



**M A R B E K**  
Resource Consultants Ltd.



**MKJA**  
MK Jaccard and  
Associates Inc

## **APPENDIX B**

### **Economic Potential Scenario**

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## B1. INTRODUCTION

This section presents the **economic potential** results for the study period 2000 to 2025. The economic potential is defined as “a future 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”. The economic potential is calculated as the difference between the energy demand of the reference case scenario and the energy demand following the economic potential scenario.

The consulting team commissioned to undertake this study brings together a long and diverse history in analyzing energy efficiency potentials. Not surprisingly, this accumulated history also brings with it varying opinions concerning the important core concepts underlying this study. In the interest of transparency, it’s important to note that there is some divergence of views concerning what is or is not economic potential.

Marbek generally accepts and uses the term and the construct as an upset, a performance ceiling to which energy efficiency market interventions can be targeted. The economic potential scenario is generally accepted by government and utilities as an important construct in assessing the remaining energy efficiency potential to be targeted within a given market boundary. All of the members of the CEM demand-side management (DSM) Working Group have at one time or another undertaken studies in which economic potential is an integral scenario.

Conversely, MKJA prefers a term like *technico-economic potential*, in recognition that the “economic potential” is usually not all economic for the individual investor or society. MKJA’s position is that the analysis of economic potential rarely accounts for the different costs of competing technologies in terms of their risks or the quality of service. For instance, a newer, more energy efficient technology with a longer payback may have higher risks of premature failure or be susceptible to other changing conditions that would render it uneconomic. A more efficient technology may not provide an identical service to the technology it is intended to replace, with convenience, comfort or other cost implications for the consumer. Consequently, MKJA’s position is that economic potential does not necessarily convey a performance ceiling to which market interventions can be targeted.

Notwithstanding this healthy difference in perspective, the design and application of the analysis, as well as presentation of the results, is the outcome of a unified approach within the consulting team. It’s also important to consider that the results are indicative, not definitive. As noted in our initial report, the Reference Case, this study is intended to provide a high level estimate of energy efficiency potential, with a particular focus on the achievable potential scenarios. As such, we are examining order of magnitude levels of opportunity, we are not designing DSM programs for specific markets.

This report is organized according to the following subsections:

- Major Modeling Assumptions and Inputs
- High level Results
- Detailed Sector Results.

## B2. MAJOR MODELING ASSUMPTIONS AND INPUTS

As discussed in the Reference Case report, the CIMS model is populated with a suite of energy end-use technologies. Each end-use category (e.g., space heating, domestic hot water) has one or more technology upgrade options. During the study period, a portion of the initial-year's stock of technologies is retired and new stock is required to meet economic growth. A lifecycle costing (LCC) competition occurs in each period to determine the market shares of new technologies, including energy efficient upgrades. A similar competition occurs for energy retrofits. In the LCC application, if the financial value of the energy savings over the useful life of an upgrade technology exceeds the incremental cost of moving to that technology, then the upgrade technology will be a candidate for the economic potential scenario. The method is analogous to a Total Resource Cost (TRC) test commonly used by utilities (without the utility program costs).

In the economic potential competition, only one technology “wins” or achieves all of the market share. Exhibit B2.1 illustrates this outcome, using refrigerators as an example.

**Exhibit B2.1: Economic Potential Induced New Market Share in 2015**

Refrigerators	Reference Case	Economic Potential
Baseline – standard option	67%	0%
Better Efficiency, 10% efficiency improvement	6%	0%
Better Efficiency, 20% efficiency improvement	1%	0%
Better Efficiency, 30% efficiency improvement	26%	100%
Most Efficient, 42% efficiency improvement	0%	0%

Two major parameters affect the LCC competition and, therefore, drive the economic potential:

- The energy long run marginal cost (LRMC) used for screening the economics of the candidate technologies (including a carbon liability value); and
- The discount rate.

Exhibit B2.2 presents a summary of key assumptions used to derive these parameters.

**Exhibit B2.2: LRMC Costs and Discount Rates for the Economic Potential**

Fuel	LRMC Costs as a share of the market price	Carbon liability value	Social Discount Rate	Private Discount Rate
Gas, RPP, Coal and Other	Market Price by Region – See Appendix A, Fuel Prices	\$15/tonne CO <sup>2</sup>	10%	0%
Electricity	Cost of new combined cycle gas turbine plus transmission and distribution costs and distribution losses	\$15/tonne CO <sup>2</sup>	10%	0%

The assumptions and approach with which the parameters in Exhibit B2.2 were derived is elaborated in the following two sections.

## **B2.1 ENERGY PRICES**

The value of the energy savings stream over the useful life of the technology upgrade is a function of energy savings and energy price. As the objective is to determine whether a given energy efficiency investment provides a positive economic return from a societal cost perspective, we use a schedule of long-run marginal costs (LRMC) as the energy price inputs to CIMS. The LRMC valuation combines the costs of generation, production, transmission and distribution. Taxes are excluded from the valuation as they are a transfer payment. The LRMC valuation is a two step exercise. First, separate valuation methods are employed to establish the LRMCs for electricity versus natural gas and Refined Petroleum Products. Second, a carbon liability value is added to all of the energy forms.

The LRMC schedule and value of the carbon liability value was communicated to and agreed to by the client group.

### **Electricity LRMC**

In general, DSM studies conducted for electric utilities set the LRMC value(s) to account for displaced or deferred generation capacity. Hence, these values are typically based on the cost of new combined cycle gas turbine (CCGT) plants. In CIMS, the electricity LRMC value is derived to estimate 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.

The specific steps are:

- **Set Generation Supply Price:** A base load CCGT plant rated at 1000 MW is assumed at the margin. This is a simplifying assumption – in reality, the capacity requirement, type (baseload, peaking, etc) and timing of those requirements may differ on a regional basis. Typically, the lifecycle levelized cost of a base load plant is lower than a small shoulder or peaking plant. Hence, the outcome is a lower, more conservative generation supply price which addresses uncertainty in assuming that all new generation at the margin in all regions will primarily come from CCGTs.
- **Apply Regional Variation.** The levelized cost of the CCGT plant embodies both capital and operating cost inputs. The supply price estimates are regionalized by setting the CCGT variable fuel cost in each 5-year period at the regional market price for industrial natural gas.
- **Account for Transmission and Distribution losses.** Transmission and distribution costs in each region are regionally calculated, and assumed to be 7% of the regional price of electricity while transmission and distribution losses are assumed to be 4%.<sup>1</sup>

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<sup>1</sup> B.C. Hydro Conservation Potential Review.

- **Reflect Sectoral Variation.** The LRMC were first developed for each of the residential, commercial and industrial sectors separately using their different market prices. These were then aggregated into one estimate that is applied to all sectors in a region.

Exhibits B2.3 and B2.4 summarize the outputs from the electricity price derivation. These LRMC estimates are consistent with other DSM studies, where the LRMC for electricity ranges between 110% and 140% of the electricity market price. See Sub-Appendix B for a review of LRMC prices used in various jurisdictions. Two notable exceptions that fall outside this range are Quebec and Manitoba where the high prevalence of low cost hydro power results in a large gap between the market price of electricity and the LRMC based on relatively high cost CCGT. That said, the LRMC for Manitoba is similar to the 6 cents/kWh assumed in recent DSM studies.

