DSM Benefit-Cost Tests–The Next Generation

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Recent proposals for a "next generation" of DSM benefit-cost tests that are based on conventional economic welfare analysis have regenerated interest in the issue of appropriate measurement of DSM benefits and costs. These new tests, however, are not yet well understood by most DSM professionals. At the same time, controversy continues about which of the standard tests (e.g., Total Resource Cost or Rate Impact Measure) should be used to determine the appropriate level of utility DSM spending; and this controversy is spreading to the issue of criteria for natural gas DSM and integrated resource planning. The principal objective of this paper is to clarify areas of potential confusion about the next generation tests, and their relationship to the standard tests. A unique graphical depiction is used to provide a new perspective on the differences between the standard tests, and to illustrate that the standard tests are special cases of the more comprehensive value-based tests. A major focus of the paper is on the issue of energy efficiency market imperfections, and the degree to which those imperfections are removed at little or no cost by utility DSM programs. Suggestions are offered on reasons that such apparent imperfections may or may not exist, and on how DSM programs might be modified to lessen the need to address such issues.

Introduction

The standard DSM benefit-cost (B-C) tests (particularly the Total Resource Cost (TRC) test and its controversial counterpart, the Ratepayer Impact Measure (RIM) produce very different estimates of DSM cost effectiveness. Furthermore, each of the tests is often advocated by one group or another as the most appropriate criterion for designing and selecting DSM programs. The result is confusion and frequent disagreement over which is the "correct" test to use in utility planning. We have argued elsewhere that *all* of the standard tests are incomplete; they ignore key elements of customer value or cost—even those tests whose names suggest a comprehensive societal perspective. This is the case because none of the standard tests is fully consistent with traditional comprehensive measures of changes in economic benefits and costs. The practical importance of the choice of appropriate test has been heightened by recent utility concerns about DSM-induced price increases and competitive pressures.

Much of the confusion and controversy surrounding the issue of measuring DSM benefits and costs comes about because of the standard practice of constructing a set of different tests that are said to measure benefits and costs from different "perspectives." This leads to a number of different estimates of DSM net benefits. In practice, however, the important issue is which test the regulatory authority decides that the utility should use as a criterion for conducting DSM programs. Here most of the controversy revolves around the TRC and RIM alternatives. In this context, since the regulators are acting as representatives of consumers, it is appropriate to use a test that measures all of the benefits and costs of DSM to all consumers. Thus, we begin by first considering the properties of a correct B-C test, and then examining the sources of DSM benefits and costs that should be accounted for.

A correct B-C test for all consumers should satisfy at a minimum two key properties. First, it should be *comprehensive.* That is, it should measure *all* of the benefits and costs associated with DSM programs. Second, it should be *consistent.* That is, it should be applicable for any type of DSM program (e.g., conservation, peak reduction, load growth), and accurate under any market conditions.

Accounting for DSM Benefits and Costs–the DSM Scoreboard

To address the comprehensiveness property, consider the following critical review of the sources of the benefits and costs associated with a typical incentive-based DSM program. To do this we will employ the concept of a DSM Scoreboard, on which we will tally DSM effects on all consumers. The left side of the scoreboard tracks costs and benefits to *All Ratepayers,* while the right side tracks costs and benefits to (non-free rider) *Participants* in the program. As shown below, one advantage of this approach is its symmetry; examining the costs and benefits to each group separately leads to an understanding of the underlying sources of any potential gain in consumer net benefits from DSM.

The typical incentive-based DSM program involves the payment of a rebate from the utility to participating customers toward the purchase of an energy efficiency measure (EEM), such as a high-efficiency air conditioner or lighting fixture. When the customer uses the EEM, energy savings occur relative to the level of energy consumption that would have been expected had the EEM not been purchased. The utility recovers the costs of the program through prices charged to all ratepayers.

Standard Practice

The DSM Scoreboard in Figure 1 lists the effects that these DSM events have on benefits and costs to both participants and all ratepayers. The effects represent changes in benefits and costs that would not occur in the absence of the program. First, when the utility operates a DSM program, it incurs certain *Program costs (1),* such as the administrative costs associated with planning, designing, implementing and evaluating the program. These appear as costs to *All Ratepayers.* (Note that while several of the effects could be considered to impact the utility, we assume that any change in utility costs is allowed to be passed on to consumers—i.e., all ratepayers—through changes in energy prices. These costs also include any regulatory-authorized shareholder incentives awarded to the utility.) When the program involves payment of financial incentives, or *Rebates (2),* to consumers for adopting a certain energy efficiency measure, then that payment also represents a cost to the utility, and thus to all ratepayers. It also represents a benefit to program participants.

