LBL-34967
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The Cost and Performance of Utility Commercial Lighting Programs

et al.

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May 1994

ENERGY & ENVIRONMENT
DIVISION

Prepared for the U.S. Department of Energy under Contract Number DE-AC03-76SF00098

Schedule - 7

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LBL-34967

A Report from the Database on Energy Efficiency Programs (DEEP) Project

The Cost and Performance of Utility Commercial Lighting Programs

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May 1994

This work was supported by the Assistant Secretary for Energy Efficiency and Renewable Energy, Office of Utility Technologies, of the U.S. Department of Energy under Contract No. DE-AC03-76SF00098; Bonneville Power Administration under Contract No. DEAI7991BP23463; and the Rockefeller Family and Associates.

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Abstract

The objective of the Database on Energy Efficiency Programs (DEEP) is to document the measured cost and performance of utility-sponsored, energy-efficiency, DSM programs. Consistent documentation of DSM programs is a challenging goal because of problems with data consistency, evaluation methodologies, and data reporting formats that continue to limit the usefulness and comparability of individual program results. This first DEEP report investigates the results of 20 recent commercial lighting DSM programs. The report, unlike previous reports of its kind, compares the DSM definitions and methodologies that each utility uses to compute costs and energy savings and then makes adjustments to standardize reported program results. All 20 programs were judged cost-effective when compared to avoided costs in their local areas. At an average cost of 3.9¢/kWh, however, utility-sponsored energy efficiency programs are not "too cheap to meter". While it is generally agreed upon that utilities must take active measures to minimize the costs and rate impacts of DSM programs, we believe that these activities will be facilitated by industry adoption of standard definitions and reporting formats, so that the best program designs can be readily identified and adopted.

Acknowledgements

We would like to thank the following people for the time and assistance they offered us as we gathered utility information for this report. Without their help, this report could not have been written:

Boston Edison Company: Janet Forman
Bangor Hydro-Electric Company: Richard Rusnica
Bonneville Power Administration: Sheila Riewer, and Patrick Wolfe (*Portland Energy Conservation, Inc.*)
Central Hudson Gas and Electric Corporation: Frank Congedo
Central Maine Power Company: Ed Gervais, Elizabeth Laiho, and David Saunders
Consolidated Edison of New York, Inc.: Jane Reilly and Steve Pertusiello
Green Mountain Power Corporation: Howard Loso, Andy Perkins, and Jim Street
Iowa Electric Light and Power Company: Dave Vognsen
New England Electric System: Dorothy Conant, Elizabeth Hicks, and Meredith Miller
Niagara Mohawk Corporation: Brandon McKnight
Northeast Utilities: Dinesh Bhagani
New York Public Service Commission: Bill Mills
New York State Electric and Gas Corporation: Scott Cunning and Dorinda Noll
Potomac Electric Power Company: Mark Kumm, and Marvin Horowitz (*Xenergy*)
Pacific Gas and Electric Company: Jay Bhalla, Jim Flanagan, Kirsten Mounzih, Jeremy Newberger, and Sam Cohen (*Barakat & Chamberlin*)
Southern California Edison Company: Tom Crooks, and Richard Ridge (*Pacific Consulting Services*)
Seattle City Light: Brian Coates
San Diego Gas and Electric Company: Gail Bennett, Judy Kelly, Robert Ladner, Dean Schiffman, and Andrew Sickels
Sacramento Municipal Utility District: Warren Lindeleaf and Vikki Wood
Vermont Public Service Board: Kari Dolan and Rick Weston

In addition, we would like to thank the individuals who reviewed this report in its draft stages: Ted Flanigan, IRT Environment, Inc.; Fred Gordon, Pacific Energy Associates; Eric Hirst, Oak Ridge National Laboratory; John Hughes, Electricity Consumers Resource Council; Ken Keating, Bonneville Power Administration; Paul Meagher, Electric Power Research Institute; Bill Miller, Pacific Gas and Electric; Peter Miller, Natural Resources Defense Council; Cynthia Mitchell; Steve Nadel, American Council for an Energy-Efficient Economy; Ralph Prahl, Wisconsin Public Service Commission; Sam Swanson, New York Public Service Commission, and Land and Water Fund of the Rockies; Tony Usibelli, Washington State Energy Office; Dan Violette, Xenergy; and Marsha Walton, New York State Energy Research and Development Authority. For their help and support, we would like to thank our LBL colleagues: Chuck Goldman, Jeff Harris, Ed Kahn, Suzie Kito, Jon Koomey, Mark Levine, and Steve Meyers.

This work was supported by the Assistant Secretary for Energy Efficiency and Renewable Energy, Office of Utility Technologies, of the U.S. Department of Energy under Contract No. DE-AC03-76SF00098; Bonneville Power Administration under Contract No. DEAI7991BP23463; and the Rockefeller Family and Associates.

Acronyms and Abbreviations

ACEEE	American Council for an Energy-Efficient Economy
BECo	Boston Edison Company
BHEC	Bangor Hydro-Electric Company
BPA	Bonneville Power Administration
CHG&E	Central Hudson Gas and Electric Corporation
C/I	Commercial and Industrial
C/I/A	Commercial, Industrial, and Agricultural
CMP	Central Maine Power Company
Con Edison	Consolidated Edison of New York, Inc.
DEEP	Database on Energy Efficiency Programs
DSM	Demand-Side Management
EI	Energy Initiative
EIA	Energy Information Administration
EPRI	Electric Power Research Institute
ESCO	Energy Service Company
GMP	Green Mountain Power Corporation
HID	High Intensity Discharge
HVAC	Heating, Ventilation, and Air Conditioning
IE	Iowa Electric Light and Power Company
IRP	Integrated Resource Planning
kWh	kilowatt-hour
LBL	Lawrence Berkeley Laboratory
NARUC	National Association of Regulatory Utility Commissioners
NEES	New England Electric System
NMPC	Niagara Mohawk Power Corporation
NORDAX	Northeast Region Demand-Side Management Data Exchange
NU	Northeast Utilities
NYSEG	New York State Electric and Gas Corporation
ORNL	Oak Ridge National Laboratory
PEPCO	Potomac Electric Power Company
PG&E	Pacific Gas and Electric Company
SAE	Statistically Adjusted Engineering Estimate
SCE	Southern California Edison Company
SCL	Seattle City Light
SDG&E	San Diego Gas and Electric Company
SMUD	Sacramento Municipal Utility District
TRC	Total Resource Cost Test

Executive Summary

In recent years, more and more utilities have begun offering demand-side management (DSM) programs, and more and more money has been spent on DSM. The Energy Information Agency (EIA) estimates that U.S. utilities spent more than $2.2 billion on DSM in 1992, up from $1.2 billion in 1991 (EIA 1993). Unprecedented growth in DSM spending has led some to become concerned that the results of DSM may be disappointing relative to the expenditures.[1] This concern regarding the economic value of DSM has been reinforced by recent work relating to the total cost and performance of utility activities to promote energy efficiency (Joskow and Marron 1992).[2]

Our study, the first in a series from the Database on Energy Efficiency Programs (DEEP), addresses concerns about the economic value of DSM activities by reporting on the total cost and measured performance of 20 utility-sponsored lighting efficiency programs in the commercial sector (Vine 1992).[3] The goal of the DEEP project is to compile and analyze the measured results of energy efficiency programs in a consistent and comprehensive fashion. The research concept for DEEP originated with previous work by the American Council for an Energy-Efficient Economy (Nadel 1990) and Lawrence Berkeley Laboratory (Krause et al. 1989), but has benefited enormously from the rapid maturation of the DSM industry, as evidenced by more utilities offering programs, many of which have now been evaluated formally. As a result, we are able to report on information previously missing from past analyses of utility DSM programs, such as customer cost contributions, and on program savings based on post-program evaluations rather than on unverified pre-program estimates.

We focus on the resource value that commercial lighting programs contribute to utilities' DSM portfolios.[4] Lighting is a major component of commercial electricity use

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[1] See Wirtshafter's (1992) comparison of the financial risks of DSM with the financial risks of nuclear power, the last new resource option aggressively pursued by the utility industry.

[2] Joskow and Marron examined 10 utility-sponsored DSM programs. They documented inconsistencies among utility accounting practices and expressed concern regarding utility reliance on pre-program savings estimates. They concluded that the evidence they collected "suggests that computations based on utility expectations could be underestimating the actual societal cost [of DSM programs] by a factor of two or more on average."

[3] We refer to these DSM programs broadly as commercial lighting programs. Although almost all programs in our sample were available to both commercial and industrial customers, and some programs were available to agricultural customers as well, most of the energy savings were attributable to commercial customers. We note in the text programs that offered non-lighting measures; and we included in our study only multi-technology programs for which lighting cost and performance data were separable from full-program data.

[4] There are, of course, other legitimate reasons for utility involvement in demand-side markets, such as equity and

(approximately 40%) and a significant component of industrial electricity use (approximately 10%) (EIA 1991). Investigations of the technical potential for efficiency improvements routinely conclude that 40% to 70% of current electricity consumption for lighting could be saved cost-effectively (see, for example, Atkinson et al. 1992, and EIA 1992). These and other estimates of lighting as a large, untapped, and cost-effective resource opportunity for energy efficiency have led U.S. utilities to promote customer adoption of energy-efficient lighting improvements as a core resource element of utility demand-side management activities.[5]

Twenty Commercial Lighting Programs

With substantial effort, we have developed a data set on the cost and performance of a significant fraction of utility spending on DSM. In aggregate, the 20 programs represent utility spending of approximately $190 million. Although not strictly comparable (because the spending for the programs we studied was spread over different years), $190 million represents about 15% of the $1.2 billion in nationwide utility spending on all DSM activities in 1991.[6]

Just as there is no such thing as a generic coal or advanced combined cycle plant, there is no such thing as a generic commercial lighting program. The commercial lighting programs we examine represent a broad cross-section of utility experience in promoting energy-efficient lighting in the commercial sector. They vary substantially in their life-cycle stages, delivery mechanisms, and technologies offered. These variations in design and implementation of DSM programs result from the evolution of energy-efficient lighting technologies in the commercial sector over time. Design variations are also the result of important differences in utilities': needs for new resources; avoided costs used to design programs; experiences with DSM programs and with local energy efficiency markets; as well as, in many cases, regulatory requirements.

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customer service. From a resource planning perspective, however, energy efficiency programs are desirable only if they cost less than the alternatives available for meeting customer energy service needs. Accordingly, the primary measure of performance for commercial lighting programs is the total resource cost of the energy savings.

[5] The Electric Power Research Institute (EPRI) reports that, in 1992, 175 utilities offered some type of lighting efficiency program. The majority of these programs targeted commercial and industrial customers (EPRI 1993).

[6] Recall that utility spending on DSM includes spending on activities in addition to energy efficiency (such as load management and retention). Thus, although $190 million represents 15% of total DSM spending, it represents a much larger portion of utility spending on DSM activities that focus on energy efficiency.

Sixteen of our programs are full-scale, although eleven have been in full-scale operation for less than two and a half years. These programs accounted for an average of 25% of the utilities' budgets for energy efficiency programs. The four remaining programs are pilot programs.

Sixteen of our 20 commercial lighting programs offered rebates to customers, and four programs offered both the lighting equipment and installation at no cost to the customer. We refer to these latter programs, which require no out-of-pocket investment on the part of the customer, as "direct install" programs.[7] Among programs offering rebates, the rebate amount, type, and delivery mechanisms differed significantly. We expressed all rebates as fractions of the total measure cost, which the utility "bought down".

The mix of technologies offered by DSM programs is changing over time as new efficient technologies emerge and older efficient technologies become standard practice. The major categories of lighting equipment offered by the programs include compact fluorescent lamps, electronic ballasts, high-efficiency magnetic ballasts, reflector systems, T-8 efficient fluorescent lamps, T-12 efficient fluorescent lamps, lighting controls or occupancy sensors, and high intensity discharge (HID) lamps.

The program descriptions and results that we provide in this report should be considered "snapshots" in time. Many of these utilities have refined and improved their commercial lighting programs as they have matured. For the purposes of this report, we have treated our utility contacts as final authorities regarding the accuracy of program data. We acknowledge that the program data we use in this report may change in response to challenges emerging from a regulatory proceeding or through subsequent examination by the utilities or others.

Our experience in attempting to develop a consistent data set for this report demonstrates that the absence of standard terms to define DSM activity and the lack of consistent reporting formats are substantial, yet avoidable, liabilities for future DSM programs. Without standardized, consistent information, one cannot accurately compare DSM program experiences. Our work reduces considerably, but does not eliminate, these uncertainties for the 20 lighting programs in our sample. Industry adoption of a standard

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[7] One rebate program provided a 100% rebate of installed costs; program participants, however, did have to make the initial cash outlay.

DSM terminology and a consistent format for reporting the results of DSM programs is important because accurate comparison of program experience is the most reliable basis for improving future programs.

The Total Resource Cost of Commercial Lighting Programs

The total resource cost for each of the 20 commercial lighting programs is presented in Figure EX-1. In this report, we consider the total resource cost of a program to be the total cost of the efficiency measures delivered through the program levelized over the lifetime energy savings achieved by the program, using a 5% real discount rate. Our findings directly address shortcomings that have been identified for previous estimates of total resource costs by (1) relying on post-program evaluations of energy savings rather than unverified pre-program estimates; and (2) accounting for the direct costs borne by both the utility and the participating customers, rather than only those costs borne by the utility.

We find that the average cost of the 20 lighting programs is 4.4¢/kWh (in 1992 dollars), ranging from a low of 1.2¢/kWh to a high of 7.6¢/kWh. Weighted by energy savings, the average cost of the programs is 3.9¢/kWh. We find that utility administrative costs, weighted by energy savings, represent about 0.5¢/kWh or approximately 13% percent of the mean total resource costs of the programs. To the extent that the savings would not have occurred but for the utility's programs, these administrative costs are also an estimate of the size of the market barriers preventing their adoption in the absence of the utility program.

The ratio of the utility's avoided cost to the total resource cost for each of the 20 programs we examine is greater than 1.0, indicating that each is cost-effective.[8]

Many of the factors that result from program design choices can be systematically related to observed variations in program costs. For example, we find that the largest programs, as measured by total annual energy savings, have been substantially less expensive on a cost per kWh basis than the smallest programs. In addition, Figure EX-1 suggests that many aspects of program design and implementation are influenced by the avoided costs of the utilities; several of the more costly programs were developed by utilities facing very high avoided costs.