**Exhibit B2.3: Long-Run Marginal Cost for Electricity (cents/kWh) Including Generation, Transmission and Distribution Costs**

	2005	2010	2015	2020	2025
Atlantic	8.57	8.90	8.70	8.48	8.22
Quebec	7.51	7.85	7.65	7.43	7.19
Ontario	10.31	10.63	10.44	10.24	10.01
Manitoba	6.57	6.94	6.77	6.59	6.38
Saskatchewan	8.84	9.19	9.03	8.87	8.68
Alberta	8.30	8.65	8.50	8.35	8.16
BC and Territories	6.12	6.49	6.32	6.14	5.92

**Exhibit B2.4: Long-run Marginal Cost for Electricity (no carbon externality) as a Percent of the Market Price**

	2005	2010	2015	2020	2025
Atlantic	121%	129%	128%	127%	126%
Quebec	165%	173%	170%	165%	161%
Ontario	120%	109%	112%	116%	122%
Manitoba	162%	178%	182%	185%	187%
Saskatchewan	130%	137%	137%	138%	137%
Alberta	129%	121%	124%	129%	136%
BC and Territories	131%	141%	141%	140%	139%

**Natural Gas and Refined Petroleum Products**

The initial LRMC value for natural gas and RPPs is based on a schedule of market prices as elaborated in Appendix A, Fuel Prices.

**Carbon Liability Shadow Price**

There is evidence that utilities commissions are beginning to force the internalization of greenhouse gas (GHG) liabilities such that these are now part of the real energy cost structure faced by utilities in their decision-making. We have included a price of \$15 / t CO<sub>2</sub>e in the modelling that is incorporated into the energy prices based on the carbon content of the affected fuels. This price was chosen as this has already been approved in at least one jurisdiction for

utility investment analysis (by the BC Utilities Commission for BC Hydro) and falls in the range of prices applied or considered in North American jurisdictions.<sup>2</sup> It also reflects the commitment from the Canadian government to the Large Final Emitters (LFE) group that their GHG reduction cost compliance will not exceed this value. Exhibit B2.5 illustrates how this carbon price of \$15/tonne CO<sub>2</sub> translates in terms of \$/GJ based on the carbon content of the fuel. The approximate change in energy price is shown, though this will vary by region, year and sector.

**Exhibit B2.5: Value of the Carbon Externality (\$15/Tonne CO<sub>2</sub>) by Fuel**

	Cost (\$/GJ)	Average change in energy price
Coal	1.20 - 1.43	57%
Natural gas	0.75	10%
Fuel oil	1.09	11%
Biomass	0	0
Electricity (gas CCGT)	1.44	8%

Note that this liability does not represent an estimate of the full externality cost of GHG or other emissions. For instance a value of \$140/tonne CO<sub>2e</sub> (70 pounds/tonne CO<sub>2</sub>) was used to evaluate energy efficiency potential in the United Kingdom.<sup>3</sup> It is simply a financial cost liability that is considered in a full calculation of LRMC, recognizing that all cost estimates have present and future uncertainties associated with them.

## B2.2 DISCOUNT RATE

The LCC competition of end-use technologies is also driven by the discount rate. As the economic potential is a societal perspective, the LCC analysis uses a social discount rate. A social discount rate of 10% real is applied for all regions and technologies. This rate reflects Treasury Board guideline of 10% used in its Cost-benefit guide.<sup>4</sup> There is considerable debate on appropriate discount rates to use; the adoption of this rate will yield a more conservative estimate of the economic potential than other studies.

The technology competition which occurs in the reference case projection uses a schedule of private discount rates that are typically much higher than the social discount rate. The private discount reflects the effective discount rates that are revealed from market data, and characterize the payback that firms and households seem to require before acquiring technologies of higher energy efficiency. Changing the discount rate from a private to a social perspective has two effects in the competition of technologies in CIMS. First, more energy efficiency measures are likely to pass the LCC test generating a positive net present value. Second, among the larger

<sup>2</sup> BC Hydro Provincial Integrated Electricity Planning Committee, “GHG Cost Comparisons Across Jurisdictions”, Meeting #6 (September 22 - 23, 2005), Information Sheet #8. “Environmental Multipliers” have also been included in some analyses to account for the fact that energy prices do not necessarily reflect the full impact of the use of energy on the environment. For instance, an environmental multiplier was incorporated into the life-cycle cost analysis of the 1997 Model National Energy Code of Canada for Buildings and the 1997 Model National Energy Code of Canada for Houses.

<sup>3</sup> Office of the Deputy Prime Minister, *Proposals for amending Part L of the Building Regulations and Implementing the Energy Performance of Buildings Directive: A Consultation Document* (London: ODPM Publication, July 2004), [www.odpm.gov.uk/pub/460/ProposalsforamendingPartLPrintVersionPDF1339Kb\\_id1131460.pdf](http://www.odpm.gov.uk/pub/460/ProposalsforamendingPartLPrintVersionPDF1339Kb_id1131460.pdf).

<sup>4</sup> This discount rate has been used in recent energy and climate change analyses and funding applications directed by the federal government, for instance the recent Opportunities Envelop Program.

number of measures that become candidates for competition, an increasing number of higher performing measures are selected as the least cost option.

### **B2.3 VARIANCE PARAMETER**

CIMS contains a variance parameter that represents sensitivity of the technology to relative LCCs. A high  $v$  value means that the technology with the lowest LCC captures almost all of the market for new equipment stock, a “winner takes all result”. A low  $v$  value means that new equipment market shares are distributed more evenly among competing technologies, even if their lifecycle costs are different. The value of the  $v$  factor is set low for the economic potential scenario thereby enabling only the least cost measure to be selected. Most DSM studies model the economic potential with the highest performing measures included that pass the economic cost test. The due diligence conducted during the CIMS modeling reveals that in most instances the highest performing measures are selected.

### **B2.4 FUEL SUBSTITUTION AND COGENERATION**

CIMS models both energy efficiency and fuel substitution. Given the weighting towards energy efficiency in this study, a preliminary test of the economic potential simulation was conducted in CIMS. The results revealed a significant degree of fuel switching and consequently, changes were employed to the modelling set-up to limit the fuel substitution effect.

The fuel substitution in the preliminary test occurred for two reasons. First, in the three target sectors there are several energy end-uses that can be serviced by technologies that use more than one fuel. There are instances where the LCC of a fuel substitution is lower than the energy efficiency alternatives. Consider, for instance, if high efficiency electric hot water heaters have the LCC, the CIMS simulation will show a reduction in natural gas demand. As stock turn-over occurs in the model, no hot water heaters that used natural gas in the reference case will have switched to the higher efficiency gas water heaters but will be replaced by the higher efficiency electric heaters. The effect of this type of phenomenon is exacerbated in the economic potential construct in which only one energy performance upgrade is selected, a winner takes all approach to the LCC competition.

Given the weighting of energy efficiency in this study we proposed that we would limit the fuel shares by end-use to those represented in the reference case. The client group agreed to constrain fuel substitution in the economic potential scenario. This approach has enabled the development of economic potentials that allow for greater comparability with those generated in other DSM studies. As a result, the reference case fuel shares change in the economic potential scenario only slightly as elaborated below.

