EUROPEAN BENEFIT/COST (EUBC) ANALYSIS METHODOLOGY FOR ENERGY EFFICIENCY PROGRAMS

Ståle E. Johansen, SRC International ApS, Copenhagen, Denmark
David T. Hoog, SRC International Inc., Bala Cynwyd, Philadelphia, USA

SYNOPSIS

This paper summarises a joint European effort to develop methodology that is able to evaluate the cost-effectiveness of DSM and energy efficiency services programs over a variety European utility industry, market and regulatory structures.

ABSTRACT

DSM programs have been implemented in several countries, under various regulatory, utility industry, and market structures, and they have been performed for very diverse reasons to achieve different goals. For this reason, one single cost-effectiveness methodology will not be relevant for all situations. Many attempts to establish benefit/cost (B/C) procedures -- or transfer procedures developed in other contexts -- have failed because these factors were not appropriately addressed. There are at least four critical issues regarding DSM programs that must be addressed initially. These are: (1) Defining the major characteristics of the environment in which the DSM program is being implemented. This includes describing the market type, utility structure, and regulation type, (2) Defining the role of government, utility industry and third party in performing DSM programs. (3) Defining main motivation fro implementing DSM and energy efficiency services programs. For example, are activities performed as a part of public policy to achieve a public policy goal, or as part of a utility strategic marketing program to increase market share and profitability, (4) What is the method for implementing the energy efficiency program? Rebates or information only? Bundled, as part of a kWh sales contract, or offered as a separate service?

This paper summarises an effort undertaken by the European Commission (DG 17) in co-operation with a cross-section of European utility experts. The principal objective is to develop methodology that is able to estimate the benefits and costs of DSM and energy efficiency services programs and to evaluate the cost-effectiveness of such activities. The methodology must be able to compare the cost-effectiveness of individual activities and be robust over a variety European utility industry, market and regulatory structures. The paper establishes a framework for addressing the questions (1)-(4), it identifies the outcomes that can be measured as a part of the cost-effectiveness evaluation, it indicates the steps that must be performed in order to apply the framework and to perform the B/C evaluations. The paper also illustrates possible application of B/C methodology to specific utility industry structure, market structure and regulatory type.

INTRODUCTION

Background

DSM and energy efficiency services options are opportunities to increase the efficiency of energy service delivery that, for some reason, are not being fully taken advantage of in the market. To make use of these options, special activities are required — DSM and energy efficiency services programs. These activities try to mobilise customers to realise cost-effective efficiency energy service improvements, thereby potentially providing significant utility, societal, and customer benefits in terms of reducing long-term costs of meeting energy needs, minimising the negative environmental impacts associated with electricity production, and increasing customer value. Without such programs, these improvements may not have occurred, or would have materialised only with significant delay.

DSM and energy efficiency services programs have been implemented in several countries, under various regulatory, utility industry, and market structures, and they have been performed for very diverse reasons to achieve different goals. For this reason, one single cost-effectiveness methodology will not be relevant for all situations. Many attempts to establish benefit/cost (B/C) procedures -- or transfer procedures developed in other contexts -- have failed because these factors were not appropriately addressed. There are at least four critical issues regarding DSM programs that must be addressed initially. These are illustrated as "Phase I: B/C Framework" in Figure 1 "Overview of Study Approach".

Without an established understanding of these issues it would be impossible to perform a meaningful discussion of how to improve methods for benefit/cost evaluation of DSM programs. This can be seen through the evolution of the applications of the "California Standard Practice" (California Public Utilities Commission (CPUC) and California Energy Commission (CEC) 1987) which defines in detail many of the calculations that are useful for evaluating DSM programs from various perspectives. In this commonly used methodology, the equations are explicit, but the framework for applying them is not. The terms in the equations include implicit assumptions about the types of utility structure (vertically integrated utilities operating in a regulated franchise market), and is not applicable to many types of DSM programs, especially those involving fuel-switching and increases in load. These are very important current considerations for European utilities. This emphasises the need to take a step back in our study approach and first analyse the framework in which the benefit-cost analysis is to take place. Without doing this, the results of such analysis would be of limited value. After this is done, the precise calculations can be defined with more confidence and broader understanding. Our study recognises this, and therefore devotes attention to establishing a robust framework for B/C analysis of DSM and energy efficiency services programs.