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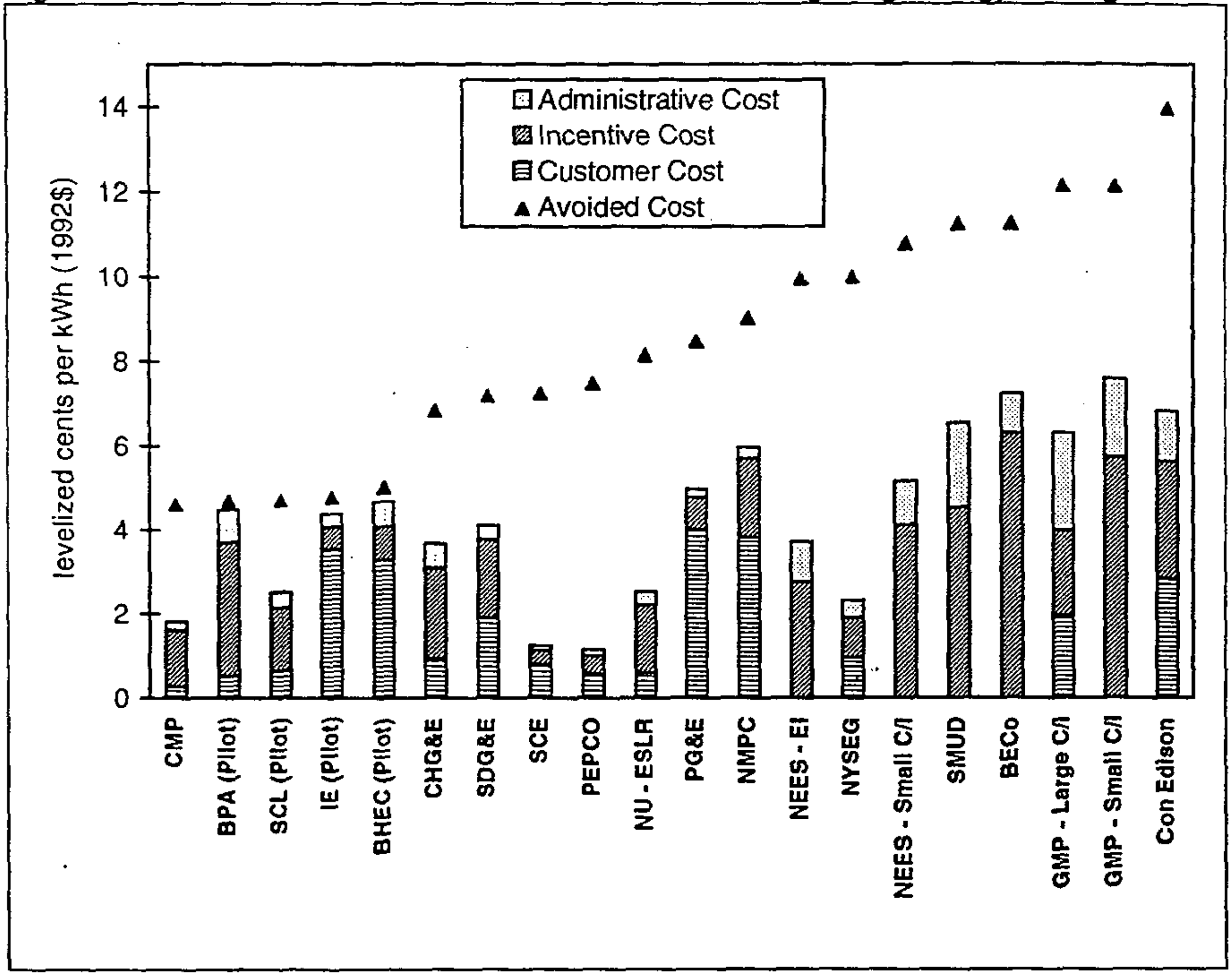
[8] *In standard DSM terminology, this ratio is referred to as the Total Resource Cost (TRC) Test.*

Figure EX-1. The Total Resource Cost of Commercial Lighting Energy Savings



Notes:

1) Levelized total resource costs and avoided costs are calculated at a 5% real discount rate.
2) Utility avoided costs are calculated by LBL from utility TRC test ratio estimates and utility estimates of program levelized costs, see Table 2-5.
3) Evaluation costs are not included in utility costs; based on the programs that do report these costs, we estimate that evaluation costs increase the utility component of total resource costs by about 3%. See the discussion of this issue in section 5.7.
4) Free riders' costs and savings are included in the calculation of levelized total resource costs. See the discussion of this issue in section 3.1.1.
5) We rely on utility post-program estimates of savings based on measured consumption data, and make no judgement on the accuracy of utility evaluation methods. For utilities who do not base post-program savings estimates on measured consumption data, we adjust their tracking database estimates of savings by the adjustment factor explained in section 5.2.

Other Measures of Program Performance

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 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 examine the characteristics of programs with low utility costs (per kWh of savings). We find 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 examine the impact of free riders on rate impacts because free riders cause the utility to incur costs that produce no net savings. We find 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 Evolving Science of Measuring Energy Savings

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.

Concluding Thoughts

Our examination of the measured performance of 20 utility-sponsored commercial lighting programs has confirmed the cost-effectiveness of a significant portion of utility industry spending on DSM. Utility-sponsored energy efficiency programs, however, are not too cheap to meter. If future programs are to achieve their expected economic benefits, utilities must take active measures to minimize program costs and rate impacts. Our review suggests that ample room remains for program innovations to achieve these ends. We feel strongly that these improvements will be facilitated by industry adoption of standard definitions and reporting formats so that the best program designs can be readily identified and adapted.

Introduction

In recent years, more and more utilities have begun offering demand-side management (DSM) programs, and more and more money has been spent on DSM. The Energy Information Agency (EIA) estimates that U.S. utilities spent more than $2.2 billion on DSM in 1992, up from $1.2 billion in 1991 (EIA 1993). Unprecedented growth in DSM spending has led some to become concerned that the results of DSM may be disappointing relative to the expenditures.[1] This concern regarding the economic value of DSM has been reinforced by recent work relating to the total cost and performance of utility activities to promote energy efficiency (Joskow and Marron 1992).[2]

Our study, the first in a series from the Database on Energy Efficiency Programs (DEEP), addresses concerns about the economic value of DSM activities by reporting on the total cost and measured performance of 20 utility-sponsored lighting efficiency programs in the commercial sector (Vine 1992).[3] The goal of the DEEP project is to compile and analyze the measured results of energy efficiency programs in a consistent and comprehensive fashion. The research concept for DEEP originated with previous work by the American Council for an Energy-Efficient Economy (Nadel 1990) and Lawrence Berkeley Laboratory (Krause et al. 1989), but has benefited enormously from the rapid maturation of the DSM industry, as evidenced by more utilities offering programs, many of which have now been evaluated formally. As a result, we are able to report on information previously missing from past analyses of utility DSM programs, such as customer cost contributions, and on program savings based on post-program evaluations rather than on unverified pre-program estimates.

We focus on the resource value that commercial lighting programs contribute to utilities'

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[1] See Wirtshafter's (1992) comparison of the financial risks of DSM with the financial risks of nuclear power, the last new resource option aggressively pursued by the utility industry.

[2] Joskow and Marron examined 12 utility-sponsored commercial lighting DSM programs. They documented inconsistencies among utility accounting practices and expressed concern regarding utility reliance on pre-program savings estimates. They concluded that the evidence they collected "suggests that computations based on utility expectations could be underestimating the actual societal cost [of DSM programs] by a factor of two or more on average."

[3] We refer to these DSM programs broadly as commercial lighting programs. Although almost all programs in our sample were available to both commercial and industrial customers, and some programs were available to agricultural customers as well, most of the energy savings were attributable to commercial customers. We note in the text programs that offered non-lighting measures, and we included in our study only multi-technology programs for which lighting cost and performance data were separable from full-program data.

DSM portfolios.[4] Lighting is a major component of commercial electricity use (approximately 40%) and a significant component of industrial electricity use (approximately 10%) (EIA 1991). Investigations of the technical potential for efficiency improvements routinely conclude that 40% to 70% of current electricity consumption for lighting could be saved cost-effectively (see, for example, Atkinson et al. 1992, and EIA 1992). These and other estimates of lighting as a large, untapped, and cost-effective resource opportunity for energy efficiency have led U.S. utilities to promote customer adoption of energy-efficient lighting improvements as a core resource element of utility demand-side management activities.[5]

This report is organized as follows. In Chapter 2, we describe the process of developing a consistent set of data on costs and energy savings for the 20 lighting efficiency programs in our sample. In addition, we summarize some of the primary difficulties in collecting data on DSM programs and suggest some ways of addressing this challenging problem. The programs are then summarized as a whole.[6] In Chapter 3, we report our major findings on the total resource cost and measured performance of the programs. We relate the differences in these costs to several of the variations in program design and implementation identified in Chapter 2. In Chapter 4, we use the basic findings on the total resource cost of the programs to provide a context for interpreting the significance of other often-cited measures of program performance, such as participation rates, energy savings per participant, and utility costs. We pay particular attention to the methodological issues associated with consistent specification of participation rates and distinguish the value of participation rates for internal utility management from their value for other purposes (e.g., cross-utility comparison). In Chapter 5, we review the evaluation methods used to estimate the energy savings, free riders and free drivers, and persistence of energy savings for the 20 lighting programs. We use this review to develop a taxonomy for classifying evaluation approaches that estimate energy savings.

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[4] There are, of course, other legitimate reasons for utility involvement in demand-side markets, such as equity and customer service. From a resource planning perspective, however, energy efficiency programs are desirable only to the extent that they cost less than the alternatives available for meeting customer energy service needs. Accordingly, the primary measure of performance for commercial lighting programs is the total resource cost of the energy savings.

[5] The Electric Power Research Institute (EPRI) reports that, in 1992, 175 utilities offered some type of lighting efficiency program. The majority of these programs target commercial and industrial customers (EPRI 1993).

[6] The programs are summarized individually in Appendix A. The DEEP data collection form is reproduced in Appendix B.

Twenty Commercial Lighting Programs

In this chapter, we describe the process of collecting data on the 20 commercial lighting programs in our sample, summarize some of the foremost difficulties in collecting data on DSM programs, and review important differences among the programs. In all cases, published utility evaluations and interviews with utility staff members were used to develop a consistent set of cost and savings data for the programs, so that all of our analyses are based on data verified by utility contacts. In several cases, utilities provided more accurate or more recent data than were available in the published sources of information on a DSM program. Utilities reviewed any adjustments we made to data provided by them (see primarily the discussions in Section 3.1 and Chapter 5). Individual descriptions of each program are provided in Appendix A.

We also review key features of the programs that provide the basis for explaining in subsequent chapters the differences in program performance and cost. We begin by establishing the role of each program in each utility's overall DSM portfolio. We then focus on specific features of the program design and implementation, including program maturity, eligible population, incentive type and structure, and lighting measures installed. We conclude our discussion by describing the economic context for the programs in terms of the average retail price of electricity for each utility and the avoided cost used in the design or regulatory approval phase of each program.

2.1 Developing Consistent Program Cost and Energy Savings Information

We began the data collection process by soliciting formal evaluation studies from candidate utilities and reviewing published articles and reports on the candidate programs. Using information from all published sources available to us, we completed as fully as possible a standardized DEEP data collection form based on those developed previously by the Northeast Region Demand-Side Management Data Exchange (NORDAX) and by Oak Ridge National Laboratory (Hirst and Sabo 1991). (The DEEP data collection form is reproduced in Appendix B.) We then established contact with one or more utility staff members familiar with the program and asked them to verify the information we had collected on their programs and to supply missing information.

Three objectives guided the process of selecting programs to study. First, we focused on commercial lighting programs because commercial lighting is perceived to be one of the largest and most cost-effective demand-side resources available to utilities. We considered three types of utility DSM programs: programs that offered only commercial lighting measures; programs whose savings were predominantly attributable to commercial lighting measures; and programs for which commercial lighting savings and costs were separable from the energy savings and costs associated with other efficient technologies offered by the program.

Second, because both lighting technologies and utility experience with demand-side programs are evolving rapidly, we sought cost and savings information for the most recent program year that it was available. We made this choice even though focusing on a single program year can complicate the attribution of costs incurred in a single year to the energy savings that occur in that same year, such as the costs of program evaluations, which almost by definition must take place in years subsequent to the energy savings. Similarly, pilot programs and programs in their first years of operation incur start-up costs that should be allocated, at least in part, to other program years. For all but six programs, five of which were terminated prior to 1991, data for the 1991 or 1992 program year were available.

Third, and most important, in order to estimate the total resource cost of energy efficiency, we considered only those commercial lighting programs for which we could obtain information on the total cost and performance of the program. For each program, we needed information on:

(1) post-program evaluation of energy savings;

(2) total cost of the program to the utility;

(3) total cost of the program to participating customers; and

(4) economic lifetimes of measures installed through the program.

These final requirements proved decisive in choosing the final set of programs analyzed in this report and restricted our focus to 20 out of the more than 50 programs we considered initially. Even for the 20 programs we chose, fewer than half formally reported all of the information required for our analysis. We frequently found that the information in the evaluation reports did not meet our needs for the following reasons:

(1) the methodology for calculating energy savings was not reported;

(2) energy savings were sometimes not identified as "net" or "gross"; and adjustments to energy savings (e.g. adjustments for free-ridership) were not always quantified or even described;

(3) the costs of the program to the utility, as well as to the program participants, were not reported;

(4) program costs, when reported, were not broken into subcategories other than incentives and administrative costs;

(5) participant costs, when reported, did not clearly indicate whether or not installation costs had been accounted for; and

(6) the number of program participants and the size of the eligible population were not reported.

Because essential data were lacking in evaluation reports, we sought information from other published material (e.g., utility filings with regulatory commissions) and contacted program managers and evaluators by telephone. In all cases, extensive discussions with utility staff members, over a period of weeks and sometimes months, were required to verify our interpretations of the utility-supplied information.

Frequently, reaching a contact at a utility and acquiring needed data was time-consuming and complicated. Utility staff members are busy, and they often did not have time to verify the information we had obtained from evaluation reports or to provide the missing pieces of information that we wanted. The hesitancy of utility contacts to assist us in our research was sometimes increased by our asking about a program year which would require them to retrieve archived data. Finally, particularly at larger utilities, we often had to contact several individuals within the organization in order to get answers to our questions regarding energy savings calculations, program costs, and eligible populations. Reaching so many staff members required additional effort and, because of the number of information sources, increased the potential for inconsistency in the data.

Even when we reached the person best able to verify our data and answer our questions, we were frequently confronted with inconsistencies — between data from the utility contact and from the evaluation reports, and even among the utility contacts themselves. The staff members sometimes informed us that the numbers we had taken from evaluation reports were no longer applicable. The most common explanations for this change were that program data had been updated, newer and better evaluation techniques were now being used on data from that program year, or that the numbers had been prepared for a regulatory filing and were not suited for our research purposes. After discovering data inconsistencies, we questioned the utility sources about which numbers to use; we were sometimes told to rely on a single report and other times were given new numbers altogether. On occasion, two contacts within a utility would disagree about the data we should use. In these cases, we asked the disagreeing parties to speak to each other and provide a joint recommendation.

