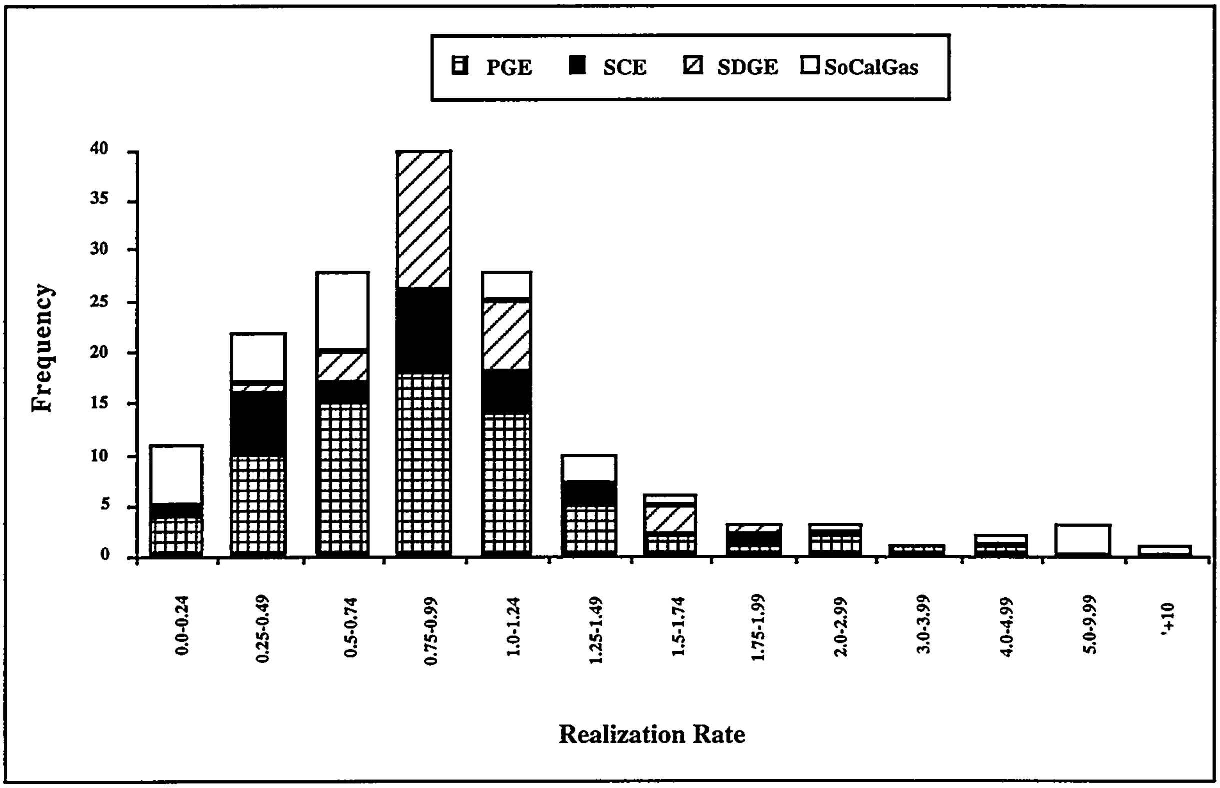


Figure 5.1 Distribution of Realization Rates (N=158)

2 For instance, if a realization rate is calculated by comparing the ex-post and ex-ante savings of a particular retrofit measure, then it would be necessary to know how many of these measures were installed to calculate the total energy savings associated with the realization rate. Alternatively, if a realization rate is calculated for a particular market segment, it would be necessary to know the number of participants in that segment to calculate the total energy savings and thereby weight the realization rate.

3 Both the mean and median values are unweighted measures of central tendency. Each realization rate is given an equal weighting in their calculation.

If we assume that each realization rate is associated with a comparable level of energy savings, then the mean value of 1.12 for all programs and program segments suggests that in aggregate, these programs saved more energy than was anticipated by their *ex-ante* estimates. (Not including the four highest realization rates, the programs saved 93% of the energy anticipated by their *ex-ante* estimates.) A typical program, however, saved only 86% of the expected savings. This finding suggests that for a majority of the programs, the *ex-ante* estimates are upwardly biased, the *ex-post* estimates are downwardly biased, or both biases are operating simultaneously.

The realization rates range widely from the low values for a Showerhead Coupon Program of 0.03 (the electric component) and 0.05 (the gas component) to 14.54 for the boiler component of a High Efficiency Commercial Equipment Program (Figure 5.1). The difference between the mean and median values reflects the skewed distribution of realization rates. Nearly one quarter (22%) of the programs delivered less than 50% of their *ex-ante* savings estimates, while 10% exceeded 150% of their *ex-ante* savings estimates and 3% exceeded 500% of their *ex-ante* savings estimates. This wide variation makes it difficult for resource planners to identify the optimum level of investment in DSM programs.

5.2 REALIZATION RATES BY SECTOR

The realization rates for commercial, industrial, and agricultural DSM programs tend to be higher than those for residential DSM programs (Table 5.2). The mean and median realization rates for C/I/A DSM programs are 1.26 and 0.91, respectively, suggesting that these programs consistently produced the magnitude of savings that they were designed to deliver. (If the four highest C/I/A realization rates are removed, the mean is 0.96 and the median is 0.89.) In contrast, the mean and median realization rates for residential DSM programs are only 0.88 and 0.69, respectively, suggesting that they consistently fell short of their projected energy savings. Some of these sectoral differences may be due to the fact that the impact studies of residential and C/I/A programs tended to rely on different *ex-post* estimation and evaluation methods.[4] Further, a higher percentage of the commercial/industrial/agricultural programs (compared with the residential programs) were operated by the utilities on the basis of shared-savings incentives, which may motivate the utilities to produce or exceed the expected levels of energy savings, thus increasing the *ex-post* savings and, thereby, the realization rate.

[4] For instance, 26 of the nonresidential realization rates resulted from *ex-post* estimates based on simplified engineering models, which had a median realization rate of 1.0. On the other hand, none of the residential realization rates used this method for *ex-post* estimation.

Table 5.2 Mean and Median Realization Rates by Sector

Sector:	Mean	Median	Number of Programs or Segments
Residential	0.88	0.69	60
Commercial/Industrial/Agricultural	1.26	0.91	98

The commercial, industrial, and agricultural DSM programs account for the five highest realization rates (Figures 5.2 and 5.3). (Tables C.11 and C.12 in Appendix C provides details on the studies summarized in Figures 5.2 and 5.3.) All of these are associated with programs operated by SoCalGas and four of them relate to commercial programs. They include:

- the High Efficiency Commercial Equipment Program (boilers, dryers, and weatherization),
- the Industrial Equipment Replacement Program (space heat), and
- the High Efficiency New Commercial Building Program (water heating).

The C/I/A programs also have a cluster of low realization rates ranging from 0.1 to 0.3. As with the high rates noted above, these low rates are also associated with programs operated by SoCalGas, but they are dominated by industrial programs. They are:

- the Industrial Equipment Replacement Program (boilers, dryers, and furnaces),
- the Industrial Heat Recovery Program, and
- the High Efficiency New Commercial Building Program (space heat and cooking).

In contrast to the C/I/A programs, none of the realization rates for residential programs exceed 3.8. (See Figure 5.2.) The two highest rates are associated with PG&E programs:

- the Ceiling Insulation Rebate Program (demand component) and
- the Residential Energy Savings Program (wraps for electric domestic hot water heaters).

In addition to the two extremely low values noted earlier for PG&E's Energy Saver Showerhead Coupon Program, eight additional residential programs or program segments have realization rates of 0.3 or less. All but one of these are associated with residential direct assistance programs, which are not promoted for resource acquisition purposes, including:

- PG&E's Energy Partners Program (gas-heated single-family dwellings with air conditioning),
- PG&E's Energy Partners Program (gas-heated single-family dwellings without air conditioning),

