Environment Canada Environnement Canada

# CANADA'S EMISSIONS TRENDS

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# Preface

The future path of greenhouse gas emissions in Canada will depend on a number of factors including: government actions, technological change, the growth in the economy, and developments in energy markets. Without incorporating the impacts of future government measures that have not yet been specified, the projections presented in this report are based on expectations of the evolution of key economic and energy drivers (such as the world oil price, gross domestic product, and population growth) derived from a variety of authoritative sources. However, as with any projection of this type, the likely outcome associated with each specific driver is subject to a high degree of uncertainty. As such, the emissions scenarios presented here should be seen as representative of a number of possible greenhouse gas emissions outcomes to 2020, depending on economic and other developments, as well as future government measures.

The analysis presented in this report incorporates the most up-to-date statistics on GHG emissions and energy availability at the time that the technical modeling was completed in December 2010[1], and is based on scenarios of emissions projections using a detailed, proven Energy, Emissions and Economy Model for Canada. In developing this analysis, we have consulted with industry experts on the detailed results, and have engaged external experts for peer review of overall results and methodologies. Annex 4 contains a brief comparison of the historical emission data shown in this report with other recent Environment Canada publications

These consultations included provincial and federal government departments, who were provided with detailed modelling results in the Fall, 2010 and invited to provide their input and suggestions for improvement. Environment Canada also worked with industry associations to improve the alignment of the projections with their key assumptions. Wherever possible, the feedback received from these consultations has been incorporated into the emissions scenarios presented here.

In addition, the majority of core data and assumptions received from sector experts and authorities for the modelled emissions scenarios has already been subjected to rigorous consultations. For example, Natural Resources Canada has extensive consultation processes in place to ensure their assumptions of energy demand and supply growth are robust, with the input they have provided to Environment Canada reflecting those consultations.

In addition to consultations, the projections have included a peer review by a panel of experts. In the peer review, the experts assessed the projections on their reasonableness and robustness, reviewed the key macroeconomic and energy-related assumptions (e.g. the assumed rate of growth in oil and gas sector activity in Canada, the evolution of Canada's electricity generation and transportation sectors), and made

[1] Emissions inventory data used for this analysis is derived from Canada's 2010 National Inventory Report on Greenhouse Gas Sources and Sinks which includes emissions from 1990-2008.

suggestions on how to continue improving the methodology in future rounds. The input from the peer review was incorporated into this report, and into plans for future emissions analysis and modelling work at Environment Canada.

Questions and requests for further information on the analysis underlying this report should be directed to: AMD_EAD@ec.gc.ca

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# Executive Summary

## Overview

When Canada signed the Copenhagen Accord in December 2009, it committed to reducing its greenhouse (GHG) emissions to 607 Megatonnes (Mt) in 2020, or 17 per cent below 2005 levels[2]. This mirrors the reduction target set by the United States.

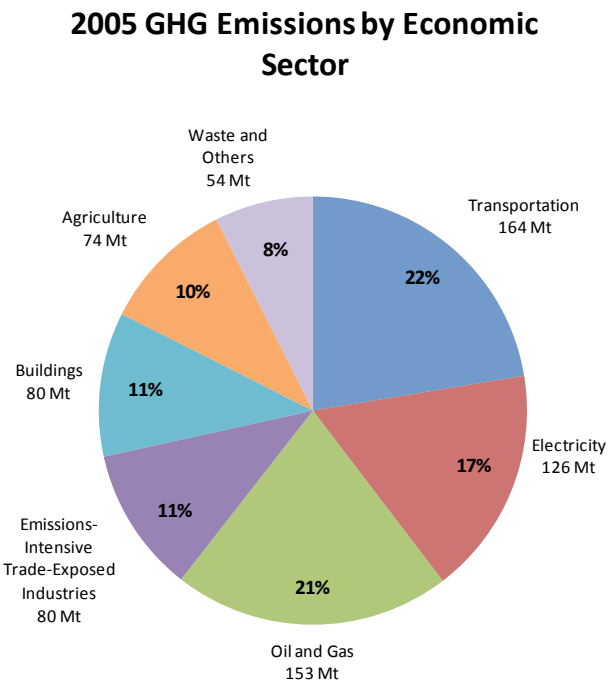
In 2005, Canada's total GHG emissions were 731 Mt, representing about two per cent of overall global GHG emissions.

