



MARBK
Resource Consultants Ltd.



MKJA
MK Jaccard and
Associates Inc

APPENDIX C

Achievable Potential Scenarios

Table of Contents

C1.	INTRODUCTION	1
C2.	CONTEXT FOR THE ACHIEVABLE POTENTIAL	3
C3.	MODELLING APPROACH, ASSUMPTIONS AND INPUTS.....	7
	C3.1 Modelling approach	7
	C3.2 Scenario 1: DSM Status Quo.....	8
	C3.3 Scenario 2: DSM Aggressive	11
	C3.4 Summary of Scenarios and Inputs to Model Simulations	18
C4.	ACHIEVABLE POTENTIAL: HIGH LEVEL RESULTS	20
	C4.1 Energy Demand Savings Impact – All Sectors	20
	C4.2 Sector Contribution.....	22
	C4.3 Fuel Specific Savings: Scenarios 1 and 2.....	24
	C4.5 Regional Impacts	26
C5.	RESIDENTIAL SECTOR RESULTS	31
	C5.1 Energy Demand Savings Impact.....	31
	C5.2 Energy Demand Savings By Fuel.....	33
	C5.3 Energy Demand Savings By End Use.....	34
	C5.4 Changes in Energy Intensities and Fuel Shares.....	38
	C5.5 Regional Impacts	39
C6.	INDUSTRIAL SECTOR.....	41
	C6.1 Energy Demand Savings Impact.....	41
	C6.2 Changes in Energy Fuel Shares and Intensities.....	45
	C6.3 End-use Impacts.....	46
	C6.4 Industry Sub-Sector Impacts	49
	C6.5 Regional Impacts	51
C7.	COMMERCIAL SECTOR RESULTS.....	53
	C7.1 Energy DEMAND Savings Impact.....	53
	C7.2 Energy demand savings by Fuel	55
	C7.3 Energy demand savings by End Use.....	56
	C7.4 Changes in Energy Intensities and Fuel Shares.....	59
	C7.5 Regional Impacts	60
C8.	DISCUSSION	63

List of Exhibits

Exhibit C2.1: Cumulative Energy Savings by All Major Household Appliances, 1992-2001	4
Exhibit C2.2: Energy Use by Sector, 1990 and 2003 (Petajoules).....	4
Exhibit C2.3: Explanations for Lower than Expected Energy Efficiency Investment	5
Exhibit C3.1: Achievable Scenario 1: Subsidy Rates by Sector	10
Exhibit C3.2: Levels and Schedule of Standards Application in CIMS.....	14
Exhibit C3.3: Summary of Renewable Subsidies.....	15
Exhibit C3.4: Reference Case Projections of Housing Stock Shares	17
Exhibit C3.5: Summary of Policies Applied in Each Scenario	18
Exhibit C3.6: Parameter changes in CIMS by Scenario	18
Exhibit C4.1: Energy Demand by Milestone Year: Achievable Potential Scenarios versus Reference Case and Economic Potential.....	21
Exhibit C4.2: Energy demand savings by Milestone Year: Achievable Potential Scenarios versus Reference Case and Economic Potential.....	21
Exhibit C4.3: Achievable Potential as a Percentage of the Economic Potential.....	21
Exhibit C4.4: Total End-use Energy Demand by Scenario, All Sectors	22
Exhibit C4.5: Comparison of Scenario 2 Savings and 1990-2003 Energy Use Growth.....	22
Exhibit C4.6: Sectoral Contributions to Energy Savings Impact in the Achievable Potential	23
Exhibit C4.7: Graphical Presentation of Sectoral Energy Demand Savings Contributions: Scenarios 1 and 2	23
Exhibit C4.8: Aggregate (All Sector) Energy Demand Savings According to Fuel.....	25
Exhibit C4.9: Fuel Specific Energy Demand Savings Impact Relative to Reference Case	26
Exhibit C4.10: Total Energy Demand Savings (PJ) in 2025 by Province/Region - All Fuels	27
Exhibit C4.11: Percentage Reduction in Energy in 2025 by Province/Region - All Fuels	27
Exhibit C4.12: Total Energy Demand Savings in 2025 by Province/Region	28
Exhibit C5.1: Annual Demand by Milestone Year: Reference Case, Economic, and Achievable Potential Scenarios.....	32
Exhibit C5.2: Annual Residential Savings in Energy Demand and Savings as a Percentage of Reference Case Demand	32
Exhibit C5.3: Annual Achievable Potential as a Percentage of Economic Potential	32
Exhibit C5.4: Total End-use Energy Demand by Scenario, Residential Sector.....	33
Exhibit C5.5: National Residential Achievable Potential Energy Reduction by Milestone Year and Fuel (PJ).....	34
Exhibit C5.6 - Residential National Energy Demand Savings in 2025 by End-Use	36
Exhibit C5.7 End-Use Savings in 2025 Relative to Reference Case	37
Exhibit C5.8: Residential Achievable Potential - Change in Energy Intensity	38
Exhibit C5.9: Residential Fuel Shares for Achievable Potential and Reference Cases.....	38
Exhibit C5.10: Residential Energy Demand Savings (PJ) in 2025 by Province/Region - All Fuels	39
Exhibit C5.11: Percentage Reduction in Residential Energy in 2025 by Province/Region - All Fuels	39
Exhibit C5.12 Total Residential Energy Demand Savings in 2025 by Province/Region.....	40
Exhibit C6.1: Annual Demand by Milestone Year: Reference Case, Economic Potential, and Achievable Potential Scenarios	43
Exhibit C6.2: Annual Industrial Savings in Energy Demand and Savings as a Percentage of the Reference Case.....	43
Exhibit C6.3: Annual Industrial Achievable Potential as a Percentage of Economic Potential.....	43

Exhibit C6.4: Total End-Use Energy Demand by Scenario, Industrial Sector	44
Exhibit C6.5: National Industrial Achievable Potential Energy Reduction by Milestone Year and Fuel (PJ)	44
Exhibit C6.6: National Industrial Achievable Potential Fuel Shares in Comparison to the Reference Case	45
Exhibit C6.7: Change in Industrial Energy Intensities by Sector.....	46
Exhibit C6.8: Industrial Energy Demand Savings in 2025 by End Use	47
Exhibit C6.9 End-Use Savings in 2025 Relative to Reference Case	49
Exhibit C6.10 Industrial Achievable Potential Savings Share per Sector in 2025	50
Exhibit C6.11: Total Industrial Energy Demand Savings in 2025 by Province for Scenarios 1 & 2.....	51
Exhibit C6.12: Industrial Energy Savings (PJ) in 2025 by Province/Region - All Fuels.....	51
Exhibit C6.13: Percentage Reduction in Industrial Energy Demand in 2025 by Province/Region - All Fuels	52
Exhibit C7.1: Annual End-Use Energy Demand by Milestone Year, Commercial/ Institutional Sector: Reference Case, Economic, and Achievable Potential Scenarios.....	53
Exhibit C7.2: Annual Commercial Savings in Energy Demand and Savings as Percentage of Reference Case Demand	54
Exhibit C7.3: Annual Achievable Potential as a Percentage of Economic Potential	54
Exhibit C7.4: Total End-Use Energy Demand by Scenario, Commercial/Institutional Sector ...	54
Exhibit C7.5: National Commercial Achievable Potential Energy Reduction by Milestone Year and Fuel (PJ)	55
Exhibit C7.6: National Commercial Energy demand savings by End Use.....	57
Exhibit C7.7 End Use Savings in 2025 Relative to the Reference Case	59
Exhibit C7.8: Commercial Achievable Potential - Change in Energy Intensity	60
Exhibit C7.9: Commercial Fuel Shares for Achievable Potential and Reference Cases.....	60
Exhibit C7.10: Commercial Energy Demand savings (PJ) in 2025 by Province/Region - All Fuels	61
Exhibit C7.11: Percentage Reduction in Commercial Energy Demand in 2025 by Province/Region - All Fuels	61
Exhibit C7.12: Energy Demand Savings in 2025 by Province	62
Exhibit C8.1: Added Cogeneration by Sector.....	65
Exhibit C8.2 Achievable Potential Performance Range from Recent DSM Studies	67

C1. INTRODUCTION

Representatives from the federal government (Natural Resources Canada), provincial governments and industry (Canadian Gas Association, Canadian Electricity Association) have come together under the auspices of the CEM Demand-Side Management (DSM) Working Group to collaborate on advancing the role and presence of energy efficiency/DSM in Canada. As a result of this collaboration, the Working Group agreed to undertake a national study to look at DSM potential across Canada. For this study, DSM includes energy efficiency, fuel substitution, cogeneration, distributed generation and demand response.

This is the third report in this study, and presents the method and results of estimating an achievable energy management potential for the study period 2005 to 2025. Other reports include the Reference Case Report (September 2005) and Economic Potential Report (January 2006).¹

The achievable potential (also often referred to as the market potential), is a measure of how a target market responds to one or more market interventions designed to expand and accelerate market take-up of energy management measures. The rationale for market interventions is to address one or more barriers and failures which impede market take-up of these measures to the level of what is economically viable, today and in the future, when market circumstances are expected to change.

The achievable potential addresses three sectors: residential, commercial and industrial. Energy supply sectors (electricity and upstream oil and gas) are not included in the study. All energy types are covered including natural gas, electricity, refined petroleum products and others such as biomass. The analysis covers a 25-year period. The base year is the year 2000, with milestone periods at 5-year increments: 2005, 2010, 2015, 2020, and 2025. The policies modeled in the achievable potential scenarios are assumed to be implemented as of 2006

The achievable potential scenarios modelled in this study represent a foundation for dialogue among Canadian policy makers in mapping a pathway forward for energy efficiency, or more broadly speaking, for energy management. As such the outcome represents a high level assessment of DSM potential in Canada. The savings potentials presented here are indicative, rather than definitive, and should not be construed as the basis for program design and development. The main intent is to encourage discussion about the opportunities and the policy mixes with which to access the opportunities.

As further elaborated in this report, two scenarios of achievable potential have been assessed. The achievable potential is calculated as the difference between the forecast energy demand of the reference case scenario and the energy demand of the achievable potential scenarios.

¹ The reference case report estimates the expected level of energy demand that would occur over the study period in the absence of new (post 2000) energy efficiency measures. The economic potential describes a scenario in which energy efficiency investments are adopted by all producers and consumers (at the rate of technology stock turn-over and/or accelerated take-up through retrofit opportunities), if the life cycle cost of the investment is lower than the long-run cost of energy supply.

This report is organized according to the following subsections:

- Context for the Achievable Potential (section 2)
- Modelling Approach, Assumptions and Inputs (section 3)
- High Level Results (section 4)
- Detailed Sector Results (sections 5 to 7)

C2. CONTEXT FOR THE ACHIEVABLE POTENTIAL

This study takes the approach that an achievable potential is specifically focused around a policy potential, thus the potential reflects the savings that would occur in response to market interventions. Before describing the policies we model, we briefly look at the context for such market interventions.

The Upward Demand Trajectory

During the past 25 years, government at all levels, together with both natural gas and electric utilities, have delivered a wide array of market interventions in an effort to reduce overall demand for energy by residential, industrial, or commercial energy users.² The energy efficiency of most equipment and buildings in Canada has steadily improved. For instance, residential appliance efficiency has improved significantly over this period (Exhibit C2.1).³ Similarly the energy intensity of industrial production has declined. Between 1990 and 2004, energy intensity in industry declined by 30%.⁴ The Office of Energy Efficiency estimates that energy efficiency improvements from 1990 to 2003 resulted in energy savings of 883.3 PJ in 2003.⁵

Notwithstanding these performance improvements, energy demand continues to climb for all sectors, as shown in Exhibit C2.2. What is happening is that the effects of economic activity, namely the growth of the housing and commercial building stock, larger homes, the market penetration of more energy using devices, and industrial production growth all serve to offset the effects of energy efficiency improvements. For example, in the commercial and residential sectors, there is a greater penetration of computers, small appliances and other high-tech equipment that increases plug loads. In an achievable potential scenario, the difficult question is how much and at what speed we can change this trend towards a stable, sustainable level of energy demand in Canada. There are some who advocate that we need to significantly reduce our environmental footprint to achieve environmental sustainability, meaning among other things, that eventually the demand curve would be flattened or bent downwards. However, addressing this question is beyond the scope of this study.

² The private sector has been an important ally to these programs and has been at the forefront in delivering energy management technologies and services to these target sectors.

³ Natural Resources Canada, *Energy Use Data Handbook, 1990-2003 and Energy Consumption of Major Household Appliances Shipped in Canada — Trends for 1990–2001*. Other performance metrics for this period: i) residential whole house energy intensity decreased by 13% between 1990 and 2001, ii) residential space heating intensity decreased by 14% between 1990 and 2003, iii) commercial lighting intensity decreased by 6% between 1990 and 2003.

⁴ Based on gross output. This is for ‘Total Industry’ (NAICS 100000). ‘Total Manufacturing Industry’ (NAICS 100001) shows a similar trend. Canadian Industrial Energy End-use Data and Analysis Centre (CIEEDAC), *Development of Greenhouse Gas Intensity Indicators for Canadian Industry, 1990 to 2004*, Burnaby: Simon Fraser University, 2005.

⁵ Office of Energy Efficiency, *Energy Efficiency Trends in Canada, 1990 to 2003*, Ottawa: Natural Resources Canada, 2005.

Exhibit C2.1: Cumulative Energy Savings by All Major Household Appliances, 1992-2001

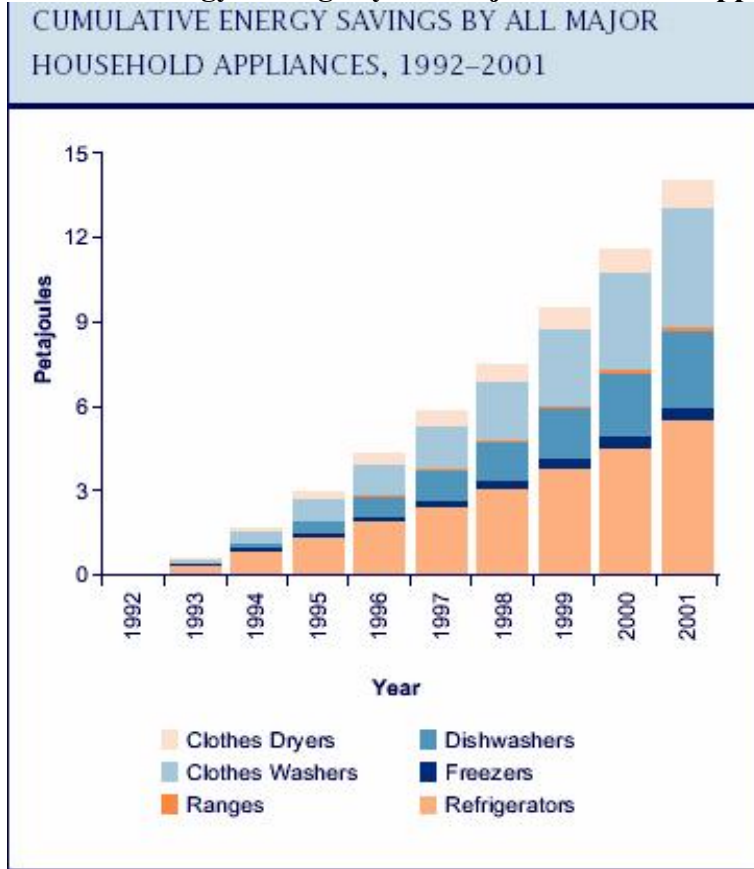
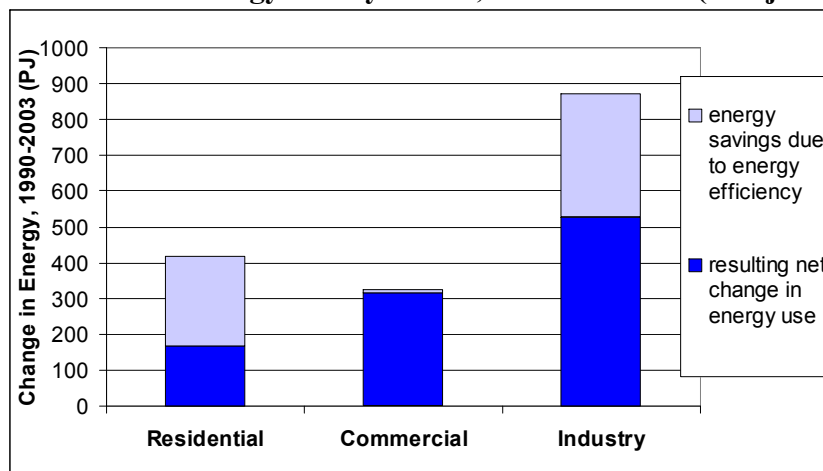


Exhibit C2.2: Energy Use by Sector, 1990 and 2003 (Petajoules)



Source: OEE, Energy Efficiency Trends in Canada, 1990 to 2003, June 2005

Mining the Incremental Energy Performance

There continues to be considerable market intervention activity in support of energy efficiency by all level of government and utilities. A challenge going forward is how to effectively mine the remaining cost-effective energy efficiency potential. At the risk of over-simplification, a good portion of the “low hanging fruit” has been attained in all three sectors, i.e., many of the lower cost, short payback measures. This includes, for example, the penetration of higher efficiency appliances, motors and lighting. Unless economic circumstances change considerably, the potential that remains will be more difficult to capture for several reasons, including: i) the target sub-markets become more challenging, e.g., small commercial, mid- and high-rise apartments, small and medium sized industry and ii) the solutions can become more complex, e.g., moving to process integration and balance of plant measures in industry; and getting industry and commerce to effectively apply corporate energy management systems.

Barriers

Equally important is the degree to which policy can influence the adoption of greater energy efficiency in the economy by addressing fundamental market barriers. Experience with market intervention over the past two decades has shown that, while many energy efficiency opportunities can be shown to be cost-effective, when the monetary value of energy savings is assessed against the initial capital cost outlays, consumers and firms forego apparently cost-effective investments in energy efficiency. Energy users appear to discount future savings of energy-efficiency investments at rates well in excess of market rates for borrowing or saving. This has often been referred to as the energy-efficiency “gap”.⁶ Exhibit C2.3 lists some of the cross-cutting barriers, market behaviours and failures identified in the literature to explain why the take up of energy-efficiency is lower than expected.

Exhibit C2.3: Explanations for Lower than Expected Energy Efficiency Investment

Category	Explanation
Price Signals	<ul style="list-style-type: none"> • Energy pricing at levels that do not integrate externalities associated with the cradle to grave lifecycle (full cost accounting). • Energy pricing signals that do not reflect real-time costs.
Consumer Awareness and Preferences	<ul style="list-style-type: none"> • Awareness that energy efficiency opportunities & products exist • Awareness of benefits – cost and co-benefits. • Consumer technical ability to assess the options. • Consumer offsetting preferences (e.g., large single detached homes). • Lack of public perception/understanding of infrastructure needs/ resource constraints/ the functionality, cost, drivers and challenges are unknown to the public.
Product and Service Availability	<ul style="list-style-type: none"> • Local or national product availability. • Existence of a viable infrastructure of trade allies. • Vendor or trade ally awareness of the efficiency options and their understanding of the technical issues.

⁶ For example, see A. Jaffe and R. Stavins, “The Energy-Efficiency Gap: What Does it Mean?” *Energy Policy* 22, 10 (1994): 804-810; J. Scheraga, “Energy and the Environment: Something New under the Sun?” *Energy Policy* 22, 10 (1994): 811-818; R. Sutherland, “The Economics of Energy Conservation Policy,” *Energy Policy* 24, 4 (1996): 361-370.

Achievable Potential Scenarios

Category	Explanation
Technology and Innovation	<ul style="list-style-type: none"> • An energy efficient technology may not be a perfect substitute for another, accepted technology for an end-use. • An energy efficient technology may not be cost-effective for all consumers, even if it is cost-effective for the average consumer. • Lack of enabling tools and techniques to facilitate market adoption of sustainable energy solutions.
Financing	<ul style="list-style-type: none"> • Access to appropriate financing. • Uncertain future energy prices, combined with the irreversible nature of energy efficiency investments. • Size of required energy efficiency investment vs. asset base. • Payback ratio – actual vs. required.
Transaction Costs	<ul style="list-style-type: none"> • Level of effort/hassle required to become informed, select products, choose contractor(s) and install.
Perceived Risk/Reward	<ul style="list-style-type: none"> • Level of perceived risk that the energy efficient product may not perform as promised. • Level of positive external/personal recognition for “doing the right thing” by installing the efficiency measure(s).
Split Incentive/Motivation	<ul style="list-style-type: none"> • Level to which the incentives of the agent charged with paying for the energy efficiency measure are aligned with those of the person(s) that would benefit.
Institutional and Regulatory	<ul style="list-style-type: none"> • Codes or standards that prohibit implementation of innovative energy efficient technologies. • Limited horizontal cooperation/coordination to integrate policies and implementation. • Municipal policies and land planning processes that supported, even encouraged, development of greenfield areas and subsidized the practice through low development fees. • Disconnect between longevity of infrastructure and short-term horizons on crucial decisions, such as budget allocations for maintenance and rehabilitation and rate structures.

