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WHAT HAS DSM ACHIEVED IN CALIFORNIA?

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Abstract

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).

This paper summarizes the results of 50 evaluation studies that assess California DSM programs operating between 1990 and 1992. The report concludes that in aggregate the California DSM programs outperformed DSM programs from the 1980's, in terms of more accurately forecasting energy and demand impacts.

Overview of the Utilities and Their DSM Experience

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). 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.

DSM expenditures for the four utilities grew significantly from 1990 (when $188 million was spent) to 1991 (when expenditures totaled $291 million) and leveled off somewhat between 1991 and 1992 (when expenditures totaled $293 million). 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).

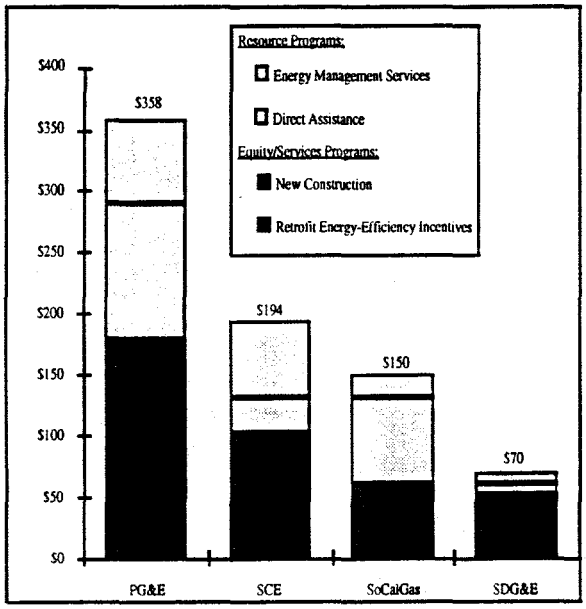
The four investor-owned California utilities operate two types of DSM programs: (1) resource programs that typically earn the utilities shared-savings incentives, and (2) equity/services programs that generally are operated for performance-adder incentives. Resource programs include a variety of retrofit 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 California Public Utilities Commission (CPUC), while the resource programs are not.

Reflecting these various programmatic differences, the CPUC employs the following classification scheme for DSM programs: (1) retrofit energy-efficiency incentives (residential and commercial/industrial/ agricultural - C/I/A); (2) residential direct assistance; (3) new construction (residential and C/I/A); and (4) energy management services (residential and C/I/A).

Retrofit energy-efficiency incentive programs accounted 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 accounted for the next largest percentage, with $225 million (29 percent). Energy management services were a close third, with $157 million (20 percent). Finally, new construction programs represented the smallest type, with only $77 million, or 10% of the total expenditure.

Figure A 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 A. DSM Expenditures (in Millions of Dollars): 1990-92

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.

Program Participation Levels

The 50 impact studies 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 the next section). 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. As a result, the data discussed here should be viewed as illustrative and not as a complete inventory.

Altogether, the residential DSM programs for which evaluation studies were submitted served an estimated 2,400,000 customers over the three-year period. Eleven residential retrofit energy-efficiency incentive programs accounted for nearly half of these participants. Commercial, industrial, and agricultural DSM programs operated by the four utilities served approximately one-fourth as many participants as their residential DSM program counterparts. SCE's energy management services program accounted for the largest number of C/I/A participants, or approximately half of the total. These figures indicate that an impressive number of customers have benefited from California's DSM programs.

Installation Levels for Selected Measures

The 50 impact studies afforded an opportunity to compare the numbers of DSM measures distributed for three residential measures.

Compact fluorescent lamps appear to be the DSM measure that was distributed to the greatest number of customers between 1990 and 1992. In particular, the annualized numbers indicate more than 775,000 lamps were distributed each year by the three utilities that deliver electric services: PG&E, SCE, and SDG&E.

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. 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). These three programs contributed to the purchase of nearly 123,000 energy-efficient refrigerators each year between 1990 and 1992.

Based on these measure penetration rates, 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.

Summary Of *Ex-Post* Impact Estimates

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.

Residential Programs

For those nine 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. Southern California Edison's Residential Appliance Efficiency Program accounts for the largest program-wide electricity savings with a total of 53,341 megawatt hours of savings between 1990 and 1992.

Nine studies reported residential gas savings at the program level, totaling 8,853 kilotherms of gas savings. The largest portion, 65%, came from retrofit incentive programs. The balance was split approximately equally between direct assistance and energy management services. Southern California Gas' Residential Conservation Program reported the largest savings among these programs, totaling 2,559 kilotherms during 1990-92.

Commercial, Industrial, and Agricultural Programs

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 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. In contrast, recall that Southern California Edison's Residential Appliance Efficiency Program is the residential program with the largest program-wide savings, totaling only 53,341 megawatt hours of savings between 1990 and 1992.