The Government of Canada's initial focus in tackling climate change has been on the largest source of Canadian emissions through regulation of the transportation sector, as well as actions to reduce emissions from electricity generation.

Existing measures announced by federal and provincial governments will reduce GHG emissions in 2020 by about 65 Mt. This represents one quarter of the reductions in emissions needed by 2020 to reach the target level of 607 Mt.

[2] Emissions presented in this report exclude Land Use, Land-Use Change and Forestry (LULUCF).

**Figure ES2 Total Canadian GHG Emissions by Economic Sector (2005 Mt $CO_2e$)[3]**




To close the remaining gap, the Government of Canada will develop and implement similar measures for other key sectors of the economy.

## Canadian Emissions in a Global Context

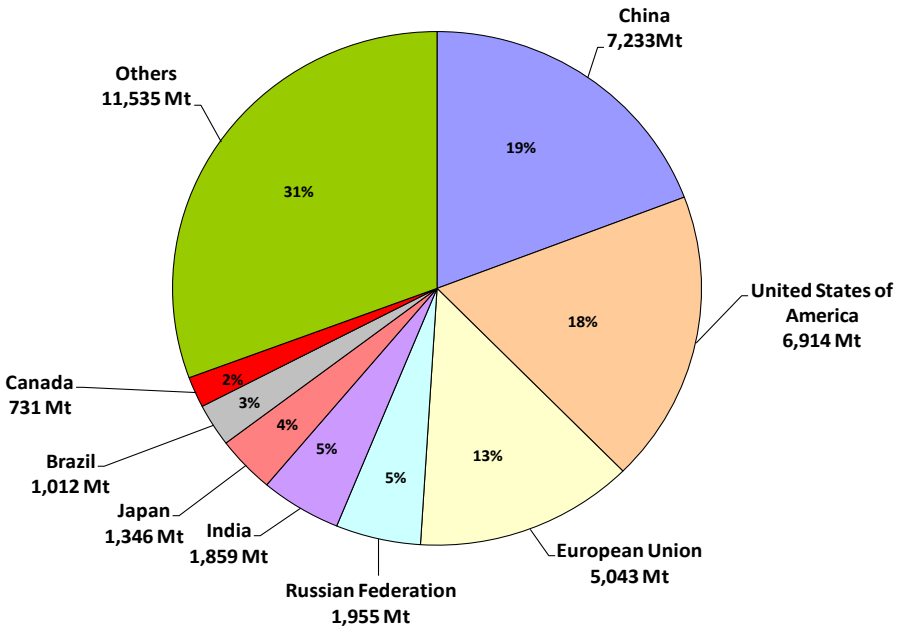
Overall, global greenhouse emissions increased by 25 per cent between 1990 and 2005. Canada's share of total global emissions, like that of other developed countries, will decline in the face of rapid emissions growth from developing countries, particularly China and India. By 2005, China had overtaken the U.S. as the world's largest overall greenhouse gas emitter, and by 2020 China's greenhouse gas emissions are expected to account for 27 per cent of global emissions, up from about 20 per cent in 2005.

The Copenhagen Accord is a critical instrument for addressing such dramatic escalation because it is signed by 140 nations, representing 85 per cent of the world's GHG emissions. For example, the Accord was signed by China, the U.S., Brazil and

[3] Canada's National Emissions Inventory allocates emissions by activity, rather than the economic sector in which they are generated. For example in the National Emissions Inventory total emissions from transportation activities were 192 Mt in 2005, or 26% of total emissions. To better analyze emissions on the basis of economic sectors, transportation emissions directly tied to specific sectors are allocated to that sector in this figure. For example emissions from farm tractors are allocated to the agriculture sector, emissions from heavy mining trucks and related equipment used in mining are allocated to the mining sector, and oil and gas pipeline emissions are allocated to the oil and gas sector.

