Electricity Conservation Potential Review 1988 - 2010:

Phase II - Achievable Conservation Potential Through Technological and Operating Change

ELECTRICITY CONSERVATION POTENTIAL

IN BC HYDRO'S SERVICE AREA

COLLABORATIVE COMMITTEE FOR

THE 1991 - 1994 CONSERVATION POTENTIAL REVIEW

VANCOUVER, B.C. - SEPTEMBER 1994

Preface from the Collaborative Committee

Introduction

The 1991 - 94 Conservation Potential Review is now complete. This report marks the culmination of countless hours of study, volumes of data and persistent questioning, discussion, debate and decision-making over three years. In our role as members of the Collaborative Committee, we have represented the views of our various stakeholder groups in overseeing this study in the hope that you will find it enlightening, useful and, most of all, stimulating--a catalyst to further explore the issue of energy conservation and realize the achievable electricity conservation potential in British Columbia.

The Conservation Potential Review was launched In 1991 to develop comprehensive and reliable estimates of the potential for electricity conservation in British Columbia to the year 2010. After receiving input from environmental and ratepayer organizations, BC Hydro undertook the Review to improve understanding of the possible size and characteristics of electricity conservation as a resource to help meet future demand for electricity.

Not only was the subject of the Conservation Potential Review groundbreaking; so was the way it was carried out. In order to arrive at estimates that all stakeholders in the province could agree on and use as a basis for decision-making, this Collaborative Committee was formed to oversee the Review. Our 13 members represent 34 organizations, including commercial, industrial and residential electricity users, environmental interests, aboriginal peoples, local governments and utilities. All have a strong interest in future electricity needs and how they will be met.

This approach was the first collaborative process in the Canadian utility industry. Using consensus-based decision-making, it has successfully brought together diverse and historically adversarial perspectives to collectively define the potential for electricity conservation in British Columbia.

The Organization of the Conservation Potential Review

The Conservation Potential Review was conducted in two parts. Phase I estimated the *unconstrained* technological, social and economic potential for electricity conservation in the province--in other words, the upper limits of conservation that could be obtained if there were no barriers to its achievement. Phase II applied practical limitations to the unconstrained potential identified in Phase I to estimate the *achievable* potential for electricity conservation to the year 2010.

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Phase I Results

Phase I of the Conservation Potential Review, completed in 1993, found that electricity conservation could be a significant component in the resource mix to meet B.C.'s future electricity needs. The unconstrained technological and social potential was estimated to be in the order of 27,000 to 33,000 gigawatt-hours (GWh) a year, depending on economic and population growth rates. Of this potential, 22,000 to 27,000 GWh was expected to be "economic", that is obtainable at a cost less than or equal to the cost of new sources of electricity supply. To put this amount in perspective, the economic potential is greater than all of the electricity sold by BC Hydro in the Lower Mainland in 1992/93. Expressed another way, the potential is equivalent to four new dams the size of BC Hydro's Revelstoke Dam.

Phase I also looked at the potential for conservation by sector. The study found that if all customers were to adopt the most electrically efficient technologies ready to be marketed by the year 2010 without regard to cost, and change their behaviour to use electricity as efficiently as possible, consumption could be reduced significantly. Consumption in the residential sector could be reduced up to 76 percent, in the commercial sector up to 69 percent, and in the industrial sector up to 42 percent compared to the electricity which would be consumed at 1988 efficiency levels.

The enormous opportunity for electricity conservation identified in Phase I set the stage for further investigation in the second phase of the Conservation Potential Review.

Phase II

The second part of the Conservation Potential Review was designed to determine how much of the unconstrained conservation potential identified in Phase I is realistically achievable, given institutional, economic and market barriers. The Phase II study is not a prediction or forecast of conservation, but rather an exploration of possible achievable potentials under varying assumptions about the marketplace and actions by consumers, utilities and governments.

The Phase II study was divided into two parts. One portion estimated the conservation potential achievable through technological and operating changes, such as the use of more efficient clothes washers or energy efficient lighting. The second portion looked at potential energy savings from lifestyle factors, or behavioural changes, ranging from simple actions like turning off lights to substantial decisions like buying smaller houses.

This report deals with the conservation potential achievable through technological and operating change. A companion report "Conservation Potential Through Lifestyle Change" discusses the conservation potential that could be achieved through changes in behaviour.

Methodology

The basic approach to estimating the conservation potential achievable through technological and operating change was to analyze the Phase I data under alternative scenarios or groups of assumptions about the B.C. marketplace. First, the Phase II consultants, Synergic Resources Corporation, reviewed the Phase I data and made refinements to reflect updates in forecasts and technology information. Five scenarios were then developed based on varying types and levels of market interventions aimed at accelerating the adoption of energy efficient technologies. The interventions included incentives, regulation, education and pricing. Several levels of pricing were used to permit sensitivity analysis.

Program experience from BC Hydro was supplemented with research conducted by the American Council for An Energy-Efficient Economy which examined successful demand-side management (DSM) programs in North America. The data for all five scenarios was then analyzed using a DSM planning software tool called COMPASS (Comprehensive Market Planning and Analysis System). The analysis yielded information about the market penetration of the various technologies being examined, the resultant energy savings and the associated benefits and costs.

This study incorporated the best data that is currently available. Important benefits of the study include identification of areas requiring more data and BC Hydro's ability to use the data and the model in its ongoing resource planning activity.

Some other methodological issues were identified in the Phase II study, including: cross-sector equity, cream skimming, and fuel switching. These are expanded upon in Chapter VI in the discussion under Section E - Limitations and Caveats.

Results

This study found that a significant portion of the unconstrained potential for electricity conservation, as identified in Phase I, is realistically achievable through technological and operating change. Specifically, the achievable potential is in the range of 11,000 to 14,000 gigawatt-hours of electricity a year by 2010. This represents about 18 to 22 percent of electricity consumption forecast for that year, or about 44 to 53 percent of the unconstrained Phase I conservation potential. By scenario, the results are as follows:

Collaborative Committee Preface

The pricing scenario uses higher prices for electricity to discourage consumption. It could achieve over 11,000 GWh a year.

The education scenario relies on information, labelling and advertising campaigns to promote the conservation benefits of various technologies. This approach could also save over 11,000 GWh a year.

The regulatory scenario uses regulations such as the building code and appliance efficiency standards to achieve conservation. It could save over 11,500 GWh per year.

Each of the pricing, education and regulatory scenarios are estimated to be capable of saving up to 44 percent of the Phase I unconstrained potential.

The utility scenario uses utility-led incentives such as direct payments, rebates on energy bills and labelling. This scenario performs better than the previous three scenarios, yielding savings in excess of 13,000 GWh or roughly 50 percent of the unconstrained potential.

An integrated scenario combines elements of all pricing, education, regulatory and utility scenarios to maximize the acceptance of energy-saving technologies. It achieves over 13,500 GWh, slightly more than the utility scenario, again accounting for about 50 percent of the unconstrained potential.