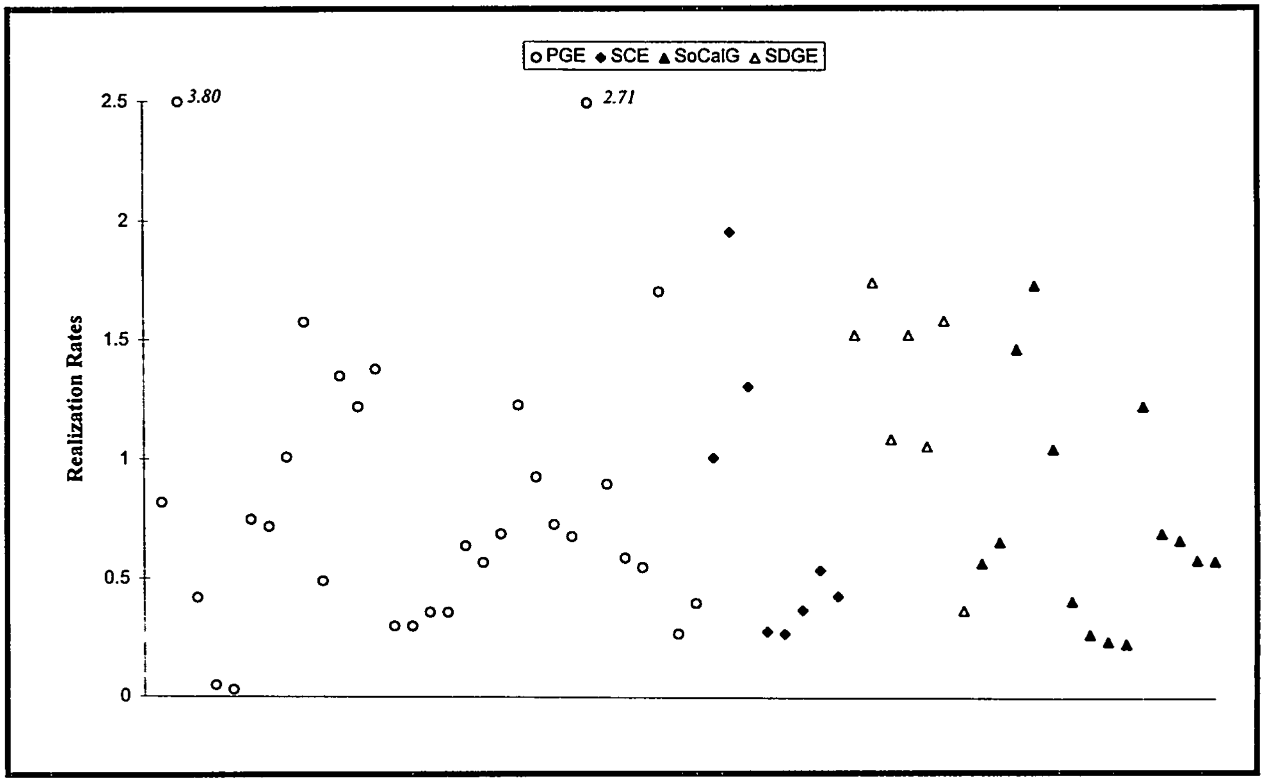


Figure 5.2 Realization Rates for all Residential Programs

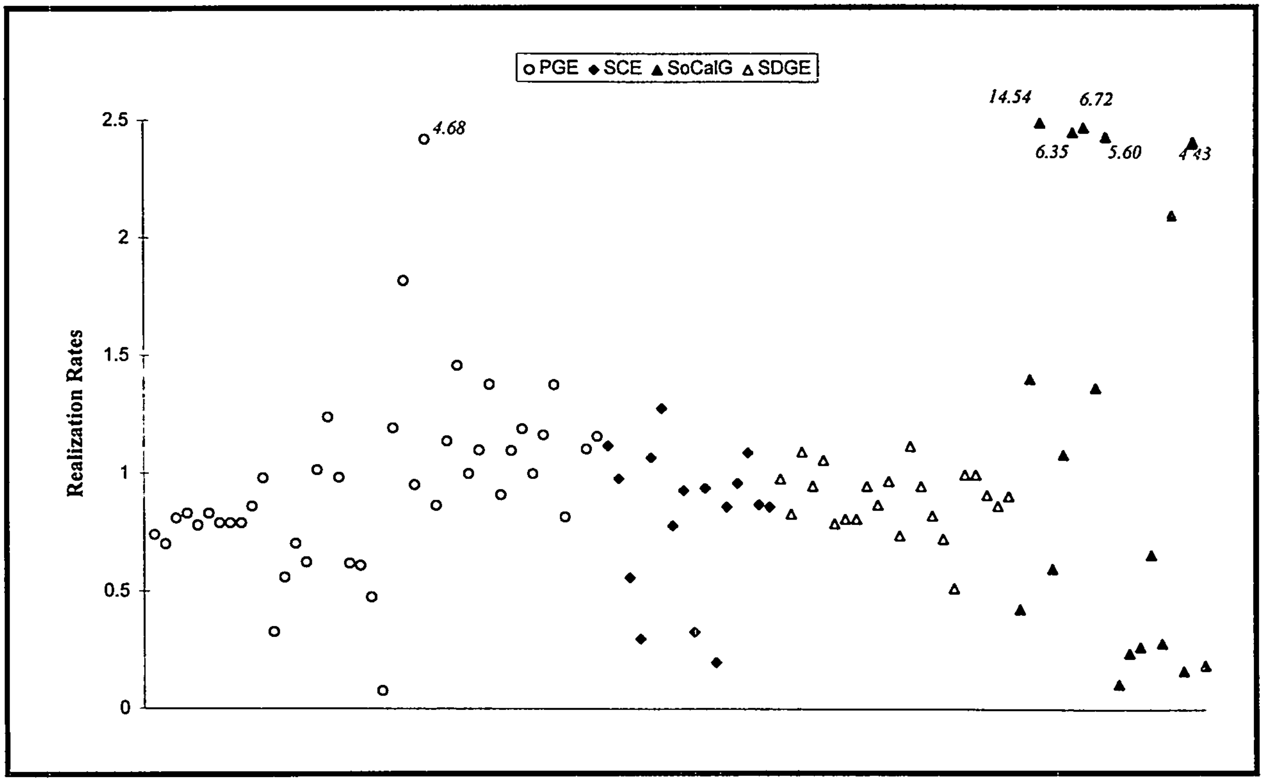


Figure 5.3 Realization Rates for all C/I/A Programs

- SCE's Customer Assistance Program (weatherization),
- SCE's Customer Assistance Program (evaporative coolers and heat pumps),
- SoCalGas's Weatherization/Conservation Program (attic insulation),
- SoCalGas's Weatherization/Conservation Program (water-heater blanket), and
- SoCalGas's Weatherization/Conservation Program (low-flow showerhead).

The other low realization rate pertains to the low-flow showerheads installed by PG&E's Residential Energy Savings Program in dwellings with gas water heaters. Altogether, four of the lowest ten residential realization rates are associated with low-flow showerheads.

5.3 REALIZATION RATES BY PROGRAM TYPE

Of the seven types of DSM programs shown in Table 5.3, the lowest realization rates are experienced by residential direct assistance programs (with a mean of 0.68 and a median of 0.53). Recall that these programs account for a large share (29%) of the total DSM expenditures of the four utilities during the three-year study period. The realization rates for the energy management services programs also tend to be less than 1.0. The residential energy management services programs tend to have particularly low realization rates, with a median of 0.59 but a mean of 1.0, reflecting a few high-

Table 5.3 Realization Rates by Type of Program

Type of Program	Mean	Median	Number of Programs or Segments
Resource Program:			
TOTAL	1.36	0.86	83
Residential retrofit incentives	1.18	1.06	17
C/I/A retrofit incentives	1.54	0.91	52
Residential new construction	0.78	0.70	8
C/I/A new construction	1.16	0.66	6
Equity/Service Program:			
TOTAL	0.85	0.86	75
Residential direct assistance	0.68	0.53	26
Residential energy management services	1.00	0.59	9
C/I/A energy management services	0.92	0.95	40

performing programs. C/I/A energy management services programs have mean and median realization rates of 0.92 and 0.95, respectively, indicating that they came close to generating the energy savings they were projected to deliver. All three of these types of programs earn performance-adder incentives for the utilities, and not shared savings incentives.

With the exception of residential new construction programs, the shared-savings incentive programs generally had higher-than-average realization rates. Residential retrofit incentive programs have the highest median realization rate (1.06 compared to 0.86 for all realization rates), and their commercial, industrial, and agricultural counterparts had the highest mean realization rate (1.54 compared to 1.12 for all realization rates). Recall that retrofit incentive programs account for the second largest share of total DSM expenditures (23%) during the three-year study period. They also are the dominant DSM expenditure for which utilities earn shared savings incentives.

5.4 REALIZATION RATES OF DIFFERENT EVALUATION METHODS

In this section, a typology of seven evaluation methods is used to examine median realization rates. In Section 5.4 we look more closely at evaluation methods in conjunction with three selected DSM measures.

Tables 5.4 presents the mean and median realization rates for the seven evaluation methods, and for residential and C/I/A programs, separately.

Table 5.4 Realization Rates for Seven Evaluation Methods

	Residential Programs			C/I/A Programs		
Evaluation Method:	**Mean**	**Median**	**Number of Programs or Segments**	**Mean**	**Median**	**Number of Programs or Segments**
Billing analysis	0.81	0.64	23	0.95	0.87	33
Conditional demand analysis	0.96	0.67	21	2.87	1.09	14
Metered data	0.93	0.86	4	NA	NA	NA
Simplified engineering model	NA	NA	NA	1.23	1.00	26
Engineering simulation model	0.94	0.48	6	3.10	0.78	6
Statistically adjusted engineering approach	0.75	0.69	13	0.86	0.87	20
Calibrated engineering model	1.22	1.31	6	0.75	0.79	13

[a] Total exceeds 158 observations due to multiple methodologies being applied in some cases.

