one or two years, a more comprehensive program is implemented for a larger group of customers. Consequently, program marketing is slow and deliberate, so that demand for program services does not outpace the program budget. In addition, program participation goals are deliberately scaled back, so that "system overloads" do not occur. For programs where participation goals are carefully managed, the effects of other program design features on participation rates may be hard to identify. In some programs, sufficiently large budgets allow utilities to meet unanticipated demand, allowing participation rates to be comparatively higher. In contrast, for several lighting programs, the exhaustion of program budgets appeared to be the only factor limiting participation. For its Large C/I Program, Green Mountain Power (GMP) immediately acquired a waiting list of prospective customers that will take several years to process. NEES's Energy Initiative Program was suspended after the first three months in 1991 because requests for participation exceeded the program budget for that year.

4.3 Comparing Participation Rates for Commercial Lighting Programs

The previously described challenges to measuring participation rates consistently led us to restrict our comparative analysis to eight programs. Four of the programs tracked participants by "account number", two programs tracked participants by "rebates paid", and the remaining two programs tracked participants by "customer". In our analysis, each "rebate paid" and "customer" corresponds to a single account number. For all eight programs, the eligible population used to calculate the participation rate is based on account numbers (see Table 4-1). This smaller sample of eight programs is more homogeneous than the total sample of 20 programs because the eight are "mature" programs that have been operating for several years. None of the eight programs is a pilot program and all have been in operation for two years or more. We found the average annual participation rate to be 4.0% (ranging from a low of 0.6% to a high of 16.1%).

We first compared annual participation rates with the total resource costs of the programs (see Figure 4-1). We were interested in learning whether annual participation is related to the total resource cost of a DSM program. We expected that the more cost-effective programs might have higher participation rates because the largest opportunities for cost-savings would be most attractive to eligible customers. For our sample of eight programs, however, the annual participation rate appears to be independent of the total resource cost of a DSM program, suggesting that any influence of total resource cost on participation is confounded by other variables that we have not examined.

Table 4-1. Annual Participation Rates for Selected Commercial Lighting Programs

Utility	Years in Operation	Program Type	Definition of Participant	Annual Participants	Annual Participation Rate	Total Resource Cost (¢/kWh)
SMUD	2.5	Direct Install	Acct #	2608	16.1%	6.5
NEES-EI	2.5	Audit/Rebate	Acct #	4114[1]	6.5%	3.7
NU	5	Audit/Rebate	Acct #	5967	3.6%	2.5
NMPC	2	Rebate Only	Rebates Paid[2]	2881	2.0%	6.0
BECo	2	Direct Install	Acct #	919	1.2%	7.2
SCE	14	Rebate[3]	Rebates Paid[4]	5603[5]	1.0%	1.2
SDG&E	2.5	Audit/Rebate	Customers[6]	789	0.7%	4.1
Con Edison	2	Rebate Only	Customers	2276	0.6%	6.8
Average					**4.0%**	

[1] This figure represents the number of participants for NEES's entire Energy Initiative program rather than the lighting component alone.

[2] IRT asserts that the number of rebates paid by NMPC is equal to the number of participating account numbers.

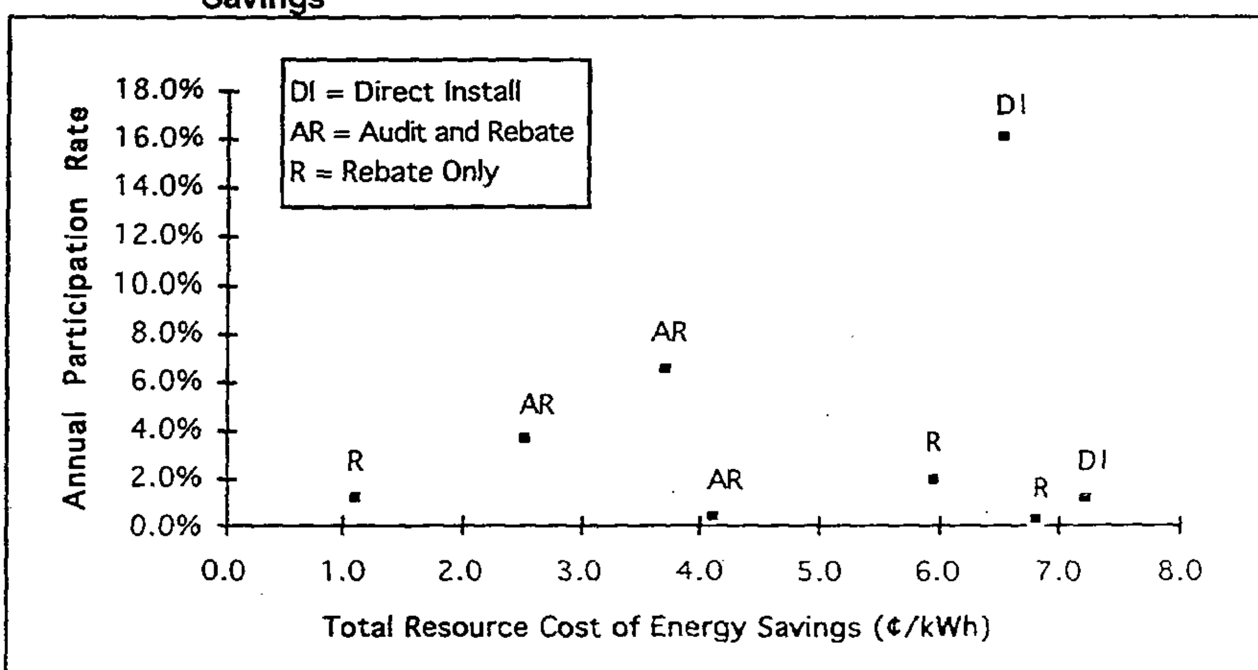
[3] Audits for participants in this program are provided through the separately funded CIA Audits program.

[4] According to our SCE contact, the number of rebates paid by SCE is approximately equal to the number of participating account numbers.

[5] This represents the number of participants for SCE's entire Energy Management Hardware Rebate Program rather than the lighting component alone.

[6] We assume for SDG&E and for Con Edison that the number of participating "customers" is equal to the number of participating account numbers.

Figure 4-1. Annual Participation Rate vs. the Total Resource Cost of Energy Savings



As discussed in Section 4.1, there are likely to be trade-offs between participation rates and some other indicators of program success. For example, we expected that attempts to maximize energy savings per participant by focusing on customers with large energy savings potential would result in lower participation rates. When we compared energy savings per participant to annual participation rates for the eight programs, no clear patterns emerged; some data confirmed our expectations while other data did not.

We also compared annual participation rates with selected program design features such as the percent of the measure cost paid by the utility, the total measure cost, and the administrative cost of the program. First, we compared annual participation rates with the percent of measure cost paid by the utility (Figure 4-2). We expected that customers would be more likely to participate in a DSM program as the utility increased the portion of the measure cost that the utility paid. Second, we compared annual participation rates with the absolute cost (per kWh saved) of the measures installed through the programs. We expected that programs offering more expensive measures, and therefore requiring larger investments by participants, would have lower participation rates. Third, we compared annual participation rates with the administrative costs of the programs (see Figure 4-3). We expected that participation would be a function of program marketing (as reflected in administrative costs, which include the cost of marketing as well as other activities). That is, we expected participation levels to be higher where more resources were devoted to trying to influence customers to participate in a program. In all three cases, some data confirmed our expectations while other data did not. Again, we were not able to discern clear relationships between annual participation rates and these program design features.

In summary, we strongly believe that the success of a utility DSM program is not a random event, but is systematically related to aspects of program design and implementation. Currently, however, a precise understanding of how program success is related to specific program features is severely limited by inconsistencies among utilities in their reporting of DSM program data. Inconsistencies in utility reporting of participation data limited our comparative analysis to less than half of our 20 programs; and because of the small size of the sample, we found it impossible to identify clear relationships between participation rates and other program characteristics. To better understand these relationships, it will be necessary to analyze a larger data set. Consequently, we strongly recommend further study of participation based on additional programs for which "participants" and "eligible populations" are defined and measured both carefully and consistently.

Figure 4-2. Annual Participation Rate vs. Percent of Measure Cost Paid by Utility

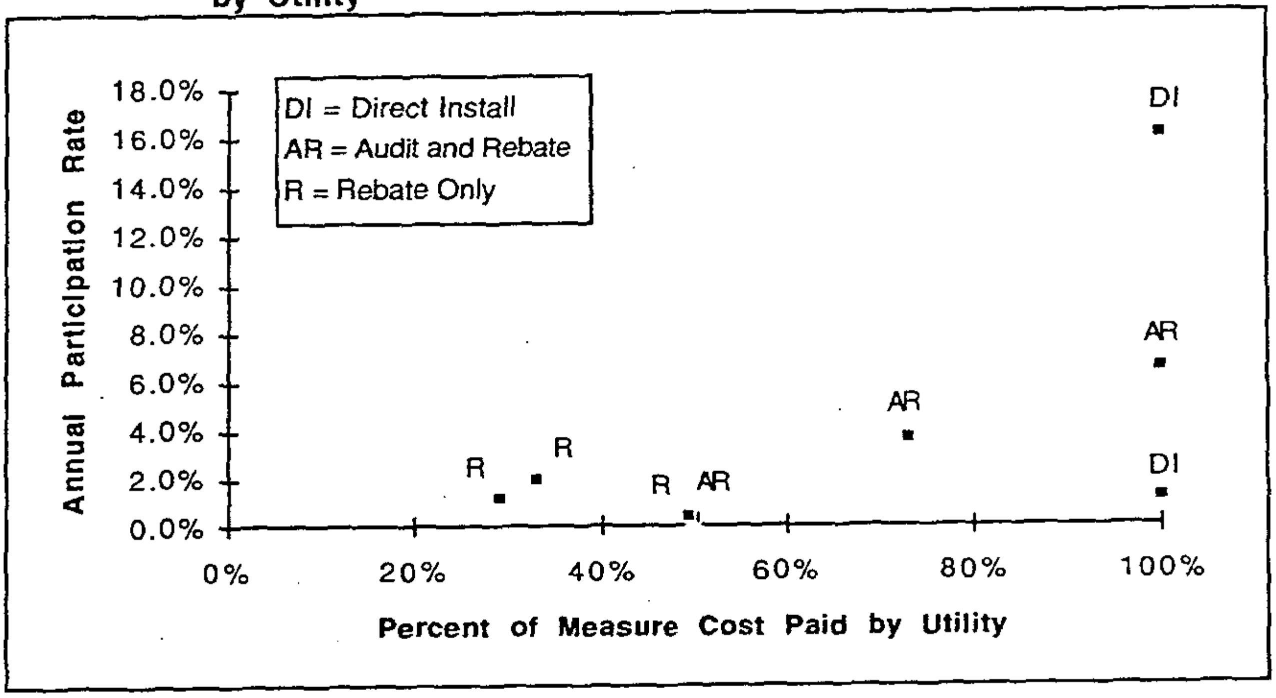
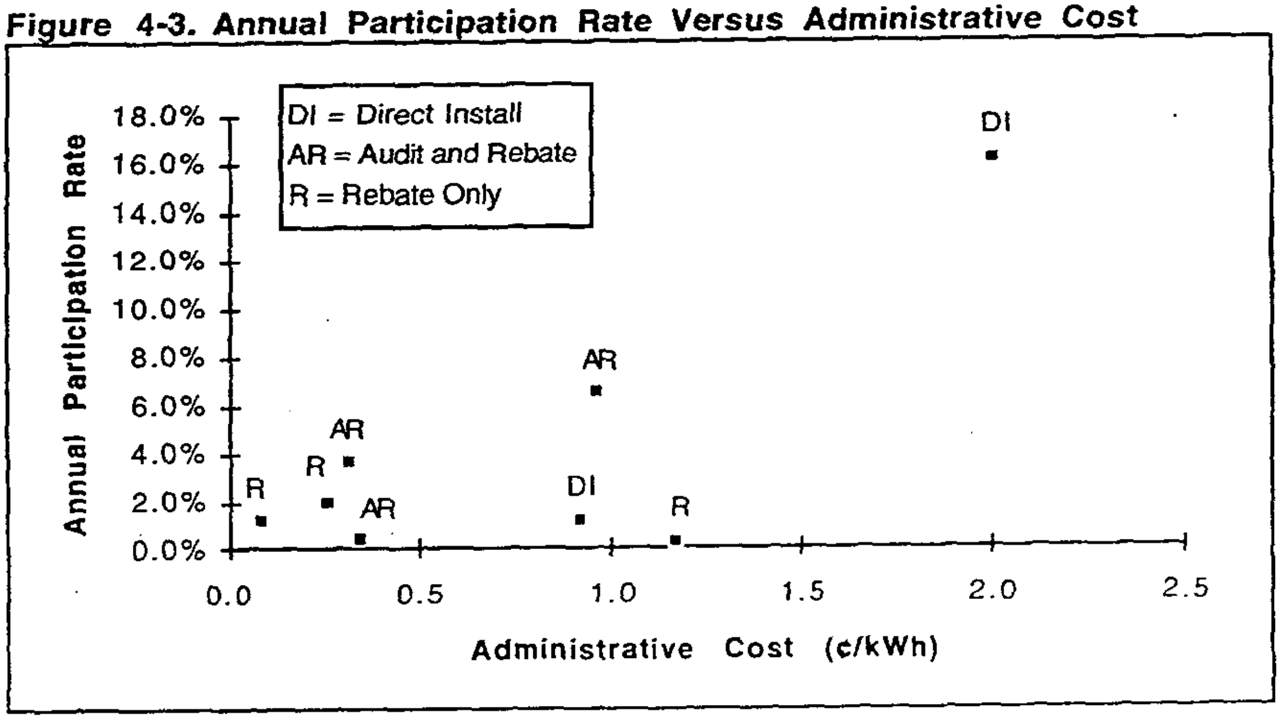


Figure 4-3. Annual Participation Rate Versus Administrative Cost



4.4 Energy Savings per Participant

Defining participants as "account numbers", "customers", or "rebates paid" does not directly account for the diversity of energy-efficient lighting technologies offered by lighting DSM programs or for the total number of measures installed. A single participant can represent the installation of a single lighting measure or 1,000 measures; similarly, the measures may all be the same technology (high intensity discharge lamps, for example) or may be an assortment of numerous different technologies. Consequently, although participation rates are valuable indicators of customer response to a program over time, savings per participant may be a more meaningful measure of a program's ability to achieve cost-effective savings for a given participant.

Indiscriminate use of savings per participant as a measure of program performance, however, could lead one to the simple conclusion that utilities should target only their largest customers for DSM participation because these customers tend to have the largest savings potentials. Targeting the comparatively small number of large customers for DSM programs can be an effective way of minimizing utility costs by reducing the number of utility transactions. Accordingly, utilities frequently promote DSM programs to their largest customers in order to achieve large energy savings. On the other hand, a utility that wishes to maximize the cost-effectiveness of energy saved in its service area is likely to have good reason for focusing on medium and small customers as well as larger ones.

In this section, we discuss three different ways of measuring the average energy savings per participant. In order of increasing precision, these include: reduction in energy use; reduction in the energy use of specific end uses (e.g., lighting); and acquisition of all cost-effective energy savings.

The most easily calculated measure of average energy savings per participant is based on the reduction in per participant energy use as a result of a DSM program. In this case, the total energy savings attributed to the program are divided by the number of program participants. The advantage of measuring the overall reduction in energy use is that customer billing data for before and after the efficiency program are typically available from the utility. The disadvantage of measuring energy savings per participant in this way is that one can neither be sure that a change in energy consumption is actually attributable to the DSM program nor attribute the changes in energy use to particular end uses. However.

because information on the reduction in pre-retrofit energy use was available for only a few of our programs, we could not draw any definitive conclusions from our data.

A more involved method for measuring the performance of a DSM program in acquiring all available cost-effective energy savings is to calculate, on a per participant basis, the energy savings as a percentage of the pre-program energy use associated with specific end uses. In other words, for lighting programs, one would compare pre-program lighting energy consumption to post-program lighting energy consumption. Acquiring end-use information on a per participant basis, however, is more expensive than collecting billing data. We were not able to acquire this information for any of our programs.

If maximizing cost-effective energy savings is a program objective, the most meaningful measure of energy savings per participant would consider energy savings as a percentage of the cost-effective savings potential. In other words, one would measure for each participant and for each end use the extent to which all cost-effective energy savings have been achieved through a given DSM program. This measure indicates the depth of energy savings achieved for each participant and provides a meaningful basis for assessing the remaining potential for energy savings. Measuring the depth of savings per participant is important for assessing the size of "lost opportunities" — energy savings that are often much more difficult and/or expensive to acquire because they were not addressed the first time a customer participated in the efficiency program. Unfortunately, estimating the energy savings potential on a per participant basis requires extensive market research as well as a large program budget. We were not able to acquire this information for any of the programs in our sample.

