Evaluation of Commercial Lighting Programs: A DEEP Assessment

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In this paper, we present key findings from a Database on Energy Efficiency Programs (DEEP) report on commercial lighting programs. In the DEEP report, which is the first in a series, we examine the measured performance of 20 utility-sponsored, demand-side management (DSM), lighting efficiency programs in the commercial and industrial (C/I) sectors. We assess the performance of the lighting programs based on four measures: the total resource costs of the programs, participation rates, energy savings per participant, and utility costs per participant. At an average cost of 3.9 ¢/kWh, these programs are judged to be cost-effective when compared to avoided costs in their areas. We critically examine participation rates, energy savings per participant, and utility costs per participant in order to understand precisely what aspects of program performance they measure. Finally, we summarize some of the primary difficulties in collecting DSM data in a consistent and comprehensive fashion, and offer some solutions to this challenging problem.

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). This increased dependence upon, and financial investment in, DSM activities often occurs at the strong urgings of state regulatory utility commissions (see, for example, Krause and Eto 1989). As governmental directives and integrated resource planning requirements increasingly motivate utilities and governments to implement energy efficiency programs, the demand for reliable data about energy efficiency programs, technologies, costs, and impacts is increasing.

In order to make it possible to compare DSM programs and to learn from previous program experiences, the U.S. Department of Energy has sponsored the development of the Database on Energy Efficiency Programs (DEEP). 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 database will summarize the results of DSM programs sponsored by electric utilities, as well as those carried out by others (e.g., governmental agencies) (Vine, Payne and Weiner 1993).[1] In order to identify qualities of successful programs, data on similar programs are summarized by marketing and delivery approach, incentive mechanism, and other program features.

In addition, DEEP staff members periodically publish reports that describe the lessons learned from particular types of programs. The first DEEP report provides an analysis of the performance of 20 utility-sponsored commercial lighting programs (Eto et al. 1994). In this paper, we present key findings from the DEEP report on commercial lighting programs.

Measures of Program Performance

We examine 20 commercial lighting programs based on four measures of program performance: total resource cost, participation rate, energy savings per participant, and utility cost per participant.[2] First, we note that trade-offs among these 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. Minimizing costs per participant may require the utility to offer smaller rebates and thus have difficulty in attracting a large number of participants. Finally, minimizing the total resource cost could lead to low participation rates, low savings per participant, or high utility costs per participant. In short, it is unclear that any one of these measures is appropriate when pursued independently of the others. The appropriateness of a specific performance measure will 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).

In this paper, we identify the difficulties involved in calculating these measures consistently and discuss the extent to which they are useful in assessing the performance of DSM programs. In addition, we summarize some of the primary difficulties involved in collecting data on DSM programs and suggest some ways of addressing this challenging problem.

Program Selection

Three objectives guided the process of selecting the DSM programs in our sample. 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. 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. 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.

Table 1 shows the life-cycle stage, start date, program year examined, and eligibility criteria 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.

A distinguishing feature of the lighting programs in our sample is that all utilities provided explicit incentives for program participation. The incentives distinguish these programs from information-only or audit-only programs, although providing information and audits is an important adjunct element of several programs. Sixteen of the twenty C/I 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.[3] Among programs offering rebates, the rebate amounts, types, and delivery mechanisms differed significantly (Eto et al. 1994).

The major categories of lighting equipment offered by the programs included compact fluorescent lamps; electronic ballasts; high-efficiency magnetic ballasts; reflector systems; T-8 efficient fluorescent lamps; T-12 efficient fluorescent lamps; lighting controls; and high intensity discharge (HID) lamps. 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 frequently, retrofits in the 20 programs we studied replaced standard incandescent and fluorescent lamps with more efficient fluorescent products.

Total Resource Costs

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. From this economic perspective, the most appropriate measure of program success is the total resource cost of energy efficiency. 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 program participants, the economic lifetimes of installed measures, and a discount rate. We report these data in a consistent fashion to allow direct comparability among programs.

Below, we briefly discuss some key features of the energy savings and cost estimates; for a detailed discussion, see Eto et al. (1994).

