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## **The Standard Practices Manual: the economic analysis of demand-side programs and projects in California**

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**This Article reflects the work of the California Interagency Green Accounting Working Group (\*). Although the Manual is used extensively within the California State Government, it does not imply or reflect official State policy at this time (June 02).**

## Abstract

Since the summer of 2001, the Interagency Green Accounting Working Group (IGAWG) has worked to revise the California Standard Practice Manual: Economic Analysis of Demand Side Programs and Project (SPM). The co-chairs of that effort (Clark and Sowell) thank Dr. Don Schultz (Project leader) and congratulate the IGAWG for all the contributions during the revision process. The SPM revision process was badly needed since the manual has not been revised since 1987 under a different Governor. It was necessary at this time in particular (the California Energy Crisis) to:

- ensure that all California state agencies, departments and commissions all apply a standard and common set of procedures when accounting for the lifecycle costs and associated benefits for projects.
- provide guidelines for the billions of dollars that have been appropriated from a variety of sources (including ratepayers, the General Fund, and Bonds) to meet current and future energy and environmental project needs.
- provide financial assistance to customers' choosing to reduce their electricity loads on the central electric grid.

The revision process is complete and the version of the SPM final in this paper, subject to periodic updates and revisions. State agencies, departments, and commissions will be applying the methodology described in the SPM when planning and assessing the costs and benefits of various energy efficiency and self-generation programs being administered by various state agencies. Such use, however, does not assure approval of funding for individual projects financed by these programs, but rather it informs the decision-making process by using a standardised methodology.

The IGAWG also contributed to the development of a spreadsheet that provides:

- 1 example calculations of cost-effectiveness for portfolios of energy efficiency and self-generation programs and projects that conform with the SPM methodology;
- 2 the forecast of long term avoided costs that are currently being used at the CPUC to forecast the lifecycle benefits of reductions in demand for energy provided by the major investor-owned Utility Distribution Companies.

The SPM spreadsheet (in Appendix A) should be a useful tool for all state agencies to institutionalise the capability to conduct lifecycle benefit-cost analyses on programs and projects that reduce the demand for energy.

**Keywords:** life cycle analysis, project and program budget, revenue management, and externalities

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No. Y, pp.000-000.

**Biographical notes:** Dr. Clark was visiting Professor of International Business Economics and Engineering at Aalborg University in Denmark. He was formerly Manager of Strategic Planning/Implementation at Lawrence Livermore National Laboratory. He had been an entrepreneur and started successful multimedia company in the 1980s. Currently he is the Senior Policy Advisor to the Governor of California, for Energy Reliability.

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(\* Over fifty state analyses and experts participated in the Standard Practices Manual revision. They are listed in the Appendix. The revision of the Manual was truly a collaborative effort that lasted over 8 months but resulted in significant accounting and analytical changes for projects and programs in California.

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## 1 Introduction: basic methodology

Since the 1970s, conservation and load management programs have been promoted by the California Public Utilities Commission (CPUC) and the California Energy Commission (CEC) as alternatives to power plant construction and gas supply options. Conservation and load management (C&LM) programs have been implemented in California by the major utilities through the use of ratepayer money and by the CEC pursuant to the CEC legislative mandate to establish energy efficiency standards for new buildings and appliances.

While cost-effectiveness procedures for the CEC standards are outlined in the Public Resources Code, no such official guidelines existed for utility-sponsored programs. With the publication of the Standard Practice for Cost-Benefit Analysis of Conservation and Load Management Programs in February, 1983, this void was substantially filled. With the informal 'adoption' one year later of an appendix that identified cost-effectiveness procedures for an 'All Ratepayers' test, C&LM program cost-effectiveness consisted of the application of a series of tests representing a variety of perspectives – participants, non-participants, all ratepayers, society, and the utility.

The Standard Practice Manual was revised again in 1987-88. The primary changes (relative to the 1983 version), were:

- 1 the renaming of the 'Non-Participant Test' to the 'Ratepayer Impact Test'
- 2 renaming the 'All-Ratepayer Test' to the 'Total Resource Cost Test.'

- 3 treating the ‘Societal Test’ as a variant of the ‘Total Resource Cost Test;’
- 4 an expanded explanation of ‘demand-side’ activities that should be subjected to standard procedures of benefit-cost analysis.

Further changes to the manual captured in this (2001) version were prompted by the cumulative effects of changes in the electric and natural gas industries and a variety of changes in California statute related to these changes. As part of the major electric industry restructuring legislation of 1996 (AB1890), for example, a public goods charge was established that ensured minimum funding levels for ‘cost-effective conservation and energy efficiency’ for the 1998-2002 period, and then (in 2000) this was extended until the year 2011. Additional legislation in 2000 (AB1002) established a natural gas surcharge for similar purposes. Later in that year, the Energy Security and Reliability Act of 2000 (AB970) directed the California Public Utilities Commission to establish, by the Spring of 2001, a distribution charge to provide revenues for a self generation program and a directive to consider changes to cost-effectiveness methods to better account for reliability concerns.

In the Spring of 2001, a new state agency – the Consumer Power and Conservation Financing Authority was created. This agency is expected to provide additional revenues – in the form of state revenue bonds – that could supplement the amount and type of public financial resources to finance energy efficiency and self generation activities.

The modifications to the Standard Practice Manual reflect these more recent developments in several ways. Firstly, the ‘Utility Cost Test’ has been renamed the ‘Program Administrator Test’ to include the assessment of programs managed by other agencies. Secondly, a definition of self generation as a type of ‘demand-side’ activity is included. Thirdly, the description of the various potential elements of ‘externalities’ in the Societal version of the TRC test is expanded. Finally the limitations section outlines the scope of this manual and elaborates upon the processes traditionally instituted by implementing agencies to adopt values for these externalities and to adopt the policy rules that accompany this manual.

### *1.1 Demand-side management categories and program definitions*

One important aspect of establishing standardised procedures for cost-effectiveness evaluations is the development and use of consistent definitions of categories, programs, and program elements.

This manual employs the use of general program categories that distinguish between different types of demand-side management programs-conservation, load management, fuel substitution, load building and self-generation. Conservation programs reduce electricity and/or natural gas consumption during all or significant portions of the year. ‘Conservation’ in this context includes all ‘energy efficiency improvements’. An energy efficiency improvement can be defined as reduced energy use for a comparable level of service, resulting from the installation of an energy efficiency measure or the adoption of an energy efficiency practice. Level of service may be expressed in such ways as the volume of a refrigerator, temperature levels, production output of a manufacturing facility, or lighting level per square foot. Load management programs may either reduce electricity peak demand or shift demand from on-peak to non-peak periods.

Fuel substitution and load building programs share the common feature of increasing annual consumption of either electricity or natural gas relative to what would have

happened in the absence of the program. This effect is accomplished in significantly different ways, by inducing the choice of one fuel over another (fuel substitution), or by increasing sales of electricity, gas, or electricity and gas (load building). self generation refers to distributed generation (DG) installed on the customer's side of the electric utility meter, which serves some or all of the customer's electric load, that otherwise would have been provided by the central electric grid.

In some cases, self generation products are applied in a combined heat and power manner, in which case the heat produced by the self generation product is used on site to provide some or all of the customer's thermal needs. Self generation technologies include, but are not limited to, photovoltaics, wind turbines, fuel cells, microturbines, small gas-fired turbines, and gas-fired internal combustion engines.

Fuel substitution and load building programs were relatively new to demand-side management in California in the late 1980s, born out of the convergence of several factors that translated into average rates that substantially exceeded marginal costs. Proposals by utilities to implement programs that increase sales had prompted the need for additional procedures for estimating program cost-effectiveness. These procedures may be applicable in a new context. AB 970 amended the Public Utilities Code and provided the motivation to develop a cost-effectiveness method that can be used on a common basis to evaluate all programs that will remove electric load from the centralised grid, including energy efficiency, load control/demand-responsiveness programs and self-generation. Hence self-generation was also added to the list of demand-side management programs for cost-effectiveness evaluation. In some cases Self-generation programs installed with incremental load are also included since the definition of self-generation is not necessarily confined to projects that reduce electric load on the grid. For example, suppose an industrial customer installs a new facility with a peak consumption of 1.5 MW, with an integrated on-site 1.0 MW gas fired DG unit. The combined impact of the new facility is *load building* since the new facility can draw up to 0.5 MW from the grid, even when the DG unit is running. The proper characterisation of each type of demand-side management program is essential to ensure the proper treatment of inputs and the appropriate interpretation of cost-effectiveness results.