India, which together account for over 40 per cent of global emissions. In contrast, none of these major emitters had commitments under the Kyoto Protocol, an agreement that involved commitments of only 40 nations representing 27 per cent of global emissions.

**Figure ES3 Global GHG Emissions by Country (2005 Mt $CO_2e$)**[4]




[4] "Climate Analysis Indicators Tool (CAIT) Version 7.0" (Washington, D.C.: World Resources Institute, 2010).

## Government Actions and Emissions Trends

Canadian GHG emissions fell in 2008 and 2009 due to the global recession. With the economic recovery, GHG emissions are now expected to begin increasing again. The future path of emissions will depend on government actions, technological change, the growth in the economy, and developments in energy markets.

Environment Canada has developed scenarios for future emissions based on different assumptions regarding future economic and energy market developments. In a scenario that assumes Canadian governments had taken no action to address climate change, the coming decade of economic growth in Canada would likely result in annual GHG emissions reaching about 850 Mt by 2020.

In reality, the Government of Canada has taken significant action to reduce GHG emissions. As well, provincial governments are contributing with significant action of their own under their respective jurisdictional targets, which in aggregate generally match the level of ambition established by the Government of Canada. Taken together, the existing measures of the federal and provincial governments are having a significant impact on emissions over the next decade. These existing measures are expected to reduce GHG emissions by 65 Mt by 2020 relative to the scenario with no government actions, reducing annual emissions in 2020 from 850 Mt to 785 Mt.

Thus, currently announced government measures will generate about one quarter of the reductions in emissions by 2020 that are needed to reach Canada's Copenhagen accord target of 607 Mt.

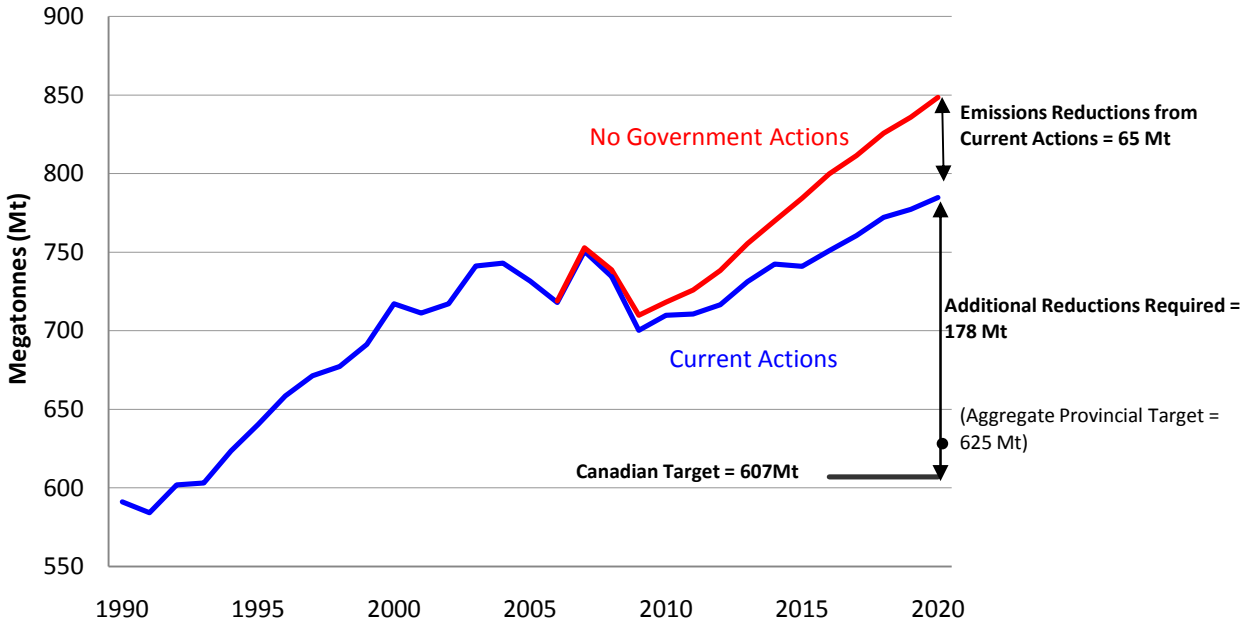
**Table ES1 Canadian GHG Emissions and Government Measures (Mt $CO_2e$)**

