USE OF SIMPLE PERFORMANCE INDICES TO HELP GUIDE REVIEW OF DSM PROGRAM PERFORMANCE

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INTRODUCTION

When demand-side management (DSM) programs are evaluated, the result is typically a thick report that few people have the time to read. While much useful information can usually be found in these reports, important information is often difficult to find, and sometimes is missing. In an effort to help utility managers and regulators acquire a quick "snap shot" of program results, this paper recommends that as part of periodic reports on program results, each utility should calculate and report a series of simple performance indices on each program.

The performance indices are as follows:

1. Participation rate -- annual and cumulative
2. Percentage savings
3. Free rider proportion
4. Indirect/direct cost ratio
5. $/kWh
6. $/kW
7. Ratio of measured savings to estimated savings

Definitions of each index and illustrative applications of each index are discussed below. In discussing these applications, we attempt to describe typical index values for different types of programs. These typical values can be used to help interpret indices for a particular program that is being evaluated. If an index value for a particular program is better than average, it tends to indicate that a program is going well (however, most programs will perform well on at least one index; a general assessment of a program should be based on a review of all of the indices for which data are available). If an index for a program is below average, it indicates that additional research is needed -- first to see if there is a reasonable rationale for the poor index value, and second, to see if program improvements might be justified in order to improve the index value. The indices described here tend to oversimplify complex programs. Thus, these indices cannot provide a full-measure of program effectiveness. However, these indices can help managers and regulators to focus their inquiries, so that a well-rounded perspective on program effectiveness can be obtained in a time-efficient manner.

PARTICIPATION RATE

Definition and Calculation

Participation rate is the number of participating customers divided by the number of eligible customers. Both the number of participating customers and the number of eligible customers are not always easy to quantify.

The number of participating customers is typically calculated in one of three ways: (a) the number of applications processed (this can include multiple applications submitted by a single account), (b) the number of unique account numbers participating in the program (this can include multiple account numbers used by the same home or business), and (c) the number of unique homes and businesses participating in the program. While definition "c" is probably the most useful, it is usually very difficult to calculate because computers can identify two accounts at the same home or business only if the name and address are spelled identically (i.e., do not differ by a single space or period). Definition "b" is much easier to calculate as identical account numbers are generally easy to match with a computer. For this reason, definition "b" is likely to be the preferred definition for most applications. Definition "a" should be avoided because many programs allow and encourage customers to participate more than once, which, using definition "a", makes it impossible to calculate how many eligible customers have not participated in a program.

Two other important issues in calculating the number of participating customers are (a) whether to count pending applications or only completed applications, and (b) whether to count all participants, or only participants who are not "free riders" (free riders are program participants who would have implemented DSM measures even if no program were offered). Since some pending applications never reach completion, it is usually best to count only completed applications. However, if only completed applications are counted, the number of participants in the first year of a program is likely to be very low. Most commonly, in calculating participation rates, no adjustment is made for free riders; instead, the free rider proportion is tracked as a separate performance index (discussed below).

The number of eligible customers for a program may be all of a utility's residential or C&I customers, or it may be a subset of this group (e.g., C&I customers with peak demand greater than 500 kW or new C&I accounts). At times, only a very limited subset is targeted. For example, the eligible population for Massachusetts Electric Company's Enterprise Zone Small C&I Program was C&I customers with annual electricity use of 240 MWh or less which were located in 20 targeted towns. Since approximately one-third of these customers were minimal use accounts (phone booths, billboards) which were highly unlikely to participate in the program, the number of eligible customers was further defined to be C&I customers in the 20 towns who used 5-240 MWh/year (New England Electric System, 1988).

Sometimes, the number of customers eligible for a program are large, but a much smaller number of customers are specifically targeted (the remaining customers may be targeted later, or they may be included in the eligible population for equity purposes: to provide an opportunity for participation, even if participation is unlikely). In cases where the number of eligible and targeted customers differ, it is usually useful to report two participation rates -- one based on eligible customers and one based on targeted customers.