The CIMS construct does not permit a full freeze of fuel shares. However, as elaborated below, the most pervasive fuel substitution effect in the economic potential is due to cogeneration applications. The cogeneration options were modelled for all three sectors, where feasible. In the residential sector, cogeneration was applied to multi-unit residential apartment buildings.

### **B3. ECONOMIC POTENTIAL: HIGH LEVEL RESULTS**

Exhibits B3.1 to B3.3 present the overall economic potential results, which combines the results of the three sectoral analyses elaborated below. The results are reported in terms of the changes in end-use energy demand (from energy efficiency and distributed electricity generation within sectors) that must be met by utilities and other energy suppliers. In 2025, the total net savings in secondary energy amount to 950 PJ, a 15% reduction relative to the reference case. This savings impact is equivalent to about 60% of the total aggregate increase in energy consumption in the three sectors between 1990 and 2003. It also amounts to about a \$10.5 billion reduction in operating savings in 2025 relative to the reference case forecast of energy demand.

The economic potential scenario comprises a significant fuel substitution effect due to cogeneration applications in all three sectors, the largest application having been modelled in the commercial sector. As elaborated in the ensuing sections, when the sectoral cogeneration effect is netted out, the economic potential results are generally conservative when compared to recent DSM studies conducted in Canada.

Exhibit B3.3 shows there is some variation in economic potential according to region. This is not surprising given that the LRMC of energy supply is also different by region, thereby affecting the economics of the energy efficiency measures.

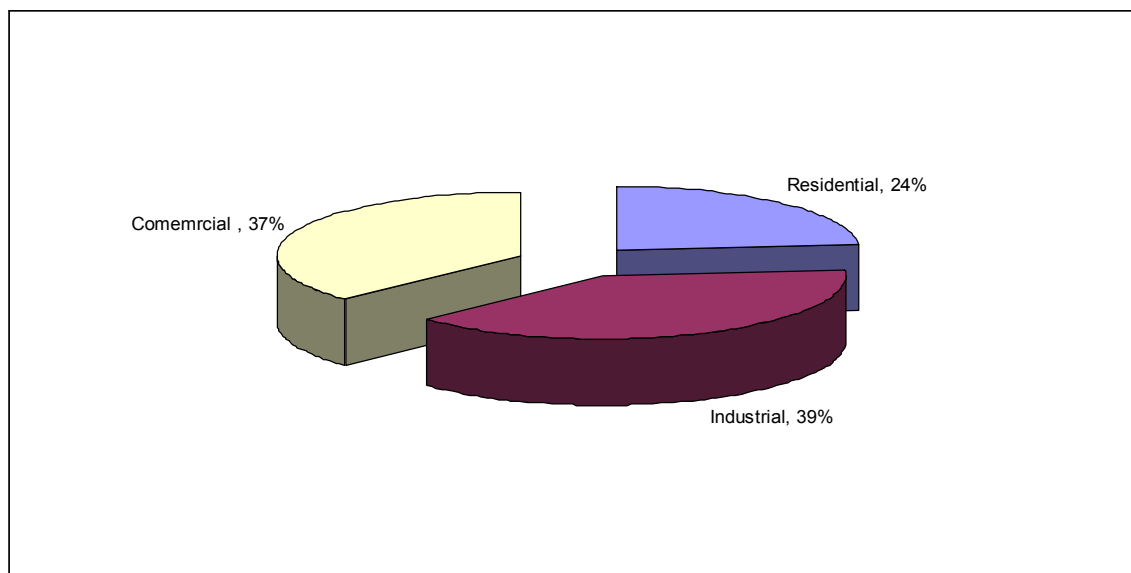
Under the economic potential scenario nearly 40 TWh of electricity will be produced from cogeneration. Nearly 60% of the cogeneration load is attributed to the commercial sector, another 28% in industry. While industry has an overall larger technical cogeneration potential, a significant portion of this is captured in the reference case.

About 50% of the total energy savings in 2025 is attributed to electricity reduction. Of this amount, about 30% is due to added cogeneration supply. Natural gas savings represent about 28% of the total reduction in 2025 and represent a larger savings when the cogeneration effect is netted out.

**Exhibit B3.1: All Sectors National Economic Potential Energy Reduction by Milestone Year and Fuel (PJ)**

	2010	2015	2020	2025
Total Energy (PJ)	415.2	618.3	773.7	924.3
% Savings Relative to Reference Case	7%	11%	13%	15%
Electricity (PJ)	184.6	285.9	380.1	467.1
% Savings Relative to Reference Case	11%	16%	20%	24%
Natural Gas (PJ)	162.7	219.6	240.6	262.9
% Savings Relative to Reference Case	7%	9%	10%	10%
Refined Petroleum Products (PJ)	21.9	29.4	39.3	48.1
% Savings Relative to Reference Case	5%	7%	9%	10%
Wood Waste/ Spent Pulping Liquor (PJ)	39.5	57.7	69.0	76.7
% Savings Relative to Reference Case	6%	8%	10%	10%
Coal, Petroleum Coke, Waste Fuels, Off gases (PJ)	14.0	33.0	51.8	77.1
% Savings Relative to Reference Case	3%	6%	9%	12%

**Exhibit B3.2: National Economic Potential by Sector Share of Energy Reduction in 2025**



**Exhibit B3.3: Percentage Reduction in Energy in 2025 By Province/Region - All Fuels**

	BC	AB	SK	MB	ON	QC	AT
Total Energy	19%	12%	11%	15%	15%	12%	16%
Electricity	30%	50%	25%	18%	25%	17%	27%
Natural Gas	13%	6%	7%	14%	12%	8%	22%
Refined Petroleum Products (RPP)	3%	21%	9%	6%	7%	13%	12%
Wood/spent pulping liquor	21%	10%	-3%	-15%	1%	10%	9%
Coal, Petroleum Coke, Waste Fuels, Off gases	2%	1%	2%	-10%	21%	3%	2%

## B4. DETAILED SECTOR RESULTS

### B4.1 RESIDENTIAL SECTOR

Exhibits B4.1 to B4.7 present the residential sector economic potential national level results. The provincial and regional results are found in Sub-Appendix B. The key findings are as follows:

- Relative to the reference case, the economic potential energy demand reduction by 2025 is 219.4 PJ, a 13% reduction. To put this into perspective, this is roughly equivalent to the incremental aggregate energy consumption that has occurred in the residential sector since 1990. Based on projected energy prices, this reduction is also roughly equivalent to about \$3.4 billion in operating cost savings.
- Among energy forms, the largest energy demand reduction opportunity resides with electricity. Nationally, the total economic potential electricity reduction potential is 126 PJ, amounting to a 20% reduction relative to the reference case. Cogeneration represents about 12% of the total electricity energy demand reduction, with the potential to offset electricity loads in apartment buildings. The 20% reduction is slightly below the range in residential electricity savings estimated from recent electricity DSM studies in the past few years.
- Lighting efficiency measures represent the largest portion of the electricity reduction opportunity, about 47% of total energy demand reduction, followed by space heating and appliances. In terms of performance improvements affecting electricity demand, residential lighting is the end use offering the largest unit savings, about 69% relative to the base case performance levels. This is due largely to the application of compact fluorescent lamps replacing incandescent lamps. DHW offers a 19% performance improvement.
- Nationally, the total economic potential natural gas energy demand reduction is 80.8 PJ, amounting to a 10% reduction relative to the reference case. It's important to note that the total reduction would have been 2% higher if not for the offsetting load building effect of increased cogeneration. A range of 10% to 12% is also slightly lower than what has been estimated from recent gas DSM studies conducted in Canada.
- Space heating represents the largest portion of the natural gas reduction opportunity, about 57% of total energy demand reduction, followed by DHW at 33% of total savings. In terms of performance improvements affecting gas, DHW is the end use offering the largest unit savings, about 16% relative to the base case performance levels. This is due to the application of higher performance water heating equipment, in particular, instantaneous heaters. A decrease in hot water demand of 4% from higher performance appliances and tap use also contributes to this potential.
- Another dimension of the economic potential is the change in residential energy intensity, measured as energy demand per household. Relative to the reference case intensity in 2025, the economic potential generates an intensity improvement of 13%.