| | 2005 | 2010[5] | 2020 |
|---|---|---|---|
| Emissions – Assuming No Government Measures | 731 | 718 | 850 |
| Emissions – with Existing Government measures | 731 | 710 | 785 |
| Difference – Impact of Existing Government Measures | 0 | -8 | -65 |

The Government of Canada's climate change plan is to regulate all major sources of emissions to generate additional reductions. The goal is to develop sufficient federal measures that, when combined with additional provincial actions, will enable Canada to bring its total GHG emissions down to the target level.

[5] Emissions for 2010 are estimated numbers/projections. During preparation of this analysis, the latest available year of actual historical emissions numbers was 2008. The 2010 National Inventory Report summarizes emissions from 1990-2008.

Figure ES3 Scenarios of Canadian Emissions to 2020 (Mt $CO_2e$)

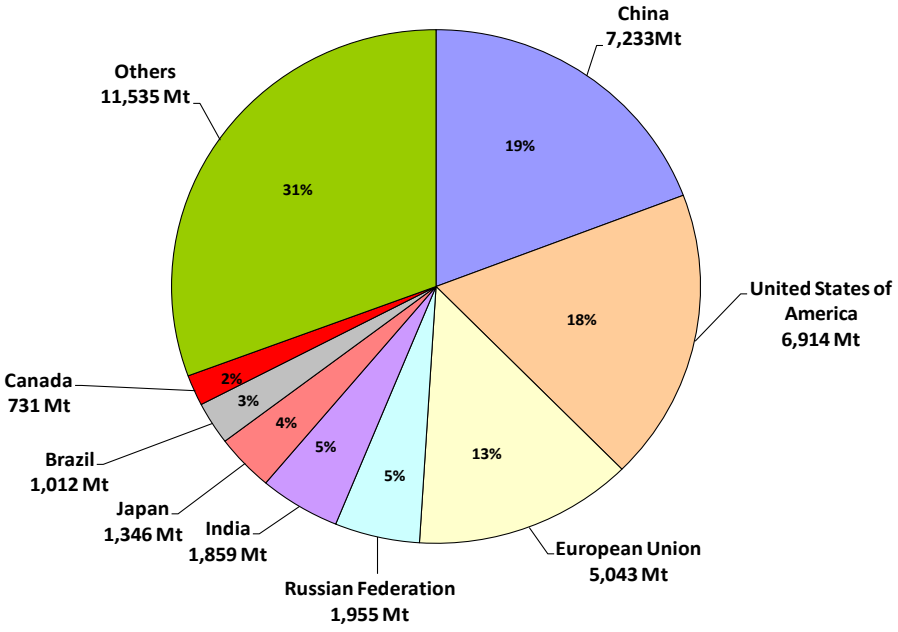


# CANADA'S GHG EMISSIONS IN A GLOBAL CONTEXT

Total greenhouse gas emissions in Canada in 2005 were 731 megatonnes of carbon dioxide equivalent[6].

According to the World Resources Institute's 2005 analysis of reported gross greenhouse gases by country of origin, Canada accounts for less than 2 per cent of total global emissions.