Billing analysis and statistically adjusted engineering approaches both produce similar results in that mean and median realization rates of less than one are observed for both residential and C/I/A programs. The tendency for billing analysis to produce lower-than-average realization rates is highlighted by the fact that it accounts for four of the six lowest C/I/A realization rates (all four of which relate to industrial programs). In the residential sector, billing analysis appears to be the "methodology of choice" for evaluating residential direct assistance programs. Thus, the association of equity programs with low realization rates may be an artifact of the methodology used to estimate their *ex-post* energy savings.

Of the remaining evaluation methods, calibrated engineering models tended to produce high realization rates in the residential sector, and low rates in the C/I/A sector. In contrast, conditional demand analysis produced high realization rates in the C/I/A sector and average rates in the residential sector. Simplified engineering models are associated with 26 realization rates in the C/I/A sector and produce a median realization rate of 1.0 and a mean value of 1.23. In contrast, simplified engineering models -- with relatively high realization rates among C/I/A programs -- were not used at all in the residential sector, which may have contributed to this sector's relatively low realization rates.

5.5 REALIZATION RATES FOR SELECTED MEASURES

Realization rates for three residential DSM measures are examined in this section: compact fluorescent lamps, low-flow showerheads, and refrigerator replacements. Collectively, these three measures have median realization rates that span the spectrum from 0.27 for low-flow showerheads to 1.23 for refrigerator replacements (Table 5.5). In addition to the wide variation in realization rates across programs offering different measures, there is also considerable variation in realization rates among programs offering similar measures. Features of the DSM programs that offer these measures and their impact evaluations are described below in an attempt to explain why realization rates are so variable.

Table 5.5 Realization Rates by Selected Measure

	Mean	Median	Number of Programs or Segments
Compact fluorescent lamps	0.90	0.83	6
Low-flow showerheads	0.57	0.27	7
Refrigerator replacements	1.29	1.23	4

Compact Fluorescent Lamps. The impact evaluations present six realization rates for compact fluorescents. These rates vary from 0.37 to 1.59, with a mean of 0.90 and a median of 0.83. Table 5.6 summarizes some of the key factors that help to explain this wide variation.

Table 5.6 Realization Rates for Compact Fluorescent Lamps

	#68C	#24G	#14	#26B	#150	#156
Realization Rate	0.37	0.68	0.75	0.90	1.09	1.59
***Ex-ante* Net Savings (kWh/bulb)**	89	71	77	142	51	32
***Ex-post* Net Savings (kWh/bulb)**	33[b]	48[b]	58	128	56[b]	51
Utility	SCE	PG&E	PG&E	PG&E	SDG&E	SDG&E
Lamps Distributed Per Participant	4.6	1.0	2.8	2.0	1.5	1.9
Evaluation Method in *Ex-post* Analysis[a]	SAE	SAE	CEM	BA	CEM	CEM
Measure Retention Rate Used in *Ex-post* Analysis	100%	90%	87%	71%	61%	80%
Rebound Effect Used to Adjust Savings in *Ex-post* Analysis	No	No	Yes	No	No	No
Free Ridership Estimate in *Ex-post* Analysis	No	No	25%	48%	No	22%
Average Wattage Replacement in *Ex-post* Analysis	75	37	55	NA	61	60
Average Hours of Use Per Day in *Ex-post* Analysis	1.8	3.2	3.2	NA	4.1	3.7

[a] SAE=statistically adjusted engineering approach
CEM=calibrated engineering model
BA=billing analysis
NA=information not reported in impact study

[b] The net-to-gross ratio is assumed to be 100% in these studies.

The magnitude of the *ex-ante* estimates of energy savings appears to explain some of the wide variation in realization rates. The six programs varied significantly in the assumed energy savings of a compact fluorescent bulb, ranging from 32 to 142 kWh/lamp, and the two programs with the largest realization rates have the lowest estimates of *ex-ante* savings. Uniformity is not to be expected, since energy savings depend upon hours of use, replaced wattages, and levels of free ridership, among other variables. However, the variability among these six programs is also a function of differences in what factors are included in the *ex-ante* estimates. For instance, the planning assumptions for several of these programs did not include the possibility of free riders and did not discount the estimated energy savings to reflect the non-installation, removal, burnout, or destruction of some lamps. Where the planning assumptions were reported in the impact studies, they tended to overstate the magnitude of likely savings. For instance, PG&E assumed an average of 5.1 hours of use per lamp in its 1992 Residential Compact Fluorescent Lighting Program, while the impact study estimated 3.2 hours. Similarly, PG&E assumed that the lamps replaced by its Targeted Customer Appliance Program averaged 100 watts, but the impact study indicated an average of 65 watts, leading to a low average wattage replacement of 37.

Different evaluation methods appear to characterize higher versus lower realization rates. Calibrated engineering models were used for both of the SDG&E programs where *ex-post* estimates exceeded *ex-ante* projections. In contrast, statistically adjusted engineering approaches were used to evaluate the two programs with the lowest realization rates. Further, as noted above, realization rates will be lower if measure installation rates, rebound effects, and free ridership are included in the *ex-post* estimation, but not in the *ex-ante* estimation.

Program features also appear to explain realization rates. For instance, the lowest realization rate and the lowest *ex-post* energy savings was experienced by SCE's Relamping Program, which installed 4.6 lamps per participating low-income participant. This rate of installation may exceed the cost-effective opportunities available in the average participant's home, given the need for a lamp to be used several hours a day so that its replacement is cost-effective. This program had the lowest average hours of use per day (1.8 hours), which is consistent with the finding in Impact Study #156 that installation and persistence rates decline as the number of compact fluorescent lamps distributed to each participating household rises.

Finally, indicators of program performance can explain the wide-ranging realization rates. For instance, the three programs that estimated free ridership produced estimates that ranged from 22% to 46%, differences which will dramatically affect *ex-post* savings estimates as well as realization rates if these estimates deviate from planning assumptions. Similarly, rates of measure retention ranged from 61% to 90%, average daily usage ranged from 1.8 to 4.1 hours per day, and average wattage replacement ranged from 37 to 75 watts. In general, the lower these values are, the lower the realization rates.

Altogether, this analysis of realization rates for compact fluorescent lamps highlights the large complex of factors that can cause actual savings to fall short (or significantly exceed) anticipated savings.

Low-Flow Showerheads. The impact evaluations present seven realization rates for low-flow showerheads. These rates vary from 0.03 to 1.75, and have a median value of 0.27. Table 5.7 summarizes some of the key features of these programs and their impact evaluations.

Table 5.7 Analysis of Realization Rates for Low-Flow Showerheads

	#13B	#13A	#130G	#26F	#26C	#155	#149
Realization Rate	0.03	0.05	0.23	0.27	0.59	1.06	1.75
***Ex-ante* Net Savings per Showerhead**	418 kWh	19 therms	43[b] therms	37 therms	· 832 kWh	26[b] therms	12[b] therms
***Ex-post* Net Savings per Showerhead**	20 kWh	1 therm	10 therms	10 therms	495 kWh	28 therms	21 therms
Utility	PG&E	PG&E	SoCalGas	PG&E	PG&E	SDG&E	SDG&E
Evaluation Method in *Ex-post* Analysis[a]	ESM	ESM	CDA	BA	BA	BA	CEM
Measure Retention Rate Used in *Ex-post* Analysis	94%	94%	100%	83%	83%	100%	97%
Free Riders Estimate in *Ex-post* Analysis	92%	92%	0%	40%	40%	0%	0%

a ESM=engineering simulation model
CDA=conditional demand analysis
BA=billing analysis
CEM=calibrated engineering model

b The net-to-gross ratio is assumed to be 100% in these studies.

As with the analysis of compact fluorescent lamps, the magnitude of *ex-ante* estimates of energy savings appears to explain some of the variation in realization rates. The *ex-ante* estimates of energy savings per low-flow showerhead vary widely, from 418 to 832 kWh/year and from 12 to 57 therms/year. The two programs with highest realization rates are both associated with relatively low *ex-ante* estimates of savings.

The use of different evaluation methods also helps to explain the magnitude of realization rates. In particular, the two highest realization rates resulted from evaluations that did not take into account the existence of free riders. In contrast, the two lowest realization rates (associated with PG&E's 1992 Energy Saver Showerhead Coupon Program) were the result of impact evaluations with extremely high estimated free ridership rates (92%) that were not anticipated when planning the program (when it was assumed that half of the participants would be free riders). *Ex-post* estimates of the retention of low-flow showerheads were fairly consistent across the impact studies, ranging from 83% to 97%. Although the planning estimates for this factor were not reported, it is unlikely that measure persistence was a major source of variation between realization rates.