Energy savings per participant, when qualified properly, can be an important measure of program performance. Without these qualifications, which indicate the fraction of cost-effective energy savings achieved by a DSM program, the measure of energy savings per participant based on billing data alone stops short of providing conclusive information on the performance of a program.

4.5 Minimizing Utility Costs

Minimizing the cost of a DSM program to the utility is commonly considered to be an important measure of the performance of a DSM program. Maximizing savings per utility dollar invested in DSM suggests that ratepayer dollars are being spent wisely. Before examining the effect of utility DSM costs on ratepayers, we describe the difficulty of comparing utility DSM costs among utilities, as well as the relationship between utility costs and some other measures of program performance.

4.5.1 The Difficulty of Comparing Utility Cost Components Among DSM Programs

As discussed in Chapter 3, the total resource costs of DSM programs can be split into measure costs and program administrative costs. Measure costs are the costs of acquiring, installing, and operating an energy efficiency measure. Administrative costs are the non-measure costs borne by the utility in implementing programs that lead to installation of efficiency measures. The components of administrative costs generally include labor; program support such as advertising and program promotion; and general administration such as departmental secretaries and administrative staff. Measurement and evaluation (M&E) costs are also sometimes included.

It is especially important to understand the components of the costs reported for a DSM program if one plans to compare costs across utilities. For example, for two utilities that report non-incentive costs for which the components are unidentified, one may include overhead and M&E costs as well as shareholder revenues while the other may include only the costs of program marketing and the labor of full-time program employees.

The cost components were rarely listed in evaluation reports for the 20 lighting programs, and it often required conversations with several contacts at a utility in order to understand the non-incentive cost components of a single program. When utilities did report administrative cost components, the components varied widely from utility to utility. Bangor Hydro, for example, classifies all non-incentive costs in two categories: Labor and Non-labor; Boston Edison breaks down non-incentive costs into the categories of Promotion, Design Teams, Utility Labor, Other, Overhead, and Measurement and Evaluation; and Con Edison breaks down non-incentive costs into the categories of Labor, Office, Data Processing, Advertising, Outside Services, Equipment, Rebates, Administration, Impact Evaluation, and Market Research and Process Evaluation.

As Berry (1989) has noted, the lack of standardized definitions for administrative cost components makes it difficult to compare these costs among programs. It is particularly difficult to allocate administrative overhead and M&E costs consistently, because they are often tracked for a utility's overall DSM activities rather than on a program-specific basis. In order to avoid the definitional problems of attempting to break the administrative costs into subcategories for our 20 programs, we simply subtracted the incentive costs from total utility costs in order to identify administrative costs in Chapter 3.

The time frame of program evaluation can also contribute to the difficulty of identifying the real cost of a program and comparing that program to programs at other utilities. Because most regulatory agencies require utilities to report the costs and savings of their DSM activities on an annual basis, DSM programs are most often evaluated for a single year. Evaluating a DSM program for a single year makes it difficult to estimate program costs accurately, since there are costs that occur both at the beginning and end of the program which should be spread out over the life of the program. For example, start-up costs are significant at the beginning of program implementation, and M&E costs are significant in the later stages of the program. Annual program evaluations will be affected by this uneven distribution of costs, as will cross-program comparisons when programs are in different stages of maturity.

4.5.2 The Relationship of Utility Costs to Program Performance

For our sample of 20 lighting programs, our analysis indicates no correlation between the utility's administrative costs per participant and the participation rate (see Section 4.3). In addition, we see no correlation between the utility's measure costs and the energy savings per participant. This is not particularly surprising because, as pointed out in Chapter 3, utility expenditures constitute only part of the cost of energy savings. For our 20 lighting programs, the percentage of the total program cost paid by the utilities ranges from approximately 20% (Pacific Gas and Electric (PG&E) at 19%, IE at 20%) to 100%, with program participants paying the remainder. Because customer costs are an important component of the total cost of a DSM program, minimizing utility costs will not necessarily lead to more cost-effective programs from a total resource cost perspective. As can be seen in Table 3-1 and Figure 3-1, there appears to be no clear relationship between utility spending as a percentage of total resource costs and the final total resource costs.

4.5.3 Utility Costs, Free Riders, and Rate Impacts

Given these findings, free riders appear to be the most important remaining influence on the utility cost and consequent rate impacts of DSM programs. As mentioned in Chapter 3, the average level of free-ridership was 17% in the 17 out of 20 programs where free riders were measured (Table 3-3). The primary effect of free riders is to reduce the *savings* directly attributable to a utility-operated DSM program. In Table 4-2, we present levelized total utility costs based on both gross energy savings and net energy savings. In the second column, we have removed the energy savings attributable to free riders. The key findings in this table are reported in the third and fourth columns. In the third column, we find that the average increase in the levelized utility costs resulting from free riders is only 0.6¢/kWh. In the fourth column, we find that the average program in our sample incurred 31% in additional utility costs as a result of free rider participation (excluding the effects of net revenue losses). Clearly, minimizing free riders should be an important design strategy for minimizing the rate impacts of DSM programs.

Table 4-2. Total Utility Cost of Free Riders

Utility	Total Utility Cost of Conserved Energy — with gross energy savings (¢/kWh)	Total Utility Cost of Conserved Energy — with net energy savings (¢/kWh)	Increase in Total Utility Cost of Conserved Energy due to Free Riders (¢/kWh)	% Increase in Total Utility Cost of Conserved Energy due to Free Riders (Rate Impact)
BECo	7.2	8.4	1.2	16%
BHEC (Pilot)	1.4	5.2	3.8	273%
BPA (Pilot)	4.0	4.0	0.0	0%
CHG&E	2.7	2.8	0.1	3%
CMP	1.5	2.0	0.4	27%
Con Ed	4.0	4.2	0.2	5%
GMP - Large C/I	4.3	5.2	0.9	21%
GMP - Small C/I	7.6	9.2	1.6	21%
IEL&P (Pilot)	0.9	1.5	0.7	79%
NEES - EI	3.7	4.0	0.3	7%
NEES - Small C/I	5.2	5.6	0.4	8%
Ni-Mo	2.1	2.5	0.3	14%
NU - ESLR	1.9	2.1	0.2	11%
NYSEG	1.3	1.7	0.4	28%
PEPCO	0.6	0.7	0.2	27%
PG&E	1.0	1.3	0.3	30%
SCE	0.4	0.5	0.1	18%
SCL (Pilot)	1.9	2.3	0.4	21%
SDG&E	2.2	2.7	0.5	22%
SMUD	6.5	6.5	0.0	0%
Average	3.0	3.6	0.6	31%
Standard Deviation	2.2	2.4	0.8	58%

Notes: Gross energy savings *include* energy savings by free riders; net energy savings *exclude* energy savings by free riders. Figures do not add due to rounding.

4.6 Summary

From a planning perspective, the total resource cost of DSM programs is probably the most important measure of program performance. However, the total resource cost is intimately related to other, often-cited measures of DSM program performance, such as participation rates, energy savings per participant, and the utility costs of DSM programs. Explicitly trading off these aspects of programs through various program designs is a primary challenge for utilities seeking cost-effective DSM. We identify current challenges to specifying participation rates, energy savings per participant, and utility costs consistently, and examine them in order to understand precisely what aspects of program performance they measure. We pay particular attention to specification of participation rates and distinguish their value for internal utility management from their value for other purposes such as cross-utility comparison.

Program participation rates, for example, are not defined consistently across utilities and, in any case, may not provide an appropriate basis for comparing programs. We found three general definitions of a program participant ("account number", "customer", and "rebates paid") as well as differences in definitions of eligible populations. Inconsistency in defining these terms can have a large effect on the calculation of participation rates (the ratio of participants to eligible population). Even when these problems of definition can be resolved, cross-utility comparisons are complicated by differences in program life-cycle stage and differences in the sizes of program budgets. Pilot programs or programs in their initial years of operation are often explicitly designed for limited participation; comparing these programs with mature programs is not appropriate. Even mature programs are sometimes limited in their performance by program budgets: we examined two programs that exhausted their budgets early in the program year and consequently had to turn participants away. Because of the factors that complicate annual participation rates, cumulative participation rates are probably more reliable indicators of performance. At the same time, the notion of a market saturation point for participation may be too limiting if the measures offered by the program are changing rapidly, which is likely because the energy efficient technologies offered by commercial lighting programs are rapidly improving and becoming less expensive.

The difficulty involved in measuring program participation consistently among DSM programs also complicates the examination of savings per participant as a measure of program performance. Moreover, for this measure to be a meaningful indicator of the "depth" of energy savings per participant, additional information is required on the cost-effective savings potential for each participant.

With regard to the utility costs of DSM, important inconsistencies in utility reporting of cost components limited our analyses to incentive costs versus all other costs (which we grouped under "administrative costs"). Because minimizing utility costs will reduce rate impacts, we examined the characteristics of programs with low utility costs (per kWh of savings). We found that utility costs are not systematically related to higher or lower total resource costs. This should come as no surprise because — except in the case of direct install programs — utility incentives cover only a portion of the total resource cost of energy efficiency. We then examined the impact of free riders on rate impacts because free riders cause the utility to incur costs that produce no net savings. We found that the rate impacts of free riders for our programs are significant — utility costs are 31% higher than they would have been without free riders. Consequently, we conclude that minimizing free riders (and taking credit for free drivers) should be an important program design strategy for minimizing rate impacts.

The Evaluation of Commercial Lighting DSM Programs

Evaluating the effect of a DSM program on energy consumption is a daunting task. The goal is to measure how much energy would have been consumed by program participants if the program had not occurred. Because energy savings can only be deduced and not directly observed, uncovering savings attributable to a program requires information on both program participants and nonparticipants (a comparison group), before and after program implementation. The state of the art in evaluation methods is evolving rapidly as utilities, consultants, and academics apply techniques from economics, statistics, and engineering to assess DSM program methods and estimate net impacts. The 20 programs assessed in this report provide an opportunity to examine the recent practice of evaluation methods in the field.

Differences in energy savings affect the calculated cost per kWh of savings, and some of these differences are due to distinctions in utility evaluation practices. By comparing and contrasting evaluation methods, we can begin to understand how differences in evaluation methods and the assumptions made in calculating lifetime energy savings affect total resource cost estimates. More complete, technical descriptions of these evaluation methods can be found elsewhere (RCG/Hagler Bailly 1991, Hirst 1991).

In this chapter, we examine evaluation methods based on billing data used by 10 programs, and end-use metering methods used by four programs. We compare total resource cost results for programs relying on tracking database estimates of savings with programs using more complex evaluation methods based on measured consumption data. We also examine the range of techniques used to estimate the proportion of free riders participating in each program, and we review the handful of programs that investigate the magnitude of free driver and spillover effects. After analyzing the effect of different measure lifetime estimates on total resource cost, we introduce a taxonomy of evaluation methods that encapsulates the strengths and weaknesses of methods for different evaluation objectives. Finally, we present some rough estimates of evaluation costs as reported by our sample of programs.

5.1 Classifying Evaluation Methods in the Sample of 20 Programs

The distinction between "engineering" and "measured data" evaluation methods figures prominently in most discussions of program evaluation results. We find this distinction misleading both in theory and in practice for the following reasons: (1) All methods of estimating energy savings rely on engineering methods to some extent. For example, even end-use metering relies upon engineering technologies (meters and data loggers). Because all methods are based on engineering and usually on statistical principles, all methods are potentially subject to stochastic and systematic errors arising from data collection and sample selection anomalies. Thus, no method elicits the absolute truth regarding program savings; (2) A trend in utility regulation is encouraging evaluators to incorporate post-program measured consumption and participant information in their estimates of savings. This use of data blurs the distinction between pure "engineering" and "measurement" evaluation methods. At the simplest level, all programs we considered construct savings estimates based on post-program records of the number of participants and measures per participant, as described in each program's tracking database.

We distinguish among three general categories of post-program impact evaluation methods:[1] (1) tracking database estimates, (2) measured consumption estimates using billing data, and (3) and measured consumption estimates using end-use metering. These three categories are not entirely distinct; some evaluation methods exist which span two or all three of these categories. But we believe these three categories better describe the methodological distinctions among evaluations than do the categories of "engineering" and "measured" evaluation. The taxonomy of evaluation methods presented later in the chapter summarizes available methods and describes each method's ability to identify and control for different components of program savings.

5.1.1 Tracking Database Estimates of Program Savings

The most straightforward attempt to determine energy savings utilizes program tracking database information on participants' installed measures along with four additional pieces of information: the operating efficiency of each measure, the baseline efficiency of the measure to be replaced, the annual hours of operation, and the measure lifetime. The

[1] Although we acknowledge the complementary nature of impact and process evaluations, the evaluations we reviewed provided little evidence of formal information sharing between the two evaluation types.

sophistication of the estimate is dependent on the sources of these four values. As noted, substantial amounts of post-program information (excluding measured consumption data) may be used in this method. Thus, tracking database savings estimates are *not* unverified, pre-program, "engineering" estimates.

Baseline Equipment Efficiency and Program Measure Efficiency

The efficiency of both the new equipment and the equipment being replaced is crucial to the estimate of savings: if equipment being replaced is more efficient than originally thought, savings will be less than predicted. If new equipment does not perform as well as expected, savings will also be reduced. In San Diego Gas and Electric's (SDG&E) retrofit program, it was originally assumed that equipment being replaced consisted of standard coil-core ballasts and F40 fluorescent lamps. However, site inspections revealed that approximately 50% of all ballasts were efficient coil-core ballasts, and 50% of all lamps were F34 Watt Miser lamps. SDG&E revised its savings figures downwards for various measures by 18% to 48% to reflect more efficient base equipment. Other programs that relied on tracking database estimates, such as Iowa Electric Light and Power Company (IE) and Sacramento Municipal Utility District (SMUD), used similar assumptions to estimate the efficiency of existing equipment.

Short-duration end-use metering studies by New England Electric System (NEES), Northeast Utilities (NU), and Pacific Gas and Electric (PG&E) inspected and metered both existing and new efficient equipment consumption, at once verifying the quantity, type, and consumption of the new equipment and the equipment being replaced, but only for a small sample of program participants. These same program evaluations found that tracking database estimates of the number of program measures installed agreed favorably with site inspections: for a limited sample of sites in each program, site inspections showed the number of measures actually installed to be between 97% and 103% of tracking database estimates. Site inspections by Central Maine Power (CMP) also found that tracking database errors, on average, did not affect savings estimates significantly.

Hours of Operation

Tracking database estimates of savings are predicated on consistent use of the equipment. If equipment is used less than originally assumed, installing efficient versions of that same equipment will have a smaller than anticipated effect on energy consumption. Most of the programs that we surveyed required that participants report their facilities' hours of operation on the rebate application or audit form. However, more rigorous methods of obtaining hours of operation used by many of the programs demonstrated that participants often over-estimated their own equipment's hours of operation. Table 5-1 lists the results of hours of operation studies performed by the utilities in our sample.

Table 5-1. Summary of Hours of Use Studies in Sample

Utility	Ratio of Second Estimate to First Estimate	Source of First Estimate	Source of Second Estimate[1]
CMP	0.70	*Customer self-reports*	*189 fixture hours of use* metering
BECo	0.73	Customer self-reports	On-site inspections of 18 sites
CHG&E	N/A	Assumptions by building type	Customer surveys of equipment hours
Con Edison	N/A	Assumptions by building type	Customer surveys of equipment hours
NEES EI	0.78	Customer self-reports	23 site end-use metering
NEES Sml C/I	1.02	Customer self-reports	21 site end-use metering
NU	0.81	Customer self-reports	30 site end-use metering
PG&E	0.85	Customer self-reports	90 site end-use metering
SDGE	0.93	Assumptions by building type	Customer self-reports
SDGE	1.18	Customer self-reports	88 site hours of use metering

Notes:

[1] Hours of use metering uses light-sensitive data loggers to measure lighting use over time and end-use metering uses load meters attached to individual appliances or circuits.

Three methods were used by evaluators to obtain hours of operation information. The most sophisticated evaluations relied on data collected by light-sensitive data loggers or end-use metering equipment. Less sophisticated evaluations used program employees to conduct on-site visits and collect information from building managers and employees. Some programs used mail or telephone surveys to obtain hours of operation information from participants.

A systematic bias in customer reports of hours of operation is apparent in our sample. Site inspections, hours-of-use metering and end-use metering by CMP, NEES, and PG&E found recorded hours were less than customer self-reported hours. In only two cases, NEES's Small C/I Program and SDG&E's Energy Management Hardware Rebate Program, end-use metering uncovered that customer self-reports underestimated equipment operating hours.

Our review also indicates that hours of operation used in tracking database estimates of savings should be disaggregated, at a minimum, by building type. In the six evaluations where hours of operation were logged electronically, annual hours varied by as much as 50% across building types, a much larger variation than is usually found in buildings of the same type (although in two cases, annual hours varied almost as widely across buildings of the same type because of vacancy and usage characteristics). Finally, the differences between customer self-reports and metered estimates of hours of use are fairly large; the additional cost of metering or site inspections may be warranted if the accuracy of savings estimates is a concern.