**Figure 1 Global GHG Emissions by Country (2005 Mt $CO_2e$)** [7]




Canada's share of total global emissions, like that of other developed countries, is expected to decline in the face of the expected rapid emissions growth from developing countries, particularly China and India. According to World Resources Institute data, China overtook the US as the largest GHG emitter by 2005, while the U.S. Energy Information Administration expects that by 2020 China alone will be responsible for 27% of total global emissions, up from about 20% in 2005.[8]

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[6] Often greenhouse gas emissions are calculated in terms of how much CO2 would be required to produce a similar warming effect. This is called the carbon dioxide equivalent ($CO_2$ e) value and is calculated by multiplying the amount of the gas by its associated global warming potential (GWP). Source: National Inventory Report.

[7] "Climate Analysis Indicators Tool (CAIT) Version 7.0" (Washington, D.C.: World Resources Institute, 2010).

[8] US Energy Information Administration *IEO2010* Reference case http://www.eia.doe.gov/oiaf/ieo/emissions.html

When Canada signed the Copenhagen Accord in December 2009, it committed to reducing its GHG emissions to 17 per cent below 2005 levels (or 607 Mt) by 2020. That is the same reduction target set by the United States.

As a signatory to the Copenhagen Accord, Canada is a member of a group of 140 countries that together are responsible for 85 per cent of global emissions. The Accord was signed by China, the U.S., Brazil and India, which together account for over 40 per cent of global emissions. In contrast, none of these major emitters had commitments under the Kyoto Protocol, an agreement that involved commitments of only 40 nations representing 27 per cent of global emissions.

# GHG EMISSIONS BY SECTOR

## Emissions by Activity and Economic Sector

In Canada's National GHG Inventory (compiled under the IPCC reporting requirements[9]) greenhouse gas emissions are categorized by emitting activity: e.g., emissions from energy use, fugitive emissions, transportation emissions, and emissions from industrial processes.

Environment Canada allocates emissions on the basis of the economic sector from which they originate, to the extent possible, for the purposes of analyzing trends and policies.

Figure 2 below shows the distribution of 2005 emissions on an activity basis (as reported in the National Inventory Report) versus an economic sector basis (used in the economic analysis and modelling presented here). Notable differences arise with respect to transportation, as this activity has large off-road and other emissions that are intrinsic to the emissions profile of specific economic sectors. Among other adjustments to transportation emissions as stated in the National Inventory report for 2005:

- Off-road transportation emissions related to farming (primarily farm tractors and other mobile machinery) are allocated to the agriculture sector instead of transportation.