C3. MODELLING APPROACH, ASSUMPTIONS AND INPUTS

This section is structured as follows:

- Section 3.1 presents the approach to modelling the achievable potential.
- Section 3.2 presents the assumptions for scenario 1.
- Section 3.3 presents the assumptions for scenario 2.
- Section 3.4 provides a summary of the scenario inputs.

C3.1 MODELLING APPROACH

The main analytical tool used to develop the achievable potential is the CIMS model and, is described in detail in the Reference Case report, Appendix A. We summarize here some of the key CIMS features as they relate to modelling the achievable potential.

CIMS contains a detailed database representing most of the energy end-use technologies that consume energy and simulates the manner in which consumers and businesses choose between alternative technologies.

In CIMS, the end-use technologies are represented in unique sub-models that meet forecasts of service growth and retirement of current technology stock. In the circumstances of both capital stock turn-over and early retirement through retrofits, prospective technology upgrades compete in the model in ways that approximate what would happen in the real world. The engine for the technology competition is the minimization of annualized life cycle technology costs, but the process of technology competition is also affected in the model by:

- Identified differences in non-financial preferences (e.g. differences in the quality of lighting from different light bulbs).
- Preferences of firms and households with respect to the risk of newness and risk of irreversible investments. Thus the levelized capital cost is calculated with effective ‘private’ discount rates that are revealed from market data.⁷
- The non-deterministic nature of market behaviour. Market shares are allocated among technologies probabilistically according to a *variance parameter*.⁸

As noted, the achievable potential is specifically focused around a policy potential - savings occur in response to market interventions applied to the reference case set up in CIMS. These market interventions are modelled by changing the conditions of technology acquisition as influenced by the policies (and represented as changes to the model’s inputs). Two achievable potential scenarios are modelled in this study, referred to as **achievable scenario 1-DSM Status Quo** and **achievable scenario 2-DSM Aggressive**. These scenarios represent considerably different visions of how various policy instruments and programming may be brought to bear on

⁷ Revealed discount rates cover both of these factors because the new technologies of interest to energy-economy modellers are those that increase energy efficiency through irreversible, long payback investments.

⁸ In contrast, the optimizing models will tend to produce outcomes in which a single technology gains 100% market share of the new stocks.

the residential, industrial and commercial/institutional markets during the study period. We outline these scenarios in detail in the next sections.

Given that energy systems in Canada differ significantly by region, the analysis constructs a national potential as an aggregation from the analysis of regional potentials (rather than a single national potential). The regional analysis in CIMS is undertaken through a set of unique sub-models for B.C., Alberta, Saskatchewan, Manitoba, Ontario, Quebec and the Atlantic region.⁹ The CIMS model is not currently set up to model the Atlantic region on a provincial basis and, therefore, the analysis of the Atlantic region potential does not reflect the diversity of energy systems, fuel availability, prices and mix, and electricity prices in the Atlantic provinces.¹⁰

C3.2 SCENARIO 1: DSM STATUS QUO

Scenario 1: DSM Status Quo (hereafter, referred to as **scenario 1**) models the achievable potential over the 25-year study period assuming a continuation of approximately the current levels and types of market interventions by government and utilities. The modelling for this scenario is designed to assess the effect of market interventions that continue the trajectory forward of the current mix of DSM policies and efficiency programs.

In consultation with the CGA client group, scenario 1 was designed to be driven primarily by two types of policy instruments: financial subsidies and information programs (in its broadest sense as elaborated below). The inclusion of energy performance standards was considered for this policy mix, since they are certainly part of the current DSM landscape in Canada. Mandatory energy performance standards are presently focused on improving equipment performance levels, less so on building performance. It was posited that there remains a considerable upside for enhanced performance standards and, consequently, it was decided to include this policy instrument in the second, more aggressive scenario.

To set the stage for the DSM Status Quo scenario, a scan of current government and utility energy market interventions was undertaken which revealed the following:

- It is estimated that current annual energy efficiency expenditures amount to between \$400 million and \$500 million per annum.¹¹ Another way to look at these values is that energy efficiency expenditures are somewhere in the order of 0.5% to 1% of the total annual energy bill to Canada.¹²

⁹ There was no scope within the budget to restructure the model and/or create new sub-models.

¹⁰ The Atlantic region accounts for 7% of the end-use energy (in 2000) for sectors represented in the study.

¹¹ This estimate is based on a scan of the following documents:

- i) NRCan "Improving Energy Performance in Canada-Report to Parliament Under the Energy Efficiency Act Fiscal 2004-05, Appendix 1". The estimate for federal expenditures is about \$165 million per year.
- ii) Canadian Electricity Association and Natural Resources Canada, Description and Results of Energy Management Programs-A Survey of Programs Operated By Electric Utility Companies in Canada, March 2003 and Update in October 2003.
- iii) Indeco in association with B. Vernon and Associates, DSM Best Practices-Canadian Natural Gas Utilities Best Practices in Demand-Side Management, undertaken for the Canadian Gas Association, 2005.

¹² NRCan estimates the annual energy bill at about \$130 billion, about 13% of GDP.

- The majority of the energy efficiency program costs borne by utilities fall into the category of subsidies of one form or another. Not surprisingly then, the majority of the utility-reported annual energy savings are attributed to the effect of these subsidies – in the vicinity of 75% of total reported savings.¹³
- Government program costs are more broadly distributed, among subsidies, energy performance standards development and administration, information, and research and development. Consequently, reported energy savings from government initiatives are attributed more broadly to the foregoing mix of instruments.

C3.2.1 Scenario 1 Subsidy Schedule

Financial subsidy is a policy instrument designed to reduce the energy management investment cost to a level commensurate to the business and consumer hurdle rates. Subsidies for energy management continue to be a prevalent means of delivering DSM in Canada and elsewhere. As discussed in the Economic Potential report, there is a considerable gap between the social and private discount rates for energy management. Hence, the argument is that if a particular energy management measure passes a societal cost test, then it is legitimate to use subsidies to induce market take-up of the measure.¹⁴

To implement subsidies in the model, decisions need to be made about which end uses or technologies are *targeted*, and the *subsidy rate* applied to the targeted end use or technology. A subsidy schedule was derived and applied to the energy efficient technologies that passed the lifecycle cost test in the in the economic potential.¹⁵

Exhibit C3.1 lists the schedule of subsidy rates applied to the targeted technologies in CIMS. The subsidy rates differ by sector and by equipment category and the levels are informed by have a cursory scan of subsidies offered in Canadian and other jurisdictions . However, it's important to note that the modeled subsidy rates are designed to mimic the details of all current subsidies in Canada. Rather, the levels are to show indicatively, what the effects of the DSM status quo subsidies would be on the target markets for the study. Consider, for example, the federal capital cost tax allowance under Class 43.1 which is applicable to cogeneration systems, The analysis does not mimic the subsidy effect of Class 43.1 but does model a capital cost subsidy to cogeneration technologies, as identified by the economic potential scenario.

¹³ This is based on in-house data/files plus a small selection of telephone conversations with gas and electric utility officials.

¹⁴ Another way of looking at this is that, if the cost of delivering the energy management measure is less than the social cost of the displaced energy form, then it is an economically legitimate investment from the standpoint of society.

¹⁵ These represent energy efficiency investments whose life cycle cost of the investment is lower than the long-run cost of energy supply. This is roughly equivalent to targeting those investments that 'passed' a Total Resource Cost test.

Exhibit C3.1: Achievable Scenario 1: Subsidy Rates by Sector

	Average Subsidy Rate as a % of Capital Cost
Residential hot water system replacement	25%
Residential furnaces replacement	25%
Residential envelope upgrades and equipment tune-up (retrofit)	35%
Residential appliance replacement	10%
Residential new construction	20%
Commercial existing retrofit/tune-up	30%
Commercial new construction	15%
Commercial equipment replacement (boilers, domestic hot water etc.)	25%
Industrial process and equipment tune-up	25%
Industrial equipment replacement	15%

The subsidy rates are input into the CIMS model as a percentage of the installed cost of the targeted energy management measure, which has the effect of reducing the measure’s installed costs, i.e., the lifecycle cost of the measure is reduced.¹⁶

When reviewing the subsidy parameters, the following additional considerations need to be kept in mind:

- The proposed subsidy levels take into account that there is a potential for program participants to stack utility and government incentives. This has the effect of increasing the average subsidy level which we have tried to capture with these values.
- The incentive categories do not differentiate among fuels but try to reflect differences by sector and end use application (e.g., equipment replacement versus retrofit).

C 3.2.2 Information Programs

The second dimension of scenario 1 is to estimate the incremental energy savings effect of a wide array of initiatives that fall into the category of “information” programs. This category can include, among other things, broad or target based information campaigns, product and building labelling, energy audits and assessments, and training. A wide range of such activities exists in Canada today. These types of activities have an important role to play in fostering market transformation of energy efficient products and [practices. They help to establish a foundation of awareness, behavior and competencies that help to ensure the sustainability of energy management measures over the long term.

Initially, it was thought possible to model the effect of these information programs in CIMS through a modification of one or more of the parameters that affect technology choices within the model, e.g., a reduction in the sector private discount rates with which

¹⁶ The subsidy reduces the capital cost of the technology in which it applies, thus changing the relative costs of each technology at the competition.

the reference case was modelled. However, this pathway raised modeling challenges that could not be addressed within the scope of the project budget, specifically, how to translate the evidence from evaluation studies etc into the parameters used to describe technology acquisition in CIMS. We concluded that it would be clearer to represent the potential impact of information programs exogenously.

The construct selected for estimating the effect of the information program category was to simply apply a multiplier to the bottom line impact of the other policy instruments, thus assuming that the impacts of subsidy based initiatives would be further enhanced. In recent years, the gas and electric utilities, as well as NRCan, have conducted some program evaluations of information based programs which provides some empirical evidence of the performance effects. Moreover, some of the utilities consulted on this topic noted that the category of information programs (again, in its broadest sense) may account for as much as 25% of the total reported DSM program energy savings.¹⁷

In the end, the impact of information based activities was calculated by simply applying a multiplier of 1.2 to the bottom line impact of the other policy instruments. So in the case of Scenario 1, the impact of the subsidy instruments was increased by another 20%.

C3.3 SCENARIO 2: DSM AGGRESSIVE

Scenario 2 models the achievable potential to 2025 as a vision of how to more effectively address market barriers and failures and consequently expand and accelerate the energy management effect in the economy over this period. The scenario includes new and expanded policy instruments involving all levels of government, utilities and the private sector that can capture a greater array of options. It also assumes that policies could do more to address fundamental changes that need to be made regarding urban land use intensity and form which, in turn, will affect needed changes to foster sustainable infrastructure.

In short, the **Aggressive DSM** scenario is conceived as a much more aggressive package of policy and program measures aimed to push the boundaries of the achievable potential, but still primarily inducing take-up of measures that cost less than the avoided cost of the energy forms being displaced. This scenario includes the following policy instruments:

- Subsidies targeted to energy efficiency measures,
- Marginal cost pricing for electricity,
- A carbon liability,
- An aggressive schedule of legislatively backed advanced minimum energy performance targets for both equipment and buildings,
- An aggressive schedule of subsidies to accelerate the market penetration of on-site renewable energy technologies to displace current fuel shares in secondary energy end uses, (i.e., not including renewables to displace primary energy supply), and

¹⁷ Based on a scan of NRCan evaluations conducted of the EnerGuide for Houses Program, the CIPEC Dollars to Sense program and the Industrial Energy Audit Program, further supplemented by interviews with a select group of gas and electric utilities.

- Changes in the shares of projected housing types (low rise versus mid- to high-rise) to mimic the potential effects of aggressive urban land use policy instruments to affect intensities, densities, shares of building types and advance community energy systems.

The application of these policy instruments is further elaborated below.

C3.3.1 Subsidies – Targeted to Energy Efficiency Measures

Energy efficiency subsidies are applied in scenario 2 as a complementary instrument to regulated energy performance standards, pricing and the other instruments discussed below. The same subsidy levels used for scenario 1 are applied but at a different rate of application.

The energy efficiency technologies eligible for subsidy application fall into two categories: i) those that will be affected by energy performance standards and ii) those that will not be affected by the standards.

As discussed below, the standards are introduced at varying schedules during the study period. Consequently, for those technologies affected by the standards (i) subsidies are applied only until the performance standard applies. Technologies not affected by the standards (ii), are subsidized throughout the simulation period.

C3.3.2 Marginal Cost Pricing: Electricity

Scenario 2 applies marginal cost pricing for electricity. With regard to electricity, the pricing schedule enables an analysis of the potential effects of advancing from a monopoly average cost pricing regime for electricity to a regime that embodies marginal cost pricing. In practice, a marginal cost policy instrument could be manifested in a number of ways: regulators requiring this for electricity pricing, or some form of time-of-use pricing measured and reported on a real time basis. This policy only applies to electricity because the prices of the other energy forms already represent marginal cost pricing as their prices are determined in competitive markets.

This policy is modelled in CIMS by revising the electricity price forecast used in the Reference Case scenario. The same long run marginal electricity price forecasts are used as calculated for the economic potential (see section 2.1 of the Economic Potential Report). These forecasts are derived from the supply price of a new combined cycle gas turbine in each jurisdiction to which is added the costs of transmission and distribution, while taking into account line losses. This is a ‘broad brush’ approach; and does not derive detailed pricing based on close examination of the capacity requirement and type (baseload, peaking, etc), and timing of new generation requirements for each individual province and region.

C3.3.3 Carbon Liability Shadow Price

Scenario 2 also applies a \$15/tonne CO₂e price adder for all fuels based on the carbon content of the affected fuels. This is representative of mechanisms that are starting to be

used by energy utilities to price or cost GHG emission reductions for use in planning, acquisition, project development or operational decisions. These mechanisms include:

- Government instituted “safety valves” or price assurance relating to CO₂ regulation
- Resource planning GHG “adders”
- Energy acquisition GHG bid price adjustments

A review of jurisdictions conducted for the BC Hydro integrated electricity planning process shows that \$15/tonne CO₂e falls in the range of how CO₂ reductions are valued in jurisdictions where this is currently applied or proposed.¹⁸ It also reflects the price assurance mechanism or safety valve for 2008-2012 as proposed by the Canadian government for the Large Final Emitters (LFE) cap and trade regulation.

This policy is modelled in CIMS by including a carbon charge in the energy price according to the carbon content of the energy. It is the same value used for the economic potential scenario.

C3.3.4 Regulations and Standards

In CIMS, equipment and building efficiency standards are specified to remove from the market some share of the capital stocks that are the least energy efficient. The reference case forecast includes current equipment performance standards that are in place as of 2005. In scenario 2, a more aggressive schedule of standards is applied as specified in Exhibit C2.8. As shown, Exhibit C3.2 specifies the following according to sector and end-use:

- The CIMS reference case specification of performance levels and market shares.
- The scenario 2 recommended performance levels and shares.
- Some commentary on the rationale for the selections.

¹⁸ BC Hydro Provincial Integrated Electricity Planning Committee, “GHG Cost Comparisons Across Jurisdictions”, Meeting #6 (September 22 - 23, 2005), Information Sheet #8. \$15/tonne CO₂e is low when compared with recent cost estimates to arrive at zero emission sources of electricity (relative to conventional fossil fuel combustion), which fall in the range of US \$50-\$70/tCO₂. Sims, R.E.H., H.-H. Rogner, and K. Gregory. 2003. Carbon emission and mitigation cost comparisons between fossil fuel, nuclear and renewable energy sources for electricity generation. *Energy Policy* 31: 1315-1326.

Exhibit C3.2: Levels and Schedule of Standards Application in CIMS

End-use	What's available in CIMS for new/replacement stock	Recommended Standard and schedule	Rationale/Discussion
RESIDENTIAL SECTOR			
New housing	Standard and Efficient (R2000) which represents a 30% performance improvement	30% is R2000 in 2010, 60% in 2015, and 100% in 2020.	Setting the level to R2000 immediately would require improved construction in approximately 95% of the housing construction, phasing in will provide a more realistic scenario.
EQUIPMENT			
Furnaces	Efficiencies (AFUEs) of 78 and 92	50% penetration of AFUE 92 by 2015 and 100% penetration by 2020.	Immediate increase to 92% would eliminate over 80% of models available, phasing in will provide a more realistic scenario.
Gas water heaters	EF 0.58, 0.65 & 0.86.	Eliminate EF 0.58 by 2015.	Improved technologies are available.
Low-Flow Fixtures	Regular or low flow	Eliminate all regular by 2010.	Regular flow is already eliminated in BC so, change is possible.
Air Conditioning	4 levels for Central (SEER 3010-2000); 2 levels for room (EER 900 to EER 820)	Eliminate lowest efficiency level in both classes by 2010.	Lots of potential for improvement in AC. Wide range of efficiencies on the market.
Refrigerators	485 kWh, 435kWh , 392 kWh, 339 kWh and 281 kWh (this is a custom fridge).	Eliminate 485 kWh in 2005 and 435 kWh in 2010.	Lots of potential for improvement in refrigerators. Wide range of efficiencies on the market.
Dishwashers	EF 0.46, EF 0.58 and EF 0.94	Eliminate 0.46 by 2010.	0.46 became the minimum in July 2004. Lots of room for improvement.
Clothes washers	MEF 23, 29, 31, 36, 46	Eliminate EF 23 in 2010, 29 in 2015, and 31 in 2020.	Lots of potential for improvement. Wide range of efficiencies on the market.
Freezers	3 levels of efficiency - 1 - standard level; 2 - efficiency improvement of 10% upright, 15% chest; 3- efficiency improvement of 10% upright, 50% chest	Eliminate standard option in 2010. Assumes constant share in study period of 75% chest and 25% upright	Lots of potential for improvement. Wide range of efficiencies on the market.
Minor Appliances	standby power loss 1 kw	Make 1kW standby mandatory by 2015.	There is a lot of interest in this area internationally and technology is available at low cost.
COMMERCIAL SECTOR			
HVAC	End-use technologies EUIs are combined in CIMS to develop whole building HVAC EUIs	In new construction, a 20% improvement in new HVAC EUIs by 2010 and a 30% improvement by 2020.	30% performance improvement relative to the reference case is currently technologically feasible. CBIP widely adopted at 25% better than MNCEB. Owner occupied buildings will be willing adopters.
Lighting	Technologies are combined in CIMS to develop lighting EUIs	35% improvement in lighting EUIs by 2015.	Technology is available. This level of saving will require control strategies and dimming which are proven technologies.
INDUSTRIAL SECTOR			
Boilers	Many different type of fuels, and improved efficiency boilers.	3-5% improvement in minimum available new boiler	Specific performance improvement depends on fuel

C3.3.5 Subsidies – Renewables Schedule

Subsidies are applied to induce a greater market penetration of some renewable energy technologies for on-site applications. In the context of DSM potential, this policy instrument is directed at on on-site renewables applications to reduce purchases of natural gas, refined petroleum products (RPPs) and electric power. Practically speaking this would include investments in on-site solar and biomass applications.

While this is characterized as an aggressive renewables policy, conceptually it corresponds well to efforts internationally. There are many examples worldwide of government, at all levels, instituting aggressive renewable energy policies and programs. For example, the California Public Utilities Commission (PUC) recently voted to adopt the California Solar Initiative (CSI), which will provide up to \$2.9 billion in incentives toward solar development over 11 years. One of the goals of this initiative is to install 3,000 MW of solar power capacity by 2017, making it the largest solar program in the U.S.¹⁹

The subsidies applied in the Scenario 2 simulation are described in Exhibit C3.3.

Exhibit C3.3: Summary of Renewable Subsidies

Measure	Subsidy level: % installed capital cost	Target sector
Solar Hot Water	30	Residential and Commercial/Institutional
Solar Photovoltaic	40	Residential
Geo-Exchange	15	Commercial/Institutional

As can be seen, there are no renewable energy subsidies applied to the industrial sector. There was some consideration given to a subsidy application for biomass-based combustion systems. However, it was felt that this might induce a double-counting market effect since the carbon liability policy instrument already encourages a switch to biomass in industry.²⁰ Moreover, subsidies are also already modelled as part of the energy efficiency schedule to encourage biomass and black liquor cogeneration.²¹

The CIMS analysis did not target wood combustion in the residential sector because wood for space heating is tied to other fuels (as the secondary fuel source), and it is not possible to separate the targeting.

¹⁹ California PUC website, CSI includes \$2.5 billion in rebates for existing homes, businesses and public buildings, to be managed by the PUC and funded through revenues collected from gas and electric utility distribution rates. The California Energy Commission (CEC) will manage another \$350 million in rebates targeted for new residential construction, utilizing funds already allocated to the CEC to foster renewable projects between 2007 and 2011.

²⁰ CIMS cannot model this effect in the residential sector because it cannot separate biomass from other fuels where they are used to service the same end-use.

²¹ No other end-use renewable technologies are represented in the CIMS industry sub-models.

C3.3.6 Introduction of aggressive urban land use policy instruments to affect intensities, densities, shares of building types and advance community energy systems.