The extremely low realization rates for PG&E's 1992 Energy Saver Showerhead Coupon Program also reflect the program's success during previous years. By 1992, the availability of high-flow showerheads to be replaced with program showerheads had shrunk dramatically, and with it, realized savings. Because the showerheads being replaced often had moderate, rather than high, gallon-per-minute flow rates, the program's *ex-post* estimate of energy savings was less than one-third of its *ex-ante* estimates. The high free ridership level in 1992 may also reflect the market impacts of the program during previous years.

Refrigerator Replacements. The impact evaluations present four realization rates for refrigerator replacements. These rates vary from 0.73 to 1.96, and have a median value of 1.23 (Table 5.8).

Table 5.8 Analysis of Realization Rates for Refrigerator Replacements

	#24F	#24E	#152	#64B
Realization Rate	0.73	0.93	1.53	1.96
Type of Program[a]	ER & RR	ER & RR	EER	EER
***Ex-ante* Net Savings (kWh/Refrigerator)**	537	422	59	146
***Ex-post* Net Savings (kWh/Refrigerator)**	392	392	90	286
Utility	PG&E	PG&E	SDG&E	SCE
Evaluation Method in *Ex-post* Analysis[b]	SAE	SAE	CEM	CDA
Free Ridership Accounted for in *Ex-post* Analysis	Yes	Yes	Yes	Yes

[a] ER=early retirement
RR=refrigerator repairs
EER=incentives to buy more energy-efficient refrigerators

[b] SAE=statistically adjusted engineering approach
CDA=conditional demand analysis
CEM=calibrated engineering model

The four realization rates listed in Table 5.8 refer to two different types of refrigerator replacement programs. PG&E's Targeted Customer Appliance Program is primarily an "early retirement" program designed to help low-income customers reduce their electricity bills by replacing their older less energy-efficient appliances with more efficient ones at no cost to the participant.[5] One of the realization rates is for 1991 (Impact Study #24E) and the second is for 1992 (Impact Study #24F). The other two programs provided incentives for households to purchase more energy-efficient refrigerators.[6]

[5] In some cases the Program repairs broken refrigerators or provides new refrigerators to households that do not have working appliances, thereby increasing their electricity consumption.

[6] SCE's Residential Appliance Efficiency Incentives Program gave $50 to $100 rebates to residential customers who bought refrigerators that were larger than 12 cubic feet and were more efficient than refrigerators conforming to the California Energy Efficiency Title 20 refrigerator efficiency standards. The SDG&E Residential Appliance Efficiency Incentives Program for refrigerators was designed to provide financial incentives to encourage

Realization rates differ by type of program. The highest *ex-ante* savings estimates and the lowest realization rates are associated with PG&E's early retirement program. The difference between the 1991 and 1992 realization rates (0.93 and 0.73, respectively) is a function of different *ex-ante* estimate of net savings. The *ex-ante* estimate for 1992 was increased based on the assumption that the 1992 program would replace more energy-inefficient refrigerators than in 1991. The lowest *ex-ante* savings estimates and the highest realization rates—both exceeding 1.5—were associated with the two programs that offered incentives to promote the purchase of more energy-efficient refrigerators. Thus, the *ex-ante* net savings of the first type were overestimated, and for the second type they were underestimated.

A variety of different evaluation methods were used to estimate the energy saved by the program per replaced refrigerator. As with the previous DSM measures, statistically adjusted engineering approaches produced lower realization rates than calibrated engineering models. Each of the evaluations accounted for free ridership in their *ex-post* estimation of net savings, but different methods were used. The PG&E program's evaluation user survey data to estimate a free ridership rate of about 30%, the SDG&E program's evaluation compared retail sales before vs. after the program to estimate net impacts, and the SCE program's evaluation used a nonparticipant group in its conditional demand analysis to adjust for free ridership. These different approaches may have had an impact on the resulting realization rates.

In sum, the impact studies reviewed here suggest that on average, California's DSM programs operating between 1990 and 1992 delivered 112% of the energy savings that were planned, and the typical program delivered approximately 86% of the energy savings it was designed to deliver. A majority of the programs (62%) delivered between 50% and 125% of their *ex-ante* savings. The implementation of initiatives to narrow this range should be a major thrust of resource planners and program managers in the four California utilities. The impact of different *ex-ante* estimation procedures warrants further examination in this regard. The *ex-ante* estimates of savings for similar DSM measures, across utilities and across programs in the same utilities, were found to be extremely wide ranging and a possible source of systematic bias in the realization rates.

No single program feature or *ex-post* evaluation method appears to dictate a program's realization rate. However, by comparing the realization rates of similar DSM measures, it is possible to identify likely influences. In the residential sector, high realization rates are associated with calibrated engineering models, relatively low *ex-ante* estimates of savings, and evaluations that fail to discount savings for free riders, rebound effects, and imperfect measure retention. Among the C/I/A

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customers to purchase high efficiency refrigerators. High efficiency refrigerators are defined as units having a capacity of 12 cubic feet or more and exceeding the Title 20 efficiency standards by at least 10%. Incentives ranged from $50 to $400, depending upon the level of efficiency improvement above current standards.

programs, high realization rates are associated with commercial-sector programs and *ex-post* evaluation methods that involve simplified engineering models and conditional demand analysis.

6. CONCLUSIONS

This report summarizes the results of more than 50 individual evaluation studies conducted by the four largest California investor-owned utilities. The effort involved the review of extensive amounts of material, including each utility's annual DSM activities reports and the individual evaluation studies themselves. It did not include (a) the collection of savings data sufficient for weighting realization rates; (b) analysis of the procedures used to generate *ex-ante* estimates of energy savings; or (c) the compilation of utility statistics, such as operating resources and the numbers of customers by sector, which would be necessary to compare and contrast the relative market penetration of each utility's DSM activities. Thus, the analysis involved the synthesis of a great deal of information, but did not include all of the data required to fully exploit the lessons to be learned by the compendium of impact studies.

Based on this review, the authors offer the following conclusions:

- The evaluation studies summarized in this report represented a monumental effort. Fifty evaluation studies, some multi-volume, were prepared at a cost of millions of dollars. Vast amounts of data were collected and analyzed. While the depth and rigor of the evaluations described in these 50 reports varied tremendously, state-of-the-art methodologies generally were employed in an attempt to quantitatively estimate the energy and demand savings associated with the DSM programs of the four utilities. In some cases, multiple methodologies were employed in parallel to converge on the savings estimates (triangulation).

- The quantity of demand and energy savings documented in the evaluation studies is substantial. Over 1.3 million mWh of electricity savings, 11,500 kilotherms of gas savings and 225 MW of demand savings, were reported across only those studies reporting at the program level. For example, PG&E's Commercial, Industrial, and Agriculture Rebate Program produced in excess of 663,000 megawatt hours over a two-year period. In aggregate, C/I/A programs generated substantially more energy savings than residential programs.

- The transferability of savings estimates from DSM programs across utilities would be a desirable outcome so that utilities could learn from each other's evaluation experience. However, the transferability of savings estimates is impaired by the lack of common reporting formats and evaluation methods. The utilities employed a wide variety of evaluation methodologies and formats for reporting results. Particularly in the commercial, industrial, and agricultural studies, the utilities pursued four entirely different approaches to both the analysis and presentation of impact results. This made the job of consistent summarization and transferability extremely difficult. Future evaluation efforts, if they are to be compared consistently, should employ more consistent evaluation methods and adopt common reporting formats. The California Protocols and Procedures for the Verification of Costs, Benefits, and Shareholder Earnings from Demand-Side Management Programs, which took effect on January 1, 1994, should ensure such consistent reporting formats in the future. This will greatly facilitate future efforts to compile savings estimates across utilities and programs. The use of consistent evaluation methods for evaluating similar types of DSM programs (e.g., all four utilities' residential direct assistance programs) would be helpful.

- The analysis of realization rates indicates that, on average, the 158 programs and program segments delivered 112% of their anticipated savings. However, this mean value is influenced by four very high realization rates, which are greater than 3 standard deviations from the mean. (This is illustrated by the median value of 0.86). If the four highest realization rates (ranging from 5.59 to 14.54) are removed from the analysis, the median remains at 0.86, but the mean realization rate drops significantly to 0.93. Overall, these results suggest that the forecasts of energy savings from the DSM programs were reasonably accurate. They also indicate that the California DSM programs operating between 1990 and 1992 have out-performed typical programs from the 1980's (both in California and nationwide), which often fell short of their expected savings by 30% to 70%. However, it was not possible to discern how much the improved performance resulted from greater actual energy savings versus improved forecasting.

