A COMPREHENSIVE COST-EFFECTIVENESS METHODOLOGY FOR INTEGRATED LEAST-COST PLANNING

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The essential element of an integrated planning process is a simultaneous (side-by-side) cost-effectiveness evaluation of supply- and demand-side resources. The selection of a cost-effectiveness test directly impacts the mix of resources selected for a utility's resource plan. Hence, the choice of cost-effectiveness criteria has been a contentious issue among utilities, regulators and conservation advocates, each defending different perspectives for evaluation.

This paper suggests that most programs which pass a Total Resource Cost test can be designed to pass both the Participant and Ratepayer Impact Measure tests. Two considerations are necessary to achieve this result. First, a comprehensive evaluation of program costs and benefits must be performed including analyses of indirect participant costs and of the value created by utility sponsorship. Second, the analysis must recognize, and the program design may even exploit, the difference between utility and customer discount rates. Utilities may be able to recover much of their "lost revenues" by designing programs to market the value created by utility sponsorship or to take advantage of the discount rate gap.

The paper proposes a two-step cost-effectiveness evaluation that reconciles the various perspectives into a comprehensive cost-effectiveness methodology for integrated planning and program design. The first step focuses on integrated planning and resource selection using the Total Resource Cost test. The second step focuses on designing the selected programs to pass both the Participant and the Ratepayer Impact Measure tests. This methodology has the benefit of providing a single clear test for program selection, making it easier for stakeholders to understand why programs were selected or rejected. At the same time, clear and consistent criteria are provided for program designers.

INTRODUCTION

The essential element of an integrated planning process is a simultaneous (side-by-side) cost-effectiveness evaluation of supply- and demand-side resources. The selection of a cost-effectiveness test directly impacts the mix of resources selected for a utility's resource plan. Hence, the choice of cost-effectiveness criteria has been a contentious issue between utilities, regulators and conservation advocates, each promoting a different perspective for evaluation. (EPRI 1988) This paper shows that it is possible to reconcile the various perspectives into a comprehensive cost-effectiveness methodology for integrated planning.

DEMAND-SIDE COST-EFFECTIVENESS TESTS

Side-by-side evaluation of supply- and demand-side resources requires a common cost-effectiveness criterion that can be used for both. There is little controversy over the choice of a supply-side criterion. However, the selection of a demand-side criterion has been hotly debated. This section summarizes the most commonly used demand-side cost-effectiveness tests. The next section considers their applicability to supply-side resources.

Four tests that are widely used nationally for evaluating the cost-effectiveness of demand-side management (DSM) resources are the Total Resource Cost (TRC) test, the Ratepayer Impact Measure (RIM) test, the Utility Cost (UC) test, and the Participant test, in the terminology of the California Joint Standard Practice Manual. (California Public Utilities Commission and California Energy Commission 1987; Woychik 1988) These tests represent the perspectives of society, non-participating ratepayers, the utility, and program participants, respectively.

Each test has cost and benefit components. A test may be expressed either as the net value of benefits less costs or as a benefit-cost ratio. In this paper, the abbreviations of the tests' names are used to indicate net benefits. Table 1 summarizes the basic cost and benefit components for each of the four tests.

Utility Cost Test

The Utility Cost (UC) test is the most basic of the four tests. It assumes that the utility's objective is to minimize revenue requirements. If a DSM program passes this test, then the utility's total revenue requirements will be lower with the program than without it.

The cost components of the UC test include the utility's program administration or Overhead Cost (OC), any Incentive (I) or rebate the utility transfers to the participants and any direct expenditure by the Utility to purchase conservation equipment or Hardware (UH). The benefits side of this test consists of the utility's Avoided Cost (AC).[1] The formula for the test is:

$$UC = AC - OC - I - UH \quad (1)$$

Total Resource Cost Test

The Total Resource Cost (TRC) test takes a broader perspective than the UC test. This test recognizes that customers do not purchase electricity as a distinct consumer good. Rather, they purchase electricity to fulfill their needs for energy services such as heating, lighting and cooking. (Sant et al. 1984) This test evaluates the impact of DSM programs on the total customer bill for energy services, including both participants and non-participants.[2]

The cost side of the TRC test includes the utility's Overhead program administration Cost (OC) as well as the Total Hardware (TH) cost of buying the actual conservation measures, regardless of who pays this cost. Transfer payments, such as any incentive or rebate, from the utility to the participant are not included because their net effect on participants and non-participants is zero. The benefits side of the TRC test consists of the utility's Avoided Cost (AC).[3] The formula is:

$$TRC = AC - OC - TH \quad (2)$$

Ratepayer Impact Measure Test

The Ratepayer Impact Measure (RIM) test is designed to measure the impact of a DSM program on the utility's rates. Since a utility's rates are equal to its revenue requirements divided by the number of kWh sold, minimizing the utility's revenue requirements is not necessarily the same as