After an energy efficiency retrofit, consumers may change their behavior so as to negate part of the efficiency gain (Hirst 1991). Such "take back" effects can decrease the energy saved, and sometimes negate it completely. Consolidated Edison of New York (Con Edison) and Central Hudson Gas and Electric (CHG&E) surveyed program participants; neither utility found any evidence of take back in its commercial lighting retrofit rebate programs. Seattle City Light (SCL) surveyed program participants and found that operating hours had increased after measure installation for a small number of participants. But because the increase in operating hours was not due to installation of efficient equipment, take back was not indicated. Our sample suggests that commercial lighting programs have generally not exhibited take back; lighting operation hours are unlikely to change simply because of cheaper operating costs. One aspect of take back not investigated by any utility, however, involves changes in lighting levels: Do customers install additional lighting as a result of lower $/lumen operating costs?[2] Such changes in customer purchasing would have profound implications for the cost-effectiveness of utility DSM. Lighting levels must be measured during pre- and post-program site inspections in order to assess changes in purchasing resulting from more efficient lighting equipment.

[2] Bonneville Power Administration's program addressed one aspect of this issue; participants who had low pre-program lighting levels were asked by the utility for an additional contribution to cover the incremental costs of raising facility lumens/square foot to acceptable levels.

approximately 95% and 88% of original savings remained after two and three years, respectively. The cause of such a degradation, however, is not limited to measure removal. Degradation of savings as evidenced by a billing comparison could be the result of increases in nonparticipants' equipment efficiency, poor maintenance of measures, or increased consumption resulting from take-back.

5.1.2 Measured Consumption Program Savings Estimates Using Billing Data

There are limitless combinations of econometric and statistical techniques that can be used to estimate energy savings from customers' energy bills. These techniques may involve simple comparisons or multivariate regressions of energy consumption across groups or time periods. More rigorous designs also incorporate weather, demographic, dwelling, and end-use data. Table 5-3 summarizes the methods used along with some characteristics of each model.

In evaluations of DSM programs, random selection of participants and nonparticipants from a pool of identical consumers is usually not possible; all qualifying customers are given equal opportunity to participate, and customers volunteer to participate in the program. Thus, the comparison group and program group are not truly random, and methods to measure savings are almost always based on quasi-experimental designs.[5] Comparison of participant and nonparticipant energy consumption, before and after efficient measures were installed, is the simplest method of estimating program-induced savings. Statistical techniques that control for the differences between comparison and program groups, and that adjust for changes in consumption resulting from weather and other exogenous factors, are also often used. Many of the more thorough evaluations used billing analyses of both participant and nonparticipants energy consumption to estimate savings.

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[5] Quasi-experimental designs are used when study and sample characteristics make locating an identical control group difficult. The classic quasi-experimental design types were first explicated by Campbell and Stanley (Campbell, 1968):

a) "One-group pre-test post-test designs" utilize program participant consumption data before and after program intervention.

b) "Static-group comparison designs" utilize program participant and nonparticipant consumption data for the period after program intervention occurred.

c) "Nonequivalent comparison group designs" utilize program participant and nonparticipant consumption data from both pre- and post-program time periods.

Table 5-3. Summary of Evaluation Methods Based on Billing Data

Utility	Type of Model Used	Comparison Group	Sample Size (total part.)	Notes (time-series data used, sample stratification, etc.)
BECo	ΔConsumption$_{part.}$ minus ΔConsumption$_{nonpart.}$	Eligible nonparticipants	772 (919) part. 5826 nonpart.	12 mos. pre, 8 mos. post; 10 strata based on size and seasonal usage
CHG&E	SAE, facility type, bldg. characteristics. vars., 2 tracking estimate vars.	Eligible nonparticipants	54 (606) part. 116 nonpart.	4-5 mos. pre, 4-5 mos. post; verified HOU w/ customer surveys
Con Edison	SAE, facility type vars.	Eligible nonpart. and soon to be participants	n/a (2,276) part. n/a nonpart.	4 mos. pre, 4 mos. post; verified HOU w/ customer surveys
NEES EI	SAE, self-selection var., bldg. char-acteristics vars, 1 tracking estimate var.	Eligible nonparticipants	369(4,114) part. 611 nonpart.	12 mos. pre, 12 mos. post
NEES Sm C/I	ΔConsumption$_{part.}$; adjusted for nonparticipants	Eligible nonparticipants	831(2,494) part. 698 nonpart.	12 mos. pre, 12 mos. post
NU	SAE, self-selection var., facility type vars., 1 tracking estimate var.	Eligible nonparticipants	1,123(5,967) part.; 1,271 nonpart.	5 mos. pre, 5 mos. post; 7 strata based on size; weather adjusted kWh
PEPCO	Pooled cross-section regression, self-selection var.	Eligible nonparticipants	341 (345) part. 1,452 nonpart.	12 mos. pre, 12 mos. post; 4 strata based on size; weather adjusted kWh
SCL	ΔConsumption$_{part.}$ minus ΔConsumption$_{nonpart.}$	Eligible nonparticipants	118 (128) part. 229 nonpart.	12 mos. pre, 12-36 mos. post
PG&E	SAE, self-selection var., bldg. char-acteristics vars., 1 tracking estimate var.	Eligible nonparticipants	724(6,432) part. 370 nonpart.	12 mos. pre, 12 mos. post
SDG&E	CDA, 12 end-use vars.	None	181(789) part.	12 mos. pre, 12 mos. post; adjusted model based on end-use metering results

Notes: *facility type vars*: dummy variables used to indicate the type of facility (office, retail, school, etc.); *building characteristics vars*: variables used to indicate changes in floorspace, participation in other DSM, recent renovation, upswing in business, etc.; *self-selection var*: variable obtained from a logit model and used to adjust for self-selection bias; *tracking estimate var*: variable used to indicate the tracking estimate of savings for each customer; *pre/post*: refers to the numbers of months of billing data compiled before and after program measures were installed.

The importance of using a comparison group in an analysis of consumption records is exemplified by the experience of Bonneville Power Administration (BPA) evaluators. The BPA Industrial Lighting Incentive Program evaluation included a regression of participant characteristics against pre- and post-program energy consumption. The model was unsuccessful in detecting a program effect, which may have resulted from the model's omission of a comparison group of nonparticipants. Using a comparison group to help identify participants' savings is especially important when the energy impact is expected to be a small proportion of total consumption, as in the case of a lighting program aimed at industrial customers.

The simplest use of customer billing data involves comparisons of participants and nonparticipants' energy bills before and after program intervention. Comparison models may detect savings, but their inability to distinguish program effects from weather (hours of operation change seasonally in some areas of the country), price, and other exogenous effects puts them at a distinct disadvantage. SCL normalized consumption records for weather changes and compared participant and nonparticipant consumption to estimate savings.

Program evaluators use econometric models to regress factors thought to affect energy conservation against actual consumption data. Some of the variables used in our sample of evaluations are: program participation, measures installed, corporate characteristics (e.g., business type, changes in business climate/productivity, number of employees, whether business expanded), structural characteristics (e.g., facility square footage), behavioral practices (e.g., changes in hours of operation, participation in other DSM programs, recent renovations), and exogenous factors (energy price and weather). If data are included on participants and nonparticipants both before and after the measures are installed, adjustments for factors such as free ridership, weather changes, energy price changes, and measure usage changes are implicit in the model.

One technique, used by a number of programs in our sample, involves regressing pre- or post-program tracking database estimates of savings for each participant (among other variables) against consumption data. This method, called the statistically adjusted engineering (SAE) method, calculates the proportion of the tracking estimate verified by the regression model. If the tracking estimates included in the model are already fairly good estimates of program savings, the SAE method results in savings estimates with considerably higher precision than regressions of billing data alone.

Estimates of the proportion of the tracking estimate verified by the regression model that are obtained using SAE models ranged from 0.53 for NEES's Energy Initiative program to 1.05 for Con Edison's C/I Efficient Lighting Program. A possible reason for the variation in SAE-obtained ratios of measured consumption savings to tracking database estimates is the differing origins of the elements within the tracking database estimates. For example, NEES used a tracking database estimate based only on rated equipment efficiencies and estimated hours of use. Con Edison adjusted its tracking database estimate based on customer survey data on hours of operation, take back, and free riders. Differences in sample size, duration of pre/post data used, and other explanatory variables used in each model also have an impact on each model's results.

5.1.3 Measured Consumption Program Savings Estimates Using End-Use Metering

Electronic meters and data-loggers to monitor energy use are effective means of measuring both energy savings and peak-demand reductions. Metering of equipment is performed both before and after measure installation. For the four programs in our sample that were metered, at NEES, NU, and PG&E, sample sizes ranged from 21 sites to 67 sites. Because all four end-use metering studies were performed by just two contractors, it comes as little surprise that similar methods were used. All four studies used spot-watt metering in tandem with metered hours of operation to determine kWh saved. Demand savings were estimated using data from the metering devices only. All four studies had meters installed for at least two weeks before and two weeks after program measures were installed.

All four metering studies were explicit in their measurement and analysis of distinct program savings parameters. Evaluation reports compared the number of measures per site, annual hours of operation, and watts saved per measure (as described in the tracking database, estimated with site inspections, and measured using end-use metering). By comparing these parameters among evaluation methods, evaluators uncovered important information about components of the ratio of measured consumption savings estimates to tracking database estimates. For example, in NEES's Energy Initiative Program, on-site estimates of measures installed were 100% of tracking database estimates, metered estimates of hours of operation were 77% of tracking database estimates, and spot-watt metered estimates of the change in watts consumed per measure were 87% of tracking database estimates. Confidence intervals were also calculated around the ratios of these parameters. Parameter level information collected in these kinds of studies can be used to improve future tracking database estimates of savings (Sonnenblick 1994).

Traditionally, the main drawback of end-use metering is its high cost. Multiple site visits are required to install, maintain, and remove the equipment. The cost of end-use metering prevents metering of all but a small sample of program participants. In none of these programs was every measure sampled at every site, so potential biases may result from sampling a nonrepresentative set of measures (e.g., those that are easiest to connect to data loggers) at each site. Another drawback of end-use metering is that site visits are also invasive; they may be perceived as a nuisance by the participant or may affect electricity use patterns.

5.2 The Ratio of Measured Consumption Program Savings Estimates to Tracking Database Program Savings Estimates

In 1991, Nadel and Keating sparked an ongoing debate on the merits and shortcomings of different evaluation techniques when they compared the differences between what they termed *pre-program* engineering estimates and *post-program* impact evaluation estimates of program savings based on billing data. Our analysis shows that, where both *post-program* tracking database estimates and *post-program* measured consumption estimates of savings exist, discrepancies between the two can be significant. Table 5-4 lists the evaluation methods and ratios of measured consumption savings estimates to tracking database savings estimates for our sample of 20 programs. In the aggregate, our findings tend to confirm previous work that concludes that tracking database estimates of energy savings represent an upper bound for measured consumption estimates of savings.[6] The measured consumption estimates (when weighted by energy savings) verified approximately 75% of tracking database estimates of savings. However, differences in tracking database algorithms and in evaluation methodologies can affect this ratio. There is no *a priori* reasonable range of values for this ratio: the determination of a measured consumption/tracking database ratio should be based on the type of tracking database estimate, the measured consumption evaluation method used, and the type of program being evaluated.[7] In the following sections we describe the evaluation methods used to calculate the estimates which are used in these ratios.

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[6] It is important to note that the ratios we provide here were determined by each utility. Most of them represent results of evaluation techniques not widely used when Nadel and Keating's initial study was performed. Thus, the results of our studies are not directly comparable.

[7] Perhaps more important than the ratio itself is understanding why the ratio acquires a particular value: is it due to failings in the tracking database, post-program savings inaccuracies, or program delivery or equipment problems? The taxonomy presented at the end of the chapter can be used to select evaluation methods that can enable

Table 5-4. Post-Program Measured Consumption Results Compared to Post-Program Tracking Database Results

Utility	Evaluation Methods Used[1]	Measured Consumption/ Tracking Database Ratio[2]	Gross Post-Program Savings (GWh)
BECo	TE BA		8.3
BHEC (Pilot)	TE		2.8
BPA (Pilot)	TE		3.2
CHG&E	TE SAE	1.05	16.1
CMP	TE EU SI	0.81	15.7
Con Edison	TE SAE	0.93	91.9
GMP - Large C/I	TE		1.4
GMP - Small C/I	TE		4.0
IE (Pilot)	TE		1.4
NEES - EI	TE EU SAE	0.53	104.2
NEES - Sm C/I	TE EU BA	0.78	23.5
NMPC	TE		134.4
NU - ESLR	TE EU SI SAE	0.69	149.8
NYSEG	TE		71.5
PEPCO	TE BA	1.26	40.5
PG&E	TE EU BA	0.89	130.0
SCE	TE		96.6
SCL (Pilot)	TE BC	0.71	16.9
SDG&E	TE BA	0.66	66.2
SMUD	TE		2.6
Weighted average[3] :		**0.75**	

Notes:

[1] BA—Billing data analysis using regression model, BC—Simple billing data comparison, TE—Tracking estimate, EU—End-use metering, SAE—Statistically adjusted engineering estimate, SI—Site inspection

[2] The measured consumption/tracking database ratio is the ratio of the savings estimates obtained using each evaluation method to tracking database savings estimates.

[3] The average is weighted by energy savings.

5.3 Evaluation Methods, Measure Lifetimes, and Total Resource Cost

In Chapter 3, we systematically adjusted the savings estimates for the nine programs whose evaluations relied only on post-program tracking database estimates of savings by applying the measured consumption/tracking database adjustment factor to adjust reported savings. Here, we consider the differences among these programs without the adjustment, in order

evaluators to calculate a ratio of post-program to tracking estimates of savings *and* understand why the ratio takes on a particular value.

to determine if a correlation exists between evaluation type and total resource cost. The results of these calculations are given in Table 5-5.

Table 5-5. Total Resource Cost Based on Evaluation Method

Evaluation Method	Number of Programs	Average Measure Lifetime (years)	Average Total Resource Cost (¢/kWh)	Standard Deviation
Tracking database	9	11.0	3.6	1.5
Measured consumption	11	13.6	4.0	1.9

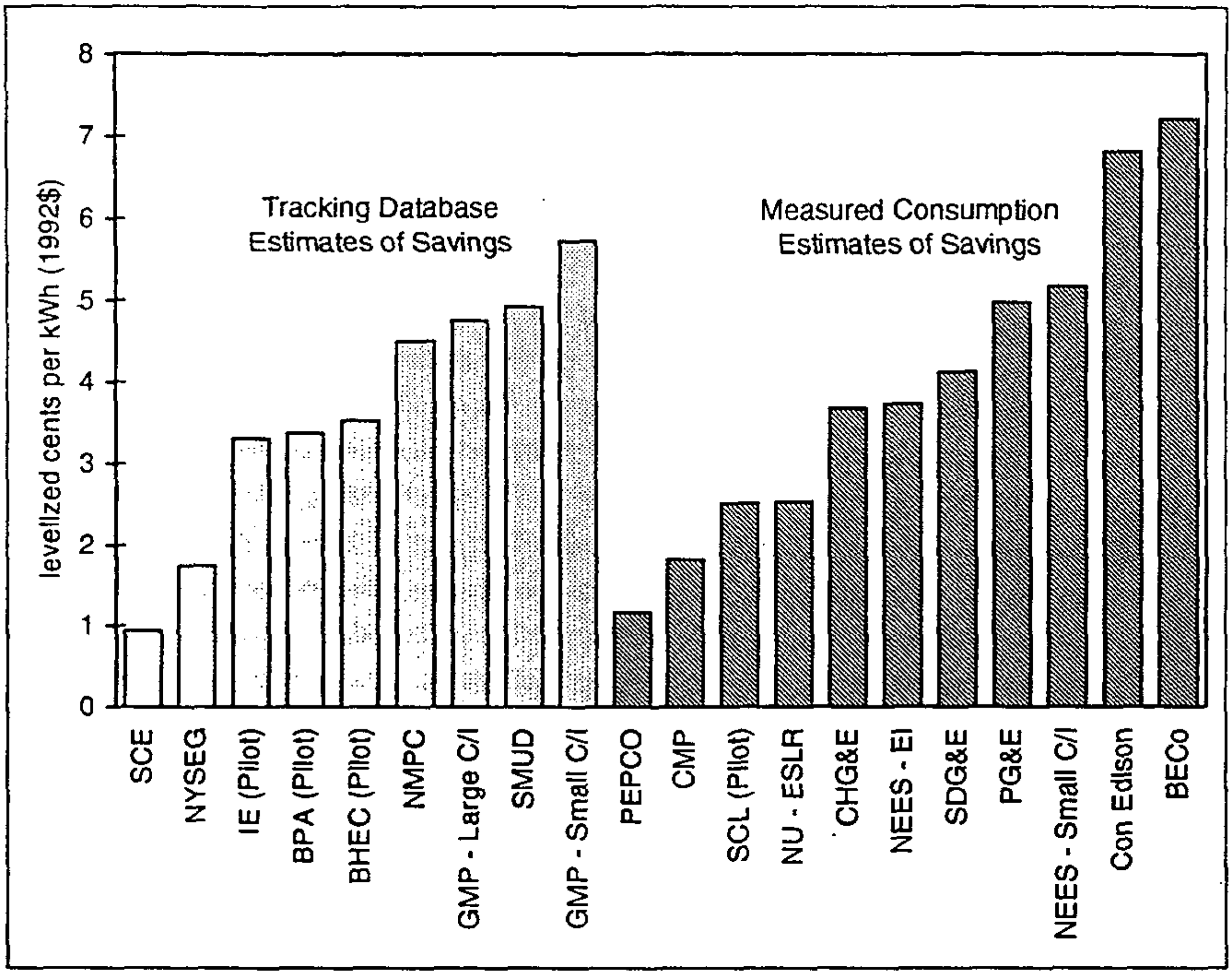
The significance of these results is two-fold. First, the differences in average total resource cost are not great (they are certainly not statistically significant). Second, the tracking database estimates are somewhat more tightly grouped (that is, the standard deviation is smaller). In other words, introducing information on measured consumption into the evaluation of programs adds variability to the findings, which is to be expected (see Figure 5-1). However, the net effect of this variability is a very small increase in the average total resource cost. This increase of 0.4¢/kWh is much smaller than the increase suggested by the average ratio of measured consumption and tracking database savings estimates using end-use metering or billing analyses (recall from Table 5-4 that the average ratio of measured consumption to tracking database savings estimates was found to be about 75%). One or more separate factors seem to cause total resource costs to converge, regardless of the evaluation method used.