- The analysis of realization rates also indicated a high degree of variability in the *ex-ante* estimates. In some cases for similar technologies and measures, *ex-ante* savings estimates varied by as much as 300%. This often had a strong impact on realization rates. Future evaluations might benefit from more consistent development and utilization of *ex-ante* approaches to narrow the range of variability. In addition, future attempts to compare and contrast realization rates would benefit from information on the methods used to produce *ex-ante* estimates of energy savings. It is recommended that the evaluation Protocols include such documentation of *ex-ante* estimation procedures in the reporting formats.

- One objective of evaluation is to enhance program performance. The lessons learned from evaluation may be factored back into program re-design to improve performance, reduce costs, and enhance savings and program efficiency. The wide degree of variation in *ex-post* savings estimates suggests that there are lessons to be learned about program design features that lead to higher or lower savings. It should be possible to identify what it is about some programs that make them generate greater savings than other programs serving the same sector and promoting similar DSM measures. The use of highly varying evaluation methods, however, makes it difficult to isolate program design effects. Future efforts may seek to evaluate similar programs using similar methods so as to identify the impacts of different program design features.

- For effective use in state-level DSM planning and forecasting, the ability must exist to aggregate savings estimates and evaluation results. The authors feel that the evaluation studies summarized in this report offer valuable information for state-level planning. However, the structure of the studies did not permit consistent aggregation. The adoption of consistent reporting formats and structures in the future via adherence to the evaluation protocols should greatly facilitate the ability to aggregate the savings results.

The primary objective of this report was to summarize California's recent DSM evaluation studies. Additional analysis and review is recommended to assess particular components of the evaluations. For example, with some additional research, realization rates could be weighted by energy savings or expenditure levels to produce a more robust indication of overall program performance.

In summary, the studies reviewed for this report provide a preliminary basis for (a) obtaining insights into the performance of California's DSM programs, (b) developing information which can be used to enhance program performance, and (c) guiding future evaluation work. The California monitoring and evaluation protocols should allow future evaluation efforts to build off this base and produce results which allow more complete summaries and comparisons across utilities.

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APPENDIX A

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APPENDIX B

OVERVIEW OF EVALUATION METHODOLOGIES

OVERVIEW OF EVALUATION METHODOLOGIES

This appendix provides a brief overview of evaluation methodologies employed to estimate energy and demand impacts in the evaluation studies. Greater detail on the methodological approaches can be found in the following sources, from which this summary was extracted:

Electric Power Research Institute, *Impact Evaluation of Demand Side Management Programs: A Guide to Current Practice*, CU 7179, Volume 1 Final Report, February, 1991

Oak Ridge National Laboratory, *Handbook of Evaluation of Utility DSM Programs*, ORNL/CON-336, December, 1991

The impact evaluation methods employed in the subject studies can basically be organized into four key categories (subcategories of evaluation methods used in the evaluation studies and assessed in this report are also indicated):

- Engineering methods,
  - -- Simplified engineering methods
  - -- Engineering simulation modeling
  - -- Calibrated engineering model
- Statistical methods,
  - -- Billing analysis
  - -- Conditional demand analysis
- Metering,
- Hybrid methods
  - -- Statistically adjusted engineering approach.

Each is briefly discussed in the following sections. The reader is referred to the above sources for greater detail.

Engineering Methods. Engineering estimation of savings typically involves equations which express energy use or demand in terms of a usage level divided by an efficiency for some period of time. There may also be terms in the equations that account for interactions with other end-uses or net gains or losses from previous time periods.

In many cases, engineering methods are concerned with unit impacts of a particular measure such as an energy efficient ballast. These simplified engineering methods rely on data on the number and type of different measures installed by program participants which is extracted from the program data base. An engineering analysis is applied to develop reliable estimates of unit impacts. These unit impacts may be derived from engineering simulations (see below) or from more simple engineering algorithms.

Simplified engineering algorithms have been developed for many common DSM measures, such as lighting, various types of HVAC, and water heating measures.

Several of the evaluation studies summarized in this report included the use of engineering simulation modeling. The primary value of such models is in estimating savings in HVAC energy use through either HVAC or envelope modifications. The advantage that simulation tools provide is their ability to account for thermal mass effects, scheduling, interactive effects between different end uses, part load efficiencies, and system dynamics. Because simulation models explicitly account for such effects in the energy use of a building, they allow for estimation of relatively small effects. Also, the number of variables are explicitly accounted for making it possible to adjust for different conditions.

There are two general types of engineering simulation models, hourly and bin. Hourly models simulate every hour of the year in sequence. The bin method, on the other hand, corresponds to a five or ten degree range of ambient temperatures known as temperature bins. A common hourly engineering simulation tool used in the impact evaluations summarized in this report is DOE-2.

Calibrated engineering models involve calibrating simulation results to some other known measurement, such as billed energy or, if available, metered load data. This calibration provides some assurance that, for example, the sum of the disaggregated end-use loads totals the building load as measured (see section on Hybrid methods).

Engineering models typically rely on engineering judgment for virtually every input. They are applied to units such as individual measures (e.g., electronic ballasts). Engineering algorithms, for example, may be applied to estimate the impacts of individual DSM measures, whereas in the case of building simulation models, the unit is almost always a building. In consequence, the impact evaluation studies summarized in this report often estimate impacts for individual measures or for representative buildings.

Statistical Methods. There are a variety of statistical approaches which are used to estimate impacts of DSM programs. These statistical methods generally fall into two basic categories:

- Comparison approaches using data available in-house at the utility, and
- Multivariate regression approaches using customer specific survey data.

Simple comparison approaches such as billing analysis can be significantly less expensive in that they only require billing data and information on when the customer began participating in the DSM program. On a simplified basis, therefore, they can be applied without the need to collect external customer data. Billing analysis is a general catch phrase for these types of simplified approaches, since the data for these analyses is usually available directly from the utility's billing file and the program tracking data base.

Such comparison approaches can be divided further:

- Time series comparison simply compares the participants energy use before the program to their energy use after the program. Any differences are then attributed to the DSM program.

- Cross sectional comparison. This approach compares the participant's post program energy use to the post program energy use of a control group of nonparticipants. Implicit in this approach is the assumption that the non participant control group is identical to the participant group in all respects except for program participation.

- Pre/post comparison. The pre/post comparison approach compares the change in the quantity of energy use over two time periods for two groups, the program participants and a control group of nonparticipants. This approach combines the features of the cross sectional and time series approaches.

These statistical comparison approaches can be augmented through weather normalization, because weather can have a large effect on energy use. The effect of such normalization is to remove the influences of weather, both over time and across participant and nonparticipant groups, thus allowing for more clear cut attribution of impacts to the DSM program. Other factors, such as underlying economic conditions, can also be similarly addressed.

Multivariate Regression. Multivariate regression approaches utilize a fuller data set than the more simple comparison approaches described above. They typically require survey data on individual customers. These multivariate statistical approaches all rely on the basic premise that changes in one variable can be explained by reference to changes in several other variables. In general, a multivariate regression model for an impact evaluation should include all measurable factors which influence energy consumption. The most commonly employed multivariate approach for energy and demand impact analysis involves using conditional demand analysis. Conditional demand frameworks are based on well defined engineering and economic principles. The conditional demand model is based on the identity that total energy consumption must be equal to the consumption of all of the energy consuming equipment in the building. There are many formulations of conditional demand models which can incorporate different levels of complexity. These models rely on external data collection, in that energy using equipment in the building must be known and incorporated in the model as well as billing data. Many of the DSM impact evaluation studies summarized in this report utilized the conditional demand analysis framework for estimating impacts.

Metering Approaches. A straight forward way of measuring the impact of a particular device is to instrument the device and collect metered data on its electricity consumption over selected time intervals. This is known in the utility industry as load research. Direct load research measures class or end-use demand (kW), energy (kWh), or reactive power (kVAR).

Implementing metering as part of any study involves several interrelated steps. These include:

- Sample design,
- Sample selection,
- Recorder selection,
- Meter placement and replacement,
- Installation record keeping,
- Meter operation and maintenance,
- Data collection,
- Data validation and editing, and
- Data analysis.

Because of the costs of the metering hardware, installation labor, and data retrieval and analysis software and labor, metering is highly expensive. The hardware must be acquired, and must be installed by trained personnel. Metering at the end-use level often requires the use of qualified electricians and the infrastructure must be in place to collect and analyze massive amounts of data.

Because of its extensive cost, metering is not frequently used in DSM evaluation, though it is often used in support of other methodologies. However, such metering usually represents an accurate measurement of energy usage since, if properly installed, it represents direct measurement of the phenomenon as opposed to estimated impacts which are derived from engineering or statistical methods.

Metering can be performed at the whole building (premise) level. This involves recording load at the point where the power service enters the building. Metering can also be performed at the end-use level. This involves instrumenting individual end-uses, such as air conditioners, refrigerators, lighting circuits, etc.

Hybrid Approaches. In some cases hybrid approaches involving combinations of engineering, statistical, and metering methods are employed in DSM program impact evaluation. These hybrid approaches often seek to improve the quality and accuracy of the estimates available from any single approach. Another key objective of such hybrid approaches is to leverage the accuracy of high cost measurement approaches such as metering by combining them in small number with more general approaches.

