Policy Options for Energy Efficiency in Canada's Commercial Buildings

Final Report

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Prepared for:

National Roundtable on the Environment and the Economy

Prepared By:
ICF Consulting Canada, Inc.
277 Wellington St. W.
Suite 808
Toronto, ON M5V 3E4

Contact:
Ralph Torrie
T: (416) 341-0638
F: (416) 341-0383

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Executive Summary

The National Roundtable on the Environment and the Economy commissioned a modelling study to examine the achievable potential for greenhouse gas reductions in Canada's commercial building sector. This paper presents the results of a study of three scenarios applied to the commercial building sector using ENERGY 2020, a multi-sector energy and emissions model for the period 2008 to 2050.

The modelling was based on work previously completed for Environment Canada to evaluate the combined impacts of the *Turning the Corner* plan, the *Regulatory Framework on Air Emissions* and selected provincial policies (the reference scenario). The three scenarios were: (1) the application of a carbon price to all fossil fuel use; (2) eight regulatory, financial or voluntary policy initiatives; and (3) the simultaneous application of (1) and (2).

In 2008, emissions in the commercial building sector (including emissions allocated from the end-use consumption of electricity) were approximately 75 Mt. All three scenarios reduced emissions from 2008 levels; however, absolute emissions in all three cases increased past 2008 levels by the end of the period.

When measured against the reference scenario, emissions under the carbon price, policy and combined scenarios were decreased by 10%, 19% and 23%, respectively. The combined scenario resulted in the largest reduction in greenhouse gas emissions, reaching 82 Mt in 2050, compared to the reference case of 105 Mt, and a baseline (or do-nothing scenario) of 155 Mt.

Although each scenario was successful in reducing absolute emissions relative to the planned policies contained in the reference scenario, further action is required in the latter half of the study period to maintain emission levels as economic growth continues. Ultimately, deeper, faster and broader programs and initiatives are required to maintain a low-carbon commercial buildings sector in Canada.

Acronyms

CBAC:	Commercial Buildings Advisory Committee
CCA:	Capital Cost Allowance
CCS:	Carbon capture and sequestration
FIRE:	Financial, Insurance and Real Estate
GHG:	Greenhouse gas
HID:	High Intensity Discharge
HVAC:	Heating, Ventilation and Air Conditioning
LEED:	Leadership in Energy and Environmental Design
MNECB:	Model National Energy Code for Buildings
Mt:	millions of metric tonnes of carbon dioxide equivalent
NBC:	National Building Code

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Introduction

In the spring of 2008, the Government of Canada released its *Turning the Corner* Plan[1] and the *Regulatory Framework for Air Emissions*[2]. These documents commit Canada to greenhouse gas (GHG) emission reduction targets of 20% below 2006 levels by 2020, and 60% to 70% below 2006 levels by 2050. The Regulatory Framework identifies short-term actions to achieve emission reductions prior to 2020, but does not recommend policies for the post-2020 period.

This project models the impacts of a set of policies, providing guidance to policymakers beyond the identification of targets and very short-term action plans to a longer-term strategic plan for policy development and implementation. The modeling conservatively estimates the achievable potential for energy efficiency technology deployment, using a variety of financial and regulatory mechanisms.

ENERGY 2020[3] uses the Standard Industrial Classification for commercial building sub-sectors, which are listed below. All of the outputs from the model included in this report are presented in these categories.

ENERGY 2020 Commercial Building Sub-Sectors

- Transportation Services
- Communication
- Electric Utilities
- Gas Utilities
- Water & Other Utilities
- Wholesale
- Retail
- FIRE (Finance, Insurance & Real Estate)
- Offices – Business Service
- Education
- Health & Social
- Food, Lodging, Recreation

Seven end-use categories are modeled for the Commercial sector, listed below:

ENERGY 2020 End Uses:

- Space Heating
- Air Conditioning
- Water Heating
- Lighting
- Refrigeration
- Substitutable loads[4]
- Non-Substitutable loads[5]

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[1] http://www.ec.gc.ca/default.asp?lang=En&n=75038EBC-1
[2] http://www.ec.gc.ca/doc/media/m_124/toc_eng.htm
[3] An outline of the ENERGY 2020 model is included in Appendix A.
[4] Substitutable loads includes devices that can use another energy form other than electricity (i.e. gas stoves & dryers)
[5] Non-substitutable loads include devices that consume electricity and can't readily use any other form of energy. This end-use can be considered mainly "plug load", including other large electricity-consuming devices found in commercial buildings, such as elevators.

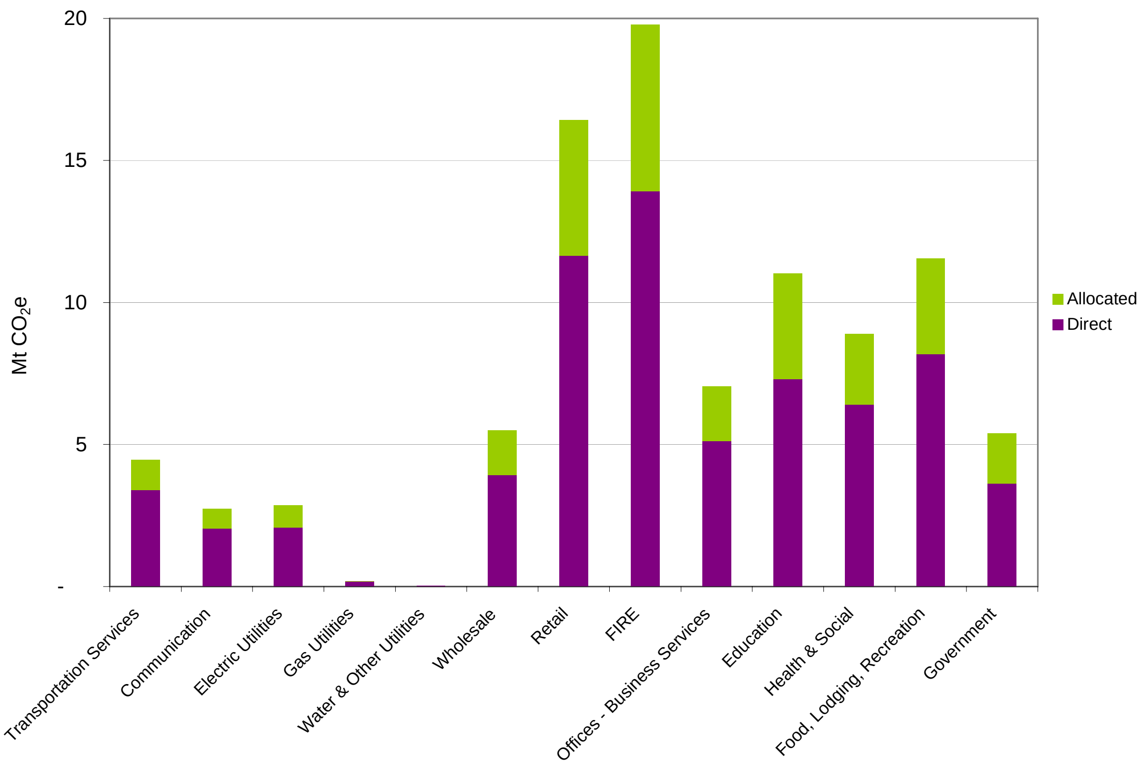
Background

Results in this paper are presented from a starting year of 2008. This section provides some basic background information on the state of the Canadian commercial buildings sector, including current emissions and energy use patterns.

Electricity typically accounts for a significant portion of commercial energy use. In order to provide a more complete picture of commercial building sector emissions the emissions associated with the production of electricity and other forms of energy (ie.the upstream oil and gas sectors) are allocated to each sub-sector in ENERGY 2020. Unless otherwise noted, all emissions presented in this report are stated as allocated emissions and therefore include not only emissions at the point of use, but all of the emissions associated with producing the energy consumed.

In 2005, the commercial and institutional sector accounted for approximately 9% of Canadian carbon emissions, a figure which does not include the allocated electricity emissions. 6,7 In 2008, emissions (including allocated electricity emissions) from the commercial building sector totalled 75 Mt. Of those, 47 Mt (64%) were from direct fuel use (for example, the on-site combustion of natural gas for space and water heating), while the balance of 28 Mt (36%) were allocated from the production of electricity. Exhibit 1 illustrates the relative contribution of direct and allocated emissions to each of the 13 commercial sub-sectors in 2008.

Exhibit 1: Direct and allocated emissions by commercial building sub-sector, 2008.



As shown above, the majority of emissions come from the FIRE (Fire, Insurance and Real Estate), Retail, Education and Food, Lodging and Recreation sectors, which account for 21%, 17%, 13% and 12% of the total commercial sector emissions in 2008, respectively.

[6] Energy Use Handbook Tables (Canada). Natural Resources Canada. Commercial/Institutional GHG Emissions by Energy Source, End-Use and Activity Type – Including Electricity-Related Emissions. http://www.oee.nrcan.gc.ca/corporate/statistics/neud/dpa/handbook_com_ca.cfm?attr=0

[7] Canada's 2006 Greenhouse Gas Inventory. Environment Canada. http://www.ec.gc.ca/pdb/ghg/inventory_report/2006/som-sum_eng.cfm

Exhibit 2 illustrates the contribution of different end-uses on greenhouse gas emissions. In the commercial sector, over 50% of the total energy is consumed in heating buildings, far ahead of the next largest energy end use, water heating (14%).

Exhibit 2: Energy demand by end use, 2008.

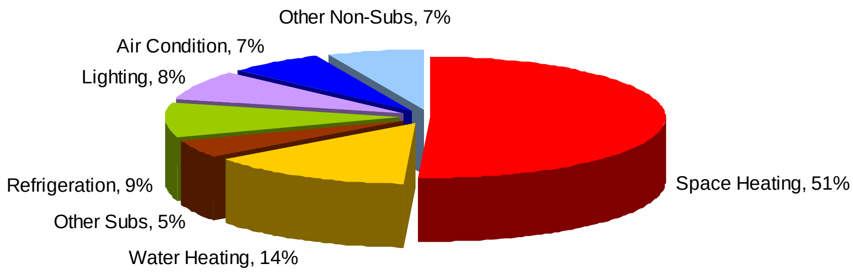
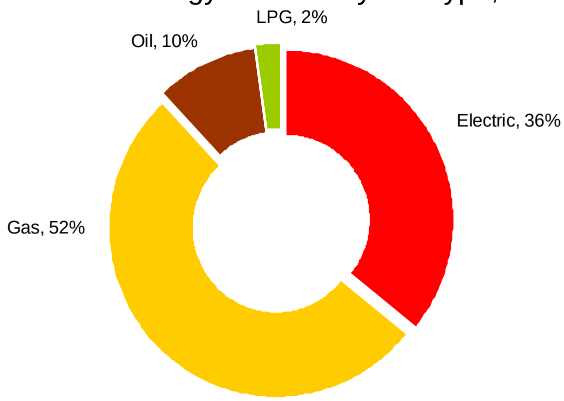


Exhibit 3: Energy demand by fuel type, 2008.



Modelling Scenarios

At a meeting in early June of 2008, the CBAC of the National Roundtable discussed and selected three scenarios to be modelled: a carbon price scenario, a scenario applying a suite of regulations, policies and other incentives, and finally, a scenario that combined the first two. These scenarios are described in greater detail below.

Carbon Price Scenario

The first scenario to be modelled applies a carbon price, as specified by the NRTEE (the "Fast and Deep" Emissions Charges, highlighted in grey, below), to the reference scenario. The carbon price is applied to all fossil fuels, based on the carbon-content of each fuel. The carbon price was applied across all sectors, thereby influencing power production (the allocated emissions) as well as direct fuel use.

	Emissions Charges (2003$/tonne)							
	2011: 2015	2016: 2020	2021 - 2025	2026: 2030	2031: 2035	2036 - 2040	2041: 2045	2046: 2050
GDP maximizing	$48	$212	$272	$286	$286	$286	$286	$286
Fast and Deep	$18	$88	$176	$264	$317	$317	$317	$317
Slow and Deep	$18	$29	$59	$117	$235	$352	$411	$411

Policy Scenario

With assistance from members of the Commercial Buildings Advisory Committee (CBAC), ICF International conducted a literature review to provide the necessary information to model a number of policies. The research effort was directed through a preliminary list that was generated by the CBAC in early June 2008.

A summarized list of the eleven original policies is shown below:

1. Include the updated Model National Energy Code for Buildings as a requirement in the National Building Code.
2. Increase the minimum energy efficiency requirements for major new building appliances and equipment.
3. Allocate an accelerated Capital Cost Allowance (CCA) to energy efficient technologies and operating control systems.
4. Require mandatory detailed external energy use labelling for commercial buildings.
5. Mandatory performance reporting and monitoring of verification and commissioning / re-commissioning processes.
6. Apply higher energy efficiency standards for government procurement of buildings and equipment.
7. Facilitate and support the acceleration of the process by which green building permits and site plan approvals may be obtained.
8. Increase training, communications, and information availability for building operators, managers, tenants, inspectors, and appraisers.
9. Provide a federal government subsidy to help offset the costs incurred by building owners for accelerated retrofits.
10. Create private-public relationships with financial institutions to encourage new products such as green loans.
11. Implement a Canadian Act that would impose unlimited liability on directors, executive officers, and others who violate federal laws for environmental practices.

Ultimately, eight of the original eleven policies were modeled, and are described below. Three of the policies (numbers 4, 10, and 11) were not modelled, as insufficient information was found to properly define modelling parameters. We would note that the decision to exclude these policies from modeling does not imply any judgement on the potential value of these policies but rather on the ability to represent them appropriately for modeling purposes.