When non-free rider consumers accept the rebate and adopt the EEM, they incur the incremental cost of the EEM, the *Measure cost (3),* that they would have been unwilling to pay had the rebate not been offered. In return for paying the incremental cost of the EEM (with the assistance of the rebate), the participant receives the associated benefits, such as the (discounted present value of) bill savings from a lower level of energy consumption, as well as other potential changes in operating and maintenance costs. Standard practice in DSM assessments is to represent those benefits by the participants' *Bill savings (4).* As shown below, however, a critical issue in measuring DSM benefits and costs is the extent to which bill savings alone, calculated in the standard way, represents an accurate measure of participants' benefits from DSM. For that reason, this term is shown in brackets, to be replaced by two additional terms in the next section.

Finally, the energy savings that participating customers achieve as a result of adopting the EEM affect both utility costs and revenues. The utility and its ratepayers benefit from the amount of *Avoided costs (5)* that are saved due to the reduced energy consumption[1]. The reduction in sales, however, also results in a *Revenue loss (6)* relative to what the utility would have achieved in the absence of the program. We assume that any net revenue "loss" is not actually lost to the utility, but is allowed to be recovered

All Ratepayers		Participants	
Costs	Benefits	Costs	Benefits
• Program costs (1) • Rebates (2) • Revenue loss (6) • Price elasticity effect (8)	• Avoided costs (5)	• Measure costs (3)	[• Bill savings (4)] • Rebates (2) • Rebound value (7) • Perceived value of EEM (9) • Extra value of EEM (10)

Figure 1. Sources of DSM Benefits and Costs—the DSM Scoreboard

through rates, either through standard rate cases or a specific DSM cost recovery mechanism.

An important feature of the benefit and cost components in Figure 1 is that they occur in different time periods. For example, the *Measure cost* and *Rebates are* typically paid immediately, while the energy savings that generate the *Bill savings, Avoided costs,* and *Revenue loss* occur over many years. In order to conduct an assessment today of the benefits and costs of the program, the future values of those components must be discounted to the present with an appropriate discounting factor. Typical practice is to use the utility's cost of capital. However, the choice of discounting factor can have a major effect on the present value of these terms, as discussed below.

Unaccounted-for Costs and Benefits

The above list of changes in benefits and costs includes the ones most commonly associated with DSM programs. However, the list is not yet complete; it does not account for all of the possible effects of DSM programs. Two such effects result from consumers' response to price changes. One effect is the rebound, or snapback actions of participating customers. This effect may occur because the financial payment and the lower operating cost of the EEM reduce the effective price of the energy services associated with the EEM, providing an incentive for consumers to increase their consumption of that service (and correspondingly reduce the amount of energy savings). The benefits that they receive from the increased level of energy services are accounted for in the *Rebound value (7).*

Second, when utilities are allowed to recover their program costs, rebate payments, and lost net revenues through higher energy prices, then all ratepayers face an additional loss in benefits that is associated with their response to the higher price. That is, consumers' change in energy consumption in response to DSM-induced price changes implies that full recovery of the utility's costs requires a larger price increase than that normally assumed by the standard tests, which ignore such price responses. The magnitude of this *Price elasticity effect (8)* depends upon several factors, including the amount of program costs, the difference between the utility's price and avoided cost (i.e., its lost net revenue), and consumers' price responsiveness, or price elasticity. It is important to note that this effect is not simply of academic interest; it represents the very competitiveness threat that has recently been expressed about DSM-induced rate increases.

A third factor not considered in standard tests is the question of the net benefits that participants actually receive from the EEM that they are induced to purchase through the program. There are two principal sources of information on consumers' benefits from investing in additional DSM. One is market data on the cost of EEM and consumers' willingness to pay. Another is engineering-economic analysis by energy efficiency experts and utility planners. A typical DSM assessment will find that the bill savings, valued at the utility's cost of capital, exceeds the measure cost by a large margin, thus implying large net benefits to participants, even before accounting for any rebate payments. However, at the same time it is assumed that the participants would not have invested in the EEM in the absence of the program. Why? It must be the case that consumers' *Perceived value of EEM (9)* is less than the measure cost (or that their perceived value is greater than the measure cost but cannot be achieved due to a significant market barrier). We designate the amount of difference between the traditional bill savings (valued at the utility's cost of capital) and participants' perceived value as the *Extra value of EEM (10).* Consumers apparently perceive that this potential extra value cannot be achieved in the absence of the utility program. A key issue for DSM assessment is to what extent DSM programs actually generate that extra value.