An example of this type of approach is statistically adjusted engineering (SAE) estimates. SAE uses engineering estimates of savings as independent variables directly in a statistical model. An alternative use of the method is to disaggregate whole house or building metered loads into individual end-uses. Statistically adjusted engineering estimates are generated by using engineering estimates as independent variables in a regression equation instead of zero-one participation variables. This has the effect of combining an initial estimate of the savings of a particular measure with the statistically estimated savings so as to improve the overall precision of the statistical methods. This therefore, brings more information to bear on the estimation problem.

Another hybrid method which has recently evolved in the literature is the employment of double ratio estimation, which is based on the enhanced theoretical statistical performance of ratio estimators. In this approach, double sampling is typically employed, whereby a small sample of higher cost but presumably more accurate measurement (such as that derived from metering) is combined with a larger sample of lower cost data such as that available from a customer survey or billing information. The approach then seeks to analyze the ratios of the different estimates to produce an estimate of the impact of the DSM measure or program with increased precision. It should be noted that such methods were not typically employed (with one exception) in the evaluation studies reviewed as part of this report as they have only been developed in the literature in recent years.

Net to Gross Methods. Net to gross methods are those techniques used to adjust impact estimates on a gross level to account for free riders. Free riders are defined as customers who would have taken the identical action without the DSM program. There are also incremental free riders and deferred free riders, who may have been to some extent influenced by the program. Incremental free riders may have taken some but not all of the measures promoted by the program on their own. Deferred free riders may have taken all or some of the measures promoted by the program on their own, but at a later date.

Several methods to estimate free ridership, and thus adjust gross savings to reflect net savings, have been employed. Survey based approaches have frequently been used to measure free riders. Participants are surveyed and are asked several questions concerning what actions they may have taken if the program was not available. Based on the results of these surveys, proportions are estimated based on the respondents reporting of actions which would have been taken, and savings are adjusted accordingly based on these proportions. Survey based approaches to free ridership estimation have been known to have problems associated with self-reporting, particularly when such surveys are administered months or even years after the participant's decision to participate in the DSM program.

In some cases, market data is used to estimate free ridership. For example, data available from appliance dealers on general sales trends may be used to develop estimates of the underlying market in terms of the rated energy efficiency of products being sold, or dealer surveys may be employed in this context to determine what customers are purchasing in general without the existence of a particular incentive program.

The use of a comparison group is also a typical evaluation technique to account for free ridership. The difference between the energy conservation actions of a sample of program participants and an appropriately selected comparison group provides an estimate of the net program impacts. However, this approach is made difficult by the challenge of finding a comparable comparison group that has not already been "contaminated" by knowledge of the existence of the program.

Statistical methods have also been used to estimate free ridership. Generally this method involves analysis of the energy related actions, characteristics, and attitudes for samples of participants and nonparticipants. Simulations are developed to predict the likelihood of the adoption of program sponsored measures with and without the program. The two estimates are then used to calculate the free rider ratio. A particular multivariate modeling approach is the discrete choice model. It uses discrete outcomes as a dependent variable. The dependent variable is 1 if the customer is a participant and 0 if the customer is a non participant. Independent variables include the factors that influence customer decisions to participate in the DSM program including: income, expected energy savings resulting from participation, and awareness of the program.

The DSM studies summarized in this report utilized several of these techniques to adjust gross estimates of savings for free ridership.

APPENDIX C

DETAILED EVALUATION TABLES

Table C.1 Numbers of Participants in Residential Programs

Study	Utility	Period	Number of Participants	Program
Retrofit Energy Efficiency Incentive				
12	PG&E	1991-92	10,988	Ceiling Insulation Rebate
14	PG&E	1992	86,499	Residential Compact Fluorescent Lighting
64A	SCE	1990-91	4,941	Res. Appliance Efficiency: AC
64B	SCE	1990-91	53,892	Res. Appliance Efficiency: Refrigerators
129A	SoCalGas	1990-92	15,552	Residential Weatherization
129B	SoCalGas	1990-92	15,197	Appliance Efficiency
144	SDG&E	1991	54,725	Res. High Eff. Central AC
149	SCG&E	1991	29,637	Low-Flow Showerheads
150	SDG&E	1991	45,058	Compact Fluorescent Light Bulbs
155	SDG&E	1990-91	20,317	Efficiency Inc: Low-Flow Showerheads
156	SDG&E	1992	61,144	Efficiency Inc: Compact Fluorescent Ltg.
	Subtotal		*397,950*	*48.97%*
Direct Assistance				
22	PG&E	1991	66,000	Energy Partners
24	PG&E	1991-92	10,598	Targeted Customer Appliance
68A	SCE	1990-91	1,449	Customer Assistance: Weatherization
68B	SCE	1990-91	4,800	Customer Assistance: Hardware
68C	SCE	1990-91	59,874	Customer Assistance: Relamping
130	SoCalGas	1990-92	31,317	Appliance Repair & Replacement
158	SDG&E	1992	11,624	Residential Direct Assistance
	Subtotal		*185,662*	*22.85%*
Energy Management Services				
26	PG&E	1991	34,155	Residential Energy Management Services
66	SCE	1990	110,043	Residential Energy Management Services
195	SoCalGas	1990	55,398	Residential Energy Management Services
157	SDG&E	1991-92	22,500	Residential Energy Management Services
	Subtotal		*222,096*	*27.33%*
New Construction				
20	PG&E	1990-92	3,178	Welcome Home Res. New Construction
76, 77	SCE	1990-92	3,333	Residential New Construction
132	SoCalGas	1990-92	407	Residential New Construction
	Subtotal		*6,918*	*0.85%*
Total Participation			**812,626**	

Table C.2 Numbers of Participants in C/I/A Programs

Study	Utility	Period	No. of Units	Unit	Program
Retrofit Energy Efficiency Incentive					
43	PGE	1991 - 1992	3,401	Projects	C/I & Agri. Retrofit Rebate
137	SoCalGas	1990 - 1992	2,017	Equip Units	High Efficiency Com Equipment
139	SoCalGas	1990 - 1992	1,327	Participants	Industrial Equipment Replacemant
165	SDGE	11/90 - 8/91	350	Project Jobs	C/I Lighting Retrofit
179	PGE	1990 - 1992	928	Applications	Customized Rebate
	Subtotal		*8,023*		*13.16%*
Energy Management Services					
162	SDGE	1987-1989	151	Participants	Non-Residential Audit Evaluation
No Number	SDGE	1991	400	Tests (app.)	Agricultural EMS
48	PGE	1990 - 1992	15,677	Audits/Tests	Non-Residential EMS
87, et al	SCE	1990 - 1992	23,983	Audits	C/I & Agri. EMS & HDWR Rebate
87, et al	SCE	1990	1,943	Customers	C/I & Agri. EMS & HDWR Rebate
137	SoCalGas	1990 - 1992	4,947	Audits	Com Energy Efficiency Analyses
139	SoCalGas	1990 - 1992	5,122	Audits	Industrial Audit
	Subtotal		*52,223*		*85.64%*
New Construction					
44	PGE	1990 - 1991	57	Buildings	Non-Residential New Construction
101	SCE	9/90 thru 9/92	584	Cases	Com New Construction Incentive
140	SoCalGas	1990 - 1992	96	Customers	High Efficiency New Com Building
	Subtotal		*737*		*1.21%*
Nonresidential Program Units			**60,983**		

Table C.3 Residential Program Level mWh Savings

Study No.	Utility	Year(s)	Program Level Reported Savings (mWh)	Program
12	PG&E	1991-92	3,699	Ceiling Insulation Rebates
13	PG&E	1992	78	Energy Saver Showerhead
14	PG&E	1992	13,807	Residential Compact Fluorescent
24	PG&E	1991-92	7,294	Targeted Customer Appliance
64	SCE	1990-92	53,341	Residential Appliance Efficiency
68	SCE	1990-91	24,381	Residential Direct Assistance
150	SDG&E	1991	4,800	Residential Compact Fluorescent
152	SDG&E	1991	4,900	Residential High Efficiency Refrigerator
156	SDG&E	1992	5,900	Residential Compact Fluorescent

Table C.4 Residential Program Level Kilotherm Savings

Study No.	Utility	Year(s)	Program Level Reported Savings (kilotherms)	Program
12	PG&E	1991-92	714	Ceiling Insulation Rebates
13	PG&E	1992	30	Energy Saver Showerhead
24	PG&E	1991-92	101	Targeted Customer Appliance
129	SoCalGas	1990-92	2,559	Residential Conservation
130	SoCalGas	1990-92	813	Appliance Repair/Replacement
195	SoCalGas	1990	1,693	Residential EMS
149	SDG&E	1990	876	Low-Flow Showerhead
155	SDG&E	1990-91	1,551	Appliance Efficiency
158	SDG&E	1992	516	Residential Direct Assistance