1. Include the updated Model National Energy Code for Buildings as a requirement in the National Building Code.

This policy assumes that as of 2011, the updated (due to be released in 2011[8]) Model National Energy Code for Buildings (MNECB) will be integrated as a part of the National Building Code, and adopted by all provinces and territories. The updated MNECB was assumed to require a

[8] National Research Council of Canada. Model National Energy Code for Buildings. http://www.nationalcodes.ca/mnecb/call_for_nominations_e.shtml. The original MNECB was published in 1997; this will be the first update of the code.

building efficiency increase of 20% in the energy performance of buildings built under current rules. Current energy performance is itself expected to be 10% greater than the 1997 MNECB by 2010. [9, 10, 11]

This regulated increase in efficiency was expected to result in a 4.2% capital cost increase for new buildings. [12, 13] For modeling purposes 85% of the new building stock was assumed to comply with this policy. [14] The increase regulations apply to the construction of any new building as well as building refits, which are assumed to occur at a rate 2.2% per annum. [15] This policy applies to all building sectors, except for Government.

In addition, the requirements of the MNECB become more stringent over time, increasing the minimum efficiency levels by 5% every 5 years, until the end of the period, as shown in the table below.[16]

Year	Percentage Improvement over current practice
2016	25%
2021	30%
2026	35%
2031	40%
2036	45%
2041	50%
2046	55%

2. Increase the scope of and mandatory minimum energy efficiency requirements for major new building appliances and equipment.

Under this policy, the minimum efficiency standards for building appliances and equipment are increased by regulation. Therefore, the average equipment and appliance efficiency increases over time driven by the replacement rate, starting between 2009 and 2015. An incremental change is applied in 2035, further increasing the minimum equipment standards for energy efficiency.[17]

The efficiency of heating, ventilation and air conditioning (HVAC) equipment is increased by 8.5%,[18,19] while chillers are increased by 9%,[20, 21] over current levels. In 2035, the minimum efficiency of HVAC equipment is increased by a further 12%, while the minimum efficiency of chillers is increased by another 13%.

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[9] Canada's Emissions Outlook: An Update. Analysis and Modelling Group. National Climate Change Process. December 1999. http://www.nrcan.gc.ca/es/ceo/outlook.pdf, pgs 13 and 14.
[10] http://www.tpsgc-pwgsc.gc.ca/sd-env/sds2007/strategy/sdd-sds2007-ch3-e.html – The PWGSC will, at a minimum, construct buildings that are 30% more efficient than MNECB (which equates to 20% based on current practice, according to footnote 1).
[11] http://www.fraserbasin.bc.ca/publications/documents/caee_manual_2007.pdf - For the Canadian version of LEED-NC, the energy requirements are based on either MNECB or ASHRAE 90.1-1999, with a minimum efficiency of 25 percent higher than MNECB for LEED® certification.
[12] Life-Cycle Economic Assessment of Energy Performance Standards Applied to British Columbia. Phase II – Cost Effectiveness of Achieving CBIP in Vancouver. April 2004.
[13] Analyzing the Cost of Obtaining LEED Certification. The American Chemistry Council. April 16, 2003. This report estimates the cost premium for a LEED Certified building at 4.5% to 11%.
[14] "It is estimated that 15-20% of buildings are not complying with the code due to lack of enforcement. Personal communication, NRCan.
[15] NRCan "Canada's Energy Outlook: The Reference Case 2006"
[16] The efficiency gains specified in the table were specified by the NRTEE.
[17] Efficiency gains in 2035 for this policy were specified by the NRTEE.
[18] http://www.energystar.gov/ia/partners/manuf_res/LCHVACFS3.pdf
[19] Energy Star. http://www.energystar.gov/index.cfm?c=lchvac.pr_lchvac
[20] New Buildings Institute. 2003. Version 1.0 Release: Energy Benchmark for High Performance Buildings.
[21] Energy Start. http://www1.eere.energy.gov/femp/procurement/eep_wc_chillers.html – The average value between the chiller that just meets the ASHRAE 90.1 standard and the recommended efficiency was assumed to be the current practice.

Starting in 2015, regulation increases minimum furnace efficiency by 15%, with a 10% increase in capital cost.[22] A further 21% incremental increase occurs in 2035, with an identical increase in cost.

Boilers with a capacity of less than 5 million Btu per hour increase their efficiency by 5% in 2015 [23, 24] and a further 7% in 2035 while larger boilers increase their minimum efficiency by 10% in 2015, with an incremental increase of 14% in 2035. Regulated changes in boiler efficiencies result in an increased capital cost of 10%, for each incremental increase. [25]

In addition, plug load efficiency increases by 25% over current levels,[26] with no increase in cost.[27] In 2035, minimum plug load efficiency is increased a further 35% over the levels established in 2015.

This policy assumes that standard fluorescent lighting efficiency increases by 30%, regular high-intensity discharge efficiency increases by 8%, and existing high-bay lighting supplied by HID fixtures increases by 40%, starting in 2009. The policy also assumes that lighting controls are applied to all standard fluorescent lighting systems, over a period of 10 years, following the increases to the lighting efficiency regulation. Lighting efficiency is further increased in the same manner in 2035, with increases of 42% from current T12; 11% for HID, and 56% for high-bay HID lighting.

3. Allocate an Accelerated Capital Cost Allowance (CCA) to energy efficient technologies and control systems.

Beginning in 2010, this policy sets the capital cost allowance rate for Class 1 equipment to 20%, and for Class 8 equipment to 35%.[28, 29] All building sectors were considered eligible for this incentive.

4. Mandatory commissioning / re-commissioning process.

This policy requires that 70% of the existing building stock in all sub-sectors except Government be required to undertake a commissioning process, resulting in building energy savings of 15%.[30] The policy was applied over a twenty-year period, beginning in 2010.

Estimated commissioning costs of 1% and 4% for new and existing buildings respectively were translated into an increased annual operating cost of 0.4% per building. [31] Buildings were assumed to incur the cost of commissioning every five years in order to maintain the level of initially realized energy savings.

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[22] http://www.epa.gov/cleanrgy/documents/webcasts/section_6_6_procurement_2-22.pdf
[23] Energy Information Administration, 1995 Commercial Buildings Energy Consumption Survey.
[24] http://www.aceee.org/ogeece/ch2_index.htm
[25] http://www.epa.gov/cleanrgy/documents/webcasts/section_6_6_procurement_2-22.pdf
[26] Energy Star. http://www.energystar.gov/index.cfm?fuseaction=find_a_product. – Energy Star products in the commercial sector are on average 30% more efficient than conventional models. On recommendation from Mike Butters, we are using 25%.
[27] http://oee.nrcan.gc.ca/publications/equipment/m144-63-2004e.cfm – "The cost premium for all types of ENERGY STAR labeled equipment compared with conventional equipment is $0."
[28] http://www.parl.gc.ca/information/library/PRBpubs/prb0606-e.htm#appendixa
[29] *http://www.manufacturinginnovation.ca/_documents/Accelerated%20CCA.ppt#402*
[30] Mills E, Bourassa N, Piette M, Friedman H, Haasl T, Powell T and Claridge D. The Cost-Effectiveness of Commissioning New and Existing Commercial Buildings: Lessons from 224 Buildings. National Conference on Building Commissioning: May 4-6, 2005.
[31] Commissioning Costs and Budgets. Building Commissioning. http://buildingcommissioning.wordpress.com/ April 2008. Values used on recommendation of NRTEE.

5. Maintaining efficiency standards for government procurement of buildings and equipment.

New government buildings are assumed to perform at LEED Gold efficiency (34% higher than current practice),[32] with a monitoring program ensures this efficiency adheres to LEED Gold. This policy requires a capital cost increase of 9.9%.[33] [34]

This policy also assumes that 60%[35] of existing buildings in the Government sector increase their energy efficiency by 11%[36] over a ten year period, beginning in 2010.

Finally, this policy assumes a 25% increase in plug load efficiency due to the mandatory use of, at minimum, Energy Star rated equipment, with no cost increase. [37]

6. Facilitate and support the acceleration of the process by which green building permits and site plan approvals may be obtained.

This policy was quantified in modelling terms through a discounted capital cost, using the analogue of decreased building permit fees.[38]

Average commercial building permitting costs were estimated as $167,000 per building.[39, 40, 41]

Beginning in 2011, this policy assumes that at efficiency levels of 30%, 40% and 50% above current practice, discounts of 10%, 20% and 30%, respectively, would be offered from the building permit cost. [42]

7. Increase training, communications and information availability for building operators, managers, tenants, inspectors and appraisers.

Research determined that decreases in energy intensity of 0.18 kWh per square foot (0. 614 thousand Btu) electricity and 0.71 thousand Btu per square foot could be achieved, at a cost of $1,400 per trainee. [43]

Based on the energy intensity of the average commercial building (approximately 135 mmBtu per square foot), [44] the above amounts to approximately one percent reduction in energy use per building.

This policy assumes a 70% compliance rate, and is incrementally implemented over a 20 year period, beginning in 2015.

8. Provide a tax incentive to corporations whose buildings increase their energy efficiency or meet a specified level of energy efficiency.

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[32] Turner C, Frankel M. Energy Performance of LEED for New Construction Buildings. Final Report. March 4, 2008. https://www.usgbc.org/ShowFile.aspx?DocumentID=3930 – See page 16 of this report. This assumes that the buildings in the United States are also being built at 10% above the MNECB level. Silver would represent a 22% increase from current practice.

[33] Analyzing the Cost of Obtaining LEED Certification. The American Chemistry Council. April 16, 2003. This report concludes that the cost premium for a LEED Certified building is between 4.5% to 11%.

[34] This calculation assumes a 25% federal, 25% provincial and 50% municipal split in floor area.

[35] Personal Communication – BOMA.

[36] BOMA Toronto news. http://www.naylornetwork.com/bto-nwl/printFriendly.asp?projID=525

[37] http://oee.nrcan.gc.ca/publications/equipment/m144-63-2004e.cfm – "The cost premium for all types of ENERGY STAR labelled equipment compared with conventional equipment is $0."

[38] It was assumed that an expedited green building permitting process would result in reduced financing costs during building planning and construction; which ultimately reduce capital costs.

[39] Commercial and Institutional Building Energy Use Survey 2000. Detailed Statistical Report, Natural Resource Canada. December 2002.

[40] Statistics Canada, CANSIM, table (for fee) 026-0008 and Catalogue no 64-001-X.

[41] Toronto 2008 Building Fee Schedule. Note: This calculation estimates the total number of meters squared of new building floor area built each year, and applies an averaged building permit cost from the City of Toronto.

[42] http://www.sustainablebuildingcentre.com/blog/helen_goodland_30

[43] Mills E, Bourassa N, Piette M, Friedman H, Haasl T, Powell T and Claridge D. The Cost-Effectiveness of Commissioning New and Existing Commercial Buildings: Lessons from 224 Buildings. National Conference on Building Commissioning: May 4-6, 2005.

[44] Commercial and Institutional Consumption of Energy Survey, Summary Report – June 2007

To qualify, the building must have an optimal performance that meets or exceeds the MNECB guidelines by 20%. The required improvement would rise along with the MNECB over time maintaining a 20% greater efficiency level.

This policy provides a tax credit equal to the value of 7% of the capital cost of the building, credited over 5 years,[45] with a cap of 40 million CAD per annum.[46] This policy excludes the Government sector, and is implemented starting in 2015.

The policy assumes that an investment of 7% of the capital cost of the building will increase the efficiency of the existing building to 20% greater than MNECB guidelines, and that the average commercial building construction cost is equal to $188 per square foot ($2,030 per m^2).[47] Seven percent of the average cost yields $142 per square metre. Therefore, 218,690 square meters annually of the 217,649,622 m^2 total floor area in Canada (minus government) is eligible annually.[48]

Results

As described previously, this analysis built upon previous modelling work performed for the federal government to describe the baseline scenario as well as the combination of the *Turning the Corner* plan, the *Regulatory Framework for Air Emissions* and select provincial policies. The baseline scenario that includes the combination of the *Turning the Corner* plan, the *Regulatory Framework for Air Emissions* and select provincial policies is called the "reference scenario" in this document. It should be noted that the reference scenario therefore includes significant efficiency improvements.

The policies and prices contained in the three scenarios (Carbon Price, Policy and Carbon Price and Policy) that the NRTEE has commissioned are additive to the reference scenario; that is, the NRTEE policies described above are 'over and above' existing government plans.

The results of the three modelling scenarios, defined by the NRTEE, are generally presented in this document with respect to the baseline and reference scenarios, illustrating the additional impacts that the policies contained in each scenario have above planned government initiatives.

Baseline and Reference Scenario

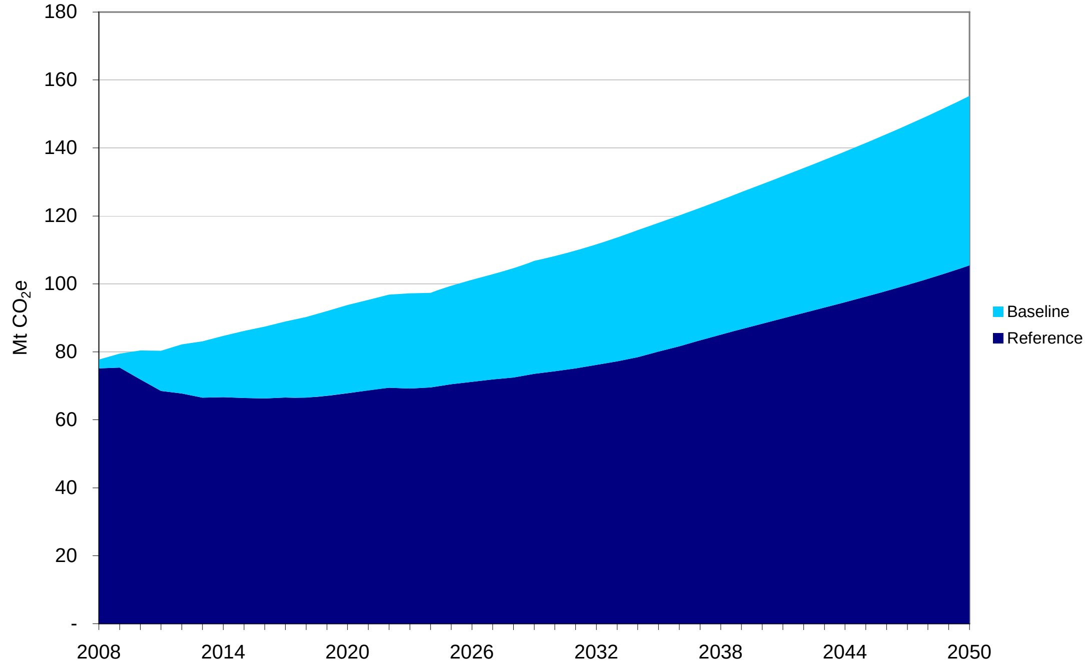
The modelling results that are presented here are all based upon the baseline and reference case modelling that was completed by ICF International in analysing the impacts of the Turning the Corner plan.[49]

Under both the baseline and reference cases, the economy grows at a rate of 2.1% per annum. The baseline scenario can be considered the 'do nothing' option; that is, where no policies, regulations, prices or incentives are implemented, and greenhouse gas emissions and energy use follow historic growth patterns.