- Exhibit B4.3 indicates that no significant changes in fuel shares are projected in the economic potential scenario.
- Exhibit B4.6 describes energy savings by region. Variations stem from differences in expected household growth, difference in regional energy price forecasts (generally higher energy price forecasts drive more EE changes in reference case) and from heatload differences (for instance, condensing gas furnaces in more recently built homes are only economic in some regions).
- Exhibit B4.7 lists the energy management actions applied to the residential economic potential scenario. As noted, the modelled energy efficiency impact is at the conservative end of the spectrum, when compared to the results of recent utility specific studies. This occurs due to differences in the representation and application of certain energy efficiency actions in CIMS as compared with other DSM studies. Exhibit B4.8 provides a brief commentary of where the CIMS analysis differed.

**Exhibit B4.1: Residential National Economic Potential Energy Reduction by Milestone Year and Fuel (PJ)**

	2010	2015	2020	2025
Total Energy (PJ)	98.0	145.2	180.7	219.4
% Savings Relative to Reference Case	7%	10%	11%	13%
Electricity (PJ)	65.3	78.4	97.8	126.2
% Savings Relative to Reference Case	12%	14%	16%	20%
Natural Gas (PJ)	29.4	60.0	72.7	80.8
% Savings Relative to Reference Case	4%	8%	10%	10%
Refined Petroleum Products (RPP) (PJ)	2.1	4.4	6.8	8.3
% Savings Relative to Reference Case	2%	3%	5%	6%
Wood (PJ)	1.1	2.4	3.4	4.1
% Savings Relative to Reference Case	1%	3%	4%	5%

**Exhibit B4.2: Residential National Economic Potential - Change in Energy Intensity**

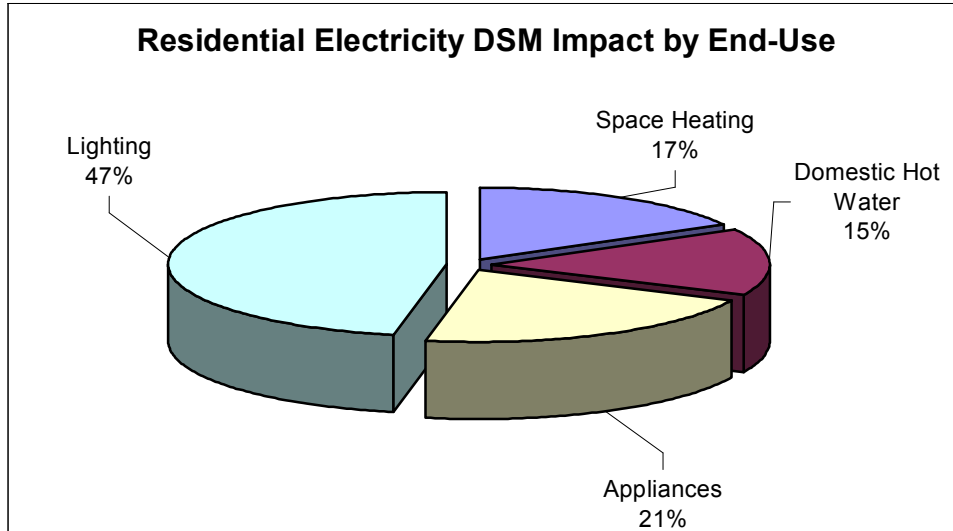
	2000	2005	2010	2015	2020	2025
Energy Intensity (GJ/hslld)						
BAU forecast	109	104	100	97	95	94
Economic forecast	109	104	93	87	84	82
% Change Relative			-7%	-10%	-11%	-13%

**Exhibit B4.3: Residential National Economic Potential Fuel Shares Relative to the Reference Case**

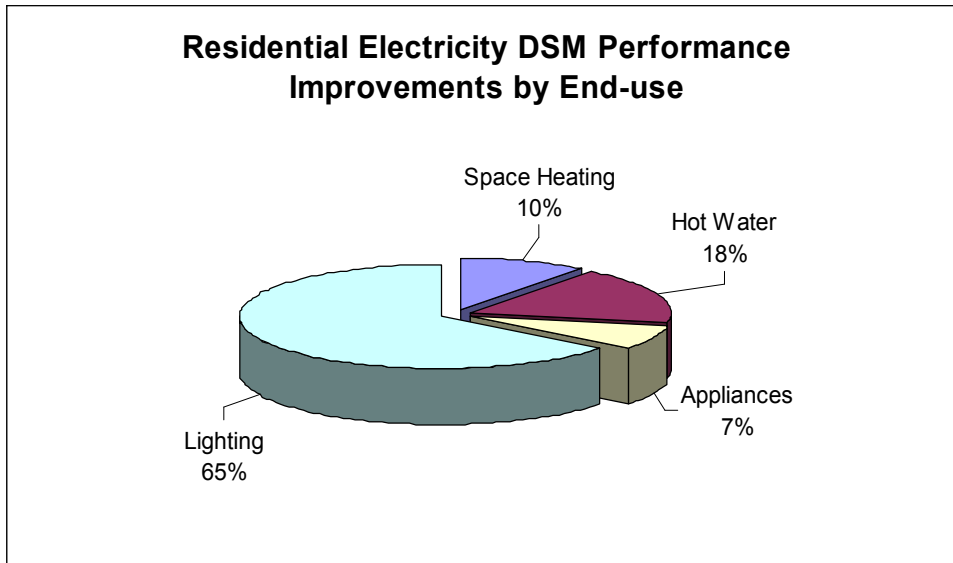
	2000	2005	2010	2015	2020	2025
<b>Electricity</b>						
BAU forecast	35.9%	36.3%	36.6%	37.0%	38.0%	38.6%
Economic forecast	35.9%	36.3%	34.4%	35.2%	35.9%	35.7%
<b>Natural Gas</b>						
BAU forecast	47.6%	47.7%	47.9%	48.1%	47.8%	47.8%
Economic forecast	47.6%	47.7%	49.3%	48.8%	48.8%	49.5%