Accounting for all Benefits and Costs–the Next Generation Tests

The DSM Scoreboard is now complete; it contains a comprehensive list of the changes in benefits and costs to *Participants* and *All Ratepayers* that occur as a result of a typical DSM program. Figure 2 converts the components listed in Figure 1 to a graphical representation of reasonable relative magnitudes that occur typically in practice. The values can be thought of in terms of total discounted present values of future benefits and costs (e.g., in $ million present value), or in levelized values (e.g., cents per kWh or kWh-saved). This DSM scoreboard represents a graphical depiction of the formal next generation of DSM B-C tests that have been labeled the Net Economic Benefit (NEB) measure (Braithwait and Caves 1994), and the Value test (Herman and Chamberlin 1992).

Implicit in the relative magnitudes of the boxes in Figure 2 are a few key assumptions that are common for many programs and utilities today. First, *Revenue loss is* shown exceeding *Avoided costs,* which in turn exceeds *Measure cost.* This implies that the utility's price exceeds its marginal cost (MC), and that the cost of the EEM is less than the electricity that it replaces. Second, participants' *Perceived value of EEM* is less than the *Measure cost;* otherwise they would have purchased it even without the program. However, there is a possibility that they can achieve additional benefits by accepting the rebate and acquiring the EEM. This potential is reflected in the question mark in the box for *Extra value of EEM,* defined

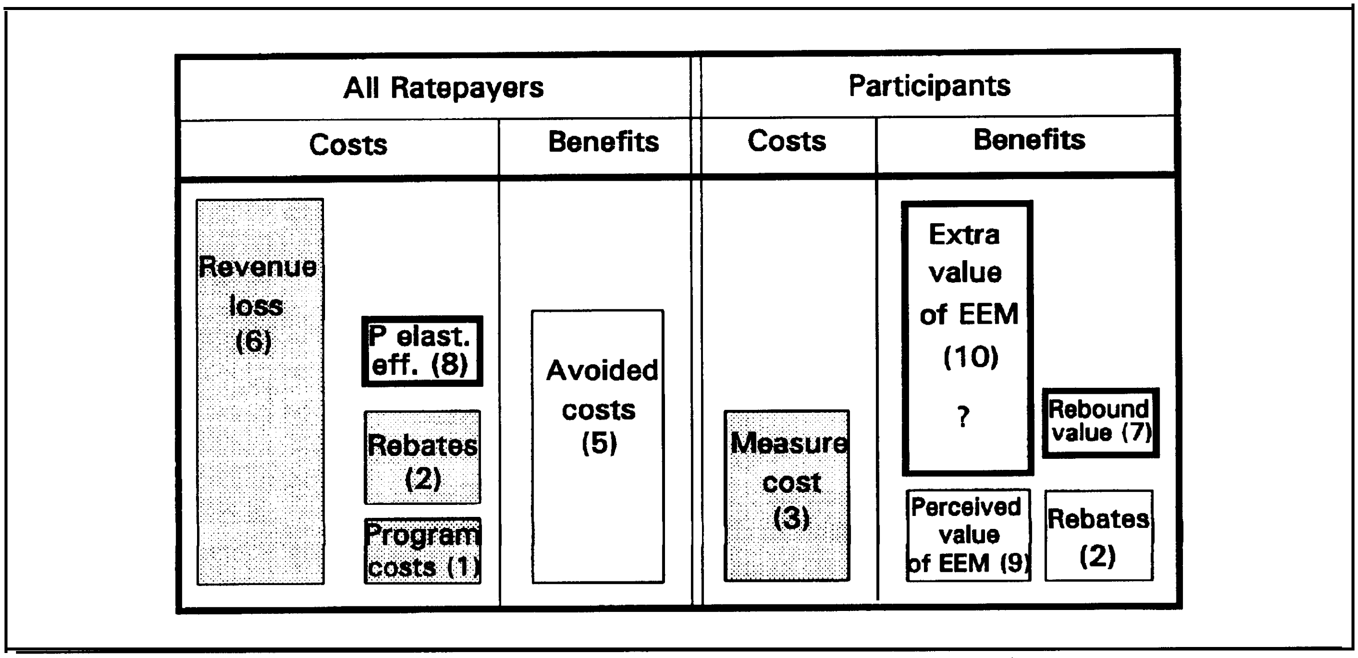

Figure 2. Measuring all DSM Benefits and Costs: the Next Generation Tests

as the difference between *Bill savings* valued at the utility's cost of capital and participants' *Perceived value of EEM.*

Standard DSM Benefit-Cost Tests—a New Perspective

Now consider how the two most common standard practice tests, the TRC and RIM, compare to the comprehensive DSM Scoreboard.