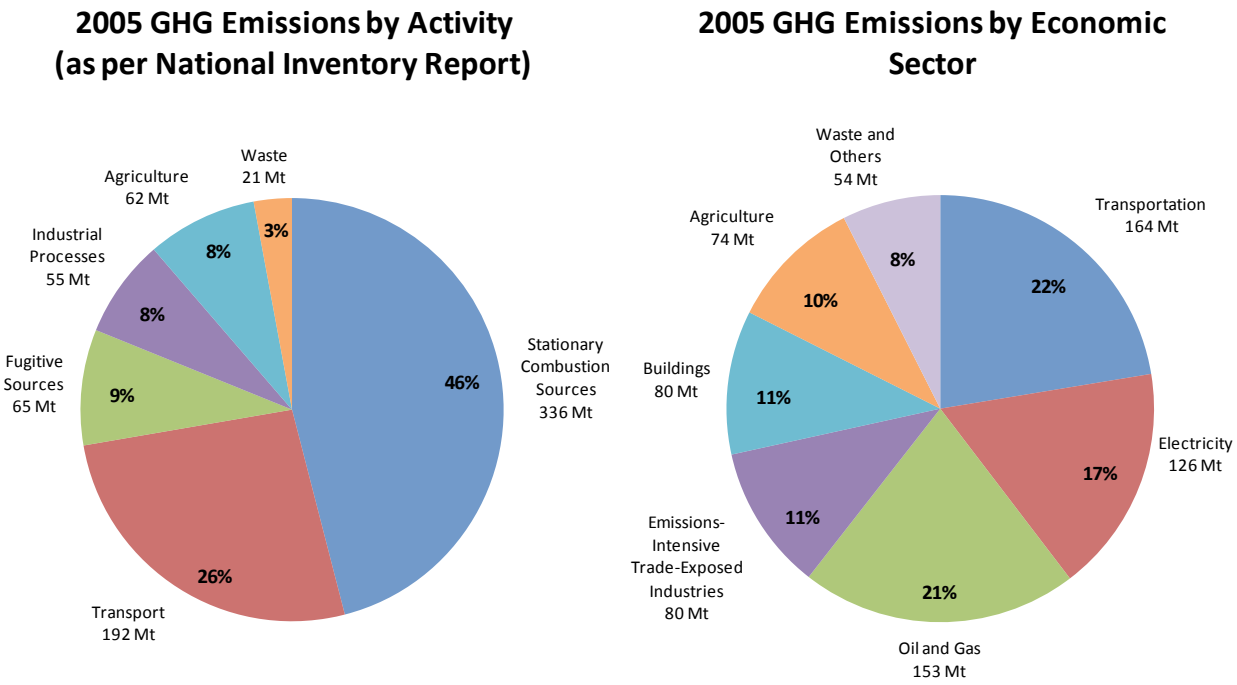
- Off-road transportation emissions related to mining operations are allocated from transportation as defined in the Inventory report to oil sands mining (oil and gas sector) and other mining operations in the Emissions Intensive Trade Exposed (EITE) sector.

- Emissions related to pipeline operations are allocated to the oil and gas sector.

In addition, stationary combustion emissions under the National Inventory report are allocated mainly to the electricity, Emissions-Intensive Trade-Exposed (EITE) industries, and buildings sectors of the economy. Almost all industrial process and fugitive emissions under the Inventory are aligned with the economic sector that generates them (primarily in the EITE sector). In addition, a portion of emissions from across various Inventory activity categories are assigned to light manufacturing industries as appropriate (combined with emissions from landfills into the Waste and Others sector in Figure 2).

[9] Canada submits an annual National Inventory Report on Greenhouse Gases Sources and Sinks to the United Nations Framework Convention on Climate Change per the reporting requirements of the International Panel on Climate Change.

**Figure 2 Total Canadian 2005 GHG emissions - Activity vs Economic Sector (MT $CO_2e$)**




## Historical Emissions

Table 1 shows historical emission levels for selected years up to 2008 (the last available year of historical emissions numbers under the National Inventory Report at the time this analysis was conducted) for each of the major economic sectors generating emissions.

**Table 1 GHG Emissions by Economic Sector (Mt $CO_2e$)**

| | 1990 | 1995 | 2000 | 2005 | 2008 |
|---|---|---|---|---|---|
| Transportation | 122 | 131 | 147 | 164 | 171 |
| Electricity | 97 | 102 | 134 | 126 | 120 |
| Oil and Gas | 101 | 124 | 148 | 153 | 158 |
| Emissions-Intensive Trade-Exposed Industries | 91 | 93 | 84 | 80 | 76 |
| Buildings | 70 | 75 | 79 | 80 | 79 |
| Agriculture | 60 | 67 | 73 | 74 | 75 |
| Waste and Others | 51 | 49 | 52 | 54 | 55 |
| **Total** | **592** | **641** | **717** | **731** | **734** |

## Transportation

Emissions from the transportation sector (including passenger, freight, and off-road emissions) are the largest contributor to Canada's greenhouse gas emissions, representing 22 per cent of overall greenhouse gases in 2005.

The increase in emissions from road transportation was due mainly to the increase in emissions from light-duty gasoline trucks and heavy-duty diesel vehicles. The number of light trucks on the road doubled between 1990 and 2008, while the number of passenger cars remained virtually constant.