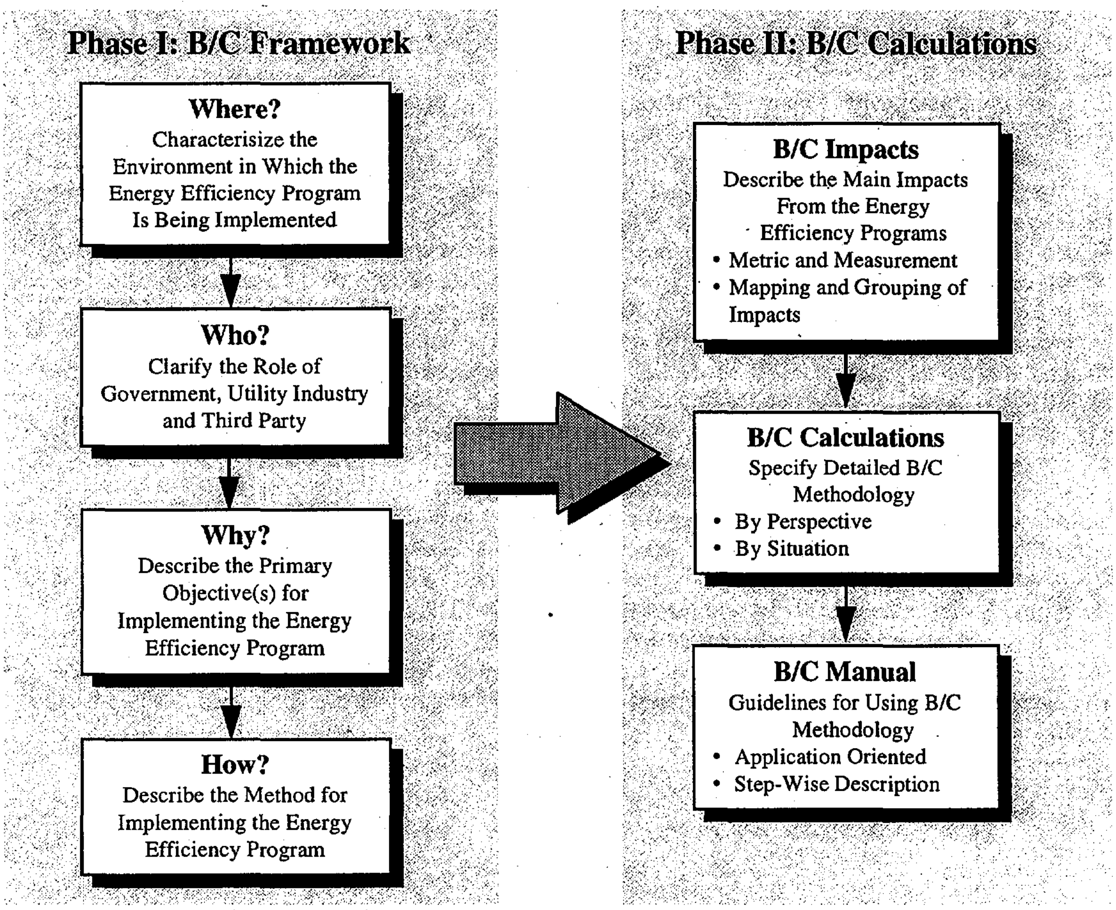


Figure 1 Overview of EUBC Study Approach

EUBC Study Objectives

The principal objective of this study is to develop methodology that is able to estimate the benefits and costs of DSM programs to stakeholders (e.g., utilities, customers, and society as a whole). The methodology must be able to compare the cost-effectiveness of DSM options and be robust over a variety of European utility industry, market and regulatory structures. The main focus of attention is on DSM/energy efficiency programs implemented through the utility industry, but the framework recognises the important role of third party -- customer energy service market and energy service companies (ESCOs). EUBC Phase I study objectives include:

- **Develop robust and applicable framework for B/C Analysis.** A general framework should be identified that can apply to all situations, but the specific analysis to be performed will be country-specific

- **Clarify perspectives.** The methodology must clarify different roles and perspectives of utility industry, customers, government and third party -- under different regulatory, industry and market structures

- **Recognise a competitive environment.** The EU commission wishes to increase competition in traditionally monopolistic industries by removing barriers to intra-community trade. This also means to assist utilities in developing strategies which are oriented towards satisfying customers while at the same time improving the operational efficiency, as well as the integration of supply and demand side elements of their business.

EUBC Phase I addresses the general questions that must be discussed upfront, it establishes a framework for addressing these questions, and it identifies the outcomes that could be measured as part of the cost-effectiveness evaluation. Phase II specifies the detailed calculations that must be performed in order to apply this general framework. EUBC Phase II objectives includes:

- **Specify the detailed B/C calculations.** This must be addressed consistent with the framework presented in this phase I report. Each of the evaluation impacts will be broken down into the individual data elements that need to be examined. Equations that can be used in the analysis must then be defined as a function of these data elements

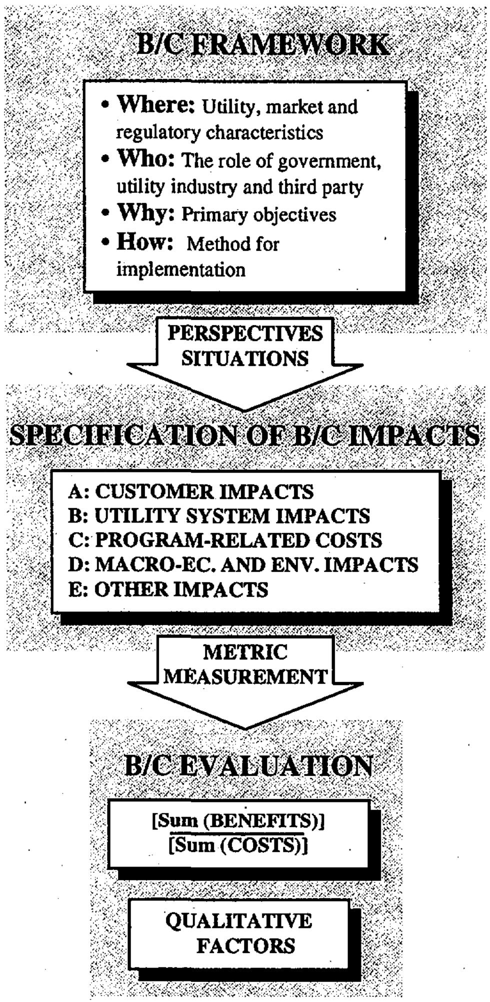
- **Indicate appropriate methodology by situation.** The specific calculations selected will depend on (1) major factors (where) and (2) major perspectives (who). It must be indicated how the situation will determine methodology and B/C components to be included into calculations

- **Provide specific case studies.** Demonstrative examples will be developed to illustrate applications of the analysis methodology for specific DSM activities

- **Develop Benefit/Cost manual.** A manual will describe the steps involved in performing B/C calculations of energy efficiency programs and will provide guidelines for application of methodology to different situations and from relevant perspectives

Outline of this Paper

This paper summarises and describes the main findings from the EUBC effort undertaken by a cross section of European utility experts. The paper establishes a framework for addressing key questions that has to be addressed upfront, it identifies and categorises the impacts (benefits and costs) that can be measured as a part of the cost-effectiveness evaluation, it indicates the steps that must be performed in order to apply the framework and to perform the B/C evaluations. The paper also illustrates the possible application of B/C methodology to specific utility industry structures, market structures and regulatory types. An overview of the B/C evaluation process is provided in Figure 2. This paper will follow this structure, a full description of each step is provided in SRC International 1995.



EUBC Phase I: Framework for B/C calculations

In order to meaningfully discuss the cost effectiveness of energy efficiency programs, it is necessary to establish a robust framework for this discussion. Each element in the framework must be addressed upfront. Such a framework was established in Phase I of this effort "Framework for B/C analysis" and is further described in SRC International 1994 and in Johansen, Hoog 1994. The elements of this framework is briefly summarised in Figure 1 and in the following.

- **The Effects from the Utility Market Situation on B/C Evaluations (Where).** The major characteristics of the environment in which the DSM and energy efficiency services programs are being implemented must be described — particularly for those efforts undertaken by the utility. Broadly speaking, these factors can be grouped into three categories of (1) Energy market characteristics and structure[1], e.g., competitive versus franchised energy market. (2) Utility industry structure, including the degree of vertical integration, single energy versus combination utility, public versus private ownership and the Degree of industry fragmentation (i.e., number of players found in the utility industry). (3) Regulatory type, for example, self regulation at the enterprise level, industry code of conduct with regulatory oversight, or external regulation by a body, independent of the industry

- **Major Perspectives And Motivation For Implementing Dsm Programs (Who And Why).** Perspectives include (1) Customer perspective, (2) Utility industry perspective, (3) Government perspective and (4) Third party perspective

[1] Another important market -- which structure and characteristics will affect DSM efforts -- is the market for customer energy services. Actors in this market include appliance manufacturers and retailers, building designers and architects.