	2000	2005	2010	2015	2020	2025
<b>Refined Petroleum Products</b>						
BAU forecast	9.6%	9.5%	9.3%	9.2%	9.0%	8.7%
Economic forecast	9.6%	9.5%	9.8%	9.8%	9.7%	9.5%
<b>Wood</b>						
BAU forecast	7.0%	6.5%	6.1%	5.7%	5.1%	4.8%
Economic forecast	7.0%	6.5%	6.5%	6.1%	5.6%	5.2%

**Exhibit B4.4: Residential National Electricity Savings By End Use**



**Exhibit B4.5: Residential Electricity End-Use Performance Improvements**



**Exhibit B4.6: Percentage Reduction in Energy in 2025 By Province/Region - All Fuels**

	BC	AB	SK	MB	ON	QC	AT
Total Energy	15%	11%	13%	13%	13%	12%	21%
Electricity	23%	23%	21%	18%	19%	17%	30%
Natural Gas	10%	8%	10%	8%	12%	4%	9%
Refined Petroleum Products	-3%	-16%	10%	-1%	7%	6%	7%
Wood	7%	0%	0%	0%	6%	0%	47%

\* negative value is growth in energy by fuel

**Exhibit B4.7: List of Actions Included in Economic Potential Analysis – Residential<sup>5</sup>**

Residential Measures
Minor appliances, new with 1 W standby power
Clothes Washer, 20% to 25% improved efficiency
Clothes Dryer, Electric/Gas, Moisture Sensor
Cooking range electric, 20% efficiency improvement
Refrigerator, New- Better Efficiency, 30% efficiency improvement
Lighting-compact fluorescent
Non-appliance hot water; low-flow devices
Hand dishwashing with tap aerator
Dishwasher, Energy Star; 26% Impr.
Electric intermittent fan, system efficiency of 34%
enhanced MNECH shell-new construction
natural gas furnace, 90% to 92% efficiency
oil furnace, 92% efficiency
electric heat pump, 145% efficiency
Water heating, Apartment, cogeneration, reciprocating engine, natural gas, apartments only
Water heater with storage tank, electric-higher efficiency (EF=0.94)
Water heater with storage tank- Apartment, Oil-fuelled, new top-rated efficiency (EF=0.68)
Water heater with storage tank-Electric with heatpump
Water heater, instant - no storage tank, Non-apartment, Natural gas-fuelled, new, standard efficiency

<sup>5</sup> Note that because the CIMS modelling was region-specific, specific inclusion of these actions differed by region.

**Exhibit B4.8: Important Differences Between CIMS and Other DSM Analyses**

Energy Efficiency Actions	Comments
Existing whole house retrofit versus specific envelope measures.	<p>CIMS models air sealing and insulation actions in existing dwellings as a whole house retrofit. This action did not pass the economic test and, consequently, was not included in the potential.</p> <p>The utility specific studies examined the effect of specific retrofit measures that did pass the economic test, specifically, air leakage sealing.</p>
Condensing furnaces- low rise residential applications.	<p>Condensing furnaces were included as an action in only a portion of the existing housing market, mainly in the older housing archetypes.</p> <p>The utility specific studies modeled condensing furnaces in all existing detached low rise dwellings.</p>
High performance boilers- apartment buildings.	<p>These are not modeled for apartment buildings because the analysis assumes that cogeneration will meet the DHW loads.</p> <p>The utility specific studies modeled condensing boilers in both existing and new buildings.</p>
Measures affecting end-uses with smaller overall consumption: e.g., fireplaces, pool heaters, LED Christmas lights.	<p>The CIMS analysis did not model these actions. However, they did not get much attention in the utility specific studies.</p>

**B4.2 INDUSTRIAL SECTOR**

Exhibits B4.9 to B4.14 present the industrial sector economic potential national level results. The provincial and regional results are found in Appendix C. The key findings are as follows:

- Relative to the reference case, the economic potential energy demand reduction by 2025 is 362 PJ, an 11% reduction. To put this into perspective, this is about 70% of the total aggregate increase in industrial energy consumption between 1990 and 2003. It is also roughly equivalent to \$2.6 billion in operating cost savings. It’s important to note that this analysis includes fuel switching as a result of cogeneration applications. The impact on electricity and gas demand of implementing all economic cogeneration is discussed below. Exhibit B4.10 shows that there is some change in fuel shares for electricity and gas as a result of the cogeneration market penetration under the economic scenario.
- Exhibit B4.11 shows that savings in the pulp and paper and iron and steel sectors account for nearly two thirds of the total economic potential, with the pulp and paper sector accounting for 50% of the overall savings. This impact is disproportionate to the shares that these sectors hold as a percentage of total energy demand in industry, respectively 26% and 7% of the total.<sup>6</sup>
- Among energy forms, the largest energy demand reduction opportunity resides with electricity. Nationally, the total economic potential electricity reduction potential is 173 PJ, amounting to a 23% reduction relative to the reference case. Cogeneration represents

<sup>6</sup> NRCan Energy Use Trends Database-Industrial Sector – Aggregated Industries Canada, Secondary Energy Use and GHG Emissions by Industry – Including Electricity-Related Emissions.

about 22% of the total electricity savings, meaning that the energy efficiency effect amounts to a reduction of about 18%. The resulting energy efficiency effect is conservative when compared to recent electricity DSM studies, where energy demand reduction projected is in the order of 25%-30%.

- Industrial electricity energy demand reduction result most significantly from process technology actions (41%) and auxiliary motor systems (41%), followed by cogeneration (22%) and lighting (4%). The category of auxiliary motor systems savings includes high efficiency motors, higher performance motor driven equipment and system improvements (e.g., variable speed drives).
- Nationally, the total economic potential natural gas energy demand reduction is 25 PJ, amounting to a 3% reduction relative to the reference case. It's important to note that the total natural gas reduction potential would have been about 8% if not for the offsetting load building effect of increased cogeneration.
- The natural gas energy demand reduction, by end-use, are distributed as follows: direct process heating- 57%; indirect process (steam systems and hot water)-28%; and HVAC – 15%. The analysis results in a reduction of steam demand of 14% contributing to the savings from steam systems. These demand changes occur mostly in pulp and paper, and to a lesser extent, in iron & steel and chemicals.
- In contrast to the other sectors, industry also contains a significant economic potential to reduce Refined Petroleum Products, wood and a category of industry feedstocks which contain coal, petroleum coke, waste fuels and off gases. Together, the reduction potential for these energy forms and feedstocks amounts to 164 PJ, nearly the same amount as the economic electricity reduction.
- Exhibit B4.12 shows the distribution of savings by sector and fuel. The results show that the savings by fuel vary considerably from one sector to the next, reflecting that fuel shares and performance improvements are very sector and process unique. For instance, the chemicals industry shows a net increase in gas demand due to this being the sector with the largest cogeneration impact in the economic potential scenario.
- The modelled energy efficiency impact of gas is at the conservative end of the spectrum, when compared to the results of recent utility specific studies. It is about 50% of the economic potential savings found from utility specific studies undertaken in the past few years.

There are two reasons for the results being at the conservative end of the spectrum. First, compared with some other studies, the CIMS modelling projected lower unit savings for efficiency improvements in providing process heat, both direct and indirect. Higher performance can be attained in boilers, furnaces, ovens, kilns and so on through optimization actions comprising improved design, burner optimization and control optimization. Together these optimization measures can generate unit savings of 15% to 25%, which is higher than what has been modeled in CIMS (which assumes around 10%). Second, cogeneration was modeled as an action in steam provision for many sectors. Consequently, actions to improve boiler efficiency were not included and these

potential savings are not reflected in the potential. Exhibit B4.13 lists the energy management measures applied to the industrial economic potential scenario.