On the other hand, the reference scenario builds upon the baseline scenario, defining a range of policies and programs that are part of the federal government's *Turning the Corner* plan and the *Regulatory Framework for Air Emissions*, along with selected provincial initiatives. The results of these two modelling scenarios are illustrated below.

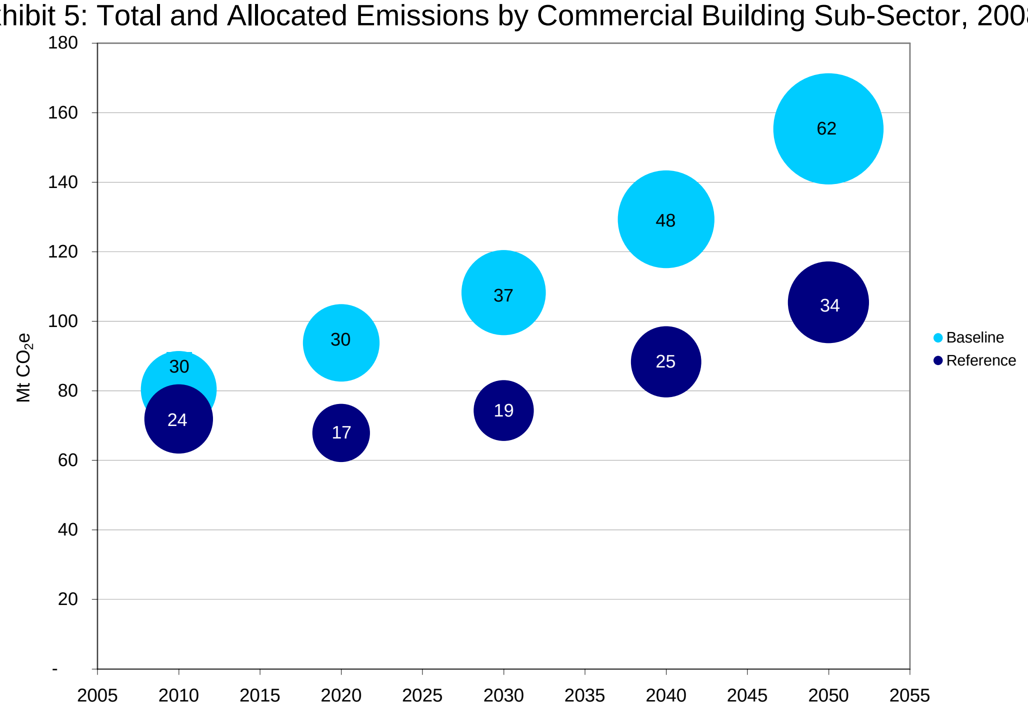
[45] New York State Green Building Tax Credit.. http://www.dec.ny.gov/energy/1540.html
[46] Personal communication, NRTEE.
[47] http://www.reedconstructiondata.com/news/2008/04/cost-increases-for-four-institutional-building-categories/
[48] Commercial and Institutional Building Energy Use Survey 2000 – Detailed statistical report.
[49] Turning the Corner: Regulatory Framework for Industrial Greenhouse Gas Emissions. Environment Canada. March, 2008. http://www.ec.gc.ca/doc/virage-corner/2008-03/541_eng.htm

Exhibit 4: Total commercial sector emissions under the baseline and reference scenarios.



Under the baseline scenario, absent recent initiatives to mitigate the release of GHG's, emissions in the commercial building sector increase to almost 95 Mt by 2020, doubling from 2008 levels, to 155 Mt by 2050.

Exhibit 5: Total and Allocated Emissions by Commercial Building Sub-Sector, 2008.



Note: The location of the bubble on the graph represents the total emissions from the commercial sector, while the area of the bubble and number contained within represents the absolute allocated emissions from electricity use, in Mt CO_2e.

When mitigation policies are applied under the reference scenario, large decreases in emissions relative to the baseline occur. The large decrease in emissions from 2009 to 2012 is due to the required 18% reduction in emission intensity in the power sector. As a result, in 2020, absolute emissions actually decrease to 68 Mt; however, emissions continue to grow with the economy. By 2035, absolute emissions have increased from 2008 levels, reaching 105 Mt by 2050.

The only sector that maintains an absolute emission reduction is the Education sector, which achieves a 5% reduction from 2008 levels. It should be noted that the small difference between the reference and baseline scenarios in 2008 is due to the implementation of some government policies prior to 2008.

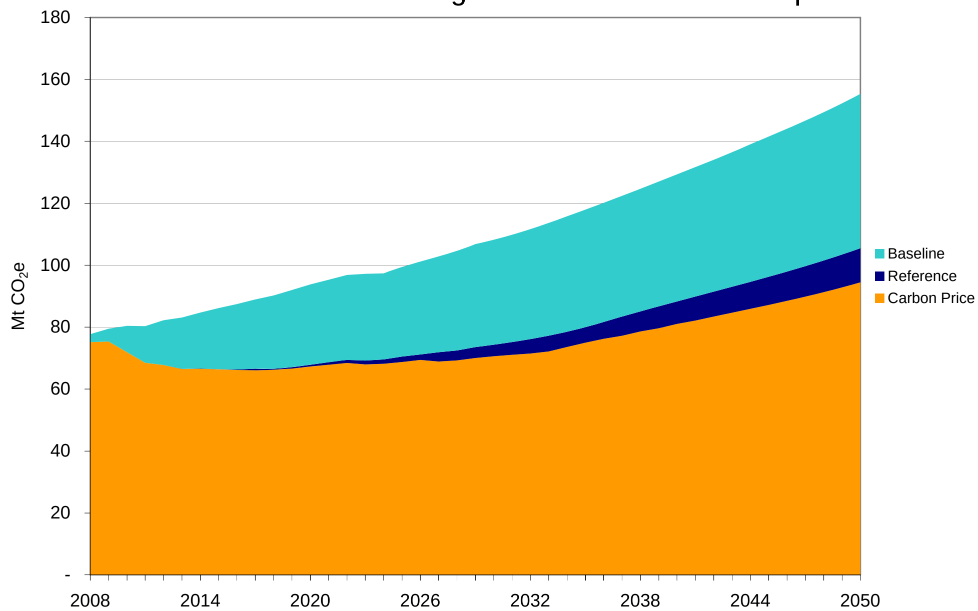
Exhibit 5 compares the impact that the allocation of electricity emissions has on the total emissions under the baseline and reference scenarios. Under the baseline, allocated electricity emissions grow by 106% from 2008 levels by 2050, while under the reference scenario, allocated emissions increase by only 21%.

The policies included in the reference scenario therefore have a large impact on electricity emissions in all subsequent scenarios, and as a result, total emissions from the commercial building sector, which uses electricity to supply 36% of its energy demand at the start of the study period.

Carbon Price Scenario

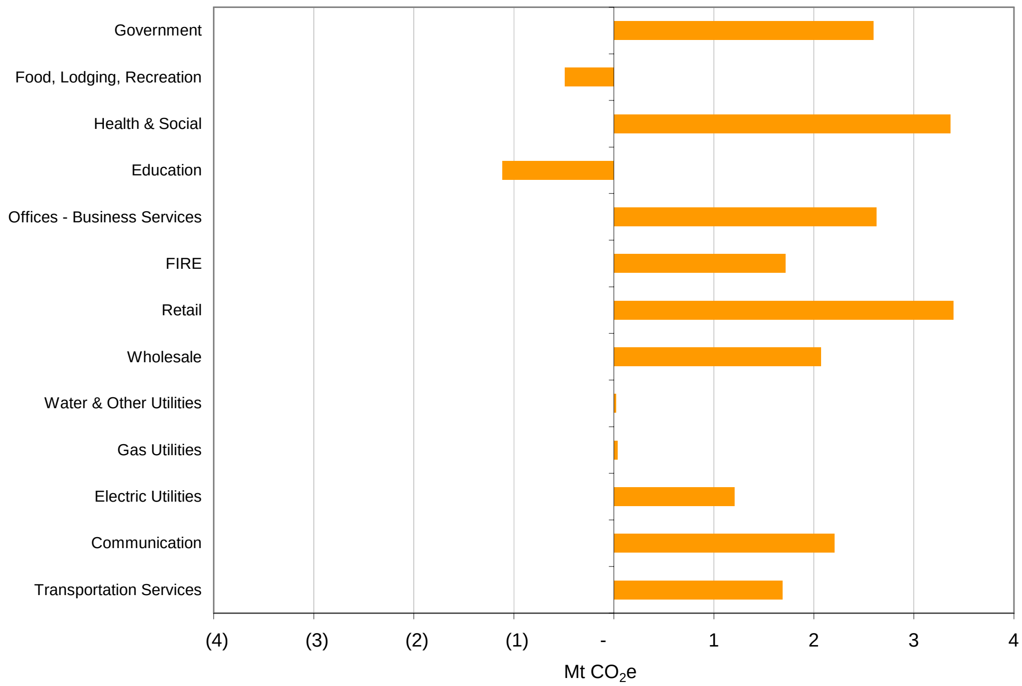
When the price of carbon as defined by the “Fast and Deep” scenario specified by the NRTEE is applied to all fossil fuels in ENERGY 2020, total emissions in the commercial building sector decrease by just over 10% when compared to the reference scenario and 39% when compared to the baseline scenario by the year 2050. The carbon price does not have a noticeable impact prior to 2020, as the reductions that would have been driven by the carbon price are achieved by the expected government policies contained in the reference scenario. This trend is shown for the entire study period, below.

Exhibit 6: Total commercial building emissions under carbon price scenario.



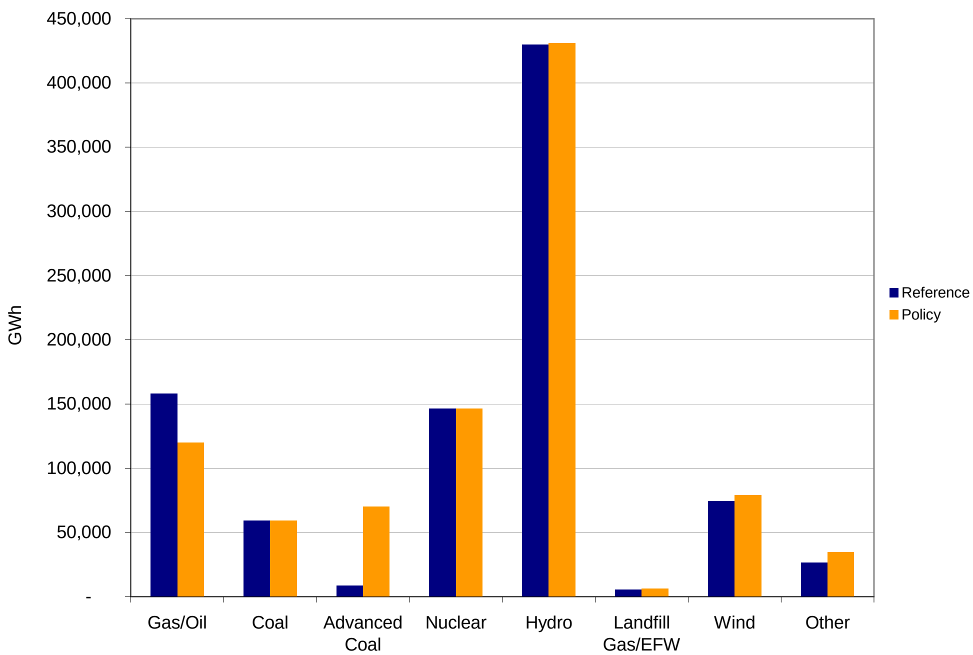
Absolute emissions remain below 2008 levels until 2036, increasing to 95 Mt by 2050, or approximately 25% greater than in 2008. This increase is due to the growth of the economy over this period; the price on carbon is unable to spur conservation to the level necessary to offset this economic growth.

Exhibit 7: Carbon price scenario absolute emission reductions from 2008 levels in 2050.



Of the thirteen commercial building sub-sectors, only two (Food, Lodging and Recreation; Education) maintain emission levels below 2008 levels, as shown below. Both sectors have relatively low rates of growth and are therefore not subject to the same upward economic pressures driving emissions as other commercial sub-sectors. The largest absolute increases in 2050 occur in the some of the largest sectors (ranked by 2008 absolute emissions) – Retail and Health & Social.

Exhibit 8: Electricity generation under the reference and carbon price scenario, 2050.