For the purposes of this report, we have treated our utility contacts as final authorities regarding the accuracy of program data. We acknowledge that the program data that we use in this report may change in response to challenges emerging from a regulatory proceeding or through subsequent examination by the utilities or others. While our decision to regard utility staff members as having the last word may suggest some bias in our findings (no one wants to document or talk about programs that might be construed as having performed poorly), we believe that biases are likely to be small. For example, no utility program was dropped from consideration because of lack of cooperation in confirming or supplementing information for our project.

Although utility contacts were generally cooperative in providing information on their DSM activities, our work has made it very clear to us that future data collection and analysis would be facilitated by greater industry standardization of the terms and reporting formats for DSM program information. In some cases, we were able to resolve apparent inconsistencies in the data through discussion with utility program staff. For example, we were generally able to clarify the cost contributions of participating customers (see Chapter 3). In other cases, we were able to make adjustments to develop consistent cost and energy savings estimates (see Chapters 3 and 5). In several cases, however, the inconsistencies were impossible to resolve. As described in Chapter 4, for example, inconsistent definitions for key program parameters such as participation rates often preclude meaningful cross-utility comparisons of what would otherwise appear to be straightforward measures of program performance.

In order to improve the comparability of DSM programs across utilities, we agree with Hirst and Sabo (1991) that there is a real need to encourage consistency in the collection and reporting of data on DSM programs. There are encouraging signs in this direction: a few states (California, New Jersey, and New York) have developed measurement and evaluation protocols to encourage consistency among utilities as they collect, analyze, and report data. The Association of Demand-Side Management Professionals is also exploring options for encouraging similar guidelines among its members. The challenge to go beyond state boundaries to national guidelines and protocols will have to be faced by national organizations, such as the U.S. Department of Energy, the Electric Power Research Institute, and the National Association of Regulatory Utility Commissioners.

2.2 Summary of 20 Commercial Lighting Programs

The commercial lighting programs we examine represent a large cross-section of utility experiences with DSM. This section focuses on some of the differences in utility DSM experiences. Program design features and implementation experiences provide a basis for explaining the variations in program costs and energy savings described in subsequent chapters.

2.2.1 The Role of Commercial Lighting Programs in Utility DSM Portfolios

The commercial lighting programs we examine represent a significant portion of recent utility experience with DSM. In aggregate, the programs represent utility spending of approximately $190 million. Although not strictly comparable (because the spending for the programs we studied was spread over different years), $190 million represents about 15% of the $1.2 billion in nationwide utility spending on all DSM activities in 1991.[1] The programs we reviewed were often the single largest component of the sponsoring utility's DSM portfolio. Table 2-1 indicates the fraction of total utility DSM budgets represented by the 20 commercial lighting programs that we studied. For the 16 full-scale programs, commercial lighting accounted for an average of 25% of the utilities' budgets for energy efficiency programs. The significance of these programs within each utilities' DSM portfolio, and the large amount of money spent on them, highlights the importance of commercial lighting programs as a resource option for utilities. Consequently, understanding the cost of energy saved by the programs greatly contributes to our knowledge of DSM resource costs.

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[1] Recall that utility spending on DSM includes spending on activities in addition to energy efficiency (such as load retention). Thus, although $190 million represents 15% of total DSM spending, it represents a much larger portion of utility spending on DSM activities that focus on energy efficiency.

Table 2-1. Fraction of Utility DSM Budgets Represented by Commercial Lighting Programs

Utility	Program Name	Year	Total Utility Expenditures on Electric Conservation Programs[1] ($Million)	Cost of Commercial Lighting Program to the Utility[2] ($Million)	Commercial Lighting Program Costs as a Percent of Total DSM Expenditures (%)
BECo	Small C/I Retrofit Program	1991	38.4	6.0	16
BHEC	Pilot Comm. Lighting Rebate Program	86-88	NA	0.2	NA
BPA	*Industrial Lighting Incentive Program*	86-87	221.1	0.9	0.4
CHG&E	Dollar $avers Rebate Program	90-91	4.9[3]	3.5	71
CMP	Comm. Lighting Retrofit Rebate Program	1992	16.4	1.4	9
Con Edison	C/I Efficient Lighting Program	1991	76.5	31.1	41
GMP	Large C/I Retrofit	1992	4.6	0.5	11
GMP	*Small C/I Retrofit*	1992	4.6	1.2	26
IE	Lighting Payback Plan	1990	NA	0.1	NA
NEES	Energy Initiative	1991	87.6	44.4	51
NEES	Small C&I	1991	87.6	12.9	15
NMPC	C/I Lighting Rebate Program	1991	42.8	20.1	47
NU	*Energy Saver Lighting Rebate*	1991	≈100	31.5	32
NYSEG	C/I Efficient Lighting Rebate Program	1991	23.5	5.5	23
PEPCO	Commercial Lighting Rebate Program	1990	20.9	1.6	8
PG&E	C/I/A Rebate: Direct Rebate Program	1992	118.0	12.0	10
SCE	Energy Management Hardware Rebate	1992	63.1	3.0	5
SCL	Commercial Incentives Pilot Program	1990	NA	3.1	NA
SDG&E	C/I Lighting Retrofit Program	1992	28.9	10.0	35
SMUD	Commercial Lamp Installation Program	1988	8.8	0.5	6

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[1] These figures are taken from evaluation reports, annual DSM summaries, and other utility literature; all utility-related literature is cited in Appendix A. In some cases, the figure may include elements of a DSM budget that are not related to energy efficiency - such as load retention.

[2] For multi-technology programs, the cost indicated applies only to the lighting component of the program. Where available, the costs of program measurement and evaluation are included.

[3] This number represents *DSM program costs incurred between 6/1/90 and 5/31/91.*

2.2.2 Program Maturity

Program costs are generally thought to be related to program maturity. Pilot programs include start-up costs that make them appear more expensive although, in fact, start-up costs should be amortized over future program years. In addition, after the first few years during which utility program managers become familiar with what works for their target markets, program designs should stabilize and costs may decrease. At the same time, the amount of energy saved and a majority of program costs depend on what measures are offered by programs and what types of customers participate. Both of these, especially the measures offered (see 2.2.5 below), can change over a program's lifetime and complicate the process of determining how much program maturity influences program costs.

Table 2-2(a) shows the life-cycle stage, start date, and program year examined for each program. DSM programs are new undertakings for many utilities. Four of our commercial lighting programs are pilot programs, while 11 have been in full-scale operation for less than two and a half years. Several of the full-scale programs have been in operation for some time, although the utility has sometimes changed the program name. Most of the full-scale programs appear to have been preceded by pilots. As noted previously, we attempted to gather program information for the most recent program year that it was available.

2.2.3 Eligible and Target Populations

The cost of saved energy depends in large part on the characteristics of participating customers. For a given program budget, assuming that processing costs are not affected by rebate size (although, in fact, they can be), a program only available to large customers will tend to spread its costs per transaction over more energy savings, lowering the cost per unit of energy saved. Other factors, such as the size of incentives offered to customers who install DSM measures, can affect the amount of energy savings per customer and, even when normalized for customer size differences, may increase or decrease savings.

Table 2-2(a) shows the eligibility criteria for each program. Although all customers who meet the eligibility criteria may participate in a DSM program, utilities often target certain subgroups of customers through the structure of incentives and measures offered. Direct installation programs, for example, generally target smaller commercial customers. Insight into the effect of program design choices, such as who the target audience will be, can only be seen in program results. Hence, when we discuss targeting in subsequent chapters, we rely on savings per participant as a measure of actual population targeting.

Table 2-2(a). Overview of Twenty Commercial Lighting Programs

Utility	Life-Cycle Stage	Start Date	Program Year[1]	Specific Eligibility Criteria
BECo	Full-Scale	Late 1989	1991	Small non-residential customers with a peak demand < 150 kW
BHEC	Pilot	March 1986	86-88	All C/I customers
BPA	Pilot	Nov. 1985	86-87	All high-ceilinged C/I warehouse facilities in the Clark County area
CHG&E	Full-Scale	June 1990	90-91	All C/I/A[2], municipal, and not-for-profit customers
CMP	Full-Scale	1985	1992	All C/I/A customers
Con Edison	Full-Scale	Jan. 1990	1991	All C/I customers
GMP (Large C/I)	Full-Scale	Dec. 1991	1992	Large C/I customers w/ average monthly elec. use >12,500 kWh from Dec. through March[3]
GMP (Small C/I)	Full-Scale	May 1992	1992	Small C/I customers w/ average monthly elec. use >300 kWh but <12,500 kWh from Dec. through March
IE	Pilot	May 1990	1990	All C/I/A customers in Spirit Lake & Marshalltown service areas
NEES (EI)	Full-Scale	July 1989	1991	All C/I customers
NEES (Small C/I)	Full-Scale	June 1990	1991	Small C/I customers with monthly billing demand <50 kW or annual usage <150,000 kWh
NMPC	Full-Scale	Nov. 1989	1991	All C/I customers
NU	Full-Scale	March 1986	1991	All non-residential customers
NYSEG	Full-Scale	Jan. 1991	1991	All C/I customers
PEPCO	Full-Scale	March 1990	90-91	All commercial customers
PG&E	Full-Scale	Jan. 1990[4]	1992	All C/I/A customers
SCE	Full-Scale	1978	1992	All C/I/A customers
SCL	Pilot	July 1986	1990	All commercial customers
SDG&E	Full-Scale	Oct. 1990	1992	All C/I/A customers
SMUD	Full-Scale	Jan. 1986	1988	Small commercial customers with an energy demand ≤ 50 kW

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[1] For each program, this is the program year examined in this report.

[2] Commercial/Industrial/Agricultural

[3] In addition, all C/I customers with five or more locations under the same corporate umbrella were eligible to participate.

[4] Although the current version of this program began in 1990, PG&E has operated some version of this C/I/A rebate program since the 1970s.

2.2.4 Incentives Offered

A distinguishing feature of the commercial lighting programs in our sample is that all utilities provide explicit incentives for program participation. The incentives distinguish these programs from information-only or audit-only programs, although providing information and audits was an important element of several programs. Table 2-2(b) shows the program type and incentive level during the program year examined for each of the 20 lighting programs. Incentives significantly raise the costs of programs to the utility (in contrast to information-only programs). While the level of incentive offered, as a fraction of total measure costs, should have little influence on the total resource costs of the energy savings, it may influence program participation rates. Aspects of this trade-off are explored in Chapters 3 and 4.

Sixteen of our 20 commercial lighting programs offered rebates to customers, and four programs offered both the lighting equipment and installation at no cost to the customer. We refer to these latter programs, which require no out-of-pocket investment on the part of the customer, as "direct install" programs.[2] Among programs offering rebates, the rebate amount, type, and delivery mechanisms differed significantly.

The most important difference among rebates is the way in which the amount of the rebates is calculated. We encountered three generic approaches:

(1) rebates based on an explicit fraction of either the direct capital or the capital and installation costs of the measures;

(2) rebates based on reducing the participant's payback time to some number of years; and

(3) rebates based solely on the value of either the energy or demand savings.

For example, Consolidated Edison of New York's (Con Edison) rebate covered 100% of the cost of efficiency measures and the customer paid the full cost of installation. In contrast, Green Mountain Power's (GMP) rebate for the Large C/I Program reduced the customer's payback time to two years. Often, approaches were used in combination. For example, Central Maine Power (CMP) paid 1¢/kWh saved, up to 80% of the equipment and installation cost.

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[2] Although NEES's Energy Initiative program provided a 100% rebate of installed cost in 1991, the participant did have to make the initial cash outlay; hence, we have classified this program as a rebate program rather than direct install.

Table 2-2(b). Overview of Twenty Commercial Lighting Programs

Utility	Program Type	Incentive Level	Program Savings Examined in this Report
BECo	Direct Install[1]	100% of installed cost	Mostly lighting[2]
BHEC	Rebate	Up to 50% of installed cost[3] (≈20%, 86-88)	Lighting only
BPA	Rebate	Reduce payback to 1 yr (≈86% of installed cost in 86-87)	Lighting only
CHG&E	Rebate[4]	≈70% of installed cost in 90-91	Mostly lighting
CMP	Rebate	Up to 80% of installed cost (≈83% in 92)	Lighting only
Con Edison	Rebate	Up to 100% of equipment cost (≈100% in 91)	Lighting only
GMP (Lg C/I)	Audit, Rebate	Reduce payback to 2 yrs (≈55% in 92)	Lighting only[5]
GMP (Sm C/I)	Direct Install[6]	100% of installed cost	Mostly lighting
IE	Rebate	≈11% of installed cost in 90[7]	Lighting only
NEES (EI)	Audit, 100% Rebate[8]	100% of installed cost[9]	Lighting only[10]
NEES (Sm C/I)	Direct Install	100% of installed cost	Lighting only[11]
NMPC	Rebate	≈33% of installed cost in 91[12]	Lighting only
NU	Info, Audit, Rebate[13]	73% of installed cost in 91	Lighting only
NYSEG	Rebate	≈100% of equipment cost[14]	Lighting only
PEPCO	Rebate	≈42% of installed cost in 90-91	Lighting only
PG&E	Rebate	≈19% of installed cost in 92[15]	Lighting only[16]
SCE	Rebate[17]	Up to 30% of installed cost (≈35% in 92)	Lighting only[18]
SCL	Audit, Rebate	70% of installed cost	Mostly lighting[19]
SDG&E	Audit, Rebate	≈50% of installed cost (≈54% in 92)	Lighting only
SMUD	Direct Install	100% of installed cost	Lighting only

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[1] "Direct Install" refers to programs in which the utility pays 100% of the installed cost of measures; no initial cash outlay is required from participant.

[2] "Mostly lighting" indicates a program for which almost all energy savings were attributable to lighting measures, although other technologies were offered. In our analysis, we include all costs and energy savings for these programs.

[3] Fixed rebate by measure, custom rebates of 1¢/kWh saved for up to 5 yrs, not to exceed 50% of installed cost

[4] The Dollar $avers program is offered concurrently with CHG&E's C/I Audit Program. Although audits aren't required in order to participate in the Dollar $avers program, some overlap exists.

[5] Other technologies were offered by the program. Lighting measures accounted for 58% of program savings.

[6] Custom measures were also available; for these, GMP reduced the payback period to one year. No custom measures were installed in 1992.

[7] DEEP estimate based on reported incentive and participant costs

[8] Although 100% of measure cost was ultimately paid by the utility, this program is not considered "Direct Install" because participants were required to make the initial capital outlay.