Categorising programs is important because in many cases the same specific device can be and should be evaluated in more than one category. For example, the promotion of an electric heat pump can and should be treated as part of a conservation program if the device is installed in lieu of a less efficient electric resistance heater. If the incentive induces the installation of an electric heat pump instead of gas space heating, however, the program needs to be considered and evaluated as a fuel substitution program. Similarly, natural gas-fired self-generation, as well as self-generation units using other non-renewable fossil fuels, must be treated as fuel-substitution. In common with other types of fuel-substitution, any costs of gas transmission and distribution, and environmental externalities, must be accounted for. In addition, cost-effectiveness analyses of self-generation should account for utility interconnection costs. Similarly, a thermal energy storage device should be treated as a load management program when the predominant effect is to shift load. If the acceptance of a utility incentive by the customer to install the energy storage device is a decisive aspect of the customer's decision to remain an electric utility customer (i.e. to reject or defer the option of installing a gas-fired cogeneration system), then the predominant effect of the thermal energy storage

device has been to substitute electricity service for the natural gas service that would have occurred in the absence of the program.

In addition to Fuel Substitution and Load Building Programs, recent utility program proposals have included reference to ‘load retention,’ ‘sales retention,’ ‘market retention,’ or ‘customer retention’ programs. In most cases, the effect of such programs is identical to either a Fuel Substitution or a Load Building program – sales of one fuel are increased relative to sales without the program. A case may be made, however, for defining a separate category of program called ‘load retention.’ One unambiguous example of a load retention program is the situation where a program keeps a customer from relocating to another utility service area. However, computationally the equations and guidelines included in this manual to accommodate Fuel Substitution and Load Building programs can also handle this special situation as well.

### *1.2 Basic methods*

This manual identifies the cost and benefit components and cost-effectiveness calculation procedures from four major perspectives: Participant, Ratepayer Impact Measure (RIM), Program Administrator Cost (PAC), and Total Resource Cost (TRC). A fifth perspective, the Societal, is treated as a variation on the Total Resource Cost test. The results of each perspective can be expressed in a variety of ways, but in all cases it is necessary to calculate the net present value of program impacts over the lifecycle of those impacts.

Table 1 summarises the cost-effectiveness tests addressed in this manual. For each of the perspectives, the table shows the appropriate means of expressing test results. The primary unit of measurement refers to the way of expressing test results that are considered by the staff of the two commissions as the most useful for summarising and comparing demand-side management (DSM) program cost-effectiveness. Secondary indicators of cost-effectiveness represent *supplemental* means of expressing test results that are likely to be of particular value for certain types of proceedings, reports, or programs.

This manual does not specify how the cost-effectiveness test results are to be displayed or the level at which cost-effectiveness is to be calculated (e.g. groups of programs, individual programs, and program elements for all or some programs). It is reasonable to expect different levels and types of results for different regulatory proceedings or for different phases of the process used to establish proposed program funding levels. For example, for summary tables in general rate case proceedings at the CPUC, the most appropriate tests may be the RIM lifecycle revenue impact, Total Resource Cost, and Program Administrator Cost test results for programs or groups of programs. The analysis and review of program proposals for the same proceeding may include Participant test results and various additional indicators of cost-effectiveness from all tests for each individual program element. In the case of cost-effectiveness evaluations conducted in the context of integrated long-term resource planning activities, such detailed examination of multiple indications of costs and benefits may be impractical.

**Table 1** Cost-effectiveness tests

<i>Participant</i>	
Primary	Secondary

Net present value (all participants)	Discounted payback (years)
	Benefit-cost ratio
	Net present value (average participant)
<i>Ratepayer Impact Measure</i>	
Primary	Secondary
Lifecycle revenue impact per Unit of energy (kWh or therm) or demand customer (kW)	Lifecycle revenue impact per unit Annual revenue impact (by year, per kWh, kW, therm, or customer) First-year revenue impact (per kWh, kW, therm, or customer)
Net present value	Benefit-cost ratio
<i>Total Resource Cost</i>	
Primary	Secondary
Net present value (NPV)	Benefit-cost ratio (BCR) Levelised cost (cents or dollars per unit of energy or demand) Societal (NPV, BCR)
<i>Program Administrator Cost</i>	
Primary	Secondary
Net present value	Benefit-cost ratio Levelised cost (cents or dollars per unit of energy or demand)

NOTE; June 15 - the table appears correct. Had experts check it too.

Rather than identify the precise requirements for reporting cost-effectiveness results for all types of proceedings or reports, the approach taken in this manual is to:

- specify the components of benefits and costs for each of the major tests
- identify the equations to be used to express the results in acceptable ways
- indicate the relative value of the different units of measurement by designating primary and secondary test results for each test.

It should be noted that for some types of demand-side management programs, meaningful cost-effectiveness analyses cannot be performed using the tests in this manual. The following guidelines are offered to clarify the appropriated 'match' of different types of programs and tests:

- 1 For generalised information programs (e.g. when customers are provided generic information on means of reducing utility bills without the benefit of on-site evaluations or customer billing data), cost-effectiveness tests are not expected because of the extreme difficulty in establishing meaningful estimates of load impacts.
- 2 For any program where more than one fuel is affected, the preferred unit of measurement for the RIM test is the lifecycle revenue impacts per customer, with gas

and electric components reported separately for each fuel type and for combined fuels.

- 3 For load building programs, only the RIM tests are expected to be applied. The Total Resource Cost and Program Administrator Cost tests are intended to identify cost-effectiveness relative to other resource options. It is inappropriate to consider increased load as an alternative to other supply options.
- 4 Levelised costs may be appropriate as a supplementary indicator of cost per unit for electric conservation and load management programs relative to generation options and gas conservation programs relative to gas supply options, but the levelised cost test is not applicable to fuel substitution programs (since they combine gas and electric effects) or load building programs (which increase sales).

The delineation of the various means of expressing test results in Table 1 is not meant to discourage the continued development of additional variations for expressing cost-effectiveness. Of particular interest is the development of indicators of program cost-effectiveness that can be used to assess the appropriateness of program scope (i.e. level of funding) for General Rate Case proceedings. Additional tests, if constructed from the net present worth in conformance with the equations designated in this manual, could prove useful as a means of developing methodologies that will address issues such as the optimal timing and scope of demand-side management programs in the context of overall resource planning.

### *1.3 Balancing the tests*

The tests set forth in this manual are not intended to be used individually or in isolation. The results of tests that measure efficiency, such as the Total Resource Cost Test, the Societal Test, and the Program Administrator Cost Test, must be compared not only to each other but also to the Ratepayer Impact Measure Test. This multi-perspective approach will require program administrators and state agencies to consider tradeoffs between the various tests. Issues related to the precise weighting of each test relative to other tests and to developing formulas for the definitive balancing of perspectives are outside the scope of this manual. The manual, however, does provide a brief description of the strengths and weaknesses of each test (Sections 2, 3, 4, and 5) to assist users in qualitatively weighing test results.

### *1.4 Limitations: externality values and policy rules*

The list of externalities identified in Section 4, in the discussion on the Societal version of the Total Resource Cost test is broad, illustrative and by no means exhaustive. Traditionally, implementing agencies have independently determined the details such as the components of the externalities, the externality values and the policy rules which specify the contexts in which the externalities and the tests are used

### *1.5 Externality values*

The values for the externalities have not been provided in the manual. There are separate studies and methodologies to arrive at these values. There are also separate processes instituted by implementing agencies before such values can be adopted formally.

### *1.6 Policy rules*

The appropriate choice of inputs and input components vary by program area and project. For instance, low income programs are evaluated using a broader set of non-energy benefits that have not been provided in detail in this manual. Implementing agencies traditionally have had the discretion to use or to not use these inputs and/or benefits on a project- or program-specific basis. The policy rules that specify the contexts in which it is appropriate to use the externalities, their components, and tests mentioned in this manual are an integral part of any cost-effectiveness evaluation. These policy rules are not a part of this manual.

To summarise, the manual provides the methodology and the cost-benefit calculations only. The implementing agencies (such as the California Public Utilities Commission and the California Energy Commission) have traditionally utilised open public processes to incorporate the diverse views of stakeholders before adopting externality values and policy rules which are an integral part of the cost-effectiveness evaluation.

## **2 Participant test**

### *2.1 Definition*

The Participants Test is the measure of the quantifiable benefits and costs to the customer due to participation in a program. Since many customers do not base their decision to participate in a program entirely on quantifiable variables, this test cannot be a complete measure of the benefits and costs of a program to a customer.