TRC Scoreboard

Figures 3 and 4 characterize two versions of the TRC test, a *Complete* version, and a *Standard* version respectively. The *Complele* version reflects the definition of the TRC test as the sum of the Participant and All Ratepayers, or RIM tests. That is, participants incur the cost of the EEM, and receive benefits in the form of bill savings and the rebate payment. The utility and its ratepayers incur the cost of the program, including rebate payments, forego the revenue from the reduced energy consumption, and in turn receive benefits in the form of avoiding the cost of supplying the conserved energy. Note that two sets of values in the complete version of the TRC appear on both the benefit and cost sides of the ledger (see dashed-line boxes). The rebate payment appears as a cost to all ratepayers and a benefit to participants, and the revenue loss to all ratepayers is offset by the bill savings to participants. These two sets of terms can be considered to cancel, yielding the *Standard* version of the TRC test in Figure 4. This version of the TRC seems to be the one most widely used by DSM practitioners.

Note three important differences between the complete version of the TRC test and the DSM Scoreboard in Figure 2:

1. TRC does not account for the rebound effect,
2. TRC does not account for the price elasticity effect, and
3. TRC assumes that participants receive value from the EEM equal to the bill savings valued at the utility's cost of capital.

Also note that the standard version of the TRC holds only if the values of the indicated terms are indeed equal and can be canceled. We examine this assumption below.

RIM Scoreboard

Now consider the RIM scoreboard, whose *Complete* and *Standard* versions are shown in Figures 5 and 6. The *Complete* version of RIM is not a familiar concept in standard DSM B-C analysis, although it is implicit in much of the discussion of the pros and cons of the RIM test. The key assumption underlying the complete RIM is that the value that participants receive from additional EEM is equal to their willingness to pay for it. In Figure 5, their perceived value is shown just equal to the net cost of the EEM *after* the rebate payment. This interpretation is consistent with the suggestion by proponents