[9] Energy Initiative paid the full cost of all measures installed in 1991, but there were some measures for which cost-sharing would have been required had they been installed (particularly HVAC measures).

[10] Other technologies were offered by the program. Lighting measures accounted for 74% of program savings.

[11] Other technologies were offered by the program, but all recorded program savings came from lighting.

[12] DEEP estimate based on reported incentive and participant costs.

[13] Pre-installation inspection by the utility is required to verify the measure recommendations of trade allies.

[14] NYSEG's goal was to rebate the *incremental* cost of the equipment, but rebates during the evaluation period actually covered 100% of the *full* cost of the measure.

[15] DEEP estimate based on reported incentive and participant costs.

[16] Other technologies were offered by the program. Lighting measures accounted for 55% of program savings.

[17] Audits of participants in this program are provided through SCE's CIA Audits program.

[18] Other technologies were offered by the program. Lighting measures accounted for ≈31% of program savings.

[19] Although other technologies are offered by the program, and there was no information on breakdown of savings by measure for 1990, information from previous program years suggests that savings are largely attributable to lighting measures.

Rebates were either prespecified by the utility or determined on a case-by-case basis through "customized" programs. In the case of fixed rebates, utilities paid a predetermined amount for each unit of a lighting technology installed by program participants. Many programs featured long lists of lighting technologies with separate rebate amounts for each item. In the case of custom rebates, utilities determined a rebate amount for measures not appearing on a fixed rebate list. The custom rebates often involved new technologies that might appear on a fixed rebate list in future program years or technologies whose savings were highly dependent on specific applications. Generally, customers participating in custom rebate programs received incentives that were calculated based on reducing payback time or on the value of energy savings, capped at some fraction of total measure costs.

One of the difficulties in evaluating rebate levels in retrofit programs is establishing a baseline against which to measure costs. Total capital and installation costs seem most appropriate for situations in which working lighting systems are retired before the end of their useful lives. In some cases, where replacement is inevitable, incremental costs (for a more efficient system relative to what would otherwise be installed) may be more appropriate. Unfortunately, little information is available on the prevalence of premature equipment replacement (retrofit) versus normal equipment replacement. To our knowledge, all references to the capital and installation costs for our programs refer to the total rather than incremental costs of the measures.

We found it convenient to express the incentives offered by the utility as a reduction in the customer's direct, out-of-pocket costs for measure adoption. Thus, we express the incentive amount as a fraction of total measure costs (including both capital and installation costs), which the utility, in effect, "buys down".

2.2.5 Lighting Measures

Energy-efficient lighting resources consist of many technologies and operational practices. The combinations of technologies offered can vary dramatically from program to program and — more importantly — from year to year, as technologies mature and new ones enter the market place.[3]. Table 2-3 summarizes the major lighting technologies offered by our programs in the years considered in this report. We also list non-lighting measures offered as part of more comprehensive programs targeting commercial customers.

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[3] The changing nature of the measures offered by lighting programs affects DSM program saturation. See Chapter 4.

Table 2-3. Technology Breakdown for Commercial Lighting Programs

Utility	Lighting Measures[1]										
	CF	EB	MB	RS	T-8	T-12	LC	HID	O/M	Other Lighting Measures	Other Measure Categories
BECo	✓	✓		✓	✓	✓	✓	✓		Halogen lamps	HVAC, Hot Water, Motors, Building Envelope, Refrigeration, Cooking
BHEC	✓	✓				✓	✓	✓		Current limiter	No
BPA								✓		No	No
CHG&E	✓	✓	✓	✓	✓	✓	✓	✓		Current limiters	HVAC, Motors
CMP	✓	✓		✓	✓	✓	✓	✓		Efficient incandescent	No
Con Edison	✓	✓	✓	✓	✓	✓	✓			No	No
GMP (Lg C/I)	✓	✓	✓	✓	✓	✓	✓	✓		No	HVAC, Hot Water, Motors, Demand Control, Building Envelope, Refrigeration, Cooking, Industrial Process
GMP (Sm C/I)	✓	✓		✓	✓	✓	✓	✓		Halogen lamps, pin socket replacement	HVAC, Hot Water, Motors, Refrigeration, Industrial Process
IE	✓	✓	✓		✓	✓				No	No
NEES (EI)	✓	✓	✓	✓	✓	✓	✓	✓		Efficient incandescents	HVAC, Hot Water, Motors, Demand Control, Building Envelope, Refrigeration, Process, Custom
NEES (Sm C/I)	✓	✓	✓	✓	✓	✓	✓	✓		No	HVAC, Hot Water
NMPC	✓	✓		✓	✓	✓	✓	✓		Hybrid ballasts	No
NU (ESLR)	✓	✓	✓	✓	✓	✓	✓	✓		Exit sign retrofits	No
NYSEG	✓	✓		✓	✓	✓	✓	✓		Reflective ceiling, hybrid ballasts	No
PEPCO	✓	✓	✓	✓	✓	✓	✓	✓		Exit sign retrofits	No
PG&E	✓	✓		✓	✓	✓	✓	✓		Halogen infrared lamps, photocell, current limiter	HVAC, Motors, Building Envelope, Refrigeration, Agriculture, Cooking
SCE	✓	✓			✓	✓	✓	✓		Halogen lamps, current limiters, exit sign retrofits, efficient incandescents, hybrid ballasts	HVAC, Hot Water, Motors, Building Envelope, Refrigeration, Custom
SCL		✓	✓			✓	✓	✓	✓	Delamping	HVAC, Hot Water, Motors, Building Envelope, Refrigeration, Demand Control
SDG&E		✓		✓	✓	✓				Hybrid ballasts, custom	No
SMUD						✓[2]				No	No

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[1] CF: Compact Fluorescent Lamps; EB: Electronic Ballasts; MB: High Efficiency Magnetic Ballasts; RS: Reflector Systems; T-8: T-8 Efficient Fluorescent Lamps; T-12: T-12 Efficient Fluorescent Lamps; LC: Lighting Controls or Occupancy Sensors; HID: High Intensity Discharge Lamps

[2] A few other technologies were offered, but fluorescent lamps accounted for 99% of program savings.

The major categories of lighting equipment offered by the programs include: compact fluorescent lamps, electronic ballasts, high-efficiency magnetic ballasts, reflector systems, T-8 efficient fluorescent lamps, T-12 efficient fluorescent lamps, lighting controls or occupancy sensors, and high intensity discharge (HID) lamps.

Three features stand out in Table 2-3. First, all of the programs but two (Bonneville Power Administration (BPA) and Sacramento Municipal Utility District (SMUD)) offered a wide range of lighting measures, in contrast to a few years ago when many lighting programs offered only a single lighting technology, such as compact fluorescent lamps or watt-miser fluorescent tubes (see Krause et al. 1989). Second, electronic ballasts are now routinely offered, while energy-efficient magnetic ballasts are no longer promoted in most of these programs. This change results directly from federal standards that, in 1988, mandated that all ballast manufacturers produce only high efficiency magnetic ballasts.[4] Third, lighting controls, which are more difficult to evaluate from an energy savings perspective, are now commonly available in most commercial lighting programs.

It is important to emphasize that, in contrast to the diversity of measures *offered* by the programs, the measures actually *installed* may be limited to a few categories. Most often, retrofits involve replacement of standard incandescent and fluorescent lamps with energy-efficient fluorescent products. Unfortunately, we have not been able to collect data systematically on the distribution of energy-efficient technologies that underlie the energy savings from each program.

2.2.6 Retail Rates and Avoided Costs

Many of the trade-offs inherent in the program design decisions described above reflect the economic environment in which the programs are developed and implemented. For example, the retail price for electricity determines the cost-effectiveness of efficiency measures for program participants. We noted earlier that many incentives or rebates are set according to the cost-effectiveness of measures for participants. More importantly, the cost-effectiveness of programs using either the Total Resource Cost Test (TRC) or the Non-Participant Test depends heavily on the avoided cost faced by the utility.[5] Other things being equal, a capacity-constrained utility with high avoided costs will be able to cost-

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[4] See National Appliance Energy Conservation Amendments of 1988.

[5] See Krause and Eto (1988) for definitions and discussions of these cost-benefit tests.

effectively pursue much more expensive energy savings than a utility with low avoided costs. Our discussions in Chapter 3 suggest that high avoided costs were an important part of the explanation for some of the more expensive programs that we studied.

Table 2-4 summarizes retail rate information by customer class; rates are expressed as a percentage of the average rate for the utility as a whole for the program years that we examined. Table 2-4 also summarizes avoided cost information developed specifically for the programs and program years examined. These costs were derived primarily from utility supplied information on the cost-effectiveness of the programs; utilities typically developed this information for filings seeking regulatory approval for the programs. The costs, therefore, represent an average developed through a weighting of the expected load shape impacts of the lighting programs and the time-differentiated energy and capacity avoided costs. It is important to bear in mind that, while these costs represent an accurate assessment of the projected value of the programs at the time the programs were approved, the costs do not represent the utilities' actual avoided costs, because these are likely to change over time.

2.3 Summary

With considerable effort, we developed a data set on the cost and performance of a significant fraction of utility DSM spending. Altogether, the 20 programs in our sample represent utility spending of approximately $190 million. Although not strictly comparable (because spending for the 20 programs was spread over different years), $190 million represents approximately 15% of the $1.2 billion in nationwide utility spending on all DSM activities in 1991.

Just as there is no such thing as a generic coal or advanced combined cycle plant, there is no such thing as a generic commercial lighting program. The commercial lighting programs we examine represent a broad cross-section of utility experience in promoting energy-efficient lighting in the commercial sector. They vary substantially in their life-cycle stages, delivery mechanisms, and technologies offered. These variations in design and implementation of DSM programs result from the evolution of energy-efficient lighting

Table 2-4. Retail Rates and Avoided Costs

Utility	Year	Average Price of Electricity Across All Sectors (92$) (¢/kWh)[1]	Price of Commercial Electricity as Percent of Average Price of Electricity	Price of Industrial Electricity as Percent of Average Price of Electricity	Levelized Avoided Cost at Time the Lighting Program Was Developed (92$) (¢/kWh)[2]	Program-Specific Avoided Cost as Percent of Average Price of Electricity
BECo	1991	9.6¢	96%	85%	11.3¢	118%
BHEC	1988	8.2¢	114%	79%	5.0¢	61%
BPA	1988	NA	NA	NA	4.7¢	NA
CHG&E	1991	8.1¢	104%	71%	6.8¢	84%
CMP	1992	8.8¢	103%	74%	4.6¢	52%
Con Edison	1991	13.1¢	94%	92%	14.0¢	107%
GMP (Lg C/I)	1992	7.3¢	107%	80%	12.1¢	165%
GMP (Sm C/I)	1992	7.3¢	107%	80%	12.1¢	166%
IE	1990	8.0¢	102%	63%	4.8¢	60%
NEES (EI)[3]	1991	9.2¢	94%	101%	10.0¢	109%
NEES (Sm C/I)	1991	9.2¢	94%	101%	10.8¢	117%
NMPC	1991	8.1¢	114%	62%	9.0¢	111%
NU[4]	1991	10.3¢	100%	84%	8.1¢	78%
NYSEG	1991	9.6¢	99%	75%	10.0¢	104%
PEPCO	1991	6.6¢	103%	84%	7.5¢	114%
PG&E	1992	10.3¢	105%	71%	8.5¢	82%
SCE	1992	10.5¢	108%	76%	7.2¢	68%
SCL	1990	3.4¢	98%	87%	4.7¢	139%
SDG&E	1992	9.3¢	97%	79%	7.2¢	77%
SMUD	1988	8.7¢	102%	81%	11.2¢	129%
Average		**8.8¢**	**102%**	**79%**	**8.5¢**	**102%**

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[1] For each utility, the average electricity prices in this table pertain to the program year examined in this report. LBL estimates of average electricity prices are based on data contained in EIA's "Financial Statistics" documents, which are cited in the general references.

[2] LBL estimates of avoided cost are derived from utility calculations of program cost-effectiveness and are based on a weighted average of energy and capacity savings.

[3] Because NEES is composed of Massachusetts Electric Company, Narragansett Electric Company, and New England Power Company, the average price of electricity across all sectors is calculated based on average prices for all three utilities.

[4] Because NU is composed of Connecticut Light & Power Company, Western Massachusetts Electric Company, and Public Service of New Hampshire, the average price of electricity across all sectors is calculated based on average prices for all three utilities.

technologies in the commercial sector over time. Design variations are also the result of important differences in utilities': needs for new resources; avoided costs used to design programs; experiences with DSM programs and with local energy efficiency markets; as well as, in many cases, regulatory requirements.

The program descriptions and results that we provide in this report should be considered "snapshots" in time. Many of these utilities have refined and improved their commercial lighting programs as they have matured. For the purposes of this report, we have treated our utility contacts as final authorities regarding the accuracy of program data. We acknowledge that the program data we use in this report may change in response to challenges emerging from a regulatory proceeding or through subsequent examination by the utilities or others.

Our experience in attempting to develop a consistent data set for this report demonstrates that the absence of standard terms to define DSM activity and the lack of consistent reporting formats are substantial, yet avoidable, liabilities for future DSM programs. Without standardized, consistent information, one cannot accurately compare DSM program experiences. Our work reduces considerably, but does not eliminate, these uncertainties for the 20 lighting programs in our sample. Industry adoption of a standard DSM terminology and a consistent format for reporting the results of DSM programs is important because accurate comparison of program experience is the most reliable basis for improving future programs.

Chapter 3

The Cost and Performance of Commercial Lighting Programs

This chapter uses the information developed for the 20 commercial lighting programs described in Chapter 2 to determine the total resource cost of the energy saved by the programs. Our findings directly address shortcomings that have been identified for previous estimates of total resource costs by (1) relying on post-program evaluations of energy savings rather than unverified pre-program estimates and (2) accounting for the direct costs borne by both the utility and the participating customer rather than only those costs borne by the utility.

We calculate the total resource costs for the 20 lighting programs by levelizing the total cost of the energy savings over lifetime energy savings. The information required for this calculation includes annual energy savings, the costs incurred by the utility as well as the program participants, the economic lifetimes of installed measures, and a discount rate.[1] We also discuss the method we adopted for treating the savings and costs associated with free riders.

We then present our findings and comment on the cost-effectiveness of the 20 programs, using the avoided costs developed in Chapter 2. We also examine how program design features appear to influence the total resource costs of the programs. In a final section, we quantify the minor influence of free riders on the total resource cost of energy efficiency.

3.1 Estimating the Total Resource Cost of Commercial Lighting Programs

The total resource cost of energy efficiency acquired through a utility-sponsored commercial lighting program is a function of: (1) the annual energy savings of program participants; (2) the total cost of the energy efficiency program, including incentives paid by the utility to participating customers, administrative costs to the utility, and the cost of the program to participating customers; (3) the economic lifetimes of installed measures; and (4) a discount rate that specifies the time value of money. This section describes the development of this information for the 20 utility programs considered in this report.