This policy focuses on the largely untapped area of land use as a means to reduce the environmental footprint of communities, particularly in the urban centres where 80% or more of the Canadian population resides. In terms of affecting reductions of energy demand, sustainable land use policy instruments can generate the following possible outcomes:

- Reduced average energy use per dwelling or building.
- Reduced transportation energy use.

The scenario 2 analysis deals with the challenge of reducing average energy use per dwelling. However, we do speak to the possible transportation energy savings due to what is referred to as the location efficiency effect (discussed in brief in section 7).

There is a wide range of possible policy instruments to affect land use change in municipalities, which, taken together, can affect: i) the type and amount of land use, ii) the intensity of use within the land boundary, and iii) the spatial distribution and location of use (e.g., degree of sprawl). Over the long run we might expect some form of hybrid approach to affect change in these three dimensions of land use, incorporating elements of the “compact city” and the “short cycles” resource use strategies.

The compact city strategy focuses on the form of the city and the efficiency of the distribution of human activities within it. Compact, mixed-use and dense land development optimizes use of the infrastructure of the city by enabling effective use of public transport and non car-based movement systems and minimizing vehicular movements. Within the compact city paradigm, brownfield sites provide particularly relevant opportunities for development because these are typically located within fully serviced urban areas. There are an estimated 30,000 brownfield sites in Canada at approximately 15.9 hectares per site which yields 4,770 km² of brownfields existing in Canada. This is roughly 12% of the existing 39,000 km² of existing urban land area.²²

The short cycles resource use strategy enables local environmental sustainability through infrastructure design and operation for more efficient use of local resources, greater local economic autonomy and a smaller ‘ecological footprint’. For example, when applied to a brownfield development such as the Vancouver False Creek development, there is an opportunity to design community energy systems that foster integration between the building and the energy source, and among a cluster of buildings. The False Creek development features an integration of green-space, energy efficient buildings, renewable

²² Round Table on the Environment and the Economy. 2003. *A National Brownfield Redevelopment Strategy for Canada Cleaning up the Past, Building the Future*. Redeveloping brownfields for commercial use (instead of greenfields) saves \$18,000/hectare in infrastructure costs. Hemson Consulting. 1998. *Retaining Employment Lands – Morningside Heights – A Report to the City of Toronto Economic Development, Tourism & Culture*. Based on approx. 22 sites or agglomerations of brownfield in Toronto. Redeveloping brownfields for residential use (instead of greenfields) saves \$66,000/hectare in transportation costs, including the impacts of lower road congestion reducing transportation costs for all commuters.

energy systems, and ground-source energy systems, all within the construct of a community energy system.

It was beyond the scope of this study to try to model all of the possible land use effects of policy instrument applications. The analysis was limited to modelling changes in the shares of projected housing types (low rise versus mid- to high-rise) to mimic the potential effects of aggressive urban land use policy instruments. It's assumed that the policy instruments will result in an intensification characterized by a shift in the market shares of dwelling types relative to what is in the reference case. In other words, there will be a growth in the number of apartment and row dwellings relative to single family dwellings (SFD). When CIMS models these changes in market shares it means that the energy efficiency improvements induced by all of the proposed policy instruments will, together, affect the new profile of dwelling types. The analysis was applied using the following assumptions.

Exhibit C3.4 shows the profile of housing stock shares in the reference case.

Exhibit C3.4: Reference Case Projections of Housing Stock Shares

Year	AB			AT			BC			MB		
	SFD	Apt	Row	SFD	Apt	Row	SFD	Apt	Row	SFD	Apt	Row
2000	71%	18%	11%	74%	19%	7%	57%	33%	10%	73%	22%	6%
2005	71%	18%	11%	74%	20%	7%	58%	32%	9%	73%	21%	6%
2010	71%	18%	11%	73%	20%	7%	59%	32%	8%	73%	21%	6%
2015	70%	18%	11%	73%	20%	7%	61%	31%	7%	74%	21%	6%
2020	70%	19%	11%	72%	21%	7%	62%	31%	7%	74%	21%	6%
2025	70%	19%	11%	72%	21%	7%	64%	30%	6%	74%	20%	6%
2030	70%	19%	11%	71%	21%	7%	65%	30%	5%	75%	20%	6%
2035	69%	19%	11%	71%	22%	8%	66%	29%	5%	75%	20%	6%
Annual change in share	-0.1%	0.1%	0.2%	-0.1%	0.3%	0.4%	0.4%	-0.4%	-2.0%	0.1%	-0.2%	0.0%

Year	ON			PQ			SK		
	SFD	Apt	Row	SFD	Apt	Row	SFD	Apt	Row
2000	56%	30%	15%	48%	44%	8%	79%	16%	5%
2005	56%	30%	15%	47%	44%	9%	77%	17%	5%
2010	56%	29%	15%	46%	44%	9%	76%	18%	6%
2015	56%	29%	15%	46%	44%	10%	75%	19%	6%
2020	56%	29%	15%	45%	44%	10%	74%	20%	6%
2025	56%	29%	15%	45%	43%	11%	73%	20%	6%
2030	57%	29%	15%	44%	43%	12%	72%	21%	7%
2035	57%	29%	15%	44%	43%	13%	71%	22%	7%
Annual change in share	0.1%	-0.1%	0.0%	-0.2%	-0.1%	1.3%	-0.3%	0.9%	0.9%

In scenario 2, the percentage of single detached dwellings was reduced in absolute terms by 25% in 2025. The re-allocation of shares from single detached to other housing was applied in equal proportions between apartment and row housing. There is a gradual ramping up of these shares to the milestone year of 2025.

C3.4 SUMMARY OF SCENARIOS AND INPUTS TO MODEL SIMULATIONS

Exhibit C3.5 summarizes how the mix of policy instruments was applied in both of the achievable potential scenarios; the dark shaded area indicates application of the instrument.

Exhibit C3.5: Summary of Policies Applied in Each Scenario

Policy Instruments	Scenario 1	Scenario 2
Subsidies-energy efficiency schedule		
Subsidies-renewables schedule		
Information		
Regulation & Standards		
Marginal cost pricing		
Carbon liability		
Change in dwelling type shares		

Note: the schedule of energy efficiency subsidies is adjusted in scenario 2 based on standards targeting. (see discussion, section 3.3.1)

Exhibit C3.6 shows how inputs in CIMS were adjusted to run the achievable potential simulations relative to the reference case and economic potential simulations.

Exhibit C3.6: Parameter changes in CIMS by Scenario

Model drivers	Reference Case	Economic Potential	Achievable Potential	
			Scenario 1	Scenario 2
Energy prices	NEB energy price forecast (techno-vert)	<ul style="list-style-type: none"> Long run marginal cost for electricity (all others as per reference case forecast) carbon price of \$15 / t co2e 	<ul style="list-style-type: none"> NEB energy price forecast (techno-vert) 	<ul style="list-style-type: none"> Long run marginal cost for electricity (all others as per reference case forecast) Carbon price of \$15 / t co2e
Discount rate	Private	Social	Private	Private
Variance parameter	Low	High	Low	Low
Technology Capital Costs	As per database	As per database	Lower for selected energy efficient technologies	lower for selected energy efficient and renewable technologies
Fuel share	No control	Controlled	No control	No control

Note: The variance parameter refers to the shape of the probability distribution in CIMS used to allocate market share between technology options. A ‘low’ setting refers to a deterministic allocation (winner-take-all)

Energy prices and carbon liability

The simulation of technology acquisition in CIMS uses a forecast of future energy prices as a model input to calculate the levelized life cycle cost of each technology option. As noted in previous reports, we adopt the National Energy Board’s 2003 techno-vert forecast of energy

prices.²³ This forecast is used as the basis for all simulations; but changes are made to it in order to represent policies in scenario 2, specifically:

- a. The electricity forecast is adjusted to represent the long run marginal cost of electricity generation. This is done to represent a marginal cost pricing policy.
- b. A carbon liability is added to the energy prices according to the carbon content of each fuel.

Variance Parameter and Discount Rate

CIMS includes parameters in its technology choice algorithm to represent observed technology acquisition behaviour (see section 3.1). This includes intangible costs which represent non-financial preferences, a private discount rate to the risk of newness and risk of irreversible investments, and a variance parameter which reflects the non-deterministic nature of market behaviour. The model is run with these parameters in both the reference case and the achievable potential scenarios. In the economic potential, these parameters were adjusted so that the model would produce a simulation equivalent to a total resource cost test, thus the discount rate was set at a social rate and the variance parameter was set so that the technology with the lowest lifecycle cost captures almost all of the market for new equipment stock – a “winner takes all result” – and so that the life cycle cost would only reflect the financial costs of the technology.

Fuel Shares

Technology options of various fuel and efficiency levels are described to meet end-use service demands in CIMS (i.e. to meet space heating demand the options include electric base board heating, heat pumps, furnaces of varying efficiencies and fuel types and integrated hot water and space heating systems). Depending on the attractiveness of various options, differing fuel shares may result. In the simulation of the achievable potential scenarios, no effort was made to ‘control’ this effect – thus some fuel switching from oil may take place to take advantage of a subsidy offered to gas but not to oil. This contrasts with the economic potential, where we limited fuel switching, in order to isolate efficiency potentials by fuel type.

Capital costs

The subsidies outlined in Exhibits C3.1 and C3.3 are applied to the capital costs of targeted technologies represented in CIMS. This will lower the capital cost of subsidized technologies relative to the technologies they compete with to meet an end-use service.

²³ National Energy Board, “Canada’s Energy Future” Scenarios for Supply and Demand to 2025. (Supply Push and Techno-Vert scenarios). http://www.neb-one.gc.ca/energy/SupplyDemand/2003/index_e.htm

C4. ACHIEVABLE POTENTIAL: HIGH LEVEL RESULTS

This section presents the results of both achievable potential scenarios, at the aggregate – all sector level, as presented in Exhibits C4.1 to C4.13. The results are presented under six themes: i) overall energy demand savings, ii) sectoral contributions, iii) fuel contributions, iv) effect of fuel substitution and cogeneration, v) regional impact and vi) comparison to other studies. The discussion of the implications arising from these results is presented in section 8.

The achievable potential impact is calculated as the difference between the demand for energy in the reference case scenario and the demand for energy in the two achievable potential scenarios. The demand for energy in the two achievable potential scenarios affects the amount of purchased energy supply required due to secondary energy efficiency improvements and on-site self-generated electricity and use of renewable energy forms such as biomass. Consequently, electricity generated on-site within these sectors serves to offset the amount of electricity that needs to be supplied, while increasing the demand for fuels needed to generate the electricity (e.g., natural gas). No attempt was made in this report to relate the savings to load curves, or to consider savings relative to base and peak energy demand.

C4.1 ENERGY DEMAND SAVINGS IMPACT – ALL SECTORS

Exhibits C4.1 to C4.5 present the overall energy demand savings impact for the achievable potential scenarios. The average annual growth rate in energy demand slows to 0.68% in scenario 1 and 0.36% in scenario 2, relative to 0.85% in the reference case. In 2025 the total reduction in energy demand ranges from 182 PJ to 647 PJ, a 2.9% to 10.1% range in savings relative to the reference case forecast (Exhibit C4.2). This also means that the range of achievable potential can supply 16% to 56% of the projected growth in energy demand to 2025.

As shown in Exhibit C4.3, the two achievable potential scenarios represent a range of 19.9% to 70.5% of the economic potential.

As shown in Exhibit C4.5, the projected savings impact under scenario 2 is equivalent to about 64% of the total aggregate increase in energy demand in the three sectors between 1990 and 2003.

Using the projected energy market prices used in the Reference Case forecast, the achievable potential savings amount to a range of \$3.2 billion to \$15.7 billion in energy operating cost savings in 2025 relative to the reference case forecast.

Scenario 2 generates larger demand savings due to the combined effect of the more aggressive mix of DSM policy instruments. The effects at play can be broken down as follows.

- *Take-up of energy efficiency measures:* Both marginal cost pricing and the carbon liability increase the price of energy, with the former having this effect on electricity prices. This makes the return on investment of energy efficiency measures more attractive. When subsidies are added to the policy mix, there will be a shift in investment to more of the higher efficiency measure options. The subsidy effect complements the added impact of enhanced performance standards. As can be seen, together these

instruments expand the energy demand savings available, particularly in the residential and commercial sector.

- *Take-up of cogeneration and fuel substitution:* The price increases associated with marginal cost pricing and the carbon liability also have an effect on cogeneration and fuel substitution investments. In response to the carbon liability, there is fuel switching to less carbon intense fuels (away from coal and oil), while marginal cost pricing encourages fuel switching away from electricity. Both of these factors affect the increased take-up of on-site renewable energy applications. Marginal cost pricing for electricity, in particular, increases the differential between gas prices and electricity prices – which is critical to cogeneration development. Indeed, the energy reductions modeled for industry are muted by significant fuel substitution and cogeneration, and reflect differences in policy targeting to that sector. These sector specific issues are discussed in the following sections.

Exhibit C4.1: Energy Demand by Milestone Year: Achievable Potential Scenarios versus Reference Case and Economic Potential

Annual Demand (PJ/yr)				
All Sectors				
Base Year	Reference Case	Economic Potential	Achievable Scenario	
			1	2
2000	5,176	5,176	5,176	5,176
2005	5,335	5,335	5,335	5,335
2010	5,567	5,150	5,512	5,441
2015	5,829	5,215	5,719	5,548
2020	6,082	5,315	5,935	5,627
2025	6,389	5,471	6,207	5,742

Exhibit C4.2: Energy demand savings by Milestone Year: Achievable Potential Scenarios versus Reference Case and Economic Potential

Year	Annual Savings (PJ/yr)			Savings as Percentage of Reference Case Demand		
	Economic Potential	Achievable Potential		Economic Potential	Achievable Potential	
		Scenario 1	Scenario 2		Scenario 1	Scenario 2
2010	417	55	125	7.49%	0.99%	2.25%
2015	614	110	281	10.53%	1.88%	4.82%
2020	768	147	455	12.62%	2.42%	7.49%
2025	918	182	647	14.37%	2.85%	10.13%

Exhibit C4.3: Achievable Potential as a Percentage of the Economic Potential

Year	Achievable Savings as Percentage of the Savings Identified in the Economic Potential	
	Scenario 1	Scenario 2
2010	13.2%	30.1%
2015	17.9%	45.8%
2020	19.2%	59.3%
2025	19.9%	70.5%

Exhibit C4.4: Total End-use Energy Demand by Scenario, All Sectors

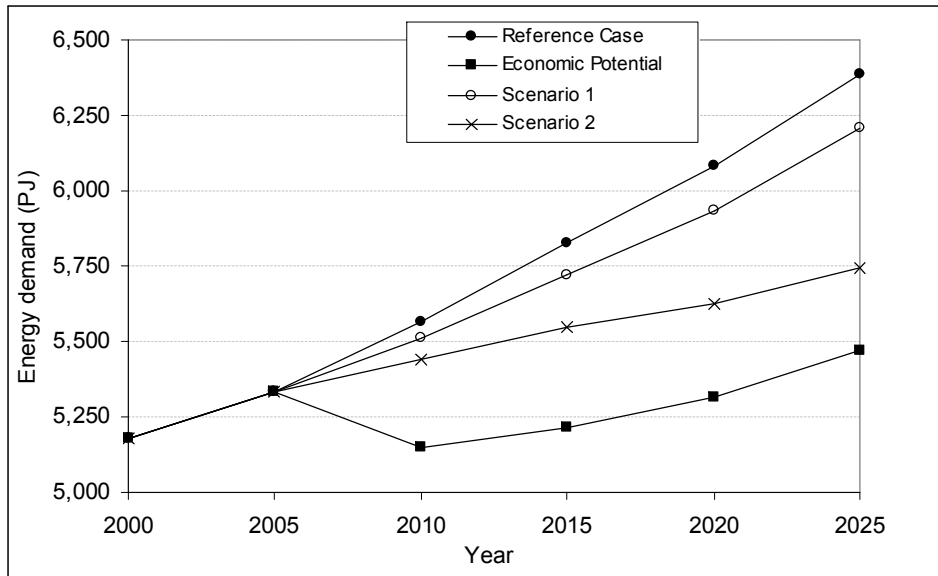
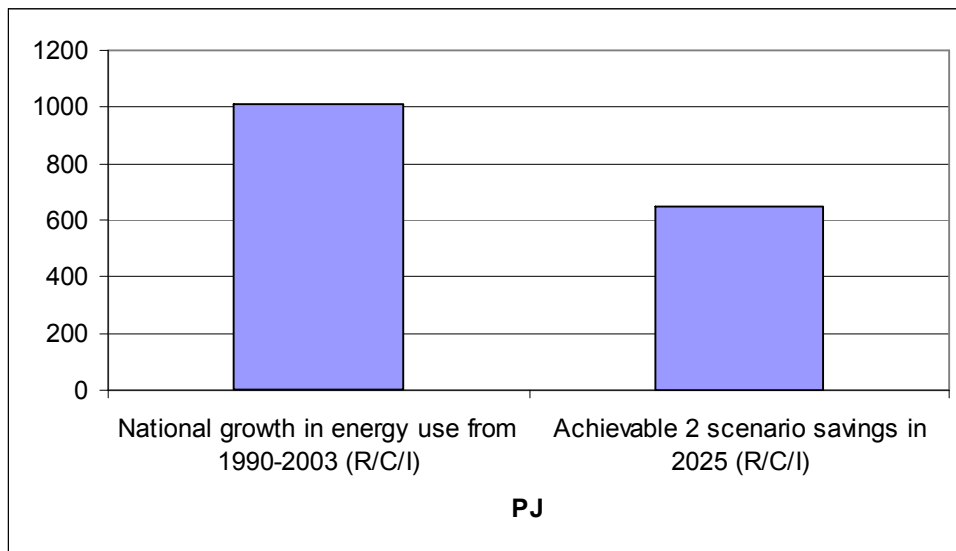


Exhibit C4.5: Comparison of Scenario 2 Savings and 1990-2003 Energy Use Growth



Note: R/C/I refers to the residential, commercial/institutional and industrial sectors

C4.2 SECTOR CONTRIBUTION

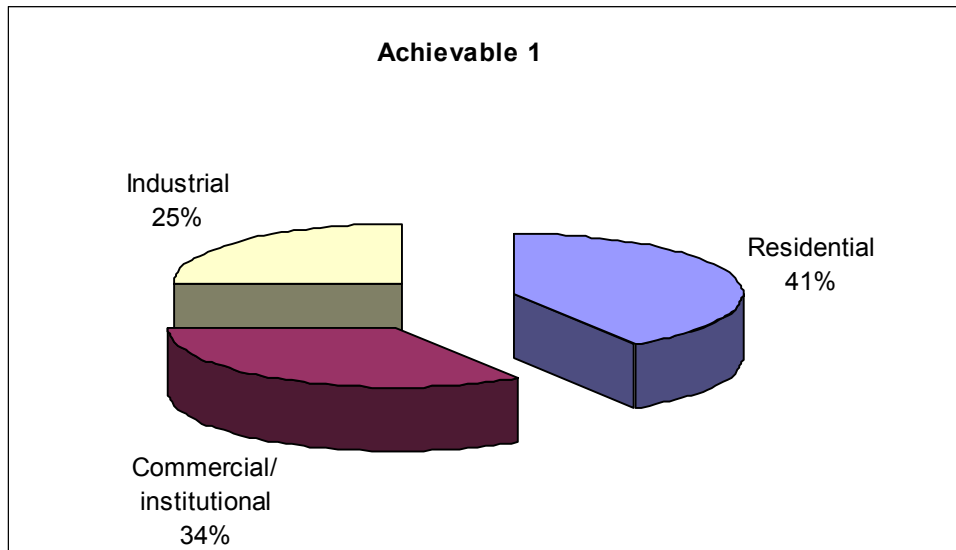
Exhibits C4.6 and C4.7 show the allocation of the scenario savings by sector. The residential sector represents the largest savings impact in both scenarios. Together, the residential and commercial sectors represent 75% and 92% respectively of the scenario 1 and scenario 2 savings.

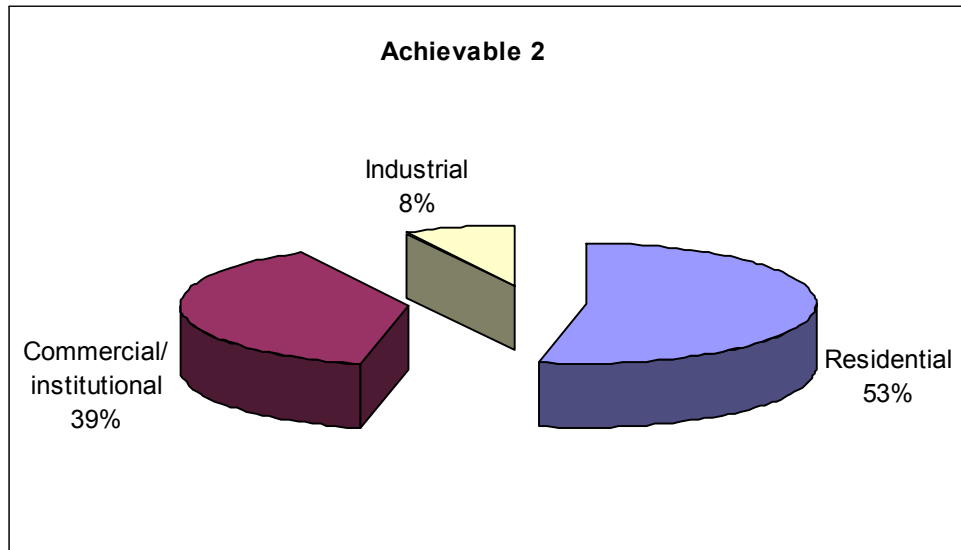
The significantly reduced share of total savings attributed to the industrial sector in scenario 2 is largely due to the nature of the policy mix in scenario 2. In particular, enhanced equipment and building performance standards have little application to industry in the scenario 2 analysis and the sector is not affected by changes in building shares. In addition, The renewables subsidies are not targeted to this sector, and.