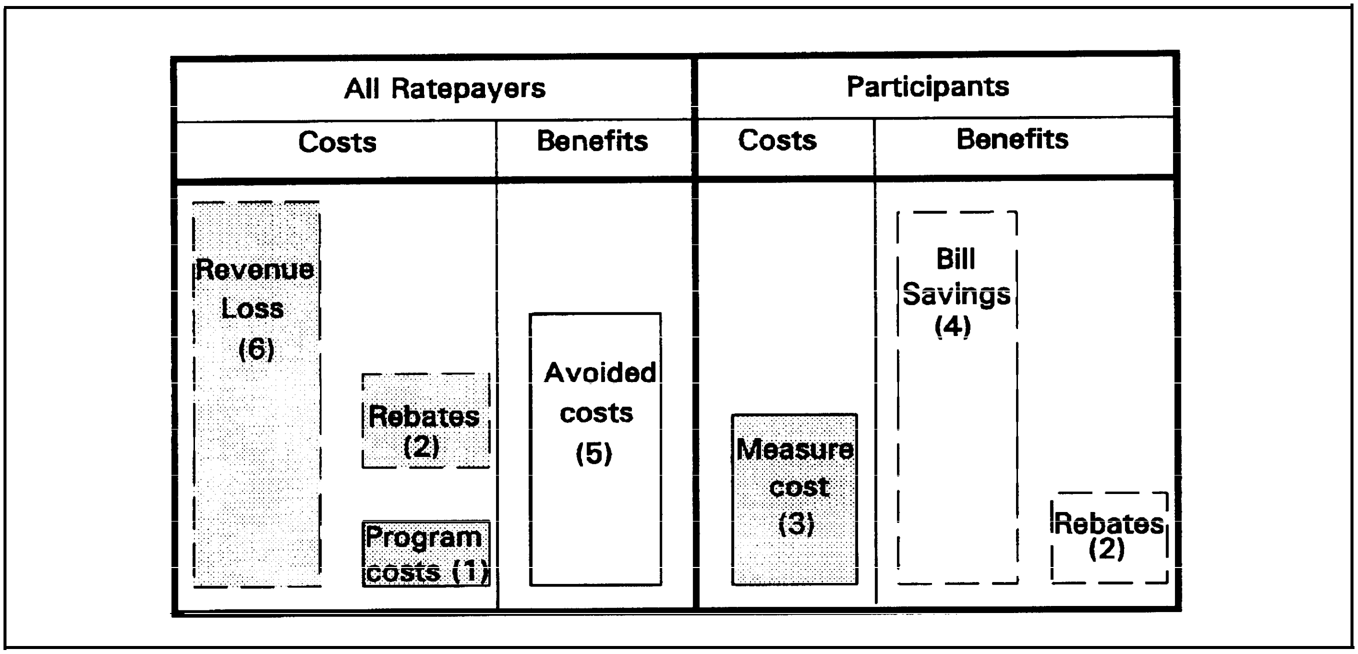

Figure 3. *Complete* TRC

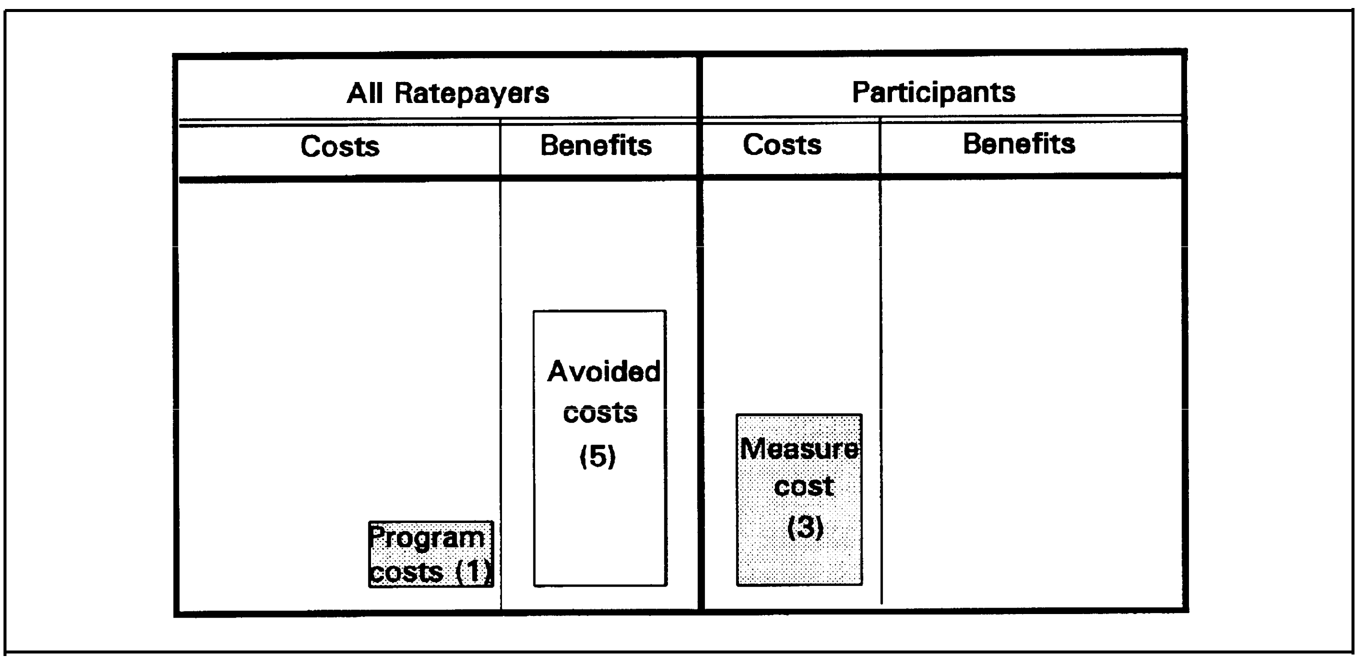

Figure 4. *Standard* TRC

of the RIM test, including a number of large industrial customers, that consumers themselves are in the best position to evaluate the benefits of energy efficiency measures, that they do so rationally, and that utility rebate payments serve only to reduce the cost of EEMs down to consumers' actual value of EEM.

Under these assumptions, the benefits and costs of EEM to participants just offset each other, leaving only the benefit and cost components for All Ratepayers, as shown in the *Standard* version of RIM in Figure 6. Referring back to the complete RIM, we again see three key differences compared to the DSM Scoreboard in Figure 2:

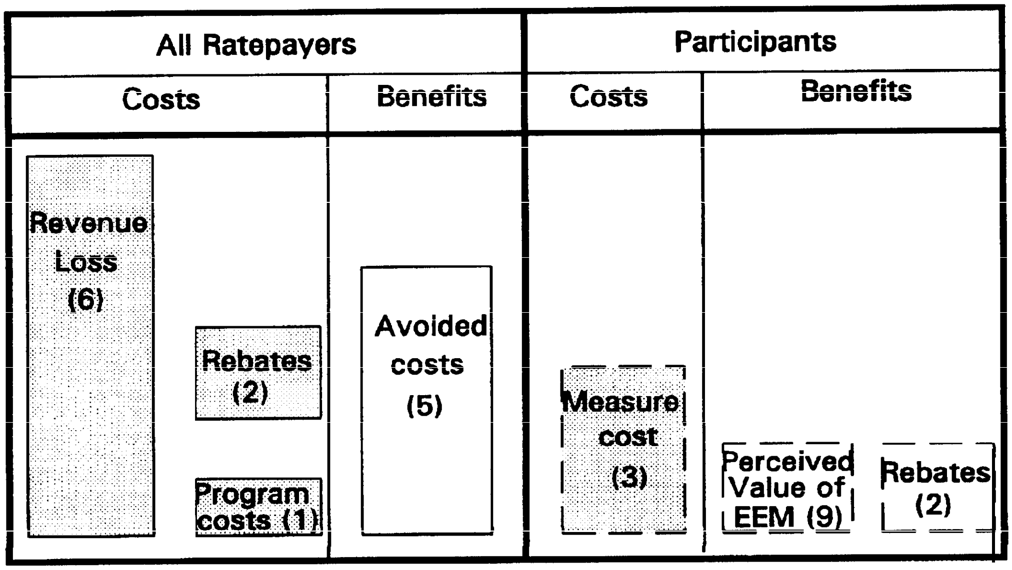

Figure 5. *Complete* RIM

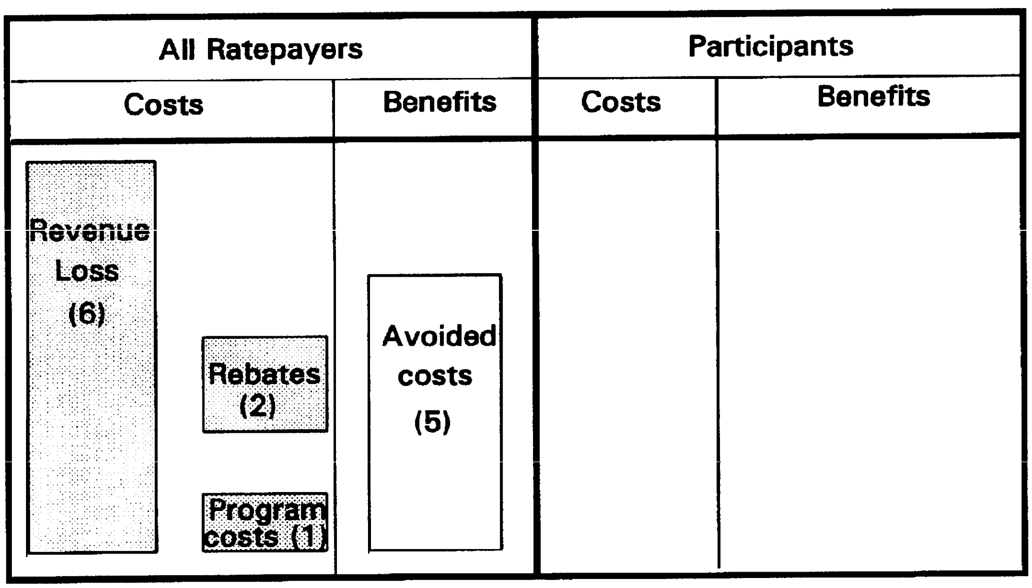

Figure 6. *Standard* RIM

1. RIM does not account for the rebound effect,
2. RIM does not account for the price elasticity effect, and
3. RIM assumes that participants receive value from the EEM equal only to the amount of the measure cost less the rebate payment.

Differences Between the TRC and RIM

Comparing Figures 3 through 6 provides new insights into the long-running controversy and confusion surrounding the TRC and RIM tests. First, comparing the standard versions of the tests reveals the reason for the common belief that the two tests measure completely different sets of benefits and costs; the components of the *standard* versions are quite different. The typical conclusions about program cost effectiveness are also quite different. Using the standard versions, for example, the TRC benefits exceed the costs, indicating that the program is cost effective, while the RIM benefits fall short of the costs, suggesting the opposite conclusion.

An unstated assumption of the usual interpretation of the difference between test results is that the two tests are based on the same set of conditions and assumptions, but simply reflect different perspectives from which to measure DSM benefits and costs. However, comparing the *complete* versions of the tests reveals a much different interpretation; each benefit and cost component of the two tests is identical, save for one—the value that participants receive from the EEM acquired through the program. The TRC test attributes to participants the amount of expected bill savings, typically valued at the utility's cost of capital. In contrast, RIM assigns an amount equal to participants' willingness to pay, implying that they receive benefits no larger than the amount paid for the EEM after the rebate.