[1] *Avoided cost is defined as the cost the utility would have incurred to generate electricity from new or existing resources if the DSM measures had not been installed. Avoided cost generally includes avoided energy, outage (or capacity), transmission and distribution costs. Some utilities also include an externalities component on the benefits side of the equation which values the air pollution, other environmental impacts or other externalities avoided when conservation is pursued. (Cavanagh 1988)*

[2] *Some authors take an even broader view of the societally oriented cost-effectiveness test. Hobbs and Nelson (1989) argue that utilities should seek to maximize the value customers assign to energy services, rather than minimizing the cost of providing the services. However, the least-cost approach is used in this paper.*

[3] *Some utilities also include an externalities component on the benefits side of the equation.*

Table 1. Components of the Basic Cost-Effectiveness Tests

	Utility (UC)	Participant (P)	Non-Participant (RIM)	Society (TRC)
Avoided Cost	+		+	+
Utility Hardware	–		–	–
Participant Hardware		–		–
Overhead	–		–	–
Incentive	–	+	–	
Lost Revenue		+	–	

minimizing rates. DSM programs reduce both the utility's revenue requirements and the number of kWh sold. Hence, it is possible for the utility's rates to increase even though revenue requirements decrease. This test is often thought of as the non-participating ratepayer's point of view. The participating ratepayer benefits from the DSM program, resulting in a reduction in his total utility bill. However, the non-participating ratepayer sees only the increase in rates, and therefore pays a higher bill. Failure to pass the RIM test indicates that non-participants are funding a portion of the DSM program benefits gained by participants. (Costello 1987; Ruff 1988)

The cost components of the RIM test are the utility's Overhead Cost (OC), any Incentive (I) or rebate the utility transfers to the participant, any direct expenditure by the Utility to purchase the conservation equipment or Hardware (UH) and the utility's Lost Revenue (LR). Lost revenue is defined as the amount of revenue the utility loses due to the reduction in kWh sold to the customers who install conservation measures. It is equal to the amount the conservation participants save on their utility bills. Of course, in the long run these revenues aren't actually lost to the utility.[4] They are still part of revenue requirements. But since the conservation participants avoid paying them, the non-participating ratepayers will pick up the extra cost in higher rates. The utility's Avoided Cost (AC) constitutes the benefits side of the equation.[5] The formula is:

$$\text{RIM} = \text{AC} - \text{OC} - \text{I} - \text{UH} - \text{LR} \qquad (3)$$

Participant Test

The Participant test views the question of cost-effectiveness from the participants' perspective, rather than the utility's perspective. The TRC, RIM and UC tests all attempt to define least-cost planning from the perspective of the utility and all its customers. The Participant test does not attempt to define least-cost planning. Instead, it seeks to determine whether the utility has provided adequate motivation for any of its customers to participate in the DSM programs.

The Participant test includes any Incentive (I) or rebate provided by the utility and the participants' bill savings on the benefit side of the equation. The participants' bill savings are identical to the utility's Lost Revenue (LR). The cost is the Participant's cost of purchasing the Hardware (PH), or other expenditures necessary to participate. The formula is:

$$\text{P} = \text{I} + \text{LR} - \text{PH} \qquad (4)$$

SUPPLY-SIDE COST-EFFECTIVENESS

Integrated planning requires a side-by-side evaluation of demand- and supply-side resources. Hence, the cost-effectiveness criterion selected to

[4] *In the short run, some revenues may actually be lost to the utility if there is no mechanism to adjust base rates to compensate for differences between actual and forecasted kWh sales.*

[5] *If externalities are included in the benefits calculation for the Utility or TRC tests, they should also be included in this test. As a consequence, the RIM test addresses the willingness of customers to pay for a cleaner environment by allowing externalities to offset rate increases from DSM programs. The RIM test can then no longer be characterized as the "hardly any winners" test. (Lovins 1985)*

analyze DSM programs should be conceptually similar to the supply-side criterion. Three of the four tests discussed above essentially collapse to one test when applied to utility-owned or purchased supply-side resources.[6]

$$SS = AC - OC - TH \quad (5)$$

The TRC and UC tests become identical because none of the utility's customers contributes directly to new power plants. Hence, there are no incentive payments paid to any "participants" and the utility pays all of the hardware cost of acquiring the new resource.