In calculating the number of eligible customers, the same rules should be used as are used for calculating number of participating customers. For example, if definition "c" is used to calculate the number of participating customers, then the pool of eligible accounts needs to be sorted to eliminate homes or businesses with more than one account.

For some programs if may be advantageous to calculate participation rates based on factors besides participating and eligible customers. For example, for equipment rebate programs, it is often useful to portray the participation rate in terms of pieces of equipment that received rebates relative to annual sales of that equipment in a utility's service territory (the latter can be estimated with the help of manufacturers, industry trade associations, and local distributors). Similarly for commercial new construction programs, the participation rate can be calculated as the floor area of buildings participating in a program divided by floor area of all new commercial buildings in the service territory.

Interpretation

In this section on interpreting participation rates, unless otherwise noted, it is assumed that participation rates are based on customer account numbers and that participation figures are not adjusted to eliminate free riders.

Participation rates can be calculated on an annual or cumulative (since program inception) basis. Both measures provide useful information and should be reported. Participation rates vary depending on the program type, number of customers being targeted, incentive strategy, marketing approach, and other factors.

Participation rates for typical programs and for particularly effective programs (denoted "best") are summarized in Table 1. The majority of programs offered to date generally have low participation rates due to limited marketing, limited incentives, start-up difficulties, lack of commitment by the sponsoring utility, and other factors. The presence of a low participation rate (substantially less than the "best programs" column in Table 1) indicates that additional research is needed to see whether the seemingly low participation rate is due to uncontrollable factors (e.g., participation rates are usually low in the start-up year of a program), or whether program improvements may be beneficial.

In interpreting participation rate figures it is important to bear in mind that the more limited and targeted the eligible population, the easier it is to achieve high participation rates, but these high rates may come at the expense of leaving some customers ineligible for a program.

Table 1. Participation Rates in Typical and "Best" Programs

Program Type	Participation Rate			
	Typical Program		Best Programs	
	Annual	Cum.	Annual	Cum.
C&I				
Audit	1-3%	1-4%	5-20%	60-90%
System-wide rebate				
Based on customer accts				
All customers	1-2	1-4	3-4	5-10
Large customers	1-4		10-20	10-25
Based on pieces of equipment sold	1-3		30-70	
Performance contracting		0-2		15
Comprehensive	1-2		3-15	30-70
Residential				
Audit	1-3	7		25-40
Low-cost retrofits			10-25	30-65
Moderate-cost retrofits		1-6		40
Comprehensive retrofits			4-6	25-85
New construction	2-15		40-80	

Notes:
Annual rates are only for programs that are offered system-wide and are targeted at large groups of customers.
"Cum. = cumulative.
"Comprehensive" programs combine substantial incentives with assistance identifying measures and arranging measure installation.
Blank spaces indicate missing data.

Source: Nadel, 1990a; Nadel, 1990b.

PERCENTAGE SAVINGS

Information on percentage savings is useful because it provides information on the "depth" of savings achieved -- i.e. are substantial savings being achieved by each participant. For DSM programs to have a large impact on future energy and capacity needs, substantial savings per participant will be needed. Programs with high percentage savings can provide insight into ways to maximize energy savings. Programs with low percentage savings can also be important, if they have high participation rates and/or if they are complemented by additional efforts to achieve additional savings among the same participants.

<u>Definition and Calculation</u>

Energy and demand savings are usually calculated in absolute terms (e.g., kWh and kW). These absolute figures are needed for detailed analysis, but are difficult to interpret unless savings data are referenced to pre-program consumption data (savings of 1000 kWh/year are commendable for a customer using 3000 kWh/year, but are near-meaningless for a customer using 1 million kWh/year). The most common way to reference savings is to calculate savings as a percentage of the average pre-program, whole-building electricity use or demand of participating customers. In this manner, a single index can be used for all programs, regardless of customer size.