For comparison purposes, achievable potential savings in the order of 13,500 GWh exceed total BC Hydro sales to residential customers in 1993/94.

Analysis of the five scenarios was further developed by examining the level of conservation that might occur with no new interventions or policies. To reflect this, an adjustment was first made to the Phase I 1988 baseline to reflect the impact of changes in practice for a number of end-uses which have occurred between 1988-1993 (i.e. new codes and standards and the effect of BC Hydro Power Smart programs). In addition, a forecast of the "natural market adoption" or the increase in penetration of energy efficiency measures from 1993 onwards that would occur without any additional programs or policies was also developed. The change in baseline and the natural market adoption forecast indicates savings in the range of approximately 8,000 GWh or electricity a year, or about 33 percent of the unconstrained potential.

When reviewing the results above, readers should remember that the scenarios represent artificial constructs: it is not likely that one group of conditions would come to pass in isolation, but rather that features of all the scenarios would combine to create a future in which a significant amount of electricity conservation could be achieved. The results of the scenario analyses are signposts that can guide energy planning and policy-making by utilities, regulators and society. Indeed, the results of the Conservation Potential Review can and should be used by all players in the energy field, from manufacturers to utility resource planners, from individual electricity consumers to the provincial government, from builders to electricity users.

The large achievable potential identified in this study has implications beyond the actual use of energy. Electricity conservation helps to protect the environment by deferring the need for new energy developments and their associated environmental impacts. As well, demand-side management can stimulate significant job creation and economic development.

Ultimately, some of the basic assumptions used in the study may have resulted in either conservative or optimistic estimates of the size of the achievable potential. Readers should remember that this study is meant to be an exploration of the achievable potential for electricity conservation, not a precise forecast. In that sense, we believe the information in the report is credible and we expect it to be useful.

The Collaborative Process

The members of this Collaborative Committee represent a wide spectrum of perspectives, backgrounds, areas of interest and experience. Our mandate has been to design and guide the conduct of the conservation Potential Review, and our activities have included approving terms of reference, selecting consultants, determining all key assumptions and parameters to be used by the consultants, and reviewing and approving all reports. Despite our diversity and our sometimes dramatic differences of opinion, we have successfully used a consensus-based process to reach agreement and make decisions.

We believe that the inclusion of input from a variety of stakeholders has made both the Review and the reports more thorough, more balanced and of higher quality than they otherwise would have been. Perhaps more important, the collaborative process should make the results more credible and thus more likely to be accepted by a broad cross-section of British Columbians.

Next Steps

Although the Conservation Potential Review is now complete, this report represents an important step towards a sustainable energy future for British Columbia. Now it is time for all the different interest groups in B.C. to use the results to discuss, debate and collectively plan that future.

We hope that BC Hydro and all stakeholders will use the Conservation Potential Review for energy planning and policy development in B.C. We are aware that the results will be used to assist in planning and developing BC Hydro's Power Smart energy efficiency program over the next several years, as the results of the Review show that Power Smart can become an even more significant component of BC Hydro's electricity planning process. The Conservation Potential Review has reduced uncertainty about the size of the resource that conservation can contribute and has identified means of achieving it. Thus, conservation can make an even greater contribution to the resource mix to meet the province's future electricity needs.

In addition, we hope that our successful experience with consensus decision-making among diverse and sometimes adversarial perspectives will encourage BC Hydro and others to try the collaborative approach in other energy planning areas. Simply put, we believe that collaboration works better in areas affecting stakeholder interests and yields better results than traditional methods of decision-making. Municipal and regional governments, planning councils and similar organizations might also benefit by using the collaborative approach as a way to balance differing views and to get the widest possible agreement on the issues being considered.

We also hope that the public will get involved in discussing the results of the Conservation Potential Review. Energy planning is not a matter to be left exclusively to planners and engineers; it is something in which every citizen has a stake. We urge all British Columbians to join the debate.

For more information

For additional copies of the Phase I or Phase II report, or for more information about the Review in general, please contact BC Hydro's Public Involvement and Community Relations toll free number at 1-800-663-1377.

If you have questions about the contents of this report or about the collaborative process that guided it, please contact BC Hydro or one of the Collaborative Committee members listed below.

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SRC REPORT NO. 7933-R4

ACHIEVABLE CONSERVATION POTENTIAL IN BRITISH COLUMBIA THROUGH TECHNOLOGICAL AND OPERATING CHANGE

Final Report

Prepared for

Conservation Potential Review Project
Collaborative Committee
Vancouver, BC Canada

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MANAGEMENT BRIEF

FOR THE ACHIEVABLE CONSERVATION POTENTIAL

IN BRITISH COLUMBIA THROUGH TECHNOLOGICAL

AND OPERATING CHANGE

This report is part of a series of documents reflecting a collaborative effort between BC Hydro and various provincial interest groups. The study is designed to estimate the achievable potential for conservation in the province through technological and operating change.[1]

OBJECTIVES

The objective of this study is to develop estimates of the achievable potential for conservation in B.C. under a series of scenarios. These scenarios include a range of interventions including: pricing, education/information, regulation, utility and integrated initiatives. Study results and data will also be used for inputs into BC Hydro future resource planning efforts.

DEFINITIONS

The achievable potential reflects the portion of the unconstrained potential (the technological and economic potential as noted in the Phase I report) which is likely to be realistically attained given institutional, economic and market barriers. Since the achievable potential is influenced by numerous factors, multiple scenarios are examined.

CAVEATS

All efforts, within the resources of the study, were directed at developing results which are as realistic as possible. However, as in any such effort, there are a number of limitations and caveats and considerable uncertainty. Thus, the reader should consider the range of potentials illustrated through the multiple scenarios. Despite the limitations

[1] A parallel study which looks at conservation potential through behavioural changes was also completed. The report, titled *Conservation Potential Through Lifestyle Change*, is available from BC Hydro Power Smart.

and caveats, we think the achievable potential forecasts are realistic; if not somewhat conservative, given aggressive and well designed initiatives.