The RIM test also collapses to the SS test. Because new generation projects do not change the amount of kWh sold by the utility, there are no "lost revenues". In supply-side planning, minimizing revenue requirements automatically minimizes rates.

The participant test has no supply-side analog.

Although the UC, TRC, and RIM tests seem to be equivalent for supply-side resources, several conceptual dissimilarities have been noted. A conceptual weakness of the UC test is illustrated by the following hypothetical situations in which customers contribute directly to the cost of constructing a new power plant. In one case, assume that a $5 surcharge specifically to purchase land for a new power plant could be billed separately to all new utility customers who are responsible for creating the need for a new power plant. In another case, suppose that a local citizens group decided to donate $100,000 in land to the construction of a new power plant in order that it might be sited in a location which is considered favorable. The utility would still include the cost of the land in its cost-effectiveness evaluations when deciding whether to construct the project. Although this cost is not paid directly in rates by all the utility's customers, it is still a cost. This analogy shows that the UC test cannot be considered conceptually equivalent to the supply-side test for cost-effectiveness because it excludes some of the costs of the DSM resources--those costs paid directly by customers.

The TRC test does include all the direct costs of purchasing the DSM resources, regardless of who pays them. Hence, it is conceptually similar to the supply-side criterion in accounting for the total cost of the resources. In addition, it also provides a more stringent test of cost-effectiveness for DSM programs because the utility will generally pay (in incentive payments and direct hardware cost) less than the total direct cost of the DSM measures.[7] For this reason, the UC test is redundant if the TRC test is utilized in the cost-effectiveness analysis.

A similar argument can be made that the RIM test, like the UC test, excludes direct customer costs of DSM measures. However, the RIM test does include the customers' bill savings and the incentive payments received from the utility; and customers' will not pursue conservation measures that cost more than the sum of their bill savings and incentive payments. Hence, the RIM test indirectly accounts for all direct customer costs of DSM measures.

A second issue concerning the RIM test is the idea that it is a test of distributional equity between participants and non-participants, whereas the supply-side criterion is a test of overall societal efficiency. A hypothetical supply-side analog to the RIM test could be created by identifying "participants" as those responsible for creating new load and "non-participants" as existing customer load. This requires the additional hypothesis that new generation is required only for the purpose of meeting demand growth (and not for other purposes which benefit all customers, such as replacing retired generation) and that it is administratively feasible to distinguish the new load from the existing load. This would be a supply-side test of distributional equity, just as the RIM test is a demand-side test of distributional equity. The

[6] *The tests will remain distinct if the utility is evaluating a bypass project.*

[7] *Incentive payments plus any hardware cost the utility pays directly should not be higher than the total cost of acquiring the DSM resource. When this problem does occur, it can be attributed to an error in the way the cost-effectiveness analysis is often performed and it should be corrected. This problem, and the solution, are discussed below.*

supply-side version of the test would test whether the "participants" were paying the full cost of the new resource, just as RIM tests whether the DSM participants are covering the cost of providing the DSM resource.

This discussion shows that the RIM test is conceptually dissimilar to the basic supply-side test of cost-effectiveness, but possesses a hypothetical supply-side analog. However, because the above hypotheses are rarely satisfied, the supply-side analog has little practical value. In addition, the idea that all customers should share the cost of meeting new load growth is well-established in regulatory practice, whereas many parties dispute the contention that all customers should share the cost of conservation measures which clearly benefit a subset of customers. Many utilities and others consider it important to avoid increasing non-participants' bills to finance participants' conservation. Hence, while the RIM test may be conceptually distinct from the supply-side test of cost-effectiveness, it provides unique information about the distributional impact of pursuing DSM and is an important element in a complete analysis of DSM cost-effectiveness.

Although the Participant test has no supply-side analog, it provides unique and essential information to the DSM planner, since it indicates whether a customer will participate at a given level of utility incentives.

ADDITIVITY OF COST-EFFECTIVENESS TESTS

The last section focused on the conceptual distinctions between the four DSM cost-effectiveness tests and the supply-side test. This section further develops the inter-relationships between the various tests. The four DSM cost-effectiveness tests are:

$$UC = AC - OC - I - UH \quad (6)$$

$$TRC = AC - OC - TH \quad (7)$$

$$RIM = AC - OC - I - UH - LR \quad (8)$$

$$P = I + LR - PH \quad (9)$$

Clearly, a program that passes the RIM test passes the UC test as well, since Lost Revenue is non-negative. As indicated above, the UC test is also less stringent than the TRC test. Hence, the UC test can be disregarded if either the TRC or RIM tests are used in a comprehensive analysis of DSM programs. Further, the sum of the Participant and RIM tests is the TRC test, year-by-year and also on a present worth basis if the same discount rate is used in all three tests:

$$TRC = RIM + P \quad (10)$$

Consequently, any conservation program which passes the TRC test can also be designed to pass the Participant and RIM tests. In other words, if the TRC benefits are greater than the TRC costs, then there are enough savings from the program to make both the participants and the non-participants at least neutral. The only difficulty lies in dividing the savings properly to achieve this Pareto optimum. Figure 1 illustrates this additivity property, with the further simplifying assumptions that overhead is zero and that participants pay the entire hardware cost.