Annual Energy Savings

The energy savings estimates in our study are based on post-program evaluations. 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

Table 1. Overview of Twenty Commercial Lighting Programs

Utility	Life-Cycle Stage	Start Date	Program Year[1]	Specific Eligibility Criteria
Boston Edison	Full-Scale	Late 1989	1991	Small non-residential customers with a peak demand < 150 kW
Bangor Hydro-Electric	Pilot	March 1986	86-88	All C/I customers
Bonneville Power Administration	Pilot	Nov. 1985	86-87	All high-ceilinged C/I warehouse facilities in the Clark County area
Central Hudson Gas & Electric	Full-Scale	June 1990	90-91	All C/I/A[2], municipal, and not-for-profit customers
Central Maine Power	Full-Scale	1985	1992	All C/I/A customers
Con. Edison of NY	Full-Scale	Jan. 1990	1991	All C/I customers
Green Mountain Power (Large C/I)	Full-Scale	Dec. 1991	1992	Large C/I customers w/ average monthly elec. use >12,500 kWh from Dec. - March[3]
Green Mountain Power (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. - March
Iowa Electric Light and Power	Pilot	May 1990	1990	All C/I/A customers in Spirit Lake & Marshalltown service areas
New England Electric System (EI)	Full-Scale	July 1989	1991	All C/I customers
New England Electric System (Small C/I)	Full-Scale	June 1990	1991	Small C/I customers w/ monthly billing demand <50 kW or annual use <150,000 kWh
Niagara Mohawk	Full-Scale	Nov. 1989	1991	All C/I customers
Northeast Utilities	Full-Scale	March 1986	1991	All non-residential customers
New York State Electric & Gas	Full-Scale	Jan. 1991	1991	All C/I customers
Potomac Electric Power Co.	Full-Scale	March 1990	90-91	All commercial customers
Pacific Gas & Electric	Full-Scale	Jan. 1990[4]	1992	All C/I/A customers
Southern CA Edison	Full-Scale	1978	1992	All C/I/A customers
Seattle City Light	Pilot	July 1986	1990	All commercial customers
San Diego Gas & Electric	Full-Scale	Oct. 1990	1992	All C/I/A customers
Sacramento Municipal Utility District	Full-Scale	Jan. 1986	1988	Small commercial customers with an energy demand ≤ 50 kW

[1] For each program, this is the program year that we examine in the DEEP 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.

program savings based on measured consumption data (such as data from billing analyses or end-use metering), we reported savings as presented by the utility without passing judgment on the accuracy of the savings estimation. This procedure was used for nine programs. Second, where the utility had estimated energy savings based on measured consumption for a previous program year, we calculated the ratio of the measured consumption estimate to the tracking database estimate from the previous year and applied the previous year's ratio to the current program year. This procedure was used for two programs. Third, where energy savings estimates were based only on a tracking database, we adjusted energy savings using a 75% adjustment factor. This procedure was used for the final nine programs. The 75% adjustment factor is based on the ratio of energy savings calculated with measured consumption data to energy savings calculated with tracking database data, for programs where both estimates were available.

We examined program performance from the total resource cost perspective, which is concerned with the total cost of efficiency measures, without regard to who bears those costs. Consequently, although many utilities adjusted their energy savings estimates downward in order to account for the effects of free riders, we added back in the energy savings from free riders to estimates that excluded them. We included free rider savings so that the savings estimates remained consistent with the measure costs. We included all costs incurred by the utility and participants (including free riders) as well as all energy savings accrued by program participants (including free riders).[4]

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 refer to the costs of acquiring and installing the energy efficiency measure. Administrative costs refer to the non-measure costs borne by the utility in implementing the programs that lead to the installation of the measures (Berry 1989). The measure and administrative costs incurred by the utilities were generally well-documented, although we found that assignment to specific cost categories was reported inconsistently (see below).

Customer cost contributions are an important, yet often overlooked, component of the total cost of a DSM program. 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 due to differences in the level of incentive offered by utilities. We used two primary approaches to develop information on customer cost contributions for the 20 programs. First, we relied on utility estimates of customer costs where they were provided, and adjusted them when necessary. Where information regarding customer cost contributions was not available from the utilities, we used 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, assuming installation costs were approximately equal to measure costs (Atkinson et al. 1992).

The Total Resource Cost of Commercial Lighting Programs

Based on the adjusted data described above, we estimated the total resource cost for each of the commercial lighting programs (see Table 2). All costs are expressed in 1992 dollars. We find the mean total resource cost of the 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. This result suggests that a commercial lighting DSM program can be a very cost-effective option for a utility, depending on the avoided cost for that utility (see Eto et al. 1994).