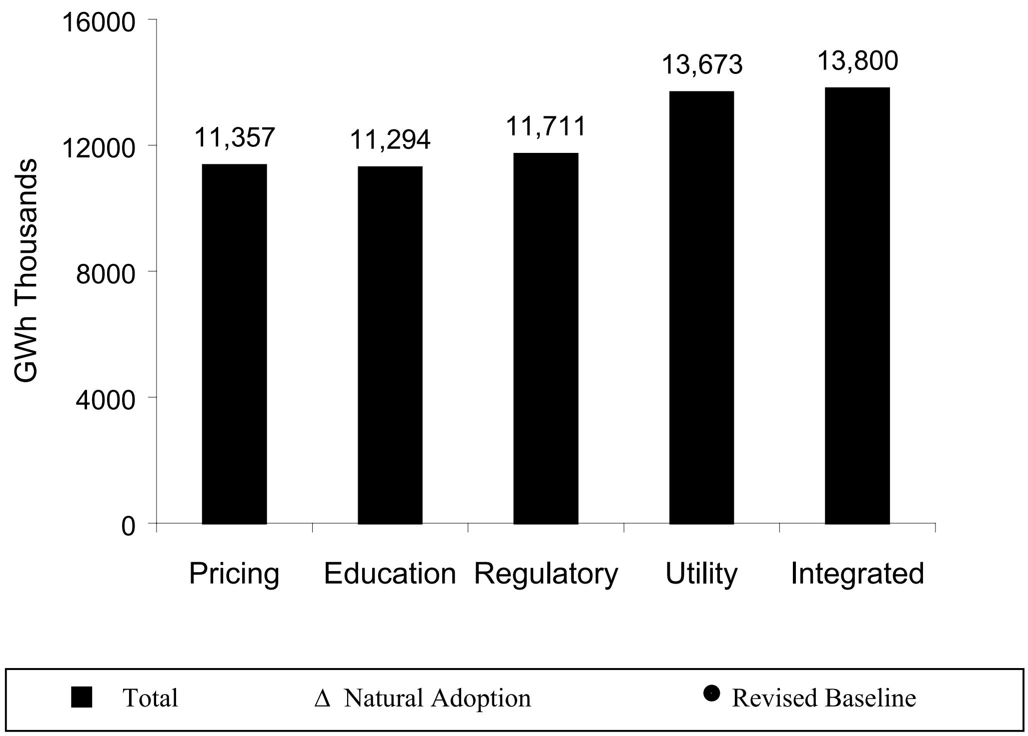
RESULTS

Table 1 summarizes the overall achievable potential by sector including a comparison with the technological potential and the net present value (NPV) of benefits from the total resource cost perspective.[2]

The achievable potential energy savings by scenario are plotted in Figure 1. The natural adoption and change in baseline forecasts are also shown for reference. The utility and integrated scenarios result in greater savings than the regulatory, education or pricing scenarios due to much higher adoption of energy efficiency measures. The incremental savings (i.e., savings in excess of the reference case savings) in the pricing and education scenarios are less than what can be achieved through the utility or regulatory initiatives in spite of the fact that for the pricing scenario there is a 30% difference in electricity price for installing energy efficiency measures. Relative to the reference case, the residential sector represents the greatest amount of additional achievable potential and the industrial sector represents the least amount of additional achievable potential.

[2] The net present value (NPV) is computed as the avoided energy cost savings minus the cost of the energy efficiency investments and program costs for the time period 1994 through 2010 using an 8% real discount rate.

Figure 1
Achievable Potential Results
Total Electricity Savings



Note: Natural adoption and revised baseline are components of the reference case as defined on pages I-6 and I-7.

Table 1

SUMMARY OF ACHIEVABLE POTENTIAL

	Reference Case	Pricing	Education	Regulatory	Utility	Integrated
Sales Forecast	62,261	62,261	62,261	62,261	62,261	62,261
Year 2010 GWh Savings						
Residential	1,608	3,062	3,062	3,137	4,327	4,025
Commercial	2,196	2,900	2,805	3,836	3,884	4,307
Industrial[1]	4,702	5,395	5,428	4,738	5,462	5,468
Total	8,506	11,357	11,294	11,711	13,673	13,800
Percent of Technical Potential	33%	44%	44%	44%	53%	53%
Percent of Forecast	14%	18%	18%	19%	22%	22%
Net Present Value		2,159	1,650	1,368	1,861	2,131
Total Resource Perspective ($ x million)						

[1] The industrial potential was based upon BC Hydro's industrial sales. There is an additional 3,800 - 4,000 GWh of industrial self-generation. If the loads served by the self-generation capacity were included, the industrial achievable potential would increase proportionately (approximately 20%).

The integrated scenario provides, marginally, the largest energy savings due to the high penetrations from the combination of aggressive utility programs, labeling, building codes, and appliance standards.

The integrated scenario utilizes a combination of strategies. For the residential and commercial sectors, modest pricing initiatives are combined with the utility scenario through the year 1999. In the year 2000, standards and codes are set mandating the implementation of all measures with a levelized cost of energy saved of less than 6 cents/kWh.[3] For the industrial sector, standards are implemented for lighting and compression, and utility rebate programs (with reduced rebates) are continued for pumping, air displacement, conveyance, process drives, and process efficiency changes.

[3] 6 cents/kWh represents the Cost of New Electricity Supply (CONES).

Overall, the reference case natural adoption and the revised baseline accounts for 8,506 GWh ranging from 58% to 75% of the scenario savings. Natural adoption and the revised baseline includes price induced savings based upon current tariffs and the effects of specific initiatives that have already been implemented such as revised building standards and past BC Hydro Power Smart programs. The savings may not be realized if these initiatives are not sustained.

CONCLUSIONS

- The achievable conservation (including the potential included in the reference case) is in the range of 8 to 14 thousand GWh by the year 2010, representing approximately 14% to 23% of the year 2010 forecasted electricity consumption.

- Integrated or mixed strategies may not substantially increase achievable savings. The aggressive incentives and promotions in the utility scenario result in similar savings as the integrated scenario, as the market penetration of cost-effective conservation measures is nearly saturated in both scenarios. The integrated strategy has several advantages including:

  - It may not be feasible to implement standards and codes enforcing all measures with a levelized cost of energy saved less than 6 cents/kWh without initiatives to develop market acceptance and infrastructure for several years prior to the implementation of the standards.

  - The utility incentive programs are expensive, so that by phasing in standards, the costs and rate impacts of utility programs can be attenuated.

  - The net present value of savings can be maximized.

  - If one strategy or initiative is less successful than anticipated, other strategies or initiatives may pick up the slack, minimizing the risk of under achieving the conservation goals.

  - Strong forces are established to accelerate technological improvements, cost reduction and market reduction.

- There are many caveats and limitations to this study as noted in Chapter VI. Overall the estimates of achievable potential are realistic and feasible given aggressive and well designed programs.

I. INTRODUCTION

I. INTRODUCTION

A. BACKGROUND AND SETTING

A collaborative planning effort between BC Hydro and various stakeholders[4] has been commissioned to explore the potential for electricity conservation in British Columbia. This study takes a comprehensive look at a full range of technological, operational and lifestyle opportunities for maximizing energy efficiency in the province. This report details the conservation potential resulting from technological and operational changes and is designed to focus on establishing estimates of what level of conservation impact is achievable given the provincial environment.