Exhibit C4.6: Sectoral Contributions to Energy Savings Impact in the Achievable Potential

Energy Demand Reduction in 2025 (PJ/yr)		
Sector	Scenario 1	Scenario 2
Residential	75	345
Commercial/ Institutional	62	251
Industrial	45	50
Total	182	646

Exhibit C4.7: Graphical Presentation of Sectoral Energy Demand Savings Contributions: Scenarios 1 and 2





C4.3 FUEL SPECIFIC SAVINGS: SCENARIOS 1 AND 2

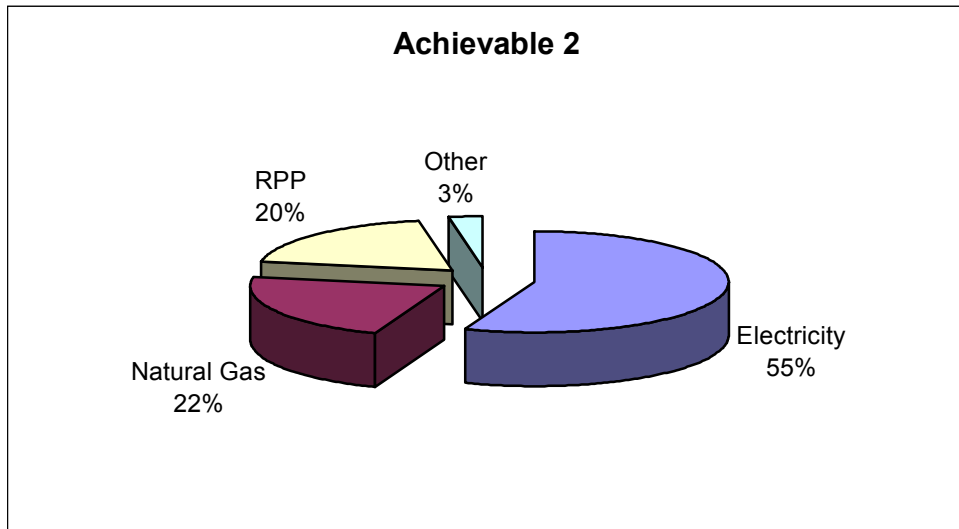
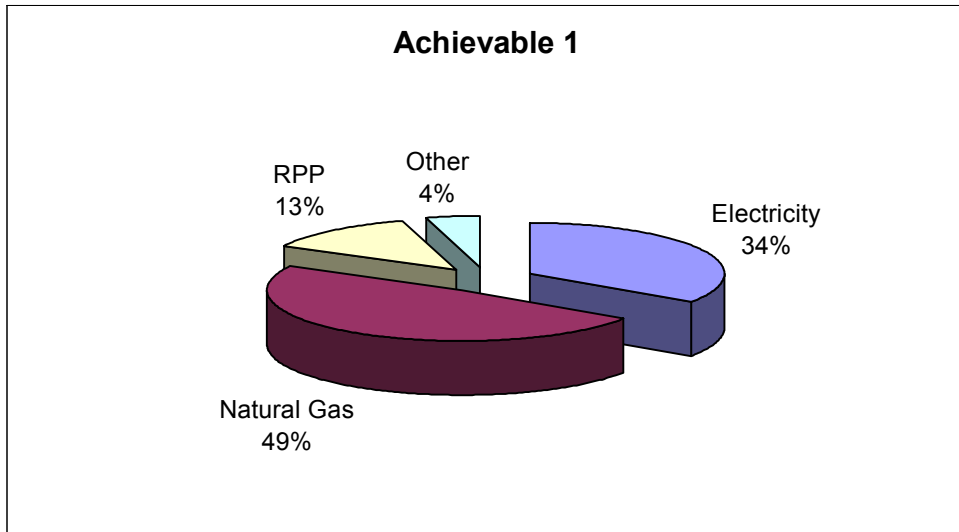
Fuel specific savings results for both scenarios are presented from two perspectives: the percentage allocation of the total savings impact according to fuel and the energy demand savings by fuel, relative to the reference case fuel demand.

Exhibit C4.8 shows the percentage allocation of the total savings impact according to fuel. For scenario 1, the largest savings impact in 2025 is achieved in secondary natural gas end-uses, representing 49% of the total savings.

The results are largely reversed under scenario 2 where the largest savings impact in 2025 is achieved in electricity reduction, representing 55% of the total savings. About 30% of the reduced demand for purchased electricity is due to the effect of added cogeneration supply. Natural gas savings represent about 22% of the total savings reduction in 2025. In scenario 2, the energy efficiency achieved among natural gas end-uses is somewhat offset by the considerable increase in natural gas consumption to build added cogeneration capacity.

Exhibit 4.9 presents the energy demand savings by fuel, relative to the reference case fuel demand in 2025. As shown, the largest performance improvement relative to the reference case occurs among the energy end-uses serviced by refined petroleum products – a 30.2% performance improvement – followed by electricity at 20.9% (both in scenario 2). Again, the natural gas impact is muted by the added load to supply cogeneration. There is also a net increase in the demand for wood wastes and spent pulping liquor, due to the fuel substitution activity in scenario 2.

Exhibit C4.8: Aggregate (All Sector) Energy Demand Savings According to Fuel



Note:

- 'Other' includes: Coal, Petroleum Coke, Waste Fuels, Off-gases, and Spent Pulping Liquor

- 'RPP' is Refined Petroleum Products

Exhibit C4.9: Fuel Specific Energy Demand Savings Impact Relative to Reference Case

Annual Savings in 2025	Achievable Potential			
	Scenario 1		Scenario 2	
Total Energy	182 PJ		646 PJ	
% Savings Relative to Reference Case	2.8%		10.1%	
Electricity	74 PJ	20.5 TWh	406 PJ	112 TWh
% Savings Relative to Reference Case	3.8%		20.9%	
Natural Gas	103 PJ	2.78 billion m ³	160 PJ	4.3 billion m ³
% Savings Relative to Reference Case	4.0%		6.1%	
Refined Petroleum Products	29 PJ		142 PJ	
% Savings Relative to Reference Case	6.2%		30.2%	
Wood Waste/ Spent Pulping Liquor	-31		-82 PJ	
% Savings Relative to Reference Case	-5.0%		-13.2%	
Coal, Petroleum Coke, Waste Fuels, Off Gases	9 PJ		20 PJ	
% Savings Relative to Reference Case	1.1%		2.6%	

C4.5 REGIONAL IMPACTS

Exhibits C4.10 to C4.12 present the energy demand savings impacts by province and region, both in tabular and graphic formats. Two aspects of performance are discussed: i) allocation by province of the total energy demand savings and ii) percentage reduction in energy demand, relative to the reference case forecast for each province or region. In Exhibits C4.11 and C4.12, the negative values indicate a net growth in demand.

As shown, the energy reduction potential varies by province/region in both scenarios but more significantly in scenario 2. The two policy instruments that most influence this greater variability are the carbon liability and marginal cost pricing for electricity.

With 3% and 3.3% reductions respectively, relative to the reference case forecast in 2025, the savings in Saskatchewan and Ontario under scenario 1 exceed the national reduction of 2.9%. Under scenario 2, all provinces except Quebec and the Atlantic region exceed the national reduction of 10.1 %.

Below we discuss key provincial differences in electricity and natural gas savings by scenario.

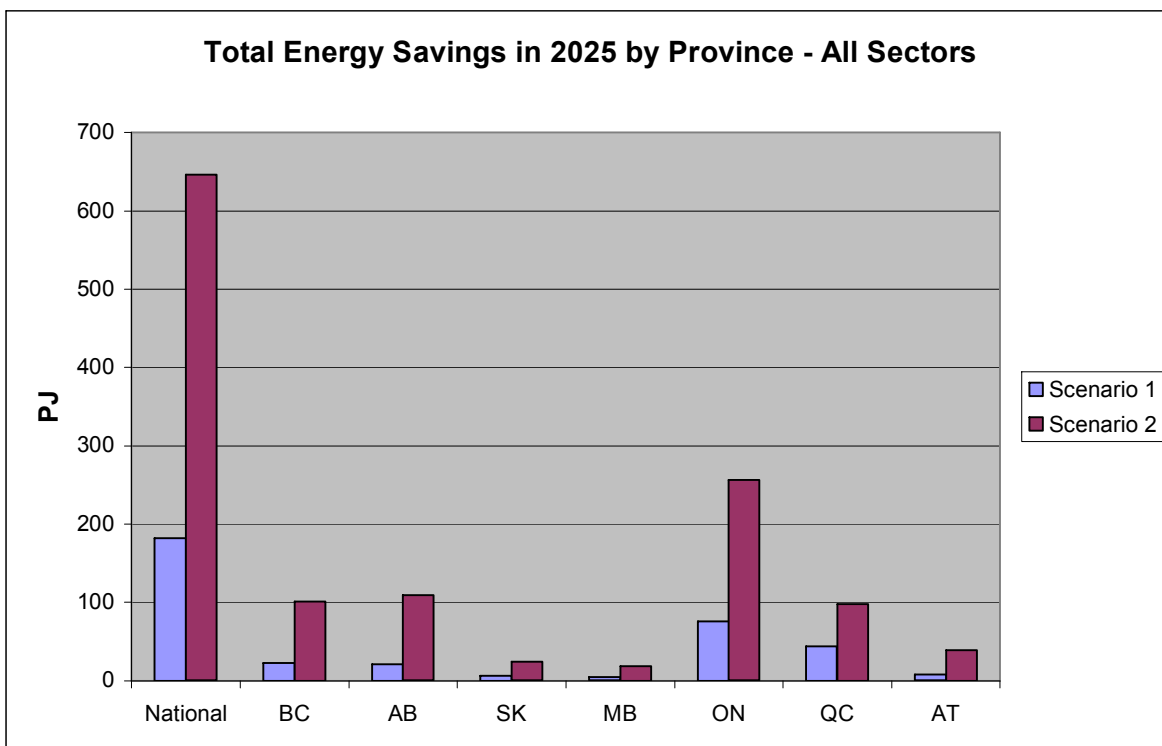
Exhibit C4.10: Total Energy Demand Savings (PJ) in 2025 by Province/Region - All Fuels

Savings (PJ)	National		BC		Alberta		Saskatchewan		Manitoba		Ontario		Quebec		Atlantic	
	Sc. 1	Sc. 2	Sc. 1	Sc. 2	Sc. 1	Sc. 2	Sc. 1	Sc. 2	Sc. 1	Sc. 2	Sc. 1	Sc. 2	Sc. 1	Sc. 2	Sc. 1	Sc. 2
Total Energy	182	646	23	101	21	109	6	24	5	19	76	256	44	98	8	39
Electricity	73	407	11	71	7	35	2	10	1	27	21	72	25	172	6	21
Natural Gas	103	158	18	43	16	74	3	10	3	-7	46	133	14	-104	4	9
Refined Petroleum Products	28	142	7	12	0	6	0	4	0	0	12	53	9	50	0	18
Wood waste	-31	-82	-15	-27	-1	-7	1	0	1	-2	-6	-7	-9	-30	-2	-9
Other	9	20	1	2	0	2	0	0	0	0	2	5	5	10	0	0

Exhibit C4.11: Percentage Reduction in Energy in 2025 by Province/Region - All Fuels

Savings (%)	National		BC		Alberta		Saskatchewan		Manitoba		Ontario		Quebec		Atlantic	
	Sc. 1	Sc. 2	Sc. 1	Sc. 2	Sc. 1	Sc. 2	Sc. 1	Sc. 2	Sc. 1	Sc. 2	Sc. 1	Sc. 2	Sc. 1	Sc. 2	Sc. 1	Sc. 2
Total Energy	2.9%	10.1%	2.5%	11.2%	2.2%	11.6%	3.0%	11.4%	2.9%	11.8%	3.3%	11.3%	2.9%	6.5%	2.0%	9.8%
Electricity	3.8%	21.0%	4.5%	28.0%	4.8%	25.4%	3.8%	19.3%	2.0%	37.5%	3.8%	13.0%	3.5%	23.5%	3.9%	14.4%
Natural Gas	4.0%	6.1%	5.2%	12.4%	2.6%	12.4%	2.1%	7.6%	3.4%	-8.7%	4.1%	11.9%	5.1%	-39.0%	10.5%	23.5%
Refined Petroleum Products	5.9%	30.2%	19.5%	32.9%	-3.4%	43.9%	1.5%	32.4%	-7.1%	-10.1%	8.8%	37.8%	5.2%	30.3%	0.3%	17.7%
Wood waste	-4.4%	-11.7%	-6.4%	-11.2%	-1.2%	-9.5%	32.9%	-4.6%	40.6%	-132.2%	-4.3%	-5.4%	-4.8%	-16.0%	-3.4%	-14.0%
Other	1.3%	2.9%	4.5%	6.3%	0.1%	1.3%	0.3%	1.7%	3.5%	33.4%	0.8%	1.7%	3.5%	6.6%	0.1%	0.7%

Exhibit C4.12: Total Energy Demand Savings in 2025 by Province/Region



C4.5.1 Electricity Savings – Scenario 1

As previously noted, when there is a high cogeneration response in the savings scenarios, this has the effect of lowering natural gas savings (due to the added demand for gas), and increasing electricity savings (due to reduced consumer purchases of electricity). Incremental cogeneration is a key driver when the provincial/regional impacts are examined.

Alberta and British Columbia both exceed the national electricity reduction of 3.8% with savings of 4.5% and 4.8% respectively, while the performance among the other provinces is on par with average national savings, except Manitoba, which achieves a smaller reduction. The greater electricity savings in Alberta are attributed to above average savings in the commercial sector, driven in part by proportionally higher cogeneration take-up. The Alberta response to subsidies is higher due to the proportionally larger gap between natural gas and electricity prices, which makes the economics of co-generation more favourable.

The greater electricity savings in British Columbia are largely the result of proportionally higher cogeneration take-up in the industrial sector, which in turn, is driven by penetration of cogeneration in the pulp and paper sector. B.C.’s pulp and paper sector contributes to secondary energy demand at a level that is proportionally higher than in other provinces – the sector is responsible for 36% of British Columbia’s energy demand, whereas the national average is 16%. In scenario 1, the subsidy effect drives incremental take-up of cogeneration fired by wood waste and spent pulping liquor.

As discussed in the reference case forecast, Manitoba has the lowest electricity rates in the country. Therefore, energy efficiency measures implemented in Manitoba will have proportionally higher payback levels compared to the same measures implemented in other provinces. In turn, the subsidies under scenario 1 have a proportionally lower effect on affecting consumer choices for the same level of energy efficiency measures. This is the case in Quebec as well, except that additional savings from energy efficiency are occurring from space heating because of that province's greater share of electrical space heating.

C4.5.2 Electricity Savings – Scenario 2

British Columbia, Alberta, Manitoba, and Quebec exceed the national electricity reduction of 21%. The move to electricity marginal cost pricing drives three effects in these provinces at a rate proportionally higher than in the other provinces: i) increased take-up of cogeneration, ii) increased fuel substitution, iii) increased take-up of electricity end-use efficiency measures. The considerably lower performance in Ontario is the main offsetting factor.

The electricity savings in Alberta occur mostly in the industrial sector, which has a large chemical products sector. Marginal cost pricing encourages the cogeneration of steam and electricity in the chemical products sector, and electricity demand declines substantially.²⁴ The marginal cost pricing effect also influences more fuel switching from electricity to natural gas in the residential sector (i.e., space heating for new homes and domestic water heating). Although Quebec has low reference case prices for electricity, relative to the other provinces, it shows less of a fuel substitution response because more electricity is used for space heating in existing homes (i.e. mainly baseboard heating), where fuel switching is limited.

C4.5.3 Natural Gas Savings – Scenario 1

There is some variation in natural gas savings by region. The percentage performance improvement for natural gas end-uses is very large in the Atlantic provinces, but the Atlantic provinces do not consume much natural gas.

In volume terms, the scenario 1 natural gas savings are largest in British Columbia and Ontario and lowest in Saskatchewan and Manitoba. The greater natural gas savings in British Columbia and Ontario are the result of fuel switching from natural gas to wood waste in the production of steam. Saskatchewan and Manitoba experience lower natural gas savings because cogeneration is more responsive in provinces with greater 'sparksread' (the cost differential between natural gas and electricity). Higher rates of cogeneration generally cause an increase in natural gas demand²⁵ because more energy is required to cogenerate steam and electricity than to generate steam alone.

²⁴ The large steam loads in chemical manufacturing are favourable for cogeneration development.

²⁵ Steam generation requires natural gas in most sectors, however in the pulp and paper sector, a substantial amount of steam is produced from wood waste or spent pulping liquor.

C4.5.4 Natural Gas Savings- Scenario 2

There are large differences in the natural gas savings between the provinces – some provinces experience savings, but others experience an increase in demand. Much of the difference between the scenarios is attributed to effects in the industrial sector.

Similar to scenario 1, both electricity and natural gas demand decline in the pulp and paper sector because of fuel switching to wood waste. The natural gas savings in the pulp and paper sector offset increases in natural gas demand in other industrial sectors.

As mentioned previously, in Manitoba and Quebec marginal cost pricing in scenario 2 has a proportionally higher effect on the price gap between electricity and natural gas. In Quebec this helps to drive the growth of gas demand in scenario 2. In the reference case, the demand for natural gas in Quebec’s residential and commercial sectors is low, and is primarily for water heating and space heating in new homes, and HVAC²⁶ systems in commercial buildings. Marginal cost pricing for electricity causes fuel switching from electricity to natural gas.

British Columbia also has a large increase in electricity prices as a result of marginal cost pricing, but it experiences net savings in natural gas.

²⁶ The term ‘HVAC’ represents space heating, space cooling and ventilation systems.

C5. RESIDENTIAL SECTOR RESULTS

This section presents the achievable potential results for the residential sector, under the following themes: i) overall energy demand savings, ii) energy demand savings by fuel, iii) changes in energy intensities and fuel shares.

C5.1 ENERGY DEMAND SAVINGS IMPACT

Exhibits C5.1 to C5.4 present the energy demand savings impact. The key findings are as follows:

- As shown in Exhibit C5.2, the total reduction in energy demand in 2025 ranges from 75 PJ to 345 PJ, a 4.5% to 20.8% savings relative to the reference case. The average annual growth rate in demand is 0.55% for scenario 1 and -0.20% for scenario 2.
- To put this into perspective, the projected savings from scenario 2 are roughly double the residential sector's incremental aggregate energy demand since 1990. Using the projected energy market prices used in the reference case forecast, this savings range amounts to \$1.9 billion to \$10.9 billion in energy operating cost savings in 2025 relative to the reference case forecast.
- As shown in Exhibit C5.3, the two achievable scenarios represent 34% to 157% of the economic potential in 2025. On first glance, it might seem incongruent to have achievable potential savings exceed the economic potential.

There are three considerations at work here. First, scenario 2 comprises policy instruments that push beyond the limits explored in the economic potential, specifically, the combined effects of marginal cost pricing and the carbon liability, aggressive standards, aggressive renewables subsidies and land use policy instruments. Within this scope of policies, there is the possibility of some market take-up of measures which currently do not pass the life cycle cost test in the Economic Potential. Second, the combined effect of the policy instrument mix can induce energy consumers to invest in measures at a pace faster than what is modelled under the economic scenario. This could include some combination of early replacement and accelerated retrofit. Third, we need to consider that an economic argument can be made for justifying policy interventions beyond the 'limit' suggested by the economic potential because the inclusion of externalities used to establish the economic potential is relatively limited.²⁷

²⁷ Over the past several years, a near-consensus has emerged among researchers and policy advisors with respect to the long-term marginal cost of moving toward a zero-emission energy system. This is likely to be in the range of US \$50-\$70 per tonne CO₂. Sims, R.E.H., H.-H. Rogner, and K. Gregory. 2003. "Carbon emission and mitigation cost comparisons between fossil fuel, nuclear and renewable energy sources for electricity generation." *Energy Policy* 31: 1315-1326.