The shorter economic lifetimes associated with the tracking database program savings estimates may be responsible for the convergence of the two estimates of average total resource cost. The average economic lifetime associated with these programs is 11 years while the average lifetime associated with the programs evaluated with billing or end-use metering methods is approximately 14 years.

This finding highlights the importance of the assumed economic lifetime on the total resource cost of the programs. As a measure of its importance, we re-calculated the total resource cost of our programs by limiting economic lifetimes to a maximum of 11 years.[8] The average total resource costs of the programs with this assumption is 5.0¢/kWh (with a standard deviation of 2.2¢/kWh) or a 14% increase in cost compared to reliance on the unadjusted utility estimates of measure life. This analysis suggests that the economic life of

[8] No adjustment to measure life was made to programs assuming economic lifetimes of 11 years or less (7 programs).

Figure 5-1. Total Resource Cost Using Tracking Database and Measured Consumption Evaluation Methods



the commercial lighting measures remains one of the most important sources of uncertainty in our calculation of the total resource cost of commercial lighting. Because the estimates of measure life used by most of the programs in our sample are not based on studies of installed equipment over its entire life-cycle, future persistence studies are just as important as the accurate estimation of savings during the years immediately following measure installation.

5.4 Free Riders

One of the key difficulties associated with the evaluation of DSM programs is the requirement of estimating only those savings *directly attributable* to the program. Thus, savings of participants who would have implemented the same set of program measures on their own (known as free riders) are excluded. The measurement of free riders is difficult. Although 19 of our 20 programs had an explicit estimate of free riders participating in the program, the methods used to identify or control for free riders varied dramatically among programs. Table 5-6 lists the utility estimates of free riders for each program in our sample along with brief descriptions of the methods used to obtain those estimates.

As shown in Table 5-6, the estimates of free riders varied dramatically among programs. Because the surveys used to obtain free rider information (and the subsequent analyses) were unique to each program, we cannot automatically attribute variations in free rider estimates to differences in each program's population or to the different technologies offered by each program. The sophistication with which a survey approaches the question of free riders affects the resulting estimate of free riders. Some surveys based their estimate of free riders on a single question which asked "Would you have installed the same [measure] if the program had not been offered to you?" Other surveys approached the issue in a less direct way, offering several different questions to check for consistency of responses.

Another difficulty we face when comparing free rider estimates is variation in the definition of what a free rider actually is. Some programs define free riders as anyone who would have installed the same measure at the time of program implementation. Other programs broaden this definition to include anyone who would have installed the measure at any time during the next few years. Some programs count those who answered free rider survey questions with "don't know" or "unsure" as free riders, or as one-quarter or one-half of a free rider. To add to this confusion, several programs include multiple questions regarding

Table 5-6. Free Rider Estimates and Estimation Methods

Utility	Free Riders	Method Used—Survey Question	Response Which Would Indicate a Free Rider (FR) or Partial Free Rider	Responses Weighted by:
BECo	14.0%	Surveyed participants: "Did you already plan to install measures?"	Yes	Not weighted
BHEC (Pilot)	73.2%	Surveyed participants: "Would you have installed ... if this program had not been available?"	Yes, Unsure	Not weighted
BPA (Pilot)	0.0%	professional judgment		
CHG&E	2.6%	Surveyed participants: "Would you have installed equipment without a rebate?"	Very likely = FR, Somewhat likely = 0.50 FR, Somewhat likely with less efficient equipment =0.25FR	Respondent savings
CMP	21.3%	Surveyed participants: "Would you have purchased...without the rebate?" and "Did you first learn about ... from CMP?"	Yes to the first question *and* No to the second question	Respondent savings
Con Edison	4.5%	Surveyed participants: "How likely is it that equipment would have been replaced in the absence of the rebate program?"	Very in 3 mos. = FR, Somewhat in 3 mos. = 0.75 FR, Very in 3-6 mos. = 0.75 FR, Somewhat in 3-6 mos. = 0.50 FR, Very in 1-2 yrs. = 0.25 FR, Somewhat in 1-2 yrs. = 0.25 FR	Respondent savings
GMP - Lg C/I	12.5%	Collaborative		
GMP - Sm C/I	0.0%	Collaborative		
IE (Pilot)	44.0%	Surveyed participants: "Suppose you were not offered this cash incentive allowance program?"	"I would have bought the same efficiency equipment this year"	Not weighted
NEES - EI	6.5%	Surveyed participants: "If EI had not been offered in 1991, would your company have spent this amount, in addition to any costs you already paid to install ... at that same time?"	Yes	Measure / respondent savings
NEES - Sm C/I	7.0%	Surveyed participants: "What action would you have taken without program?"	Installed same efficiency equipment this year	Measure / respondent savings
NMPC	12.7%	Discrete choice model based on participant/nonparticipant characteristics		
NU - ESLR	10.0%	Estimated from billing analysis		
NYSEG	22.0%	Surveyed participants: "What would you have done if the rebate had not been available?" and "How much did the rebate influence decision to purchase?"	Installed same efficiency equipment *and* strong or some influence	Respondent savings
PEPCO	21.0%	Surveyed participants: "Which statement best characterizes your actions...?"	Basically did what I had planned to do anyway	Not weighted
PG&E	23.0%	Discrete choice model based on participant/nonparticipant characteristics		
SCE	15.0%	Participant survey; no further information	unknown	unknown
SCL (Pilot)	N/A			
SDG&E	18.1%	Vendor and contractor surveys; no further information	unknown	unknown
SMUD	0.0%	Professional judgment		
Averages	**16.2%**			
Standard Dev.	17.0%			

free riders in their surveys and then, inexplicably, use the results of only one of those questions to calculate net savings. Table 5-6 describes only those questions that were actually used to generate utility estimates of free riders.

An evaluation based on billing data utilizing an appropriate comparison group (i.e., customers who were not offered the program but are otherwise identical to program participants in that they would participate if given the chance) can implicitly control for free riders. Several utilities in our sample assume that because their billing analyses include comparison groups (usually a random group of nonparticipants, matched to participants according to energy consumption patterns, as described in Table 5-3), they have controlled for free riders when estimating energy savings. But the proportion of customers installing program measures without a rebate in a random group of nonparticipants is likely to be lower than that proportion in a group of participants (who, by stating their willingness to participate, may be more inclined to install the measures without a rebate). Thus, the comparison groups used by the utilities in our sample may not accurately control for free riders (Train 1993). We are unable to estimate the extent of this bias but expect that its effect would be to slightly underestimate actual free riders.

When billing analyses with comparison groups are not used, surveys of participants and nonparticipants generally are used to estimate free riders. The most sophisticated use of survey data is illustrated by Niagara Mohawk Power Corporation (NMPC) and PG&E, who used logit models calibrated with participant and nonparticipant survey responses to provide an estimate of the proportion of free riders.[9] Although logit models are sophisticated statistical techniques, they are dependent on selection of an appropriate comparison group.

5.5 Market Transformation

Utility DSM programs can result in additional energy savings for participants and nonparticipants if the program influences customers to undertake additional energy-efficient equipment investment on their own. We broadly classify these effects as "market transformation." Estimating the extent to which DSM encourages participants and

[9] Logit models are a specialized type of regression model which fit data to a nonlinear, logistic equation. In order to predict the probability of participation in a program, or the probability of adoption of an energy conservation measure in the absence of a program for a given individual, the model is calibrated with detailed demographic data on program participants and nonparticipants.

nonparticipants to install efficient equipment without a rebate requires extensive surveys of all customers regarding program awareness and their decisions to adopt efficient equipment. Alternatively, aggregate sales data for efficient equipment can be compiled and analyzed. Both techniques are difficult and considered too expensive for inclusion into the standard practice of utility program evaluation. However, four programs attempted to estimate the magnitude of participant spillover effects — "spillover" occurs when program participants install additional efficient measures, without rebates, as a result of their participation in the program. One program also asked survey questions aimed at verifying the existence of free drivers: nonparticipants who install efficient equipment as a result of hearing about the program or about program measures from those customers with firsthand program experience. The results of these studies are summarized in Table 5-7.

Table 5-7. Evidence of Free Drivers and Spillover from Evaluation Surveys

Utility	Affirmative Responses		Survey Question
	Participants	Nonparticipants	
CHG&E	25%	NA	Influenced by program to buy efficient equipment on your own?
NEES EI	65%	NA	Would you now install equipment w/o a rebate?
NEES Small C/I	51%	NA	Would you now install equipment w/o a rebate?
NU	51%	13%	Influenced by program to buy efficient equipment on your own?

Although none of the programs estimated the additional energy saved through spillover or by free drivers, the survey results suggest that the effects of the programs on customer behavior and perceptions of efficient technologies could drive, and eventually transform, the market for efficient equipment. Free drivers and spillover effects represent a new resource that, when properly measured, could affect utility and total resource cost results significantly. This is in contrast to free riders, who do not reduce actual resource savings (free riders do save energy), but instead represent a transfer of capital from the utility, and thus ratepayers, to the free riders.

5.6 Taxonomy of Evaluation Methods and Utility Evaluation Strategies

The diversity of impact evaluation techniques used in our 20 programs is illustrated in Table 5-8. One of the most important distinctions demonstrated in this taxonomy is the distinction between methods that implicitly account for different factors that affect savings and methods that allow one to explicitly quantify the effects of those same factors. For example, site inspections allow evaluators to discover explicitly the number of sites at which efficient equipment was removed or malfunctioning. A billing analysis automatically (implicitly) accounts for removed and malfunctioning equipment since this equipment does not contribute to savings. But the evaluators conducting the billing analysis are unaware of precisely *why* measured savings are lower than originally estimated; they only see the reduced estimate of savings (often in the form of a ratio of measured consumption and tracking database estimates of program savings).

Because no single method provides both an accurate estimate of program savings and a quantification of individual factors that affect savings, strategies that combine the results of multiple evaluation methods are quite useful. Such evaluation strategies enable evaluators to increase the statistical precision of their savings estimates and enhance their understanding of program strengths and weaknesses. The complexity of interactions among the utility, the program delivery, the program technologies, and the participants suggests that evaluation would benefit from holistic approaches incorporating methods from a multitude of evaluation perspectives. Different measurement and evaluation techniques can be used to verify each other and generate composite estimates with improved precision.

At this time, most utilities at least implicitly acknowledge the complementary roles of different evaluation techniques. For example, tracking database estimates of savings based on auditor inspections of installed equipment are used until end-use metering data are available. A combination of end-use metering data and tracking database estimates are used until a billing analysis based on monthly energy consumption data is available. Thus the savings estimate is continually refined based on the latest information.[10] At issue here is the formalization of this process through explicit recognition and prioritization of various evaluation techniques over a multi-year time horizon.

NEES uses an iterative process in which savings estimates for the current program year are based on billing analyses from evaluations of previous program years. They use a number of methods, including end-use metering and billing analyses, to estimate energy savings. NU also augments estimates of savings based on the program auditors' tracking database with on-site equipment assessments, end-use metering, and analysis of billing records.

[10] This process contributes to confusion in the literature regarding the significance of ratios of savings estimates developed at different times in a program's life cycle (see Section 5.2).

Table 5-8. Taxonomy of Impact Evaluation Methods Used in Commercial Lighting DSM Programs

Attribute → / Evaluation Method ↘	Implicit Accounting of Attributes in Savings Calculations				Explicit Examination of Program Attributes		
	Adjusts for technology failure/ misuse[1]	Controls for exogenous factors[2]	Adjusts for take back effects	Adjusts for free riders and other selection biases	Identifies/ quantifies technology failure/ misuse	Identifies/ quantifies take back effects	Examines customer satisfaction and adoption process
Tracking estimate							
Tracking estimate with hours of use verification			Partially			Yes[3]	
Tracking estimate with site inspections	Yes				Yes	Yes[3]	Yes
Tracking estimate with short-term metering	Yes	Partially	Yes		Yes	Yes	
Bill comparison of participants / nonparticipants	Yes	Partially	Yes	Partially			
Billing analysis (regression of consumption data)	Yes	Yes	Yes	Yes[4]			
Statistically adjusted engineering analysis (SAE)	Yes	Yes	Yes	Yes[4]			
Logit model evaluating participation decision				Yes (explicitly quantifies)			

[1] Technology failure/misuse includes participant failure to install, participant sabotage.

[2] Exogenous factors include weather, business and structure characteristics, and fuel prices.

[3] If performed both before and after measure installation

[4] Only with the appropriate control group

SDG&E relies upon tracking database estimates until hours of operation information are available from participants, at which point tracking database estimates are adjusted based on the new hours of operation information. When billing analyses become available, usually a year or two after program implementation, tracking estimates are adjusted based on billing analysis results.

PG&E has improved the precision of its savings estimates significantly by leveraging the smaller sample results from end-use metering against results from the tracking database and from regression models based on billing records.

Eventually, refinements in our understanding of the factors that affect program savings may make extensive evaluation unnecessary and allow us to adjust tracking database estimates using measured consumption information from a small sample of participants. Evaluation methods could then be selected which focus on specific program uncertainties, as identified by previous evaluations. If the cost of each evaluation technique was known beforehand, then the cost of the evaluation could be traded off directly against the probable increase in precision associated with each evaluation method.

5.7 Evaluation Costs

The costs of measuring and evaluating program savings should be included in the total resource cost of energy efficiency. Unfortunately, utility accounting conventions prevented us from collecting reliable evaluation cost information that we could tie directly to the evaluations described in this chapter. We were only able to collect the evaluation costs incurred during the year the program was implemented, which generally represent the costs of evaluating a previous program year or years. These costs are given in Table 5-9.

For the 12 programs that reported measurement and evaluation costs, costs ranged from less than 1% to about 6% of the utility component of the total resource cost of the program savings. The average percentage of total utility expenditures on evaluation during the program year for these 12 programs is 3%. Using the average evaluation cost figure in this way requires the following caveats: (1) evaluations are becoming more sophisticated over time, so that evaluation costs for earlier years may understate those costs for more recent years; (2) evaluations may be performed over several years (end-use metering in the first year, billing analysis in the second year, site-inspections for persistence in the third year, etc.), so costs incurred during one year may not represent total evaluation expenditures; and

(3) utilities did not consistently distinguish between the evaluation costs and the operational costs of maintaining a tracking database, so in some cases administrative costs include what we consider evaluation costs, and reported evaluation cost estimates understate total evaluation costs.

Table 5-9. Evaluation Costs

Utility	Post-Program Savings (GWh)	Evaluation Costs[1]	Utility DSM Program Costs	Proportion Spent on Evaluation
BECo	5.5	$7,349	$6,225,000	0.1%
BPA (Pilot)	3.2	$15,000	$1,004,000	1.5%
CMP	12.4	$3,000	$1,404,000	0.2%
Con Ed	89.0	$1,665,000	$30,438,000	5.2%
GMP - Large C/I	4.0	$18,588	$469,000	3.8%
GMP - Small C/I	2.1	$19,628	$1,172,000	1.6%
IE (Pilot)	1.4	$430	$80,000	0.5%
NEES - EI	132.0	$653,000	$45,381,000	1.4%
NEES - Sm C/I	21.8	$739,000	$12,600,000	5.5%
NMPC	117.4	$329,189	$20,397,000	1.6%
NU - ESLR	133.9	$516,000	$32,614,000	1.6%
SDG&E	54.2	$1,562,000	$10,040,000	13.5%
Average				**3.0%**

Notes:
[1]Evaluation costs are costs incurred during the first year of the program to evaluate previous program years' performance.