In calculating savings, it is useful to distinguish between "gross" savings and "net" savings. Gross savings measures the change in energy use among participating customers between the pre-program and post-program period. Gross savings are not necessarily due to program influences, but can instead be due to the effects of weather, prices, and other factors. Gross savings will also include savings achieved by free riders and will not include savings achieved by "free drivers" (both free riders and free drivers are discussed below). Net savings differ from gross savings in that they explicitly adjust or control for these other factors. This is most commonly done by including a control group in the analysis. The control group is similar to the group of participants, except the control group includes only nonparticipants. Since the control group is affected by the same non-program factors that affect the participant group, by subtracting control group energy savings from participant group gross savings, participant group net savings can be calculated. Since net savings identifies the savings specifically due to program influences, net savings figures should be used whenever possible.

Energy savings may be calculated based on engineering estimates, or on statistical analysis of metered energy use and demand. Engineering estimates are only as accurate as the assumptions used to calculate them. Many times, information on which to base assumptions is not available. Also, engineering estimates often do not adjust for complex interactions among systems (for example savings on lighting reduces internal heat gains, which reduces the need for air conditioning but increases the need for space heating). Furthermore, it is almost possible to calculate net savings for a program from engineering estimates. For these reasons, engineering estimates are often inaccurate.

Statistical analysis of metered data is usually more accurate, than engineering estimates, particularly if the statistical analysis employs a control group of non-participants. Depending on the statistical techniques employed and judgement calls made by the evaluator, different estimates of net savings attributable to a program may be produced (see Nadel and Ticknor, 1989 for example). Still, when competently done, statistical analysis should produce a reasonable estimate of net energy savings.

Interpretation

Percentage savings for typical programs and particularly effective programs are summarized in Table 2. In general, comprehensive programs which seek to implement all cost-effective conservation measures at a site should reduce participating customer energy use by at least 10% and sometimes 20% or more. Programs targeted only at specific measures, which do not emphasize comprehensive retrofits, usually save less than 10%. When savings are less than 10-20%, it usually means that (a) modifications to the program are warranted in order to capture additional savings, or (b) other complementary programs are needed, to capture additional savings at the same facilities.

Table 2. Percentage Savings in Typical and "Best" Programs

	Percentage Savings	
Program Type	Typical Programs	Best Programs
C&I		
Audits	4-5%	6-8%
Lighting rebate	2-3	
Lighting direct install		10
New constructn comprehensive		20-30
Multiple end-use rebate		7
Mult. end-use comprehensive	10	15-23
Residential		
Audit	3-5	
Low-cost retrofit	3-5	
Moderate-cost retrofit	2-7	
Comprehensive retrofit		10-20
New construction	10	25-40

Blank spaces indicate missing data.
Source: Nadel, 1990a; Nadel, 1990b.

FREE RIDER PROPORTION

Free riders are program participants who would have taken DSM actions anyway, even if no program were offered. Free riders are important because they contribute to program costs but do not provide any benefits. Nearly all programs have at least some free riders.[1]

Definition and Calculation

There are several types of free riders which are useful to distinguish. First, there are "total" free riders -- program participants whose actions were unaffected by the program. Second, there are "partial" free riders -- program participants who would have taken some action in the absence of the program, but took additional actions due to the program (e.g., they planned to install energy-saving lamps, but due to the program they also installed energy-saving ballasts). Third, there are "temporal" free riders -- program participants who would have taken DSM actions at some time in the future, but due to the program, they speeded up their implementation decision.

Free riders may be estimated by customer surveys, analysis of sales data relative to similar areas not eligible for a program, or statistical analysis.

Customer surveys are probably the least accurate way to measure free riders, as they suffer from a number of problems including poor recall of purchase decisions made many months ago, a tendency to try to please the interviewer, and a tendency to exaggerate one's plans to pursue socially desirable behavior (saving energy cost-effectively) in the absence of program incentives. The accuracy of customer surveys can be improved by asking questions a number of different ways, and using the different responses to establish a likely range for the proportion of free riders. This issue is discussed more extensively by Nadel (1990a). Survey data can be used to separately estimate the different types of free riders, if the appropriate questions are asked.

Sales data can be used to estimate free riders for equipment rebate programs. Data can be obtained from manufacturers and distributors comparing sales of efficient products within the program area to nearby areas not served by the program. Sales data can identify free riders for individual types of equipment (including total and partial free riders), but can not usually be used to quantify temporal free riders.