**Exhibit C5.1: Annual Demand by Milestone Year:
Reference Case, Economic, and Achievable Potential Scenarios**

Annual Demand (PJ/yr)					
Residential					
Year	Base Year	Reference Case	Economic Potential	Achievable Potential	
				Scenario 1	Scenario 2
2000	1,384	1,384	1,384	1,384	1,384
2005		1,419	1,419	1,419	1,419
2010		1,444	1,346	1,419	1,372
2015		1,501	1,356	1,454	1,356
2020		1,576	1,396	1,516	1,332
2025		1,663	1,443	1,588	1,317

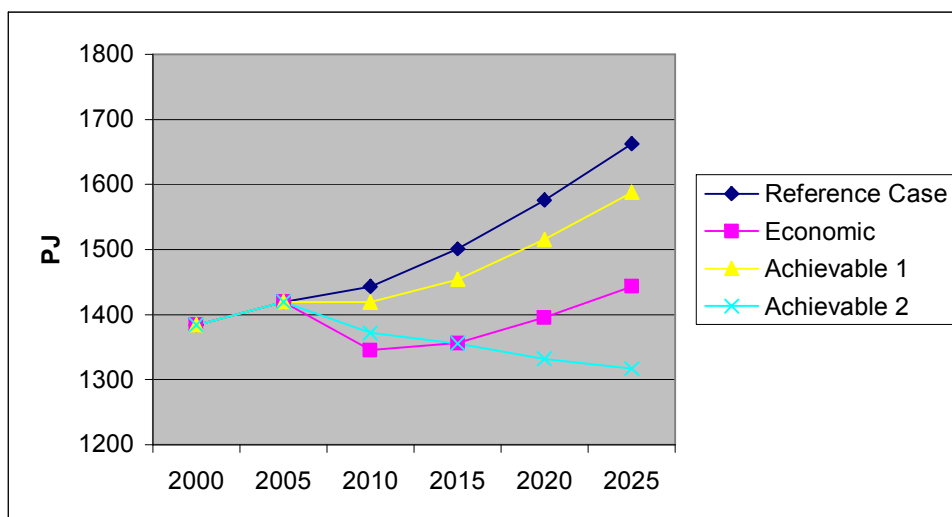
Exhibit C5.2: Annual Residential Savings in Energy Demand and Savings as a Percentage of Reference Case Demand

Year	Potential Annual Savings (PJ/yr)			Savings as Percentage of Reference Demand		
	Economic Potential	Achievable Potential		Economic Potential	Achievable Potential	
		Scenario 1	Scenario 2		Scenario 1	Scenario 2
2010	98	25	72	6.8%	1.7%	5.0%
2015	145	47	145	9.7%	3.1%	9.7%
2020	181	61	244	11.5%	3.9%	15.5%
2025	219	75	345	13.2%	4.5%	20.8%

Exhibit C5.3: Annual Achievable Potential as a Percentage of Economic Potential

Year	Achievable Potential Savings as Percentage of Economic Potential Savings	
	Scenario 1	Scenario 2
2010	25.2%	73.4%
2015	32.4%	100.0%
2020	33.6%	135.2%
2025	34.2%	157.4%

Exhibit C5.4: Total End-use Energy Demand by Scenario, Residential Sector



C5.2 ENERGY DEMAND SAVINGS BY FUEL

Exhibit C5.5 profiles the residential energy demand savings according to fuel. The key observations are:

Electricity

- The total achievable potential electricity reduction ranges from 28 PJ to 175 PJ (7.8 billion to 48.6 TWh), amounting to a 4.4% to 27.2% reduction relative to the reference case in 2025. These reductions reflect efficiency savings, fuel switching, cogeneration and a greater adoption of on-site renewable energy technologies for electric power.
-
- There is a more significant fuel switching effect in scenario 2 because marginal cost pricing for electricity encourages some switching from electricity towards gas and oil for space and water heating.
-
- Cogeneration represents a range of 5% to 7% of the total electricity savings in the achievable scenarios with the applications occurring in the multi-residential sector.

Natural Gas

- The total achievable potential natural gas reduction ranges from 44 PJ to 94 PJ (1.18 billion to 2.53 billion m³), amounting to a 5.6% to 11.8% reduction relative to the reference case.
-
- The total gas reduction impact would have been slightly higher (about half a percent) if not for the offsetting load building effect of increased cogeneration.

Exhibit C5.5: National Residential Achievable Potential Energy Reduction by Milestone Year and Fuel (PJ)

	2010		2015		2020		2025	
	Sc. 1	Sc. 2	Sc. 1	Sc. 2	Sc. 1	Sc. 2	Sc. 1	Sc. 2
Total Energy	25	72	47	145	61	244	75	345
% Savings Relative to Reference Case	1.7%	5.0%	3.1%	9.7%	3.9%	15.5%	4.5%	20.8%
Electricity	6	81	15	134	22	148	28	175
% Savings Relative to Reference Case	1.2%	15.4%	2.6%	24.2%	3.7%	24.6%	4.4%	27.2%
Natural Gas	16	-26	29	-24	35	39	44	94
% Savings Relative to Reference Case	2.3%	-3.8%	4.0%	-3.3%	4.7%	5.2%	5.6%	11.8%
Refined Petroleum Products	1	13	2	28	2	48	1	64
% Savings Relative to Reference Case	1.1%	10.1%	1.5%	20.1%	1.3%	33.5%	0.4%	44.1%
Wood Waste	1	3	1	7	2	10	2	12
% Savings Relative to Reference Case	0.6%	3.8%	1.5%	8.3%	2.2%	12.0%	2.6%	15.70%
Other	0	0	0	0	0	0	0	0
% Savings Relative to Reference Case	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%

C5.3 ENERGY DEMAND SAVINGS BY END USE

Exhibits C5.6 and C5.7 profile the allocation of the residential electricity and natural gas savings in 2025 by end-use. These exhibits explore two dimensions of end-use savings: i) the contribution that savings in an end-use represent relative to the total sector energy demand savings, and ii) the savings achieved in a particular end-use relative to the demand by that end-use in the reference case, referred to as the performance impact. The key observations, by fuel, are as follows.

Electricity

- There is a reallocation from one scenario to the other in terms of the contributions that savings among individual energy end-uses make to the total electricity savings. Together, lighting and appliance efficiency measures constitute the largest portion of the savings in both scenarios.
- The contribution of lighting ranges from 23% to 32% of the total savings, respectively, for scenarios 2 and 1. When we examine the performance impact, there is a considerable ramping up of savings, from 14% to 49%, relative to the reference case, for scenarios 1 and 2 respectively. The lighting measures constitute replacement of incandescent lamps with compact fluorescent lamps and in scenario 2, the take-up of LED lamps. While the incentive levels are the same in both scenarios, the application of marginal cost pricing (and to a lesser extent, the carbon price) strongly influence the take up of more efficient lighting in scenario 2.

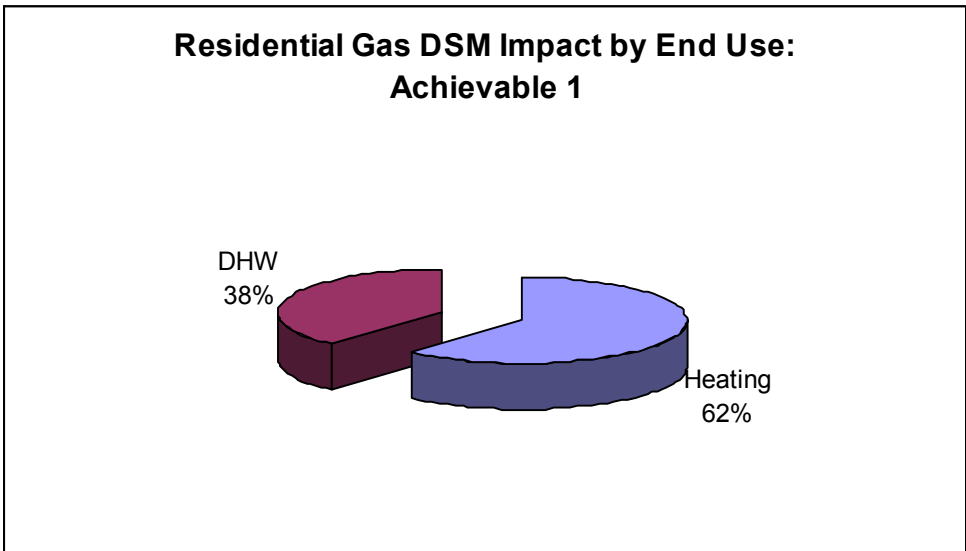
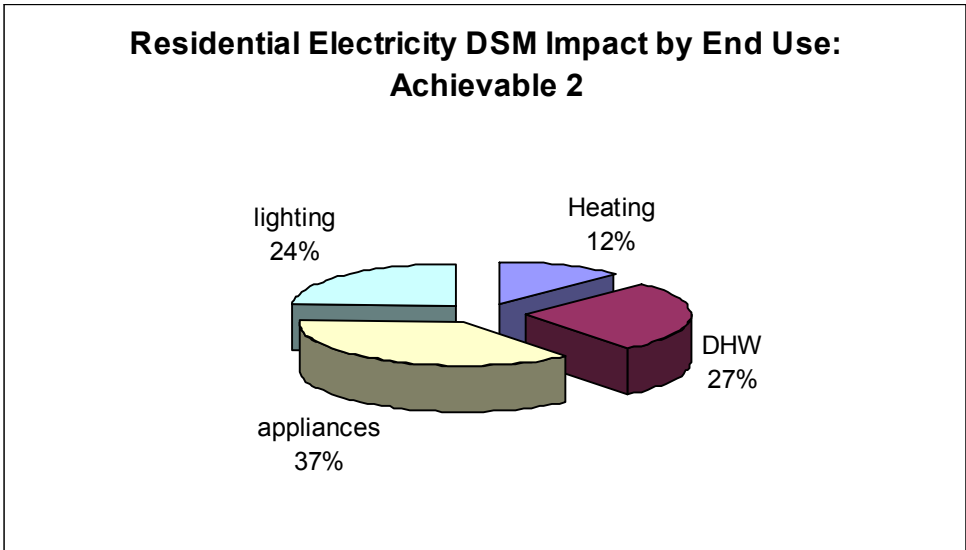
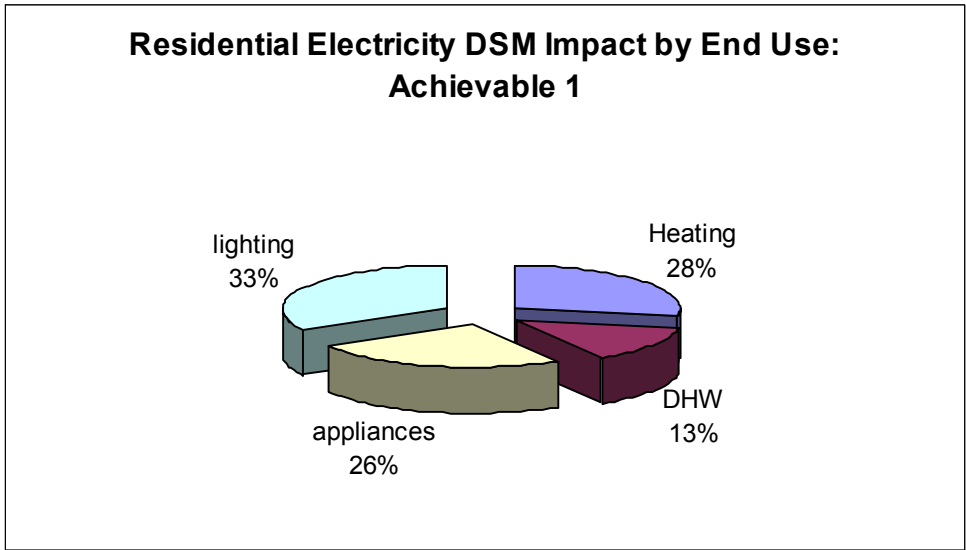
- The contribution of appliances ranges from 25% to 34% of the total savings, respectively, for scenarios 1 and 2. The performance impact for appliances ranges from 2% in scenario 1 to 19% relative to the reference case. Again, the key drivers affecting the difference between the two scenarios are the application of appliance standards as well as marginal cost pricing.
- The contribution of space heating efficiency drops from 27% to 12% of the total savings, respectively, for scenarios 1 and 2. At the same time, the performance impact grows from 5% in scenario 1 to 11% in scenario 2, relative to the reference case. The space heating savings occur primarily from improved envelope construction (and to a lesser extent from the greater adoption of heat pumps) and obviously have a greater effect in the regions of the country where there is a proportionally higher degree of electric heating. The increased performance improvement in scenario 2 is driven in part by fuel switching to gas, in response to marginal cost pricing and is limited to applications in new construction.

Natural Gas

- In both scenarios, space heating contributes the largest portion of the natural gas reduction opportunity with a range of 62% to 95% of total savings for scenarios 1 and 2 respectively. The savings are driven by improved envelope performance in new construction and greater adoption of condensing furnaces in existing homes.²⁸ A fuel switching response also occurs in scenario 2; the dominant switch is from oil to natural gas heating in response to the carbon price.
- In terms of performance improvements, the space heating performance improves from 4% to 14% while the DHW (domestic hot water) performance drops from 8% to 5%, respectively, for scenarios 1 and 2. The DHW performance improvements are driven in part by subsidies to higher performance water heating equipment, in particular instantaneous heaters.

²⁸ In most regions condensing furnaces are not targeted with a subsidy in new dwellings.

Exhibit C5.6 - Residential National Energy Demand Savings in 2025 by End-Use



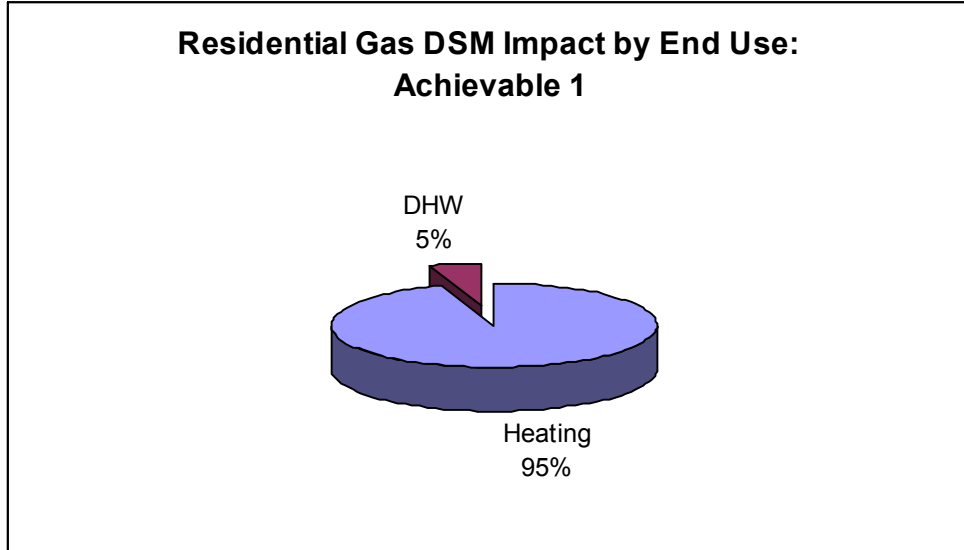


Exhibit C5.7 End-Use Savings in 2025 Relative to Reference Case

Residential-electricity

	% savings relative to end use base		
	Scenario 1	Scenario 2	Economic Potential
space heating	5%	11%	11%
domestic hot water	5%	48%	26%
appliances	3%	19%	26%
lighting	14%	49%	69%
cogeneration			
	Scenario 1	Scenario 2	Economic Potential
Cogeneration GWh	420.9	3,425.3	6,166.4

Residential-gas

	% savings relative to end use base		
	Scenario 1	Scenario 2	Economic Potential
space heating	4%	14%	9%
domestic hot water	8%	5%	22%
appliances	-3%	-23%	6%

C5.4 CHANGES IN ENERGY INTENSITIES AND FUEL SHARES

Exhibits C5.8 and C5.9 profile the changes in energy intensity and fuel shares for the two scenarios.

- Residential energy intensity is measured as energy demand per household. Relative to the reference case (BAU – business as usual) intensity in 2025, the scenarios generate intensity improvements ranging from 4% to 15% respectively for scenarios 1 and 2.
- Exhibit C5.9 indicates a gradual increase in the fuel share of natural gas in scenario 2.

Exhibit C5.8: Residential Achievable Potential - Change in Energy Intensity

Scenario 1

	2000	2005	2010	2015	2020	2025
Energy Intensity (GJ / hslld)						
BAU forecast	109	104	100	97	95	94
Scenario 1	109	104	98	94	92	91
% Relative Change	0%	0%	-1%	-3%	-3%	-4%

Scenario 2

	2000	2005	2010	2015	2020	2025
Energy Intensity (GJ / hslld)						
BAU forecast	109	104	100	97	95	94
Scenario 2	109	104	96	90	85	80
% Relative Change	0%	0%	-4%	-7%	-11%	-15%

Exhibit C5.9: Residential Fuel Shares for Achievable Potential and Reference Cases

	2000	2005	2010	2015	2020	2025
Electricity						
BAU Forecast	35.9%	36.3%	36.6%	37.1%	38.0%	38.7%
Scenario 1	35.9%	36.3%	36.8%	37.2%	38.1%	38.7%
Scenario 2	35.9%	36.3%	33.3%	32.2%	34.7%	36.2%
Natural Gas						
BAU Forecast	47.6%	47.7%	47.9%	48.1%	47.8%	47.8%
Scenario 1	47.6%	47.7%	47.7%	47.7%	47.4%	47.4%
Scenario 2	47.6%	47.7%	51.6%	53.7%	52.5%	52.1%
Refined Petroleum Products						
BAU Forecast	9.6%	9.5%	9.3%	9.2%	9.0%	8.7%
Scenario 1	9.6%	9.5%	9.3%	9.3%	9.2%	9.0%
Scenario 2	9.6%	9.5%	8.9%	8.3%	7.5%	6.7%
Wood						
BAU Forecast	7.0%	6.5%	6.1%	5.7%	5.1%	4.8%
Scenario 1	7.0%	6.5%	6.2%	5.7%	5.2%	4.9%
Scenario 2	7.0%	6.5%	6.2%	5.7%	5.3%	5.0%

C5.5 REGIONAL IMPACTS

Exhibits C5.10 and C5.11 profile the residential savings impact in 2025 by province and region.

Exhibit C5.10: Residential Energy Demand Savings (PJ) in 2025 by Province/Region - All Fuels

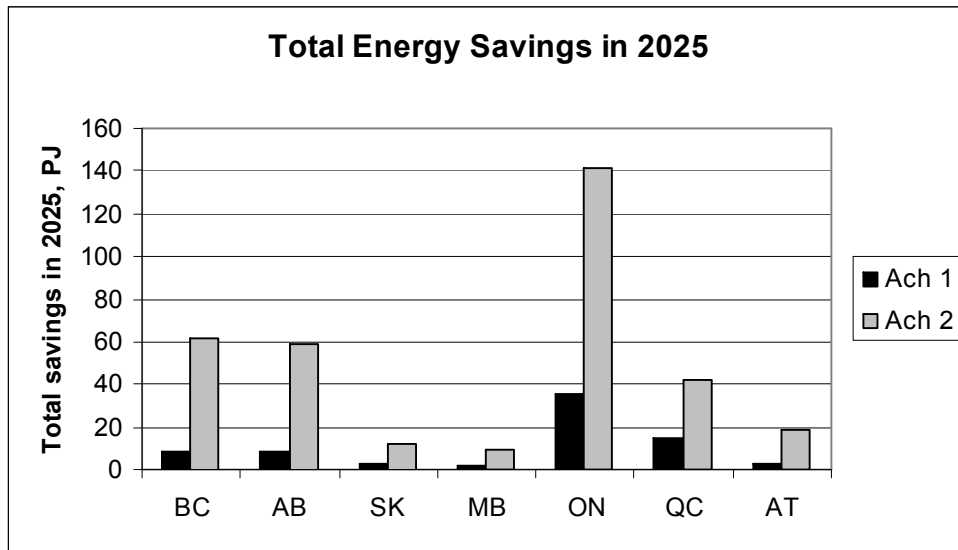
	BC		AB		SK		MB		ON		QC		AT	
	Sc. 1	Sc. 2	Sc. 1	Sc. 2	Sc. 1	Sc. 2	Sc. 1	Sc. 2	Sc. 1	Sc. 2	Sc. 1	Sc. 2	Sc. 1	Sc. 2
Total Energy	8	62	8	59	3	12	2	10	36	141	15	43	3	19
Electricity	2	45	1	9	0	3	1	10	8	27	12	73	3	8
Natural Gas	4	13	7	49	2	9	1	-1	26	78	2	-56	2	0
Refined Petroleum Products	2	3	0	0	0	0	0	0	1	27	1	26	-4	8
Wood Waste	0	1	0	0	0	0	0	0	1	9	0	0	1	2
Other	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Exhibit C5.11: Percentage Reduction in Residential Energy in 2025 by Province/Region - All Fuels

	BC		AB		SK		MB		ON		QC		AT	
	Sc. 1	Sc. 2	Sc. 1	Sc. 2	Sc. 1	Sc. 2	Sc. 1	Sc. 2	Sc. 1	Sc. 2	Sc. 1	Sc. 2	Sc. 1	Sc. 2
Total Energy	4%	31%	4%	27%	5%	25%	3%	20%	6%	22%	4%	11%	3%	19%
Electricity	3%	54%	3%	24%	4%	28%	2%	43%	4%	15%	5%	29%	6%	15%
Natural Gas	4%	13%	4%	27%	6%	24%	4%	-2%	6%	19%	6%	-165%	35%	6%
Refined Petroleum Products	21%	34%	-1%	15%	12%	5%	15%	34%	3%	60%	2%	49%	-10%	22%
Wood Waste	5%	12%	0%	0%	0%	0%	0%	0%	3%	52%	0%	0%	22%	46%
Other	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%

* negative values represent a growth in demand for that fuel

Exhibit C5.12 Total Residential Energy Demand Savings in 2025 by Province/Region



C6. INDUSTRIAL SECTOR

This section presents the achievable potential results for the industrial sector, under the following themes: i) overall energy demand savings, ii) changes in energy intensities and fuel shares, iii) energy end-use impacts and iv) regional impacts.