B. STUDY OBJECTIVES

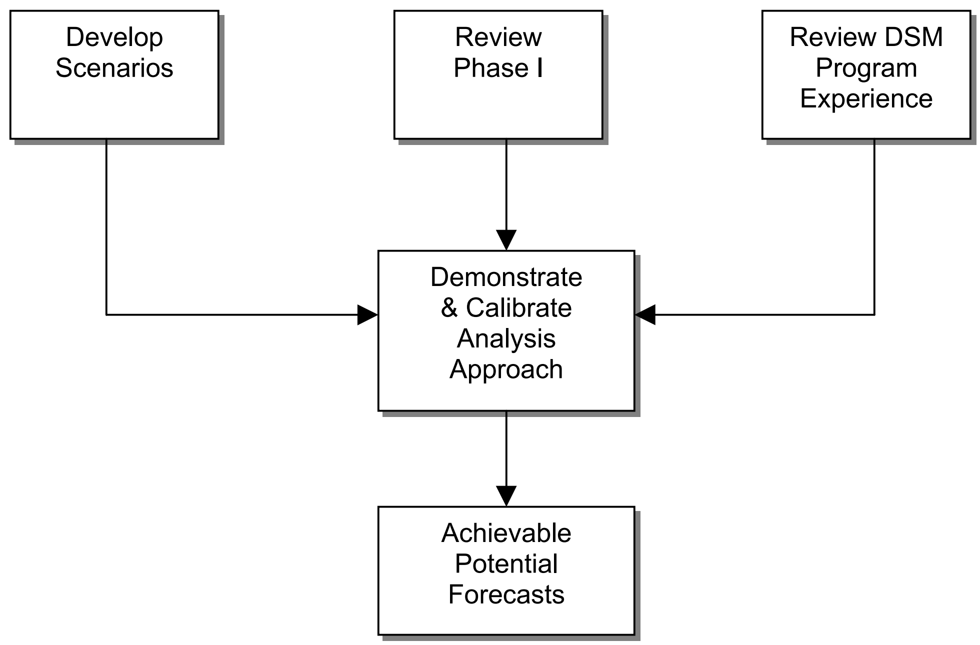
The primary objective of this study is to develop estimates of achievable electricity conservation in British Columbia. Since electricity-usage is influenced by a number of variables and possible policy directions, the estimation process is designed to examine conservation potential under a range of scenarios. These scenarios include variables such as price intervention, education, regulatory initiatives and utility-led efforts. These scenarios are described in greater detail later in this chapter.

[4] The collaborative group included people representing industrial, commercial and residential customers, First Nations' Peoples, environmental organizations, local governments and BC Hydro.

OVERVIEW OF STUDY METHODOLOGY

The forecasts of achievable potential were developed by analyzing the Phase I technological data under alternative scenarios. An overview of the major study elements is provided in figure I-1. These elements included the following:

Figure I-1
OVERVIEW OF PROJECT APPROACH



- **Review of Phase I -** this analysis represents the second phase of the work with the development of technology data completed in Phase I. Thus, the Phase I reports were reviewed in detail. This review identified some updates to the data to reflect B.C.'s current environment. These changes are noted in the individual sector analysis chapters presented later in this report (Chapters III, IV, and V).

- **Review of DSM Program Experience** - a parallel effort examined the experiences of exemplary demand-side management (DSM) programs at other utilities. This work was conducted by the American Council For An Energy-Efficient Economy (ACEEE). The results of this paper are used as a point of comparison in the scenario design process and in assessing the impacts of programs. A copy of the complete paper is provided in Appendix G.

- **Scenario Development** - a series of five scenarios based on varying levels of incentives, regulation, education and pricing were developed. The data from these scenarios were translated into modeling inputs and used as parameters in conducting the analysis. A more detailed discussion of the scenarios is provided later in this section.

- **Calibrate Model/Conduct Demonstration** - the analysis was conducted in a DSM planning software tool called COMPASS (Comprehensive Market Planning and Analysis System). This software is currently used within BC Hydro for DSMN program planning. As part of this task, the data was loaded into the model to demonstrate the analytical routines and calibrate model inputs and provide a basis for future BC Hydro DSM evaluation and planning efforts.

As part of the methodology, it is important to gain an understanding of the framework and inputs required to conduct the scenario analysis. Figure I-2 presents an overview of the analytical approach. As shown, distinct sets of data were required. These include: Phase I technology data, BC Hydro system data and program cost data, as well as specific scenario parameters and the market penetration (consumer response) functions. In addition, the information from the working paper on program experience was used to calibrate program market penetration forecasts and help develop program cost estimates.

All these inputs were loaded into the COMPASS model. The COMPASS model provides annual forecasts of penetration of energy efficiency measures as well as the streams of program benefits and costs representing various perspectives (i.e., customer, society, and utility). More specifically, the results include three types of output:

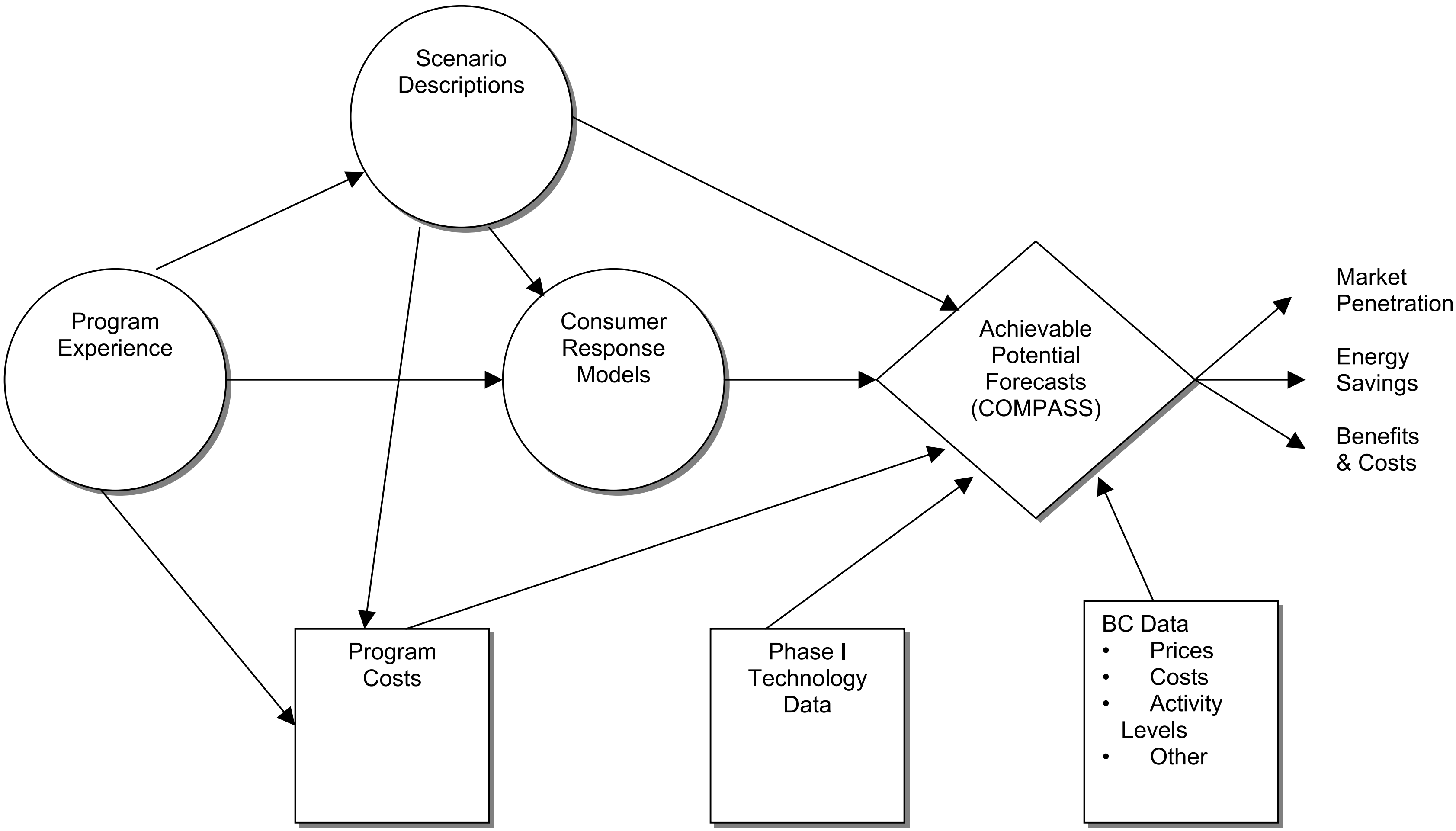
- Market Penetration - annual estimates of market adoption by program.
- Energy Savings - annual estimates of program energy savings.
- Benefit-Costs - comparisons of aggregate program costs and benefits from various economic perspectives.