These assumptions enable us to represent a specific DSM program by two numbers--the hardware cost and the incentive. In Figure 1, hardware cost is plotted on the horizontal axis and incentive is plotted on the vertical axis. Hence, given the above assumptions, a DSM program can be represented by a single point in Figure 1. The essential insights of Figure 1 remain valid when these assumptions are relaxed.

Each test is represented as a constraint, indicating the combinations of hardware cost and incentive for which the net present value of the test is zero. Any program with hardware cost less than avoided cost passes the TRC test. Hence, any program to the left of the TRC constraint passes TRC test. Any program to the right fails because the hardware cost is higher than the utility's avoided cost. The TRC constraint is a vertical line because incentive is not included in the TRC test.

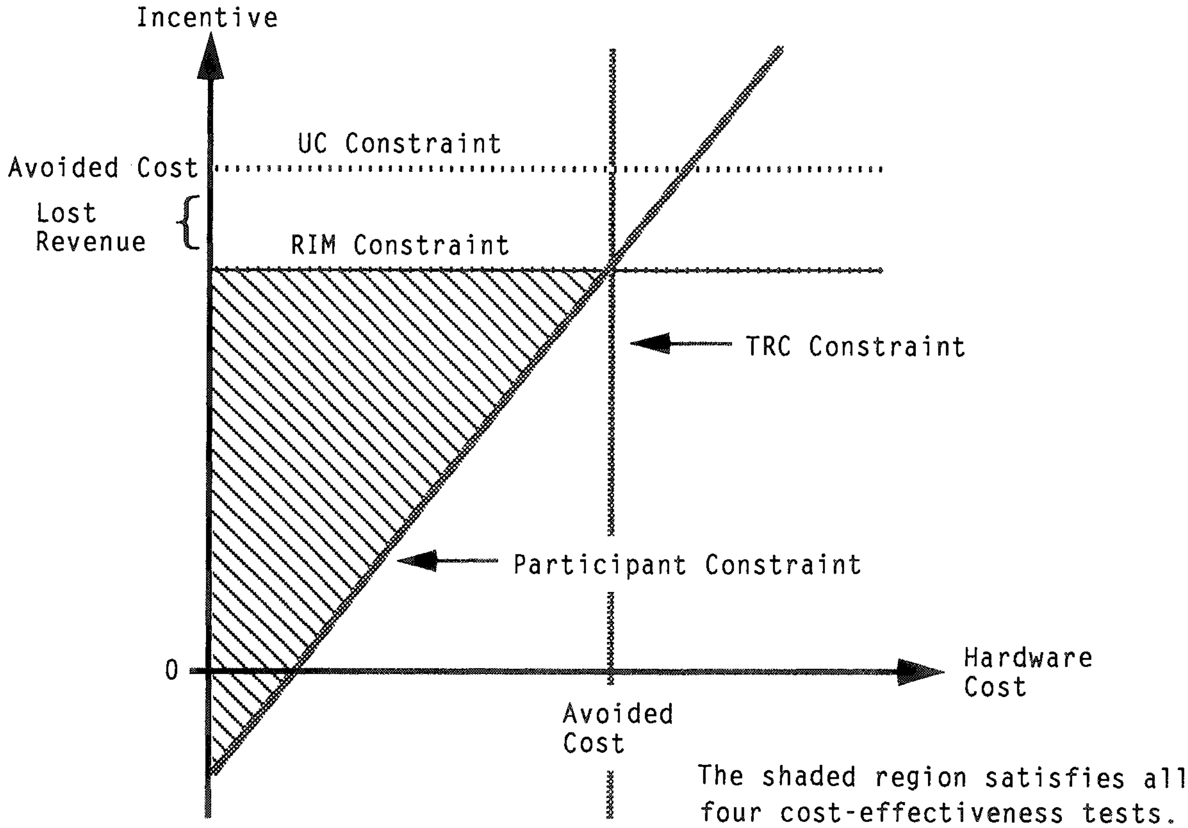

Figure 1. Relationship Between the Cost-Effectiveness Tests

Any program below the UC constraint passes the UC test because the incentive is less than avoided cost. Similarly, any program below the RIM constraint passes the RIM test because the incentive plus the utility's lost revenue is less than avoided cost. Both of these constraints are horizontal lines because hardware cost is not included in these tests. Figure 1 makes it apparent that the UC test is redundant if the RIM test is to be used. Any program which falls below the RIM constraint line necessarily falls below the UC constraint line, given that lost revenue is greater than zero.