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: 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. 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.

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.

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, 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

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

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

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". "Account number", used as the defining unit for program participation, can vary in meaning. Many small businesses have only one account number. Iowa Electric Light and Power Company, for example, processed only one rebate application per customer, and each customer had only one account number. The program was available to all C/I 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—such as a university or government complex.

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 of a building or a single 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.

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. 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 bulbs were 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.

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.

Criteria for Limiting the Size of the Eligible Population. Comparing participation rates among utilities can also be complicated by the different ways in which utilities define the number of customers eligible for program participation. In our sample of 20 C/I 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. For Boston Edison Company's Small C/I Retrofit Program, for example, only non-residential customers with a peak demand of less than 150 kW were eligible.

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. Businesses with larger facilities 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. 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.

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. 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, 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). 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. 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.

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 are implemented 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 one or two years, a more comprehensive program is implemented for a larger group of customers. Consequently, program marketing is calculated, so that demand for program services does not outpace the program budget. In addition, program participation goals are staged incrementally, 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.

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. 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 strongly believe that the success of a utility-sponsored 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 DSM 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 (e.g., percent of measure cost paid by utility). 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.

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 (HID 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.

Achieving a high level of energy savings per program participant is commonly considered to be a measure of the performance of a DSM program. 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 bean 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. Yet, 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 cannot be sure that a change in energy consumption is actually attributable to the DSM program nor can one 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 our programs.

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.

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.

The Difficulty of Comparing Utility Costs Among DSM Programs

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.

For most of our 20 lighting programs, utilities did not report administrative costs that were broken down by component. When utilities did report administrative cost components, the components varied widely from utility to utility. 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. However, 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.

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. In addition, we see no correlation between the utility's measure costs and the energy savings per participant. This is not particularly surprising because 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% 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.

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. The average level of free-ridership was 17% in the 17 out of 20 programs where free riders were measured. The primary effect of free riders is to reduce the *savings* directly attributable to a utility-operated DSM program. In our project, we examined levelized total utility costs based on both gross energy savings and net energy savings. We find that the average increase in the levelized utility costs resulting from free riders is only 0.6¢/kWh. We also 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.

The Challenges to Comparing Utility DSM Programs

Although our original intention was to rely upon data reported in process and impact evaluation documents for the 20 lighting programs, we frequently found that the information contained within the evaluation reports did not meet our needs, for the following reasons:

- the methodology for calculating energy savings was not reported;
- 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;
- the costs of the program to the utility, as well as to the program participants, were not reported;
- program costs, when reported, were not broken into subcategories other than incentives and administrative costs;
- participant costs, when reported, did not clearly indicate whether or not installation costs had been accounted for; and
- 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.

Conclusions

In the DEEP project, we have shown that it is possible to compile and analyze the measured results of energy efficiency programs in a consistent and comprehensive fashion. 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. 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. If these national organizations are interested in comparisons of performance of utility DSM programs across the country, more resources will need to be devoted to (1) assist other states in the development and implementation of measurement and evaluation protocols that are similar to those already being implemented, and (2) sponsor workshops, demonstrations, and forums for the development and implementation of national measurement and evaluation guidelines.

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Endnotes

1. Other sponsors of DEEP are the Electric Power Research Institute, The Energy Foundation, Bonneville Power Administration, and the Rockefeller Family and Associates. Eventually, the database will also include information about programs sponsored by gas utilities.

2. Some of these programs involve only industrial customers and some include non-lighting measures. We include in our study only those multi-technology programs for which lighting cost and performance data were separable from full-program data.

3. New England Electric System's Energy Initiative program provides a 100% rebate of installed cost, but the participant does have to make the initial cash outlay.

4. For 17 of our programs, we use the free-ridership estimates provided by the utilities. Because one program relied on an evaluation method that corrected for free riders endogenously (i.e., a billing analysis) and did not estimate free-ridership with a separate evaluation (as did the other utilities relying on billing analyses), we assume free riders to be 20%, based on the mean free-ridership found for the 17 programs mentioned above. For the two programs in which free-ridership was determined by a collaborative process, we substitute our 20% estimate for the collaborative estimate.

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