As expected, fuel expenditures for the commercial building sector increase significantly under the carbon price scenario, as the cost of the carbon price is passed on to the energy consumer. With the carbon price, fuel expenditures increase in every sub-sector, with the largest increase in the Gas Utility sector. Fuel expenditures reach a peak of 25% above the reference scenario around 2035, dropping off slightly to 21% by the end of the period.

Exhibit 9: Commercial energy demands by end use under the carbon price scenario.

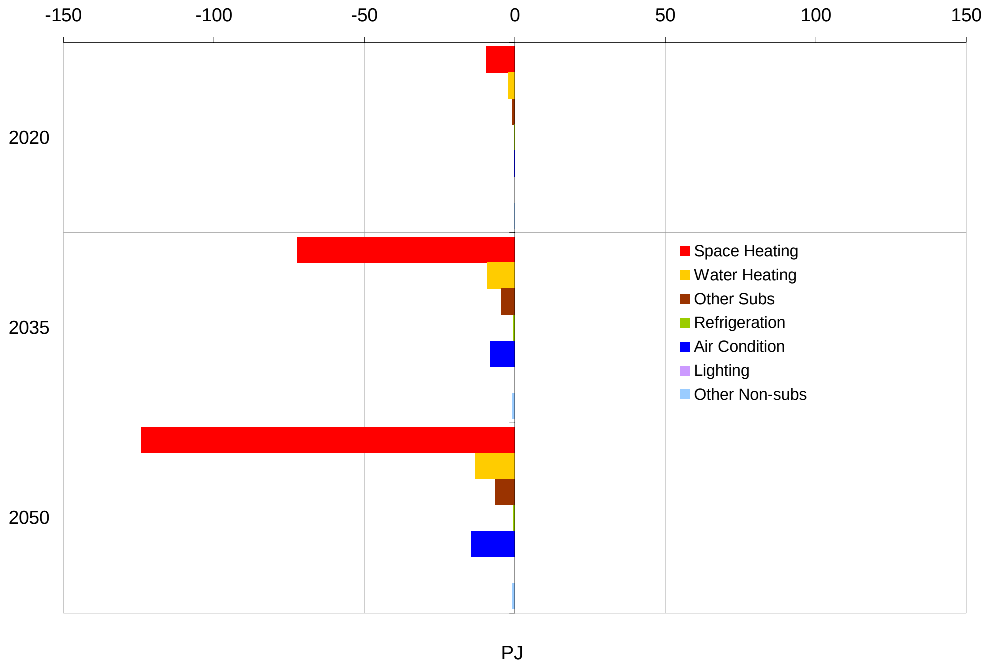
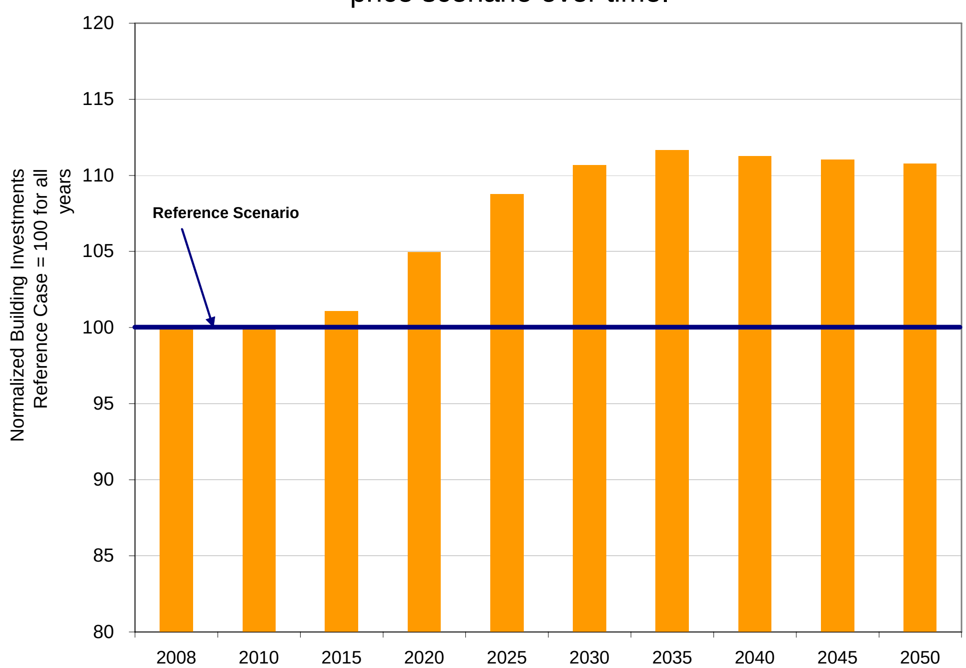


Exhibit 10: Normalized total building investments relative to the reference under the carbon price scenario over time.



The increased fuel expenditures are driven by a large increase in the price of natural gas, the cost of which reaches almost 80% above the reference scenario by 2050. Electricity prices increase as well, peaking at 11% above the reference around 2035, declining to 7% above by 2050.

Electricity prices are not as affected by the carbon price, due to the influence of non-fossil generation. Due to the increased cost of natural gas, there is a significant increase in advanced coal (carbon capture and storage or CCS) under the carbon price scenario, with a commensurate decline in natural gas generation, as the addition of a carbon cost makes CCS more economically attractive.

The total energy demands decrease by 7% from 2050 levels, with space heating contributing the most significant decrease at 124 PJ (or 11%) from 2008 levels. In general, the most significant reductions occur in the space conditioning (heating and air conditioning) end uses.

Electricity demands actually increase by 4% by 2050 compared to the reference, as new buildings begin to select electricity for substitutable loads and heating requirements, as opposed to more expensive natural gas sources.

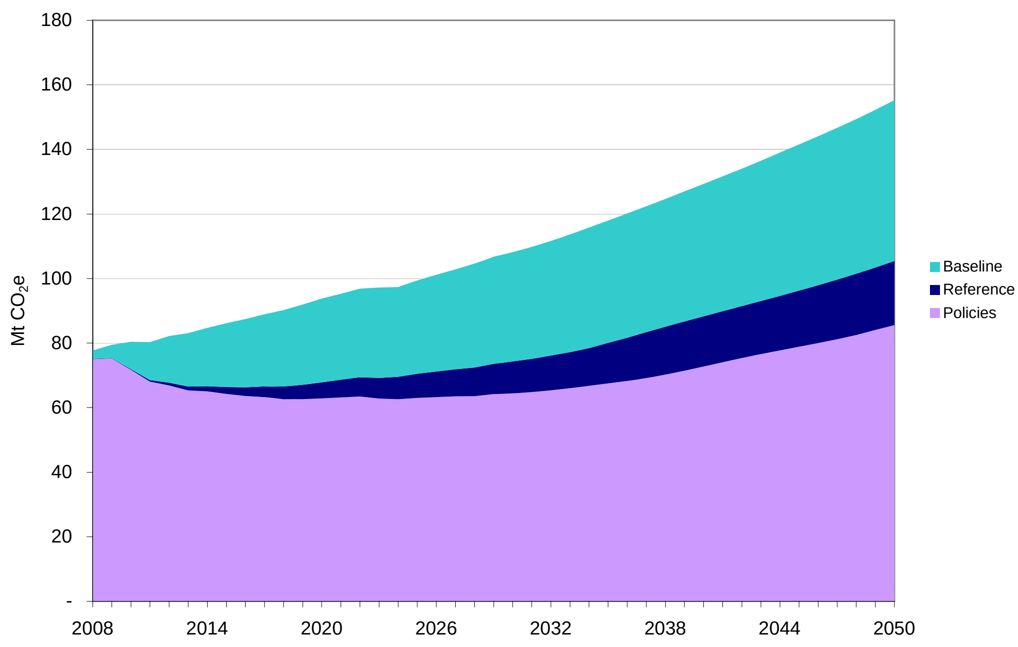
The carbon price also results in an increased investment in building infrastructure and equipment, growing to approximately 11% above the reference case by 2050.

Policy Scenario

When all eight policies as described previously are added to the reference scenario, a 19% reduction in greenhouse gas emissions is achieved from the reference in 2050 (45% below the baseline scenario). However, while total absolute emissions reductions are sustained for an extended period, total emissions eclipse 2008 levels in 2042, rising with the economy to 86 Mt in 2050. The minimum level of emissions achieved under this scenario is 63 Mt in 2018.

Generally, the emissions reductions exceed those achieved under the carbon price scenario, with slightly more sustained emission reductions and a lower total emission level in 2050.

Exhibit 11: Total commercial building emissions under the policy scenario.



Absolute reductions from 2008 levels occur in the Education, Food, Lodging & Recreation and FIRE sectors, reaching reductions of 2.0 Mt, 1.1 Mt and 0.3 Mt respectively.

The largest absolute increases in emissions under this scenario occur in the Government and Health & Social sectors. However, emission intensity (in this case, greenhouse gas emission decreases across all sub-sectors, by 17% on average, with the greatest increases in efficiency occurring in the FIRE, Offices and Wholesales sectors.

Exhibit 12: Policy scenario absolute emission reductions from 2008 levels in 2050.

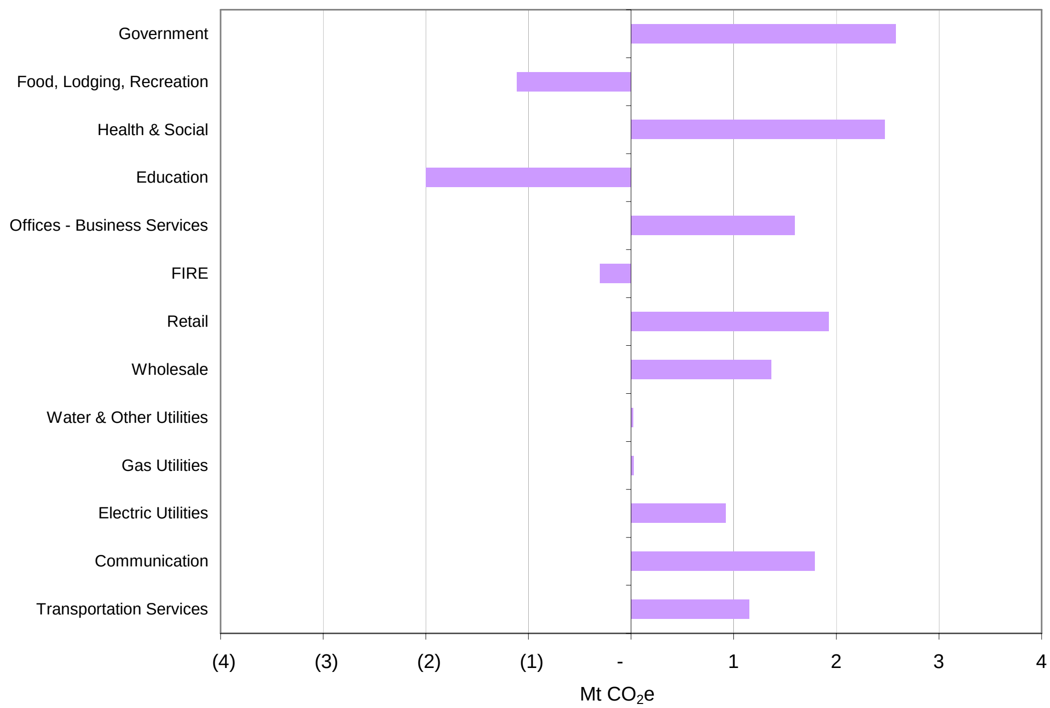
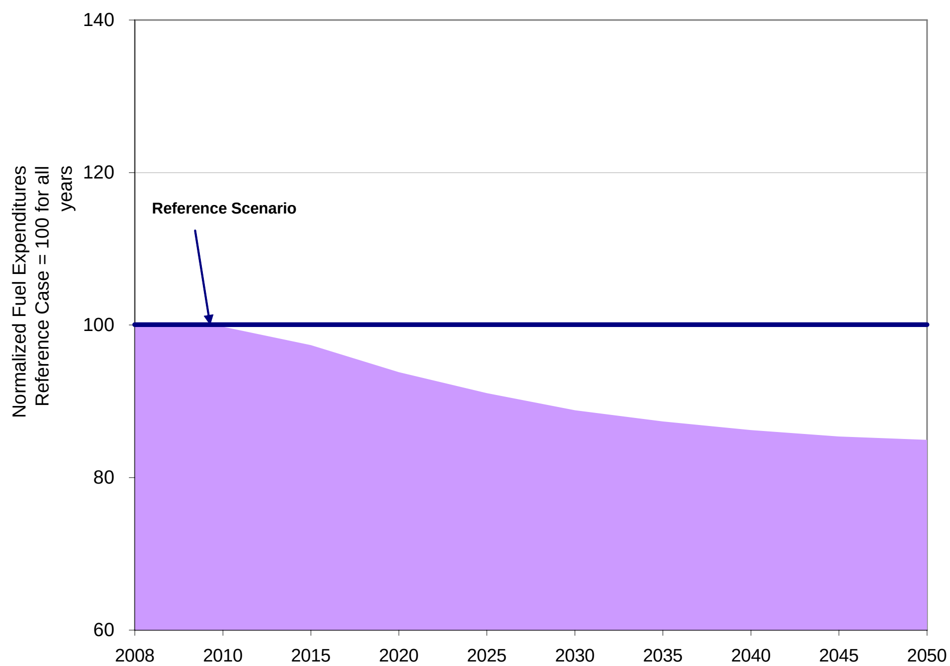
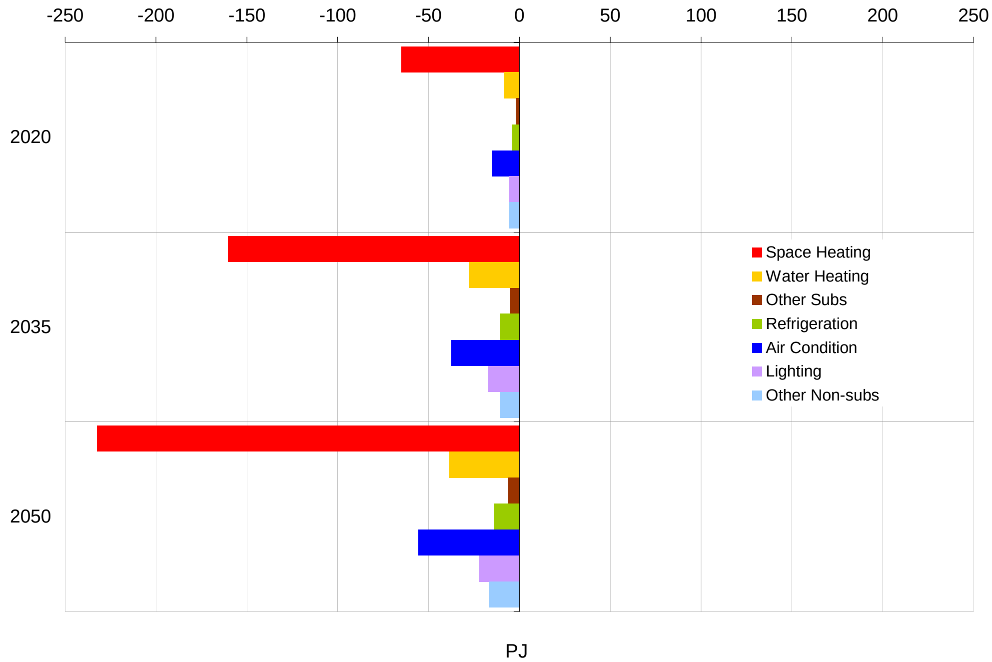


Exhibit 13: Normalized total fuel expenditures relative to the reference under the policy scenario over time.