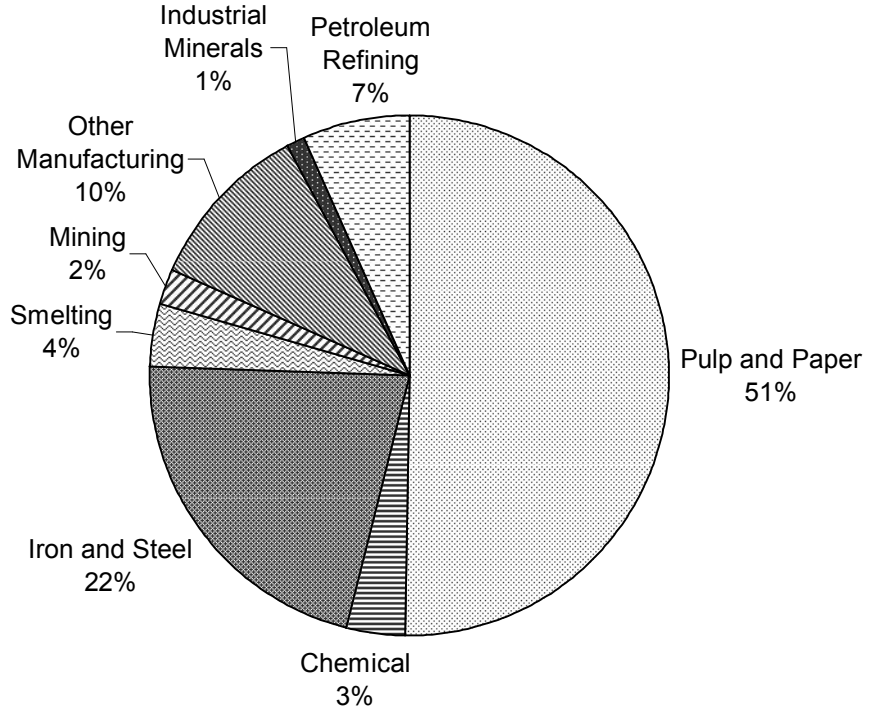
**Exhibit B4.9: Economic Potential Energy Reduction by Milestone Year and Fuel (PJ)**

	2010	2015	2020	2025
Total Energy (PJ)	121.4	214.1	286.3	361.9
% Savings Relative to Reference Case	4%	7%	9%	11%
Electricity (PJ)	46.2	100.4	139.5	172.8
% Savings Relative to Reference Case	6%	14%	19%	23%
Natural Gas (PJ)	18.4	19.1	19.3	25.2
% Savings Relative to Reference Case	2%	2%	2%	3%
Refined Petroleum Products (PJ)	4.5	6.4	10.3	14.2
% Savings Relative to Reference Case	3%	3%	5%	6%
Coal, Petroleum Coke, Waste Fuels, Off gases (PJ)	14.0	33.0	51.8	77.1
% Savings Relative to Reference Case	2%	5%	8%	11%
Wood Waste/ SPL (PJ)	38.4	55.3	65.5	72.5
% Savings Relative to Reference Case	7%	10%	11%	12%

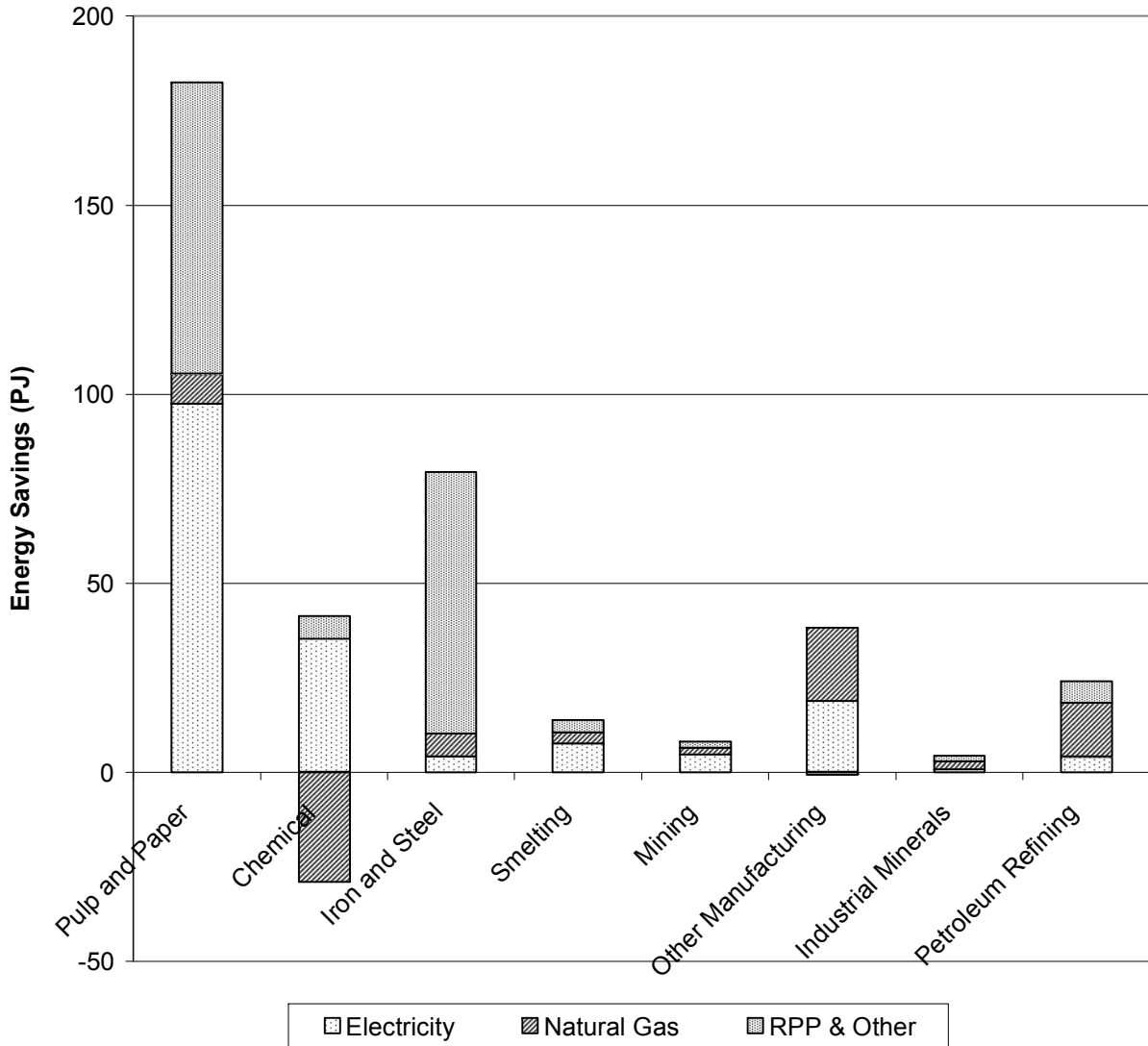
**Exhibit B4.10: BAU and Economic Potential Fuel Shares**