- **Methods For Implementing Dsm Programs (How).** Methods for implementing DSM can include, general information, site-specific information, demonstration campaigns, financial incentives to end-use customers, voluntary or mandatory labelling, incentives to manufacturers, equipment and/or building standards, esco implementation, co-operation between government, utility industry and other manufacturers, research & development, warranties, financing, leasing

SPECIFICATION OF B/C IMPACTS

As illustrated in Figure 2, all relevant impacts (benefits of costs) to be included into the B/C analysis must be identified and specified. This section provides an overview of relevant impacts, as well as a suggested grouping [SIAD1]. The impacts may be economic, environmental, and/or social in nature and may be directly linked to the utility sector or external costs. There will also be primary, secondary, and other downstream impacts. The study has determined that not all of these impacts can be computed, and that some of these impacts should therefore be measured qualitatively.2

Grouping of B/C Impacts Into Families

As indicated in Figure 2, B/C impacts that should be examined in the cost-effectiveness analysis can be grouped into the following five general categories or "families":

Family ACustomer Impacts — changes in the manner and/or cost of how customers use energy

Family BUtility System Impacts — changes in the manner and/or cost of how energy is supplied

Family CProgram-related Impacts — Costs incurred by implementing the program

Family DMacro-economic and Environmental Impacts — Impacts affecting the economy in a broad sense or the local or global environment

Family EOther Impacts — other impacts that could be considered, but may be more esoteric

The categorisations are intended to make the presentation and descriptions of the impacts more manageable. A listing of all impacts included into each family is provided in Table 1. The analyst may prefer to make his/her own grouping of impacts for the specific analysis. A description of each impact is provided in SRC International 1995.

Family A Customer Impacts	Family B Utility System Impacts	Family C Program-related Impacts	Family D Macro-ec. and Env. Impacts	Family E Other Impacts
Consumption of Other Fuels	Generation Capacity Costs	Non-Utility Program Cost	Anti-Competitiveness and Market Interference	Ease of Evaluation
Customer O&M	Transmission Capacity Costs	Third Party Incentives	Diminishment of Natural Resources	Ease of Implementation
Customer Value	Distribution Capacity Costs	Tax Credits	Environmental Effects of Supply	Current Level of Market Activity
Customer Bills	Transmission and Distribution Losses	Utility Program Cost	Environmental Effects of Consumption	Manufacturer Market Share
Customer Capital Investment	Controllability of Load	Utility Incentive Payments	Regional Employment	Proven Performance
Industrial Productivity	Energy Costs	Utility Revenue	Tariff Changes	Public Image
Other Customer Transaction Costs	Power Purchase Cost			Cash Flow
Taxes	Risk and Reliability			Utility Market Share
Third Party incentives				Availability of Capital

Metric and Measurement

Following the logic from Figure 2, the next step in the analysis process is to decide on an appropriate metric and measurement for each B/C impact. By metric and measurement we mean the following:

[2] It is important to remember that we are only interested in the *incremental* impacts that result from the energy efficiency program activity. Because there are many impacts, it is important to be sure not to double-count the same effect.

Following the logic from Figure 2, the next step in the analysis process is to decide on an appropriate metric and measurement for each B/C impact. By metric and measurement we mean the following:

- **Metric.** The specific metric(s) that can be used for each impact. The metrics can be measured on three different levels. The levels that are relevant for each impact are provided. The levels of metrics are:

  (1) *Qualitative* - impacts that are purely judgmental in nature. There can be a relative ranking (such as low, medium, high), but no numeric computations are performed.
  (2) *Quantitative* - a numerical value is provided, which allows ranking of options, but the value cannot be easily added as a component of a financial benefit-cost computation.
  (3) *Monetized* - impacts are measured in ECU or other monetary equivalent. This could be a direct financial calculation or a monetization of a non-financial variable.

- **Measurement.** For some impacts it is possible to indicate how to measure the specific impact. That is, where appropriate, generic equations are included showing how the impact may be measured to be included into a B/C calculation.

A description of each measurement is provided in the EUBC Phase II study report (SRC International 1995). Illustration of the use and interpretation of impact-measurements in the B/C calculations is provided in subsequent sections of this paper. The use will largely depend on situation at hand and perspective taken.