### *2.2 Benefits and costs*

The benefits of participation in a demand-side program include the reduction in the customer's utility bill(s), any incentive paid by the utility or other third parties, and any federal, state, or local tax credit received. The reductions to the utility bill(s) should be calculated using the actual retail rates that would have been charged for the energy service provided (electric demand or energy or gas). Savings estimates should be based on gross savings, as opposed to net energy savings [1].

In the case of fuel substitution programs, benefits to the participant also include the avoided capital and operating costs of the equipment/appliance not chosen. For load building programs, participant benefits include an increase in productivity and/or service, which is presumably equal to or greater than the productivity/service without participating. The inclusion of these benefits is not required for this test, but if they are included then the Societal test should also be performed.

The costs to a customer of program participation are all out-of-pocket expenses incurred as a result of participating in a program, plus any increases in the customer's

utility bill(s). The out-of-pocket expenses include the cost of any equipment or materials purchased, including sales tax and installation; any ongoing operation and maintenance costs; any removal costs (less salvage value); and the value of the customer's time in arranging for the installation of the measure, if significant.

### *2.3 How the results can be expressed*

The results of this test can be expressed in four ways: through a net present value per average participant, a net present value for the total program, a benefit-cost ratio or discounted payback. The primary means of expressing test results is the net present value for the total program; discounted payback, benefit-cost ratio, and per participant net present value are secondary tests.

The discounted payback is the number of years it takes until the cumulative discounted benefits equal or exceed the cumulative discounted costs. The shorter the discounted payback, the more attractive or beneficial the program is to the participants. Although 'payback period' is often defined as undiscounted in the textbooks, a discounted payback period is used here to approximate more closely the consumer's perception of future benefits and costs [2].

Net present value (NPVp) gives the net dollar benefit of the program to an average participant or to all participants discounted over some specified time period. A net present value above zero indicates that the program is beneficial to the participants under this test.

The benefit-cost ratio (BCRp) is the ratio of the total benefits of a program to the total costs discounted over some specified time period. The benefit-cost ratio gives a measure of a rough rate of return for the program to the participants and is also an indication of risk. A benefit-cost ratio above one indicates a beneficial program.

### *2.4 Strengths of the Participant Test*

The Participants Test gives a good 'first cut' of the benefit or desirability of the program to customers. This information is especially useful for voluntary programs as an indication of potential participation rates.

For programs that involve a utility incentive, the Participant Test can be used for program design considerations such as the minimum incentive level, whether incentives are really needed to induce participation, and whether changes in incentive levels will induce the desired amount of participation.

These test results can be useful for program penetration analyses and developing program participation goals, which will minimise adverse ratepayer impacts and maximise benefits.

For fuel substitution programs, the Participant Test can be used to determine whether program participation (i.e. choosing one fuel over another) will be in the best interest of the customer in the long run. The primary means of establishing such assurances is the net present value, which looks at the costs and benefits of the fuel choice over the life of the equipment.

### 2.5 Weaknesses of the Participant Test

None of the Participant Test results (discounted payback, net present value, or benefit-cost ratio) accurately capture the complexities and diversity of customer decision-making processes for demand-side management investments. Until or unless more is known about customer attitudes and behaviour, interpretations of Participant Test results continue to require considerable judgment. Participant Test results play only a supportive role in any assessment of conservation and load management programs as alternatives to supply projects.

### 2.6 Formulae

The following are the formulas for discounted payback, the net present value (NPV<sub>p</sub>) and the benefit-cost ratio (BCR<sub>p</sub>) for the Participant Test.

$$\begin{aligned} \text{NPV}_p &= \mathbf{Bp} - \mathbf{Cp} \\ \text{NPV}_{\text{avp}} &= (\text{Bp} - \text{Cp}) / P \\ \text{BCR}_p &= \text{Bp} / \text{Cp} \\ \text{DP}_p &= \text{Min } j \text{ such that } \text{B}_j \geq \text{C}_j \end{aligned}$$

Where:

NPV <sub>p</sub>	=	Net present value to all participants
NPV <sub>avp</sub>	=	Net present value to the average participant
BCR <sub>p</sub>	=	Benefit-cost ratio to participants
DP <sub>p</sub>	=	Discounted payback in years
Bp	=	NPV of benefit to participants
Cp	=	NPV of costs to participants
B <sub>j</sub>	=	Cumulative benefits to participants in year j
C <sub>j</sub>	=	Cumulative costs to participants in year j
P	=	Number of program participants
J	=	First year in which cumulative benefits are cumulative costs.
d	=	interest rate (discount)

The Benefit (Bp) and Cost (Cp) terms are further defined as follows:

$$\text{Bp} = \sum_{t=1}^N \frac{\text{BR}_t + \text{TC}_t + \text{INC}_t}{(1+d)^{t-1}} + \sum_{t=1}^N \frac{\text{AB}_{\text{at}} + \text{PAC}_{\text{at}}}{(1+d)^{t-1}}$$

$$C = \sum_{t=1}^N \frac{PC_t + BI_t}{(1 + d)^{t-1}}$$

Where:

$BR_t$  = Bill reductions in year t

$BI_t$  = Bill increases in year t

$TC_t$  = Tax credits in year t

$INC_t$  = Incentives paid to the participant by the sponsoring utility in year t [3]

$PC_t$  = Participant costs in year t to include:

- initial capital costs, including sales tax [4]
- ongoing operation and maintenance costs including fuel cost
- removal costs, less salvage value
- value of the customer's time in arranging for installation, if significant

$PAC_{at}$  = Participant avoided costs in year t for alternative fuel devices (costs of devices not chosen)

$Ab_{at}$  = Avoided bill from alternative fuel in year t

The first summation in the Bp equation should be used for conservation and load management programs. For fuel substitution programs, both the first and second summations should be used for Bp.

Note that in most cases, the customer bill impact terms ( $BR_t$ ,  $BI_t$ , and  $AB_{at}$ ) are further determined by costing period to reflect load impacts and/or rate schedules, which vary substantially by time of day and season. The formulas for these variables are as follows:

$$BR_t = \sum_{i=1}^I (\Delta EG_{it} \times AC:E_{it} \times K_{it}) + \sum_{i=1}^I (\Delta DG_{it} \times AC:D_{it} \times K_{it}) + OBR_t$$

$AB_{at}$  = (Use  $BR_t$  formula, but with rates and costing periods appropriate for the alternate fuel utility)

$$BI_t = \sum_{i=1}^I (\Delta EG_{it} \times AC:E_{it} \times (K_{it} - 1)) + \sum_{i=1}^I (\Delta DG_{it} \times AC:D_{it} \times (K_{it} - 1)) + OBI_t$$

where

$\Delta EG_{it}$	Reduction in gross energy use in costing period $i$ in year $t$
$\Delta DG_{it}$	Reduction in gross billing demand in costing period $i$ in year $t$
$AC:E_{it}$	Rate charged for energy in costing period $i$ in year $t$
$AC:D_{it}$	Rate charged for demand in costing period $i$ in year $t$
$K_{it}$	1 when $\Delta EG_{it}$ or $\Delta DG_{it}$ is positive (a reduction) in costing period $i$ in year $t$ , and zero otherwise
$OBR_t$	Other bill reductions or avoided bill payments (e.g. customer charges, standby rates).
$OBI_t$	Other bill increases (i.e. customer charges, standby rates).
$I$	Number of periods of participant's participation

In load management programs such as TOU rates and air-conditioning cycling, there are often no direct customer hardware costs. However, attempts should be made to quantify indirect costs customers may incur that enable them to take advantage of TOU rates and similar programs.

If no customer hardware costs are expected or estimates of indirect costs and value of service are unavailable, it may not be possible to calculate the benefit-cost ratio and discounted payback period.

### 3 The ratepayer impact measure test [5]

#### 3.1 Definition

The Ratepayer Impact Measure (RIM) test measures what happens to customer bills or rates due to changes in utility revenues and operating costs caused by the program. Rates will go down if the change in revenues from the program is greater than the change in utility costs. Conversely, rates or bills will go up if revenues collected after program implementation are less than the total costs incurred by the utility in implementing the program. This test indicates the direction and magnitude of the expected change in customer bills or rate levels.

#### 3.2 Benefits and costs

The benefits calculated in the RIM test are the savings from avoided supply costs. These avoided costs include the reduction in transmission, distribution, generation, and capacity costs for periods when load has been reduced and the increase in revenues for any periods in which load has been increased. The avoided supply costs are a reduction in total costs or revenue requirements and are included for both fuels for a fuel substitution program. The increase in revenues are also included for both fuels for fuel substitution programs. Both the reductions in supply costs and the revenue increases should be calculated using net energy savings.