C6.1 ENERGY DEMAND SAVINGS IMPACT

Exhibits C6.1 to C6.5 present the energy demand savings impact. The key findings are as follows:

- As shown in Exhibit C6.2, the total reduction in energy demand in 2025 ranges from 45 PJ to 50 PJ, a 1.4% to 1.5% savings relative to the reference case in 2025 respectively for scenarios 1 and 2. The average annual growth rate is 0.72% for both scenarios.
- The projected savings in demand from scenario 2 are about 10% of the industrial sector's incremental aggregate energy demand since 1990. Using the projected energy market prices used in the reference case forecast, this savings range amounts to \$578 million to \$1.5 billion in energy operating cost savings in 2025 relative to the reference case forecast.
- When we examine the energy demand savings impact by fuel category in Exhibit C6.5, there is a considerable change in results from one scenario to the other. In scenario 1, the natural gas savings of 31 PJ (0.83 billion m³) in 2025 exceeds the 22 PJ (6.1 TWh) savings achieved in electricity, followed by savings in Refined Petroleum Products of 17 PJ.
- In scenario 2, two policy instruments, the carbon emissions charge and marginal cost pricing for electricity, help to make energy efficiency investments slightly more attractive. The energy demand savings in electricity use increase to 108 PJ (30 TWh), by far the largest portion of the energy demand savings in scenario 2 and amounting to a 14% reduction relative to the reference case.
- The electricity savings exceed the overall reduction in energy use in industry because of the significant fuel substitution effects that occur, including cogeneration, driven by electricity marginal cost pricing and the carbon liability. In scenario 2, the emissions charge increases the price of natural gas less than the price increase of electricity driven by marginal cost pricing. Exhibit C6.5 shows considerable load growth due to fuel substitution to natural gas and wood waste.

As shown, natural gas demand is actually projected to grow by 26 PJ (0.7 billion m³) in 2025 under scenario 2. What this means is that the energy efficiency gains associated with natural gas energy end-uses are more than offset by the added load from cogeneration. When the increase in natural gas demand caused by cogeneration is excluded, scenario 2 still results in a net increase in gas demand of 7.5 PJ (0.2 billion m³) due to other fuel substitution investments induced by the mix of policy instruments.

As shown in Exhibit C6.3, the two achievable scenarios represent 11% to 12% of the economic potential in 2025. This is a considerable decline in savings performance when compared with the economic potential results. There are several reasons:

- Scenario 1 is largely driven by subsidies. It appears that the reduced payback induced by the subsidies is not enough to address the gap between the social and private discount rates for industry, keeping in mind that the economic potential analysis is based on a social discount rate. At the same time, the subsidies induce some fuel switching which offsets the energy efficiency gains.

The introduction in scenario 2 of marginal cost pricing for electricity increases its price relative to other fuels. This drives additional fuel switching for end-uses where these fuels can be substitutes, particularly combustion. The end-use efficiency of electric heating is always higher than for direct combustion of fuels, resulting in additional secondary energy demand for the affected end-uses. This drop in performance is particularly evident where there is a considerable switch to the utilization of wood waste in industry; wood waste use increases fairly significantly in scenario 2.

Further driving the fuel substitution effect is the take-up of cogeneration in scenario 2, which represents 34% of the total energy demand savings impact (i.e. decline of purchased electricity by industry). This means that the reduction in electricity demand caused by energy efficiency improvements amounts to 71 PJ (19.7 TWh), representing an 8% reduction in industrial electricity demand.
- As previously noted, the effect of standards in industry is limited in comparison to the effect in the other sectors. This is limited by the nature of custom manufacturing equipment setup/ unique circumstance of each plant. For instance, while there are considerable potential savings in auxiliary motor systems, the ability to improve system efficiency by including such actions as adding variable speed drive is site specific, and not something that could be 'regulated in'. The only standard applied to industry is to steam generation systems, which only affects boiler efficiencies (between 3% & 5% efficiency improvement depending on the fuel). Renewable subsidies are not targeted to this sector, and the sector is not affected by changes in building shares.
- Most of the remaining industrial energy management solutions extend beyond equipment replacement (particularly given that high efficiency motors have a reasonably high stock penetration). That is why the modelled savings for electricity efficiency relate largely to auxiliary system performance improvements. Note – the modelling is limited to energy end-use performance improvements within plants and does not include plant system wide improvements such as energy cascading.

**Exhibit C6.1: Annual Demand by Milestone Year:
Reference Case, Economic Potential, and Achievable Potential Scenarios**

Annual Demand (PJ/yr)					
Industrial					
Year	Base Year	Reference Case	Economic	Achievable	
				Scenario 1	Scenario 2
2000	2,714	2,714	2,714	2,714	2,714
2005		2,785	2,785	2,785	2,785
2010		2,931	2,776	2,923	2,936
2015		3,053	2,797	3,034	3,047
2020		3,154	2,827	3,122	3,134
2025		3,296	2,871	3,250	3,246

Exhibit C6.2: Annual Industrial Savings in Energy Demand and Savings as a Percentage of the Reference Case

Year	Potential Annual Savings (PJ/yr)			Savings as a Percentage of Reference Demand		
	Economic	Achievable		Economic	Achievable	
		Scenario 1	Scenario 2		Scenario 1	Scenario 2
2010	155	8	-4	5.29%	0.30%	-0.14%
2015	256	19	6	8.39%	0.61%	0.21%
2020	327	32	20	10.37%	1.02%	0.64%
2025	425	45	50	12.89%	1.38%	1.51%

Exhibit C6.3: Annual Industrial Achievable Potential as a Percentage of Economic Potential

Year	Achievable Potential Savings as a Percentage of Economic Potential Savings	
	Scenario 1	Scenario 2
2010	5.61%	-2.73%
2015	7.24%	2.54%
2020	9.83%	6.14%
2025	10.69%	11.68%

Exhibit C6.4: Total End-Use Energy Demand by Scenario, Industrial Sector

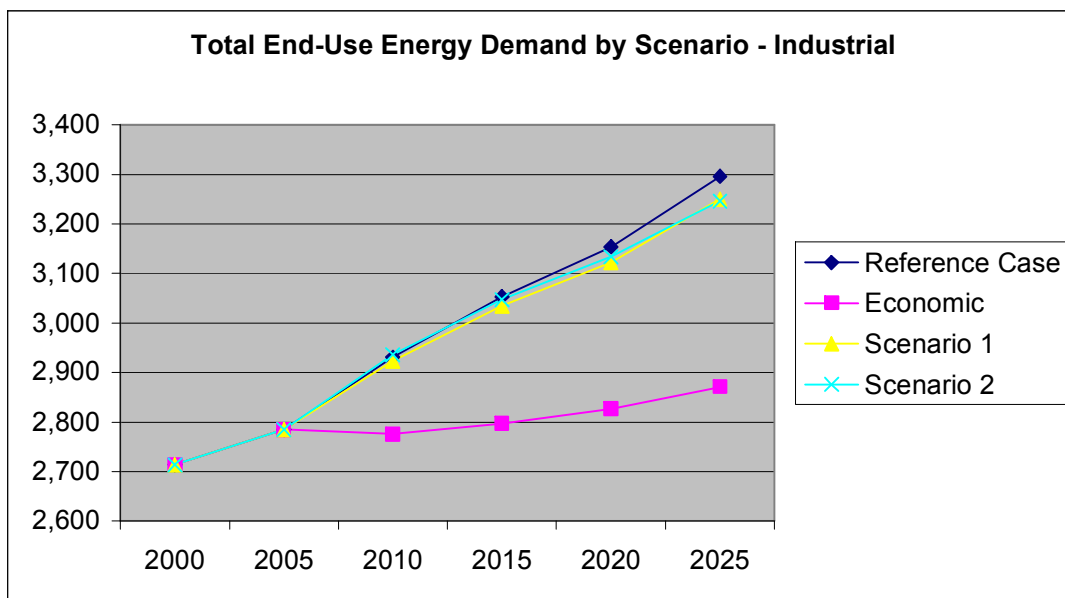


Exhibit C6.5: National Industrial Achievable Potential Energy Reduction by Milestone Year and Fuel (PJ)

	2010		2015		2020		2025	
	Sc. 1	Sc. 2	Sc. 1	Sc. 2	Sc. 1	Sc. 2	Sc. 1	Sc. 2
Total Energy	9	-4	19	6	32	20	45	50
% Savings Relative to Reference Case	0.3%	-0.1%	0.6%	0.2%	1.0%	0.6%	1.4%	1.5%
Electricity	4	33	10	61	16	85	22	108
% Savings Relative to Reference Case	0.5%	4.6%	1.3%	8.4%	2.2%	11.5%	2.9%	14.3%
Natural Gas	7	-42	14	-46	21	-45	31	-26
% Savings Relative to Reference Case	0.8%	-4.5%	1.4%	-4.9%	2.2%	-4.7%	3.1%	-2.6%
Refined Petroleum Products	3	12	8	21	12	31	17	41
% Savings Relative to Reference Case	1.8%	6.7%	4.3%	11.0%	6.0%	15.0%	7.5%	18.7%
Wood Waste	-6	-11	-15	-37	-23	-64	-33	-94
% Savings Relative to Reference Case	-1.1%	-2.0%	-2.5%	-6.3%	-3.9%	-10.8%	-5.3%	-15.2%
Other	1	4	2	7	6	13	9	20
% Savings Relative to Reference Case	0.2%	0.7%	0.3%	1.2%	0.9%	2.1%	1.3%	2.9%

C6.2 CHANGES IN ENERGY FUEL SHARES AND INTENSITIES

The changes in energy fuel shares and intensities for both achievable potential scenarios are profiled and compared to the reference case forecast in Exhibits C6.6 and C6.7.

Exhibit C6.6 tracks the changes in fuel shares from the reference case forecast for the two achievable potential scenarios. To build on the foregoing observations, we can see a pattern of declining electricity fuel shares due to fuel substitution and cogeneration measures. That is why natural gas and wood waste shares increase.

There is also virtually no improvement in energy intensity in 2025, relative to the reference case projection of intensities. This is shown in Exhibit C6.7, which tracks the changes in energy intensities by specific industry sector between the reference case forecast and the two achievable potential scenarios.

Exhibit C6.6: National Industrial Achievable Potential Fuel Shares in Comparison to the Reference Case

	2000	2005	2010	2015	2020	2025
Electricity						
BAU Forecast	24.7%	24.3%	24.4%	23.8%	23.4%	23.0%
Scenario 1	24.7%	24.3%	24.4%	23.7%	23.2%	22.7%
Scenario 2	24.7%	24.1%	23.5%	22.2%	21.3%	20.5%
Natural Gas						
BAU Forecast	34.0%	33.0%	31.5%	31.0%	30.4%	30.3%
Scenario 1	34.0%	33.0%	31.4%	30.7%	30.1%	29.9%
Scenario 2	34.0%	33.4%	32.7%	32.3%	31.8%	31.4%
Refined Petroleum Products						
BAU Forecast	5.9%	6.0%	6.1%	6.3%	6.5%	6.7%
Scenario 1	5.9%	6.0%	6.0%	6.1%	6.3%	6.3%
Scenario 2	5.9%	5.9%	5.7%	5.7%	5.7%	5.7%
Wood						
BAU Forecast	17.1%	18.5%	19.3%	19.9%	20.7%	21.2%
Scenario 1	17.1%	18.5%	19.4%	19.9%	20.7%	21.3%
Scenario 2	17.1%	18.4%	19.2%	19.7%	20.5%	21.0%
Other						
BAU Forecast	18.3%	18.3%	18.6%	19.1%	18.9%	18.8%
Scenario 1	18.3%	18.3%	18.9%	19.5%	19.7%	19.9%
Scenario 2	18.3%	18.2%	18.9%	20.1%	20.7%	21.4%

Exhibit C6.7: Change in Industrial Energy Intensities by Sector

Sector		2000	2005	2010	2015	2020	2025
	Energy Intensity						
Pulp and Paper GJ/tonne of pulp or paper	BAU forecast	43	41	40	39	37	36
	Scenario 1	43	41	40	39	37	36
	Scenario 2	43	41	39	38	37	36
Chemical GJ/tonne of chemicals	BAU forecast	13	12	12	12	11	11
	Scenario 1	13	12	12	12	11	11
	Scenario 2	13	12	12	12	11	11
Iron and Steel GJ/tonne of molten steel	BAU forecast	18	17	16	16	15	15
	Scenario 1	18	17	16	16	15	15
	Scenario 2	18	17	16	16	15	15
GJ/tonne of refined products	BAU forecast	52	63	62	60	57	55
	Scenario 1	52	63	62	60	56	53
	Scenario 2	52	63	62	59	56	53
Mining GJ/tonne of mineral ores	BAU forecast	0.4	0.5	0.5	0.5	0.5	0.5
	Scenario 1	0.4	0.5	0.5	0.5	0.5	0.4
	Scenario 2	0.4	0.5	0.5	0.5	0.5	0.4
Other Manufacturing GJ/gross output (1997 dollars)	BAU forecast	4,329	4,287	4,245	4,245	4,242	4,260
	Scenario 1	4,329	4,287	4,221	4,200	4,182	4,185
	Scenario 2	4,329	4,287	4,229	4,223	4,208	4,212
Industrial Minerals GJ/tonne of clinker	BAU forecast	5.3	5.1	5.0	5.0	4.9	4.9
	Scenario 1	5.3	5.1	5.0	4.9	4.9	4.8
	Scenario 2	5.3	5.1	5.0	4.9	4.9	4.8
Petroleum Refining GJ/1000 m3 of RPP	BAU forecast	3.4	3.0	3.0	3.1	3.1	3.2
	Scenario 1	3.41	3.01	3.00	3.04	3.09	3.15
	Scenario 2	3.41	3.01	3.00	3.04	3.08	3.15

C6.3 END-USE IMPACTS

Exhibits C6.8 and C6.9 illustrate the allocation of the industrial electricity and natural gas energy demand savings in 2025, according to fuel specific end-uses. These exhibits explore two dimensions of end-use savings: i) the contribution that savings in an end-use represent relative to the total sector energy demand savings, and ii) the savings achieved in a particular end-use relative to the demand by that end-use in the reference case, referred to as the performance impact. The main observations, according to fuel type are as follows.

Electricity

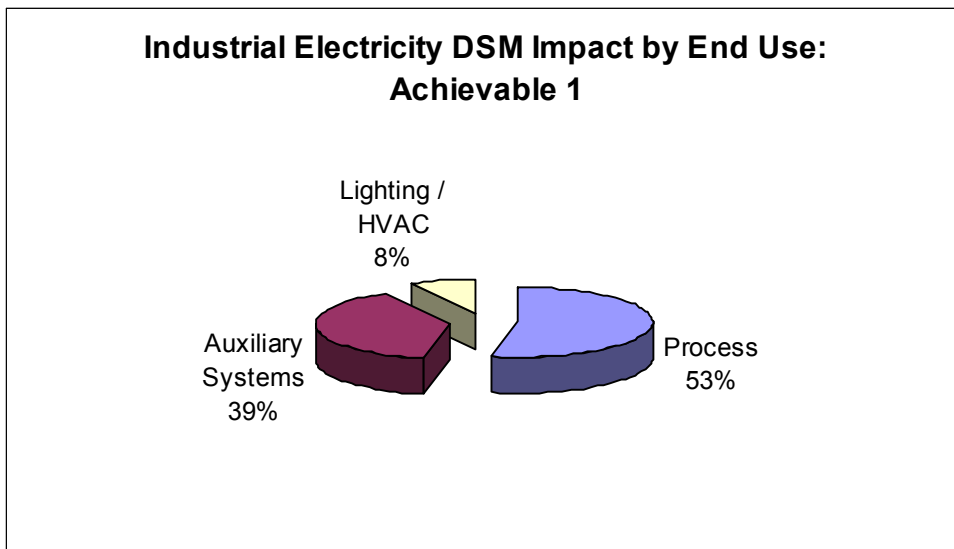
- As shown, auxiliary systems and other process savings together account for the majority of the electricity savings, ranging from 92% to 95% of the total savings respectively for scenarios 1 and 2.
- Process savings refer to sector specific specialized processes, such as in metal refining and smelting and the chemicals sector. Energy efficiency measures that have been modeled in the process category include nickel electrolytic low voltage cells with metal anodes; zinc electrolytic refining with new electrolysis cells; ultra-high power electric arc furnaces; and sodium chlorate electrolysis.

- The category of auxiliary motor systems savings includes high efficiency motors, higher performance motor driven equipment and system improvements (e.g., variable speed drives).

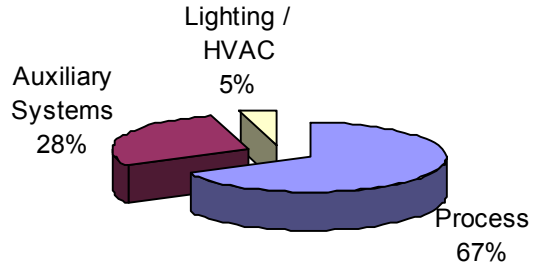
Natural Gas

- The indirect process (steam systems and hot water) end use contributes most of the savings in both scenarios - 83% and 88% respectively for scenarios 1 and 2. The reduction of steam demand of 14% occur mostly in pulp and paper, and to a lesser extent, in iron & steel and chemicals.
- There is no performance impact projected for the direct process end-use, which is due to the fuel substitution effect. The increase in gas demand for direct process heating accounts for most of the increase in natural gas demand (32.4 PJ or 0.87 billion m³).
- Most of the increase in natural gas demand occurs in the “other manufacturing” sector, where there is substantial fuel switching from electricity to natural gas. The pulp and paper sector partially offsets the increase in natural gas demand, due to fuel switching from natural gas to wood waste.