Statistical analysis offers probably the most accurate way to measure free riders. This analysis, which typically involves

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[1] It should be noted that in addition to free riders, many programs also have "free drivers" -- people who did not participate in a program, but were induced by the program to take DSM actions (e.g., program publicity, or the impact of the program on local availability of efficient equipment, sparked the DSM action). Free drivers enter into the determination of net savings (discussed above). Data explicitly quantifying free drivers is rarely collected.

analyzing conservation actions by program participants and non-participants with probabilistic models, is too complex to describe here -- Train et. al. (1985) provide a general description of the approach. Statistical analysis can identify free riders for each DSM measure, thereby identifying both total and partial free riders. Thus far, statistical analysis has not been used to identify temporal free riders.

Interpretation

The free rider proportion for DSM programs can vary from 0% to 80% or more. Approximately 30% free riders is typical for measures included in DSM programs (Nadel, 1990a; Nadel, 1990b). Lower free rider proportions can be obtained by promoting advanced equipment that currently has very low market share (this is illustrated in Table 3). However, by limiting incentives to a few products, participation rates are likely to be low for several years. Alternatively, a low free rider proportion can often be obtained by limiting incentives for rapid payback measures (e.g., one year payback or less), where free riders are likely, and increasing incentives for longer payback measures (Weedall and Gordon, 1990). Finally, limited research indicates that free riders may be lower for comprehensive direct installation programs, than for rebate programs (an example is shown in Table 3).

Table 3. Free Rider Estimates for NEES Lighting Programs

Measure	Free Rider %
Fluorescent lamps	65%
Fluorescent ballasts	20
Compact fluorescents	5
HID retrofits	10
Reflectors	17
Direct installation package	12

Source: Nadel, 1990a.

Conversely, high free rider proportions are not always bad. If costs per participant are low and/or benefits per participant are high, even programs with a large number of free riders may be cost-effective. For example, New England Electric found that the benefit-cost ratio of its C&I lighting rebate program was 2:1, even though free riders represented 60-80% of program participants (Nadel, 1988). Thus, the presence of a high free rider rate indicates that further research is needed. While utilities should seek to lower free rider proportions when possible, if efforts to limit free riders severely restrict participation, higher free rider rates may be acceptable. In order to decide whether a low or high free rider approach is best for a particular program, the relative energy savings and cost-effectiveness of the different approaches need to be compared.

INDIRECT/DIRECT COST RATIO

Definition and Calculation

Direct program costs are generally defined as monies paid to customers and contractors towards the installation of DSM measures. Indirect costs are all other program costs including funds paid for staff, marketing, consultants, etc. The indirect/direct cost ratio is simply the indirect costs divided by the direct costs -- calculated either on an annual basis, or a present-value cumulative basis. Typically, costs to plan and evaluate a specific program are included as part of indirect costs. Costs to prepare a general integrated resource plan are usually charged to the company-wide planning function and are not included in an accounting of program-specific costs. In calculating direct costs, most utilities include only the utility share of measure costs, because data on customer costs are usually not available. A few utilities include customer costs in addition to utility costs. In future years, it is likely that more and more utilities will collect customer cost data, and that calculations will be based on the sum of utility and customer costs. Further discussion of these issues can be found in Berry (1989).

Interpretation

For purposes of this section, we assume that the indirect/direct cost ratio is calculated only for utility costs, and that customer costs are not included. We use this definition because it is the approach that is most widely used today.

Typical indirect/direct cost ratios are shown in Table 4. These results indicate that typical programs will have an indirect/direct cost ratio of approximately .25-.40. Ratios will be higher during the start-up periods of programs. A few programs also report higher ratios after many years of program operation, as marketing becomes more difficult in the last years of a long-term program (Berry, 1989). High ratios are also likely (and desirable) for technical assistance and marketing programs that pay little or no financial incentives. Since financial incentives are not paid, direct costs are zero, and the indirect/direct cost ratio is infinitely large. Thus, high indirect/direct cost ratios (greater than .40) can be expected during the first 1-2 years of a program and for programs with little or no direct costs. If the ratio is greater than .40 after several years, further investigation is often warranted.