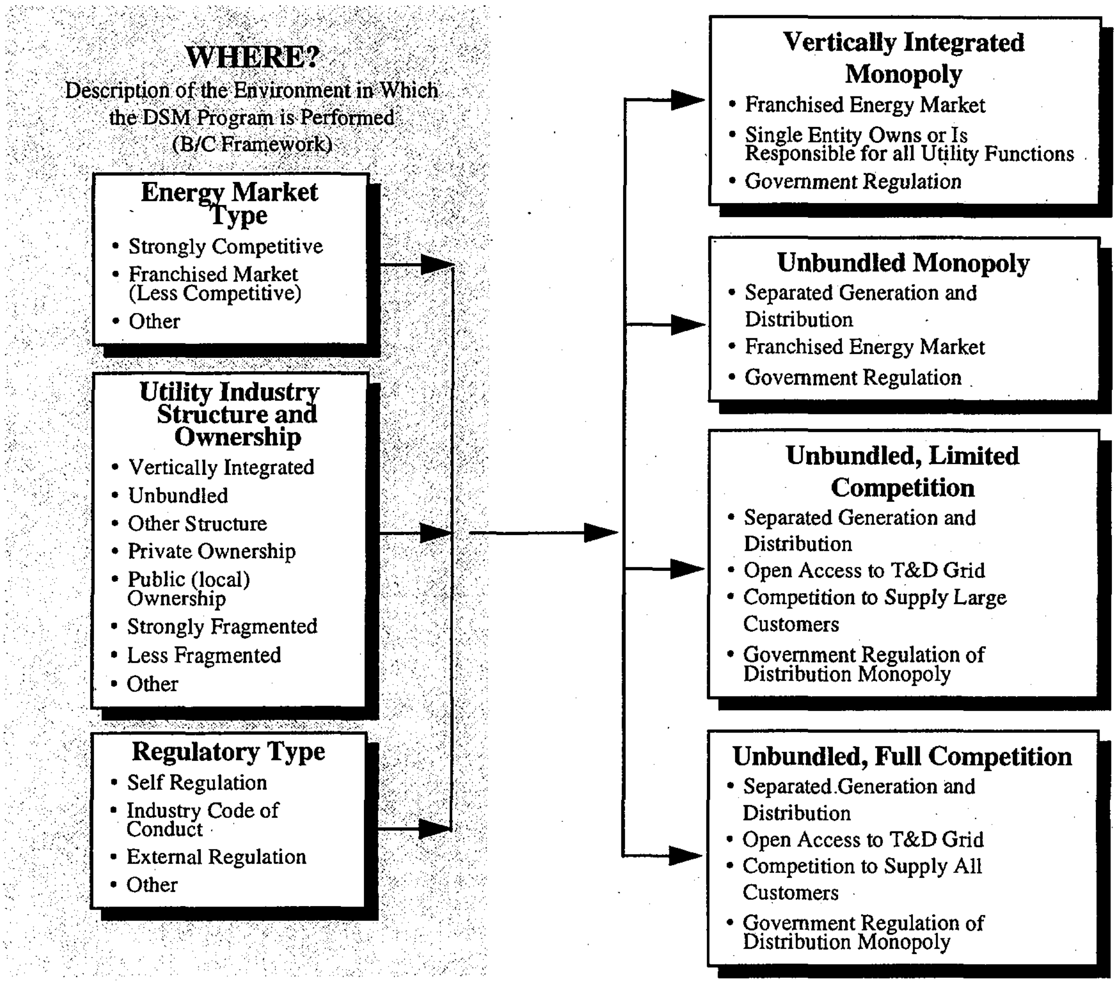
EXAMPLE OF MAPPING B/C IMPACTS TO GENERIC MARKET-UTILITY SITUATIONS

One unique effort of the EUBC study is that it offers a framework for classifying key factors and for discussing their potential impact on B/C evaluations. Each European country represent its own unique situation and, as such, the B/C framework may be used to define a large number of situations. It is impossible to discuss every single situation that can be constructed, therefore we use a limited set of generic, rather than country specific, situations. From these generic situations the analyst can select the one of the four that fits best to the specific situation to be analysed, possibly with making appropriate modifications.3 This section discusses a set of generic situations and a mapping of B/C impacts to these situations.

Description of Generic Situations

The generic situations are created to (1) represent the most important characteristics of current restructuring trends, and (2) illustrate the major characteristics that are likely to impact the approach to evaluating the cost-effectiveness of energy efficiency programs. The situations range from vertical integration and monopoly (situation 1) to unbundled industry structure with full competition (situation 4). Each situation is not designed to fit one country's market structure, utility industry structure or regulation in particular, but rather be generic and represent a close correspondence with the situations in representative European countries. An overview of this approach and the link between B/C framework and generic situations is provided in Figure 3.

[3] A similar approach was taken in UNIPEDE 1994 and in IEA DSM Programme 1995. In the EUBC study we attempt to use as consistent and comparable definitions as possible.



Mapping of Impacts to perspectives: Example of two situations
Following the logic from Figure 2, the specific B/C evaluation and B/C equations are best defined through a series of examples. These examples are best considered as illustrations from which additions, subtractions, or modifications can be made. Therefore, every B/C analysis performed does not have to look exactly like the one shown here. For purposes of brevity in the paper, only two mapping examples are given here (1) in the case of "unbundled monopoly," and (2) in the case of "unbundled full competition."

Assume an electric conservation program being implemented by a distribution utility for the purpose of promoting customer loyalty and providing social benefits through more efficient use of electricity. Assume that the program is an information-based campaign promoting an energy efficient water heater. We assume that this one-year program saves 500 kWh per year (0.1 kW peak demand reduction) for a single participant, and that there are 1,000 participants in that year (of whom, 25% would have bought the efficient equipment without the program). Many of the following assumptions are grossly simplified, and are only meant to be illustrative. Assumptions include:

- Incremental cost of efficient water heater = ECU 250
- Present value of 1 kWh saved = ECU 1
- Present value of 1 kW of generation capacity = ECU 150
- Present value of 1 kW of transmission capacity = ECU 25
- Present value of 1 kW of distribution capacity = ECU 75
- Present value of bill savings per kWh = ECU 2 (including .5 tax)
- Distribution utility purchases power at 20% above generation cost
- Environmental impact of generation =ECU 0.1 per kWh

There are 6 primary perspectives that should be examined in the analysis of situation (1); Participating Customer, Non-participating Customer, Wholesale Utility, Distribution Utility, Government, and Society. For situation (2), there will also be additional utility perspectives. The perspectives selected for any actual analysis can vary from these.

Perspective	Included In Primary Equation	Otherwise Accounted
Participating Customer	Change In Bill Productivity Capital Investment Equipment O&M Consumption of Other Fuels Utility Incentives Other Incentives Tax Credits Taxes Other Transaction Costs (*) Value Changes (*) Tariff Changes (*)	Proven Performance Ease Of Implementation Availability Of Capital (Other Transaction Cost (*)) (Value Changes (*))
Non-participating Customer	Utility Revenue Change Utility Program Cost Utility Incentive Payments Power Purchase Costs Distribution Capacity Costs Tariff Changes (*)	(Tariff Changes (*))
Wholesale Utility (Generation Utility)	Energy Costs Generation Capacity Cost Transmission Cap Cost Power Purchase Revenue Wholesale Utility Program Costs Wholesale Utility Incentive Payments Risk and Reliability (*)	Public Image (Risk And Reliability (*))
Distribution Utility	Power Purchase Cost Utility Revenue Distribution Capacity Cost Distribution Utility Program Costs Distribution Utility Incentive Payments Effects Of Tariff Changes (*)	Market Share Vs. Other fuels Public Image Proven Performance Ease Of Implementation Ease Of Evaluation Availability Of Capital Cash Flow (Effects of tariff Changes(*))
Government	Tax Revenues Govt. Program Costs Tax credits Environmental Effects Of Supply (*) Environmental Effects Of Consumption (*)	Productivity Employment Public Image Diminishment Of Natural Resources Anti-Competitiveness (Environmental Effects Of Supply (*)) (Environmental Effects of Consump. (*))
Society	Utility Program Costs Govt. Program Costs 3rd Party Program Cost Environmental. Effects Of Supply (*) Environmental. Effects Of Consumption (*) Effects Of Tariff Changes (*)	Productivity Employment Diminishment Of Natural Resources Anti-Competitiveness (Environmental. Effects Of Supply (*)) (Environmental. Effects of Consump. (*)) (Effects Of Tariff Changes (*))

Tables 2 and 3 list the impacts for each perspective in the respective two situations (1) and (2). Impacts marked with a (*) indicate that they should be included in the primary equation if they are translated into monetary equivalents. Otherwise, they should be considered along with other non-Monetized impacts (the right-had column). In the tables, impacts that would have a zero value for the specific program discussed are crossed off so that they do not have to be carried through the analysis.