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[1] Because the practice of program evaluation is evolving rapidly, we address separately (in Chapter 5) the savings evaluation methods employed by the utilities and the influence of alternative uses of these methods on the results presented in this chapter.

3.1.1 Annual Energy Savings

The energy saved by a commercial lighting DSM program cannot be observed directly because it is the difference between (a) an estimate of the energy use that would have occurred in the absence of participation in the utility's program and (b) the actual energy use as a result of participation. The use of efficient lighting equipment affects the difference in energy use before and after participation; however, the change in energy use is also affected by changes in the lighting amenities provided (e.g., changes in lighting operating hours, areas lit, and lumens of light delivered) as well as by interactions among lighting and non-lighting energy uses (most notably, HVAC energy use). Before post-program evaluation studies were done, estimates of the net energy savings realized by utility DSM programs were, of necessity, based on unverified planning assumptions.

All energy savings estimates presented in this chapter are based on post-program evaluations and were either taken from an evaluation report and then verified by the utility or received directly from a utility contact. Relying on post-program evaluation information greatly increases our confidence in several aspects of the energy savings calculation. At a minimum, the actual number of program participants or installations has been verified; and for several programs, limited end-use metering and on-site inspections further increase the accuracy of the savings calculation. We refer to post-program energy savings developed in this fashion as *tracking database* estimates. In addition, many of the programs have used quasi-experimental program evaluation designs to introduce billing and other measured consumption data into the estimation of post-program and baseline energy use. We refer to post-program energy savings developed in this fashion as ***measured consumption*** estimates. These distinctions are discussed in detail in Chapter 5.[2]

To ensure consistency in the specification of energy savings across programs, we subjected the energy savings reported by the utilities to a three-step review. First, where a utility had estimated program savings based on measured consumption, we reported savings as presented by the utility without passing judgment on the accuracy of the savings estimation.[3] This procedure was used for nine programs.[4] Second, where the utility had

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[2] Keating and Nadel (1992) examined the ratio of pre-program to post-program savings estimates. We examine a related ratio of post-program tracking database estimates to measured consumption estimates. Chapter 5 discusses the differences in these two perspectives.

[3] We are aware that the savings provided to us by several of the utilities are currently being reviewed in regulatory proceedings.

[4] For program evaluations that relied on billing analyses of both participants and a comparison group, a separate

estimated energy savings based on measured consumption for a previous program year, we calculate the ratio of the measured consumption estimate to the tracking database estimate from the previous year and apply the previous year's ratio to the current program year.[5] This procedure was used for two programs (Pacific Gas and Electric (PG&E) and San Diego Gas and Electric (SDG&E)). Third, where energy savings estimates were based only on a tracking database, we adjusted energy savings using the average of the measured consumption/tracking database adjustment factors for the nine of the first 11 programs where such adjustment factors were available. The average adjustment factor was found to be 75% (see Table 5-4). We adjusted the energy savings of the final nine programs in our data set using this 75% measured consumption/tracking database adjustment factor. The development of this adjustment factor and the influence of our use of this procedure on the total resource cost of the programs is explored in Chapter 5.

Free riders are customers who participate in a utility's program but who would have installed measures that are the same as, or similar to, those offered by the utility even without the program.[6] Because free riders essentially take program dollars from utility ratepayers and provide no net savings for the utility, utilities adjust their savings estimates downward to obtain a more precise measure of the savings that are attributable to their programs.[7] For purposes of this analysis, we included the energy savings from free riders in order to develop a measure that indicates total program energy savings and that is consistent with the utility cost data. That is, since costs incurred by all parties are included in our analysis, we must also include the savings accrued by all parties, including free riders.[8]

We approached our adjustments for free-ridership in the same way we approached our

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adjustment is made later for free riders. See discussion following.

[5] See Chapter 5 for the development of this adjustment. Although this ratio is related to what has been termed a *realization rate* in the DSM program evaluation literature, there is some confusion over the exact definition of a realization rate. Consequently, we have chosen to avoid using the term, instead referring to the ratio less succinctly, but more precisely, as the "measured consumption/tracking database adjustment factor".

[6] In Chapter 5, we observe that the phenomenon of free-ridership is generally not defined coherently and not consistently measured by current utility evaluations.

[7] We note that the additional savings resulting from free drivers (customers who install energy-saving measures offered by the utility but who do not participate in the utility's program) are rarely included in utility estimates of the savings from their programs. Unlike free riders, who primarily represent transfers of dollars between ratepayers and participants, free drivers represent net gains to society as a result of a utility's program.

[8] Although this method is consistent with the total resource cost framework, we acknowledge that this framework does not make explicit the effect of free-ridership on electricity rates. We describe this effect of free-ridership in Chapter 4.

adjustments for energy savings. For 17 programs, we used the free-ridership estimates provided by the utility. Because one program (Seattle City Light (SCL)) relied on an evaluation method that corrected for free riders endogenously (i.e., a billing analysis) yet did not estimate free-ridership with a separate evaluation (as did the other utilities relying on billing analyses), we assumed free riders to be 17%, based on the mean free-ridership for the 17 programs mentioned above. Because their free-ridership estimates were determined by a collaborative process, we also substituted our 17% free-ridership estimate for the two programs offered by Green Mountain Power (GMP). The fact that the collaborative process involved extensive negotiations among various parties led us to believe that our 17% estimate was more plausible than those the utility used for the two programs. For example, it was estimated that there were no free riders in GMP's Small C/I Program; this estimate contrasts sharply with the much higher estimates for other small C/I programs that base their free rider estimates on participant surveys and other measured data.

Generally speaking, the savings information on the programs we reviewed did not consider lighting amenity changes. Some of the savings estimation methods did account for the energy impacts of the interaction between lighting and HVAC technologies. Where utilities did address this interaction, they considered only energy relationships between electricity-consuming technologies.

3.1.2 Costs

The total resource cost of energy efficiency acquired through utility-sponsored commercial lighting 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. These are the costs that a customer adopting the measure could expect to bear in the absence of a utility program. In a utility program, the utility may bear some or all of these costs. For example, rebates transfer some of the capital and installation costs of an energy efficiency measure from the customer to the utility; in direct installation programs, the utility bears all of the measure costs.[9]

Administrative costs are the non-measure costs borne by the utility in implementing programs that lead to installation of efficiency measures (Berry 1989). These costs

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[9] Logically, other agents, such as contractors, engineering firms, vendors, etc., will also incur costs as a result of involvement in the program. Conventionally, it is assumed that these agents are fully compensated by the primary agents to the transactions, either the utility or the customer.

represent the cost to ratepayers and society of utility intervention in demand-side markets.[10]

The measure and administrative costs incurred by the utilities were generally well-documented, although we found that assignment of costs to specific categories was reported inconsistently (see Section 4.5.1).[11] For five programs, utility cost information for the commercial lighting component of a multi-technology program was not separated, or only partially separated, from total program costs. For the three of these programs where almost all energy savings were attributable to lighting measures (Boston Edison Company (BECo), GMP Small C/I, and SCL), we used the total costs and energy savings for each program in our calculations. For New England Electric System's (NEES) Energy Initiative Program, in which lighting measures account for 74% of program energy savings, we attributed 74% of program costs to the program's lighting component; this estimate is likely to be high because administrative costs for lighting are generally lower than for other technologies. For GMP's Large C/I Program, in which 58% of savings were attributable to lighting measures, the incentive cost of the program's lighting component was available but the administrative component was not. In this case, we used the ratio of the lighting incentives to total program incentives (45%) to estimate the lighting portion of administrative costs. As with GMP, this is likely to be an overestimate of the costs attributable to lighting savings.

We chose not to include information on the cost to the utility of measurement and evaluation (M&E) of program savings. M&E costs were identified for 11 programs; our utility contacts informed us, however, that the M&E expenditures in the current year were most likely used to evaluate the savings from previous program years. In addition, to calculate M&E costs accurately, some portion of the ongoing costs of program tracking and accounting would also need to be included. We chose instead to develop a set of costs that correspond to the energy savings achieved in the current year of program operation. Chapter 5 reviews the costs associated with program evaluation. This review indicates that the effect of including these costs would increase the utility component of the total resource cost of programs by about three percent (see Figure 3-1 and Section 5.7).

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[10] We do not consider the extent to which utility programs reduce or eliminate the so-called "hidden costs" of energy efficiency, which may otherwise prevent adoption of measures. Hidden costs refer to costs borne by program participants that arise when various factors preventing adoption of these measures without the utility program are not completely eliminated through participation in the program (e.g., interruption in the workplace during a retrofit). For a discussion of this issue, see Herman and Chamberlin (1993).

[11] It is particularly difficult to allocate administrative overhead and measurement and evaluation costs consistently because they are often tracked for a utility's overall DSM activities rather than on a program-specific basis.

Customer cost contributions are the critical difference between a utility and total resource cost perspective on the costs of DSM (Krause and Eto 1988). For utility programs that do not pay the full incremental cost of a DSM measure, omission of the customer cost contribution will understate the total resource costs of DSM. Comparisons of DSM programs that rely only on utility costs will be misleading because of differences in program rebate levels.

For more than half of our 20 programs, the utility estimated the cost of the program to participating customers. Wherever possible, we relied on utility-reported estimates of customer costs. Twelve utilities provided complete information on total customer cost contributions; for five of these twelve programs, there was no cost to the participant. Two more utilities (PG&E, Bangor Hydro-Electric Company (BHEC)) provided information on the cost of the efficiency *measures* to the customers, but did not include the cost of *installation,* for which customers were entirely responsible. For BHEC, our utility contact stated that installation costs account for approximately 20% of the total cost of parts and labor for the program. For PG&E, we relied on a recent LBL report on the cost of energy-efficient lighting to determine installation costs (Atkinson et al. 1992). The report indicated that, for a wide range of lighting efficiency measures, installation costs are approximately equal to equipment costs.

For the remaining six programs, we relied on the design of the rebate (e.g., "pays 50% of installed cost") to estimate the cost of the program to participants. Where the reported rebate level referred to the measure cost rather than the installed cost (e.g., "pays 100% of the equipment cost"), we added in installation costs based on information from the LBL report mentioned above.

Changes in ongoing non-energy costs that result from the adoption of energy efficiency measures, such as the costs of operation and maintenance, are another component of the total resource cost of energy efficiency. These cost changes are generally thought to accrue to the customer, but there may also be ongoing program costs assignable to the utility. None of the studies we reviewed considered these costs explicitly.

Throughout this report, all costs are indexed to 1992 using a time series of GNP implicit price deflators from the *Economic Report of the Office of the President.*

3.1.3 The Economic Lifetimes of Installed Measures

The economic lifetimes of the measures installed through commercial lighting DSM programs are currently the most uncertain inputs to the calculation of the cost-effectiveness of these programs because the expected life of most commercial lighting measures exceeds the time period over which post-program evaluations have been conducted. As a result, we are forced to rely on estimated measure lives. In Chapter 5, we review current studies of short-term measure persistence and demonstrate the effect of alternative lifetime assumptions on our findings for the total resource costs of the programs.

The program evaluations we reviewed most often provided estimates that appeared to be based on equipment lifetimes. These estimates ranged from 14 to 18 years. For two of the shorter estimates (seven and 10 years, for Central Maine Power (CMP) and Central Hudson Gas and Electric (CHG&E), respectively), utility contacts informed us that equipment failure and early removal were considered when the economic lives of the measures were estimated. However, the shortest economic lifetime estimate (five years for Sacramento Municipal Utility District (SMUD)) was based on equipment lifetimes; this program replaced standard fluorescent lamps with more efficient fluorescent lamps.

3.1.4 The Time Value of Savings

In essence, the adoption of energy-efficiency measures represents the substitution of capital today for energy savings tomorrow. From an economic perspective, the wisdom of making this substitution depends on the present value of the savings that are expected to accrue in the future. Specification of a discount rate to reflect alternative uses of this capital is the conventional means for evaluating this trade-off.

Each utility must specify such a discount rate when justifying the value of its programs relative to some other activity the utility might have engaged in.[12] To enhance comparability, we have chosen to use a single real discount rate of 5% for this purpose. This choice is consistent in real terms (i.e., net of inflation) with the range of nominal discount rates encountered in the utility information that we reviewed.

We calculate the total resource cost for each program by using the discount rate to levelize total costs over the average economic lifetime of installed measures for each program. The

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[12] The value of this alternative activity is typically measured by an avoided cost.

levelized costs are then divided by annual energy savings. The total resource cost, also known as the cost of conserved energy (Meier 1982), provides a basis for comparing demand-side energy savings with supply-side resource options.

3.2 The Total Resource Cost of Commercial Lighting Programs

We find the mean total resource cost of our 20 commercial lighting programs, weighted by energy savings, to be 3.9¢/kWh. The simple average is 4.4¢/kWh with a standard deviation of 1.9¢/kWh, and the median is 4.4¢/kWh. All costs are expressed in 1992 dollars. Table 3-1 reports the total resource costs for our sample of 20 commercial lighting programs as well as the elements used to calculate them. Figure 3-1 summarizes the total resource costs graphically.

Joskow and Marron (1992), relying primarily on 1991 data from 12 utility-sponsored commercial lighting programs, found the simple average of levelized costs to be 3.6¢/kWh with a standard deviation of 2.8¢/kWh (both figures have been re-expressed in 1992 dollars). Joskow and Marron further observed that the data they examined were incomplete or unverified, typically did not provide estimates of customer cost contributions, and relied on pre-program engineering estimates of savings. Our efforts to address these data limitations confirm Joskow and Marron's conclusion that their levelized cost findings understate the total resource cost of utility energy-efficiency programs.

Our results indicate that, for our sample of commercial lighting programs, the total resource cost of energy efficiency resulting from a comprehensive and accurate accounting of program costs and savings is approximately 20% higher[13] than Joskow and Marron's findings. Although our results are not strictly comparable, they do not support Joskow and Marron's general conclusion that, by not accounting for these factors, the costs of energy efficiency have been understated "by a factor of two or more on average."

We also find that lighting programs have been cost-effective. Table 3-1 reports the TRC test ratio of utility avoided costs (see Chapter 2) to total resource costs. A ratio in excess of 1.0 indicates that the program benefits, based on a utility's avoided cost, outweigh the cost of the program. It is our understanding that all of the programs were initially projected by

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[13] This ratio is calculated using the simple average of the costs of conserved energy for the 20 programs rather than the lower weighted average.