2. Development of Scenarios

A critical step in the process was the need to develop scenarios to address the greatest concerns over market uncertainties and possible future environments for BC Hydro. The Collaborative Committee developed a series of logical and consistent scenarios for this analysis. A set of five scenarios were developed. These are:

- **Price-Driven:** This scenarios forecasts the impacts of pricing initiatives on market acceptance of DSM technologies. The key interventions include incentive-based BC Hydro pricing strategies. Pricing strategies could include seasonal rates, conservation service rates, time of use rates, marginal cost pricing, and externality adders coupled with efficiency discounts. The scenarios also includes labeling of equipment.

Figure I-2
ANALYTICAL FRAMEWORK



- **Education Scenario:** This scenario forecasts the effects of customer information and promotion to communicate program benefits and increase market acceptance. Interventions include aggressive utility media campaigns, equipment labeling and certification, and workshops and seminars.

- **Regulatory Scenario:** This scenario forecasts the impacts of non-utility interventions in the marketplace including: aggressive building codes and equipment efficiency standards, government pricing policies for other producers and a significant equipment and appliance labeling and certification effort. The scenarios also includes a government-sponsored tax credit/grant for customers, manufacturers, and Energy Service Companies. The primary actor is the B.C. government.

- **Utility-Led Scenario:** This scenario forecasts the impacts of aggressive efforts by BC Hydro including rebates, leasing, financing, and performance guarantees. The utility is also assumed to undertake aggressive advertising/promotional campaigns, labeling/certification efforts, workshops and other informational activities.

- **Integrated Scenario:** A fifth scenario combining the most attractive elements across the initial four scenarios was also developed. The scenario is designed to examine the potential for market transformation where joint utility and government initiatives are used to accelerate the introduction and market acceptance of energy efficient technologies. This includes using pricing, incentives at initial stages of the product introduction coupled with extensive education and labeling efforts. After the measures have achieved market acceptance, standard and codes would be upgraded to include these measures.

Estimates of the achievable potential depend on the set of conditions or interventions reflected by these scenarios. These scenarios allow an investigation into the achievable potential that would occur given different actions and actors. A reference case reflecting conservation that might occur with no new initiatives or policies was also developed. This reference case includes two components:

- **Change in Baseline -** the baseline practice for many end-uses has improved substantially between 1988 and 1993. Examples include:

  - new building codes effective 1994, require some of the Phase I efficiency measures for the residential sector.

  - the 1988 baseline water heater is no longer available. By 1993, the minimum efficiency water heater available corresponded to a high efficiency model evaluated as part of Phase I.

  - in the industrial sector, high efficiency motors now represent more than 60% of sales.

  These changes in baseline have occurred for a variety of reasons including: (1) natural market adoption; (2) new codes and standards; and (3) BC Hydro's Power Smart programs. In developing the 1993 baseline adjustments, we examined available data concerning 1993 practice. These baseline adjustments include all Power Smart achievements between 1988 and 1993. We did not identify nor analyze specific causes of the change in practice. For example, BC Hydro survey data on the penetration of different types of lighting systems was used to update the data on current lighting practices. Some of the observed increased penetration of high efficiency lighting systems may be attributed to: (1) Power Smart; (2) natural market adoption; and (3) people designing to the new standards prior to formal implementation and adoption. We did not, for example, analyze Power Smart programs to assess either: (1) the portion of the change in baseline that could be attributed to the programs; or (2) whether the change in baseline is consistent with the reported impacts of these programs. With the exception of industrial motors, no specific Power Smart programs were explicitly examined.

The scenario estimates of achievable potential assume: (1) the 1993 penetration is the starting point; and (2) existing Power Smart programs cease in 1993 and are replaced by the initiatives specified within each scenario.

- **Natural Market Adoption -** this is a forecast of the increase in penetration of energy efficiency measures from 1993 onwards that would occur without any programs or policies to promote energy efficiency. No Power Smart programs were included.

The reference case embodies current and anticipated circumstances. Changes in those circumstances could lead to a different level of natural adoption.

A set of interventions was assigned to each scenario. Then, each of the interventions was introduced into the model via a direct change in parameters or assumptions (e.g., a change in rate levels). The resulting forecasts were checked against results from "exemplary" DSM programs as summarized in the ACEEE review (Appendix G). Table I-1 summarizes the initiatives included in each of the scenarios. A detailed review of the scenarios and how these initiatives were modeled is provided in Chapter VI.