Six studies estimated the electrical demand (MW) savings of commercial, industrial, and agricultural programs. (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 for the 1991-92 period.

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.

In summary, 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.

Selected Residential Measures

Three residential measures are discussed here, where multiple impact studies provide estimates of measure savings. In all cases, *ex-post* net savings are reported.

Based on three impact studies, the annual savings per refrigerator vary widely, from 90 kWh to 392 kWh. This variation reflects some combination of differences in program design characteristics (e.g., refrigerator replacement versus early retirement programs) and evaluation methods. For example, two of the studies covered programs which provide incentives to purchase refrigerators with greater energy efficiency (resulting in estimated savings of 90 and 286 kWh per refrigerator), while the third program offered early retirement of refrigerators and refrigerator repair (saving 392 kWh per refrigerator).

Similar comparisons are available for residential lighting measures. Again, a wide variation of net kilowatt hour savings per lamp is reported (34 kWh to 128 kWh), reflecting some combination of differences in program design and implementation features (e.g., the number of lamps installed per home) and evaluation methods.

Low-flow showerheads also exhibited wide variation in *ex-post* net savings. Being a measure directed at both electricity and natural gas savings, the applicable per showerhead savings were 20 kWh to 495 kWh and 1 therm to 28 therms. Again, these ranges reflected substantial variation in program design, evaluation method, and approach to free-ridership estimation.

Ex-Post vs. *Ex-Ante* Impact Estimates

In defining their programs, the individual utilities formulated preliminary estimates of program impacts, known as *ex-ante* impact estimates. In most cases, these estimates are based on engineering calculations. The formal evaluation studies summarized here estimate impacts based on post-implementation measurement and/or estimates of key parameters. Their estimates are therefore called *ex-post* impact estimates.

This section 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. 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.

Realization Rates In Aggregate

The distribution of realization rates associated with 158 programs and program segments is shown in Figure B. 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% (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.

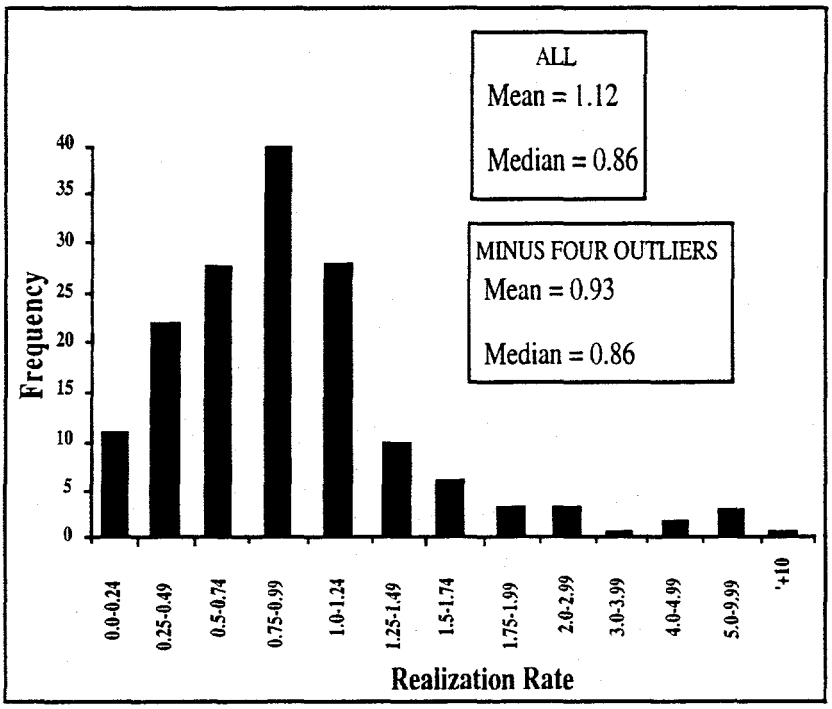


Figure B. Distribution of Realization Rates (N=158)

The realization rates presented in this report are unweighted. That is, the realization rate for each program or program segment 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. This wide variation makes it difficult for resource planners to identify the optimum level of investment in DSM programs. 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.

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 1). 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. (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.) 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.

Table 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.

Realization Rates By Program Type

Of the seven types of DSM programs shown in Table 1, 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-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.

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.

Conclusions

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.

References

Division of Ratepayer Advocates, California Public Utilities Commission. 1993. *Demand-Side Management Expenditures and Cost Effectiveness: Trends and Patterns, 1988-Current,* August.

Hirst, Eric. 1994. *Costs and Effects of Electric-Utility DSM Programs: 1989 Through 1997,* Oak Ridge National Laboratory, ORNL/CON-392, June.

Schlegel, Jeff, et al., 1993. *Evaluation of DSM Shareholder Incentive Mechanisms,* Madison, WI: Wisconsin Energy Conservation Corporation, January.

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