Table C.5 Non-Residential Program Level mWh and MW Savings

Study No.	Utility	Year(s)	Program Level Reported Savings (mWh)	Program Level Reported Savings (MW)	Program
179	PG&E	1990-91	208,468	34.5	Customized Rebate
48	PG&E	1990-92	176,963	40.6	Non-Residential EMS
43	PG&E	1991-92	663,263	110.5	Retrofit Rebate
44	PG&E	1990-91	20	4.8	New Construction
101	SCE	1990-92	68,070	31.7	New Construction
174	SDG&E	1992	54,210	–	Energy Efficiency Incentives
162	SDG&E	1985-89	12,000	3.6	Non-Residential Audit

Table C.6 Non-Residential Program Level Kilotherm Savings

Study No.	Utility	Year(s)	Program Level Reported Savings (kilotherms)	Program
48	PG&E	1990-92	2,572	Non-Residential EMS
162	SDG&E	1985-89	140	Non-Residential Audit

Table C.7 Savings per Residential Refrigerator Replaced

Study No.	Utility	Year(s)	Program Attributed Savings (kWh)	Program Type
24F	PG&E	1991	392.0	Early Refrigerator Retirement and Refrigerator Repair
152	SDG&E	1991	89.5	Incentives to Purchase Energy Efficient Refrigerators
64B	SCE	1990-92	286.0	Incentives to Purchase Energy Efficient Refrigerators

Table C.8 Savings per Residential Compact Fluorescent Bulb

Study No.	Utility	Year(s)	Annual Savings (kWh)	Program
24G	PG&E	1991-92	48	Targeted Customer Appliance
26B	PG&E	1991	128	Residential Energy Savings
14	PG&E	1992	57.8	Residential Compact Fluorescent
68C	SCE	1990-91	34	CAP Relamping
150	SDG&E	1991	56.1	Residential Compact Fluorescent
156	SDG&E	1992	50.79	Appliance Efficiency Incentives

Table C.9 Electrical Savings for Selected Non-Residential Measures

Study No.	Utility	Year	Measure Class	Gross Annual Savings Per Unit (kWh)	Demand Savings (kW)	Program Type
87	SCE	1990	HVAC Energy Mgt. Sys.	90,276	0	C/I/A Energy Management and Hardware Rebate Program
			Indoor Lamps	22,616	5	
			Indoor Lighting Sys.	19,164	14.5	
			Package AC	21,300	5	
			Reflectors	96,960	19	

Table C.10 Gas Savings for Selected Non-Residential Measures

Study No.	Utility	Year	Measure Class	Net Annual Savings Per Unit (Therms)	Net Annual Program-Level Savings (kilotherm)	Program
137	SoCalGas	1990-92	High Efficiency AC	17,201	120	High Efficiency Commercial Equipment
			High Eff. Boiler	12,295	1,979	
			High Eff. Cooking	878	1,105	
			High Eff. Spc. Heat	142	257	
139	SoCalGas	1990-92	Industrial Boiler	1,611	89	Industrial Demand-Side Management
			Ind. Furnace	3,053	183	
			Ind. Space Heat	466	19	

Table C.11 Realization Rates for all Residential Programs

Obs.	Rpt.	Period	Program	Application	Rlz. Rt.
1)	12A	1991-1992	Ceiling Insulation Rebate	Elec. Energy Savings	0.82
2)	12B	1991-1992	Ceiling Insulation Rebate	Capacity Savings	3.80
3)	12C	1991-1992	Ceiling Insulation Rebate	Gas Savings	0.42
4)	13A	1992	Energy Saver Showerhead Coupon	Gas	0.05
5)	13B	1992	Energy Saver Showerhead Coupon	Electric	0.03
6)	14	1992	Residential CFLB	CFLB	0.75
7)	20	3/91 thru 12/92	Residential New Construction		0.72
8)	20	3/91 thru 12/92	Residential New Construction		1.01
9)	20	3/91 thru 12/92	Residential New Construction		1.58
10)	22A	1991	Energy Partners	SF w/AC-electric	0.49
11)	22B	1991	Energy Partners	SF w/o AC-electric	1.35
12)	22C	1991	Energy Partners	MF w/AC-electric	1.22
13)	22D	1991	Energy Partners	MF w/o AC-electric	1.38
14)	22E	1991	Energy Partners	SF w/AC-gas	0.30
15)	22F	1991	Energy Partners	SF w/o AC-gas	0.30
16)	22G	1991	Energy Partners	MF w/AC-gas	0.36
17)	22H	1991	Energy Partners	MF w/o AC-gas	0.36
19)	24A	1991-1992	Targeted Customer Appliance	1991 electric (MWh)	0.64
19)	24B	1991-1992	Targeted Customer Appliance	1991 electric (MWh)	0.57
20)	24C	1991-1992	Targeted Customer Appliance	1991 gas	0.69
21)	24D	1991-1992	Targeted Customer Appliance	1992 gas	1.23
22)	24E	1991	Targeted Customer Appliance	Refrig. replacements	0.93
23)	24F	1992	Targeted Customer Appliance	Refrig. replacements	0.73
24)	24G	1991-1992	Targeted Customer Appliance	CFLB	0.68
25)	26A	1991	Residential Energy Savings	DHW wraps-electric	2.71
26)	26B	1991	Residential Energy Savings	CFLB-electric	0.90
27)	26C	1991	Residential Energy Savings	Low-flow showerhead-electric	0.59
29)	26D	1991	Residential Energy Savings	Indirect savings-electric	0.55
29)	26E	1991	Residential Energy Savings	DHW wraps-gas	1.71
30)	26F	1991	Residential Energy Savings	Low-flow showerhead-gas	0.27
31)	26G	1991	Residential Energy Savings	Indirect savings-gas	0.40
32)	64A	1990-1992	Residential Appliance Efficiency Incen.	Air conditioners	1.01
33)	64B	1990-1992	Residential Appliance Efficiency Incen.	Refrigerators	1.96
34)	66	1990	Residential Energy Management Service		1.31
35)	68A	1990-1991	CAP: Weatherization	Refrigerator replacements	0.28
36)	68B	1990-1991	CAP: Hardware	E.-Eff Hdwr Install/Evap Cool	0.27
37)	68C	1990-1991	CAP: Relamping	Relamping	0.37
38)	76	1990	"Welcome Home" Res. New Const.		0.54
39)	77	1991	"Welcome Home" Res. New Const.		0.43
40)	144	1991	Central AC Program		1.53
41)	149	1991	Low-Flow Shoerhead		1.75
42)	150	1991	Residential CFLB		1.09
43)	152	1991	Residential High Efficiency Refrigerator		1.53
44)	155	1990-1991	Appliance Efficiency Incentives: Low-Flow Showerhead		1.06

Table C.11 Realization Rates for all Residential Programs (cont'd)

Obs.	Rpt.	Period	Program	Application	Rlz. Rt.
45)	156	1992	Appliance Efficiency Incentives: CFLB		1.59
46)	158	1992	Residential Direct Assistance		0.37
47)	129A	1990-1992	Residential Weatherization	Water Heater Wrap	0.57
48)	129B	1990-1992	Appliance Efficiency	High-efficiency DWH	0.66
49)	129C	1990-1992	Appliance Efficiency	High-efficiency space heaters	1.47
50)	130A	1990-1992	Appliance Repair & Replace	Furnaces	1.74
51)	130B	1990-1992	Appliance Repair & Replace	Water Heaters	1.05
52)	130C	1990-1992	Appliance Repair & Replace	Rantes	0.41
53)	130D	1990-1992	Weatherization/Conservation	Attic insulation	0.27
54)	130F	1990-1992	Weatherization/Conservation	DHW blanket	0.24
55)	130G	1990-1992	Weatherization/Conservation	LF showerhead	0.23
56)	130I	1990-1992	Appliance Repair & Replace	Program-wide statistics	1.23
57)	132A	1990-1991	Residential New Construction known as	High-efficiency space heat	0.70
58)	132B	1990-1991	Five Star Energy Saver	High-efficiency water heat	0.67
59)	132C	1990-1991	Five Star Energy Saver	Wall Insulation	0.58
60)	195	1990	Residential EMS		0.58