This interpretation of the difference between the tests differs strikingly from the conventional characterization that the two tests involve very different formulas, and that RIM focuses on rate impacts and TRC on overall resource costs. The conclusion to be drawn from the complete versions is the following:

> *The TRC and RIM tests are based on the same general benefit-cost framework; the only difference between them is the assumption made about the value, or benefits received by participants from the energy efficiency measure adopted.*

This conclusion has a number of implications. First, it reveals that the principal disagreement over which is the appropriate test for DSM cost effectiveness is not over alternative formulas, but instead over alternative market assumptions. Second, the principal reason that programs pass the TRC but fail the RIM is the large benefits relative to costs that are presumed by the TRC to be achieved by participants. This large difference between participant benefits and costs implies the existence of market imperfections that prevent consumers from adopting the measures outside of the program, but are overcome at little cost by the program (i.e., the extra value of EEM greatly exceeds the utility's program costs). Finally, the alternative assumptions that underlie the TRC and RIM tests *cannot both be correct.* If the RIM assumption about participants' value of EEM is correct, then the TRC test overstates the benefits of the program. If the TRC assumption of large benefits relative to costs that can be acquired by participants through the program is correct, then RIM understates those benefits. These alternative assumptions are also not merely of academic interest; for large programs, the difference can mean a swing from tens of millions of dollars of positive net benefits, to tens or hundreds of millions of dollars of economic losses (i.e., higher, rather than lower overall costs).

Differences Between the Standard and Next Generation Tests

One useful property of the DSM Scoreboard and of the complete versions of the TRC and RIM is their symmetry; the sources of benefits and costs for each group of consumers is easily identified. For example, examining the All Ratepayers portion of the scoreboard indicates that net benefit gains are available whenever *Avoided costs* (i.e., marginal cost) differ from *revenue loss* (i.e., price). Thus, load *reductions can* generate net benefit gains when MC > Price, and load *increases can* generate net benefit gains when MC < Price. Under the conditions shown, DSM-induced load reductions create economic losses.

Examining the Participant portion of the scoreboard, net benefit gains are available only when DSM programs can be shown to overcome market imperfections and thus generate extra benefits over and above those indicated by market-based evidence of consumers' willingness to pay for energy efficiency. A major conclusion from the overall scoreboard is that under typical conditions facing utilities today, energy efficiency programs are properly seen as a consumer resource that benefits primarily program participants.

Comparing the next generation DSM scoreboard and the standard tests has shown that the standard tests have three principal shortcomings. In particular, TRC and RIM do not account for the rebound effect, nor the price elasticity effect, and TRC and RIM assume different and polar extreme values for the value of EEM to participants. The first two are clear omissions. The important question for those effects is how large they are likely to be in practice. Most studies of rebound effects have concluded that such effects are relatively small. For purposes of this paper we will accept that conclusion and not consider rebound effects further. The potential size of the price elasticity effect has been examined previously (see Braithwait and Caves 1994, and Herman 1994); typical magnitudes have ranged from 8 to 15% of the amount of All Ratepayer, or RIM net benefits.

That leaves the issue of the value of EEM to participants. Here the question is not one of omission, but of accurate measurement of the benefits that participants receive from EEMs acquired through DSM programs. The reason that this is important can be seen by examining a typical Participant or complete TRC test result, in which the discounted present value of bill savings greatly exceeds the measure cost, even before the rebate payment. This is usually taken to imply that the measure is highly beneficial to potential participants. However, it is important to remember that non-free rider participants are assumed to be unwilling to adopt the measure without the program even given the large apparent net benefits. A discounted present value of bill savings that greatly exceeds the measure cost implies one of three things must be true: (1) consumers are irrational, making highly uneconomic decisions, (2) a host of market imperfections prevent consumers from obtaining the large extra benefits without the program, but they can be obtained through the program; or (3) the estimates of measure cost and/or bill savings are inaccurate, and the actual values are much closer together. Let us set aside the first possible reason. For space reasons we will also not discuss the issue of market imperfections directly. Instead, we will focus on possible reasons that the difference between bill savings and measure cost may be estimated inaccurately.