5.8 Summary

Current practice in DSM program evaluation is evolving quickly. Five years ago we would have been hard pressed to find even a handful of programs with evaluations incorporating multiple measurement methods. We found it useful to distinguish between savings estimates that relied on tracking databases, which had been updated with substantial post-program information (such as hours of use, measures installed, etc.), and savings estimates based on analyses of measured consumption data (such as bills or end-use metering). Utilizing stringent selection criteria, we found almost a dozen programs with both tracking database and measured consumption savings estimates.

Surprisingly, we find little difference in the estimates of total resource cost based on the tracking databases and those based on measured consumption data. In part, this seems to be a result of different utility assumptions regarding the economic lifetimes of installed measures. Because measure lifetimes are a crucial component of energy savings and total resource cost estimates, we expect that current practice will begin to embrace medium- and long-term persistence studies in the near future. The short-term persistence studies in our sample of programs suggest that persistence in the first few years of measure operation is relatively high.

In our sample, ratios of measured consumption savings estimates to tracking database estimates ranged from 0.53 to 1.26, with a mean (weighted by energy savings) of 0.75. However, the diversity of methods used to calculate both types of savings estimates makes it difficult to draw conclusions about a reasonable range for this ratio. The particular methods one uses to calculate these savings estimates, and not just program design and implementation characteristics, profoundly affect the resulting ratio estimate.

Our review of free rider evaluation methods suggests that there is little consensus among utilities about the definition of a free rider. Although the absence of consensus is a secondary concern for the total resource cost of energy efficiency programs, free riders have important consequences for the impacts of programs on utility rates and thus ratepayers. We note, with some irony, that comparatively little attention has been devoted to measuring free-drivers and spillover effects, which both reduce total resource cost of energy efficiency and mitigate the rate impacts of these programs.

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Appendix A

Lighting Program Summaries and References*

* In the references, a "DEEP #" refers to the number which is assigned to the document in the library of the Database on Energy Efficiency Programs (DEEP) at the Lawrence Berkeley Laboratory.

Boston Edison Company (BECo):

BECo's "Small Commercial and Industrial Retrofit Program" is a direct install program that began in late 1989. In this report, we examine the 1991 program year. The program is available to non-residential customers with a peak demand of less than 150 kW. The program promotes the installation of energy efficient measures for lighting, HVAC, refrigeration, weatherization, hot water heating improvements, cooking, and industrial processes. Based on engineering estimates, approximately 93% of program savings were attributable to lighting measures. In 1991, higher efficiency fluorescent lamps with ballasts replaced the installation of standard efficient fluorescent lamps; in addition, occupancy sensors, high-pressure sodium lamps, metal halide lamps, and fixture replacement became available through the program.

BECo representatives perform an audit of the facilities of participating customers in order to identify measures for installation. As of the 1991 program year, customers are also permitted to submit self-designed retrofits and to use an electrical contractor of their choice. During the 1991 program year, there was a backlog of program applicants. Customers wishing to participate in the program are handled on a first come - first serve basis. Our utility contact indicated that BECo hoped to reduce the backlog of applications by beginning to require a cost-sharing component in 1993.

Data Analysis:

Information regarding this program was initially obtained from a utility contact, the "First Annual 1991 DSM Program Reconciliation Report," and - at the recommendation of the contact - the IRT report cited below. Presently, we use the updated and revised program costs, net energy savings, and annual participation numbers which appear in the "Second Annual 1991 & 1992 DSM Program Reconciliation Report." This document was deemed confidential by the utility and not made publicly available until early 1994. Since this is a direct install program, we assume that there were no participant costs. The cumulative number of participants and average measure life were taken from the IRT report.

BECo estimates 1991 program savings based on a billing analysis of program participants and a comparison group. Free riders are estimated to be 14%, based on a telephone survey of program participants.

In order to extrapolate net savings to gross savings, we use the free rider estimate of 14% reported in the first annual "Reconciliation Report."

References:

Boston Edison Company. 1992. "First Annual 1991 DSM Program Reconciliation Report." Boston, MA: Boston Edison Company. DEEP# MA/BE/6. May.

Boston Edison Company. 1993. "Second Annual 1991 & 1992 DSM Program Reconciliation Report." Boston, MA: Boston Edison Company. DEEP# MA/BE/8. June.

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The Results Center. 1992. "Boston Edison: Small Commercial and Industrial." Vol. 31. Aspen, CO: IRT Environment, Inc. DEEP# MA/BE/IRT/31.

Bangor Hydro-Electric Company (BHEC):

BHEC's "Pilot Lighting Rebate Program" began in March 1986 and ran through September 1989. In our analysis, we examine the program from March 1986 through December 1988 because that is the period evaluated by the utility. It was not possible to disaggregate all the necessary data for a single year. The program offered incentives for energy efficient lighting measures including compact fluorescents, electronic ballasts, lighting controls, HID lamps, and current limiters. Both fixed and custom rebates were available; a six percent loan was also offered, but no participants applied for the loan. The custom rebate paid 1¢/kWh saved for up to five years, not to exceed 50% of the installed cost of efficiency measures. Results for the program through September 1989 show that the average rebate paid to participants covered 23% of the equipment cost of the new lighting systems. Because initial response to the program was slow (only 16 rebate requests in 1986), BHEC began offering a Walk-Through Lighting Analysis service designed to help customers identify potential applications for high efficiency lighting. By the end of 1988, 138 customers had participated in the program.

Data Analysis:

Except for the average measure life, which was received from our utility contact, all program information was obtained through the evaluation report cited below.

BHEC estimates energy savings for this program based on their tracking database.

Based on the utility estimate of rebate level noted above, we assume that the program pays the customer a rebate covering an average of 25% of the equipment cost. We estimate participant costs based on this 25% rebate level and our utility contact's assertion that installation costs account for approximately 20% of the cost of parts and labor. In our calculation of total resource cost, we consider program energy savings to be 75% of BHEC's estimate, based on information from other programs with measured data from end-use metering and billing analyses. We extrapolate gross savings to net savings using BHEC's free-ridership estimate of 73%.

References:

Bangor Hydro-Electric Company. 1989. "Pilot Lighting Rebate Program Evaluation." Bangor, ME: Bangor Hydro-Electric Company. Docket Nos. 85-190, 85-229, 86-24, 88-46, 89-13. DEEP# ME/BHEC/2. December 29.

Bonneville Power Administration (BPA):

BPA's "Industrial Lighting Incentive Program" was a pilot program in Clark County, WA that began in November 1985 and ran through January 1988. Because it was not possible to disaggregate all the necessary data for a single program year, we examine the full life of the program in our analysis. The purpose of the program was to determine the amount of electrical energy that could be saved by retrofitting high-ceilinged industrial and warehousing facilities with high intensity discharge (HID) lighting. As an incentive, participating customers were required to pay only an amount equal to the first year's energy savings of the new lighting system. The program was administered by Portland Energy Conservation, Inc., a non-profit organization, and marketed by contractors and lighting manufacturers' representatives.

Data Analysis:

All program information was obtained through the process and impact evaluation reports cited below.

BPA estimates the energy savings for this program based on their tracking database, which contains auditor records of new and old lamp wattages and quarterly customer self-reports of operating hours. In addition, BPA constructed a regression model based on 24 months of participant billing data; the model, however, was unsuccessful in detecting a statistically significant effect. The failure may have occurred because no comparison group was used or because of a small effect size relative to total energy use. BPA assumes that there was no free-ridership in this program, so savings numbers are not adjusted for free riders.

In our calculation of total resource cost, we consider program energy savings to be 75% of BPA's estimate, based on information from other programs with measured data from end-use metering and billing analyses.

References:

Portland Energy Conservation, Inc. 1989. "Industrial Lighting Incentive Program Impact Evaluation." Portland, OR: Portland Energy Conservation, Inc. DEEP# BPA/63(2). April 30.

Portland Energy Conservation, Inc. 1988. "Industrial Lighting Incentive Program Process Evaluation." Portland, OR: Portland Energy Conservation, Inc. DEEP# BPA/631). May 27.

Central Hudson Gas and Electric Corporation (CHG&E):

CHG&E's "Dollar $avers Rebate Program" began in January 1990 although, according to a utility contact, the program did not really get underway until rebates began to be issued in June 1990. In this report, we examine the program from June 1990 through May 1991. This time period corresponds to CHG&E's rate year, and is the first year of the program for which savings were estimated. The program provides rebates to commercial, industrial, agricultural, municipal, and not-for-profit customers who install energy efficient equipment through one of the program's four components: Lighting, Air Conditioning, Motors, and "Anything Goes" (a custom component which, during the evaluation period, provided rebates for almost exclusively lighting measures). Almost all program energy savings during the evaluation period were attributable to lighting measures. Rebates are based on the reduction in summer and/or winter peak demand that is anticipated as a result of equipment installation. Contractors play a key role in promoting the program, and an ESCO assists CHG&E with program implementation.

Data Analysis:

Almost all program information was obtained from the "Annual Evaluation," and the process and impact reports cited below. Rebate level, evaluation costs, and average measure life were obtained from our utility contact.

CHG&E initially calculated energy savings for this program based on their tracking database estimates and then adjusted them to reflect the results of a billing analysis. An adjustment factor of 1.047 was used to calculate net energy savings for lighting, and a factor of 0.712 was used to calculate net energy savings for the "Anything Goes" component. Based on a participant survey, free riders are estimated to be 2.6% for the lighting component, and 3% for the "Anything Goes" component. The utility estimate of net savings is also adjusted for weather; interactivity between lighting and cooling; building occupancy; installation of additional equipment; repair, replacement, removal, or retrofit of existing equipment; thermostat setting and schedule; hours of operation on a per measure basis; and industrial production.

We estimate participant costs based on the program rebate level. In this report, we use 2.6% free-ridership rather than 3%, because the savings resulting from the lighting component are five times greater than the savings from "Anything Goes". We extrapolate net savings to gross savings using CHG&E's 2.6% estimate of free-ridership.

References

Central Hudson Gas & Electric Corporation. 1991. "Central Hudson Gas & Electric Corporation Demand Side Management: Annual Evaluation for the Period 6/1/90-5/31/91 and Estimated Results for the Period 6/1/91-5/31/92." Poughkeepsie, NY: Central Hudson Gas & Electric Corporation. DEEP# NY/CHGE/7. December 1.

RCG/Hagler, Bailly, Inc. 1992. "Impact Evaluation of Central Hudson's Dollar Savers Rebate Program." Final Report. Poughkeepsie, NY: Central Hudson Gas & Electric Corporation. DEEP# NY/CHGE/2. January 22.

RCG/Hagler, Bailly, Inc. 1992. "Process Evaluation of Central Hudson Gas and Electric Corporation's Dollar $avers Rebate Program." Final Report. Poughkeepsie, NY: Central Hudson Gas & Electric Corporation. DEEP# NY/CHGE/1. January 28.

Central Maine Power Company (CMP):

CMP's "Commercial Lighting Retrofit Rebate Program" began full-scale operation in April 1989. The program operated as a pilot from October 1985 through March 1989. In this report, we examine the 1992 program year. The program encourages commercial, industrial, and agricultural customers to replace existing lighting equipment with energy efficient alternatives. In 1992, the program paid 1¢/kWh saved, up to 80% of the equipment and installation cost. A procedure was developed during the full-scale program to ensure the cost-effectiveness of any project having a potential rebate of $10,000 or more. Retrofits of this size require a cost-effectiveness test that is calculated on a standard worksheet by a CMP representative.

Data Analysis:

Program costs to the utility and participants, energy savings, and participation data were obtained from the Quarterly Report cited below. All other program information was obtained from a utility contact.

CMP calculates energy savings for this program based on their tracking database estimates which have been adjusted for hours of operation as well as free riders. The hours of operation data were collected by a small number of data loggers installed at participant sites. CMP estimates free-ridership for the program to be 21.3%, based on participant surveys from an earlier program year. CMP's estimated average participant cost is based on a random sample of 100 participants in the 1992 program.

We extrapolate net savings to gross savings using CMP's 21.3% free-ridership estimate.

References:

Evaluation and Assessment Department, Central Maine Power Company. "Demand-Side Management Quarterly Report: Quarter 4, 1992." Augusta, ME: Central Maine Power Company. DEEP# ME/CMP/03E.

Offices of Energy Management Program Evaluation and Resource Planning and Budgets. 1990. "Commercial Lighting Retrofit Rebate Program Impact Evaluation (T&C 19.10)." Augusta, ME: Central Maine Power Company. DEEP# ME/CMP/28. June 26.

Xenergy Inc. 1993. "Final Results of Verification Audits: Volume 1." Prepared for Central Maine Power Company. Burlington, MA: Xenergy. DEEP# ME/CMP/41. June.

Consolidated Edison of New York, Inc. (Con Edison):

Con Edison's "Commercial and Industrial Efficient Lighting Program" began full-scale operation in 1990. The program operated as a pilot from 1986 though 1989. In this report, we examine the 1991 program year. The program offers fixed rebates to commercial and industrial customers who install fluorescent lamps, ballasts, compact fluorescents, lighting control devices, and fixture replacements. Customized lighting projects are also eligible for rebates. The goal of the program is to reduce peak demands, energy usage, and operating costs for the customer. In 1991, trade allies became much more prominent in the promotion of the program and routinely called or dropped in on potential participants. The program has been overwhelmed with applications. The program goal for 1991 was to approve 1,320 rebate applications; in fact, the program approved 9,550 applications. The program paid rebates on 2,501 applications to 2,276 customers in 1991. The rebates covered 100% of equipment cost; participants paid for installation.

Data Analysis:

Information regarding this program was obtained from a variety of sources. Information regarding calculation of program energy savings, the number of 1991 participants, and free-ridership comes from the impact evaluation cited below. Because the impact evaluation does not provide cost information, program costs were obtained from a utility contact. Average measure life and rebate level were also obtained from the utility contact.

Con Edison's calculation of energy savings for this program is based on tracking database estimates that have been adjusted by the results of surveys on free ridership, snapback, and hours of operation. Free-ridership was found to be 4.5%, on average. Analysis of participant and non-participant billing data led the utility to estimate a realization rate of 93% of tracking estimates. Con Edison provides both a gross and a net savings estimate, and these are the figures that we use in our calculations.

There is no record of the cost to participants of equipment installation. Based on a recent LBL report on the cost of energy efficient lighting, we assume that installation costs are equal to equipment costs (Atkinson et al. 1992). Consequently, because Con Edison typically covers 100% of the equipment cost, the costs to the participants in this program (installation costs) are assumed to be equal to the incentives paid to them.

References:

RCG/Hagler, Bailly, Inc. 1992. "Impact Evaluation of the Consolidated Edison Commercial and Industrial DSM Rebate Programs: Final Report." Program *Evaluation of Con Edison's Demand Side Management Programs: Impact Evaluations, 1993 Measurement Criteria.* New York: Consolidated Edison of New York. DEEP# NY/CE/06(2). November.

RCG/Hagler, Bailly Inc. 1992. "Process Evaluation of the Consolidated Edison Commercial and Industrial DSM Rebate Programs: Final Report." *Program Evaluation of Con Edison's Demand Side Management Programs: Process Evaluations.* New York: Consolidated Edison of New York. DEEP# NY/CE/07(1). November.

The Results Center. 1992. "Consolidated Edison: Enlightened Energy." Vol. 8. Aspen, CO: IRT Environment, Inc. DEEP# NY/CE/IRT/08.

Green Mountain Power Corporation (GMP):

GMP's "Large Commercial and Industrial Retrofit Program" began in December 1991. The program operated as a pilot from December 1990 through November 1991. In this report, we examine the 1992 program year. The program offers audits and rebates to commercial and industrial customers with an average electricity consumption of at least 12,500 kWh per month from December through March. The program promotes installation of energy efficiency equipment for lighting, HVAC, hot water, refrigeration, cooking, motors, and industrial processes. Lighting measures accounted for 58% of program savings in 1992. The program pays an incentive which reduces the customer's payback time to two years. As soon as the program began operation, it acquired a waiting list of prospective customers that would take several years to process. Consequently, very little program-specific marketing has been necessary.

Data Analysis:

Almost all program information was obtained from the "1992 Annual Report" on DSM cited below. Although information regarding program cost was included in the annual report, our utility contact provided us with updated cost figures.

GMP calculates energy savings for this program based on tracking database estimates. Savings are adjusted for 12.5% free-ridership, based on a collaborative decision.

In our analysis, we use only those energy savings attributable to lighting measures. Because GMP's free-ridership estimate is based on a collaborative decision, we substitute for their 12.5% estimate a more conservative free rider estimate of 17%. Our estimate is based on the average level of free-ridership in the 17 of our 20 lighting programs where free riders were measured. In our calculation of total resource cost, we consider program energy savings to be 75% of GMP's estimate, based on information from other programs with measured data from end-use metering and billing analyses.