The costs for this test are the program costs incurred by the utility, and/or other entities incurring costs and creating or administering the program, the incentives paid to

the participant, decreased revenues for any periods in which load has been decreased and increased supply costs for any periods when load has been increased. The utility program costs include initial and annual costs, such as the cost of equipment, operation and maintenance, installation, program administration, and customer drop-out and removal of equipment (less salvage value). The decreases in revenues and the increases in the supply costs should be calculated for both fuels for fuel substitution programs using net savings.

### *3.3 How the results can be expressed*

The results of this test can be presented in several forms: the lifecycle revenue impact (cents or dollars) per kWh, kW, therm, or customer; annual or first-year revenue impacts (cents or dollars per kWh, kW, therms, or customer); benefit-cost ratio; and net present value. The primary units of measurement are the lifecycle revenue impact, expressed as the change in rates (cents per kWh for electric energy, dollars per kW for electric capacity, cents per therm for natural gas) and the net present value. Secondary test results are the lifecycle revenue impact per customer, first-year and annual revenue impacts, and the benefit-cost ratio.  $LRI_{RIM}$  values for programs affecting electricity and gas should be calculated for each fuel individually (cents per kWh or dollars per kW and cents per therm) and on a combined gas and electric basis (cents per customer).

The lifecycle revenue impact (LRI) is the one-time change in rates or the bill change over the life of the program needed to bring total revenues in line with revenue requirements over the life of the program. The rate increase or decrease is expected to be put into effect in the first year of the program. Any successive rate changes such as for cost escalation are made from there. The first-year revenue impact (FRI) is the change in rates in the first year of the program or the bill change needed to get total revenues to match revenue requirements only for that year. The annual revenue impact (ARI) is the series of differences between revenues and revenue requirements in each year of the program. This series shows the cumulative rate change or bill change in a year needed to match revenues to revenue requirements. Thus, the  $ARIRIM$  for year six per kWh is the estimate of the difference between present rates and the rate that would be in effect in year six due to the program. For results expressed as lifecycle, annual, or first-year revenue impacts, negative results indicate favourable effects on the bills of ratepayers or reductions in rates. Positive test result values indicate adverse bill impacts or rate increases.

Net present value ( $NPV_{RIM}$ ) gives the discounted dollar net benefit of the program from the perspective of rate levels or bills over some specified time period. A net present value above zero indicates that the program will benefit (lower) rates and bills.

The benefit-cost ratio (BCR  $RIM$ ) is the ratio of the total benefits of a program to the total costs discounted over some specified time period. A benefit-cost ratio above one indicates that the program will lower rates and bills.

### *3.4 Strengths of the Ratepayer Impact Measure (RIM) Test*

In contrast to most supply options, demand-side management programs cause a direct shift in revenues. Under many conditions, revenues lost from DSM programs have to be made up by ratepayers. The RIM test is the only test that reflects this revenue shift along with the other costs and benefits associated with the program.

An additional strength of the RIM test is that the test can be used for all demand-side management programs (conservation, load management, fuel substitution, and load building). This makes the RIM test particularly useful for comparing impacts among demand-side management options.

Some of the units of measurement for the RIM test are of greater value than others, depending upon the purpose or type of evaluation. The lifecycle revenue impact per customer is the most useful unit of measurement when comparing the merits of programs with highly variable scopes (e.g. funding levels) and when analysing a wide range of programs that include both electric and natural gas impacts. Benefit-cost ratios can also be very useful for program design evaluations to identify the most attractive programs or program elements.

If comparisons are being made between a program or group of conservation/load management programs and a specific resource project, lifecycle cost per unit of energy and annual and first-year net costs per unit of energy are the most useful way to express test results. Of course, this requires developing lifecycle, annual, and first-year revenue impact estimates for the supply-side project.

### 3.5 Weaknesses of the Ratepayer Impact Measure (RIM) Test

Results of the RIM test are probably less certain than those of other tests because the test is sensitive to the differences between long-term projections of marginal costs and long-term projections of rates, two cost streams that are difficult to quantify with certainty.

RIM test results are also sensitive to assumptions regarding the financing of program costs. Sensitivity analyses and interactive analyses that capture feedback effects between system changes, rate design options, and alternative means of financing generation and non-generation options can help overcome these limitations. However, these types of analyses may be difficult to implement.

An additional caution must be exercised in using the RIM test to evaluate a fuel substitution program with multiple end use efficiency options. For example, under conditions where marginal costs are less than average costs, a program that promotes an inefficient appliance may give a more favourable test result than a program that promotes an efficient appliance. Though the results of the RIM test accurately reflect rate impacts, the implications for long-term conservation efforts need to be considered.

Formulae: the formulae for the lifecycle revenue impact (LRI RIM), net present value (NPV RIM), benefit-cost ratio (BCR RIM), the first-year revenue impacts and annual revenue impacts are presented below:

$$LRI_{RIM} = (C_{RIM} - B_{RIM}) / E$$

$$FRI_{RIM} = (C_{RIM} - B_{RIM}) / E \quad \text{for } t = 1$$

$$ARI_{RIMt} = FRI_{RIM} \quad \text{for } t = 1$$

$$= (C_{RIMt} - B_{RIMt}) / E_t \quad \text{for } t=2, \dots, N$$

$$NPV_{RIM} = B_{RIM} \cdot C_{RIM}$$

$$BCR_{RIM} = B_{RIM} / C_{RIM} \text{ where:}$$

$$LRI_{RIM} = \text{Lifecycle revenue impact of the program per unit of energy (kWh or therm) or demand (kW) (the one-time change in rates) or per customer}$$

(the change in customer bills over the life of the program). (Note: An appropriate choice of kWh, therm, kW, and customer should be made).

- $FRI_{RIM} =$  First-year revenue impact of the program per unit of energy, demand, or per customer.
- $ARI_{RIM} =$  Stream of cumulative annual revenue impacts of the program per unit of energy, demand, or per customer. (Note: The terms in the ARI formula are not discounted; thus they are the nominal cumulative revenue impacts. Discounted cumulative revenue impacts may be calculated and submitted if they are indicated as such. Note also that the sum of the discounted stream of cumulative revenue impacts *does not* equal the LRI RIM').
- $NPV_{RIM} =$  Net present value levels
- $BCR_{RIM} =$  Benefit-cost ratio for rate levels
- $B_{RIM} =$  Benefits to rate levels or customer bills
- $C_{RIM} =$  Costs to rate levels or customer bills
- $E =$  Discounted stream of system energy sales (kWh or therms) or demand sales (kW) or first-year customers. (See Appendix D for a description of the derivation and use of this term in the  $LRI_{RIM}$  test.)

The  $B_{RIM}$  and  $C_{RIM}$  terms are further defined as follows:

$$B_{RIM} = \sum_{t=1}^N \frac{UAC_t + RG_t}{(1+d)^{t-1}} + \sum_{t=1}^N \frac{UAC_{at}}{(1+d)^{t-1}}$$

$$C_{RIM} = \sum_{t=1}^N \frac{UIC_t + RL_t + PRC_t + INC_t}{(1+d)^{t-1}} + \sum_{t=1}^N \frac{RL_{at}}{(1+d)^{t-1}}$$

$$E = \sum_{t=1}^N \frac{E_t}{(1+d)^{t-1}}$$

Where

$UAC_t =$  Utility avoided supply costs in year t

$UIC_t =$  Utility increased supply costs in year t

$RG_t =$  Revenue gain from increased sales in year t

$RL_t$  = Revenue loss from reduced sales in year t

$PRC_t$  = Program Administrator program costs in year t

$E_t$  = System sales in kWh, kW or therms in year t or first year customers

$UAC_{at}$  = Utility avoided supply costs for the alternative fuel in year t

$RL_{at}$  = Revenue loss from avoided bill payments for alternate fuel in year t  
(i.e., device not chosen in a fuel substitution program)

For fuel substitution programs, the first term in the B RIM and C RIM equations represents the sponsoring utility (electric or gas), and the second term represents the alternative utility. The RIM test should be calculated separately for electric and gas and combined electric and gas.

The utility avoided cost terms ( $UAC_t$ ,  $UIC_t$ , and  $UAC_{at}$ ) are further determined by costing period to reflect time-variant costs of supply:

$$UAC_t = \sum_{i=1}^I (\Delta EN_{it} \times MC:E_{it} \times (K_{it})) + \sum_{i=1}^I (\Delta DN_{it} \times MC:D_{it} \times K_{it})$$

$$UAC_{at} = \text{(Use } UAC_t \text{ formula, but with marginal costs and costing periods appropriate for the alternate fuel utility.)}$$

$$UIC_t = \sum_{i=1}^I (\Delta EN_{it} \times MC:E_{it} \times (K_{it} - 1)) + \sum_{i=1}^I (\Delta DN_{it} \times MC:D_{it} \times (K_{it} - 1))$$

Where:

[Only terms not previously defined are included here.]