Table 3-1. The Total Resource Cost of Commercial Lighting Energy Savings

Utility	Program Year	Gross Annual Energy Savings (GWh)	Economic Lifetime of Measure (years)	Admin. Costs of Utility ($,000)	Incentives Paid by Utility ($,000)	Customer Costs ($,000)	Levelized Total Resource Cost (¢/kWh)[1]	TRC Test Ratio[2]
BECo	1991	8.3	15.0	$792	$5,433	$0	7.2¢	1.6
BHEC (Pilot)	'86-'88	2.8	10.0	$94	$132	$528	4.7¢	1.1
BPA (Pilot)	'86-'87	3.2	15.0	$199	$805	$133	4.5¢	1.1
CHG&E	'90-'91	16.1	10.0	$708	$2,689	$1,152	3.7¢	1.9
CMP	1992	15.7	7.0	$172	$1,232	$251	1.8¢	2.5
Con Edison	1991	91.9	11.0	$8,943	$21,496	$21,496	6.8¢	2.1
GMP - Large C/I	1992	1.4	14.7	$251	$217	$212	6.3¢	1.9
GMP - Small C/I	1992	4.0	6.1	$284	$888	$0	7.6¢	1.6
IE (Pilot)	1990	1.4	12.0	$29	$51	$329	4.4¢	1.1
NEES - EI	1991	104.2	18.0	$11,701	$33,680	$0	3.7¢	2.7
NEES - Small C/I	1991	23.5	15.0	$2,561	$10,039	$0	5.2¢	2.1
NMPC	1991	134.4	13.0	$2,464	$17,933	$36,418	6.0¢	1.5
NU - ESLR	1991	149.8	17.0	$5,313	$27,301	$10,098	2.5¢	3.2
NYSEG	1991	71.5	10.0	$1,612	$4,007	$4,007	2.3¢	4.3
PEPCO	90-'91	40.5	9.5	$450	$1,282	$1,770	1.2¢	6.4
PG&E	1992	130.0	15.9	$2,406	$9,626	$50,086	5.0¢	1.7
SCE	1992	96.6	12.9	$680	$2,268	$5,515	1.2¢	5.8
SCL (Pilot)	1990	16.9	16.0	$616	$2,683	$1,150	2.5¢	1.9
SDG&E	1992	66.2	15.0	$1,562	$8,478	$8,635	4.1¢	1.7
SMUD	1988	2.6	5.0	$173	$392	$0	6.5¢	1.7
				Itemized Costs per kWh Saved:			**Total:**	
Weighted Average				**0.5¢**	**1.7¢**	**1.7¢**	**3.9¢**	**1.9**
Average				**0.7¢**	**2.3¢**	**1.3¢**	**4.4¢**	**1.3**
Standard Deviation				0.6	1.7	1.4	1.9	2.1

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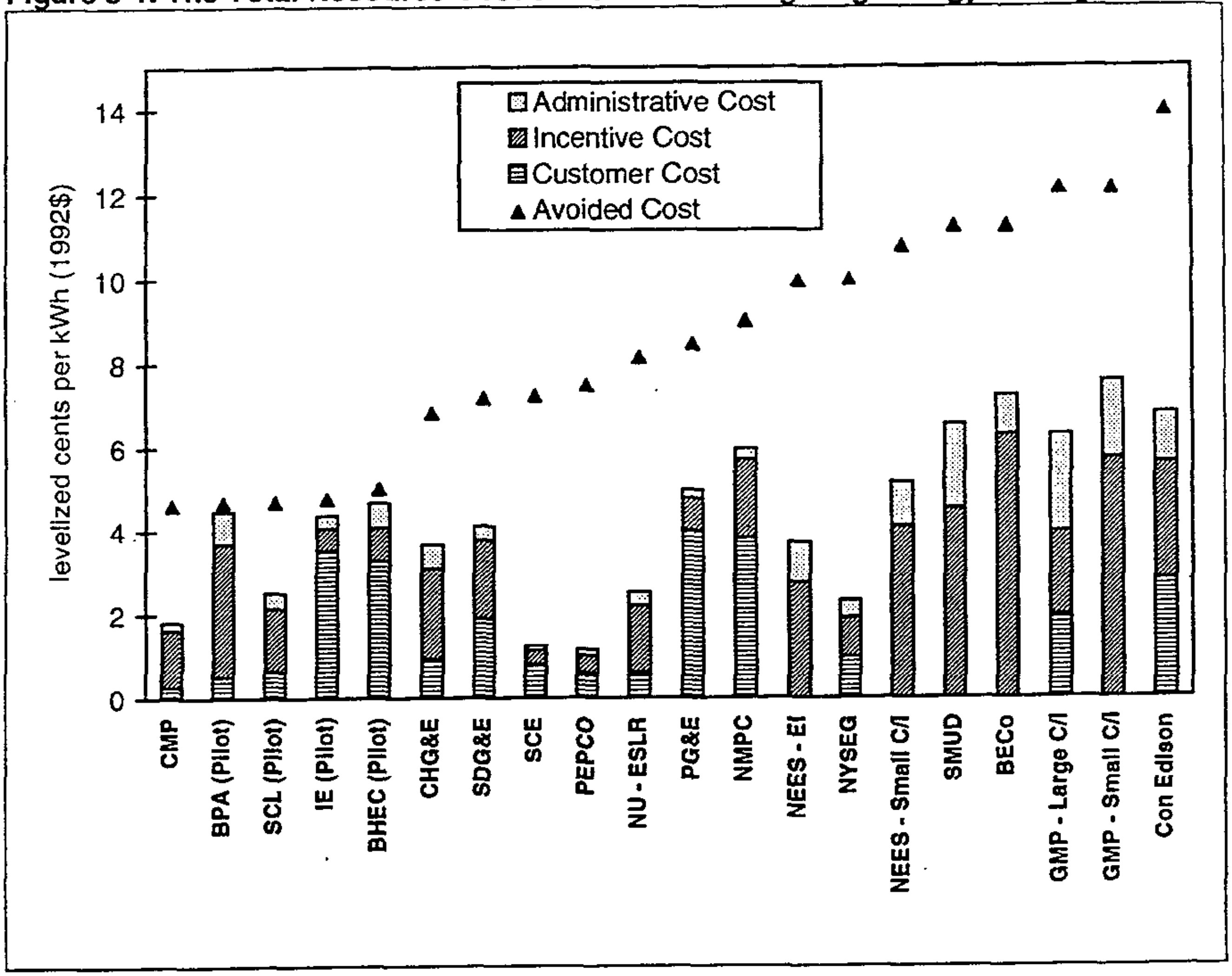
[1] Levelized total resource costs and avoided costs are calculated at a 5% real discount rate.

[2] See Table 2-5 for avoided costs.

Figure 3-1. The Total Resource Cost of Commercial Lighting Energy Savings



Notes:

1) Levelized total resource costs and avoided costs are calculated at a 5% real discount rate.
2) Utility avoided costs are calculated by LBL from utility TRC test ratio estimates and utility estimates of program levelized costs, see Table 2-5.
3) Evaluation costs are not included in utility costs; based on the programs that do report these costs, we estimate that evaluation costs increase the utility component of total resource costs by about 3%. See the discussion of this issue in section 5.7.
4) Free riders' costs and savings are included in the calculation of levelized total resource costs. See the discussion of this issue in section 3.1.1.
5) We rely on utility post-program estimates of savings based on measured consumption data, and make no judgement on the accuracy of utility evaluation methods. For utilities who do not base post-program savings estimates on measured consumption data, we adjust their tracking database estimates of savings by the adjustment factor explained in section 5.2.

the utilities to be cost-effective by this criterion. Based on our detailed re-estimation of program costs (i.e., systematic accounting for customer cost contributions and reliance on post-program savings evaluations), we conclude that all 20 programs remain cost-effective.

Joskow and Marron also express concern that the wide variation among costs of programs represents a major source of uncertainty. If this uncertainty is irreducible, it represents an important additional liability to be considered in selecting energy efficiency resources. However, we believe the detailed information we have developed reduces this uncertainty considerably. The first reduction in uncertainty is achieved by accounting for missing costs and relying on more precise estimates of savings.[14] The second reduction is achieved by relating selected program design features and aspects of program implementation to program costs.

First, a comment on methodology. Although information on 20 commercial lighting programs represents at least twice the amount of information that has been previously examined at this level of detail (see, for example, Krause et al. 1989, and Joskow and Marron 1992), ours is nonetheless a small sample. Multi-variate regression analysis is clearly not viable for samples of this size. Consequently, we focus on trends as indicated by differences in means and associated standard deviations. Where appropriate, we will indicate the statistical significance of these differences using t-tests[15] with varying confidence intervals.

Table 3-2 compares mean total resource costs for three subsets of the 20 programs. We find that there are apparent economies of scale in commercial lighting programs. The seven programs saving less than 15 GWh/year saved energy at a mean cost of 5.9¢/kWh. The 13 programs saving more than 15 GWh/year had a mean cost of 3.5¢/kWh. The difference between these two means is statistically significant at the 99% confidence level.

We hypothesized that economies of scale may be associated with participant savings. As shown in Table 3-2, total resource costs in programs with the smallest savings per participant (less than 30 MWh/participant/year) are slightly — but not significantly —

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[14] The relative precision of our unweighted mean is 44% (1.9/4.3); for Joskow and Marron's sample, the relative precision of the unweighted mean is 78% (2.8/3.6).

[15] A t-test measures the statistical significance of the difference between two means. The significance is expressed using confidence levels, which refer to the likelihood that the difference is not random. The higher the confidence level, that smaller the chance that the difference is random.

higher than in programs with the largest savings per participant (more than 80 MWh/participant/year). Programs with moderate savings per participant (between 30 and 60 MWh/participant/year), however, had significantly higher total resource costs than programs with smaller participant savings or than programs with larger participant savings (significant at the 93% and 99% confidence levels, respectively). These counter-intuitive findings may be the result of confounding factors or the small size of our sample.

Table 3-2. Explaining Variations in the Total Resource Cost of Commercial Lighting Programs

Program Savings[1]	Number of Programs	Mean Total Resource Cost (¢/kWh)	Std. Dev.
< 15 GWh/year	7	5.9	1.2
> 15 GWh/year	13	3.5	1.7
Participant Savings[2, 3]			
< 30 MWh/participant/year	12	4.3	2.0
30 < x < 60 MWh/participant/year	4	5.9	0.9
> 80 MWh/participant/year[4]	4	3.1	1.3
Avoided Cost[5]			
< 8¢/kWh	9	3.1	1.4
> 8¢/kWh	11	5.4	1.7

Notes:

[1] The difference in total resource cost is significant at the 99% confidence level.

[2] The difference in total resource cost between programs with smallest savings/participant and moderate savings/participant, and between programs with largest savings/participant and moderate savings/participant are significant at the 99% confidence level.

[3] A definition of participant can be found in Chapter 4.

[4] No programs saved between 60 and 80 MWh/participant/year.

[5] The difference in total resource cost is significant at the 99% confidence level.

Fundamentally, the total resource cost of energy efficiency is a function of the cost of the measures installed and the energy saved by these installations. We observed in Chapter 2 that there was an important difference between the variety of measures offered by a program and the actual distribution of measures installed (and underlying this, the operating characteristics of the installations themselves). Utility avoided costs provide indirect evidence that these differences were implicitly acknowledged in program design and implementation. For example, several programs were implemented at times when the projected avoided costs of electricity were high.

Higher avoided costs, other things being equal, mean that more costly energy savings (either in the form of more expensive measures or increased utility administrative costs) are cost-effective. We find evidence that the design of more expensive programs was associated with high avoided costs. Table 3-2 compares means of program total resource costs for different ranges of avoided costs. The mean cost of programs developed with avoided costs in excess of 8.0¢/kWh is 5.4¢/kWh, while the mean cost of programs developed with avoided costs of less than 8.0¢/kWh is 3.1¢/kWh. This difference is statistically significant at the 99% confidence level.

3.3 The Societal Cost of Free Riders

Table 3-3 presents additional information on the utility administrative costs of conducting these programs. These figures approximate the added cost incurred by society when utilities administer energy-efficiency programs. To the extent that the savings would not have occurred but for the utility's programs, the administrative costs are also an estimate of the size of the market barriers preventing their adoption in the absence of the utility program.

We find that utility administrative costs, weighted by energy savings, represent about 0.5¢/kWh or approximately 13% of the mean total resource costs of the programs. The simple mean is 0.7¢/kWh, with a standard deviation of 0.6¢/kWh.

The total resource costs of DSM programs are not significantly affected by free riders. The impact of free riders is limited to only the additional utility administrative (not incentive) costs of a program (Krause 1989). On the one hand, the utility incentives received by free riders represent transfers between the utility and the free rider but do not affect the total resource cost of the measure (unless some unique aspect of the utility program causes the direct costs of energy-efficiency measures to increase or decrease). On the other hand, additional utility administration costs are required in order to run a program for participants who would have adopted measures in the absence of the program. Therefore, the impact of free riders on the cost of an energy efficiency program depends on the number of free riders and the magnitude of program administrative costs.

Table 3-3 reports free rider percentages (with adjustments, as discussed in Section 3.1) along with the additional utility administrative costs resulting from the participation of free riders in our 20 DSM programs. We conclude that free riders have had a very small impact on the total cost of the energy saved as a result of utility-sponsored commercial lighting programs (ranging from no effect on program cost at all to a maximum of 1.6¢/kWh, with

Table 3-3. Administrative Costs and Free Rider Effects on the Total Resource Costs of Energy Savings

Utility	Administrative Cost / kWh Saved (¢/kWh)[1]	Free Rider Fraction (%)[2]	Additional Administrative Cost of Free Riders (¢/kWh)
BECo	0.9	14	0.15
BHEC (Pilot)	0.6	73	1.60
BPA (Pilot)	0.8	0	0.00
CHG&E	0.6	3	0.02
CMP	0.2	21	0.05
Con Edison	1.2	5	0.06
GMP - Large C/I	2.3	17	0.49
GMP - Small C/I	1.8	17	0.39
IE (Pilot)	0.3	44	0.25
NEES - EI	1.0	7	0.07
NEES - Small C/I	1.1	7	0.08
NMPC	0.3	13	0.04
NU - ESLR	0.3	10	0.03
NYSEG	0.4	22	0.11
PEPCO	0.1	21	0.04
PG&E	0.2	23	0.06
SCE	0.1	15	0.02
SCL (Pilot)	0.3	17	0.07
SDG&E	0.3	18	0.08
SMUD	2.0	0	0.00
Weighted Average	0.5	—	0.06
Average	0.7	17	0.18
Standard Deviation	0.6	16	0.35

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[1] Administrative costs per kWh saved are calculated from data in Table 3-1.

[2] Free rider estimates based on collaborative negotiations are replaced by the average of the other estimates (GMP Large and Small C/I programs). Utility estimation of free riders is discussed in Chapter 5.

the second largest effect being 0.49¢/kWh). In other words, based on the weighted averages, free riders have increased the average utility administrative cost by 0.06¢/kWh, or approximately 12%. Because utility administrative costs from our programs average only 13% of the total resource cost of the energy-efficiency savings, based on the weighted averages, the net societal impact of free riders has been to add less than two percent to these costs.