Fuel expenditures decrease significantly under the policy scenarios, dropping by 15% from the reference scenario. Decreasing gradually over time fuel expenditures decline across all the commercial sub-sectors; driven by a similar decrease in energy demand. The decrease reaches a level 16% below the reference case in 2050.

Exhibit 14: Commercial energy demands by end use under the policy scenario.



The largest decrease in energy demand occurs in space heating, similar to the carbon price scenario. There are also relatively significant reductions in water heating and air conditioning (14% and 33% below reference, respectively). The greatest absolute reductions continue to occur in the space heating sector, which accounts for over 60% of the total energy demand reduction. Overall, 62% of the energy demand reduction is due to decreased consumption of natural gas, with the vast majority of the remainder from electricity.

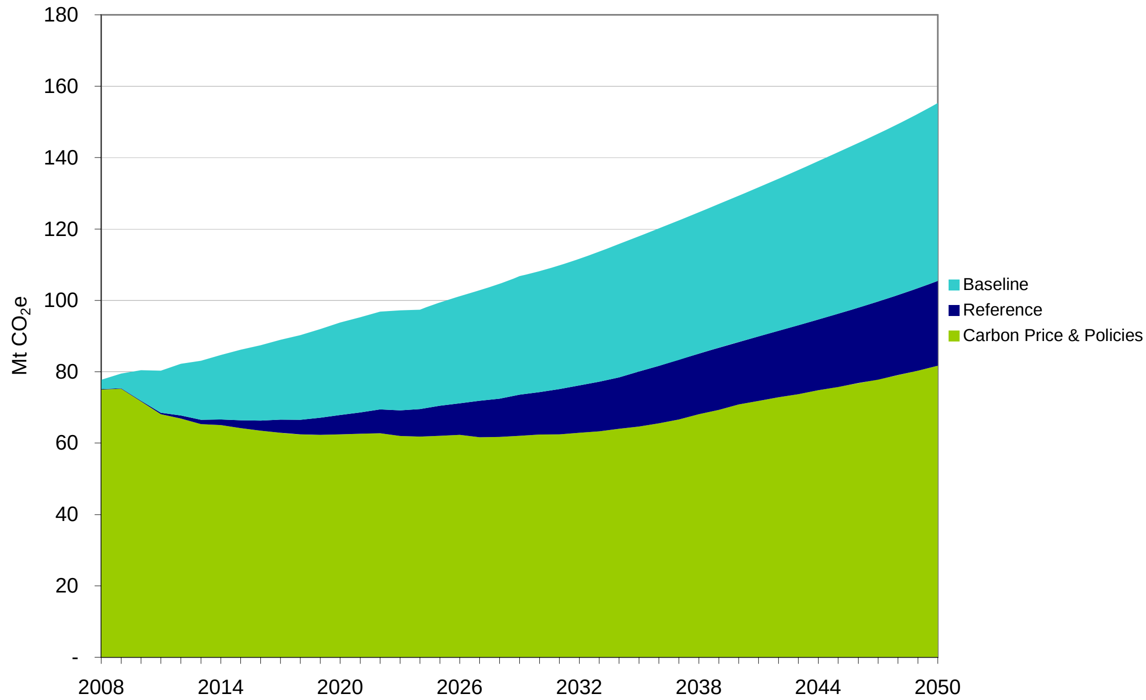
With respect to electricity generation for the grid, the only significant decrease occurs in the natural gas generation, which decreases by 12% relative to the reference case in 2050. Carbon capture and sequestration is not significant as energy prices do not change by any significant amount, and therefore do not increase the economic viability of CCS relative to natural gas generation.

Combined (Carbon Price and Policy) Scenario

The final scenario evaluated in this exercise is the combination of the initial two scenarios: the carbon price and policy scenarios. As expected, this scenario achieves the greatest reductions in greenhouse gases of the three scenarios. Emissions are reduced by 24% from reference by 2050, with the greatest absolute decreases occurring in the FIRE and Retail sectors (3.5 Mt and 2.6 Mt reductions, respectively).

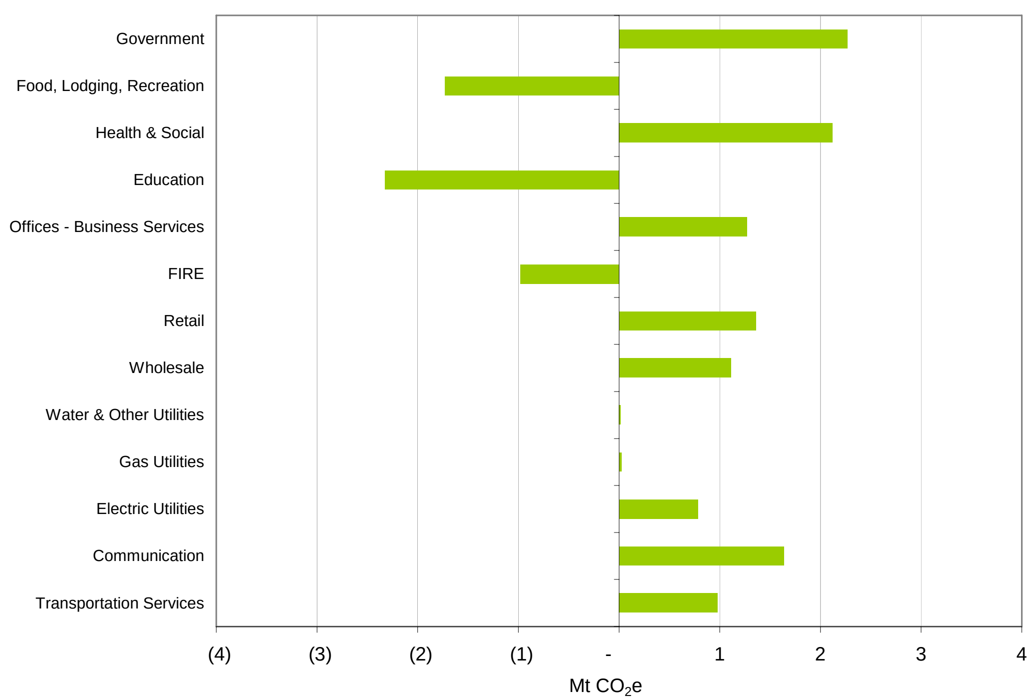
The total reduction under this scenario is not the combined total of the carbon price and policy scenarios. Instead, some of the reductions that were driven by the price on carbon overlap with the reductions being driven by the policies; in essence, they overlap. The reduction is therefore not equal to the sum of the reductions achieved by the two policies when implemented independently.

Exhibit 15: Total commercial building emissions under the combined scenario.



Absolute emissions remain below 2008 levels until 2044, after which they climb to 82 Mt in 2050. Emissions bottom out at 62 Mt in 2023.

Exhibit 16: Combined scenario absolute emission reductions from 2008 levels in 2050.



It should be noted that across all of the scenarios the government sector,sees a smaller decrease than other sectors. The modeling took into account a number of existing government policies which already mandate higher levels of efficiency. As a result this left less room for improvement in terms of energy consumption in that sector.

As with the policy scenario, three of the thirteen commercial building sub-sectors maintain reduced absolute emissions from 2008 levels throughout the period. These sectors are Education; Food, Lodging & Recreation; and the FIRE sector, reducing emissions by 2.3 Mt, 1.7 Mt and 1.0 Mt respectively.

Exhibit 17: Normalized total fuel expenditures relative to the reference under the combined scenario over time.

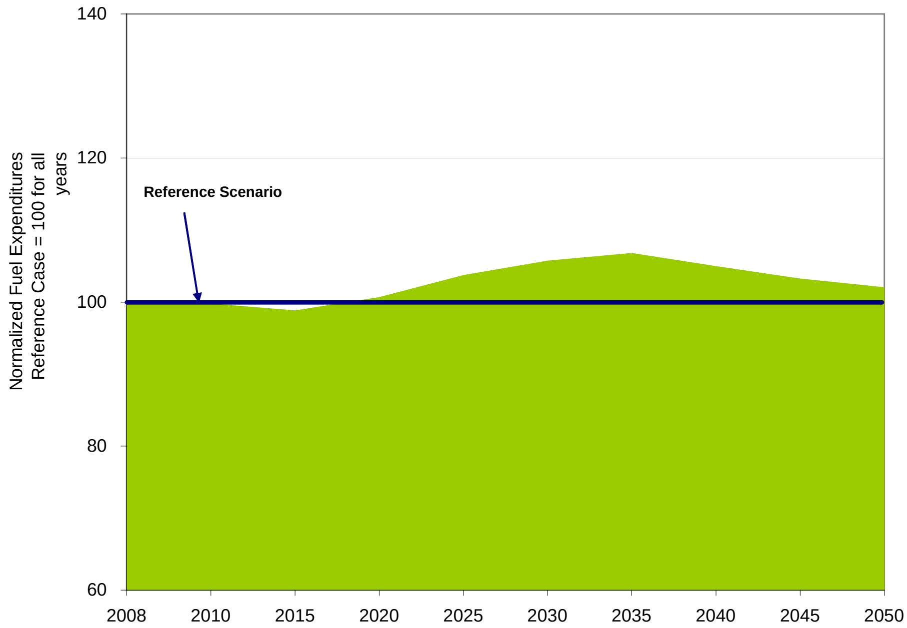
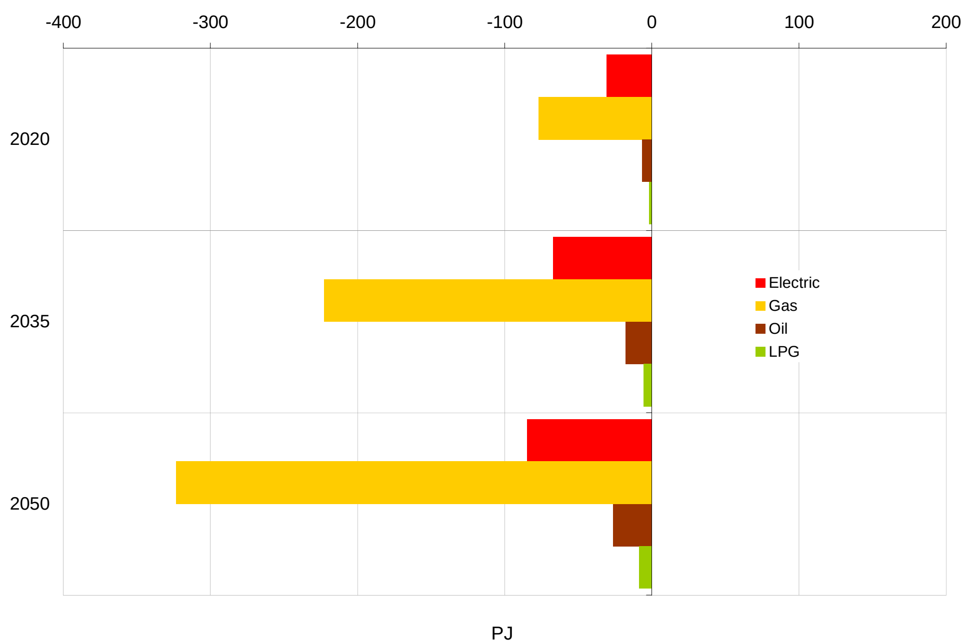
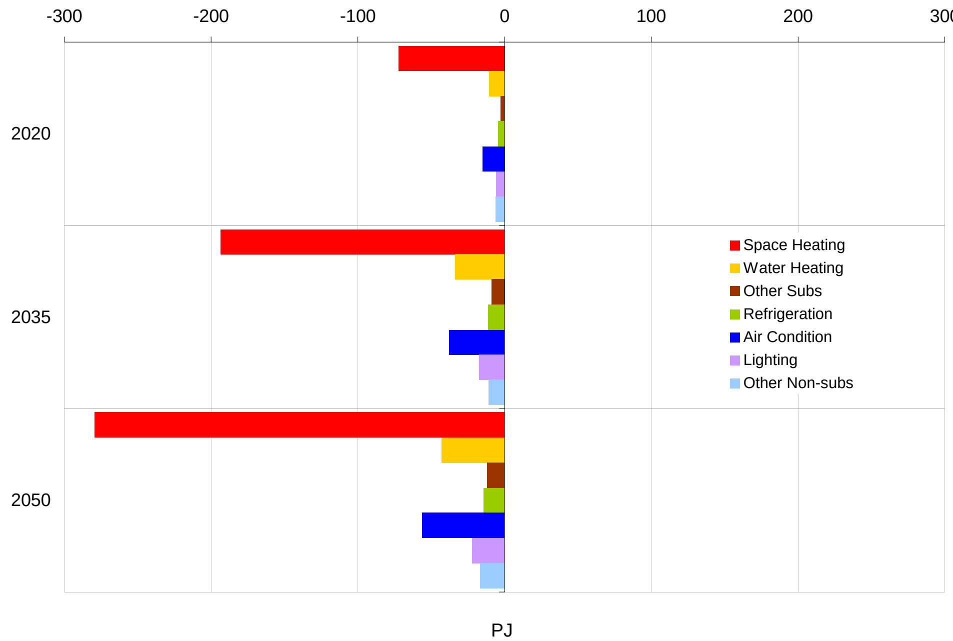


Exhibit 18: Absolute change in energy demand under the combined scenario from 2008 levels, by fuel type, for selected years.