$\Delta EN_{it}$  = Reduction in net energy use in costing period i in year t

$\Delta DN_{it}$  = Reduction in net demand in costing period i in year t

$MC:E_{it}$  = Marginal cost of energy in costing period i in year t

$MC:D_{it}$  = Marginal cost of demand in costing period i in year t

The revenue impact terms ( $RG_t$ ,  $RL_t$ , and  $RL_{at}$ ) are parallel to the bill impact terms in the Participant Test. The terms are calculated in exactly the same way with the exception that the net impacts are used rather than gross impacts. If a net-to-gross ratio is used to differentiate gross savings from net savings, the revenue terms and the participant's bill terms will be related as follows:

$$RG_t = BI_t * (\text{net-to-gross ratio})$$

$$RL_t = BR_t * (\text{net-to-gross ratio})$$

$$RL_{at} = AB_{at} * (\text{net-to-gross ratio})$$

## 4 Total resource cost test [6]

### 4.1 Definition

The Total Resource Cost Test measures the net costs of a demand-side management program as a resource option based on the total costs of the program, including both the participants' and the utility's costs.

The test is applicable to conservation, load management, and fuel substitution programs. For fuel substitution programs, the test measures the net effect of the impacts from the fuel not chosen versus the impacts from the fuel that is chosen as a result of the program. TRC test results for fuel substitution programs should be viewed as a measure of the economic efficiency implications of the total energy supply system (gas and electric).

A variant on the TRC test is the Societal Test. The Societal Test differs from the TRC test in that it includes the effects of externalities (e.g. environmental, national security), excludes tax credit benefits, and uses a different (societal) discount rate.

Benefits and Costs: this test represents the combination of the effects of a program on both the customers participating and those not participating in a program. In a sense, it is the summation of the benefit and cost terms in the Participant and the Ratepayer Impact Measure tests, where the revenue (bill) change and the incentive terms intuitively cancel (except for the differences in net and gross savings).

The benefits calculated in the Total Resource Cost Test are the avoided supply costs – the reduction in transmission, distribution, generation, and capacity costs valued at marginal cost – for the periods when there is a load reduction. The avoided supply costs should be calculated using net program savings, savings net of changes in energy use that would have happened in the absence of the program. For fuel substitution programs, benefits include the avoided device costs and avoided supply costs for the energy-using equipment not chosen by the program participant.

The *costs* in this test are the program costs paid by both the utility and the participants plus the increase in supply costs for the periods in which load is increased. Thus *all* equipment costs, installation, operation and maintenance, cost of removal (less salvage value), and administration costs, no matter who pays for them, are included in this test. Any tax credits are considered a reduction to costs in this test. For fuel substitution programs, the costs also include the increase in supply costs for the utility providing the fuel that is chosen as a result of the program.

### 4.2 How the results can be expressed

The results of the Total Resource Cost Test can be expressed in several forms: as a net present value, a benefit-cost ratio, or as a levelised cost. The net present value is the primary unit of measurement for this test. Secondary means of expressing TRC test results are a benefit-cost ratio and levelised costs. The Societal Test – expressed in terms of net present value, a benefit-cost ratio, or levelised costs – is also considered a secondary means of expressing results. Levelised costs as a unit of measurement are inapplicable for fuel substitution programs, since these programs represent the net change of alternative fuels which are measured in different physical units (e.g. kWh or therms). Levelised costs are also not applicable for load building programs.

Net present value (NPVTRC) is the discounted value of the net benefits to this test over a specified period of time. NPVTRC is a measure of the change in the total resource costs due to the program. A net present value above zero indicates that the program is a less expensive resource than the supply option upon which the marginal costs are based.

The benefit-cost ratio (BCRTRC) is the ratio of the discounted total benefits of the program to the discounted total costs over some specified time period. It gives an indication of the rate of return of this program to the utility and its ratepayers. A benefit cost ratio above one indicates that the program is beneficial to the utility and its ratepayers on a total resource cost basis.

The levelised cost is a measure of the total costs of the program in a form that is sometimes used to estimate costs of utility owned supply additions. It presents the total costs of the program to the utility and its ratepayers on a per kilowatt, per kilowatt-hour, or per therm basis levelised over the life of the program.

The Societal Test is structurally similar to the Total Resource Cost Test. It goes beyond the TRC test in that it attempts to quantify the change in the total resource costs to society as a whole rather than to only the service territory (the utility and its ratepayers). In taking society's perspective, the Societal Test utilises essentially the same input variables as the TRC Test, but they are defined with a broader societal point of view. More specifically, the Societal Test differs from the TRC Test in at least one of five ways. Firstly, the Societal Test may use higher marginal costs than the TRC test if a utility faces marginal costs that are lower than other utilities in the state or than its out-of-state suppliers. Marginal costs used in the Societal Test would reflect the cost to *society* of the more expensive alternative resources. Secondly, tax credits are treated as a transfer payment in the Societal Test, and thus are left out. Thirdly, in the case of capital expenditures, interest payments are considered a transfer payment since society actually expends the resources in the first year. Therefore, capital costs enter the calculations in the year in which they occur. Fourthly, a societal discount rate should be used [7]. Finally, marginal costs used in the Societal Test would also contain externality costs of power generation not captured by the market system. An illustrative and by no means exhaustive list of 'externalities and their components' is given below (Refer to the Limitations section for elaboration.) These values are also referred to as 'adders' designed to capture or internalise such externalities. The list of potential adders would include for example:

- 1 The benefit of avoided environmental damage: the CPUC policy specifies two 'adders' to internalise environmental externalities, one for electricity use and one for natural gas use. Both are statewide average values. These adders are intended to help distinguish between cost-effective and non cost-effective energy-efficiency programs. They apply to an average supply mix and would not be useful in distinguishing among competing supply options. The CPUC electricity environmental adder is intended to account for the environmental damage from air pollutant emissions from power plants. The CPUC-adopted adder is intended to cover the human and material damage from sulphur oxides (SOX), nitrogen oxides (NOX), volatile organic compounds (VOC, sometimes called reactive organic gases or ROG), particulate matter at or below 10 micron diameter (PM10), and carbon. The adder for natural gas is intended to account for air pollutant emissions from the direct combustion of the gas. In the CPUC policy guidance, the adders are included in the tabulation of the benefits of energy efficiency programs. They represent

reduced environmental damage from displaced electricity generation and avoided gas combustion. The environmental damage is the result of the net change in pollutant emissions in the air basins, or regions, in which there is an impact. This change is the result of direct changes in powerplant or natural gas combustion emission resulting from the efficiency measures, and changes in emissions from other sources, that result from those direct changes in emissions.

- 2 The benefit of avoided transmission and distribution costs – energy efficiency measures that reduce the growth in peak demand would decrease the required rate of expansion to the transmission and distribution network, eliminating costs of constructing and maintaining new or upgraded lines.
- 3 The benefit of avoided generation costs – energy efficiency measures reduce consumption and hence avoid the need for generation. This would include avoided energy costs, capacity costs and a T&D line.
- 4 The benefit of increased system reliability: the reductions in demand and peak loads from customers opting for self generation, provide reliability benefits to the distribution system in the forms of:
  - avoided costs of supply disruptions
  - benefits to the economy of damage and control costs avoided by customers and industries who need greater than 99.9 level of reliable electricity service from the central grid since these industries depend on the electronics delivered from electrical systems.
  - marginally decreased System Operator’s costs to maintain a percentage reserve of electricity supply above the instantaneous demand
  - benefits to customers and the public of avoiding blackouts.
- 5 Non-energy benefits: Non-energy benefits might include a range of program-specific benefits such as saved water in energy-efficient washing machines or self generation units, reduced waste streams from an energy-efficient industrial process, etc.
- 6 Non-energy benefits for low income programs: The low income programs are social programs which have a separate list of benefits included in what is known as the ‘low income public purpose test’. This test and the specific benefits associated with this test are outside the scope of this manual.
- 7 Benefits of fuel diversity include considerations of the risks of supply disruption, the effects of price volatility, and the avoided costs of risk exposure and risk management.