The Participant constraint line is diagonal because both incentive and hardware cost are included in the Participant test. The diagonal line represents the combinations of incentive and hardware cost which keep the participant neutral, given the amount of money the participant will save on his utility bill. Any program above and to the left of the Participant constraint passes the Participant test. Any program below and to the right fails because the sum of the incentive and lost revenue (which is a benefit to the participant) is inadequate to cover the hardware cost. The Participant constraint drops below the horizontal axis because, if a conservation measure has low enough hardware cost and high enough bill savings, the participant would still be better off with the conservation than without even if a negative incentive could be imposed on him.

At the point where the RIM, TRC, and Participant constraints intersect, the three tests are zero. Any point within the shaded region passes all three tests, and the UC test as well.

Cicchetti and Hogan (1989) and Joskow (1990) argue that the RIM constraint is necessary for societal efficiency by showing that there can be programs that satisfy both the UC and Participant constraints, but not the TRC constraint--programs within the unshaded triangle bounded by the UC and Participant constraints and to the right of the TRC constraint in Figure 1. Cicchetti and Hogan are concerned that, in the context of a bidding system, the TRC test will not be used, and therefore the RIM test must be used to guarantee that all of the selected programs are societally efficient. However, it is more straightforward in least-cost planning to use the TRC test directly to test for societal efficiency.

In addition, Figure 1 shows that there are programs that are societally efficient and satisfy the UC constraint, but do not satisfy the RIM constraint--programs within the rectangle bounded by the vertical axis and the RIM, UC, and TRC constraints. Therefore, the policy decision to enforce the RIM constraint remains fundamentally an equity issue. But the additivity property implies that both efficiency and equity can be satisfied.

It would seem that the additivity property completely resolves the debate about which cost-effectiveness test should be used for DSM analysis. Three tests can be used together, and the fourth (UC) test is redundant. Hence, it should be possible to satisfy both those who believe that utilities should pursue all DSM programs which lower society's total bill for energy services (TRC perspective) and those who believe that it is unfair for non-participants' rates to be raised to benefit those who conserve (RIM perspective).

APPARENT FAILURE OF THE ADDITIVITY PROPERTY

Despite the additivity property, many utilities seem to find that most of their conservation programs are designed in a way that fails the RIM test, in order to realize substantial penetration, even though they pass the TRC and Participant tests. In other words, estimated net benefits to participants often exceed net benefits to society, leaving negative net benefits to non-participants. However, lowering the utility incentive to the participants would significantly reduce market penetration. The Pareto optimality implied by the additivity property fails if participants require a disproportionate share of the savings, rather than simple neutrality.

The apparent failure of the additivity property often stems from an incomplete analysis of the costs and benefits of a proposed conservation program, rather than excessively greedy program participants. The next two sections discuss some of the common problems and omissions in DSM cost-effectiveness analysis and some potential solutions.

A COMPREHENSIVE EVALUATION OF COSTS AND BENEFITS

The apparent failure of the additivity property points to a problem which has long been acknowledged in the literature on cost-effectiveness testing. Many (if not most) of the conservation measures supported by utilities actually pass the Participant test assuming no utility involvement. In other words, the utilities' customers should be voluntarily pursuing significant levels of conservation on their own. Yet, for some reason, which is unfathomable to many who work with conservation programs every day, customers decline the opportunity to reduce their total energy bills by investing in conservation. This reluctance is generally attributed to market barriers.

Participants incur many indirect costs in implementing conservation measures such as lack of information, inability to obtain equipment, time spent analyzing and installing measures, and other "hassle costs". In addition, participants may intuitively or analytically factor a return on their investment of time and effort into their evaluation of whether to implement conservation measures. These indirect participant costs, or market barriers, are what is currently preventing energy consumers from installing many "cost-effective" measures themselves. When all of the indirect costs are taken into account, the measures are not cost-effective as far as the consumers are concerned. A true Participant test of cost-effectiveness must therefore include indirect participant costs in the cost side of the equation. In addition, these indirect participant costs must be considered to be societal costs and included in the TRC test. A customer's lost time and productivity while conservation measures are researched and installed constitute societal costs.