Table I-1

MATRIX SUMMARY OF SCENARIOS

Scenario	DSM Investment by Utility	DSM Investment by Others	Info/Promotion by BC Hydro	Info/Promotion by Others	Stds/Regulatory Interventions	Pricing Strategies
Pricing Led	• Aggressive performance guarantees	• Moderate trade ally share savings • Moderate trade ally cost reductions	• Aggressive general media • Utility labelling/ certifications	• Aggressive trade ally • Trade ally and government labelling/ certification of buildings and equipment		• Marginal cost pricing • Externally adders • Efficiency standard discounts • Other pricing approaches
Education Led			• Aggressive general media • Labelling/certification • Workshops/seminars • Curriculum efforts	• Aggressive trade ally • Trade ally and government labelling/ certification • Gov't sponsored curriculum • Workshop/seminars		
Regulatory/Government		• Aggressive trade ally shared savings • Aggressive trade ally service warranties • Customer/ manufacturer tax credits • ESCO tax credit/ insurance bill		• Lebelling/ certification of buildings • Workshop seminars for public • Gov't sponsored curriculum	• Aggressive building codes • Aggressive equipment standards	
Utility Led	• Aggressive performance guarantees • Aggressive financing/ leasing • Aggressive rebate strategies	• Moderate trade ally cost reductions • Comprehensive trade ally service warranties	• Aggressive general media • Utility labelling/ certification • Utility workshop/ seminars • Utility curriculum efforts • Utility demonstration efforts		• Utility connection standards • Moderate gov't equipment efficiency regulations	• Conservation service rates
Integrated	• Aggressive initial rebates • Aggressive performance guarantees	• Customer/ manufacturer tax credits • Development initiatives	• Aggressive general media • Utility labelling/ certification • Utility workshop seminars • Utility curriculum efforts • Utility demonstration efforts	• Labelling/ certification of buildings	• Aggressive equipment standards and codes after initial period	• Externality adders • Conservation service rates/discounts

3. Market Penetration Approach

Two different approaches were used to develop realistic estimates of market penetration of the technologies. These are:

- **Customer Economics:** an initial set of penetration estimates were developed through the use of linking participation to customer economics. More specifically, a set of payback-acceptance curves based on North American data reflecting the likelihood of adoption in relationship to the simple payback of a technology were used. For example, the research indicates that a six year payback for a residential heating/cooling-type decision will result in 32% of the eligible market adopting the measure. There are different curves for each sector (residential versus non-residential) and by type of purchase (heating/cooling system or appliances). A detailed review of the customer economics approach is contained in Chapter VI.
- **Utility Experiences:** a compendium of utility DSM program results and impacts was developed to help calibrate the customer economics results. This research focused on issues of program/market acceptance, program costs, measure life and resulting levelized program costs. A copy of this report is contained in Appendix G - the ACEEE report.

The resulting analysis provides forecasts of the market penetration for each program measure and promotion strategy for each year within the planning horizon. These forecasts are used to determine the aggregate energy impacts over the period.

Another important element in the market penetration approach is the need to develop a natural market adoption estimate. The natural market adoption forecast estimates those customers who would have purchased the eligible measure outside of any utility program intervention. The natural market adoption estimate provides a "benchmark" to compare changes in demand under different scenarios and helps provide a clear picture of program-influenced savings versus savings reflecting those who would have adopted the measure anyway.

4. Data Development

In completing a study of this magnitude, there are many data points and pieces of information which are required to properly conduct an analysis. An overview of the data types and sources is presented on Figure I-3. A more detailed review of these elements follows.

- **Technology Data:** the primary technology data was developed in the Phase I analysis. In some cases, the Phase I data was revised to reflect recent findings and new information. All technology data is presented in Appendices A-C reflecting the residential, commercial and industrial sectors, respectively.

- **Utility Data:** the utility data, including the costs of new electricity supply (CONES) were all provided by BC Hydro. The CONES data is used to compare the conservation investment costs to assess cost-effectiveness. A listing of utility data is shown in Appendix E.

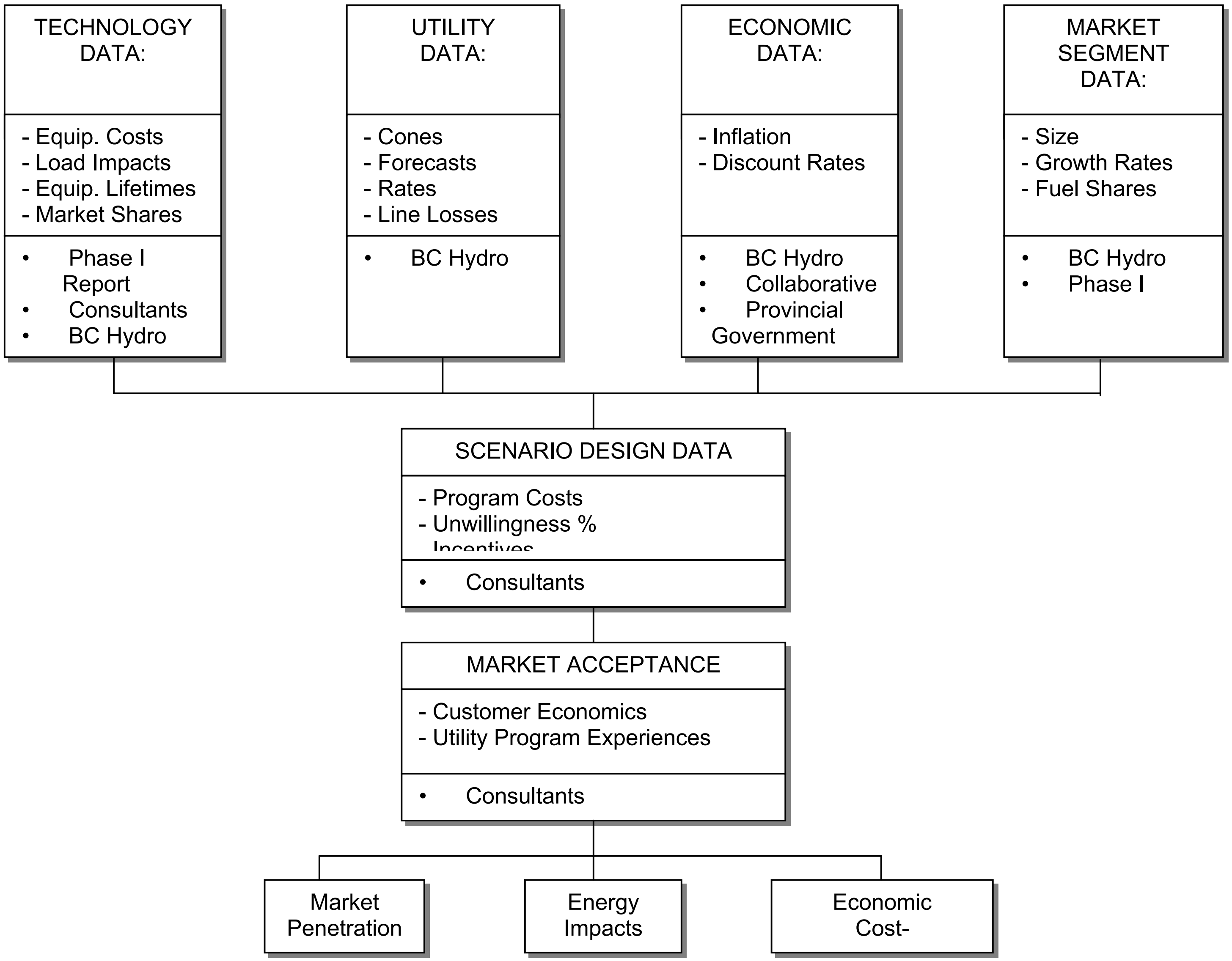
- **Economic data:** these data reflecting inflation rates and discount rates were provided by BC Hydro and the provincial government. These data were reviewed and approved by the Collaborative Committee. The data are summarized in Appendix E.