#### *4.3 Strengths of the Total Resource Cost test*

The primary strength of the Total Resource Cost (TRC) test is its scope. The test includes total costs (participant plus program administrator) and also has the potential for capturing total benefits (avoided supply costs plus, in the case of the societal test variation, externalities). To the extent supply-side project evaluations also include total costs of generation and/or transmission, the TRC test provides a useful basis for comparing demand- and supply-side options.

Since this test treats incentives paid to participants and revenue shifts as transfer payments (from all ratepayers to participants through increased revenue requirements), the test results are unaffected by the uncertainties of projected average rates, thus reducing the uncertainty of the test results. Average rates and assumptions associated with how other options are financed (analogous to the issue of incentives for DSM programs) are also excluded from most supply-side cost determinations, again making the TRC test useful for comparing demand-side and supply-side options.

#### 4.4 Weakness of the Total Resource Cost test

The treatment of revenue shifts and incentive payments as transfer payments – identified previously as a strength – can also be considered a weakness of the TRC test. While it is true that most supply-side cost analyses do not include such financial issues, it can be argued that DSM programs *should* include these effects since, in contrast to most supply options, DSM programs do result in lost revenues.

In addition, the costs of the DSM ‘resource’ in the TRC test are based on the total costs of the program, including costs incurred by the participant. Supply-side resource options are typically based only on the costs incurred by the power suppliers.

Finally, the TRC test cannot be applied meaningfully to load building programs, thereby limiting the ability to use this test to compare the full range of demand-side management options.

#### Formulas:

The formulas for the net present value (NPV<sub>TRC</sub>)’ the benefit-cost ratio (BCR<sub>TRC</sub> and levelised costs are presented below:

$$NPV_{TRC} = B_{TRC} - C_{TRC}$$

$$BCR_{TRC} = B_{TRC} / C_{TRC}$$

$$LC_{TRC} = LCRC / IMP$$

Where

NPV<sub>TRC</sub> = Net present value of total costs of the resource

BCR<sub>TRC</sub> = Benefit-cost ratio of total costs of the resource

LC<sub>TRC</sub> = Levelised cost per unit of the total cost of the resource (cents per kWh for conservation programs; dollars per kW for load management programs)

B<sub>TRC</sub> = Benefits of the program

C<sub>TRC</sub> = Costs of the program

LCRC = Total resource costs used for levelising

IMP = Total discounted load impacts of the program

PCN = Net Participant Costs

The  $B_{TRC}$ ,  $C_{TRC}$ ,  $LCRC$ , and  $IMP$  terms are further defined as follows:

$$\begin{aligned}
 B_{TRC} &= \sum_{t=1}^N \frac{UAC_t + TC_t}{(1+d)^{t-1}} + \sum_{t=1}^N \frac{UAC_{at} + PAC_{at}}{(1+d)^{t-1}} \\
 C_{TRC} &= \sum_{t=1}^N \frac{PRC_t + PCN_t + UIC_t}{(1+d)^{t-1}} \\
 LCRC &= \sum_{t=1}^N \frac{PRC_t + PCN_t - TC_t}{(1+d)^{t-1}} \\
 IMP &= \frac{\sum_{t=1}^N \frac{I}{\sum_{i=1}^I [(\Delta EN_{it}) \text{ or } (\Delta DN_{it} \text{ where } i = \text{peak period})]}{(1+d)^{t-1}}}{(1+d)^{t-1}}
 \end{aligned}$$

(All terms have been defined in previous sections).

The first summation in the  $B_{TRC}$  equation should be used for conservation and load management programs. For fuel substitution programs, both the first and second summations should be used.

## 5 Program Administrator Cost Test

### 5.1 Definition

The Program Administrator Cost Test measures the net costs of a demand-side management program as a resource option based on the costs incurred by the program administrator (including incentive costs) and excluding any net costs incurred by the participant. The benefits are similar to the TRC benefits. Costs are defined more narrowly.

### 5.2 Benefits and costs

The benefits for the Program Administrator Cost Test are the avoided supply costs of energy and demand – the reduction in transmission, distribution, generation, and capacity valued at marginal costs – for the periods when there is a load reduction. The avoided supply costs should be calculated using net program savings, savings net of changes in energy use that would have happened in the absence of the program. For fuel substitution programs, benefits include the avoided supply costs for the energy-using equipment not chosen by the program participant only in the case of a combination utility where the utility provides both fuels.

The costs for the Program Administrator Cost Test are the program costs incurred by the administrator, the incentives paid to the customers, and the increased supply costs for the periods in which load is increased. Administrator program costs include initial and annual costs, such as the cost of utility equipment, operation and maintenance, installation, program administration, and customer dropout and removal of equipment (less salvage value). For fuel substitution programs, costs include the increased supply costs for the energy-using equipment chosen by the program participant only in the case of a combination utility, as above.

In this test, revenue shifts are viewed as a transfer payment between participants and all ratepayers. Though a shift in revenue affects rates, it does not affect revenue requirements, which are defined as the difference between the net marginal energy and capacity costs avoided and program costs. Thus, if  $NPV_{pa} > 0$  and  $NPVRIM < 0$ , the administrator's overall total costs will decrease, although rates may increase because the sales base over which revenue requirements are spread has decreased.

### *5.3 How the results can be expressed*

The results of this test can be expressed either as a net present value, benefit-cost ratio, or levelised costs. The net present value is the primary test, and the benefit-cost ratio and levelised cost are the secondary tests.

Net present value ( $NPV_{pa}$ ) is the benefit of the program minus the administrator's costs, discounted over some specified period of time. A net present value above zero indicates that this demand-side program would decrease costs to the administrator and the utility.

The benefit-cost ratio ( $BCR_{pa}$ ) is the ratio of the total discounted benefits of a program to the total discounted costs for a specified time period. A benefit-cost ratio above one indicates that the program would benefit the combined administrator and utility's total cost situation.

The levelised cost is a measure of the costs of the program to the administrator in a form that is sometimes used to estimate costs of utility-owned supply additions. It presents the costs of the program to the administrator and the utility on a per kilowatt, per kilowatt-hour, or per therm basis levelised over the life of the program.

### *5.4 Strengths of the Program Administrator Cost Test*

As with the Total Resource Cost test, the Program Administrator Cost test treats revenue shifts as transfer payments, meaning that test results are not complicated by the uncertainties associated with long-term rate projections and associated rate design assumptions. In contrast to the Total Resource Cost test, the Program Administrator Test includes only the portion of the participant's equipment costs that is paid for by the administrator in the form of an incentive. Therefore, for purposes of comparison, costs in the Program Administrator Cost Test are defined similarly to those supply-side projects which also do not include direct customer costs.

### 5.5 Weaknesses of the Program Administrator Cost Test

By defining device costs exclusively in terms of costs incurred by the administrator, the Program Administrator Cost test results reflect only a portion of the full costs of the resource.

The Program Administrator Cost Test shares two limitations noted previously for the Total Resource Cost test:

- 1 by treating revenue shifts as transfer payments, the rate impacts are not captured
- 2 the test cannot be used to evaluate load building programs.

#### Formulas

The formulas for the net present value, the benefit-cost ratio and levelised cost are presented below:

$$NPV_{pa} = B_{pa} - C_{pa}$$

$$BCR_{pa} = B_{pa} / C_{pa}$$

$$LC_{pa} = LC_{pa} / IMP$$

Where

$NPV_{pa}$  Net present value of Program Administrator costs

$BCR_{pa}$  Benefit-cost ratio of Program Administrator costs

$LC_{pa}$  Levelised cost per unit of Program Administrator cost of the resource

$B_{pa}$  Benefits of the program

$C_{pa}$  Costs of the program

$LC_{pc}$  Total Program Administrator costs used for levelising

$$B_{pa} = \sum_{t=1}^N \frac{UAC_t}{(1+d)^{t-1}} + \sum_{t=1}^N \frac{UAC_{at}}{(1+d)^{t-1}}$$

$$C_{pa} = \sum_{t=1}^N \frac{PRC_t + INC_t + UIC_t}{(1+d)^{t-1}}$$

$$LC_{pc} = \sum_{t=1}^N \frac{PRC_t + INC_t}{(1+d)^{t-1}}$$

(All variables are defined in previous chapters.)

The first summation in the Bpa equation should be used for conservation and load management programs. For fuel substitution programs, both the first and second summations should be used.