Overall, energy demand under this scenario decreases by 19%, with space heating and air conditioning achieving reductions of 25% and 34% from reference case levels, respectively. Energy demands decrease in every end-use; once again, most significantly in space heating, which makes up 63% of the reduced demand. The strong reduction in space heating is paralleled by a large and analogous decrease in the demand for natural gas, with natural gas accounting for almost three-quarters of the decreased energy demand. On average, emission intensity was reduced by 21%, with all sectors decreasing.

Exhibit 19: Commercial energy demands by end use under the combined scenario.



Over the period that energy demand drops , energy prices rise in a manner very similar to that of the carbon price scenario. Natural gas prices increase to almost 80% greater than the reference case by 2050, while electricity prices peak at 11% higher, in 2035.

As a result of the efficiency gains, fuel expenditures are not nearly as affected as under the carbon price scenario – in this case, fuel expenditures rise only slightly (2%) by 2050, peaking at 7% above reference levels. In fact, expenditures in 2050 actually decrease in the Education and Health & Social sectors (which had the largest reductions in GHG emitted).

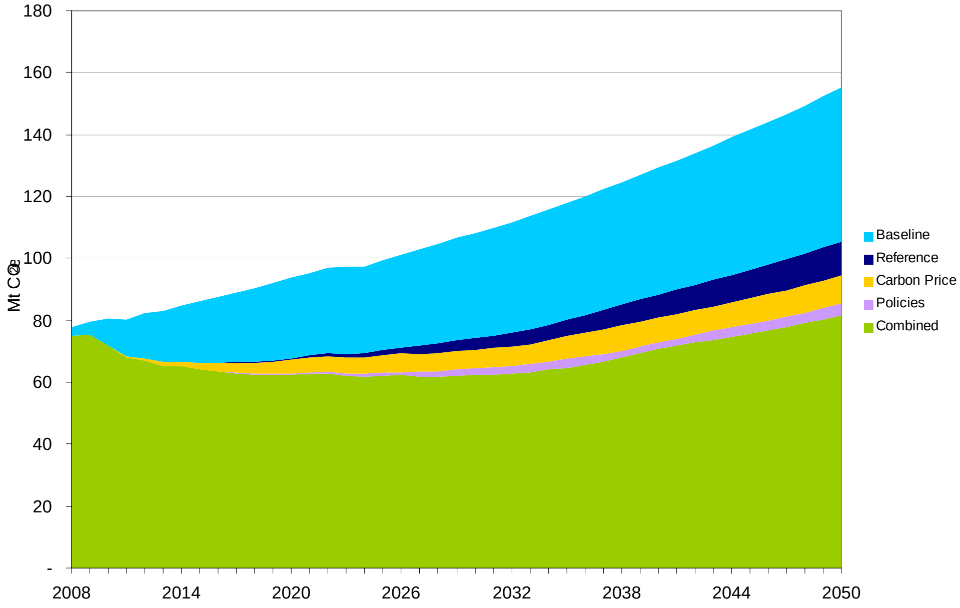
As was the case under the carbon price scenario, CCS increases by a significant amount (400% from the reference by 2050) reaching three-quarters of the output of conventional coal, in terms of total electricity generated. In addition, there is a decrease in natural gas generation, which drops by just over 30% from the reference, with wind increasing slightly.

Building investments increase relative to the reference case, and are approximately 18% greater in 2050, peaking in 2020 at 22% above the reference scenario. This investment is partially due to increased equipment and building costs that occur with step-changes under normal turnover rates. This increase in building investment may also be explained by accelerated equipment and refit schedules, spurred on by increased operating costs under the carbon price.

Comparison

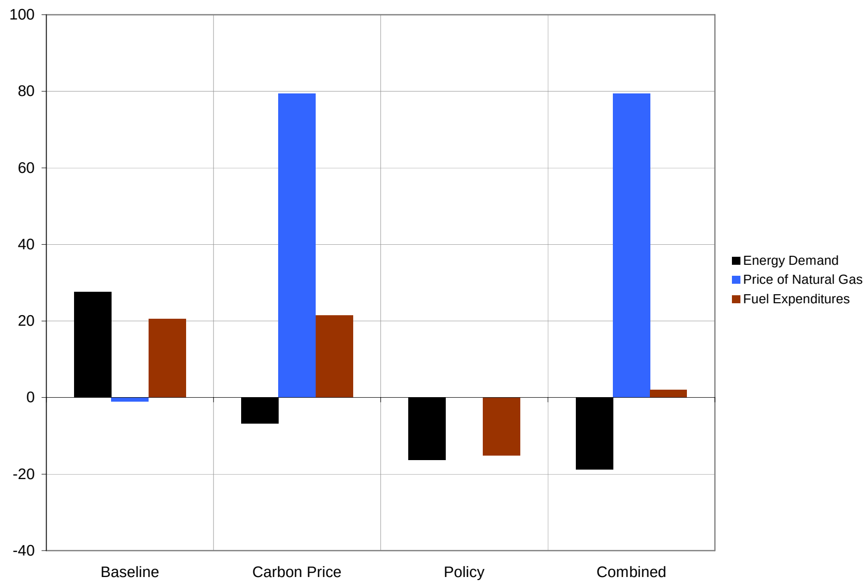
The most significant greenhouse gas reductions were achieved under the combined (carbon price and policy) scenario. Overall, this scenario reduced emissions from the reference scenario by 23%, or 82 Mt in absolute terms. Under the baseline scenario at the other extreme, emissions reach 155 Mt by 2050, more than double the emissions in 2008.

Exhibit 20: Comparison of the emissions under each scenario, including the reference and baseline.



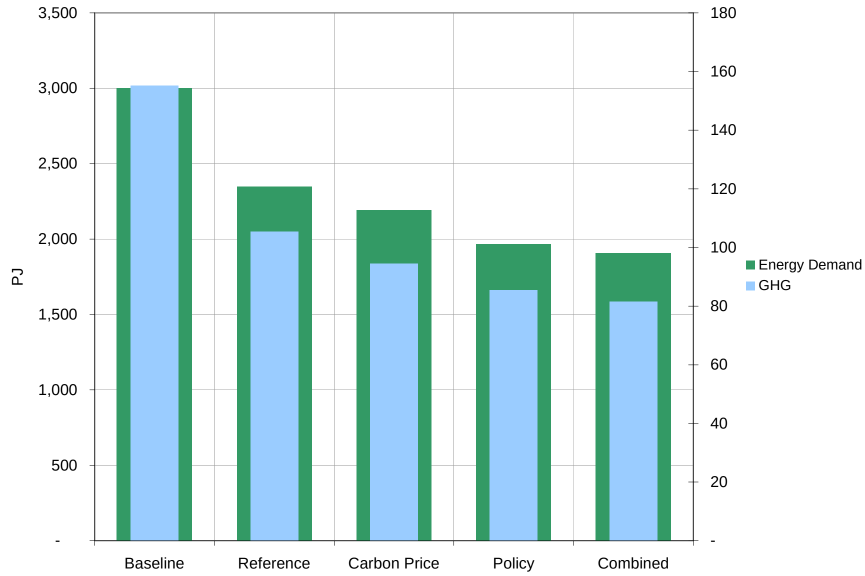
As illustrated in the graph below, the beneficial effects of each scenario increase over time, however, none of the scenarios are able to maintain an absolute emission reduction on an absolute basis from 2008 levels over the study period. In the carbon price, policy and combined scenarios, emissions pass 2008 levels in the late 2030's, the early 2040's and the mid 2040's respectively.

Exhibit 21: Comparison of energy demand, fuel cost and fuel expenditures between scenarios, 2050.



It is also important to note the relationship between the price of energy, energy demand and fuel expenditures. As shown in the following chart, fuel expenditures do not necessarily increase with the price of energy; in the combined scenario, increased fuel costs are offset by a reduction in energy demand – and fuel expenditures are relatively constant.

Exhibit 22: Comparison of energy demands and GHG emissions under different scenarios, 2050.



As expected, energy demands decrease with increasing regulation, as shown below, which is a main driver of greenhouse gas reductions.

Moving Forward

While the combined impact of the carbon price together with the eight policies reduces greenhouse gas emissions and energy demand in the commercial building sector by a significant amount, absolute emissions continue to increase over the period.

Over the short term, each of the three scenarios is able to reduce absolute emissions year by year. Each scenario then more or less plateaus and emissions begin to rise again between the late 2020's and mid 2030's as the sector continues to expand. All scenarios eventually exceed 2008 emission levels, inevitably rising with the growth of the economy.

Obviously, the policies contained in the scenario are working, reducing absolute emissions over the short term. However, in order to maintain these gains in efficiency over the long term, more aggressive policies are required in the latter portion of the study period.

There are a number of possibilities for further reductions that could be considered to maintain these reductions and reduce the absolute greenhouse gas emissions from the commercial building sector into the future.

- First, policy definition during this modelling exercise was consciously performed in a conservative manner, in order to examine the 'achievable' potential. This therefore means that there are significant gaps between what is technically possible, and the results presented here. For instance, one report suggests that an appropriate course of action is to adopt the requirement of 70% more efficient buildings in the National Building

Code by 2020.[50] This principle could be applied across each of the existing policies – with deeper, more aggressive actions.

- Second, this modelling focuses on actions that could be taken by the federal government, and a large number of policy options that would typically fall under provincial or municipal jurisdiction are not included. This should in no way suggest that these policies are less likely to have an impact; in fact, large reductions can and should be pursued at those levels as well and it is expected that action will be required at all levels to achieve the deep reductions required.

In addition to provincial and municipal level policy options, there are a number of other (potentially) federal-level policies that were not considered as a part of this modelling work. Unfortunately, not all policies lend themselves easily to definition in modelling terms, including such items as mandatory building labelling, incentives for developer / owner communication, reduced liability for industry leaders and private-public green loan mechanisms, to name a few. Once again, this should not suggest the difficult-to-model policies would be less effective than those presented here.

Finally, this work does not analyse the use of building-integrated renewable energy technologies as a decision was made by the CBAC to focus on efficiency measures. Therefore, building integrated technologies, including solar (photovoltaic, hot water) and wind were not considered, In the same vein, this work did not explicitly encourage greater use of district heating systems. Of course, electricity supply to the grid changed under the scenarios presented here, but that did not take into account the possibility for reduced demand from the use of building-integrated technologies.

The scenarios presented here were able to achieve significant reductions in greenhouse gas emissions from the commercial sector; however, a more aggressive, broad and deep suite of policy initiatives is required to maintain absolute emission reductions to 2050 and beyond.

[50] Harvey, L. D. D. Assessment of the Potential for Reducing Energy Use in the Commercial Buildings Sector of Canada. Department of Geography, University of Toronto. April 25, 2008.

Appendix A: ENERGY 2020

ENERGY 2020 is an integrated multi-region energy model that provides complete and detailed, all-fuel demand and supply sector simulations. These simulations can additionally include macroeconomic interactions to determine the benefits or costs to the local economy of new facilities or changing energy prices. The model can be used in regulated as well as deregulated and transitioning environments. It portrays the interaction of market competitors in a realistic, as opposed to an idealized, fashion, including transmission-system market-dynamics. It focuses on the imperfections of the market, including market gaming, and therefore, is extremely useful for M&A and asset evaluation. Pollution emissions and costs, including allowance and trading, are endogenously determined, thereby, allowing assessment of environmental business-risks.

Overview:

ENERGY 2020 is an outgrowth of the FOSSIL2/IDEAS model developed for the US Department of Energy (DOE) and used for all national energy policy since the Carter administration.[51] This early version of ENERGY 2020 was developed in 1978 at Dartmouth College for the DOE's Office of Policy Planning and Analysis.

The basic implementation of ENERGY 2020 for North America now contains the user-defined level of aggregation down to the 12 provincial and 50 state (and sub-state) level. ENERGY 2020 is historically parameterized to simulate all 3500 interacting energy suppliers in North America as needed. This historical validation captures limits to future actions that market players can pursue as market rules change. Current efforts are adding the South American and European databases to the model, and allowing holding companies to see the combined portfolios crossing the continents.

ENERGY 2020 is parameterized with local data for each region/state/province as well as the all the associated energy suppliers it simulates. Thus, it captures the unique characteristics (physical, institutional and cultural) that affect how people make choices and use energy. National models typically reproduce history from 1975 to partially validate structure and results. Collections of state and provincial models are currently validated from 1988 to the latest quarterly numbers because of limited historical data associated with electric utilities.[52]

ENERGY 2020 can be linked to a detailed macroeconomic model to determine the economic impacts of energy/environmental policy and the energy/environmental impacts of national policy. For US regional and state level analyses, the Informetrica macroeconomic model is regularly linked in ENERGY 2020.[53] The macroeconomic model (that includes inter-state/provincial, US and world trade flows) simulates the real-time impact of energy and environmental concerns on the economy and vice versa.