Utility participation in conservation programs can, however, decrease or eliminate some of these indirect costs. By educating customers, making technology readily available, and aiding installation, utilities may be able to reduce significantly indirect participant costs and remove some of the market barriers which are currently impeding the spread of energy efficiency technologies. In many cases, a dollar of utility spending can reduce indirect participant costs by more than a dollar. These benefits represent the value created by utility sponsorship. Although these benefits are, in many programs, transferred directly to the participants, they are also societal benefits and should be included in the TRC test as well as in the Participant test.

To restore the additivity property, indirect participant costs and the benefits created by utility sponsorship must be evaluated and included in the appropriate cost-effectiveness tests. The TRC and Participant tests will now include a cost term entitled Indirect Cost (IC). This term represents the net of indirect participant costs and benefits created by utility sponsorship. It is not appropriate to include this term in the RIM test, because it is not a cost to non-participating ratepayers and it does not impact the utility's rates.

$$TRC = AC - OC - TH - IC \tag{11}$$

$$P = I + LR - PH - IC \tag{12}$$

Unfortunately, indirect costs are not simple to evaluate. There is currently only sketchy data available concerning the value customers assign to lost time, frustrating searches for information or technology, lost productivity and changes in form or function of the service provided. Lack of information concerning existing market barriers makes it difficult to determine what value the utility adds through sponsorship, or how the utility can most effectively overcome the barriers. In addition, these relationships change over time. When a utility first begins to support a certain new program or technology, it may find that market barriers are very high. Because customers know little about the product's records or applications, they may be quite adverse to trying it. The utility may have to offer a high incentive to compensate. But as the utility continues to support the product, it should be able to create an infrastructure to supply the product and an awareness of the product's uses. The utility can utilize these gains due to utility sponsorship to lower incentive payments as time passes. Hence, the indirect costs of a measure, as well as the incentive schedule, need to be re-evaluated each year.

Because this type of data can be difficult and costly to obtain, indirect costs are often assumed to be zero in performing DSM cost-effectiveness evaluations. This assumption reaches beyond the debate over cost-effectiveness criteria. By studying consumer behavior and targeting spending at overcoming market barriers, utilities could achieve better conservation results for fewer dollars. Therefore, utilities and others should conduct market research to obtain data on indirect costs and incorporate the data into the evaluation and marketing of DSM programs.

THE DISCOUNT RATE GAP

The discussion so far has assumed that the TRC, RIM and Participant tests are performed using the same discount rate. However, it is well known that utility customers, particularly residential customers, often use higher discount rates in making decisions than those typically used by utilities. The relatively high interest rates found on credit cards are evidence in support of this conclusion. This "discount rate gap" increases the share of the savings required to elicit customer participation, again leading to an apparent failure of the additivity property.

The discount rate gap must be defined carefully to avoid confusing it with indirect participant costs and with the truncation of benefits in customer evaluation of conservation measures (to be discussed below). All three problems yield the same symptom: customers declining to implement conservation measures that appear, to the utility, to be cost-effective.[8] However, different factors are at work in

8 *Some authors have calculated "implicit discount rates" for consumer investments in conservation assuming that all market barriers can be included in the discount rate gap. (Lovins 1985) The implicit discount rate is viewed as a proxy for a large set of non-financial barriers. This methodproduces implicit discount*

each situation and a different utility approach is required to deal with each issue. In this paper, discount rate gap refers only to the difference in time value of money to utilities and their customers. Other market barriers are treated separately.

Most of the participants' costs are incurred up-front, at the time the conservation measure is installed. The benefits the customer receives in incentive payments from the utility are also gained up-front. However, the benefits the customer receives in bill savings are accrued over a period of years. Typically, a conservation measure lasts from five to fifteen years. When these benefits are evaluated at the utility's discount rate, the customer seems to be requiring an excessive amount of benefits. However, evaluating these benefits at the participants' discount rate reveals that the participants are actually asking for a fairly small share of the savings--as far as they're concerned.[9]

The solution to this apparent dilemma lies in utilizing the discount rate gap as an advantage. Participants require their savings up-front, but may be willing to pay back some of the costs over time. The many credit cards in use by consumers and the many successful rent-to-own programs which are available tend to support this idea. In addition, the shared savings agreements which are utilized by many Energy Services Companies are an example of how conservation costs can be recovered over time. Both the Energy Services Companies and their customers benefit from the transaction due to the difference in their discount rates. Early attempts to implement this concept have met with mixed success. But, as utilities gain more experience with this type of arrangement, they may be able to structure more of their programs to recoup some of the program costs over time without sacrificing market penetration. This structure turns the discount rate gap into an advantage for both the utilities and their customers.