3.4 Summary

The total resource cost for each of the 20 commercial lighting programs is presented in Figure 3-1. In this report, we consider the total resource cost of a program to be the total cost of the efficiency measures delivered through the program levelized over the lifetime energy savings achieved by the program, using a 5% real discount rate. Our findings directly address shortcomings that have been identified for previous estimates of total resource costs by (1) relying on post-program evaluations of energy savings rather than unverified pre-program estimates, and (2) accounting for the direct costs borne by both the utility and the participating customer, rather than only those costs borne by the utility.

We find that the average cost of the 20 lighting programs is 4.4¢/kWh (in 1992 dollars), ranging from a low of 1.2¢/kWh to a high of 7.6¢/kWh. Weighted by energy savings, the average cost of the programs is 3.9¢/kWh. We find that utility administrative costs, weighted by energy savings, represent about 0.5¢/kWh or approximately 13% percent of the mean total resource costs of the programs. To the extent that the savings would not have occurred but for the utility's programs, these administrative costs are also an estimate of the size of the market barriers preventing their adoption in the absence of the utility program.

The ratio of the utility's avoided cost to the total resource cost for each of the 20 programs we examine is greater than 1.0, indicating that each is cost-effective.[16]

Many of the factors that result from program design choices can be systematically related to observed variations in program costs. For example, we find that the largest programs, as measured by total annual energy savings, have been substantially less expensive on a cost

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[16] In standard DSM terminology, this ratio is referred to as the Total Resource Cost (TRC) Test.

per kWh basis than the smallest programs. In addition, Figure 3-1 suggests that many aspects of program design and implementation are influenced by the avoided costs of the utilities; several of the more costly programs were developed by utilities facing very high avoided costs.

Other Measures of the Performance of Commercial Lighting Programs

One of the foremost goals of utility-sponsored lighting efficiency programs is the acquisition of a cost-effective energy resource in the context of an integrated resource plan. In Chapter 3, we assert that the total resource cost of a commercial lighting program is the most important measure of the performance of the program in this regard. In this chapter, we turn our discussion to three additional, often-cited measures of program performance:

- participation rates,
- energy savings per participant[1], and
- utility costs per participant.

We critically examine these measures in order to understand precisely what aspects of program performance they measure. We pay particular attention to the methodological issues associated with consistent specification of participation rates and distinguish the value of participation rates for internal utility management from their value for other purposes such as cross-utility comparison.

4.1 Measures of Program Performance

Previous comparisons of DSM programs have emphasized numerous measures of program performance. Flanigan (1992), for example, presented more than 20 indices by which to measure the success of DSM programs. The indicators included large energy and/or demand savings; successful targeting of specific customer groups; energy and/or demand savings exceeding projections; high participation rates; rapid program delivery; systematic design and retrofits as opposed to cream skimming; large energy and/or demand savings per customer; large program budget; large dollar expenditures per customer; low-cost savings; and low administrative costs. Nadel (1991) used a more abbreviated approach and focused on program costs, energy and demand savings, cost-effectiveness, and participation rates as measures of program performance.

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[1] Although demand savings are also a common measure of program success, the primary goal of the programs we examine in this report is energy savings.

For this discussion, we have chosen to focus on three broad, interrelated measures of program performance. It is commonly thought that successful DSM programs (1) have *high participation rates,* (2) *maximize energy savings per participant,* and (3) *minimize* utility costs per participant. Yet, none of these features — a high participation rate, large energy savings per participant, or low utility costs per participant — guarantees a cost-effective DSM program. Trade-offs among program objectives are likely. For example, a high participation rate may come at the expense of higher utility costs per participant because of increased marketing costs and/or the need to pay larger incentives to attract additional participants. Maximizing savings per participant might lead to higher utility costs per participant because of the need for more site-specific auditing as well as incentive approaches that are tailored to the needs of certain customers. In addition, given a fixed program budget, the maximization of savings per participant may result in a lower participation rate. Minimizing costs per participant may require the utility to offer smaller rebates and thus have difficulty in attracting a large number of participants.

In short, it is unclear that any one of these three objectives is appropriate if pursued independently of the others. For this reason, we believe that the total resource cost remains the appropriate "bottom-line" against which inevitable trade-offs among these other measures of program performance should be considered. The appropriateness of a specific performance measure will then depend on the perspective one uses in examining DSM programs (e.g., acquiring a cost-effective resource, meeting internal organization objectives, or comparing program performances among utilities).

4.2 Program Participation

Attracting large numbers of customers to a DSM program is considered by some to be one of the most critical factors affecting a program's performance (Nadel, Pye, and Jordan 1994): the higher the participation rate, the more successful the program. From a resource planning perspective, the implicit assumption is that more participants will lead to greater energy savings for the program, so long as savings per participant do not decline and utility marketing costs do not increase disproportionately. Underlying this perspective is the belief that there is a specific number of customers who would be willing to participate in a specific energy-efficiency program and that the program should reach all potential customers as fast as possible. From the related but somewhat different perspective of the people who plan and implement DSM programs, a high participation rate indicates a successful marketing campaign. Underlying their perspective is a utility's internal program-planning process in which DSM budgets and specific programmatic marketing goals are defined annually.

Although achieving high participation rates is important from both the resource planning and program implementation perspectives, the actual measurement of participation rates is not a straightforward process. As described below, we find that neither the numerator (the number of program participants) nor the denominator (the number of customers eligible to participate in the program) used to calculate participation rates is defined consistently and precisely among utilities. In addition, even when utilities define participation consistently, other issues (such as repeat participation and the criteria used to limit the size of the eligible population) complicate comparison of participation rates among utilities. Comparing participation rates also requires consideration of the length of time a program has been operating (program maturity) and of the resources devoted to program implementation (program budget).

4.2.1 Defining Program Participants and Eligible Participants

An important barrier to consistent measurement of participation rates for DSM programs, particularly in the non-residential sectors, has been the absence of standard terms and protocols for defining program participants and eligible program participants. Certainly, it is easier to define and collect data on participation rates for some sectors and for some end uses than it is for others. For example, in residential weatherization programs, where most utility-sponsored DSM activities originated in the late 1970s, the simplest and most logical unit by which to define a participant is the owner/occupier of a single-family dwelling. The owner/occupier both inhabits the dwelling and pays the utility bill; he or she is therefore the decision maker who can choose to participate in a DSM program. Defining the eligible population in the case of residential weatherization is also straightforward. Because there is generally one account number per household, the number of eligible participants can be assumed to be the number of residential account numbers. Thus, the number of participants divided by the number of residential account numbers gives a reliable participation rate.

This basic model for calculating a participation rate in a residential weatherization program breaks down when applied to commercial customers participating in lighting efficiency programs. In the commercial sector, the decision to participate in a DSM program might be made by the owner of a building but could also be made by a building tenant. For owners of franchises, such as chains of restaurants or department stores, the decision to participate in a DSM program may be made by someone in the regional or national headquarters.

In our sample of 20 commercial lighting programs, program participants were generally defined as "account numbers", "customers", or "rebates paid". As the following discussion reveals, the use of these various terms for defining program participation makes it difficult to compare participation rates among utilities.

"Account Numbers"

The use of "account numbers" as the defining units for program participation in small commercial enterprises can resemble the residential weatherization scenario described above, where there is one tenant or owner/occupier per building and the number of "customers" directly corresponds to the number of account numbers. Many small businesses, like most residences, have only one account number. Iowa Electric Light and Power Company (IE), for example, processed only one rebate application per customer, and each customer had only one account number. The program was available to all commercial and industrial customers within a given service area, so the eligible population was equal to the number of C/I account numbers in that service area.

The one-to-one correspondence between a single "customer" and an account number is less common for larger enterprises, however. On the one hand, large companies and industries can have multiple account numbers. A chain of grocery stores in a single town, for example, is likely to have an account number for each store. On the other hand, one account number can represent a large number of buildings. One utility contact told us that a city block full of buildings at a local university has a single account number, and would thus be considered a single participant in one of their DSM programs.

"Customers"

The use of "customers" as the defining units for program participation can also have a variety of meanings. Often, "customer" is synonymous with "business" or "company" and indicates an organization with a single owner. A customer can be a small business occupying part or all of a building or can be a much larger organization. For Sacramento Municipal Utility District (SMUD), counting customers corresponded closely to counting account numbers because the businesses participating in their program were small and generally had only one account number. In contrast, Consolidated Edison of New York (Con Edison) counts "unique customers". In this case, a bank with several branches would be considered a single participant even if each branch had its own account number. For the Bangor Hydro-Electric Company (BHEC) program, a single "customer" is considered to be a single decision maker. According to our BHEC contact, a multi-site paper mill where one person has the authority to decide that the whole organization will participate in a DSM program would be counted as one participant - even though the mill has 10 account numbers or applies for two rebates per site. On the other hand, if the individual site managers had the authority to decide to participate in a DSM program, each site would be considered a program participant.

"Rebates Paid"

The use of "rebates paid" as the defining units of program participation, like the use of "customers", can have a variety of meanings. "Account numbers" and "customers" sometimes correspond to single rebates and sometimes do not. Our Southern California Edison (SCE) contact asserts that the number of rebates the utility paid through the lighting component of the 1992 Energy Management Hardware Rebate Program is roughly equal (within 10%) to the number of account numbers, because there is usually no more than one application per account number.

In addition, rebates sometimes correspond to a single efficiency measure (a lighting control system, for example) and other times correspond to a large number of measures. According to one utility contact, when a local club was given more than 10,000 compact fluorescent bulbs to resell for $3/bulb, the transaction was considered to be a single rebate. In contrast, large businesses housed in multiple buildings might submit one rebate application for each structure. Multiple rebate applications per customer are particularly common in multi-technology programs where the application for efficient lighting equipment is likely to be separate from the application for other types of measures (such as efficient HVAC equipment).

If the number of rebates paid corresponds directly to a number of account numbers or a quantifiable number of customers, rebates can be used to determine a participation rate. When numerous rebates are available to single customers or account numbers, however, it is difficult to determine the number of potential rebates and thus difficult to determine a participation rate. Nadel's research (1990) indicates, for a limited sample of programs, an average of 1.75 rebates paid per account number; we did not have the necessary data, however, to determine whether or not that ratio is applicable to our sample of lighting programs.

Complications of Comparison Among Terms Defining Program Participants

Participation rates determined by the three general terms described above have important internal uses for utilities. As long as participation is measured consistently, a utility can compare participation rates among its own DSM programs and over a number of years for a single program. Because the terms used to define participation vary among utilities, comparisons of participation rates among different utilities are less straightforward. One must ensure that the units used to compare participation among utilities are defined in the same way. According to our Central Maine Power (CMP) contact, for example, a participating customer could be the owner of a single business that has three account numbers and receives two rebates per account number. CMP, because they track "rebates paid", would consider this to be six participants; a utility tracking "account numbers" would consider this to be three program participants; and a utility tracking "customers" is likely to consider this to be only one participant.

Criteria for Limiting the Size of the Eligible Population

Comparing participation rates among utilities can also be complicated by the different ways that utilities define the number of customers eligible for program participation. In our sample of 20 lighting programs, the number of eligible participants was most commonly defined as either the total population of C/I customers in a given service area or the portion of the C/I customer population that met specific criteria (see Section 2.2.3). In the latter group, eligibility was specific to the program. For Boston Edison Company's (BECo) Small C/I Retrofit Program, for example, only non-residential customers with a peak demand of less than 150 kW were eligible (see Table 2-2(a)).

Generally, for programs that define a subset of the entire C/I population as eligible, participation rates will tend to be higher. For example, Bonneville Power Administration's (BPA) program was available only to high-ceilinged C/I warehouse facilities in one county; because of these limiting eligibility criteria, the program was available to only 207 participants. Consequently, with only 24 participants, BPA had a participation rate of 11.6% over two years. In contrast, Central Hudson Gas and Electric (CHG&E) offered incentives to all of its C/I customers. Although the CHG&E program had close to 50 times as many participants in a single year as BPA had during the two-year life of its program, CHG&E's annual participation rate was only 3% because the program was available to the approximately 35,000 account numbers — CHG&E's entire C/I customer classes.

Repeat Participation

Even when the terms used to define participation are consistent, determining a participation rate can be complicated by those who participate more than once in a single DSM program. Repeat participation is especially common for large commercial customers. Returning to our residential example, in most weatherization programs a participant receives incentives for efficiency measures (such as ceiling insulation or weather stripping) that, once installed, will not need to be installed again in the near future. Businesses with larger facilities, however, may use an ongoing DSM program to retrofit separate buildings or even wings or floors of the same building over the course of several years. If the business submits a new rebate application each year and is counted as a separate participant each year by the utility sponsoring the program, the resulting cumulative participation rates can be inflated. As discussed below, repeat participation is particularly important in lighting programs because new technologies are often offered by the programs each year and satisfied former participants often wish to reapply.

In addition to considering the defining terms, repeat participation, and the limiting criteria of the eligible population, in order to compare participation rates among utilities one must consider the length of time a program has been operating (program maturity) and the resources devoted to program implementation (program budget).

4.2.2 Program Maturity

Because program planners and marketing staff members are often evaluated on how well a DSM program performs in a given year, they are often interested in annual participation rates. Resource planners within utilities, however, are more likely to be interested in cumulative participation rates because these rates are indicative of the lifetime energy savings potential of a DSM program. Because most analysis of DSM programs is done on a yearly basis, it is important for researchers and evaluators to understand how participation rates can change over the life of a program. In the early years of a DSM program, as word slowly spreads about the program, participation rates are typically low. As the market delivery system matures, however, participation rates should become higher and more indicative of the overall performance of the program. For example. BHEC's pilot lighting program paid only 16 rebates in its first year (1986) but provided rebates to more than 130 participants by the end of 1988 (resulting in a 1.4% cumulative participation rate). Similarly, NEES's Small C/I Program had 666 participants in its first year, followed by 2,152 participants in the second year, and 2,494 in the third (resulting in a 9.7%

cumulative participation rate). Finally, Niagara Mohawk Power Corporation (NMPC) had 2,393 participants in its first year, followed by 2,881 in the second year, and 4,755 in the third. Thus, for programs that have only been operating for one to two years — as have the majority of programs we examine in this report — annual participation rates may not be as meaningful as cumulative participation rates.[2]

As mentioned above, repeated participation in a DSM program by a single customer can artificially inflate cumulative participation rates. Because the weatherization measures installed through residential programs have generally not changed enough to warrant cost-effective repeat participation, repeat participation is unlikely in these programs, and cumulative participation rates are thus useful indicators of market saturation.[3] This is not the case for commercial DSM programs that offer efficient lighting technologies. During the last few years, energy-efficient lighting technologies have changed dramatically in availability, cost, and features offered. Although commercial programs may be stable in their overall design, the availability of newer, more cost-effective technologies suggests that the eligible population is in fact growing over time. Therefore, as noted earlier, satisfied participants in an older version of an existing program may be excellent candidates for renewed participation because of their prior familiarity with the utility's program and their previously demonstrated desire to take advantage of better technologies. Consequently, the eligible population for commercial lighting programs will be a moving target as long as technological innovations continue to bring newer, cost-effective technologies into the market; saturating the market for a fixed set of commercial lighting technologies is therefore not a reasonable goal.