- **Market Segment Data:** these data define the size and growth rates of the various market (and sub-market) segments. For example, the commercial market comprises 13 building types. These data were established in the Phase I report and reviewed by BC Hydro staff. The growth rates (e.g., forecasted number of new homes) was updated to be consistent with BC Hydro's 1993 forecast.

- **Scenario Design Data:** the specific components of the scenario analysis includes the application of the modeling variables impact into the COMPASS model. This also includes estimates of program costs to serve as a proxy for the level of societal expenditures to implement the interventions noted in each scenario.

Figure 1-3

TYPES AND SOURCES OF PROJECT DATA



The result of this analysis is a delineation of total program adopters, energy impacts and economic benefit-cost analyses. Within the report, the benefit-cost estimates are provided for the utility cost test and the total resource cost tests. These tests reflect the following perspectives:

- **Utility Cost Test:** compares the DSM program cost (including incentives, but excluding any cost not incurred by the utility) to the cost of new supply. The net benefits for this test are total avoided energy cost savings (that is, cost of new electricity supply times energy savings, minus the utility program costs).
- **Total Resource Cost Test:** includes a comparison of total costs (including program and measure costs) of the program with the avoided cost of new supply. The net benefits for this test are the avoided energy cost savings minus program and measure costs.

The specific benefit-cost ratios for these technologies are discussed within the context of the detailed sector results (Chapters III, IV, and V).

A more detailed delineation of the various economic tests is provided in Appendix D.

5. Sensitivity Analysis

A final consideration in recognizing the uncertainty of this analysis is the need to conduct some iterations to identify the level of confidence with results. As part of this study the following sensitivity analyses were completed:

- **Discount rates:** the reference case analysis includes a real discount rate of 8%. An additional set of simulations with a 4% discount rate was also completed. The 8% discount rate represents a rate typically used by firms and governments for evaluating new investments. The 4% rate represents a social discount rate reflective of low risks and intergenerational transfer considerations.
- **Growth Rates:** effects of high and low activity (e.g., a number of households, industrial production) corresponding to the 1993 high and low electricity load forecasts were estimated.

As a means of addressing some of the sensitivity analysis issues, an aggregate supply curve for conservation measures organized by sector is provided. The supply curve presents a graphic depiction of energy savings per measure sorted by levelized energy cost. This results in a step-function graph and allows the readers of the report to estimate from the graph the additional conservation justified for increases in environmental adders or changes in CONES.

II. KEY FINDINGS

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A. OVERVIEW

This chapter summarizes the overall achievable potential for the five scenarios that were analyzed. Detailed results for each sector (residential, commercial and industrial) are provided in subsequent chapters. First the overall achievable potentials are presented and compared with the technological potential. Next, the sensitivity of the achievable potential to various considerations is examined. The last section of this chapter includes the conclusions from this phase of this study.

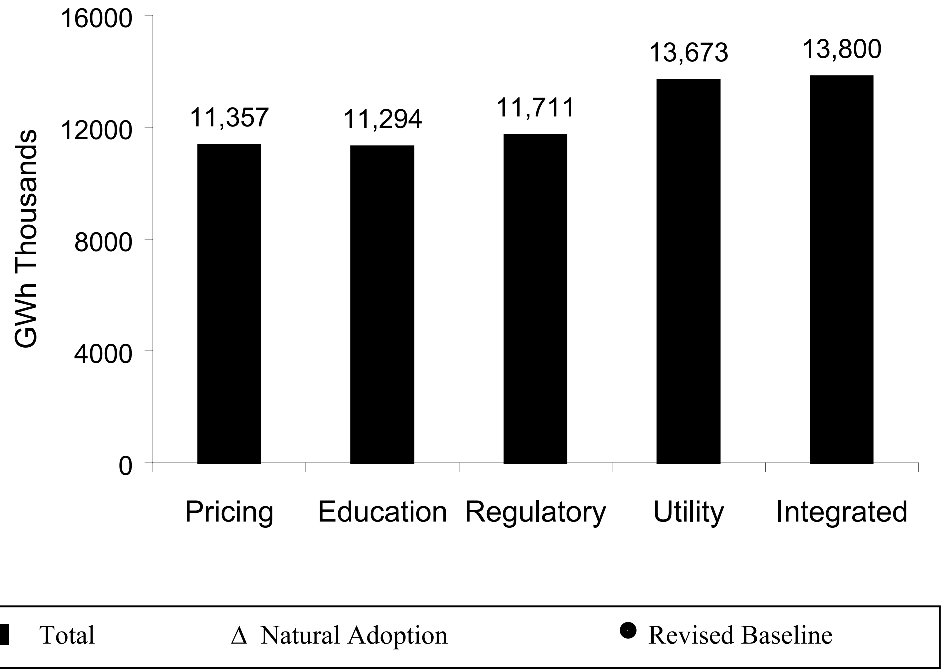
B. ACHIEVABLE POTENTIAL RESULTS

Table II-1 summarizes the overall achievable potential by sector including a comparison with the technological potential and the net present value (NPV) of benefits from the total resource cost perspective.[5]

The achievable potential energy savings by scenario are plotted in Figure II-1. The natural adoption and change in baseline forecasts are also shown for reference. The utility and integrated scenarios result in greater savings than the regulatory, education or pricing scenarios due to much higher adoption of energy efficiency measures. The incremental savings (i.e., savings in excess of the reference case savings) in the pricing and education scenarios are less than what can be achieved through the utility or regulatory initiatives in spite of the fact that for the pricing scenario there is a 30% difference in electricity price for installing energy efficiency measures. Relative to the reference case, the residential sector represents the greatest amount of additional achievable potential and the industrial sector represents the least amount of additional achievable potential.

[5] The net present value (NPV) is computed as the avoided energy cost savings minus the cost of the energy efficiency investments and program costs for the time period 1994 through 2010 using an 8% real discount rate.

Figure II-1
Achievable Potential Results
Total Electricity Savings



Note: Natural adoption and revised baseline are components of the reference case as defined on pages I-6 and I-7.