	2000	2005	2010	2015	2020	2025
<b>Electricity</b>						
BAU forecast	24.7%	24.3%	24.4%	23.8%	23.4%	23.0%
Economic forecast	24.7%	24.3%	23.8%	22.1%	20.9%	19.9%
<b>Natural Gas</b>						
BAU forecast	34.0%	33.0%	31.5%	31.0%	30.4%	30.3%
Economic forecast	34.0%	33.0%	32.3%	32.6%	32.8%	33.2%
<b>Refined Petroleum Products</b>						
BAU forecast	5.9%	6.0%	6.1%	6.3%	6.5%	6.7%
Economic forecast	5.9%	6.0%	6.2%	6.5%	6.8%	7.0%
<b>Coal, Petroleum Coke, Waste Fuels, Off gases</b>						
BAU forecast	17.1%	18.5%	19.3%	19.9%	20.7%	21.2%
Economic forecast	17.1%	18.5%	19.7%	20.2%	21.0%	21.2%
<b>Wood Waste/ SPL</b>						
BAU forecast	18.3%	18.3%	18.6%	19.1%	18.9%	18.8%
Economic forecast	18.3%	18.3%	18.1%	18.5%	18.5%	18.6%

**Exhibit B4.11: Industrial Economic Potential Savings By Sector**



**Exhibit B4.12: Industrial Economic Potential Savings By End-Use**



**Exhibit B4.13: Percent Reduction in Energy in 2025 By Province/Region - All Fuels**

	BC	AB	SK	MB	ON	QC	AT
Total Energy	17%	8%	6%	6%	12%	9%	11%
Electricity	39%	86%	13%	11%	26%	12%	26%
Natural Gas	3%	-1%	6%	0%	3%	7%	15%
Refined Petroleum Products	0%	39%	-7%	-7%	5%	7%	8%
Coal, Petroleum Coke, Waste Fuels, Off gases	2%	1%	2%	-10%	21%	3%	2%
Wood Waste/ SPL	21%	12%	-4%	-14%	-1%	10%	5%

**Exhibit B4.14: List of Actions Applied in Economic Analysis – Industrial**

Diffusion washer
Thermo pulp
Kraft batch digester with RDH/superbatch
Semi-bleaching Elemental Chlorine Free, computer control group D
Full bleach with a hypochlorite stage, >70% substitution in the first step, computer control group D
Efficient tissue paper disc refining and screening
Tissue dryer with steam with computer control
Efficient coated wood free disc refining and screening
Coated paper dryer with steam or electricity and high intensity drying
Efficient uncoated wood free disc refining and screening
Uncoated paper dryer with steam and high intensity drying
Linerboard dryer with steam, high intensity drying
Tomlinson recovery furnace black liquor gasification, computer control and cogeneration, 1200 PSIG with low odour configuration, high solids firing and computer control
Lime kiln with flash dryer
Vapour recompression evaporators
Efficient catalytic reforming
Lube oil manufacture, increased efficiency unit
Coking with soaker visbreaking
Fluid/flexi coking
Fluid/Flexi-coking with gasification,
Efficient hydrocracking unit, low API feed, hydraulic turbine power recovery
Standard fluidized catalytic cracking unit
Efficient vacuum unit, mechanical vacuum system
Atmospheric distillation using lower grade crude, high efficiency
Efficient hydrofluoric acid alkylation tower
Efficient sulfuric acid alkylation tower
Efficient isomerization tower
Natural gas/liquefied petroleum gas/oil fired furnaces, direct heat, increased efficiency
High efficient electricity heaters
Still gas fired furnace and boiler- increased efficiency
Hydrogen via nat gas steam reformation, e3m3/yr
Efficient heating system fueled by natural gas
Efficient direct heating
HVAC System improvement
Efficient hot water boiler
High efficiency hot water boiler, electric
High efficiency hot water boiler, oil
Fluidized bed drying and cleaning of potash with heat recovery
Fine grinding of underground metal ores with computer control
Fine grinding of open pit metal ores with computer control, iron only
Spray drying and cleaning of open pit metal concentrate
Fine grinding of open pit metal ores with computer control
Hall-Heroult electrolysis of aluminum, inert anode, wetted cathode
Bayer production of alumina from bauxite, natural gas, retrofits to facility in Quebec
Recycling of Aluminum, efficient natural gas plant

*Economic Potential Scenario*

Nickel electrolytic low voltage cell with metal anodes
Nickel top blown rotary converter
Nickel fluidized bed roasting
Nickel sinter roasting
Copper top blown rotary converter
Zinc electrolytic refining with new electrolysis cell
Flash roaster to oxidize zinc sulphate
Titanium electrolytic refining with new electrolysis cell
Production of Pre-bake anode; natural gas baking furnace with improved oven controls
Continuous annealing
Slab strip casting
Ultra-high power electric arc furnace, gas with water cooled walls, oxygen lance, preheated scrap
Corex process, direct smelted iron, basic oxygen furnace, gas
Corex process, direct smelted iron, basic oxygen furnace, oil
Finishing mill with computer controls
Roughing mill with computer controls
Gas-fired direct rolling reheat furnace
Oil-fired recuperated heat furnace
Rotary lime kiln preheat
Finish roller mill
Rotary cement kiln, new dry, preheating and precalcining process with efficient cooler
Hydrogen peroxide process using methyl-benzyl-alcohol
Caustic/chlorine electrolysis, membrane cell
Sodium chlorate electrolysis, metal anode cell
New AMV type process to convert air and natural gas to ammonia and methanol in one process
Advanced Reforming/reactors ammonia synthesis
Pyrolysis Cracking Furnace - by-product gas, non-ethane feedstock, new catalyst
Boiler natural gas @ 600 psig with heat recovery and regenerative burners
Boiler low sulfur residual @ 600 psig with heat recovery and regenerative burners
Heavy fuel oil-fired boiler, high efficiency
Cogenerator heavy fuel oil steam turbine 1250 psig
Standard coke-fired cogeneration
iron process gas- fired cogeneration
Natural Gas Turbine cogeneration with heat recovery steam generator, 40 MW, high heat to power ratio
Back pressure steam turbine, turbine inlet pressure 1250 psi, 30 MW
Combined cycle gas turbine cogeneration, 250 MW, Low H:P ratio
Spark ignition reciprocating engine cogeneration, natural gas, 6MW
Motor speed controller, variable speed drive and direct coupling
High efficiency fans
High efficiency conveyors
High efficiency compressors
Mid to High efficiency pumping systems
Efficient motors
More efficient Lighting, same lighting type ratios (between HID & other), but Super T8 instead of T8, and Highbay Fluorescent instead of Metal Halide

### **B4.3 COMMERCIAL SECTOR**

Exhibits B4.15 to B4.19 present the commercial sector economic potential national level results. The provincial and regional results are found in Appendix D. The key findings are as follows:

- Relative to the reference case, the economic potential energy demand reduction by 2025 is 343 PJ, a 24% reduction. To put this into perspective, this is about 1.1 times the aggregate increase in energy consumption in the commercial sector between 1990 and 2003. It is also roughly equivalent to \$4.5 billion in operating cost savings. It's important to note that this analysis includes some fuel switching as a result of cogeneration applications; the impact on electricity and gas demand of implementing all economic cogeneration is discussed below. However, when the cogeneration effect is netted out, there is virtually no difference to the total savings impact, 24% versus 25%, relative to the reference case.
- Exhibit B4.17 indicates a slight change in fuel shares between electricity and gas over the study period. The increase in gas share relative to the small decrease in electricity share, is due to the cogeneration effect.
- Among energy forms, electricity energy demand reduction constitutes a slightly higher aggregate impact. Nationally, the total economic potential electricity reduction potential is 168 PJ, amounting to a 31% reduction relative to the reference case when cogeneration is included. Indeed, cogeneration represents about 48% of the total electricity savings. When the cogeneration effect is netted out, the electricity reduction amounts to 16 % relative to the reference case. This level of energy demand reduction is comparable to the commercial sector electricity savings estimated from recent electricity DSM studies.
- When the cogeneration effect is netted out, the commercial electricity savings by end-use, as a percentage of the total sector savings, are lighting 65%, HVAC 25% and water heating 10%.
- Nationally, the total economic potential natural gas energy demand reduction potential is 157 PJ, amounting to a 20% reduction relative to the reference case. The reduction potential would be 32% if the load building effect of increased cogeneration was netted out. This is, in fact, higher than the economic potential savings found from utility specific studies undertaken in the past few years. When the cogeneration effect is netted out, the commercial gas savings by end-use, as a percentage of the total sector savings, are space heating 74%, water heating 22% and food preparation 20%.

**Exhibit B4.15: National Commercial Economic Potential Energy Reduction by Milestone Year and Fuel (PJ)**

	2010	2015	2020	2025
Total Energy (PJ)	195.8	259.0	306.7	343.0
% Savings Relative to Reference Case	16%	20%	22%	24%
Electricity (PJ)	73.0	107.1	142.8	168.1
% Savings Relative to Reference Case	15%	21%	27%	31%
Natural Gas (PJ)	114.9	140.6	148.7	157.0
% Savings Relative to Reference Case	18%	20%	20%	20%
Refined Petroleum Products (PJ)	15.3	18.6	22.2	25.7
% Savings Relative to Reference Case	17%	19%	22%	24%

**Exhibit B4.16: National Commercial Economic Potential Change in Energy Intensity**

	2000	2005	2010	2015	2020	2025
<b>Energy Intensity (GJ/hslld)</b>						
BAU forecast	109	104	100	97	95	94
Economic forecast	109	104	93	87	84	82
% Change Relative			-7%	-10%	-11%	-13%

**Exhibit B4.17: National Commercial Economic Potential Fuel Shares Relative to the Reference Case**

	2000	2005	2010	2015	2020	2025
<b>Electricity (GJ)</b>						
BAU forecast	41.5%	40.7%	39.7%	38.9%	38.0%	37.4%
Economic forecast	41.5%	40.7%	40.2%	38.2%	35.6%	33.8%
<b>Natural Gas (GJ)</b>						
BAU forecast	51.1%	51.8%	52.9%	53.7%	54.5%	55.2%
Economic forecast	51.1%	51.8%	51.8%	53.6%	56.3%	58.2%
<b>Refined Petroleum Products (GJ)</b>						
BAU forecast	7.4%	7.5%	7.4%	7.4%	7.4%	7.4%
Economic forecast	7.4%	7.5%	7.3%	7.5%	7.5%	7.3%

**Exhibit B4.18: Percent Reduction in Energy in 2025 By Province/Region - All Fuels**

	BC	AB	SK	MB	ON	QC	AT
Total Energy	28%	25%	18%	27%	22%	24%	26%
Electricity	27%	44%	39%	31%	28%	33%	23%
Natural Gas	31%	18%	6%	26%	20%	11%	38%
Refined Petroleum Products	15%	7%	28%	27%	14%	32%	25%

**Exhibit B4.19: Commercial Sector Energy Efficiency Actions Modelled**

Improved efficiency hot water tank with service load reduction
New shell, roof and wall upgrades
High bay lighting; high efficiency: High Intensity Fluorescent instead of Metal Halide and Super T8 instead of standard T8
Service area lighting; high efficiency: use of Super T8 and CFL where appropriate
General area lighting; high efficiency: use of Super T8 and CFL where appropriate
Ground source heat pump, and BAS/FMS/EMCS and VSD/VFD
Improved natural gas heating efficiency (90%), boiler controls, BAS/FMS/EMCS and VSD/VFD
Natural gas cogeneration, BAS/FMS/EMCS and VSD/VFD
Oil heating improved heating efficiency (90%) and boiler controls
Oil cogeneration
New HVAC, ground source heat pump
New HVAC, natural gas heating, solar heating
Natural gas cogeneration, BAS/FMS/EMCS, VSD/VFD and VAV
New HVAC, cogeneration, improved air conditioning efficiency
Improved heating efficiency (90%), boiler controls, improved air conditioning efficiency

**SUB-APPENDIX B.1**  
**Overview of Price Adders in DSM Studies, By Fuel and Jurisdiction**

Fuel	Jurisdiction	Pricing	Marginal Cost	Transmission and Distribution	Externality
Electricity	NB	DSM Peaking: combustion turbine DSM Baseload: natural gas combined cycle units Recent use of market price and not peaking power.	5.54 c/kWh 5.76 c/kWh	4.59 c/kWh 4.59 c/kWh	No
Electricity	PQ	Peaking: Yes Baseload: Yes; Different by end-use	Yes	Yes	No
Electricity	MB	Generally dependant on the value of energy on the export market, but can also be the cost of import energy or of thermal generation in low flow conditions	\$.0615/kWh	T&D costs are combined with that of generation and built into the avoided cost	
Electricity	BC	Long-run marginal cost of gas-fired Combined Cycle Gas Turbines	\$.06/kWh	No, but 4% transmission loss is a price adder	
Electricity	BC	Long-run marginal cost of gas-fired Combined Cycle Gas Turbines	\$.06/kWh	Peaky load values were adjusted upwards by 5% from the average CPR values and flat load values were adjusted downwards by 5%.	adjusted upwards by 7% (3% area transmission and 4% distribution) to account for losses between the busbar and the customer.
Electricity	ON	Wholesale cost of electricity (competitive market) from Annual Report of the IMO	6.6 c/kWh	Yes, plus debt retirement	\$40/tonne CO <sub>2</sub> can be applied as a catch all for externalities, including non-carbon
GAS	ON	Space Heating Service Hot Water	4.03 \$/GJ (2002\$) 3.00 \$/GJ (2002\$)	Unsure	~65% of price
GAS	ON	Separate rates for water heating; space heating; industrial process and water and space heating combination	Wholesale price forecast with no retail mark-up and no local distribution cost	\$1.18/GJ increasing 1.55 p.a.	Can include a price adder of \$40 per tonne of CO <sub>2</sub> . Price reflects a range of environmental externalities and not just COs damages.
Gas	MB	Pass through of commodity cost (primary and supplemental) plus the recovery of fixed and variable non-commodity costs including administration, transmission, distribution and storage.	~\$.2808/m <sup>3</sup>	~\$.0317/m <sup>3</sup> (transmission and storage only)	A value for GHG credits is included in marginal cost