Because lighting rebates accounted for 45% of total rebates paid, and the administrative, audit, and evaluation costs of the program's lighting component were not disaggregated by GMP, we assume that 45% of these costs were attributable to lighting.

References:

Green Mountain Power. 1993. "Green Mountain Power Corporation Demand Side Management Programs 1992 Annual Report." South Burlington, VT: Green Mountain Power Corporation. DEEP# VT/GMP/02(1). March 1.

Green Mountain Power Corporation (GMP):

GMP's "Small Commercial and Industrial Retrofit Program" began in May 1992. In this report, we examine the 1992 program year. The program is designed to reduce energy use and costs, while improving operating efficiency, for small commercial and industrial customers. GMP provides eligible customers with a free audit of their facilities. After the audit, the customer is provided with a written list of recommended energy efficiency measures. The entire equipment and installation cost of certain "base measures" is covered by GMP. Base package measures include lighting upgrades, lighting controls, HVAC controls, electrically-heated domestic water tank and pipe insulation, and water conservation hardware. GMP also provides a custom package of site-specific conservation measures; in this track of the program, GMP "buys down" the customer cost to a one-year payback period. Typical measures installed with a custom package include large motors, refrigeration systems, and HVAC systems. In 1992, lighting measures accounted for more than 97% of energy savings. Customer reception of the program has been extremely positive as indicated by the fact that, by the end of 1992, approximately ten customers per week were enrolling in the program as a result of "word of mouth" referrals. Because no custom measures were installed in 1992, we consider this a direct install program.

Data Analysis:

Most program information was obtained from the "1992 Annual Report" on DSM cited below. Our utility contact provided information about the collaborative determination of free riders, and a detailed description of the program was obtained from the IRT report cited below.

GMP's calculation of energy savings for this program is annualized, and is based on tracking database estimates. Based on a collaborative decision, the utility assumes that this program has no free riders.

Because GMP's free-ridership estimate of 0.0% is based on a collaborative decision, we substitute a more conservative free rider estimate of 17%. Our estimate is based on the average level of free-ridership in the 17 of our 20 lighting programs where free riders were measured. In our calculation of total resource cost, we consider program energy savings to be 75% of GMP's estimate, based on information from other programs with measured data from end-use metering and billing analyses.

References:

Green Mountain Power. 1993. "Green Mountain Power Corporation Demand Side Management Programs 1992 Annual Report." South Burlington, VT: Green Mountain Power Corporation. DEEP# VT/GMP/02(1). March 1.

The Results Center. 1993. "Green Mountain Power: Small Commercial and Industrial Retrofit." Vol. 48. Aspen, CO: IRT Environment, Inc. DEEP# VT/GMP/IRT/48.

Iowa Electric Light and Power Company (IE):

IE's "Lighting Payback Plan" was a pilot program that operated from May though December of 1990. In this report, we examine the life of the program. The program was available to commercial, industrial, and agricultural customers in two of IE's municipal service areas, and offered fixed rebates to those customers who replaced incandescent with compact fluorescent lamps or upgraded fluorescent lamp and ballast efficiency. The program was promoted primarily by seminars and direct mail. Rebate offers were made to 3,720 customers; only 25 customers applied for, and received, rebates.

Data Analysis:

All information regarding the program was obtained from the "Final Project Report" cited below.

IE's estimate of energy savings for this program is annualized and was calculated based on tracking database estimates. Although IE estimated 44% free riders for the program, they did not adjust their savings estimate for free riders.

For our analysis, we extrapolate gross savings to net savings using IE's 44% free-ridership estimate. In our calculation of total resource cost, we consider program energy savings to be 75% of IE's estimate, based on information from other programs with measured data from end-use metering and billing analyses.

References:

Iowa Electric Light and Power Company. 1992. "Lighting Rebate Pilot Project: Final Project Report." Cedar Rapids, IA: Iowa Electric Light and Power Company. INU-86-11. DEEP# IA/IELPC/2. February 12.

New England Electric System (NEES):

NEES's "Energy Initiative" program began in July 1989. In this report, we examine the 1991 program year. The program is a comprehensive rebate program for commercial and industrial customers in the NEES service territory. The program is marketed primarily by equipment vendors, and provides fixed rebates for lighting measures, energy-efficient motors and variable-speed drives, HVAC equipment, and building shell measures. The program also offers custom measures with a calculated rebate. In 1991, approximately 74% of program savings were attributable to lighting measures. Although the 1991 program required customer cost-sharing for some measures, particularly HVAC, all 1991 program participants received 100% rebates for efficiency measures installed. The response to the program was so enthusiastic that, by late March, customer requests for program participation exceeded the annual program budget. Consequently, the program was suspended on March 25, 1991, and did not open again until 1992.

Data Analysis:

Most of the information for this program was obtained from our utility contact. The contact sent us a copy of the 1991 program summary from the Northeast Region Demand-Side Management Data Exchange (NORDAX). The contact recommended that we use NORDAX because the database provides collective, system-wide figures for Massachusetts Electric Co., Narragansett Electric Co., and the New England Power Co. In contrast, the utility reports cited below provide data for only Massachusetts Electric Company. We were informed by our utility contact that there were no costs to participants in the 1991 program year. In order to calculate a weighted average of free-ridership for the program (6.5%), we used the free rider and program savings estimates (by measure) for Massachusetts Electric in the "1991 DSM Performance Measurement Report" cited below .

NEES's estimate of program energy savings for lighting measures is based on an SAE model calibrated with consumption records of participants and non-participants. NEES claims that the inclusion of data for non-participants enables them to control for free riders in their savings analysis. End-use metering was used to develop estimates of demand savings and to verify energy savings estimates.

Since lighting accounts for ≈74% of program energy savings, and because NEES does not provide information on the fraction of program costs devoted to the lighting component of the program, we assume that 74% of program costs are attributable to lighting. We extrapolate net savings to gross savings using 6.5% free-ridership.

References:

Freeman Research Resources. 1991. "A Process Evaluation of Energy Initiative. Volume 1: Final Report." Monterey, MA: Freeman Research Resources. DEEP# NEES/06. May.

Massachusetts Electric Company. 1992. "1991 DSM Performance Measurement Report." Submitted to the Department of Public Utilities. Commonwealth of Massachusetts by Massachusetts Electric. DEEP# NEES/04. June.

NEES. 1993. Program data provided to "Northeast Region Demand-Side Management Data Exchange" (NORDAX).

RCG/Hagler, Bailly, Inc. 1992. "Impact Evaluation of the Energy Initiative Program." *1991 DSM Performance Measurement Report. Appendix J.* Submitted to the Department of Public Utilities. Commonwealth of Massachusetts by Massachusetts Electric. DEEP# NEES/04J.

RLW Analytics, Inc., and The Fleming Group. 1992. "New England Power Service Company Energy Initiative Program: Impact Evaluation Using Short-Duration Metering." *1991 DSM Performance Measurement Report, Appendix I.* Submitted to the Department of Public Utilities, Commonwealth of Massachusetts by Massachusetts Electric. DEEP# NEES/04I. June.

HBRS, Inc. 1992. "Results of the Energy Initiative Process Evaluation."*1991 DSM Performance Measurement Report, Appendix H.* Submitted to the Department of Public Utilities, Commonwealth of Massachusetts by Massachusetts Electric. DEEP# NEES/04H.

New England Electric System (NEES):

NEES's "Small Commercial and Industrial Program" is a direct install program that began full-scale operation in June, 1990. A pilot version of this program was initially developed in Rhode Island as part of the 1989 Statewide Lighting Program. In this report, we examine the 1991 program year. The program is implemented by ESCOs and targets commercial and industrial customers with less than 50 kW monthly demand or 150,000 kWh annual usage. The efficiency measures installed through the program are predominantly lighting measures and, in 1991, all recorded program savings were from lighting. NEES did, however, add water heater wraps, programmable thermostats, and other small measures to the list of technologies available for the 1991 program year. Each ESCO participating in the program is given a list of eligible customers in its service district, and the ESCOs recruit participants by telephone. The program has been so successful that it requires minimal marketing. According to IRT, fewer than one percent of customers contacted have refused the program.

Data Analysis:

All of the data for this program, except for that on ridership, were obtained from our utility contact. Our contact sent us a copy of the 1991 program summary from the Northeast Region Demand-Side Management Data Exchange (NORDAX). Our utility contact recommended that we use NORDAX because the database provides collective, system-wide figures for Massachusetts Electric Co., Narragansett Electric Co., and the New England Power Co. In contrast, the utility reports cited below provide data only for Massachusetts Electric Company. In order to calculate a weighted average of free-ridership (7%), we used the free rider and program savings estimates (by measure) for Massachusetts Electric in the "1991 DSM Performance Measurement Report" cited below.

NEES's estimate of energy savings for the program is based on a regression of billing information for participants and non-participants. NEES claims that the inclusion of data for non-participants enables them to control for free riders in their savings analysis. End-use metering was used to verify energy savings.

For our analysis, we extrapolate net savings to gross savings using 7% free-ridership.

References:

HBRS, Inc. 1992. "Final Report for Small C&I Program Process Evaluation." *1991 DSM Performance Measurement Report, Appendix M.* Submitted to the Department of Public Utilities, Commonwealth of Massachusetts by Massachusetts Electric. DEEP# NEES/04M. June.

Massachusetts Electric Company. 1992. "1991 DSM Performance Measurement Report." Submitted to the Department of Public Utilities. Commonwealth of Massachusetts by Massachusetts Electric. DEEP# NEES/04. June.

NEES. 1993. Program data provided to "Northeast Region Demand-Side Management Data Exchange" (NORDAX).

RLW Analytics, Inc., and The Fleming Group. 1992. "Small Commercial/Industrial Program: Impact Evaluation Using Short-Duration Metering." *1991 DSM Performance Measurement Report. Appendix N.* Submitted to the Department of Public Utilities. Commonwealth of Massachusetts by Massachusetts Electric. DEEP# NEES/04N. June.

The Results Center. 1992. "New England Electric System: Small Commercial & Industrial." Vol. 01. Aspen, CO: IRT Environment. Inc. DEEP# NEES/IRT/01.

Niagara Mohawk Power Corporation (NMPC):

NMPC's "Commercial and Industrial Lighting Rebate Program" began in November 1989. In this report, we examine the 1991 program year. The program provides fixed rebates to encourage installation of energy-efficient lighting measures, and is marketed primarily through direct mail and bill inserts to eligible customers. For rebates under $5,000, the customer simply submits a receipt and a rebate application to NMPC; rebates in excess of $5,000 require pre-approval.

Data Analysis:

Almost all program information was obtained from the program evaluation cited below. The numbers of cumulative eligible participants and the details of program delivery were taken from the IRT report. Our utility contact provided the average measure lifetime.

NMPC's calculation of program energy savings is based on tracking database estimates which were then adjusted for synergistic HVAC effects and free riders. The proportion of free riders (12.5%) was determined using a discrete choice model.

In our calculation of total resource cost, we consider program energy savings to be 75% of NMPC's estimate, based on information from other programs with measured data from end-use metering and billing analyses.

References:

The Results Center. 1993. "Niagara Mohawk Power Corporation: Commercial/Industrial Lighting." Vol. 69. Aspen, CO: IRT Environment, Inc. DEEP# NY/NM/IRT/69.

Xenergy, Inc. 1992. "1991 Commercial and Industrial Lighting Rebate Program Evaluation (IMP-12)." *Niagara Mohawk Power Corporation Annual Evaluation Report: 1991 Demand-Side Management Program, Vol. 3.* Syracuse, NY: Niagara Mohawk Power Corporation. DEEP# NY/NM/01(3)B(12).

Northeast Utilities (NU):

NU's "Energy Saver Lighting Rebate Program" (ESLR) began operation in 1986. In this report, we examine the 1991 program year. The program provides fixed rebates to commercial and industrial customers who install energy efficient lighting measures. In 1991, although the program was available to all non-residential Connecticut Light and Power and Western Massachusetts Electric customers, smaller customers were targeted. Although all sizes of customers are targeted by ESLR today, larger customers in 1991 were encouraged to participate instead in NU's Energy Action Program. At that time, incentives were also provided to trade allies, who played an active role in promoting the program. During 1991, rebates levels were reduced for participants and eliminated for trade allies due to program oversubscription. Trade allies continue to market the program indirectly.

Data Analysis:

Almost all program information was obtained from our utility contact. Because NU altered the methodology for the calculation of energy savings several times during the program, our utility contact suggested that we take the gross savings number that was reported to the Public Utility Commission (in the "Determination of Energy Savings Document" cited below) and apply the realization rate found in the June 1993 impact evaluation of the 1991 program (69%). The average measure life was also taken from the "Determination" document. In addition, our contact provided us with information on program costs, rebate level, free riders, and participation. This information was either unavailable in the evaluation report and "Determination" document, or the utility wished to substitute alternate figures.

NU calculated program energy savings based on tracking database estimates. The tracking estimates were adjusted with a 69% realization rate based on survey, billing analysis, and end-use metering data. The statistical model used to calculate the realization rate incorporated many behavioral variables (e.g., participation in previous efficiency programs), as well as hours of operation, building function, etc. Based on the billing analysis, there was estimated to be an upper bound of 24% on free riders; our contact informed us that in-house research based on data from comparable programs at other utilities led NU to refine this estimate to 10%. Our contact estimated that NU's rebates for ESLR in 1991 covered 73% of the installed cost. He suggested that we calculate participant costs based on this percentage.

For our analysis, we extrapolate net savings to gross savings using the utility's free-ridership estimate of 10%. We calculate participant cost based on the assumption that NU rebates covered 74% of the installed cost of efficient lighting measures.

References:

Appel, J, R. Bordner, and V. Kreitler. 1990. "Process Evaluation of NU's Commercial Lighting Program." Final Report. Bala Cynwyd, PA: Synergic Resources Corporation. SRC Report No. 7269B-R1. DEEP# NU/17. April.

Monitoring and Evaluation Section, Northeast Utilities. 1992. "Conservation and Load Management Determination of Energy Savings Document for Measures Installed in 1991." Berlin, CT: Northeast Utilities. DEEP# NU/27(1). May 12.

Monitoring and Evaluation Section, Northeast Utilities. 1992. "Conservation and Load Management Appendices to: Determination of Energy Savings Document for Measures Installed in 1991." Berlin, CT: Northeast Utilities. DEEP# NU/27(2). May 12.

RLW Analytics, Inc., and The Fleming Group. 1992. "Energy Saver Lighting Rebate: Results of the 30-Site Short Duration Monitoring Test." Berlin, CT: Northeast Utilities. DEEP# NU/24. March.

RLW Analytics, Inc., and The Fleming Group. 1991. "Northeast Utilities Conservation and Load Management Department: ESLR Short-Duration Monitoring Interim Report." Berlin, CT: Northeast Utilities. DEEP# NU/16. March 21.

Xenergy, Inc. 1993. "Impact Evaluation of Northeast Utilities' Energy Saver Lighting Rebate Program: Final Report." Berlin, CT: Northeast Utilities. DEEP# NU/26. June.

New York State Electric and Gas Corporation (NYSEG):

NYSEG's "Commercial/Industrial Lighting Rebate Program" began in 1991. In this report, we examine the 1991 program year. The program is designed to reduce peak demand and annual energy usage by encouraging installation of energy-efficient lighting equipment. The program provides commercial and industrial customers, as well as trade allies, with financial incentives and technical assistance for installing efficient lighting measures. Measures eligible for rebates include T-8 and T-12 efficient fluorescent lighting systems with electronic or hybrid ballasts; compact fluorescent lamps; HID lamps; optical reflectors; occupancy sensors; and custom measures such as daylighting controls. In 1991, the program also included a number of adjunct features such as street lighting rebates, "Pizza Lunch" promotional lighting give-aways, and a Rotary Club direct sales campaign for compact fluorescents.

Data Analysis:

Information regarding this program was obtained from a variety of sources. The gross energy savings for the program were taken from the impact evaluation; and, in order to calculate a weighted average of free-ridership (22%) for the program, we used the free rider and program savings estimates (by measure) in the impact evaluation. Because cost data were not found in the impact and process evaluations, we take cost information from the "Bimonthly Report on Incentive Programs" cited below. The number of rebate applications for 1991 was taken from the process report. Additional program information was obtained from our utility contact. The cost of the program to participants was not available.

NYSEG calculated program energy savings based on tracking database estimates, and then augmented the tracking estimates with the results of a mail-in hours of operation survey. Our utility contact stated that the estimated savings were also adjusted for building function, although this is not mentioned in the impact report.

Because participant costs were not available, we assume in this report that participants pay 50% of the installed cost of measures. This assumption is based on the fact that NYSEG attempts to rebate 100% of the incremental cost and our earlier stated assumption that installation costs are equal to equipment costs. In our calculation of total resource cost, we consider program energy savings to be 75% of NYSEG's estimate, based on information from other programs with measured data from end-use metering and billing analyses.