Perspective	Included In Primary Equation	Otherwise Accounted
Participating Customer	Change In Bill Productivity Capital Investment Equipment O&M Consumption of Other Fuels Utility Incentives Other Incentives Tax Credits Taxes Other Transaction Costs (*) Value Changes (*) Tariff Changes (*)	Proven Performance Ease Of Implementation Availability Of Capital (Other Transaction Cost (*)) (Value Changes (*))
Non-Participating Customer	Utility Revenue Change Utility Program Cost Utility Incentive Payments Power Purchase Costs Distribution Capacity Costs Tariff Changes (*)	(Tariff Changes (*))
Wholesale Utility (Generation Utility)	Energy Costs Generation Capacity Costs Transmission Capacity Costs Power Purchase Revenue Generation Utility Program Costs Generation Utility Incentives Risk and Reliability (*)	Market share (wholesale) Public Image (Risk and Reliability (*))
Retail Supplier	Power Purchase Costs Revenue Retail Supplier Program Costs Retail Supplier Incentives	Market Share Public Image Proven Performance
Distribution Utility (Monopoly)	Distribution Utility Revenue Distribution Capacity Costs Distribution Utility Program Costs Distribution Utility Incentives Payments	Effects of Distribution Tariff Changes Public Image Proven Performance Ease of Implementation Ease of Evaluation
Government	Tax Revenues Government Program Costs Tax Credits Environmental Effects Of Supply (*) Env. Effects Of Consump. (*)	Industrial Productivity Regional Employment Public Image Diminishment of Natural Resources Anti-Competitiveness (Environmental Effects of Energy Supply (*)) (Env. Effects of Energy Consump. (*))
Societal	Energy Costs Generation Capacity Cost Transmission Capacity Cost Distribution Capacity Cost Utility Program Costs Government Program Costs Third Party Program Costs Environmental Effects Of Supply (*) Env. Effects Of Consump. (*) Effects of (Distr.) Tariff Changes (*)	Industrial Productivity Employment Diminishment of Natural Resources (Effects of (Distr.) Tariff Changes (*)) (Environmental Effects of Energy Supply (*)) (Env. Effects of Energy Consump. (*))

The study report (SRC International 1995) contains more detailed and in-depth interpretations of the above tables which help in forming different perspectives, and provides further guidance in performing the actual B/C analysis.
Interpretation of Impacts for Situation (1): Unbundled Monopoly
As indicated in Figure 2, the presentation of the result would contain two pieces - the metric (NPV or B/C ratio or other) using the positive and negative impacts from the first column, and a description of other impacts in the second column. With this approach, valuable information about the program is not lost just because it is not expressed in a monetary unit. Multiple metrics can also be presented for the primary equation.

Participating Customer Perspective

Change in Bill - The participating customer will reduce energy consumption, which will reduce the energy bill. This is 500 kWh x 1.5 = 750 per participant.

Taxes - Energy taxes associated with the reduced consumption will also be reduced.. This is 500 kWh x 0.5 = 250 per participant.

Capital Investment - Any costs incurred for making the efficiency improvement, including any installation costs. If the investment is financed, the interest charges are a cost. If it is a replacement of equipment that would have been replaced anyway, only the incremental cost for the energy efficiency should be counted. This is 250 per participant.

Equipment O&M - If there are additional operating costs or maintenance requirements, these will be costs. Only the incremental cost from the base option should be counted. O&M costs are the same for both, so this cost is 0.

Other Transaction Costs - The value of the time invested in researching the decision and arranging the change in equipment would be a cost to a commercial or industrial customer. It is possible that a residential customer would also incur a direct cost for time spent (for example, staying home from work for an installation or delivery). This is a replacement program, so the time spent by the customer is the same. Therefore zero cost.

Effects of Tariff Changes - If the distribution utility changes the retail price as a result of the program, customers may change consumption patterns, potentially resulting in a loss of the consumer surplus that would have been obtained. This effect is assumed to be small compared to the benefits for the participants, but there is an impact on non-participants [see below].

Productivity - For residential customers, there should be no effect. For commercial or industrial customers, the cost reduction could result in reduced productivity (for example, if lighting levels are reduced). Zero for this program.

Consumption of Other Fuels - Since this is a conservation measure, there would not be additional consumption of another fuel. In some cases, however, it is possible to have an indirect effect. For example, if lighting energy is reduced, you may need additional space heating. If heating is supplied by electricity, this would have to be netted from the direct electricity savings from the lighting improvement.
Utility Incentive Payments - There are no payments from the utility to the customer, as it is an information-based program. If the utility offered financing for efficiency investments, the present value of the loan (using the customer's economic cost of capital) would be considered an incentive.

Other Incentives - There are no direct payments from other parties, such as government loans.

Tax Credits - If the government offered direct income tax credits for purchasing the efficient equipment promoted by the utility, this would be a benefit to the customer. In this program, there is no such benefit. Do not double count the reduction in energy taxes.

Proven Performance - If the customer has a high reliability criterion, the lack of common experience with certain efficient measures may produce an insurmountable cost. Also, when weighing two alternative efficiency options, one may have a higher level of acceptability. In this program, the equipment being promoted is well established, so there is no difference among options.

Ease of Implementation - If the customer has multiple choices for efficient equipment, then there may be a legitimate reason for favouring one that is easier to implement. This criteria must be distinguished from any "transaction cost" that is assessed on this decision. You must be careful not to count the same cost in each.

Availability of Capital - If the customer had limited access to capital to make the purchase, this could create an insurmountable cost. If investment capital is available, then there is no cost. The cost of borrowing (or the opportunity cost of using the money) can be included in the discount rate for computing present values.

Value Changes - If the level of end use service is the same, there is no cost or benefit. But if there is reduction in service due to the decrease in consumption, then this would be a legitimate cost to the customer. If changes in productivity are being measured, they must not be included here. If the customer implements measures such as insulating pipes as part of the water heating upgrade, then it is possible that there will be some quality gains due to the decrease in transfer heat loss. In this case, this is considered too small to quantify.