## Notes

- 1 Gross energy savings are considered to be the savings in energy and demand seen by the participant at the meter. These are the appropriate program impacts to calculate bill reductions for the Participant Test. Net savings are assumed to be the savings that are attributable to the program. That is, net savings are gross savings minus those changes in energy use and demand that would have happened even in the absence of the program. For fuel substitution and load building programs, gross-to-net considerations account for the impacts that would have occurred in the absence of the program.
- 2 It should be noted that if a demand-side program is beneficial to its participants ( $NPVp \geq 0$  and  $BCRp \geq 1.0$ ) using a particular discount rate, the program has an internal rate of return (IRR) of at least the value of the discount rate.
- 3 Some difference of opinion exists as to what should be called an incentive. The term can be interpreted broadly to include almost anything. Direct rebates, interest payment subsidies, and even energy audits can be called incentives. Operationally, it is necessary to restrict the term to include only dollar benefits such as rebates or rate incentives (monthly bill credits). Information and services such as audits are not considered incentives for the purposes of these tests. If the incentive is to offset a specific participant cost, as in a rebate-type incentive, the full customer cost (before the rebate must be included in the  $PC_1$  term).
- 4 If money is borrowed by the customer to cover this cost, it may not be necessary to calculate the annual mortgage and discount this amount if the present worth of the mortgage payments equals the initial cost. This occurs when the discount rate used is equal to the interest rate of the mortgage. If the two rates differ (e.g. a loan offered by the utility), then the stream of mortgage payments should be discounted by the discount rate chosen.
- 5 The Ratepayer Impact Measure Test has previously been described under what was called the 'Non-Participant Test.' The Non-Participant Test has also been called the 'Impact on Rate Levels Test.'
- 6 This test was previously called the All Ratepayers Test.
- 7 Many economists have pointed out that use of a market discount rate in social cost-benefit analysis undervalues the interests of future generations. Yet if a market discount rate is not used, comparisons with alternative investments are difficult to make.

## Appendix A

### *Inputs to equations and documentation*

A comprehensive review of procedures and sources for developing inputs is beyond the scope of this manual. It would also be inappropriate to attempt a complete standardisation of techniques and procedures for developing inputs for such parameters as load impacts, marginal costs, or average rates. Nevertheless, a series of guidelines can help to establish acceptable procedures and improve the chances of obtaining reasonable levels of consistent and meaningful cost-effectiveness results. The following 'rules' should be viewed as appropriate guidelines for developing the primary inputs for the cost-effectiveness equations contained in this manual:

- 1 In the past, marginal costs for electricity were based on production cost model simulations that clearly identify key assumptions and characteristics of the existing

generation system as well as the timing and nature of any generation additions and/or power purchase agreements in the future. With a deregulated market for wholesale electricity, marginal costs for electric generation energy should be based on forecast market prices, which are derived from recent transactions in California energy markets. Such transactions could include spot market purchases as well as longer term bilateral contracts and the marginal costs should be estimated based on components for energy as well as demand and/or capacity costs as is typical for these contracts.

- 2 In the case of submittals in conjunction with a utility rate proceeding, average rates used in DSM program cost-effectiveness evaluations should be based on proposed rates. Otherwise, average rates should be based on current rate schedules. Evaluations based on alternative rate designs are encouraged.
- 3 Time-differentiated inputs for electric marginal energy and capacity costs, average energy rates, and demand charges, and electric load impacts should be used for
  - load management programs
  - any conservation program that involves a financial incentive to the customer
  - any Fuel Substitution or Load Building program.Costing periods used should include, at a minimum, summer and winter, on-, and off-peak; further disaggregation is encouraged.
- 4 When program participation includes customers with different rate schedules, the average rate inputs should represent an average weighted by the estimated mix of participation or impacts. For General Rate Case proceedings it is likely that each major rate class within each program will be considered as program elements requiring separate cost-effectiveness analyses for each measure and each rate class within each program.
- 5 Program administration cost estimates used in program cost-effectiveness analyses should exclude costs associated with the measurement and evaluation of program impacts unless the costs are a necessary component to administer the program.
- 6 For DSM programs or program elements that reduce electricity and natural gas consumption, costs and benefits from both fuels should be included.
- 7 The development and treatment of load impact estimates should distinguish between gross (i.e. impacts expected from the installation of a particular device, measure, appliance) and net (impacts adjusted to account for what would have happened anyway, and therefore not attributable to the program). Load impacts for the Participants test should be based on gross, whereas for all other tests the use of net is appropriate. Gross and net program impact considerations should be applied to all types of demand-side management programs, although in some instances there may be no difference between gross and net.
- 8 The use of sensitivity analysis, i.e. the calculation of cost-effectiveness test results using alternative input assumptions, is encouraged, particularly for the following programs: new programs, programs for which authorisation to substantially change direction is being sought (e.g. termination, significant expansion), major programs

which show marginal cost-effectiveness and/or particular sensitivity to highly uncertain input(s).

The use of many of these guidelines is illustrated with examples of program cost-effectiveness contained in Appendix B.

## Appendix B

### *Summary of equations and glossary of symbols*

#### *I Basic Equations*

##### *Participant Test*

$$\begin{aligned} NPV_p &= B_p - C_p \\ NPV_{avp} &= (B_p - C_p) / P \\ BCR_p &= B_p / C_p \\ DP_p &= \min_j \text{ such that } B_j > C_j \end{aligned}$$

##### *Ratepayer Impact Measure Test*

$$\begin{aligned} LRI_{RIM} &= (C_{RIM} - B_{RIM}) / E \\ FRI_{RIM} &= (C_{RIM} - B_{RIM}) / E \quad \text{for } t = 1 \\ ARI_{RIMt} &= FRI_{RIM} \quad \text{for } t = 1 \\ &= (C_{RIMt} - B_{RIMt}) / E_t \quad \text{for } t=2, \dots, N \\ NPV_{RIM} &= B_{RIM} - C_{RIM} \\ BCR_{RIM} &= B_{RIM} / C_{RIM} \end{aligned}$$

##### *Total Resource Cost Test*

$$\begin{aligned} NPV_{TRC} &= B_{TRC} - C_{TRC} \\ BCR_{TRC} &= B_{TRC} / C_{TRC} \\ LC_{TRC} &= LCRC / IMP \end{aligned}$$

##### *Program Administrator Cost Test*

$$\begin{aligned} NPV_{pa} &= B_{pa} - C_{pa} \\ BCR_{pa} &= B_{pa} / C_{pa} \\ LC_{pa} &= LC_{pa} / IMP \end{aligned}$$

*II Benefits and costs*

*Participant Test*

$$B_p = \sum_{t=1}^N \frac{BR_t + TC_t + INC_t}{(1+d)^{t-1}} + \sum_{t=1}^N \frac{AB_{at} + PAC_{at}}{(1+d)^{t-1}}$$

$$C_p = \sum_{t=1}^N \frac{PC_t + BI_t}{(1+d)^{t-1}}$$

*Ratepayer Impact Measure Test*

$$B_{RIM} = \sum_{t=1}^N \frac{UAC_t + RG_t}{(1+d)^{t-1}} + \sum_{t=1}^N \frac{UAC_{at}}{(1+d)^{t-1}}$$

$$C_{RIM} = \sum_{t=1}^N \frac{UIC_t + RL_t + PRC_t + INC_t}{(1+d)^{t-1}} + \sum_{t=1}^N \frac{RL_{at}}{(1+d)^{t-1}}$$

$$E = \sum_{t=1}^N \frac{E_t}{(1+d)^{t-1}}$$

*Total Resource Cost Test*

$$B_{TRC} = \sum_{t=1}^N \frac{UAC_t + TC_t}{(1+d)^{t-1}} + \sum_{t=1}^N \frac{UAC_{at} + PAC_{at}}{(1+d)^{t-1}}$$

$$C_{TRC} = \sum_{t=1}^N \frac{PRC_t + PCN_t + UIC_t}{(1+d)^{t-1}}$$

$$L_{TRC} = \sum_{t=1}^N \frac{PRC_t + PCN_t - TC_t}{(1+d)^{t-1}}$$

$$IMP = \sum_{t=1}^n \frac{[\sum_{i=1}^n \Delta EN_{it}] \text{ or } (\Delta DN_{it} \text{ where } I = \text{peak period})}{(1+d)^{t-1}}$$