Market Imperfections – Key Factors

In order to examine this issue carefully, let us review how the benefits and costs of EEM to participants are typically estimated for purposes of the participant component of the complete TRC test. The measure cost represents in principle the incremental cost of acquiring the EEM. This includes any incremental purchase and installation cost relative to the version that would have been purchased otherwise, any additional costs due to disrupting operations for installing and maintaining the device over time, search costs for researching the device, and any risk associated with an unfamiliar technology. Some of these costs are difficult to measure, and often not considered in DSM assessments. The benefits of EEM that are typically counted are the bill savings resulting from the anticipated energy savings and the rebate from the utility. Most of the costs are typically presumed to occur in the first year, except for any assumed changes in maintenance costs over time. The bill savings, however, take place over the presumed life of the measure. The usual approach is to calculate the discounted present value (DPV) of the future benefits and costs using the utility's cost of capital as the discount factor.

Three key factors combine to determine the DPV of, for example, bill savings—the annual energy savings, the measure life, or number of years for which energy savings are assumed to occur, and the discounting factor. Changes in any one of these factors can dramatically affect the DPV of the bill savings. Consider some of the possible reasons that the DPV of bill savings may be found inaccurately to exceed the measure cost by a wide margin.

First, some relevant measure costs may be understated. Second, the energy savings may be overstated. This has proven to be the case frequently throughout the history of utility conservation and DSM programs. Third, the effective economic life of the measure, as perceived by consumers, may fall considerably short of the potential physical lifetime typically used in DSM assessments. This issue is being addressed in numerous recent studies of the persistence of DSM measures. Fourth, most DSM assessments use as a discount factor the utility's cost of capital. At the same time, numerous studies have indicated that most consumers, including commercial and industrial customers, typically require a higher rate of return in their investment decision making. Finally, bill savings themselves are an overly narrow measure of the benefits of EEMs. After all, consumers are interested in all of their costs, not just those for energy, and many EEMs may have effects on labor, material, and other operational costs, including costs associated with the risk of new technologies that affect consumers' assessment of the value of such measures, There is an important reason that the actual values of many of these factors may be miss-estimated by utility planners. That is that information on the value of EEM to consumers is best known only to themselves, and is very difficult to determine by utility planners due to the considerable diversity among consumers.

It is also important to note that DSM assessments are typically conducted in the context of long-term (e.g., 20-year) integrated resource plans. However, as utilities increasingly face a more competitive environment, their planning horizon will naturally be shortened, leading them to discount more heavily those benefits to be received in the distant future.

Implications of Next Generation Tests

The implications of the proposed next generation of DSM tests can be viewed at several levels. First, the proposed next generation tests correct existing biases in the standard TRC and RIM tests, as illustrated by comparing the comprehensive DSM Scoreboard to the complete versions of the TRC and RIM tests. Second, the next generation tests are applicable to any type of DSM program, including conservation, load management and load growth, thus providing a consistent evaluation tool. Third, even if not adopted formally, the next generation tests suggest that the *complete,* rather than standard version of the TRC test should be used in DSM assessments, and that DSM planners be required to justify explicitly any large difference between the benefits and costs of a program to non-free rider participants. Fourth, regarding additional data requirements if the next generation tests were adopted, it is clear from comparing the complete versions of the tests that much of the required data are already available from the standard tests. Others, such as the price elasticities needed to calculate the unaccounted-for price elasticity effect should be available from load forecast studies. However, the major issue of market imperfections suggests the need for utilities to develop a better understanding of customer value.

Most important, however, the new insights into the nature of standard DSM tests suggest new ways of thinking about traditional DSM programs. For example, the largest contributor to the cost of DSM programs is often the rebate payments made to participants. At the same time, the same condition that is required for programs to produce positive net benefits under today's typical conditions is that participants receive large extra benefits from programs overcoming market imperfections. This suggests an obvious strategy for minimizing program costs. That is, utilities should begin examining mechanisms designed to recover DSM program costs primarily from the benefiting participants. To the extent that EEM market imperfections exist and utilities are successful in overcoming them, then cost recovery from participants may be possible, and they will receive the resulting benefits of net reductions in their overall costs. Such a process would require innovative energy service offerings and financial arrangements but would have the positive outcomes of recovering costs directly from those who benefit, and avoiding excessive DSM costs.

Furthermore, such "shared savings" programs would subject DSM programs to a *market* test of their cost-effectiveness, rather than a *regulatory* test as is the current standard practice. This would provide additional benefits, such as requiring less expenditures on costly program evaluations to justify the prudency of program expenditures.

Endnote

1. The reduction in energy consumption may also result in avoiding certain additional environmental externality costs associated with the generation and distribution of electricity. Those could be added to the avoided cost component. However, since the primary objective of this paper is to make a conceptual point, and since externality costs are often not considered explicitly in DSM assessments, the discussion will focus on avoided private costs.

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