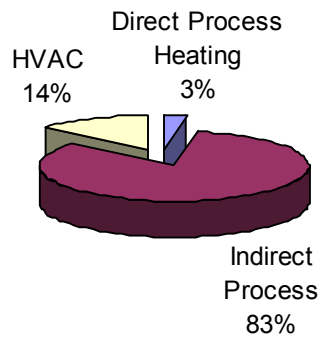
Exhibit C6.8: Industrial Energy Demand Savings in 2025 by End Use



**Industrial Electricity DSM Impact by End Use:
Achievable 2**



**Industrial Gas DSM Impact by End Use:
Achievable 1**



**Industrial Gas DSM Impact by End Use:
Achievable 2**

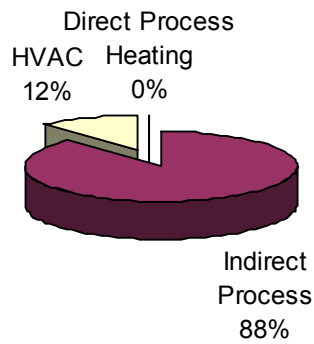


Exhibit C6.9 End-Use Savings in 2025 Relative to Reference Case

	1	2	econ
Process	2%	11%	2%
Auxiliary Systems	1%	4%	15%
Lighting / HVAC	2%	6%	13%
	1	2	economic
Cogeneration GWh	1,350.2	6,887.6	26,144.3

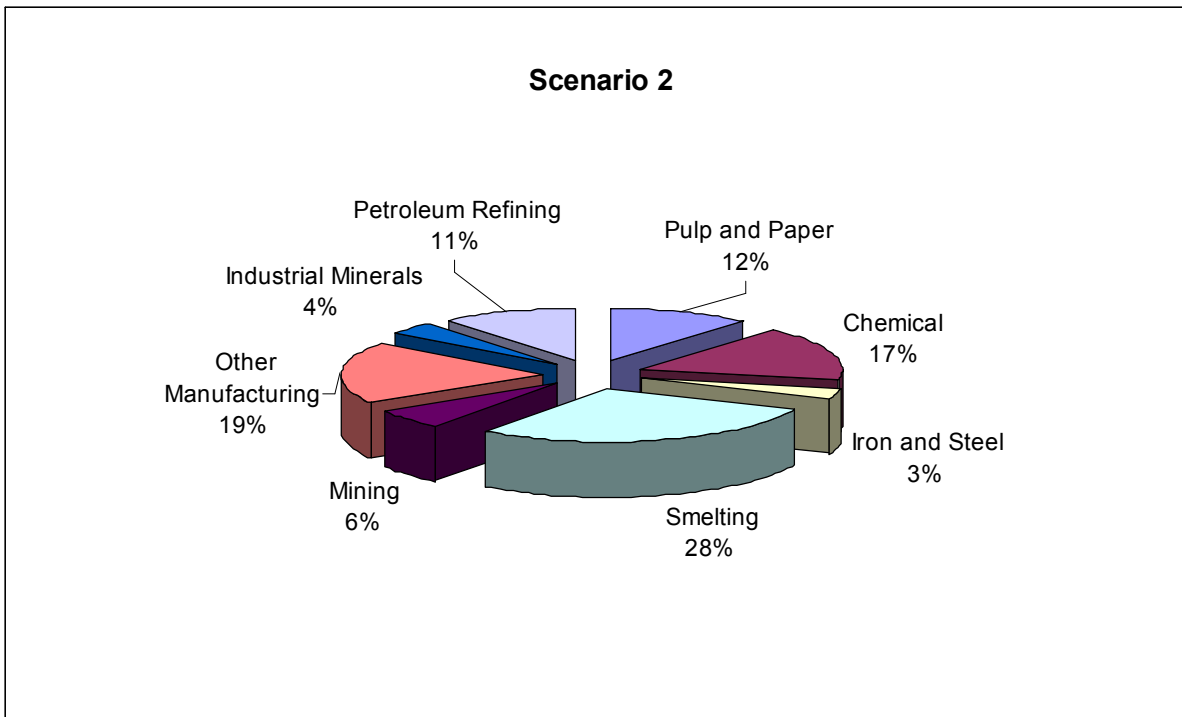
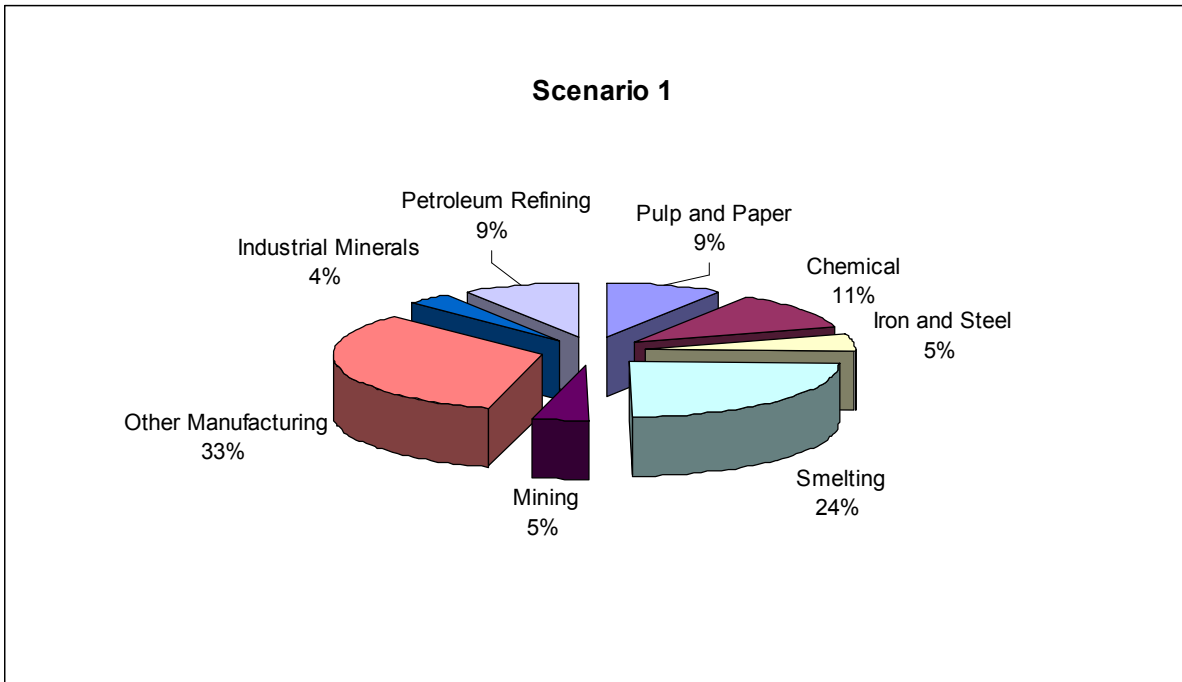
Industrial - gas

	% savings relative to reference case		
	1	2	econ
Direct Process Heating	0%	-7%	6%
Indirect process	6%	8%	13%
HVAC	8%	8%	18%

C6.4 INDUSTRY SUB-SECTOR IMPACTS

Exhibit C6.10 profiles the allocation of the industry savings according to sub-sector. As shown, the allocations change from one scenario to the other. In scenario 1, other manufacturing and smelting together account for 57% of the total energy reduction in 2025. These sectors still account for 47% of the total savings in scenario 2 but there is a significant increase in the savings attributed to the chemicals sector. The chemicals sector attains a net increase in gas demand as it has a large cogeneration potential. The pulp and paper sector did not contribute greatly to total energy reductions because it experienced substantial fuel switching from natural gas and electricity to wood waste products.

Exhibit C6.10 Industrial Achievable Potential Savings Share per Sector in 2025



C6.5 REGIONAL IMPACTS

Exhibits C6.11 to C6.13 profile the industry savings according to province and region. Exhibit C6.11 is a graphical presentation followed by two tabular profiles, one each for scenarios 1 and 2. Not surprisingly, the largest portion of the savings occurs in Ontario, Quebec and Alberta. All provinces show an increase in savings from scenario 1 to scenario 2, with the exception of Manitoba and Ontario, which actually show a decline. This is due to a proportionally higher level of fuel substitution.

Exhibit C6.11: Total Industrial Energy Demand Savings in 2025 by Province for Scenarios 1 & 2

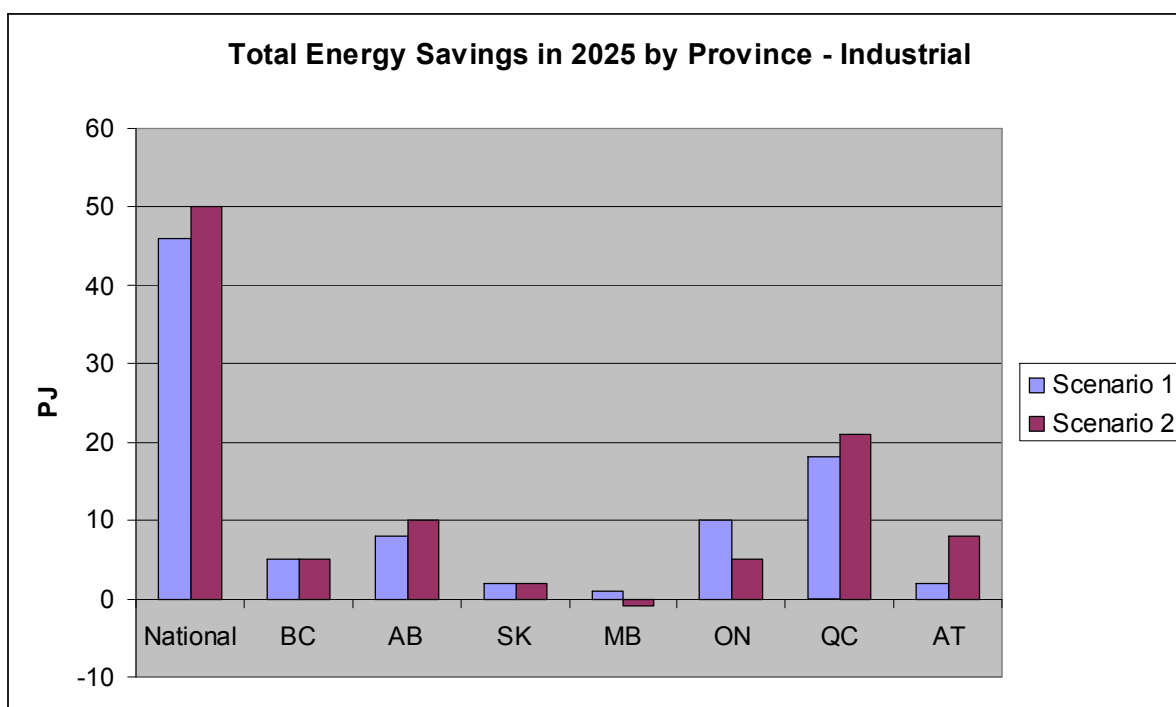


Exhibit C6.12: Industrial Energy Savings (PJ) in 2025 by Province/Region - All Fuels

	BC		AB		SK		MB		ON		QC		AT	
	Sc. 1	Sc. 2	Sc. 1	Sc. 2	Sc. 1	Sc. 2	Sc. 1	Sc. 2	Sc. 1	Sc. 2	Sc. 1	Sc. 2	Sc. 1	Sc. 2
Total Energy	5	5	8	10	2	2	1	-1	10	5	18	21	2	8
Electricity	5	10	1	12	1	2	0	12	4	12	9	55	2	5
Natural Gas	12	16	7	-1	0	-2	0	-11	3	-14	8	-22	1	7
Refined Petroleum Products	2	4	1	3	0	2	-1	-1	7	17	5	8	3	7
Wood waste / SPL	-15	-27	-1	-7	1	0	1	-2	-6	-17	-9	-30	-3	-11
Other	1	2	0	2	0	0	0	0	2	5	5	10	0	0

* negative values represent a growth in demand for that fuel

Exhibit C6.13: Percentage Reduction in Industrial Energy Demand in 2025 by Province/Region - All Fuels

	BC		AB		SK		MB		ON		QC		AT	
	Sc. 1	Sc. 2	Sc. 1	Sc. 2	Sc. 1	Sc. 2	Sc. 1	Sc. 2	Sc. 1	Sc. 2	Sc. 1	Sc. 2	Sc. 1	Sc. 2
Total Energy	1%	1%	2%	2%	2%	2%	1%	-1%	1%	0%	2%	2%	1%	4%
Electricity	6%	10%	3%	33%	3%	10%	1%	39%	2%	8%	2%	15%	3%	9%
Natural Gas	7%	10%	3%	0%	0%	-4%	1%	-48%	1%	-4%	6%	-16%	4%	35%
Refined Petroleum Products	10%	24%	10%	47%	-2%	27%	-35%	-53%	10%	24%	7%	10%	7%	18%
Wood waste / SPL	-7%	-12%	-1%	-9%	33%	-5%	41%	-132%	-6%	-14%	-6%	-22%	-6%	-20%
Other	5%	6%	0%	1%	0%	2%	3%	33%	1%	2%	3%	7%	0%	1%

* negative values represent a growth in demand for that fuel

C7. COMMERCIAL SECTOR RESULTS

This section presents the achievable potential results for the commercial sector, under the following themes: i) overall energy demand savings, ii) energy demand savings by fuel, iii) changes in energy intensities and fuel shares.

C7.1 ENERGY DEMAND SAVINGS IMPACT

Exhibits C7.1 to C7.4 present the energy demand savings impact. The key findings are as follows:

- As shown in Exhibit C7.2, the total reduction in energy demand in 2025, relative to the reference case projection, ranges from 62 PJ to 251 PJ, a 4.3% to 17.5% savings for scenarios 1 and 2 respectively.
- To put this into perspective, the projected savings from scenario 2 are just less than the commercial sector's incremental aggregate energy demand since 1990. Using the projected energy market prices used in the reference case forecast, the projected savings range from \$0.7 billion to \$3.3 billion in energy operating cost savings in 2025, for scenarios 1 and 2 respectively.
- As shown in Exhibit C7.3, the two achievable scenarios represent a range of 24% to 97% of the economic potential.

Exhibit C7.1: Annual End-Use Energy Demand by Milestone Year, Commercial/Institutional Sector: Reference Case, Economic, and Achievable Potential Scenarios

Annual Demand (PJ/yr)					
Commercial					
Year	Base Year	Reference Case	Economic	Achievable	
				Scenario 1	Scenario 2
2000	1078	1078	1078	1078	1078
2005		1130	1130	1130	1130
2010		1192	1007	1170	1162
2015		1275	1029	1231	1170
2020		1352	1059	1298	1182
2025		1431	1103	1369	1180

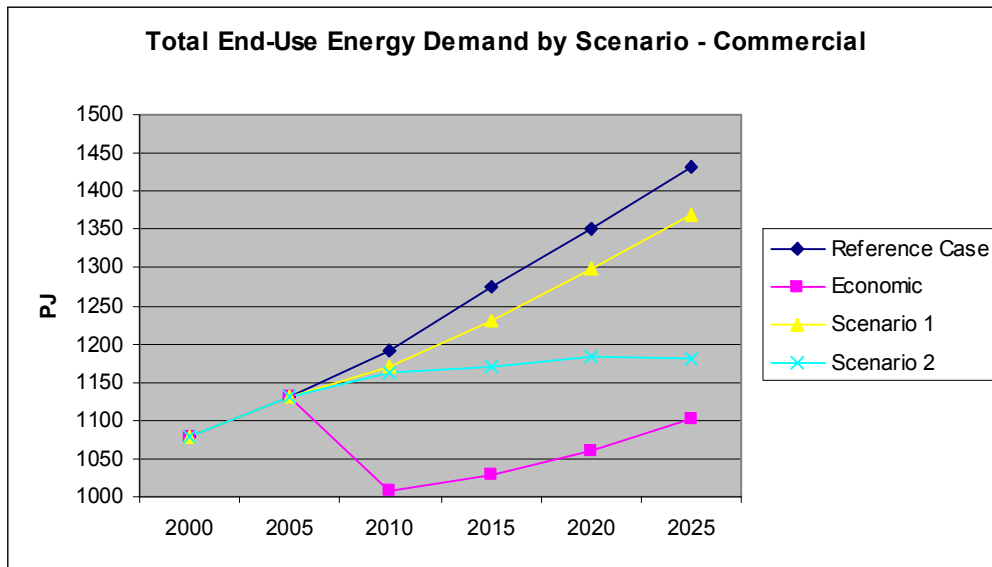
Exhibit C7.2: Annual Commercial Savings in Energy Demand and Savings as Percentage of Reference Case Demand

Year	Potential Annual Savings (PJ/yr)			Savings as Percentage of Reference Case Demand		
	Economic	Achievable		Economic	Achievable	
		Scenario 1	Scenario 2		Scenario 1	Scenario 2
2010	196	22	29	15.4%	1.8%	2.5%
2015	259	44	105	19.3%	3.5%	8.2%
2020	259	54	170	21.6%	4.0%	12.6%
2025	259	62	251	22.9%	4.3%	17.5%

Exhibit C7.3: Annual Achievable Potential as a Percentage of Economic Potential

Year	Achievable Potential Savings as Percentage of Economic Potential Savings	
	Scenario 1	Scenario 2
2010	11.0%	15.0%
2015	17.0%	40.4%
2020	20.9%	65.7%
2025	23.9%	96.8%

Exhibit C7.4: Total End-Use Energy Demand by Scenario, Commercial/Institutional Sector



C7.2 ENERGY DEMAND SAVINGS BY FUEL

Exhibit C7.5 profiles the commercial energy demand savings according to fuel. The key observations are:

Electricity

- The total achievable potential electricity reduction ranges from 24 PJ to 123 PJ (6.7 billion to 34.2 TWh), or a 4.4% to 22.8% reduction relative to the reference case in 2025 for scenarios 1 and 2 respectively. These results represent end-use efficiency changes, fuel switching and co-generation.
- Cogeneration represents 12% of the reduction in electricity demand in scenario 1 and 20% of the savings in scenario 2. The main driver for the increased take-up of cogeneration in scenario 2 is the marginal cost pricing policy instrument.

Natural Gas

- The total achievable potential natural gas reduction ranges from 28 PJ to 90 PJ (0.75 billion to 2.42 billion m³), or a 3.5% to 11.5% reduction relative to the reference case in 2025 for scenarios 1 and 2 respectively.
- The natural gas reduction potential would be 4.5% and 17% for scenarios 1 and 2 respectively if the load building effect of increased cogeneration was netted out.

Exhibit C7.5: National Commercial Achievable Potential Energy Reduction by Milestone Year and Fuel (PJ)

	2010		2015		2020		2025	
	Sc. 1	Sc. 2	Sc. 1	Sc. 2	Sc. 1	Sc. 2	Sc. 1	Sc. 2
Total Energy	22	29	44	105	54	170	62	251
% Savings Relative to Reference Case	1.8%	2.5%	3.5%	8.2%	4.0%	12.6%	4.3%	17.5%
Electricity	8	24	16	60	21	91	24	123
% Savings Relative to Reference Case	1.7%	5.0%	3.3%	12.0%	4.1%	17.6%	4.4%	22.8%
Natural Gas	9	-4	19	24	23	49	28	90
% Savings Relative to Reference Case	1.5%	-0.6%	2.8%	3.6%	3.2%	6.8%	3.5%	11.5%
Refined Petroleum Products	4	9	9	21	10	29	11	37
% Savings Relative to Reference Case	4.9%	10.1%	9.0%	21.7%	9.6%	29.2%	10.0%	35.2%
Wood Waste	0	0	0	0	0	0	0	0
% Savings Relative to Reference Case	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Other	0	0	0	0	0	0	0	0
% Savings Relative to Reference Case	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%

C7.3 ENERGY DEMAND SAVINGS BY END USE

Exhibits C7.6 and C7.7 profile the allocation of the commercial electricity and natural gas savings by end-use. These exhibits explore two dimensions of end-use savings: i) the contribution that savings in an end-use represent relative to the total sector energy demand savings, and ii) the savings achieved in a particular end-use relative to the demand in that end-use in the reference case, referred to as the performance impact. The key findings are as follows.

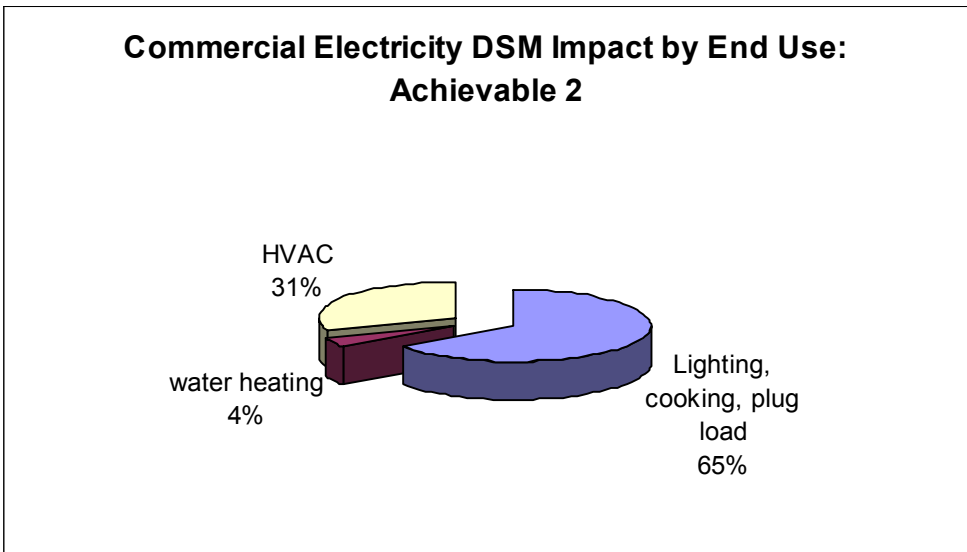
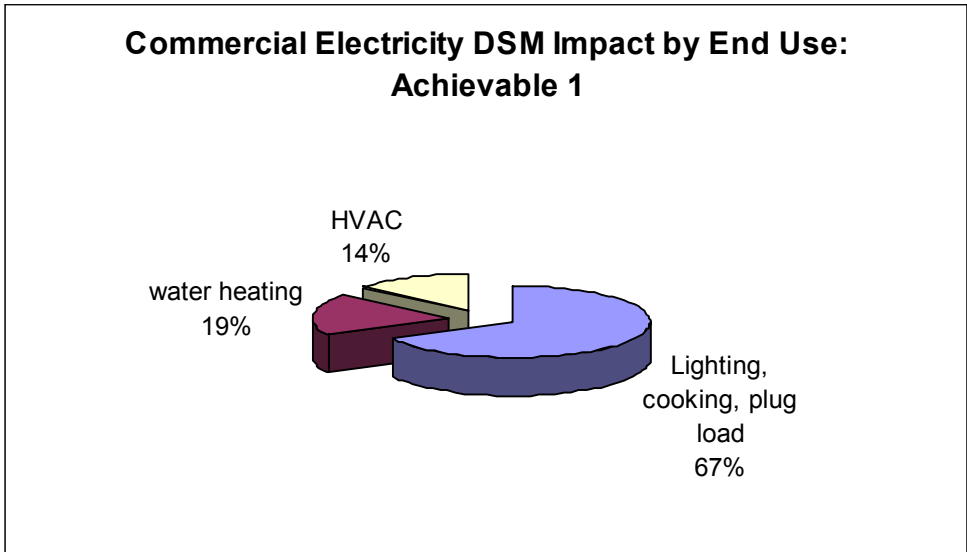
Electricity

- As shown, there is a change in the distribution of savings by end-use between the two scenarios. In scenario 2, HVAC savings grow as a proportion of the total savings. However, in both scenarios, lighting and plug loads constitute at least 50% of the electricity savings. These savings stem from more efficient computer equipment as well as the greater adoption of Super T8 fluorescent lighting over standard T8, the use of compact fluorescents over incandescent and the use of highbay fluorescent lighting over metal halide.
- The lighting performance impact increases from 4% to 18% relative to the reference case. While the incentive levels are the same in both scenarios, the application of marginal cost pricing together with improved performance standards influences the take up of more efficient lighting in scenario 2.
- The contribution of water heating to the total sector savings drops from 19% in scenario 2 to 4% in scenario 1. The contribution of HVAC performance increases. No standards were applied to this end-use. There is some minor fuel switching to natural gas in scenario 2.
- The improved HVAC savings in scenario 2 are mainly influenced by the introduction of building standards, which increase the performance of A/C and auxiliary motor systems. The introduction of marginal electricity pricing also influences a switch to gas heating, though the national market share of electric heating in the reference case is small.