The shared savings concept can be introduced into the cost-effectiveness tests by dividing the Incentive (I) term into two parts: Utility Incentive (UI) and Customer Payment (CP). The utility incentive is the amount of up-front payment the utility makes to the participant. Customer payment represents the return payment by the customer to the utility over time. Table 2 summarizes the cost-effectiveness tests as extended to include indirect costs and customer payments. The RIM and Participant tests become:

$$RIM = AC - OC - UI - UH - LR + CP \qquad (13)$$

$$P = UI + LR - PH - IC - CP \qquad (14)$$

A shared savings deal must be structured so that the RIM test (at the utility's discount rate) and the Participant test (at the participants' discount rate) are both greater than or equal to zero. Fortunately, there are many solutions to these equations.

TRUNCATION OF BENEFITS

A separate issue from the discount rate gap is the truncation of benefits in customer evaluation of conservation measures. Customers frequently count only the first two or three years of benefits and ignore the remaining years, not because they have a high discount rate for economic benefits in later years or even because they are uncertain about the benefits in later years, but because they actually expect not to receive the benefits. For example, a residential customer may decide not to add insulation because he plans to sell his house within a few years and he doesn't expect to be able to recover the added cost of insulation in the selling price. He would rather spend the money on upgrading the kitchen or bathroom instead, because these expenditures can be recovered in the selling price of the house, perhaps with profit.

rates of higher than 50% for conservation investments, making it appear that the utility must absorb all conservation costs because consumers are unwilling to make even minor expenditures for conservation. However, while the utility cannot alter customers' financial discount rates, it can lower other market barriers. Hence, the use of implicit discount rates produces misleading conclusions and is not recommended.

9 *The discount rates used in the three tests must be selected carefully. The utility cost of capital is a convenient number, but is not necessarily the most appropriate discount rate to use in even the RIM and TRC tests. It may be appropriate to use a higher discount rate to reflect more accurately both participants' and non-participants' time value of money. On the other hand, some have argued that a societal perspective requires a lower discount rate. (Lovins 1985)*

Table 2. Components of the Extended Cost-Effectiveness Tests

	Participant (P)	Non-Participant (RIM)	Society (TRC)
Avoided Cost		+	+
Utility Hardware		–	–
Participant Hardware	–		–
Overhead		–	–
Utility Incentive	+	–	
Lost Revenue	+	–	
Indirect Cost	–		–
Customer Payment	–	+	

The underlying problem is that there is not yet a resale market for home energy efficiency. The benefits that would be provided by the insulation would be a windfall to the buyer. A customer payment term will not correct this problem so long as the obligation falls on the current homeowner.

Some utilities and Energy Services Companies have solved the truncation of benefits problem by tying shared savings charges to the meter so that the service charge continues even if ownership changes. With this type of contract, the current owner can truncate both benefits and costs at the same point in his evaluation of cost-effectiveness. Hence, the same measures will be cost-effective in the customer's 3-year evaluation and the utility's 20-year evaluation.

The appropriate long-term solution may be to create a resale market for home energy efficiency, perhaps through requiring an energy audit with an estimate of the annual energy bill whenever a house is sold. If energy efficiency improvements were as profitable as bathroom upgrades in the resale market, utilities would not even need to offer shared savings contracts to savvy investors. But in the short-term, if a shared savings contract is not possible, it may be possible to achieve the societal benefits of insulation only by creating a windfall for home buyers at the expense of other ratepayers.

A TWO-STEP COST-EFFECTIVENESS METHODOLOGY

PG&E currently employs a two-step cost-effectiveness methodology that relies on the additivity property. The TRC, RIM and Participant tests are all incorporated into the methodology. The two-step methodology acknowledges that both supply- and demand-side resources go through a planning and selection phase and a design phase. For demand-side resources it is appropriate to use a two-step cost-effectiveness criterion which focuses on the distinct goals of each phase. For supply-side resources, the criterion collapses to the single supply-side cost-effectiveness test.

The first step focuses on integrated planning. The goal of integrated planning is to compare demand- and supply-side resources in a consistent manner and to select the least-cost resource mix. The TRC test is utilized to develop an integrated least-cost plan. In this step it is important to incorporate all indirect participant costs and utility sponsorship benefits which can be estimated. If these costs and benefits are left out, it may not be possible to meet the requirements in the second step. Accurate evaluation of these items is particularly important for programs which will be implemented in the near term. For long term planning, a rougher estimate should suffice.

The second step focuses on program design. The goal in DSM program design is to select a design which will be workable (people will participate) and which fairly distributes the benefits of the program between participants and non-participants. Combined use of the Participant and RIM tests will aid program designers in meeting these goals. This design step is usually performed shortly before program implementation.