Non-Participating Customer Perspective

Net Utility Revenue Change - The decrease in consumption by participants causes a decrease in the revenues collected by the distribution utility. Some of these revenues were needed to offset fixed costs, which means these revenues must be collected from the entire customer base. These increases are a cost to all non-participating customers, and are based on the decreased revenue and program cost net of the distribution utility's power purchase and capacity cost savings (as described in Distribution Utility Perspective). If the distribution utility chooses not to recover these costs, there is no associated cost to the non-participating customer. The net loss to the distribution utility is {(1.5 x 500) - (1.2 x 1 x 500) - (75 x .1)} x (75% of 1000) = 106,875. This amount must be recovered from all customers, including non-participants.

Tariff Changes - If the distribution utility changes the retail price as a result of the program, customers may change consumption patterns, potentially resulting in a loss of the consumer surplus that would have been obtained. Using the equation for 'change in consumer surplus' from Nelson & Hobbs 1989, it is estimated that lost revenues create consumer surplus loss of between ECU 20,000 and ECU 40,000. This range is used because of using two different estimates of price elasticity of demand.

Distribution Utility Perspective

Power Purchase Cost - The decrease in consumption will allow a reduction in the power purchased from the wholesale utility. This includes energy and capacity components. The decrease in purchase cost is (1.2 x 500) x (75% of 1000) = 450,000

Utility Revenue - Customer bill savings from reduced consumption will be lost revenue. In this situation, it is likely that the distribution utility recovers these revenues from all customers through the general tariffs, so this is not actually a cost to the utility. If they are not, then it is a direct cost to the utility. Revenue losses are passed on to all customers in this case, so this is not a cost in this example.

Distribution Capacity Cost - Reductions in distribution investments resulting from the decrease in consumption are a benefit for the program. Reduced distribution capacity investment is (75 x .1) x (75% of 1000) = 5,625.

Distribution Utility Program Costs - All expenses associated with operating the program are included. These are staff costs, advertising, program materials, subcontracts, administration, and management effort expended. The total cost of this campaign is assumed to be ECU 500,000.

Distribution Utility Incentive Payments - There are no payments from the utility to the customer, as it is an information-based program. If the utility offered financing for efficiency investments, the present value of the loan (computed using the utility's cost of capital) would be considered an incentive.

Effects of Tariff Changes - If the distribution utility changes the retail price as a result of the program, customers may change consumption patterns, potentially resulting in further losses in sales. If these losses are passed on again to customers, there is no direct cost to the utility. Using the same logic as above from Hobbs and Nelson 1989, the additional loss of sales (due to the price increase) can be estimated to be 25,000 kWh.

Market Share - For end uses with which there is another fuel choice for the customer, the information on lower operating cost may increase the portion of the market that purchases electric equipment. This benefit is difficult to quantify, but would be an additional motivating factor for the utility. For this program, there is some value to maintaining electric market share, but it is unknown. This should be left as a non-quantified positive attribute of the program, to be weighed against the financial costs.

Public Image - Because the program promotes environmental benefits, the distribution utility would gain positive recognition by its customers, and possibly the government. This cannot be quantified, but may produce future benefits such as favourable legislative treatment and customer loyalty. For this program, this is considered a smaller benefit than the potential increase in market share, but is still considered a benefit in case the program is marginal based on other factors.

Proven Performance - If the campaign promotes specific equipment, the utility could damage its reputation by promoting a measure that does not deliver the service that the customer requires. This can be considered a benefit for options that have proven performance.. In this program, the equipment being promoted is well established, so there is no difference among options.

Ease of Implementation - If the campaign promotes specific equipment, the utility could suffer adverse public relations if customers have difficulty using the recommended equipment. Also, this program may be favoured by the utility if it is easier to run the information campaign as opposed to alternative marketing options.

Ease of Evaluation - It will be difficult to evaluate the effectiveness of the information program, which could be a disadvantage if the utility wants to measure this outcome.

Availability of Capital - A smaller utility, such as a municipal, may be restricted by a given budget; or raising additional capital may require a great deal of effort. This may limit the size of the program or make large scale advertising difficult. The budget for this program is relatively small, so this is not considered an issue.

Wholesale Utility Perspective

Energy Costs - Decreased sales will translate into lower fuel and variable O&M costs for the generator. This is (1 x 500) x (75% of 1000) = 375,000.

Generation Capacity Cost - Lower peak demands will reduce the need for new generating capacity. The benefit may be the value of deferring an investment by a year or more. This is (150 x .1) x (75% of 1000) = 11,250.

Transmission Capacity Cost - If new generation is avoided, then some transmission lines will also not be needed. Certain upgrades may also be avoided. This is (25 x .1) x (75% of 1000) = 1,875.

Power Purchase Revenue - Reduction in sales to the distribution utility will reduce revenues, which is a cost to the wholesale utility. If the utility, instead, can pass these costs onto other distribution utilities, then it becomes a cost to them, not the wholesaler. This is (1.2 x 500) x (75% of 1000) = 450,000.

Wholesale Utility Program Costs - The distribution utility incurs all of the direct costs of the program.

Wholesale Utility Incentive Payments - The wholesale utility is making any direct payments to customers or to the distribution utility..

Risk and Reliability - The wholesale utility should estimate the changes in demand and recalculate the system parameters, such as loss of load probabilities or maintenance schedules. This could introduce an additional cost or cancel the benefits of reducing the power requirement. In this case, the effect on the system is considered negligible.

Public Image - There is not benefit, because the wholesale utility is not directly involved in the program.

Government Perspective

Tax Revenues - Reductions in energy taxes paid by participants are a cost to the government, which could be local or national. These revenue losses may or may not be passed on to the general population. This is (0.5 x 500) x (75% of 1000) = 187,500.

Government Program Costs - There are not direct costs for running the program.

Tax Credits - In this program, the government does not offer direct tax credits to participating customers.

Productivity - Changes in the productivity of participating customers (as described in participating customer perspective) could impact the economic activity and tax revenues. Zero for this program.

Employment - Increased investment in efficient technologies may increase employment in sectors that the government wants to promote. There are compensating losses in employment in energy supply, such as fuel development. These compensating factors would have to be weighed as a cost and a benefit. According to an economic input-output analysis, there will be losses of employment in fuel supply sectors, but gains due to increased investment in durable goods. If there is no local mining activity, there will not be political pressure to maintain these jobs, so there should be a net gain in employment. Precise quantification is possible, but not reliable, so this is maintained as a non-quantified benefit.