Table II-1

SUMMARY OF ACHIEVABLE POTENTIAL

	Reference Case	Pricing	Education	Regulatory	Utility	Integrated
Sales Forecast	62,261	62,261	62,261	62,261	62,261	62,261
Year 2010 GWh Savings						
Residential	1,608	3,062	3,062	3,137	4,327	4,025
Commercial	2,196	2,900	2,805	3,836	3,884	4,307
Industrial[1]	4,702	5,395	5,428	4,738	5,462	5,468
Total	8,506	11,357	11,294	11,711	13,673	13,800
Percent of Technical Potential	33%	44%	44%	44%	53%	53%
Percent of Forecast	14%	18%	18%	19%	22%	22%
Net Present Value Total Resource Perspective ($ x million)		2,159	1,650	1,368	1,861	2,131

[1] The industrial potential was based upon BC Hydro's industrial sales. There is an additional 3,800 - 4,000 GWh of industrial self-generation. If the loads served by the self-generation capacity were included, the industrial achievable potential would increase proportionately (approximately 20%).

The integrated scenario provides, marginally, the largest energy savings due to the high penetrations from the combination of aggressive utility programs, labeling, building codes, and appliance standards.

The integrated scenario utilizes a combination of strategies. For the residential and commercial sectors, modest pricing initiatives are combined with the utility scenario through the year 1999. In the year 2000, standards and codes are set mandating the implementation of all measures with a levelized cost of energy saved of less than 6 cents/kWh. For the industrial sector, standards are implemented for lighting and compression, and utility rebate programs (with reduced rebates) are continued for pumping, air displacement, conveyance, process drives, and process efficiency changes.

Overall, the reference case natural adoption and the revised baseline accounts for 8,506 GWh ranging from 58% to 75% of the scenario savings. Natural adoption and the revised baseline includes price induced savings based upon current tariffs and the effects of specific initiatives that have already been implemented such as revised building standards and past BC Hydro Power Smart programs. The savings may not be realized if these initiatives are not sustained. Table II-2 summarizes the costs, benefits and net benefits by scenario and sector. The pricing and integrated scenarios have the highest net benefits, although the 30% price increases in the pricing scenario is not included as a cost.

Table II-2

Summary of Costs and Benefits
by Scenario and Sector

SCENARIO/SECTOR	TOTAL COSTS (000s $)	AVOIDED ENERGY COST SAVINGS (000s $)	NET BENEFITS (000s $)
PRICING			
RESIDENTIAL	313,791.9	623,387.0	309,595.1
COMMERCIAL	210,793.1	659,552.0	448,758.9
INDUSTRIAL	98,176.0	1,499,017.0	1,400,841.0
TOTAL	**622,761.0**	**2,781,956.0**	**2,159,195.0**
EDUCATION			
RESIDENTIAL	485,991.2	650,734.0	164,742.8
COMMERCIAL	351,785.8	637,241.0	285,455.2
INDUSTRIAL	101,579.0	1,301,174.0	1,199,594.0
TOTAL	**939,356.0**	**2,589,149.0**	**1,649,792.0**
REGULATORY			
RESIDENTIAL	332,350.1	618,812.0	286,461.9
COMMERCIAL	1,099,788.6	1,211,226.0	111,437.4
INDUSTRIAL	76,110.0	1,045,985.0	969,875.0
TOTAL	**1,508,248.7**	**2,876,023.0**	**1,367,774.3**
UTILITY			
RESIDENTIAL	713,576.3	771,290.0	57,713.7
COMMERCIAL	433,805.4	914,481.0	480,675.6
INDUSTRIAL	126,137.0	1,448,692.0	1,322,556.0
TOTAL	**1,273,518.7**	**3,134,463.0**	**1,860,945.3**
INTEGRATED			
RESIDENTIAL	431,075.4	702,010.0	270,934.6
COMMERCIAL	558,329.7	1,043,020.0	484,690.3
INDUSTRIAL	126,603.0	1,502,549.0	1,375,946.0
TOTAL	**1,116,008.1**	**3,247,579.0**	**2,131,570.9**

C. SENSITIVITY

The estimates in Table II-1 represent one forecast of achievable potential under differing initiatives. In reality, there is a considerable range of achievable potential. For example, there is uncertainty about the cost of new electricity supply that the conservation avoids as well as the environmental costs associated with electricity production. Table II-3 shows the amount of achievable potential as a function of levelized cost for each 2 cent increment from 4 to 12 cents. For example, the achievable potential of 8 cents/kWh could correspond to either: 1) a CONES of 8 cents/kWh; 2) a CONES of 6 cents/kWh and environmental externality cost of 2 cents/kWh; or 3) a CONES of 4 cents/kWh and an environmental externality cost of 4 cents/kWh. Note that the scenario estimates include some adoption of measures regardless of the levelized cost of energy saved. Thus, the total potential for the scenarios[6] exceed the numbers in Table II-3 where measures with higher costs than the specified value are excluded. The results in Table II-3 show only the conservation resource available at or less than the various specified cost levels.

The small sensitivity to avoided costs is partially due to: 1) diminishing returns, that is, the phenomena that as efficiency improves, further improvements become increasingly more difficult; and 2) less effort and time having been spent by governments, utilities and consultants in characterizing options that cost more than 6 cents/kWh because there have not generally been regarded as cost-effective resources.

Table II-3
ACHIEVABLE POTENTIAL AT DIFFERENT COST LEVELS
(GWhs in Year 2010)

Cents/kWh	Pricing	Education	Regulatory	Utility	Integrated
4	9,951	9,763	9,492	10,981	9,826
6	10,781	10,671	11,711	12,532	12,703
8	10,982	10,764	11,711	12,653	13,215
10	11,092	10,934	11,711	13,099	13,360
12	11,203	11,068	11,711	13,330	13,456

[6] Reflected in Tables II-1 (page II-3), Table III-3 (page III-6), Table IV-3 (page IV-7) and Table V-3 (page V-7).

D. CONCLUSIONS

- The achievable conservation is in the range of 8 to 14 thousand GWh by the year 2010, representing approximately 14% to 23% of the year 2010 forecasted electricity consumption.

- Integrated or mixed strategies may not substantially increase achievable savings. The aggressive incentives and promotions in the utility scenario result in similar savings as the integrated scenario, as the market penetration of cost-effective conservation measures is nearly saturated in both scenarios. The integrated strategy has several advantages including:

  - It may not be feasible to implement standards and codes enforcing all measures with a levelized cost of energy saved less than 6 cents/kWh without initiatives to develop market acceptance and infrastructure for several years prior to the implementation of the standards.

  - The utility incentive programs are expensive, so that by phasing in standards, the costs and rate impacts of utility programs can be attenuated.

  - The net present value of savings can be maximized.

  - If one strategy or initiative is less successful than anticipated, other strategies or initiatives may pick up the slack, minimizing the risk of under achieving the conservation goals.

  - Strong forces are established to accelerate technological improvements, cost reduction and market reduction.

- There are many caveats and limitations to this study as noted in Chapter VI. Overall the estimates of achievable potential are realistic and feasible given aggressive and well designed programs.