4.2.3 Program Budget

One of the most important impediments to cross-utility comparisons of participation rates is the internal constraint on participation established by the annual DSM budgeting process of most utilities. Some programs ramp up quickly, deplete their allocated budgets, and are then suspended until additional funds are available and/or financial incentives are reduced in order to curb demand. Most utilities wish to avoid this stop-and-go process and plan for a gradual phase-in of their programs; typically, a small pilot program is initiated and, after

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[2] After a program has had several years to mature, however, the annual participation rate may become a more reliable indicator of how well a program is reaching its customers.

[3] In certain situations, revisiting weatherization customers may be feasible if the initial program had low measure saturation and if the marginal cost justifies the investment.

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%**	

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[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.

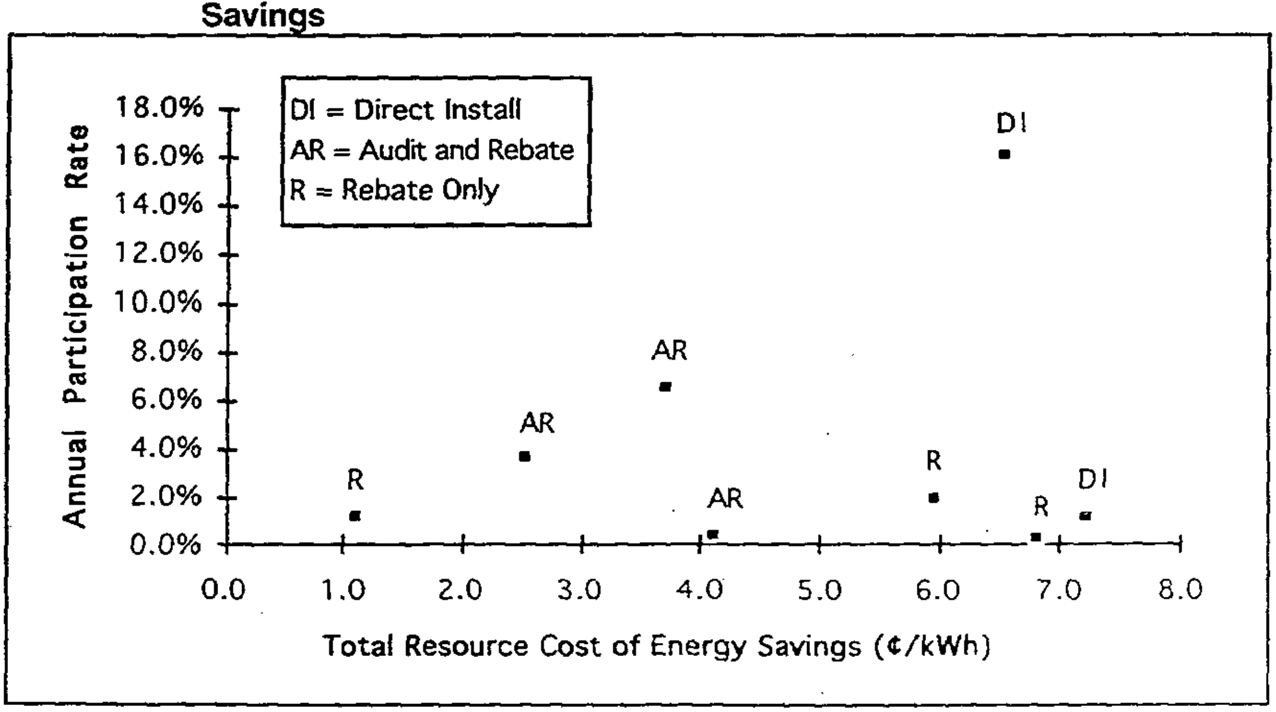
[3] Audits for participants in this program are provided through the separately funded CIA Audits program.

[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

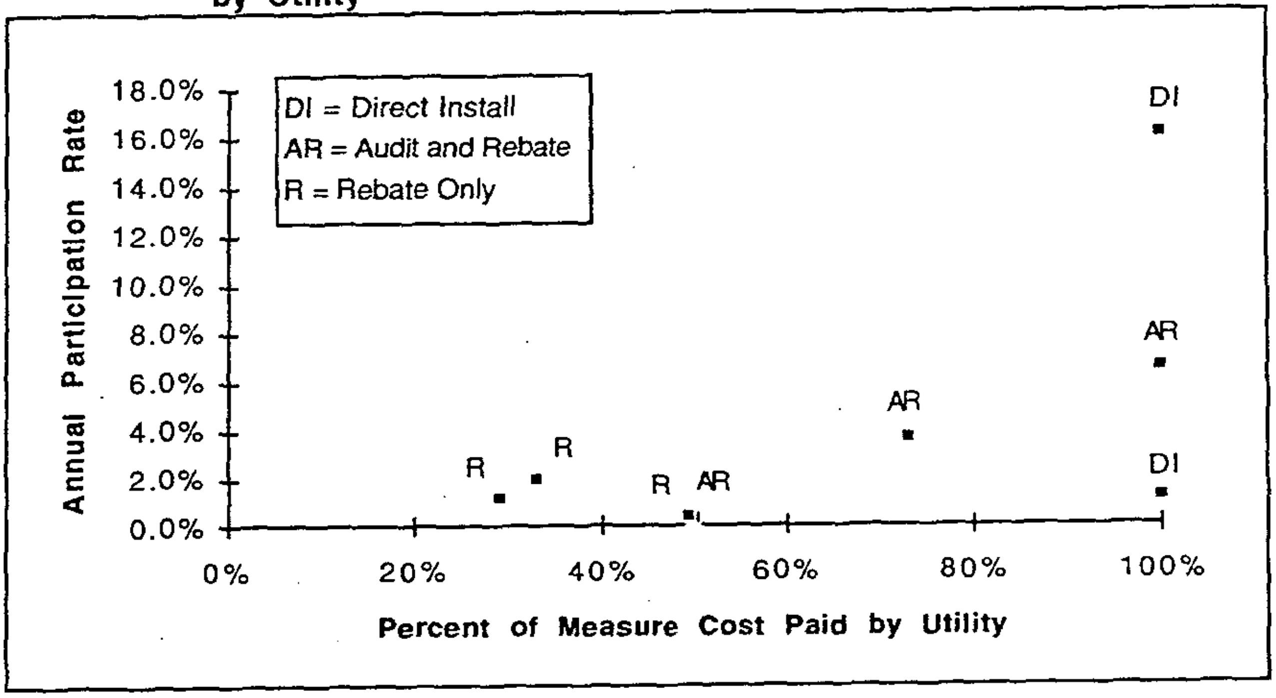
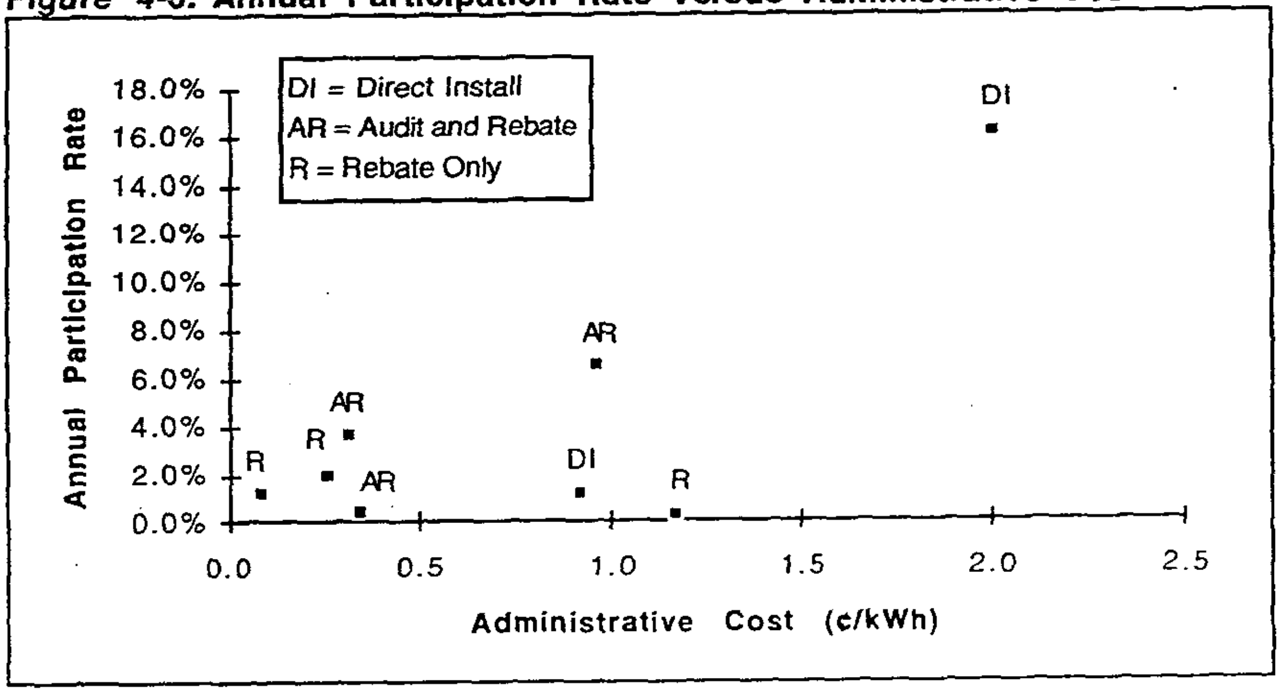


Figure 4-3. Annual Participation Rate Versus Administrative Cost



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

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[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.

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[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$_{\text{part.}}$ minus ΔConsumption$_{\text{nonpart.}}$	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$_{\text{part.}}$; 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$_{\text{part.}}$ minus ΔConsumption$_{\text{nonpart.}}$	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

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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

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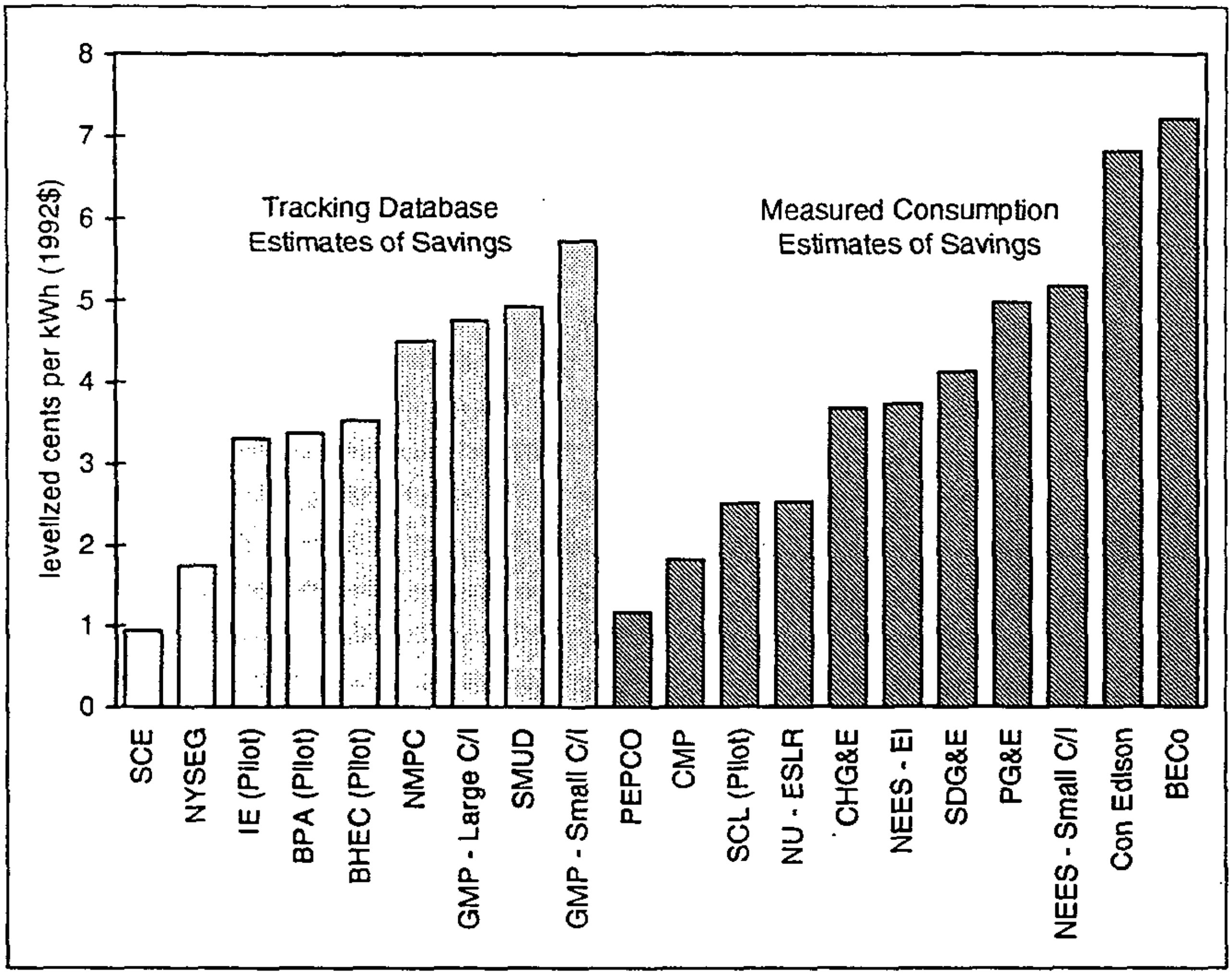
[8] No adjustment to measure life was made to programs assuming economic lifetimes of 11 years or less (7 programs).

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

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[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

	Affirmative Responses		
Utility	**Participants**	**Nonparticipants**	**Survey Question**
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.

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[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)			

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[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[*]

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[*] 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."

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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%.

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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.

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[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.

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[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*

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* 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:	*Values Used:*
☐ Cents per kWh	Time period ________
☐ Dollars per KW	Average measure lifetime ________
☐ Cents per therm	Discount rate ________
☐ Cents per MBtu	
☐ Other ____________________	

☐ 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
- ☐ 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) ______________________________