NOTE:  
June 17 -  
- correct  
-- should  
these 'n'  
be

$$(1+d)^{t-1}$$

*Program Administrator Cost Test*

$$B_{pa} = \sum_{t=1}^N \frac{UAC_t}{(1+d)^{t-1}} + \sum_{t=1}^N \frac{UAC_{at}}{(1+d)^{t-1}}$$

$$C_{pa} = \sum_{t=1}^N \frac{PRC_t + INC_t + UIC_t}{(1+d)^{t-1}}$$

$$LCPA = \sum_{t=1}^N \frac{PRC_t + INC_t}{(1+d)^{t-1}}$$

*III Glossary of symbols*

$AB_{at}$	=	Avoided bill reductions on bill from alternate fuel in year t
$AC:D_{it}$	=	Rate charged for demand in costing period i in year t
$AC:E_{it}$	=	Rate charged for energy in costing period i in year t
$ARI_{RIM}$	=	Stream of cumulative annual revenue impacts of the program per unit of energy, demand, or per customer. Note that the terms in the ARI formula are not discounted, thus they are the nominal cumulative revenue impacts. Discounted cumulative revenue impacts may be calculated and submitted if they are indicated as such. Note also that the sum of the discounted stream of cumulative revenue impacts does not equal the $LRI_{RIM}^*$
$BCR_p$	=	Benefit-cost ratio to participants
$BCR_{RIM}$	=	Benefit-cost ratio for rate levels
$BCR_{TRC}$	=	Benefit-cost ratio of total costs of the resource
$BCR_{pa}$	=	Benefit-cost ratio of program administrator and utility costs
$BI_t$	=	Bill increases in year t
$B_j$	=	Cumulative benefits to participants in year j
$B_p$	=	Benefit to participants
$B_{RIM}$	=	Benefits to rate levels or customer bills
$BR_t$	=	Bill reductions in year t
$B_{TRC}$	=	Benefits of the program
$B_{pa}$	=	Benefits of the program

$C_j$	=	Cumulative costs to participants in year $i$
$C_p$	=	Costs to participants
$C_{RIM}$	=	Costs to rate levels or customer bills
$C_{TRC}$	=	Costs of the program
$C_{pa}$	=	Costs of the program
$d$	=	discount rate
$\Delta DG_{it}$	=	Reduction in gross billing demand in costing period $i$ in year $t$
$\Delta DN_{it}$	=	Reduction in net demand in costing period $i$ in year $t$
$DP_p$	=	Discounted payback in years
$E$	=	Discounted stream of system energy sales - (kWh or therms) or demand sales (kW) or first-year customers
$\Delta EG_{it}$	=	Reduction in gross energy use in costing period $i$ in year $t$
$\Delta EN_{it}$	=	Reduction in net energy use in costing period $i$ in year $t$
$E_t$	=	System sales in kWh, kW or therms in year $t$ or first year customers
$FRI_{RIM}$	=	First-year revenue impact of the program per unit of energy, demand, or per customer.
$IMP$	=	Total discounted load impacts of the program
$INC_t$	=	Incentives paid to the participant by the sponsoring utility in year $t$
		First year in which cumulative benefits are $\geq$ cumulative costs.
$K_{it}$	=	1 when $\Delta EG_{it}$ or $\Delta DG_{it}$ is positive (a reduction) in costing period $i$ in year $t$ , and zero otherwise
$LCRC$	=	Total resource costs used for levelising
$LC_{TRC}$	=	Levelised cost per unit of the total cost of the resource
$LCPA$	=	Total Program Administrator costs used for levelising
$LC_{pa}$	=	Levelised cost per unit of program administrator cost of the resource
$LRI_{RIM}$	=	Lifecycle revenue impact of the program per unit of energy (kWh or therm) or demand (kW) - the one-time change in rates - or per customer – the change in customer bills over the life of the program.
$MC:D_{it}$	=	Marginal cost of demand in costing period $i$ in year $t$
$MC:E_{it}$	=	Marginal cost of energy in costing period $i$ in year $t$
$NPV_{avp}$	=	Net present value to the average participant
$NPV_P$	=	Net present value to all participants
$NPV_{RIM}$	=	Net present value levels
$NPV_{TRC}$	=	Net present value of total costs of the resource

$NPV_{pa}$	=	Net present value of program administrator costs
$OBI_t$	=	Other bill increases (i.e. customer charges, standby rates).
$OBR_t$	=	Other bill reductions or avoided bill payments (e.g. customer charges, standby rates).
$P$	=	Number of program participants
$PAC_{at}$	=	Participant avoided costs in year t for alternate fuel devices
$PC_t$	=	Participant costs in year t to include: <ul style="list-style-type: none"> <li>• Initial capital costs, including sales tax</li> <li>• Ongoing operation and maintenance costs</li> <li>• Removal costs, less salvage value</li> <li>• Value of the customer's time in arranging for installation, if significant</li> </ul>
$PRC_t$	=	Program Administrator program costs in year t
$PCN$	=	Net Participant Costs
$RG_t$	=	Revenue gain from increased sales in year t
$RL_{at}$	=	Revenue loss from avoided bill payments for alternate fuel in year t (i.e., device not chosen in a fuel substitution program)
$RL_t$	=	Revenue loss from reduced sales in year t
$TC_t$	=	Tax credits in year t
$UAC_{at}$	=	Utility avoided supply costs for the alternate fuel in year t
$UAC_t$	=	Utility avoided supply costs in year t
$PA_t$	=	Program Administrator costs in year t
$UIC_t$	=	Utility increased supply costs in year t

## Appendix C

### *Derivation of rim lifecycle revenue impact formula*

Most of the formulas in the manual are either self explanatory or are explained in the text. This appendix provides additional explanation for a few specific areas where the algebra was considered to be too cumbersome to include in the text.

### *Rate Impact Measure*

The Ratepayer Impact Measure lifecycle revenue impact test ( $LRI_{RIM}$ ) is assumed to be the one-time increase or decrease in rates that will re-equate the present valued stream of revenues and stream of revenue requirements over the life of the program.

Rates are designed to equate long-term revenues with long-term costs or revenue requirements. The implementation of a demand-side program can disrupt this equality by

changing one of the assumptions upon which it is based: the sales forecast. Demand-side programs by definition change sales. This expected difference between the long-term revenues and revenue requirements is calculated in the  $NPV_{RIM}$ . The amount which present valued revenues are below present valued revenue requirements equals  $-NPV_{RIM}$ .

The  $LRI_{RIM}$  is the change in rates that creates a change in the revenue stream that, when present valued, equals the  $-NPV_{RIM}$ \*. If the utility raises (or lowers) its rates in the base year by the amount of the  $LRI_{RIM}$ , revenues over the term of the program will again equal revenue requirements. (The other assumed changes in rates, implied in the escalation of the rate values, are considered to remain in effect.)

Thus, the formula for the  $LRI_{RIM}$  is derived from the following equality where the present value change in revenues due to the rate increase or decrease is set equal to the  $-NPV_{RIM}$  or the revenue change caused by the program.

$$-NPV_{RIM} = \sum_{t=1}^N \frac{LRI_{RIM} \times E_t}{(1+d)^{t-1}}$$

Since the  $LRI_{RIM}$  term does not have a time subscript, it can be removed from the summation, and the formula is then:

$$-NPV_{RIM} = LRI_{RIM} \times \sum_{t=1}^N \frac{E_t}{(1+d)^{t-1}}$$

Rearranging terms, we then get:

$$LRI_{RIM} = -NPV_{RIM} / \sum_{t=1}^N \frac{E_t}{(1+d)^{t-1}}$$

Thus,

$$E = \sum_{t=1}^N \frac{E_t}{(1+d)^{t-1}}$$

## Appendix A

### SPM Spread Sheet

#### **Purpose**

These worksheets, developed by the California Interagency Green Accounting Working Group, are designed to calculate the various cost-benefit tests as prescribed in the *Standard Practice Manual: Economic Analysis of Demand-Side Programs and Projects* (October, 2001). Currently in place on the sheets are examples of the application of the cost effectiveness tests to various self-generation and energy efficiency programs. Future versions of this workbook may include sample calculations for load management programs.

#### **Using the Spreadsheet**

The input values in the worksheets can be modified for those who wish to use these worksheets to evaluate the cost-effectiveness of an actual energy efficiency or self-generation program or project. All values that should be modified are in blue. Changes in the input values on these worksheets to conduct analyses of actual programs will produce cost-benefit results that conform with the *SPM*.

All other values in black or red; any changes to the formulas or values in the black cells may produce cost-effectiveness results that do not conform with the *SPM*.

#### **Avoided Costs**

The avoided cost values used in the analysis in this spreadsheet--the primary parameter for establishing the benefits of reduced purchases of electricity from the central grid--are based on long term forecasts developed in the year 2000, and are currently used to estimate the lifecycle costs and benefits of energy efficiency and self generation programs under the regulatory oversight of the California Public Utilities Commission. When these avoided cost forecasts are updated, the updated forecasts will be incorporated into this spreadsheet by replacing the values shown in the Avoided Cost worksheet.

**Appendix B****List of Co-Authors**

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