The structure of the model is well tested and has been used to simulate not only US and the Canada energy and environmental dynamics but also those of several countries in Western, Central, and Eastern Europe. Current efforts include strategic and tactical analyses for South America deregulation. The US EPA uses ENERGY 2020 to perform the regional (energy, environmental and macroeconomic) impacts of proposed Kyoto initiatives at the 50-state level. Further, the model has been used successfully for deregulation analyses in over 50 energy suppliers and in all the US states and Canadian provinces. Many US and Canadian energy suppliers currently use the model for the analysis of combined electricity and gas deregulation

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[51] FOSSIL2 was the original version but was renamed to IDEAS a few years ago to reflect its evolutionary development since its original construction

[52] Energy supplier data comes from Resources Data International, Inc., Boulder, Colorado. US and Canadian fuel and demand data come the US Department of Energy and Natural Resources Canada, respectively. US and Canadian pollution data come from US EPA and Environment Canada, respectively.

[53] Regional Economic Models, Inc., Amherst, Massachusetts.

dynamics.[54] The model contains confidence and validity packages that allow it to determine how to take maximal advantage of RTO rules. The ISO NE used the model to find "gaps" in its rules and to develop more efficient market conditions. The model was used for the CAPX/ISO to model to show, before-the-fact, many of the "games" played in the California market.

The default model simulates demand by three residential categories (single family, multi-family, and agriculture/rural), commercial, industrial by 2-digit SIC, and three transportation services (residential, commercial, industrial). There are approximately six end-uses per category and six technology/mode families per end-use.[55] Currently the technology families correspond to six fuels (oil[56], gas, coal, electric, solar and biomass). The transportation modes include automobile, truck, bus, train, plane, marine and electric vehicles. Added end-uses, technologies, and modes can be added as data allow. (Added sectoral detail comparable to the 13 building-types in the national model's commercial sector can be added as well.) For all end-uses and fuels, the model is parameterized based on historical locale-specific data. The load duration curves are dynamically built up from the individual end-uses to capture changing condition under consumer choice and combined gas/electric programs.

Each energy demand sector includes cogeneration, self-generation, and distributed generation simulation including mobile-generation, micro-turbines, and fuel-cells. Retail wheeling and fuel-switching responses are rigorously determined. The technology families (which can be split, as an option, to portray specific technology dynamics) are aggregates that, within the model, change building shell, economic process and device efficiency and capital costs as price or other information that the decision makers see, changes. ENERGY 2020 utilizes that data the group develops for parameterizing and disaggregating the model. ENERGY 2020 provides feedback on the implications of future assumptions. Its demand and prices forecasts are impeccably accurate even under extreme market conditions

The supply portion model includes endogenous detailed electric supply simulation of capacity expansion/construction, rates/prices, financial/accounting, load shape variation due to weather, and changes in regulation.[57]

The electric sector can additionally simulate the full spectrum of deregulated markets, whether these include a power exchange, ISO, Poolco, Gridco, Transco, or any RTO configuration. The model dispatches plants according to the specified rules whether they are optimal or heuristic and recognizes transmission constraints as well as the associated costs.[58] A sophisticated dispatch routine selects critical hours along seasonal load duration curves as a way to provide a quick but accurate determination of system generation. Peak and base hydro usage is explicitly modelled to capture hydro-plant impacts on the electric system.

Where the model departs from conventional (idealized) approaches is in the overall behaviour of the market players. Each utility (or energy provider, as appropriate) is represented in the model by four business units: distribution, transmission, marketing, and generation. The first two remain regulated but the last two can be deregulated to any degree. All market participants use the rules to their best self-interest. Many organizations do not have the financial or physical

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[54] ENERGY 2020 is the only model known to have simulated and predicted the dynamics that occurred in the UK electric deregulation. These include gaming, market consolidation and re-regulation dynamics.
[55] End-uses include Process Heat, Space Heating Water Heating, Other Substitutable, Refrigeration, Lighting, Air Conditioning, Motors, and Other Non-Substitutable (Miscellaneous). Detailed modes include: auto, light truck, medium weight truck, bus, train, airplane, and marine. Each mode type can be characterized by gasoline, diesel, electric, NG, propane, or hybrid vehicles.
[56] Different petroleum products are associated with specific end-uses and categories.
[57] ENERGY 2020 does include a complete, but aggregate representation of the gas and electric transmission system. Gas transmission data are provided by CERI and electric transmission data provide by Resource Data, International via the National Electric Reliability Council. The dispatch technologies in the basic model include: Oil/Gas Combustion turbine, Oil/Gas Combined Cycle, Oil/Gas Steam Turbine, Coal Steam Turbine, Advanced Coal, Nuclear, Baseload Hydro, Peaking Hydro, Renewables, Baseload Purchase Power Contracts, Baseload Spot Market, Intermediate Purchase Power Contracts, Intermediate Spot Market, Peaking PP Contracts, Peaking Spot Market, and Emergency Purchases.
[58] A 60 node transmission system is used in the default model.

where with all to undertake or survive certain activities in the market. They can be (and maybe should be) easily victimized. Other players with locational, financial or generation advantages play them to the detriment of other competitors -- just as do the competitors in any other industry. New market entrants, asset sales/purchases, mergers, acquisitions, takeovers, and bankruptcy are explicitly modelled because that will be the realistic behaviour of the market. Players may bid what economics predicts on average, but the deregulation transition is volatile and non-linear. There is no unique economic solution. This allows players to try multiple strategies that, while inconsistent with the long-term stability, are successful and therefore economically efficient in the local sense.

The process of deregulation requires a careful consideration of market power dynamics. ENERGY 2020 can examine how potential rules can be used to by market participants to take advantage of the market. It can then be used to help design rules that limit the potential for exercising market power. ENERGY 2020 does produce the Herfindahl-Hirschman Index of Concentration (HHI). It can also readily generate the indexes found in DOJ/FTC Merger Guidelines, FERC Order Nos. 592, 888 and other FERC reports. The model can also simulate the Direct Analysis of Market Power (DAMP) by using HYPERSENS to test the ability of participants to manipulate the market.

The gas distribution utility dynamics are also simulated, but the generic state/provincial models does not contain oil or gas production; only a simplified simulation to determine delivered-product prices.

ENERGY 2020 is written in a language called PROMULA (PROcessor of MUltiple LAnguages) that by its nature allows other client analytical or accounting systems to run under it.

ENERGY 2020 can include oil, gas, and coal supply sectors (they exist in the FOSSIL2/IDEAS model) and it is an option (as is the alcohol supply simulation) not incorporated in the basic model implementation. Energy used in primary production and emissions associated with primary production and its distribution is included in the model.

ENERGY 2020 includes pollution accounting for both energy (by fuel, end-use and sector) and non-energy (by economic activity) for SO2, NO2, N2O, CO, CO2, CH4, TSP, VOC, CF4, C2F6, SF6, and HFC. Other (gaseous, liquid and solid) pollutants can be added as desired. Pollution is not determined directly by coefficients but rather by the accumulation of capital investments that result in pollution emission with usage. National and international Allowance trading is also included. Plant dispatch can consider emission restrictions.

The model uniquely captures the feedback among energy consumers, energy suppliers, and the economy. For example, a change in price affects demand that then affects future supply and price. Increased economic activity increases demand; increased demand increases the investment in new supplies. The new investment affects the economy and energy prices. The energy prices also affect the economy. While this feedback makes for more self-consistent forecasts and characterization of policy impacts, it also adds increased complexity to the detriment of consensus building among stakeholders. As such, the model can be run without the feedback active.

The ENERGY 2020 user interface allows the user to arbitrarily specify output tables and graphics. All information in the model can be interrogated and modified interactively. A MS Windows menuing system allows automated policy analysis and scenario specification. These same capabilities allow the user to save multiple scenarios and analyses and then compare them with each other graphically or in tabular form.

Finally, the system includes confidence and validity testing software that places uncertainty bounds on simulation results, quantifies confidence intervals, and ranks the contributions to uncertainty in future conditions. This feature can be used to limit data efforts to information important to the analysis and to determine those strategies and tactics that will most likely result in the desired conditions.

ENERGY 2020 can simulate a technology-by technology, asset-by-asset modelling approach. Via menus, the user can define new technologies and determine their value and impacts in the marketplace. ENERGY 2020 is designed for scenario testing. The introduction of a new technology is associated with many market considerations that include market applicability, sub-market niche distinctions, marketing/advertising strategy, and categorization of the technology as a new "family" or part of an existing family of technologies. Additionally, incentives such as rebates, tax breaks, and subsidies can be considered. The impact of potential changes in technical characteristics such as cost, lifetime, operating costs and efficiency can then be addressed.

Appendix B: Summarized Results

Carbon Price Scenario

GHG Emissions *(Mt)*	**2008**	**2020**			**2050**			**Change from**
	Reference	**Baseline**	**Reference**	**Policy**	**Baseline**	**Reference**	**Policy**	**Reference in 2050**
Transportation Services	3.5	4.7	3.4	3.4	8.4	5.7	5.1	-9.7%
Communication	1.8	2.8	2.1	2.0	6.5	4.5	4.0	-10.0%
Electric Utilities	2.2	2.8	2.1	2.1	5.4	3.8	3.4	-9.6%
Gas Utilities	0.2	0.2	0.2	0.2	0.3	0.2	0.2	-6.3%
Water & Other Utilities	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-8.0%
Wholesale	4.1	5.4	3.9	3.9	10.3	7.0	6.2	-11.4%
Retail	12.5	16.3	11.6	11.5	26.3	17.6	15.9	-9.9%
FIRE	15.8	19.2	13.9	13.8	28.8	19.6	17.5	-10.8%
Offices - Business Services	5.5	7.0	5.1	5.1	13.3	9.1	8.1	-11.3%
Education	9.7	10.1	7.3	7.2	14.2	9.5	8.6	-10.3%
Health & Social	6.7	8.9	6.4	6.4	16.4	11.0	10.0	-9.2%
Food, Lodging, Recreation	9.3	11.2	8.2	8.1	14.7	10.2	8.8	-13.2%
Government	4.0	5.0	3.6	3.6	10.6	7.2	6.6	-8.0%
Total	**75.1**	**93.8**	**67.8**	**67.3**	**155.3**	**105.4**	**94.5**	**-10.4%**

Fuel Expenditures *(millions CAD / year)*	**2008**	**2020**			**2050**			**Change from**
	Reference	**Baseline**	**Reference**	**Policy**	**Baseline**	**Reference**	**Policy**	**Reference in 2050**
Transportation Services	1,330	2,082	1,789	1,934	6,600	5,385	6,597	22.5%
Communication	792	1,482	1,299	1,406	5,821	4,913	6,089	24.0%
Electric Utilities	836	1,263	1,085	1,169	4,247	3,479	4,266	22.6%
Gas Utilities	31	42	34	39	113	86	122	42.5%
Water & Other Utilities	18	27	26	28	90	86	108	25.6%
Wholesale	1,679	2,621	2,304	2,509	8,643	7,272	9,018	24.0%
Retail	4,551	7,032	6,065	6,524	19,928	16,348	19,600	19.9%
FIRE	6,176	8,922	7,815	8,534	23,530	19,655	24,315	23.7%
Offices - Business Services	2,203	3,326	2,911	3,177	11,207	9,389	11,812	25.8%
Education	3,481	4,358	3,770	4,067	10,682	8,711	10,494	20.5%
Health & Social	2,485	3,971	3,421	3,664	12,678	10,391	12,433	19.6%
Food, Lodging, Recreation	3,500	4,874	4,242	4,585	11,196	9,314	11,071	18.9%
Government	1,823	2,700	2,385	2,500	9,468	8,023	9,235	15.1%
Total	**28,905**	**42,698**	**37,143**	**40,136**	**124,202**	**103,051**	**125,159**	**21.5%**

Investments *(millions CAD / year)*	**2008**	**2020**			**2050**			**Change from**
	Reference	**Baseline**	**Reference**	**Policy**	**Baseline**	**Reference**	**Policy**	**Reference in 2050**
Transportation Services	763	1,557	1,490	1,555	8,972	8,525	9,377	10.0%
Communication	585	1,466	1,387	1,468	10,596	9,969	11,316	13.5%
Electric Utilities	301	611	583	606	3,770	3,577	3,878	8.4%
Gas Utilities	23	42	39	42	207	180	211	17.0%
Water & Other Utilities	11	5	5	5	22	21	22	6.3%
Wholesale	1,010	2,057	1,958	2,062	12,425	11,750	13,081	11.3%
Retail	940	1,864	1,782	1,863	9,596	9,119	10,014	9.8%
FIRE	2,746	5,281	5,030	5,304	25,461	24,139	26,908	11.5%
Offices - Business Services	931	1,883	1,789	1,889	11,589	10,935	12,385	13.3%
Education	560	925	886	927	4,161	3,955	4,365	10.4%
Health & Social	1,177	2,489	2,371	2,484	14,555	13,798	15,304	10.9%
Food, Lodging, Recreation	628	1,136	1,088	1,134	4,724	4,493	4,911	9.3%
Government	1,035	2,096	1,920	1,989	13,824	12,517	13,390	7.0%
Total	**10,709**	**21,411**	**20,327**	**21,328**	**119,900**	**112,977**	**125,160**	**10.8%**