Public Image - Without a direct role in the program, the government would gain no public relations benefits with the general public.

Diminishment of Natural Resources - Reduced consumption of certain fuels would help the government maintain energy reserves. In this case, this may not be a direct benefit, but may slightly reduce dependence on fuel imports.

Anti-Competitiveness - The distribution utility is not participating directly in the market for electric equipment, so there is no effect.

Environmental Effects of Supply - Reductions in electricity generation help the national government (or European Commission) meet targets for emission reductions. There is not likely to be a monetary value for this, but it could be quantified. For this example it is valued at (0.1 x 500) x (7% of 1000) = 37,500.

Environmental Effects of Consumption - There are not likely to be any direct environmental benefits from using less electricity at the end use level.

Societal Perspective

Distribution Utility Program Costs - All expenses associated with operating the program are included. These are staff costs, advertising, program materials, subcontracts, administration, and management effort expended. The distribution utility's cost is .

Government Program Costs - There are not direct costs for running the program.

Other Party Program Costs - There are no direct costs for other parties, such as manufacturers.

Effects of Tariff Changes - If the distribution utility changes the retail price as a result of the program, customers may change consumption patterns, potentially resulting in a loss of the consumer surplus that would have been obtained. This loss in value is a dead-weight loss to society. Using the value as above, this is 20,000 to 40,000.

Productivity - Changes in the productivity of participating customers (as described in participating customer perspective) could impact the economic activity and tax revenues. This would hurt the customer and the government. Zero for this program.

Employment - Increased investment in efficient technologies may increase employment in some sectors of the economy. There are compensating losses in employment in energy supply, such as fuel development. These compensating factors would have to be weighed as a cost and a benefit. Overall net employment impacts might be determined by a macroeconomic model or input-output analysis. If the 'societal view' is considered to be national, there is likely to be a net gain in employment due to the increased investment in durable goods.

Diminishment of Natural Resources - Reduced consumption of scarce fuels produces a benefit for society that cannot be easily monetized.

Anti-Competitiveness - The distribution utility is not participating directly in the market for electric equipment, so there is no effect.

Environmental Effects of Supply - Reductions in electricity generation help the national government (or European Commission) meet targets for emission reductions. There is not likely to be a monetary value for this, but it could be quantified. For this example it is valued at (0.1 x 500) x (7% of 1000) = 37,500.

Environmental Effects of Consumption - There are not likely to be any direct environmental benefits from using less electricity at the end use level.

Table 4 summarises these benefit-cost results for each of these perspectives.

Perspectives	Financial Benefits	Financial Costs	Other Impacts
Participant	Bill savings: ECU 362,500 Tax savings: ECU 187,500	Capital Costs: ECU 187,500	None
Non-participant	None	Net revenue loss: ECU 106,875	Consumer surplus loss: ECU 20,000-40,000
Distribution Utility	Power Purchase: ECU 450,000 Distribution Capacity: ECU 5,625	Program costs: ECU 500,000	Extra loss of 25,000 kWh Increased Market Share (from other fuels) Public Image Benefits (difficult to evaluate)
Wholesale Utility	Energy costs: ECU 375,000 Generation capacity: ECU 11,250 Transmission capacity: ECU 1,875	Lost revenue: ECU 450,000	None
Government	None	Lost taxes: ECU 189,500	Employment benefits Reduced Fuel Impacts Environmental effects of supply: ECU 37,500
Society	Energy Costs: ECU 375,000 Generation Capacity: ECU 11,250 Transmission Capacity: ECU 1,875 Distribution Capacity: ECU 1,875 Environmental effects of supply: ECU 37,500	Program costs: ECU 500,000	Employment benefits Reduced Fuel Use Consumer surplus loss: ECU 20,000-40,000

As expected, the participant perspective is very good, and the nonparticipant has nothing but costs without compensating benefits. This is expected, and is not discussed. The wholesale utility and government perspectives are also poor, but they are not likely to be decision-makers in this process. The government would need to weigh the social benefits against the practical considerations of tax revenue loss.

The distribution utility perspective is poor from a financial viewpoint, but with the possibility of increased market share for electric water heat, the utility considers this a good investment. This is one of the most important reasons for structuring the benefit-cost methodology in the way that it has been structured. The impacts that are measurable are not always the most important ones, and it is not always necessary to quantify each impact in order to use it in the evaluation.

Societal evaluation is difficult, and would require more research into the value of the non-quantified benefits. This is useful, though, because a strictly financial evaluation would show a B/C ratio of approximately 0.85, which is definitely not good. If "society's" boundaries are defined as the nation, the employment benefits and reduced reliance on fuels could easily be enough to compensate. Evaluation from this perspective is therefore considered to be uncertain.

Space considerations do not allow a full description of each scenario, but the major differences in running this program between situation (1) and (2) are

- The ability of the distributor to increase general tariffs to pay for the lost revenues
- The separation of distribution and sales.

In situation (2) of "unbundled full competition", the more social-oriented objectives of the program would not be important to the competitive businesses. Also, the impacts of tariff changes would be non-existent because the power must be sold at the competitive market price. The perspective of the sales utility becomes much worse for this particular program because the lost revenues remain as costs. Also, there is not a 'non-participant' perspective, because they are unaffected.

Also, the sales utility will not have capacity costs to help motivate programs that decrease sales volume. The distribution utility has the primary capacity cost motive, which makes the objectives of the different parties more disparate in this scenario.

This simple example demonstrates the importance of selecting the right perspective and making sure all relevant impacts are included in the evaluation, whether they are quantified or not. There are, of course, practical difficulties in using non-monetized impacts, but their inclusion can only serve to make better decisions.