$/KWH AND $/KW

Definition and Calculation

Cost per kWh and kW provide a quick approximation of program cost-effectiveness. Calculation of these indices does not substitute for a detailed cost-benefit analysis.

Table 4. Indirect/Direct Cost Ratios for Selected Programs.

Utility/Program	Indirect/Direct Cost Ratio Year 1	Year 2	Year 3	Year 4
Central Maine Power				
Residential retrofit loans	.74	.28	.20	
Residential energy audits	.93	.57	.18	
Appliance rebates	1.84	.84		
Water heater wraps	.52	.38		
Motor rebates	1.34	.36		
Puget Power				
Comm'l insulation	7.57	1.72	.72	.35
Comm'l lighting	1.06	.51	.08	
Seattle City Light				
Home energy loan				.24
Low income electric				.35
Multifamily conservation				.25
Water heater rebate				.48
Water heater retrofit direct installation				.14
Wisconsin Electric				
Smart money (C&I)		.32		

Blank spaces indicate missing data.
Source: Berry, 1989.

Costs per kW are calculated by simply taking program costs on an annual or cumulative present value basis, and dividing by kW savings. Generally, savings are taken at the customer level, and do not include adjustments for transmission and distribution losses on the utility side of the meter, nor are utility reserve margin requirements taken into account. To be most useful, these calculations should include both direct and indirect costs. Savings should be estimated for the time of the system peak (i.e., not all lights will be on at the time of the peak, so coincident peak savings will be less than the nominal reduction in the connected lighting load). Generally only utility costs are included in these calculations, because most utilities do not collect data on customer costs. As customer cost data becomes available, it should be included in the calculations and reference values adjusted accordingly.

Costs per kWh are generally calculated on an average basis, over the life of the measures installed. This is generally done by assuming that annual program costs are financed with a loan, with an interest rate equal to the utility cost of capital (typically 6% real [net of inflation]), and a loan term equal to the average installed measure life. The average cost per kWh is the annual "loan payment" divided by the kWh savings in one year. As with costs per kW, costs per kWh should be based on both direct and indirect costs. Kwh savings should be at the customer level. To the extent data on customer costs are available, they should generally be included and figures labeled accordingly. Average measure life is not the rated engineering life of a product, but rather, the length of time the measure is likely to be installed in a facility (often equipment is removed before the end of its engineering life due to remodeling and other building changes). Estimates of installed lives for many measures can be found in Gordon et. al. (1988).

Interpretation

Costs per kW and kWh can be interpreted in two ways. First, costs can be compared to reference values based on utility avoided costs ($/kWh) and to the cost of new power plants ($/kW). Whenever utility DSM program costs are substantially less than these reference values, there is a excellent chance a program will be cost-effective from the utility perspective (only when customer costs are included in the calculations can cost-effectiveness from the total resource perspective be determined[2]). Of course, a definitive estimate of cost-effectiveness requires a full cost-benefit analysis. Such an analysis is especially needed where program costs and the reference value are similar. In particular, use of the $/kWh index does not give any credit for kW savings (and visa versa). Programs which are not cost-effective based on kW or kWh savings alone, may be cost-effective when both benefits are included. In examining costs per kW, costs for peak clipping measures should be compared to the cost of new peaking plants, while costs of baseload measures should be compared to baseload plants.

Second, costs per kW and kWh can be compared to values from other programs around the country. Some of these values are summarized in Table 5. Where program costs are significantly in excess of these values, explanations should be sought. Many times a reasonable explanation will be available. For example, the typical rebate program pays incentives equal to less than half of measure costs -- where higher incentives are paid, the cost to the utility will be higher. However, where no reasonable explanation exists, program modifications should be investigated. Where program costs are less than these values, it may indicate that "cream skimming" is taking place, meaning that low cost conservation measures are being implemented, but cost-effective measures with somewhat higher costs are being ignored.