References:

Applied Energy Group, Inc. 1992. "New York State Electric and Gas Evaluation of Commercial and Industrial DSM Programs, Final Report of Findings, Volume I: Impact Evaluation." Binghamton, New York: New York State Electric and Gas Corporation. DEEP #NY/NYSEG/01(1).

Applied Energy Group, Inc. 1992. "New York State Electric and Gas Evaluation of 1991 Commercial and Industrial DSM Programs, Final Report of Findings, Volume II: Process Evaluation." Binghamton, New York: New York State Electric and Gas Corporation. DEEP #NY/NYSEG/02(1).

New York State Electric and Gas. 1991. "Bimonthly Report on Incentive Programs." December 31.

Potomac Electric Power Company (PEPCO):

PEPCO's "Commercial Lighting Rebate Program" began in March 1990. In this report, we examine the program from March 1990 through May 1991 because that is the time period examined in the process and impact evaluations cited below. The program provides incentives to commercial customers to invest in energy efficient lighting technologies.

Data Analysis:

The data for this program were obtained from a variety of sources. Information on energy savings, participation, and free riders was obtained from the impact and process evaluations cited below. Because it was not included in the evaluation reports, information on average measure life, the cost of the program to the utility, and rebate level was obtained from our utility contact.

PEPCO calculated the energy savings associated with the program based on a billing analysis of participants and non-participants. PEPCO estimates free riders to be 21%, based on a survey of participants.

We extrapolate net savings to gross savings using PEPCO's free-ridership estimate of 21%. Because only incentive costs were available for the time period evaluated, we estimate administrative costs for the program based on the ratio of administrative costs to incentive costs between March and December 1990. We calculate participant costs based on PEPCO's estimation that rebates covered 42% of the installed cost of efficiency measures during the evaluation period.

References:

Market Analysis Department. 1992. "A Process Evaluation of the Commercial Lighting Rebate Program." Volumes 1-4. *1992 Integrated Least-Cost Resource Plan, Appendix O*. Washington, D.C: Potomac Electric Power Company. DEEP# DC/PEPCO/1O. January.

Xenergy Inc. 1992. "Impact Evaluation of Commercial Lighting Rebate Program." *1992 Integrated Least-Cost Resource Plan, Appendix P.* Washington, D.C: Potomac Electric Power Company. DEEP# DC/PEPCO/1P(2).

Pacific Gas and Electric Company (PG&E):

PG&E's "Retrofit Program" began operation in its present form in 1990. PG&E, however, has offered some version of the program since the 1970s. In this report, we examine the 1992 program year. The program offers rebates to commercial, industrial, and agricultural customers who install energy efficient electric or gas equipment in any of five end-use groups: air conditioning, agricultural, lighting, refrigeration and cooking equipment (combined), and motors. The program is primarily marketed to small and medium commercial customers and municipal water districts. In 1992, approximately 55% of program savings were attributable to lighting measures.

Data Analysis:

Most of the information for this program was obtained from the "Annual Summary Report" for DSM programs and its "Technical Appendix" cited below. Energy savings and non-administrative costs were obtained from the "Annual Summary." Because PG&E tracks DSM administrative costs by sector (C/I/A) rather than program, costs for the "Retrofit Program," which operates in all three sectors, were not available from the utility. The number of rebates paid in 1992 was obtained from our utility contact.

PG&E calculations of program energy savings for 1992 were based on tracking database estimates and adjusted by a customer survey of hours of operation. Based on a customer survey, PG&E estimates 23% free-ridership for this program.

We extrapolate net savings to gross savings using PG&E's 23% estimate of free-ridership. We consider the program energy savings to be 89% of the utility's estimate, based on the adjustment factor from PG&E's evaluation of 1991 program savings which was released in the September 1993 "Final Report" cited below. The evaluation of 1991 savings used end-use metering, site-inspections, and a regression of consumption data to estimate a savings adjustment factor. We estimate the average measure life of lighting technologies installed through the program to be 15.9 years; this measure life estimation is based on dividing the annual program savings into the lifetime program savings for lighting technologies installed through the commercial component of the direct rebate program. A utility contact informed us that PG&E estimates administrative costs to be 20% of total utility cost for this program; consequently, we calculate the administrative cost of the lighting component of the program based on the amount of incentives paid for lighting measures.

References:

Pacific Gas and Electric Company. 1993. "Annual Summary Report on Demand Side Management Programs in 1992 and 1993." San Francisco, CA: Pacific Gas and Electric Company. DEEP# CA/PG&E/14(1). March.

Pacific Gas and Electric Company. 1993. "Annual Summary Report on Demand Side Management Programs in 1992 and 1993: Technical Appendix." San Francisco, CA: Pacific Gas and Electric Company. DEEP# CA/PG&E/14(2). April.

Pacific Gas and Electric Company. 1992. "Commercial, Industrial, and Agricultural Direct Rebate Programs: Hours of Operation Study." San Francisco, CA: Pacific Gas and Electric Company. CIA-92-HO6. DEEP# CA/PG&E/04.

Xenergy, Inc., Cambridge Systematics, Inc., The Fleming Group, and RLW Analytics Inc. 1993. "Evaluation of the CIA Retrofit Program: Final Report." San Francisco, CA: Pacific Gas and Electric Company. CIA-93-X0. DEEP# CA/PG&E/18. September.

The Results Center. 1992. "Pacific Gas & Electric: Retrofit Program." Vol. 25. Aspen, CO: IRT Environment, Inc. DEEP# CA/PG&E/IRT/25.

Southern California Edison Company (SCE):

SCE's "Energy Management Hardware Rebate Program" (EMHRP) began in 1978. In this report, we examine the 1992 program year. The program provides cash incentives to commercial, industrial, and agricultural customers for installing survey-recommended energy efficiency measures. EMHRP provides incentives for lighting, water heating, heating and cooling, window treatment, roof and wall insulation, electronic adjustable speed drives, energy-efficient motors, and customized efficiency improvements. In 1992, lighting measures accounted for approximately 31% of program savings.

Data Analysis:

Most of the information for this program was obtained from the "Annual DSM Summary Report" and its "Technical Appendix," cited below.[1] A detailed program description was obtained from the IRT report cited below. An updated free-ridership estimate (15%, based on a recent study of the 1990 program) and the number of rebate coupons issued in 1992 were obtained from our utility contact.

SCE's calculation of net energy savings in 1992 was based on tracking database estimates, and adjusted for 50% free-ridership. According to our utility contact, the former free rider estimate of 50% is based at least partly on quarterly surveys that were done for two years in the mid- to late 1980s. Our contact asserted that the new free rider estimate is more appropriate for our calculations.

We extrapolate net savings to gross savings using SCE's free-ridership estimate of 50%, since that is the free ridership figure with which net savings were calculated by SCE. For the rest of our calculations involving free-ridership, we use the updated free-ridership estimation of 15%. We estimate the average measure life of lighting technologies installed through the program to be 12.9 years; this measure life estimation is based on dividing the annual program savings into the lifetime program savings for lighting technologies installed through the commercial and industrial components of the program. In our calculation of total resource cost, we consider program energy savings to be 75% of SCE's estimate, based on information from other programs with measured data from end-use metering and billing analyses.

References:

Southern California Edison. 1993. "Demand Side Management Annual DSM Summary Report: 1992 Results - 1993 Plans." Rosemead, CA: Southern California Edison. DEEP# CA/SCE/03(1). March.

Southern California Edison. 1993. "Demand Side Management Technical Appendix: 1992 Results." Rosemead, CA: Southern California Edison. DEEP# CA/SCE/03(2). March.

The Results Center. 1992. "Southern California Edison: Energy Management Hardware Rebates." Vol. 28. Aspen, CO: IRT Environment, Inc. DEEP# CA/SCE/IRT/28.

[1] The umbrella term "Nonresidential Energy Management Incentives" includes the EMHRP as well as the "Air Conditioner Inspection and Maintenance Rebate Program." In SCE reports, cost and savings from these programs are found under the "Nonresidential Energy Efficiency Incentives."

Seattle City Light (SCL):

SCL's "Commercial Incentives Pilot Program" began in July 1986 and operated through September 1990. In this report, we examine the program costs and energy savings for those participants who applied to the program in 1990; accounted for in these cost and savings numbers are those participants who did not complete their retrofits, and thus did not receive their rebates, until 1991 (after the program was officially terminated).[1] The program encouraged the installation, and operation and maintenance, of energy conservation measures in the SCL territory. Although most energy-saving technologies were eligible for rebates through the program, lighting accounted for 84% of measures installed.

Data Analysis:

Most of the information regarding this program was obtained from a draft of SCL's "Energy Conservation Accomplishments: 1977-1992" cited below. Our utility contact encouraged us to use the energy savings numbers in the "Accomplishments" document, rather than the 1992 "Longitudinal Evaluation" cited below, because the "Accomplishments" document contains data on a few buildings which were left out of the longitudinal analysis. Average measure life was obtained from the 1991 "Energy Savings and Cost-Effectiveness" document cited below. The program rebate level was obtained from the 1992 "Longitudinal Evaluation." Because SCL does not break out costs and savings by technology, we assume for the purposes of this report that all costs and savings are attributable to lighting measures.

SCL calculated energy savings for the 1990 program by taking a weighted average of the first year incremental savings per square foot for the 1987, 1988, and 1989 program years (calculated with a billing analysis of participants and non-participants), and then multiplying this weighted average by the average square footage in the buildings for the 1990 program year. The "Longitudinal Evaluation" reports the incremental savings for 1987-1989 and describes the methodology used to calculate energy savings.

Because SCL provides no information on the cost of the program to participants, we calculate participant cost based on the fact that the program provided rebates covering 70% of the installed cost of efficiency measures. Thus, we assume that participants pay 30% of the total program cost. Our utility contact informed us that no specific examination of free riders had been done for the program; consequently, we use a free rider estimate of 17%, based on the average level of free-ridership in the 17 of our 20 lighting programs where free riders were measured. Net savings are extrapolated to gross savings using the 17% free-ridership estimate.

References:

Adefris, W., and J. C. Shaffer. 1989. "A Process Evaluation of the Commercial Incentives Pilot Program." Seattle, WA: Seattle City Light. DEEP# WA/SCL/05.

Coates, Brian. 1991. "Energy Savings and Cost-Effectiveness in the Commercial Incentives Pilot Program." Seattle, WA: Seattle City Light. DEEP# WA/SCL/06. March.

Coates, Brian. 1992. "Longitudinal Evaluation of Energy Savings in the Commercial Incentives Pilot Program." Seattle, WA: Seattle City Light. DEEP# WA/SCL/07. June.

[1] Funding for the program ended on September 30, 1990, and all contracts with customers were executed by this date. Installation of the energy conservation measures in some of the buildings and payment of some of the rebates, however, continued into 1991.

Coates, Brian. 1990. "Survey of 1987 and 1988 Participants in the Commercial Incentives Pilot Program. "Seattle, WA: Seattle City Light. DEEP# WA/SCL/12.

Tachibana, D.O., J.C. Schaffer, B. Coates, and D. Pearson. 1993. "Energy Conservation Accomplishments: 1977-1992." Draft Report. Seattle, WA: Seattle City Light.

San Diego Gas and Electric (SDG&E):

SDG&E's "Commercial Lighting Retrofit Program" began in September 1990. In this report, we examine the 1992 program year. The program provides incentives to commercial, industrial, and agricultural customers who retrofit their existing lighting systems with energy efficient lighting measures. An SDG&E lighting representative audits the facilities of customers interested in the program. The representative identifies equipment to be installed and then selects an installation contractor through a competitive bidding process. Program representatives are provided a base salary and then are eligible for a two-tiered commission based on their success. In addition, dissatisfied customers cost these representatives money, as they must repay twice the value of their commission on the job as a penalty.

Data Analysis:

The information for this program comes from a variety of sources. The cost and energy savings figures come from SDG&E's March 1993 "Annual Summary of DSM Activities" and its "Technical Appendix," cited below. The average measure life, average rebate level, number of cumulative and annual participants, and a detailed program description were obtained from the IRT report cited below.

SDG&E calculates program energy savings for 1992 based on tracking database estimates. Our utility contact estimates actual program savings to be 66% of the tracking estimate, based on the data in the June 1993 and November 1993 reports cited below.

We calculated the weighted average of free riders (18%) based on the free-ridership reported by measure in the "Technical Appendix." According to our utility contact, the free-ridership percentages reported in the Appendix are based on informal surveys of lighting vendors and contractors. SDG&E does report measure lives for individual technologies in the "Technical Appendix," but does not provide an average measure life for the measures installed through the program; consequently, we use the average measure life reported by IRT (15 years). We extrapolate net savings to gross savings using 18% free-ridership. For our calculation of total resource cost, we consider the program energy savings to be 66% of the utility's estimate, based on the calculations of the utility contact mentioned above.

References:

Marketing Information & Planning Department, San Diego Gas and Electric. 1993. "Commercial and Industrial Energy Efficiency Incentives: Lighting Retrofit, Using Metered Hours-of-Operation to Adjust Estimates of Demand and Energy Impacts." MIAP-91-P50-185-345; CEC Report No. 185. San Diego Gas & Electric: San Diego, CA. DEEP# CA/SDGE/28. November.

San Diego Gas and Electric. 1993. "Annual Summary of Demand-Side Management Activities." DEEP# CA/SDGE/23(1). San Diego, CA: San Diego Gas and Electric. March.

San Diego Gas and Electric. 1993. "Annual Summary of Demand-Side Management Activities: Technical Appendix." San Diego, CA: San Diego Gas and Electric. DEEP# CA/SDGE/23(2). April.

Schiffman, D. A., A. Besa, A. Sickels, and J.C. Martin. 1993. "Commercial/Industrial Energy Efficiency Incentives: Lighting Retrofit: Estimation of Gross Energy-Demand Impacts." San Diego, CA: San Diego Gas & Electric. MIAP-92-P50-S01-R320; CEC Report No. 174. DEEP# CA/SDGE/04. June.

Sickels, Andrew D. 1991. "Commercial/Industrial Lighting Retrofit Program: Analysis of Base Case Equipment by Measure." San Diego, CA: San Diego Gas and Electric. Project MIAP-91-049. DEEP# CA/SDGE/03. October.

Sickels, Andrew D. 1991. "Commercial/Industrial Lighting Retrofit Program: Analysis of Customer Cost by Measure." San Diego, CA: San Diego Gas and Electric. Project MIAP-91-055. DEEP# CA/SDGE/02. October.

Sickels, Andrew D. 1991. "Commercial/Industrial Lighting Retrofit Program: Base Equipment Saturation and Operating Hours by Building Type." San Diego, CA: San Diego Gas & Electric Company. MIAP-91-050. DEEP# CA/SDGE/12. August.

Terzakis, T., and K. A. Bacchioni. 1993. "Commercial Lighting Retrofit Program: Program Evaluation by Participating Customers." San Diego, CA: San Diego Gas & Electric. DEEP# CA/SDGE/13. January.

The Results Center. 1993. "San Diego Gas & Electric: Commercial Lighting Retrofit." Vol. 53. Aspen, CO: IRT Environment, Inc. DEEP# CA/SDGE/IRT/53.

Sacramento Municipal Utility District (SMUD):

SMUD's "Commercial Lamp Installation Program" (CLIP) was a direct install program that began operation in January 1987 and ran through December 1988. The program operated as a pilot from July 1986 until the full-scale program began in January 1987. In this report, we examine the 1988 program year. Initially, the program was available to commercial customers who had an energy demand of less than 30 kW, and generally consumed less than 48,000 kWh annually. In 1988, customers with a demand between 30 kW and 50 kW were also eligible. The program was designed to reduce the utility's summer peak demand and the electric bills for SMUD's small commercial customers. SMUD offered replacement of standard fluorescent lamps with energy-efficient fluorescent lamps, at no cost to the customer. The customer's only decision was whether or not to accept the free service and agree to a few program requirements. The program staff made all technical decisions and installation arrangements.

The program was marketed extensively. Program auditors methodically visited eligible customers in one zip-code area at a time. On a daily basis, the auditors passed on the names of businesses willing to participate in the program to program supervisors who then scheduled work orders for the installation crews. By early 1988, all eligible customers had been approached once. SMUD then went through the area again, contacting new businesses as well as customers who did not participate in the program the first time it was offered. By the time SMUD terminated the program, 45% of eligible customers had participated in the program.

Data Analysis:

Most of the data for this program come from the IRT report cited below. We were encouraged by our utility contact to use the information contained in the IRT report for a number of reasons: SMUD's evaluation report examined the program only through June 1988; most of the program records have been discarded; and most of the program staff no longer work for the utility.

SMUD's calculation of energy savings for this program was based on tracking database estimates. SMUD considered free-ridership for this program to be less than 5%, based on a small business audit program in which less than 10% of potential participants retrofitted energy efficient lamps after SMUD had provided a free audit.

In our calculation of total resource cost, we consider program energy savings to be 75% of SMUD's estimate, based on information from other programs with measured data from end-use metering and billing analyses. The pilot program is included in the cumulative numbers for participation.