Table C.12 Realization Rates for all C/I/A Programs

Obs.	Rpt.	Period	Program	Application	Rlz. Rt.
1)	43	1991-1992	C/I & Agri. Retrofit Rebate	Net Demand Savings (Total)	0.74
2)	43	1991-1992	C/I & Agri. Retrofit Rebate	Agricultural (Gross)	0.70
3)	43	1991-1992	C/I & Agri. Retrofit Rebate	Commercial (Gross)	0.81
4)	43	1991-1992	C/I & Agri. Retrofit Rebate		0.83
5)	43	1991-1992	C/I & Agri. Retrofit Rebate	Gross Savings (Total)	0.78
6)	43	1991-1992	C/I & Agri. Retrofit Rebate	Net Savings ((Total)	0.83
7)	43	1991-1992	C/I & Agri. Retrofit Rebate	Industrial (Gross)	0.79
8)	43A	1991-1992	C/I & Agri. Retrofit Rebate	Agricultural (Net Demand)	0.79
9)	43A	1991-1992	C/I & Agri. Retrofit Rebate	Agricultrual (Net)	0.79
10)	43B	1991-1992	C/I & Agri. Retrofit Rebate	Lighting (Net Demand)	0.86
11)	43B	1991-1992	C/I & Agri. Retrofit Rebate	Lighting (Net)	0.98
12)	43C	1991-1992	C/I & Agri. Retrofit Rebate	HVAC (Net Demand)	0.33
13)	43C	1991-1992	C/I & Agri. Retrofit Rebate	HVAC (Net)	0.56
14)	44	1990-1991	Non-Residential New Construction	KWH	0.70
15)	44	1990-1991	Non-Residential New Construction	KW	0.62
16)	48	1990-1992	Non-Residential EMS	MWH/AII	1.01
17)	48A	1990-1992	Non-Residential EMS	Commercial	1.24
19)	48A	1990-1992	Non-Residential EMS	Commercial	0.98
19)	48A	1990-1992	Non-Residential EMS	Commercial	0.62
20)	48B	1990-1992	Non-Residential EMS	Industrial	0.61
21)	48B	1990-1992	Non-Residential EMS	Industrial	0.48
22)	48B	1990-1992	Non-Residential EMS	Industrial	0.08
23)	48C	1990-1992	Non-Residential EMS	AG Pump Tests	1.19
24)	48C	1990-1992	Non-Residential EMS	AG Pump Tests	1.82
25)	179	1990-1991	Customized Rebate	Agricultural	0.95
26)	179	1990-1991	Customized Rebate	Agricultural	4.68
27)	179	1990-1991	Customized Rebate	Agricultural	0.86
29)	179	1990-1991	Customized Rebate	Commercial	1.14
29)	179	1990-1991	Customized Rebate	Commercial	1.46
30)	179	1990-1991	Customized Rebate	Commercial	1.00
31)	179	1990-1991	Customized Rebate		1.10
32)	179	1990-1991	Customized Rebate		1.38
33)	179	1990-1991	Customized Rebate		0.91
34)	179	1990-1991	Customized Rebate	Industrial	1.10
35)	179	1990-1991	Customized Rebate	Industrial	1.19
36)	179	1990-1991	Customized Rebate	Industrial	1.00
37)	179A	1990-1991	Customized Rebate	Lighting, sample (n=73)	1.17
38)	179A	1990-1991	Customized Rebate	Lighting, sample (n=73)	1.38
39)	179B	1990-1991	Customized Rebate	Refrigeration, sample (n=73)	0.82
40)	179B	1990-1991	Customized Rebate	Refrigeration, sample (n=73)	2.71
41)	179C	1990-1991	Customized Rebate	Miscellaneous, sample (n=73)	1.11
42)	179C	1990-1991	Customized Rebate	Miscellaneous, sample (n=73)	1.60
43)	87B	1990	C/I & Agri. EMS & HDWR Rebate	HVAC EMS	1.12
44)	87A	1990	C/I & Agri. EMS & HDWR Rebate	Packaged A/C	0.98
45)	87C	1990	C/I & Agri. EMS & HDWR Rebate	Clock Thermostate	0.56
46)	87D	1990	C/I & Agri. EMS & HDWR Rebate	Indoor Lighting System	0.30
47)	87E	1990	C/I & Agri. EMS & HDWR Rebate	Reflectors	1.07
48)	87F	1990	C/I & Agri. EMS & HDWR Rebate	Insulation	1.28
49)	87G	1990	C/I & Agri. EMS & HDWR Rebate	Outdoor Lights	0.78

Table C.12 Realization Rates for all C/I/A Programs (cont'd)

Obs.	Rpt.	Period	Program	Application	Rlz. Rt.
50)	87H	1990	C/I & Agri. EMS & HDWR Rebate	Time Clocks	0.93
51)	87I	1990	C/I & Agri. EMS & HDWR Rebate	Chemical Dishwasher	0.33
52)	87J	1990	C/I & Agri. EMS & HDWR Rebate	Flexible Barriers	0.94
53)	87K	1990	C/I & Agri. EMS & HDWR Rebate	Grouped HVAC	0.20
54)	87L	1990	C/I & Agri. EMS & HDWR Rebate	Grouped Lighting	0.86
55)	87M	1990	C/I & Agri. EMS & HDWR Rebate	Grouped Process Hardware	0.96
56)	87N	1990	C/I & Agri. EMS & HDWR Rebate	Window Treatment	1.09
57)	87O	1990	C/I & Agri. EMS & HDWR Rebate	Indoor Lamps	0.87
58)	101	9/90 thru 9/92	Commercial New Construction Incen.		0.86
59)	162	1985-1989	Non-Residential Audit Evaluation	kW (Total)	0.98
60)	162	1985-1989	Non-Residential Audit Evaluation	kWh (Total)	0.83
61)	N/A	1991	Agricultrual EMS	Agricultural EMS (Therms)	1.09
62)	0	1985-1989	Non-Residential Audit Evaluation	Therms (Total)	0.95
63)	162A	1985-1989	Non-Residential Audit Evaluation	Space Cooling (kW)	1.06
64)	162A	1985-1989	Non-Residential Audit Evaluation	Space Cooling (kWh)	0.79
65)	162B	1985-1989	Non-Residential Audit Evaluation	Space Heating (kW)	0.81
66)	162B	1985-1989	Non-Residential Audit Evaluation	Space Heating (kWh)	0.81
67)	162B	1985-1989	Non-Residential Audit Evaluation	Space Heating (Therms)	0.95
68)	162C	1985-1989	Non-Residential Audit Evaluation	Lighting (kWh)	0.87
69)	162C	1985-1989	Non-Residential Audit Evaluation	Lighting (kW)	0.97
70)	162D	1985-1989	Non-Residential Audit Evaluation	Motor Loand (kWh)	0.74
71)	162D	1985-1989	Non-Residential Audit Evaluation	Motor Load (kW)	1.12
72)	162E	11/90-8/91	Non-Residential Audit Evaluation	Process Heating (Therms)	0.95
73)	165A	11/90-8/91	C/I Lighting Retrofit	Ballast: Hybrid	0.82
74)	165B	11/90-8/91	C/I Lighting Retrofit	Ballast: Electronic	0.73
75)	165C	11/90-8/91	C/I Lighting Retrofit	Ballast: T-8 Electronic	0.52
76)	165D	11/90-8/91	C/I Lighting Retrofit	Lamp: F34	1.00
77)	165E	11/90-8/91	C/I Lighting Retrofit	Lamp: F32	1.00
78)	165F	11/90-8/91	C/I Lighting Retrofit	Lamp: Delamping	0.91
79)	165G	11/90-8/91	C/I Lighting Retrofit	Delamp 1 + Opt. Reflectors	0.87
80)	165H	11/90-8/91	C/I Lighting Retrofit	Delamp 2 + Opt. Reflectors	0.91
81)	137A	1990-1992	High Efficiency Commercial Equipment	Cooking	0.43
82)	137B	1990-1992	High Efficiency Commercial Equipment	Space Heat	1.41
83)	137C	1990-1992	High Efficiency Commercial Equipment	Boiler	14.54
84)	137D	1990-1992	High Efficiency Commercial Equipment	Air Conditioner	0.60
85)	137E	1990-1992	High Efficiency Commercial Equipment	Water Heater	1.09
86)	137F	1990-1992	High Efficiency Commercial Equipment	Dryer	6.35
87)	137G	1990-1992	High Efficiency Commercial Equipment	Weatherization	6.72
88)	137H	1990-1992	Commercial Energy Efficiency Analyses	Audits	1.37
89)	139A	1990-1992	Industrial Equipment Replacement	Space Heat	5.60
90)	139B	1990-1992	Industrial Equipment Replacement	Boiler	0.11
91)	139C	1990-1992	Industrial Equipment Replacement	Dryer	0.24
92)	139D	1990-1992	Industrial Equipment Replacement	Furnace	0.27
93)	139E	1990-1992	Industrial Equipment Replacement	Process Cooking	0.66
94)	139F	1990-1992	Industrial Audit	Not Applicable	0.29
95)	139G	1990-1992	High Efficiency New Commercial Bldg.	Not Applicable	2.11
96)	140A	1990-1992	High Efficiency New Commercial Bldg.	Space Heat	0.17
97)	140B	1990-1992	High Efficiency New Commercial Bldg.	Water Heating	4.43
98)	140C	1990-1992	High Efficiency New Commercial Bldg.	Cooking	0.19