A review of the data in Table 5 indicates that C&I programs are often less expensive per kWh than residential programs and that comprehensive programs (which involve extensive services in addition to incentives) are more expensive per kWh than simple programs. However, as shown in Tables 1 and 2, comprehensive programs generally have higher participation rates and percentage savings. Thus, comprehensive programs provide greater savings, but these extra savings come at a cost.

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[2] The different cost-effectiveness perspectives, including the utility and total resource perspectives are discussed in Krause and Eto, 1989.

Table 5. Utility Costs per kW and per kWh for Typical Programs

Program Type	Typical Utility Cost* $/kW	$/kWh
C&I		
Rebate	$250-350	$.01
Loan		.008
Performance contracting	$1090	.028
Comprehensive		.03
Residential		
Low-cost retrofit		.02-.04
Moderate-cost retrofit		.06-.08
Comprehensive retrofit		.02-.05
Compact fluorescent		.025
New construction		.02-.03

* For C&I programs, costs are median costs for programs examined in Nadel, 1990a.
Blank spaces indicate missing data.
Source: Nadel, 1990a; Nadel, 1990b.

RATIO OF MEASURED TO ESTIMATED SAVINGS

The ratio of measured savings (as determined by statistical analysis of electricity consumption data) to estimated savings (typically calculated using engineering estimates) indicates how close energy savings estimates used in program planning come to actual program results. As discussed previously, measured savings should generally be determined by comparing savings for a group of participants to a control group of nonparticipants.

Interpretation

Measured savings and estimated savings should be in fairly close agreement (within 10% of each other). Where the two figures differ substantially, either the analysis procedures used to calculate the original estimates need correcting, or the program needs to be improved, so results more closely correspond to the earlier estimates. Comparisons of measured savings and estimated savings for several programs are summarized in Table 6. At times, the discrepancy between the two figures is substantial. Often this discrepancy is explained by inadequacies in the engineering estimates. Common mistakes include failure to adjust savings estimates for use of secondary fuels (e.g., some of the savings are taken in the form of wood, not gas or electricity), failure to allow for temperature setbacks, misestimating equipment operating hours, and erroneously assuming that installed equipment will operate perfectly every time. At times the discrepancy can be explained by problems in program operations -- problems such as poor quality control in measure installation, and improper commissioning of measures.

Table 6. Measured Vs. Estimated Savings for Selected Programs.

Program	Measured as % of Estimated	Reasons for Difference
Residential Retrofit:		
CMP Pkdg WZ	36%	Use of secondary fuels
GPU RECAP	22-44%	
NU Perform. Contracting	22%	Mat'l & work quality
BPA Weatherization	53%	Secondary fuels, occupant interactions
NEES Weatherization Pilot	>100%	
Residential New Construction:		
SW Public Service	131%	
BPA Super Good Cents	<100%	Baseline getting more efficient.
C&I Retrofit:		
SCE Hardware Rebate	96%	
BPA CIPP - Sm. & Med.	36%	
BPA CIPP - Lg.	109%	
BPA Institutional	~60%	Optimistic estimates.
NEES Small C&I	~101%	Small customers saved less than expected, lg. customers saved more.
C&I New Construction:		
BPA Energy Edge	72%	QC and commissioning problems

Source: Nadel, 1990b.

DISCUSSION

The definitions and data discussed above provide a good starting point for assessing the effectiveness of programs. By using these definitions and interpretive data, utility managers and regulators can see which programs are going well, and which require further investigation.

However, the definitions and data summarized in this report still need refinement. Definitions need to be refined and standardized so that all utilities can calculate values unambiguously. A taskforce has recently been formed to develop these definitions (Hirst, 1990).

Furthermore, utilities often do not calculate and report these indices, many gaps remain in our interpretive data, and even the data we do have can benefit from further refinement. As more and more utilities report these index values for their programs, the database of interpretive data can be expected to grow quickly.

In addition to the program specific indices discussed here, it might be useful to develop indices to measure a utility's overall performance in the DSM area. Illustrative indices and examples are discussed in Geller and Nadel (1989). Additional work to refine these indices would be useful.

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