Some utilities may choose to make this second step binding -- only programs which can be successfully designed to achieve sufficient market penetration and still pass the RIM test will be implemented. This will require careful analysis of indirect costs and shared savings possibilities. Utilities will have to find opportunities to reduce existing market barriers through utility sponsorship and to make their programs financially acceptable to participants. Others may prefer to relax this criterion for some programs and allow some transfers from the non-participants to the participants. Some utilities may choose to provide a broad spectrum of programs which allow all customers the opportunity to participate. In this case, the transfer will be between participants in different DSM programs. Particularly in the early phases of utility sponsorship, relaxing the RIM criterion may prove to be the best way to overcome customer reluctance to try new conservation measures.

PG&E has chosen this two-step approach to cost-effectiveness for several reasons. First, because of the additivity property, the two steps are completely consistent. Any program that passes the TRC test can later be designed to pass both the Participant and RIM tests. However, the second criterion can be relaxed on a case-by-case basis to meet other conservation program goals.

Second, the two-step methodology avoids doing unnecessary program design prior to program selection. Crafting an effective conservation program design is a time-consuming process. The program design must be carefully evaluated for each type of program and combination of measures. By using step one as a screening step, short term planners can avoid wasting time on program design for programs which are not societally beneficial (fail the TRC test). Long term planners can quickly and efficiently develop an integrated least-cost resource plan, using the step one criteria. There is no need to develop detailed implementation plans for programs which are not societally beneficial or are not forecast to begin until ten or fifteen years in the future.

Finally, this methodology has the benefit of providing a single clear test for program selection, making it easier for stakeholders to understand why programs were selected or rejected. This allows the stakeholders to focus on the data and assumptions behind the conservation programs and forecast, rather than the choice of cost-effectiveness test. At the same time, clear and consistent criteria are provided for program designers.

CONCLUSION

The debate over the selection of a cost-effectiveness criterion for integrated planning is now several years old. Each of the points of view provides valuable and essential insight into the selection and design of DSM programs. A comprehensive cost-effectiveness methodology for integrated least-cost planning which incorporates and reconciles these many perspectives is feasible. One such methodology has proven to be effective for PG&E. While the debate over the selection of a cost-effectiveness test may be subsiding, there is still additional work to be done in the general area of DSM cost-effectiveness. In particular, better information on market barriers and consumer discount rates for conservation investments should be gathered and used in designing the next generation of conservation programs. Utilities should seek to develop program designs that exploit the specific value added by utility sponsorship. As this information becomes better known and analyzed, it should be possible to create DSM programs which have the ultimate goals of reducing market barriers to energy efficiency and creating a resale market for energy efficient homes and buildings.

REFERENCES

California Public Utilities Commission and California Energy Commission. 1987. *Standard Practice Manual: Economic Analysis of Demand-Side Management Programs.* CEC 400-87-006, Sacramento, California.

Cavanagh, R. 1988. "Responsible Power Marketing in an Increasingly Competitive Era." *Yale Journal on Regulation* 5(2):331-366.

Cicchetti, C. J., and W. Hogan. 1989. "Including Unbundled Demand-Side Options in Electric Utility Bidding Programs." *Public Utilities Fortnightly* 123(12):9-20.

Costello, K. W. 1987. "Ten Myths of Energy Conservation." *Public Utilities Fortnightly* 119(6):19-22.

Electric Power Research Institute. 1988. *Status of Least-Cost Planning in the United States*. EPRI EM-6133, Project 2982, Palo Alto, California.

Hobbs, B. F., and S. K. Nelson. 1989. "Assessing Conservation Payments: Least-Cost, Least-Rates, or Most-Value?" *The Electricity Journal* 2(6):28-39.

Joskow, P. L. 1990. "Understanding the 'Unbundled' Utility Conservation Bidding Proposal." *Public Utilities Fortnightly* 125(1):18-28.

Lovins, A. B. 1985. "Saving Gigabucks with Negawatts." *Public Utilities Fortnightly* 115(6):19-26.

Ruff, L. E. 1988. "Least-Cost Planning and Demand-side Management: Six Common Fallacies and One Simple Truth." *Public Utilities Fortnightly* 121(9):19-26.

Sant, R. W., D. W. Bakke, and R. F. Naill. 1984. *Creating Abundance--America's Least-Cost Energy Strategy*. McGraw Hill Book Company, New York, New York.

Woychik, E. C. 1988. "Toward a Standard Practice Approach to Integrated Least-Cost Utility Planning." *Public Utilities Fortnightly* 121(5):27-33.