Commercial Energy Demands *(PJ/year)*	**2008**	**2020**			**2050**			**Change from**
	Reference	**Baseline**	**Reference**	**Policy**	**Baseline**	**Reference**	**Policy**	**Reference in 2050**
Space Heating	756	1,031	787	778	1,575	1,101	977	-11.3%
Water Heating	209	273	237	235	396	336	322	-3.9%
Other Subs	70	93	85	85	136	123	117	-5.3%
Refrigeration	136	171	167	167	266	258	258	-0.2%
Lighting	117	150	123	123	227	186	186	0.0%
Air Condition	99	133	110	110	213	167	152	-8.6%
Other Non-Subs	98	124	120	120	186	180	179	-0.4%
Total	**1,486**	**1,974**	**1,630**	**1,617**	**3,000**	**2,351**	**2,192**	**-6.8%**

Commercial Energy Demands *(PJ/year)*	**2008**	**2020**			**2050**			**Change from**
	Reference	**Baseline**	**Reference**	**Policy**	**Baseline**	**Reference**	**Policy**	**Reference in 2050**
Electric	532	715	624	627	1,111	935	973	4.0%
Gas	777	1,054	831	815	1,602	1,180	1,000	-15.3%
Coal	0	1	0	0	1	1	1	0.0%
Oil	143	155	130	130	209	168	155	-8.0%
Biomass	-	-	-	-	-	-	-	0.0%
Solar	0	-	0	0	-	1	1	57.6%
LPG	34	49	44	44	75	65	61	-6.5%
Steam	1	1	1	1	2	1	2	115.9%
Total	**1,486**	**1,974**	**1,630**	**1,617**	**3,000**	**2,351**	**2,192**	**-6.8%**

Policy Scenario

GHG Emissions *(Mt)*	**2008**	**2020**			**2050**			**Change from**
	Reference	**Baseline**	**Reference**	**Policy**	**Baseline**	**Reference**	**Policy**	**Reference in 2050**
Transportation Services	3.5	4.7	3.4	3.2	8.4	5.7	4.6	-19.1%
Communication	1.8	2.8	2.1	1.9	6.5	4.5	3.6	-19.3%
Electric Utilities	2.2	2.8	2.1	1.9	5.4	3.8	3.1	-17.1%
Gas Utilities	0.2	0.2	0.2	0.2	0.3	0.2	0.2	-12.1%
Water & Other Utilities	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-8.8%
Wholesale	4.1	5.4	3.9	3.6	10.3	7.0	5.5	-21.5%
Retail	12.5	16.3	11.6	10.8	26.3	17.6	14.4	-18.2%
FIRE	15.8	19.2	13.9	12.7	28.8	19.6	15.4	-21.1%
Offices - Business Services	5.5	7.0	5.1	4.7	13.3	9.1	7.1	-22.6%
Education	9.7	10.1	7.3	6.8	14.2	9.5	7.7	-19.6%
Health & Social	6.7	8.9	6.4	6.0	16.4	11.0	9.1	-17.3%
Food, Lodging, Recreation	9.3	11.2	8.2	7.6	14.7	10.2	8.2	-19.3%
Government	4.0	5.0	3.6	3.5	10.6	7.2	6.6	-8.2%
Total	**75.1**	**93.8**	**67.8**	**62.9**	**155.3**	**105.4**	**85.6**	**-18.8%**

Fuel Expenditures *(millions CAD / year)*	**2008**	**2020**			**2050**			**Change from**
	Reference	**Baseline**	**Reference**	**Policy**	**Baseline**	**Reference**	**Policy**	**Reference in 2050**
Transportation Services	1,330	2,082	1,789	1,679	6,600	5,385	4,562	-15.3%
Communication	792	1,482	1,299	1,225	5,821	4,913	4,226	-14.0%
Electric Utilities	836	1,263	1,085	1,023	4,247	3,479	2,959	-14.9%
Gas Utilities	31	42	34	32	113	86	71	-17.0%
Water & Other Utilities	18	27	26	26	90	86	83	-3.4%
Wholesale	1,679	2,621	2,304	2,149	8,643	7,272	6,070	-16.5%
Retail	4,551	7,032	6,065	5,688	19,928	16,348	13,819	-15.5%
FIRE	6,176	8,922	7,815	7,268	23,530	19,655	16,401	-16.6%
Offices - Business Services	2,203	3,326	2,911	2,714	11,207	9,389	7,764	-17.3%
Education	3,481	4,358	3,770	3,522	10,682	8,711	7,244	-16.8%
Health & Social	2,485	3,971	3,421	3,227	12,678	10,391	8,908	-14.3%
Food, Lodging, Recreation	3,500	4,874	4,242	3,968	11,196	9,314	7,797	-16.3%
Government	1,823	2,700	2,385	2,328	9,468	8,023	7,616	-5.1%
Total	**28,905**	**42,698**	**37,143**	**34,847**	**124,202**	**103,051**	**87,521**	**-15.1%**

Investments *(millions CAD / year)*	**2008**	**2020**			**2050**			**Change from**
	Reference	**Baseline**	**Reference**	**Policy**	**Baseline**	**Reference**	**Policy**	**Reference in 2050**
Transportation Services	763	1,557	1,490	1,801	8,972	8,525	10,044	17.8%
Communication	585	1,466	1,387	1,771	10,596	9,969	12,278	23.2%
Electric Utilities	301	611	583	702	3,770	3,577	4,188	17.1%
Gas Utilities	23	42	39	47	207	180	215	19.6%
Water & Other Utilities	11	5	5	6	22	21	24	14.1%
Wholesale	1,010	2,057	1,958	2,454	12,425	11,750	14,202	20.9%
Retail	940	1,864	1,782	2,167	9,596	9,119	10,763	18.0%
FIRE	2,746	5,281	5,030	6,331	25,461	24,139	29,116	20.6%
Offices - Business Services	931	1,883	1,789	2,260	11,589	10,935	13,439	22.9%
Education	560	925	886	1,082	4,161	3,955	4,691	18.6%
Health & Social	1,177	2,489	2,371	2,903	14,555	13,798	16,388	18.8%
Food, Lodging, Recreation	628	1,136	1,088	1,301	4,724	4,493	5,240	16.6%
Government	1,035	2,096	1,920	1,872	13,824	12,517	12,145	-3.0%
Total	**10,709**	**21,411**	**20,327**	**24,697**	**119,900**	**112,977**	**132,731**	**17.5%**

Commercial Energy Demands *(PJ/year)*	**2008**	**2020**			**2050**			**Change from**
	Reference	**Baseline**	**Reference**	**Policy**	**Baseline**	**Reference**	**Policy**	**Reference in 2050**
Space Heating	756	1,031	787	722	1,575	1,101	869	-21.1%
Water Heating	209	273	237	228	396	336	297	-11.5%
Other Subs	70	93	85	83	136	123	117	-4.9%
Refrigeration	136	171	167	163	266	258	245	-5.3%
Lighting	117	150	123	117	227	186	164	-11.8%
Air Condition	99	133	110	95	213	167	111	-33.3%
Other Non-Subs	98	124	120	115	186	180	164	-9.2%
Total	**1,486**	**1,974**	**1,630**	**1,524**	**3,000**	**2,351**	**1,967**	**-16.4%**

Commercial Energy Demands *(PJ/year)*	**2008**	**2020**			**2050**			**Change from**
	Reference	**Baseline**	**Reference**	**Policy**	**Baseline**	**Reference**	**Policy**	**Reference in 2050**
Electric	532	715	624	590	1,111	935	821	-12.3%
Gas	777	1,054	831	767	1,602	1,180	941	-20.3%
Coal	0	1	0	0	1	1	1	0.0%
Oil	143	155	130	124	209	168	145	-13.9%
Biomass	-	-	-	-	-	-	-	0.0%
Solar	0	-	0	0	-	1	1	-11.5%
LPG	34	49	44	42	75	65	59	-10.2%
Steam	1	1	1	1	2	1	1	-22.4%
Total	**1,486**	**1,974**	**1,630**	**1,524**	**3,000**	**2,351**	**1,967**	**-16.4%**

Combined (Carbon Price and Policy) Scenario

GHG Emissions *(Mt)*	2008	2020			2050			Change from
	Reference	Baseline	Reference	Policy	Baseline	Reference	Policy	Reference in 2050
Transportation Services	3.5	4.7	3.4	3.1	8.4	5.7	4.4	-22.1%
Communication	1.8	2.8	2.1	1.9	6.5	4.5	3.4	-22.8%
Electric Utilities	2.2	2.8	2.1	1.9	5.4	3.8	3.0	-20.8%
Gas Utilities	0.2	0.2	0.2	0.2	0.3	0.2	0.2	-13.3%
Water & Other Utilities	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-13.7%
Wholesale	4.1	5.4	3.9	3.6	10.3	7.0	5.2	-25.2%
Retail	12.5	16.3	11.6	10.8	26.3	17.6	13.9	-21.4%
FIRE	15.8	19.2	13.9	12.6	28.8	19.6	14.8	-24.6%
Offices - Business Services	5.5	7.0	5.1	4.7	13.3	9.1	6.7	-26.2%
Education	9.7	10.1	7.3	6.7	14.2	9.5	7.3	-23.0%
Health & Social	6.7	8.9	6.4	6.0	16.4	11.0	8.8	-20.5%
Food, Lodging, Recreation	9.3	11.2	8.2	7.5	14.7	10.2	7.6	-25.4%
Government	4.0	5.0	3.6	3.5	10.6	7.2	6.3	-12.6%
Total	**75.1**	**93.8**	**67.8**	**62.5**	**155.3**	**105.4**	**81.7**	**-22.5%**

Fuel Expenditures *(millions CAD / year)*	2008	2020			2050			Change from
	Reference	Baseline	Reference	Policy	Baseline	Reference	Policy	Reference in 2050
Transportation Services	1,330	2,082	1,789	1,802	6,600	5,385	5,508	2.3%
Communication	792	1,482	1,299	1,317	5,821	4,913	5,192	5.7%
Electric Utilities	836	1,263	1,085	1,095	4,247	3,479	3,571	2.6%
Gas Utilities	31	42	34	36	113	86	101	18.2%
Water & Other Utilities	18	27	26	28	90	86	104	21.3%
Wholesale	1,679	2,621	2,304	2,325	8,643	7,272	7,495	3.1%
Retail	4,551	7,032	6,065	6,076	19,928	16,348	16,417	0.4%
FIRE	6,176	8,922	7,815	7,880	23,530	19,655	20,104	2.3%
Offices - Business Services	2,203	3,326	2,911	2,940	11,207	9,389	9,680	3.1%
Education	3,481	4,358	3,770	3,771	10,682	8,711	8,596	-1.3%
Health & Social	2,485	3,971	3,421	3,433	12,678	10,391	10,493	1.0%
Food, Lodging, Recreation	3,500	4,874	4,242	4,258	11,196	9,314	9,141	-1.9%
Government	1,823	2,700	2,385	2,433	9,468	8,023	8,770	9.3%
Total	**28,905**	**42,698**	**37,143**	**37,392**	**124,202**	**103,051**	**105,173**	**2.1%**

Investments *(millions CAD / year)*	2008	2020			2050			Change from
	Reference	Baseline	Reference	Policy	Baseline	Reference	Policy	Reference in 2050
Transportation Services	763	1,557	1,490	1,803	8,972	8,525	10,023	17.6%
Communication	585	1,466	1,387	1,773	10,596	9,969	12,243	22.8%
Electric Utilities	301	611	583	704	3,770	3,577	4,213	17.8%
Gas Utilities	23	42	39	47	207	180	218	21.1%
Water & Other Utilities	11	5	5	6	22	21	24	14.6%
Wholesale	1,010	2,057	1,958	2,457	12,425	11,750	14,172	20.6%
Retail	940	1,864	1,782	2,169	9,596	9,119	10,744	17.8%
FIRE	2,746	5,281	5,030	6,340	25,461	24,139	29,071	20.4%
Offices - Business Services	931	1,883	1,789	2,263	11,589	10,935	13,409	22.6%
Education	560	925	886	1,083	4,161	3,955	4,682	18.4%
Health & Social	1,177	2,489	2,371	2,906	14,555	13,798	16,360	18.6%
Food, Lodging, Recreation	628	1,136	1,088	1,303	4,724	4,493	5,223	16.3%
Government	1,035	2,096	1,920	1,937	13,824	12,517	13,278	6.1%
Total	**10,709**	**21,411**	**20,327**	**24,790**	**119,900**	**112,977**	**133,658**	**18.3%**

Commercial Energy Demands *(PJ/year)*	2008	2020			2050			Change from
	Reference	Baseline	Reference	Policy	Baseline	Reference	Policy	Reference in 2050
Space Heating	756	1,031	787	715	1,575	1,101	822	-25.4%
Water Heating	209	273	237	226	396	336	293	-12.7%
Other Subs	70	93	85	83	136	123	111	-9.7%
Refrigeration	136	171	167	163	266	258	244	-5.5%
Lighting	117	150	123	117	227	186	164	-11.8%
Air Condition	99	133	110	95	213	167	111	-33.6%
Other Non-Subs	98	124	120	115	186	180	164	-9.2%
Total	**1,486**	**1,974**	**1,630**	**1,514**	**3,000**	**2,351**	**1,909**	**-18.8%**

Commercial Energy Demands *(PJ/year)*	2008	2020			2050			Change from
	Reference	Baseline	Reference	Policy	Baseline	Reference	Policy	Reference in 2050
Electric	532	715	624	593	1,111	935	850	-9.1%
Gas	777	1,054	831	754	1,602	1,180	857	-27.4%
Coal	0	1	0	0	1	1	1	0.0%
Oil	143	155	130	123	209	168	142	-15.6%
Biomass	-	-	-	-	-	-	-	0.0%
Solar	0	-	0	0	-	1	1	20.6%
LPG	34	49	44	42	75	65	57	-13.1%
Steam	1	1	1	1	2	1	1	52.1%
Total	**1,486**	**1,974**	**1,630**	**1,514**	**3,000**	**2,351**	**1,909**	**-18.8%**

277 Wellington Street West

Suite 808

Toronto, ON   M5V 3E4