SUMMARY OF MAIN FINDINGS AND RECOMMENDATIONS

This paper emphasises that evaluating the cost-effectiveness of DSM and energy efficiency services options is more than simply computing a B/C ratio and determining if it is greater than 1. The background and objectives must be completely understood and defined before any attempt can be made to specify what the proper calculations are. Without this, the B/C evaluation can easily be irrelevant and use up valuable resources in the process, and results from analysis may be of limited value. The main findings from this study may be summarised into the following necessary steps in B/C evaluation of energy efficiency programs:

- **Situation must be examined.** DSM programs have been implemented in several countries, under various regulatory, utility industry, and energy market structures, and they have been performed for very diverse reasons, to achieve different goals. For this reason, one single set of cost-effectiveness calculations will not be relevant for all situations. Many attempts to establish benefit-cost procedures -- or transfer procedures developed in other contexts -- have failed because these factors were not appropriately addressed

- **The analysis needs consistent definitions.** There is a need to establish a consistent set of definitions for terms such as DSM, energy efficiency, market transformation and IRP, at a minimum. Without this, results of analysis will be misinterpret and misused

- **There is a need for a robust B/C framework.** There must be established a robust framework from which to perform a discussion of cost-effectiveness of DSM programs. This study offers such a framework. Without the framework is would be very difficult to perform a meaningful discussion, and results would be of very limited value. Further, the framework must address at least four critical issues. These reflect major strategic choices which have to be made regarding DSM programs, these are summarised in this paper

- **There is not one single B/C methodology.** The best procedure is to provide a solid cross-section of illustrations so that appropriate calculations can be defined for any situation. Guidelines must be provided in terms of how to map impacts to situations and perspectives. And in how to appropriately include these impacts into the B/C evaluation.

At the time of writing this paper, the study is still continuing, and further results will be available.

References

Association for the Conservation of Energy. 1991, *Least-Cost Planning in the European Community,* prepared for the Commission of European Communities, Directorate General for Energy, February 1991.

Björkvist, O. and C.O. Wene 1993 "Transaction Costs for Energy Efficiency Investments in the Residential Sector", *Paper presented at the 2nd International DSM and Energy Efficiency Conference*, Stockholm, Sept. 1993

Borison, A. and G. Balachandran 1992, "Choosing Options", *Public Utilities Fortnightly*, Dec. 15, 1992.

Braithwait, S. D., and D.W. Caves 1993, "Three Fundamental Biases in Standard DSM Cost-Effectiveness Tests: Diagnosis and Proposed Treatment," *Working Paper, Christensen Associates*, Madison, WI, March 1992.

Capasso, A., et.al. 1993 "Validation Tests and Application of a Model for Demand-Side-Management Studies in Residential Load Areas", ENEL, Diretzione Studi e Richerche Centro di Ricerca Elettrica, *paper presented to CIRED, 1993.*

Chamberlin, J. and P. Herman 1993, "Why All Good Economists Reject the RIM Test", *Proceedings of National Conference on Utility DSM Programs*, USA, March 1993.

Commission of the European Communities 1991, *Cost-Effective Analysis of CO2 Reduction Options,* Synthesis Report, DG XII, JOULE Program, May 1991.

Commission of the European Communities 1993, *Proposal for a COUNCIL DIRECTIVE to introduce rational planning techniques in the electricity and gas distribution sectors (IRP Directive)*

Costello, K.W. and P.S. Galen, 1985 "An Approach to Evaluating Utility-Financed Energy Conservation Programs," *Resources and Energy*, Vol. 7, 1985.

California Public Utilities Commission (CPUC) and California Energy Commission (CEC) 1987, *Standard Practice Manual for Economic Analysis of Demand-Side Management Programs,* Sacramento, CA, December 1987.

Deegan, J. 1993, "The TRC and RIM tests, How They Got That Way, and When to Apply Them", *The Electricity Journal*, November 1993

Electric Power Research Institute (EPRI) 1987, *Cost-Benefit Analysis of Demand-Side Planning Alternatives,* EM-5068, February 1987.

Hirst, E. 1992, "Quantifying Tradeoffs Between Costs and Prices in Utility DSM Programs", *The Electricity Journal,* May 1992.

Hobbs, B. F. 1991, "The `Most Value' Test: Economic Evaluation of Electricity Demand-Side Management Considering Customer Value," *The Energy Journal,* Vol. 12, No. 2, 1991.

Hobbs, B.F. and Nelson, S.K. 1989, "Assessing Conservation Payments: Least-Cost, Least-Rates, or Most Value?", *The Electricity Journal,* July 1989.

Hoch, L. J. and Regina Roberts 1992, "Towards A DM Cost-Effectiveness Test for Australian Utilities," *Proceedings of the First National DM Conference*, Melbourne, Australia, May 1992.

IEA DSM Programme 1995 *Review and Documentation of Utility Structure and characteristics in Agency Member Countries (Subtask IV/1 Final Report)*, report published by the IEA DSM Programme, April 1995

Johansen, S.E. and Hoog, D.T. 1994, "European Benefit/Cost Analysis Methodology For DSM And Energy Efficiency Programs," *Paper presented at the EU Conference "The SAVE Program: Overview and Future",* Florence, 26-28,. October 1994.

Kahn, A. 1991 "An Economically Rational Approach to Least-Cost Planning", *The Electricity Journal,* June 1991

National Association of Regulatory Utility Commissioners (NARUC) 1988, *Least Cost Utility Planning Handbook for Public Utility Commissioners Volume 2, The Demand Side: Conceptual and Methodological Issues,* National Association of Regulatory Utility Commissioners, Room 110 ICC Builiding, P.O. Box 684, Washington D.C. 20044.

Moen, J. 1993, "Regulation and DSM, Catalyst or Troublemaker", *proceedings from IEA Korea International conf. on DSM,* Nov. 4-5, 1993, Soul, Korea

Ruff, L. E. 1992, "Equity vs. Efficiency: Getting DSM Pricing Right", Electricity Journal, Nov. 1992

SRC International 1994, *European Benefit/Cost Analysis Methodology For DSM and Energy Efficiency Services Programs Phase I: Framework for B/C Calculations,* report prepared for the European Commission (DG 17).

SRC International 1995, *European Benefit/Cost Analysis Methodology For DSM and Energy Efficiency Services Programs Phase II: B/C Calculations,* report to be prepared for the European Commission (DG 17).

UNIPEDE 1992, *Least-Cost Planning in the Electricity Supply Industry: Experiences in the United States and Europe,* Ad Hoc Group on Least-Cost Planning, March 1992.

Woolf, T. and C. Mickle 1992, *Integrated Resource Planning in Europe,* prepared for Greenpeace International, October 5, 1992.

ACKNOWLEDGMENTS

This paper summarizes a study which was developed under contract with SRC International by a Project Advisory Committee (PAC), consisting of experts from a cross-section of European utility markets, including Belgium (Electrabel), Denmark (ELSAM & NESA), France (ADEME), Finland (VTT), Germany (VDEW), the Netherlands (N.V. SEP), Norway (NVE), Portugal (EDP), Spain (IBERDROLA & Grupo ENDESA), Sweden (NUTEK & Vattenfall AB), and UK (EA Technology & Energy Saving Trust). The study is supported by the European Commission (DG 17), and the organizations represented in the PAC.