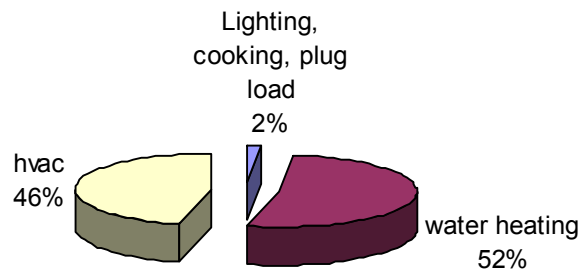
Natural Gas

- The HVAC (primarily space heating) share of the natural gas savings in 2025 grows from 46% to 86% for scenarios 1 and 2 respectively. The growth in share for scenario 2 is influenced considerably by the introduction of advanced building performance standards.
- In Scenario 1 water heating represents the largest proportion of the natural gas reduction opportunity at 52%. The share of this end use drops considerably in scenario 2, to 13%.

Exhibit C7.6: National Commercial Energy demand savings by End Use



**Commercial Gas DSM Impact by End Use:
Achievable 1**



**Commercial Gas DSM Impact by End Use:
Achievable 2**

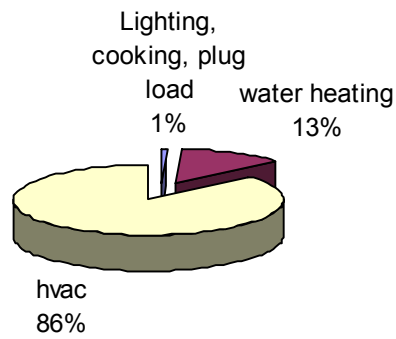


Exhibit C7.7 End Use Savings in 2025 Relative to the Reference Case

Commercial-elec

	% savings relative to end use base		
	1	2	econ
Lighting, cooking, plug load	4%	18%	20%
water heating	20%	21%	45%
HVAC	1%	11%	11%
cogeneration	0%	0%	0%
	1	2	economic
Cogeneration Gwh	792.4	6,829.3	22,273.4

Commercial-gas

	% savings relative to end use base		
	1	2	econ
cooking	1%	1%	20%
water heating	17%	14%	47%
hvac	2%	15%	34%

C7.4 CHANGES IN ENERGY INTENSITIES AND FUEL SHARES

Exhibits C7.8 and C7.9 profile the changes in energy intensity and fuel shares for the two scenarios.

- Commercial energy intensity is measured as energy demand per unit of floor space. Relative to the reference case intensity in 2025, the intensity improvements range from 4% to 15% respectively for scenarios 1 and 2.
- Exhibit C7.9 indicates a slight reduction in electricity fuel share for Scenario 1, and a slight reduction in refined petroleum products fuel share for both scenarios, compared to the BAU forecast. In effect, there is a loss of market share to natural gas for which fuel share increases to 55% and 58% in scenarios 1 and 2 respectively.

Exhibit C7.8: Commercial Achievable Potential - Change in Energy Intensity**Scenario 1**

	2000	2005	2010	2015	2020	2025
Energy Intensity (GJ / m²)						
BAU forecast	1.86	1.78	1.71	1.67	1.64	1.62
Scenario 1	1.86	1.78	1.68	1.62	1.59	1.56
% Relative Change	0%	0%	-2%	-3%	-4%	-4%

Scenario 2

	2000	2005	2010	2015	2020	2025
Energy Intensity (GJ / m²)						
BAU forecast	1.86	1.78	1.71	1.67	1.64	1.62
Scenario 2	1.86	1.78	1.67	1.56	1.47	1.38
% Relative Change	0%	0%	-3%	-9%	-12%	-17%

Exhibit C7.9: Commercial Fuel Shares for Achievable Potential and Reference Cases

	2000	2005	2010	2015	2020	2025
Electricity						
BAU Forecast	41.5%	40.9%	40.0%	39.2%	38.4%	37.7%
Scenario 1	41.5%	40.9%	40.1%	39.3%	38.4%	37.7%
Scenario 2	41.5%	40.9%	39.2%	37.9%	36.6%	35.8%
Natural Gas						
BAU Forecast	51.1%	51.6%	52.5%	53.4%	54.2%	54.9%
Scenario 1	51.1%	51.6%	52.7%	53.6%	54.5%	55.3%
Scenario 2	51.1%	51.6%	53.9%	55.6%	57.1%	58.1%
Refined Petroleum Products						
BAU Forecast	7.4%	7.5%	7.4%	7.5%	7.5%	7.4%
Scenario 1	7.4%	7.5%	7.2%	7.1%	7.1%	7.0%
Scenario 2	7.4%	7.5%	6.9%	6.6%	6.3%	6.1%

C7.5 REGIONAL IMPACTS

Exhibits C7.10 and C7.11 present the provincial and regional impacts for both scenarios, first in terms of volume and then shown according to percentage changes. The key observations are:

- As shown, scenario 2 results in a greater energy reduction than scenario 1 in all of the provinces/regions.
- In scenario 1, the overall savings in 2025 for all provinces/regions exceed the national reduction of 4.3%, except for Alberta, Saskatchewan and Quebec which fall below. In scenario 2, all provinces/regions exceed the national reduction of 17.5%, except for Saskatchewan, Quebec, and the Atlantic region.

Achievable Potential Scenarios

- From the standpoint of electricity savings, in scenario 1 only B.C. and Alberta exceed the national average of 4.4%. In scenario 2, Saskatchewan, Manitoba, Quebec, and the Atlantic region exceed the national reduction of 22.8%, especially Quebec at a 37% reduction.
- From the standpoint of natural gas, in scenario 1 only Manitoba, Ontario and the Atlantic region exceed the national reduction of 3.5%. This is due to the significant fuel substitution and cogeneration that occurs in B.C., Alberta and Quebec. In scenario 2, all provinces/regions exceed the national reduction of 11.5%, except for Saskatchewan.

Exhibit C7.10: Commercial Energy Demand savings (PJ) in 2025 by Province/Region - All Fuels

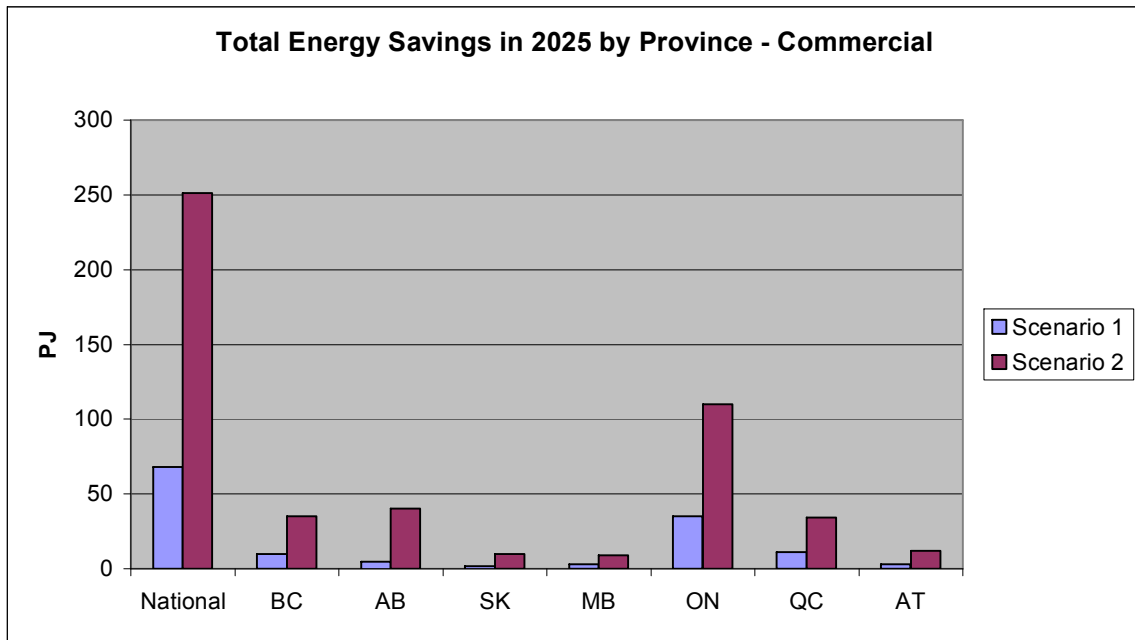
Savings PJ	National		BC		AB		SK		MB		ON		QC		AT	
	Sc. 1	Sc. 2	Sc. 1	Sc. 2	Sc. 1	Sc. 2	Sc. 1	Sc. 2	Sc. 1	Sc. 2	Sc. 1	Sc. 2	Sc. 1	Sc. 2	Sc. 1	Sc. 2
Total Energy	62	251	10	35	5	40	2	10	2	9	30	110	10	34	3	12
Electricity	24	123	4	16	4	13	1	5	0	5	9	33	4	44	1	8
Natural Gas	28	90	2	14	2	25	1	3	2	4	17	68	3	-26	1	2
Refined Petroleum Products	11	37	4	5	-1	2	0	3	0	0	4	9	3	16	1	2
Wood waste	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Other	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Exhibit C7.11: Percentage Reduction in Commercial Energy Demand in 2025 by Province/Region - All Fuels

	National		BC		AB		SK		MB		ON		QC		AT	
	Sc. 1	Sc. 2	Sc. 1	Sc. 2	Sc. 1	Sc. 2	Sc. 1	Sc. 2	Sc. 1	Sc. 2	Sc. 1	Sc. 2	Sc. 1	Sc. 2	Sc. 1	Sc. 2
Total Energy	4%	18%	5%	20%	2%	20%	3%	17%	4%	18%	5%	18%	4%	13%	5%	17%
Electricity	4%	23%	5%	22%	7%	22%	4%	24%	3%	28%	4%	15%	4%	37%	3%	23%
Natural Gas	3%	12%	2%	16%	1%	18%	3%	8%	5%	13%	4%	18%	4%	-27%	9%	16%
Refined Petroleum Products	10%	35%	38%	49%	-27%	51%	5%	43%	19%	24%	17%	39%	7%	42%	4%	9%
Wood waste	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Other	0%	15%	0%	12%	0%	0%	0%	0%	0%	0%	0%	52%	0%	0%	0%	46%

* negative values represent a growth in demand for that fuel

Exhibit C7.12: Energy Demand Savings in 2025 by Province



C8. DISCUSSION

The results from the two scenarios establish an achievable potential of between 2.9% and 10.3% reduction in the demand for energy relative to the reference case forecast. In the previous sections we discuss how the dynamics of the various modeling assumptions affect the results at the sector level. This section addresses some of the broader issues and implications of the analysis, while also reiterating some of the factors that have been at play in affecting the results of the industry sector analysis.

Impact on Industry

In 2003 the industrial sector represented the largest percentage of Canada's secondary energy consumption, 38% of the total (including transportation). Nevertheless, the achievable potential analysis reduction in energy demand for industry is considerably less than that of the residential and commercial sectors. On the surface, it would appear that the energy efficiency performance gains in the residential and commercial sector are not attainable in industry. That would be a misleading conclusion because, as shown in the last part of this section, other studies that focus solely on energy efficiency have shown significant economic and achievable potential in industry. Rather, it is important to understand that the modeling construct and dynamics of this study provide some insight into how a particular mix of policy instruments might affect industry, but in a more dynamic, less linear fashion than shown in some of the other energy efficiency studies.

We have seen from the analysis that, in a dynamic- integrated modeling construct, industry could chose fuel substitution and cogeneration investments as alternative investments to energy efficiency or which could offset some of the energy efficiency gains. Therefore, to reiterate, the key factors influencing the outcomes of the industry achievable potential results are:

- Scenario 1 was largely driven by subsidies. It appears that, relative to the dynamics of the residential and commercial sectors, the reduced paybacks induced by the subsidies do not have the same effect for industry in addressing the gap between the social and private discount rates. This may be due to the typically higher hurdle rates that industry demands for energy efficiency investments.
- In scenario 2, the application of standards in industry was limited and did not play the same role as building and end-use equipment standards do in the commercial/institutional and residential sectors. In addition, the renewable energy subsidies and the changes in building types (to mimic urban land use policies) had a far less application to industry than the other sectors.
- In scenario 2, the marginal cost pricing instrument has a considerable effect on industry energy use dynamics as electricity prices increase relative to other fuels. This drives additional fuel switching for end-uses where these fuels can be substitutes, particularly combustion. The end-use efficiency of electric heating is always higher than for direct combustion of fuels, resulting in additional secondary energy demand for the affected end-uses. This drop in performance is particularly evident where there is a considerable switch to the utilization of wood waste in industry; wood waste use increases fairly significantly in scenario 2.

Finally, it is also important to reiterate that the study did not examine the energy management potential in the upstream oil and gas sector, which is an energy intensive and growing sector of the economy.

The Role of Fuel Substitution

CIMS is structured such that technological alternatives of differing levels of efficiency and fuel type can meet an energy service demand. The policies (as represented in CIMS by changes in capital costs or changes to energy prices) result in both fuel switching and the adoption of more efficient technologies in the simulation. Marginal cost electricity pricing and the carbon liability in particular result in fuel switching responses because they affect different fuels unevenly. In response to the carbon liability, there is fuel switching to less carbon intense fuels (away from coal and oil), while marginal cost pricing encourages fuel switching away from electricity. Due to the limitations of the study, the CIMS modelling was not set up to factor out the fuel substitution effect from the overall savings reduction.

The Role of Co-Generation

The policies simulated in the achievable potential bolster the economic conditions for cogeneration, which has a significant impact on the results.²⁹ Exhibit C8.1 summarizes the amount of additional electricity that is induced by the policies simulated in the two scenarios. As shown, the incremental cogeneration output ranges from 9.2 PJ to 61.7 PJ (2.6 TWh to 17.1 TWh). The upper value is equivalent to nearly 40% of the installed cogeneration capacity in Canada in 2003.³⁰ It is also about 40% of the economic cogeneration potential.

While more than 95% of the current installed cogeneration capacity is in the industrial sector, the commercial sector offers the highest potential for incremental cogeneration, in the range of 31% to 40% of the total for the two scenarios.

At the present time, high natural gas prices are making cogeneration less economic because they are reducing the “spark spread”, i.e. the cost differential between natural gas and electricity, so that self-generation becomes less cost effective. However, the simulation of the achievable potential includes policies that favorably influence the economics of cogeneration – in particular, marginal cost pricing for electricity increases the differential between gas prices and electricity prices – which is critical to cogeneration development.

²⁹ Cogeneration (or combined heat and power) produces both electricity and useful thermal energy simultaneously from the same fuel (or fuels). This allows cogeneration to generate electricity and thermal energy using less input fuel than the stand-alone alternatives, such as boilers and centralized utility generation of electricity.

³⁰ Mark Jaccard and Associates, **Strategic Options for Combined Heat and Power in Canada, For Natural Resources Canada, August 2004, p.40**. The installed capacity in 2003 was 6.8 TWe. Assuming an average capacity factor of 70% and an average heat-to-power ratio of 2.5, the amount of electricity currently produced is approximately 40 TWh and the amount of thermal energy produced is approximately 100 TWh per year. This amounts to approximately 6% of total electricity generation in Canada in 2003.

Exhibit C8.1: Added Cogeneration by Sector

	Achievable Potential		Economic Potential
	Scenario 1	Scenario 2	
Additional Electricity Generated (TWh/year)			
Total	2.56	17.14	54.58
Residential	1.35	6.89	26.14
Commercial	0.42	3.43	6.17
Industrial	0.79	6.83	22.27
Additional Electricity Generated (PJ/year)			
Total	9.23	61.71	196.50
Residential	4.86	24.80	94.12
Commercial	1.52	12.33	22.20
Industrial	2.85	24.59	80.18

Macro-economic Impacts

The scenarios did not utilize CIMS' energy price and macro-economic feedback systems. This level of analysis was beyond the scope of the study. If CIMS had been allowed to iterate between the energy demand and supply sectors, we would have seen the impacts of reduced consumption of electricity on its cost of production, and hence its price. If the price change had been significant, the energy-demanding residential, commercial and industrial models would have been re-run until a new energy supply and demand equilibrium was achieved. If the macro-economic feedbacks had been run, particularly in scenario 2, increased production costs in industry may have caused increased final prices and lower production demands, which would have led to secondary macroeconomic effects in the residential and commercial sectors.

Transportation Benefits: Location Efficiency

In scenario 2, we touched briefly on the possible energy reduction effect of advanced urban land use policies. This was modeled by changing dwelling shares running into the future, to reflect increased urban densities. There is a possible transportation dividend to be reaped from such policies. Numerous studies have been completed in the past 15 years on the energy and lifestyle cost savings of dense urban areas relative to sprawling urban areas – thus termed “location efficiency”.

Research has consistently shown savings of 20%-40% in urban transportation energy as urban density doubles. For instance, if policy makers targeted a density of 10 people/hectare in 2030 in Canadian urban areas, which would be a 43% increase in urban density compared with current patterns, this could result in a 10%-20% annual reduction in urban transportation energy consumption. To put this into perspective, a 10%-20% annual savings applied in 2003 in Canada's urban areas would save roughly 100 PJ-200 PJ annually in *passenger* transportation alone.

System Savings

The projected savings in electricity demand have been calculated at the customer level. However, these savings have a significant impact on capacity requirements to meet the demand.

A unit of electric demand reduction is worth more (12% to 30% more depending on the generation mix) than a unit of additional supply in terms of generation capacity.³¹

Comparison to Other Studies

There have been many North American studies in the past five years investigating the achievable potential for energy efficiency in various sectors. Comparisons of study outputs from one study to another are always difficult because of often different analytical constructs, modelling approaches, data sets and assumptions. Nevertheless, the comparisons provide another source of estimates to consider, and an indication of how the current study relates to other efficiency potential studies that have been undertaken.

The two achievable potential scenarios generate savings reductions ranging from 2.9% to 10.3% in 2025, relative to the reference case forecast. These results are of the same order of magnitude as those generated by a 2005 U.S. study investigating energy efficiency potential in all sectors which produced a savings range of 4% to 9%, also for two scenarios running to 2025.³² The U.S. study used the National Energy Modelling System (NEMS) and considered a wide range of policy instruments, and like the current study, assessed the potential by directly representing policies in an energy-economy model.

Exhibit C8.2 compares the range of achievable potential savings from some recent demand-side management (DSM) studies conducted in Canada, distinguished according to sector and fuel.

The comparison shows that, with the exception of the industrial results, the upper bound (the scenario 2 results) exceeds the upper bound of these recent DSM studies. Indeed, it is clear that the CIMS industrial results offset the performance from the other sectors when the overall reduction in demand is considered.

In interpreting this difference, it is important to bear in mind that scenario 2 as defined in this project includes price and regulatory instruments that extend beyond the scope of current utility programs. The analysis also incorporates land-use measures, cogeneration and renewables, and includes the interactive effects of the policies, including their impact on fuel switching.

Industry shows a lower potential for several reasons. First, the regulatory, land use and renewable subsidy policies are largely targeted to the residential and commercial sectors. Second, fuel switching to gas and the additional natural gas required to cogenerate (the cogeneration effect) simply outweighs the gains in energy efficiency gains in industry. Although there is fuel substitution and cogeneration in the other sectors, the other elements in the scenario induce significantly more efficiency over the long run.

³¹ To meet electricity demand, you need to have a generation capacity that exceeds your demand by a minimum of around 12% for hydro generators to around 30% for coal-fired generators to handle routine maintenance and down time of equipment.

³² Energy Information Administration, Office of Integrated Analysis and Forecasting, **Assessment of Selected Energy Efficiency Policies**, May 2005 U.S. Department of Energy Washington, DC 20585.

Exhibit C8.2 Achievable Potential Performance Range from Recent DSM Studies

Sector and Fuel	Savings Range			
	Lower %		Upper %	
	Other studies	CIMS analysis	Other studies	CIMS analysis
Residential				
Electricity	3	4.4	7.5-14	27
Natural Gas	2	5.6	3-7	11.8
Commercial				
Electricity	3	4.4	3-5	22.8
Natural Gas	3	3.5	6-10	11.5
Industrial				
Electricity	2	2.9	15-25	14.3
Natural Gas	3	3.3	7-10	-2.7