References:

NEOS Corporation. 1989. "Operating a Commercial Lamp Installation Program." Final Report. Lafayette, CA: NEOS Corporation. DEEP# CA/SMUD/5. January.

The Results Center. 1992. "Sacramento Municipal Utility District: Commercial Lighting Installation Program." Vol. 13. Aspen, CO: IRT Environment, Inc. DEEP# CA/SMUD/IRT/13.

Appendix B

DEEP Data Collection Instrument*

* The version of the Data Collection Instrument (DCI) that is reproduced in this Appendix is the most recent version used in our lighting research efforts. It should be noted that the development of the DCI is an ongoing process, and that the DCI has evolved over the course of our research. We will continue to revise and improve the DCI as we analyze DSM programs in the future.

DEEP DATA COLLECTION INSTRUMENT

Refer to the instructions for a description of terms

Data Base Entry Person: ____________________

Date Submitted: ____________________

Data Collection Phase: ☐ First Data Submittal ☐ Data Update

Utility Name: ____

Program Name: ____

Program Start Date: ☐ Ongoing
☐ Terminated - Program End Date:

Program Status:

- ☐ Planned
- ☐ Pilot
- ☐ Full Scale
- ☐ Phase Out

Program Objectives:

- ☐ Energy Efficiency
- ☐ Load Shifting
- ☐ Valley Filling
- ☐ Peak Clipping
- ☐ Load Building

Implementing Agent:

- ☐ Utility
- ☐ Energy Service Company
- ☐ Government Agency
- ☐ Contractor
- ☐ Other (specify: __________)

Eligible Markets:

- ☐ New Construction

Existing:

- ☐ Replacement
- ☐ Retrofit
- ☐ Retirement

Program Type:

- ☐ General Information (Brochures, etc.)
- ☐ Site-Specific Information (Audits, etc.)
- ☐ Installation of Conservation Measures
- ☐ Operations and Maintenance
- ☐ Load Control
- ☐ Hook-Up Fees
- ☐ Fuel Switching (From ______ to ______)
- ☐ Research and Development
- ☐ Building Standards

Alternative rates:

- ☐ Time-of-Use
- ☐ Interruptible/Curtailable
- ☐ Other (specify): __________

Program Participation: Customer Applications

Residential

- ☐ All
- ☐ Single-Family
- ☐ Multi-Family
- ☐ Mobile Home
- ☐ Low-Income
- ☐ Elderly/Seniors
- ☐ Public Housing
- ☐ Specify: ______________________

Industrial

- ☐ All
- ☐ Specify 2-digit SIC code(s): __________

Agricultural

- ☐ All
- ☐ Specify: ______________________

Commercial

- ☐ All
- ☐ Offices
- ☐ Retail
- ☐ Restaurant
- ☐ Public (govt.) Facilities
- ☐ Grocery Store
- ☐ Health Care
- ☐ Education
- ☐ Lodging (Hotels/Motels)
- ☐ Warehouses
- ☐ Specify: ________________

- ☐ Other - Specify: ________________

Summary Program Description

(Include e.g. type of program, end uses promoted, implementing agents, program cost, and energy savings)

____

____

____

____

____

____

____

____

____

____

End Use and End Use Technologies

- [ ] All Measures

- [ ] **HVAC**
  - [ ] High Efficiency
  - [ ] Multi-Stage Compressors
  - [ ] Economizers
  - [ ] Control Systems
  - [ ] Variable Air Volume
  - [ ] Variable Speed Drives
  - [ ] Load Control (Cycling)
  - [ ] Gas Air Conditioning
  - [ ] Thermal Storage
  - [ ] Heat Pump
  - [ ] Heat Recovery
  - [ ] Occupancy Sensors
  - [ ] Duct Sealing and Balancing
  - [ ] Operations and Maintenance
  - [ ] Other (specify: __________)

- [ ] **Water Heating**
  - [ ] Load Control (Cycling)
  - [ ] High Efficiency
  - [ ] Heat Pump
  - [ ] Insulation Blankets
  - [ ] Low-Flow Showerheads
  - [ ] Low-Flow Aerators
  - [ ] Solar Assisted
  - [ ] Operations and Maintenance
  - [ ] Other (specify: __________)

- [ ] **Motors**
  - [ ] High Efficiency
  - [ ] Variable Speed Drives
  - [ ] Operations and Maintenance)
  - [ ] Other (specify: __________)

- [ ] **Demand Control**
  - [ ] Direct Load Control
  - [ ] Distributed Load Control
  - [ ] Energy Management System
  - [ ] Other (specify: __________)

- [ ] **Lighting**
  - [ ] Compact Fluorescents
  - [ ] Electronic Ballasts
  - [ ] High Efficiency Magnetic Ballasts
  - [ ] Reflector Systems
  - [ ] Efficient Fluorescent Lamps (T-8 etc.)
  - [ ] Lighting Controls
  - [ ] Occupancy Sensors
  - [ ] High Intensity Discharge
  - [ ] Operations and Maintenance
  - [ ] Other (specify: __________)

- [ ] **Building Envelope**
  - [ ] Insulation
  - [ ] Infiltration Control
  - [ ] Glazing and Glazing Control
  - [ ] Operations and Maintenance
  - [ ] Other (specify: __________)

- [ ] **Refrigeration**
  - [ ] High Efficiency
  - [ ] Controls
  - [ ] Variable Speed Compressors
  - [ ] Multi-Stage Compressors
  - [ ] Operations and Maintenance
  - [ ] Other (specify: __________)

- [ ] **Other**
  - [ ] Cogeneration (specify: __________)
  - [ ] Industrial (specify: __________)
  - [ ] Fuel Switching (specify: __________)
  - [ ] Other (specify: __________)

Marketing Incentives (√ if used)

	Recipients of Incentives			
Incentive Type	Customers	Trade Allies	Manufacturers	Government
Rebates				
Subsidized Financing/Loans		–	–	
Bill Credits		–	–	
Services				
Direct Installation		–	–	
Leasing		–	–	
Rate Discounts		–	–	
Cooperative Advertising	–			–
Bulk Purchasing			–	
Gifts			–	–
Tax Incentives		–	–	
Other (specify: ________)				

Marketing Methods

❑ Direct Mail
❑ Newspaper Ads
❑ Radio/TV Ads
❑ Telemarketing

❑ Bill Inserts
❑ Brochures
❑ Newsletters
❑ General Advertising

❑ Seminars/Workshops
❑ Shows & Exhibits
❑ Tests/Demonstrations
❑ Other (specify: ____)

Direct Contact By:
❑ Utility
❑ Trade Ally
❑ ESCO

Targeted Market Group

❑ Homeowners
❑ Non-Res. Building Owners
❑ Renters
❑ Non-Res. Leasors/Renters
❑ Building Operators/Managers
❑ Other (specify: ________)

❑ A/E Firms
❑ Realtors
❑ Developers
❑ Builders
❑ Contractors
❑ Trade Associations

❑ Manufacturers
❑ Wholesalers
❑ Retailers
❑ Energy Service Companies
❑ Non-Profit/Not-for-Profit Groups
❑ Government

Data Period

DEEP data covers program activities from: __________ to: ____________

Changes From Previous Program Description

____

____

____

Eligibility Requirements (used to define eligible market and participation)

____

____

____

Number of Eligible Customers: ______________

Describe Units Used for Eligible Market

____

____

____

Size of Eligible Market (*in units defined above*): ______________

Definition of Target Market

____

____

____

	Annual	Cumulative
Number of Customer Participants	______	______
Number of Participating Units (*Defined above*)	______	______
Participation Rate (% of Eligible Customer Class)	____ %	____ %
Participation Rate (% of Eligible Market)	____ %	____ %

For Audit and Equipment Installation Programs:

Percent of customers contacted that were audited: ____ %

Percent of customers audited that installed measures: ____ %

PROGRAM IMPACTS

Source of Savings Data

❐ Estimated ❐ Measured ❐ Both For what year: ________

Energy Effects

	Electricity Effects (MWh) (+ = Energy Savings) (- = Increased Energy Use)	Gas Effects (MTherms) (+ = Energy Savings) (- = Increased Energy Use)
Incremental		
Annual		
Cumulative		

Diversified Coincident Peak Demand
(MW)
(+ = Demand Savings)
(- = Increased Demand)

	Summer	Winter
Incremental		
Annual		

End Use Technology Savings

Is there information on energy and demand savings for particular end uses? ❐Yes ❐No
If Yes, see Appendix II.

Savings Adjustments

Indicate if results have been adjusted in order to produce savings estimates that are representative of standard, average, or forecast conditions for each of the following parameters.

- ❐ No adjustments
- ❐ Control group
- ❐ Free riders (specify percentage of program participants, if available) ______%
- ❐ Free drivers (specify percentage of program participants, if available) ______%

Changes during program year in:

- ❐ Weather
- ❐ Daylight/daylength
- ❐ Building occupancy
- ❐ Building function
- ❐ Installation of additional equipment
- ❐ Repair, replacement, removal, or retrofit of existing equipment
- ❐ Thermostat schedule and settings
- ❐ Hours of operation
- ❐ Power outages and other supply disruption
- ❐ Industrial production
- ❐ Agricultural production
- ❐ Other (specify) ________________________________

IMPACT METHODOLOGIES

Basis of Energy Savings Estimates

What kind of energy data was collected on participants and the control group?

Participants	Control Group	Data Sources
☐	☐	Engineering Data
☐	☐	Data from Other Sources
☐	☐	Utility Billing History
☐	☐	Spot Metering
☐	☐	Whole-Building Load Data
☐	☐	End-Use Load Data
☐	☐	Equipment Specifications
☐	☐	Site Specific Data
☐	☐	Other (specify) ________________

Sample Size and Response Rates:

For data sources involving sampling, please indicate the following:

Group	Sample Size (N)	Response Rate (%)
Participant Group		
Control Group		
Other Group (Specify: ________)		

Sampling Dates:

Pre-installation: ________________ **Post-installation:** ________________

What kind of methods were used to analyze energy use of participants and the control group?

Participants	Control Group	Analytical Methods
☐	☐	Engineering Analysis
☐	☐	Statistical Analysis
☐	☐	Hybrid (Combination) Methods
☐	☐	Other (specify) ________________

Load Shapes:

What Types of Load-Shape Data Are Available On This Program?

☐ 24-hour Load Shapes for __________ Day Types

☐ 8760-Hour Annual Load Shapes

PROGRAM COSTS

Note: Please report cost information in nominal dollars.

Specify Dollar Year Used: ____________

Annual Information for Year: ____________

Cumulative Information from Year ________ **to Year** ________

Utility Costs (in $1,000s)

	Annual	Cumulative
Incentives:		
Equipment	______	______
Installation	______	______
Other (specify)	______	______
Subtotal	______	______
Administrative	______	______
Measurement & Evaluation	______	______
Other (specify)	______	______
Total Program Costs	______	______
Planning	______	______
General Administration	______	______
Shareholder Incentives	______	______
Other (specify)	______	______
Total Other Costs	______	______
Total Utility Costs	______	______

Non-Utility Costs (in $1,000s)

	Annual	Cumulative
Participants' Incremental Costs	______	______
Other (specify)	______	______
Total Non-Utility Costs	______	______

Life-Cycle Program Costs

Type of Savings:

- ❒ Electricity
- ❒ Gas
- ❒ Electricity & Gas

Levelized Program Cost (total program cost/ total energy savings): ________

Cost Units:

- ❒ Cents per kWh
- ❒ Dollars per KW
- ❒ Cents per therm
- ❒ Cents per MBtu
- ❒ Other ____________________

Values Used:

Time period ________
Average measure lifetime ________
Discount rate ________

- ❒ Environmental costs included - specify: ____________
- ❒ Environmental costs NOT included

- ❒ Incentive costs included - specify: ____________
- ❒ Incentive costs NOT included

- ❒ Net loss revenue costs included - specify: ____________
- ❒ Net loss revenue costs NOT included

Cost-Effectiveness

Benefit-Cost Tests (✔ if used)

	Test Value	Discount Rate	Time Period	Consumer Energy Cost	Utility Avoided Cost
❒ Utility cost test				N/A	
❒ Participant test					N/A
❒ Non-participant test					
❒ Total resource cost test				N/A	
❒ Societal test				N/A	

Any information on bill impacts? ❒ Yes ❒ No

If Yes: specify:

PROGRAM PARTICIPATION

Demographics of participants:

____

____

Demographics of non-participants:

____

____

Reasons for participating in program:

- ❐ Energy savings
- ❐ Rebate
- ❐ Desired technology in program
- ❐ Environmental reasons
- ❐ Other (specify: __________)

Reasons for not participating in program:

- ❐ Up-front costs
- ❐ Disruptions to home/business
- ❐ Application process burden
- ❐ Insufficient estimated energy savings
- ❐ Not enough information provided
- ❐ Rebate was inadequate
- ❐ Desired technology not in program
- ❐ Uncertainty about technology
- ❐ Lack of available funds
- ❐ Other (specify: __________)

Reasons for satisfaction and dissatisfaction with program:

	Customer		**Trade Ally**	
	Satisfaction	Dissatisfaction	Satisfaction	Dissatisfaction
General Service Level				
Application Process				
Rebate Processing				
Rebate Level				
Type of Information Provided				
Energy Savings			–	–
Equipment Issues			–	–
Program Promotion & Marketing	–	–		
Sales	–	–		
Availability of Desired Technology	–	–		

Sample Size and Response Rates:

Group	Sample Size (N)	Response Rate (%)
Participant Group		
Control Group		
Other Group (Specify: ________)		

Year Sample Taken: ________ Year of Sample Group's Program Participation: ________

Process evaluation methods employed:

Participants	Control Group	Data Sources
☐	☐	Telephone surveys
☐	☐	Mail surveys
☐	☐	In-person interviews
☐	☐	Focus groups
☐	☐	Other (specify: ____________)

Market evaluation methods employed:

Participants	Control Group	Data Sources
☐	☐	Telephone surveys
☐	☐	Mail surveys
☐	☐	In-person interviews
☐	☐	Focus groups
☐	☐	Other (specify: ____________)

Market Impacts Examined:

- ☐ Increased availability of products in market
- ☐ Decreased prices of products in market
- ☐ Customer Energy Awareness
- ☐ Free riders
- ☐ Free drivers
- ☐ Persistence of Savings
- ☐ Other (specify) ______________________________

Type of program tracking database:

____

____

Additional Program Information

Related Programs

Lessons Learned

(Include difficulties encountered in program implementation, evaluation, and end use technologies; significant program changes due to evaluation; recommendations for program improvement; and key elements for program success)

DOCUMENTATION

Process and Impact Evaluation (√ if available)

- ❐ Process evaluation data are available for this program
- ❐ Process evaluation reports are available for this program

- ❐ Impact evaluation data are available for this program
- ❐ Impact evaluation reports are available for this program

Additional evaluations planned or ongoing:

Publications:
(include title, author, date published, DEEP library number, report availability, summary, and comments)

APPENDIX I

Program Manager

Name ______________________________ Title ______________________

Address ____

____

City __________________ State ___ Zip __________

Phone # _______________ Fax # ________________

Program Evaluator

Name ______________________________ Title ______________________

Address ____

____

City __________________ State ___ Zip __________

Phone # _______________ Fax # ________________

APPENDIX II

Electricity Effects for Specific End-Use Technologies:

	Energy Effects (MWh) (–) = Increased Energy Use (+) = Energy Savings	Diversified Coincident Peak Demand (MW) (–) = Increased Demand (+) = Demand Savings	
		Summer	Winter
HVAC			
Incremental			
Annual			
Cumulative			
Water Heating			
Incremental			
Annual			
Cumulative			
Motors			
Incremental			
Annual			
Cumulative			
Lighting			
Incremental			
Annual			
Cumulative			
Refrigeration			
Incremental			
Annual			
Cumulative			
Other			
Incremental			
Annual			
Cumulative			

Gas Effects for Specific End-Use Technologies:

	Energy Effects (MTherms) (+ = Energy Savings) (- = Reduced Energy Use)
HVAC	
Incremental	______
Annual	______
Cumulative	______
Water Heating	
Incremental	______
Annual	______
Cumulative	______
Building Envelope	
Incremental	______
Annual	______
Cumulative	______
Other	
Incremental	______
Annual	______
Cumulative	______

Savings Adjustments

Indicate if results have been adjusted in order to produce savings estimates that are representative of standard, average, or forecast conditions for each of the following parameters.

- ☐ No adjustments
- ☐ Control group
- ☐ Free riders (specify percentage of program participants, if available) ____ %
- ☐ Free drivers (specify percentage of program participants, if available) ____ %

Changes during program year in:

- ☐ Weather
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- ☐ Building occupancy
- ☐ Building function
- ☐ Installation of additional equipment
- ☐ Repair, replacement, removal, or retrofit of existing equipment
- ☐ Thermostat schedule and settings
- ☐ Hours of operation
- ☐ Power outages and other supply disruption
- ☐ Industrial production
- ☐ Agricultural production
- ☐ Other (specify) ______________________________