## Electricity

Historically over the 1990 to 2008 period, emissions from the electricity sector (including heat generation) increased in parallel to rising demand for electricity both domestically and to satisfy export to the United States. Additionally, fossil fuel power generation became more prominent in the overall generating portfolio between 1990 and 2002. Electricity-related emissions declined between 2002 and 2008 because of measures such as a return to service of a number of nuclear units and fuel switching to natural gas, as well some decline in coal-fired electricity generation in Ontario.

## Oil and Gas Production and Refining

Conventional oil and gas production and petroleum refining emissions are related primarily to the production, transmission, processing, refining and distribution of all oil and gas products. Canada's oil and gas production increased by approximately 70 per cent from 1990 to 2008, in large part due to increased exports to the U.S. As a result of increased output, emissions from the sector increased 57 Mt over this period.

## Emissions-Intensive and Trade-Exposed Industries (EITE)

Greenhouse gas emissions from the EITE industries decreased by 15 Mt between 1990 and 2008. The decline in emissions was due to a modest rate of economic growth in the resource-based industries coupled with technology improvements. The installation of nitrous oxide abatement technology in Canada's only adipic acid manufacturing plant and the improved emission control technologies for perfluorocarbons within the aluminum industry contributed significantly to the overall decrease in greenhouse gas emissions in this sector.

## Buildings

Emissions in Canada's commercial and residential buildings increased by 9 Mt overall between 1990 and 2008. This increase was driven by strong growth in Canada's service-oriented industries. Emissions in the commercial sector increased by 36 % while residential emissions decreased by 1%. The reduction in residential emissions was mainly due to improved energy standards for homes and the adoption of higher-efficiency furnaces and other improved appliances.

## Agriculture

Canada's agriculture emissions are made up mostly of emissions of methane and nitrous oxide from agricultural production systems. Between 1990 and 2008 emissions increased by 15 Mt. This was mainly due to the expansion of the beef cattle and swine populations, and increases in the application of synthetic nitrogen fertilizer in the Prairies.

## Waste and Others

From 1990 to 2008, emissions from waste and others increased by 4 Mt. GHG emissions from landfills increased by over 15% over that period - lower than the population growth of approximately 20% - mainly due to recycling and other waste-management practices.

# EMISSIONS TRENDS

## Emissions Scenarios and Key Drivers

Greenhouse gas emissions in Canada are driven by a number of economic drivers (e.g., energy demand and supply mix, economic growth, among others). Looking ahead, projections of future emissions are greatly influenced by the underlying assumptions about the expected development of these economic drivers over time[10]. Changing assumptions about any of these factors will alter the future path of emissions.

The approach adopted for development of the emissions scenarios presented here relies on a baseline set of assumptions. In this respect, the economic projections are calibrated to those used by Finance Canada in the Fall 2010 Fiscal Update. The longer-term projections incorporate productivity growth projections developed in consultation with Finance Canada officials and Statistics Canada's population growth projections. Similarly, forecasts of major energy supply projects (e.g., oil sands production, large hydro capacity expansions, nuclear refurbishment and additions) from Natural Resources Canada were incorporated. Supply forecasts are based on consultation with industry experts and reflect the most recent views regarding the evolution of Canada's energy supply sector. The projections also incorporate data from the National Greenhouse Gas Emissions Inventory, the National Energy Board, and the U.S. Energy Information Administration. For a more detailed summary of key economic data and assumptions see Annex 1.

It is impossible to predict Canada's greenhouse gas emissions with certainty, given the importance of the economic drivers and the intrinsic uncertainty related to these drivers (e.g. GDP, energy prices) in the future. Government policy also has a significant impact on emissions. In this respect, future emissions will be shaped by existing government measures, as well as future measures that will be implemented as part of Canada's plan to reduce emissions to the target established in the Copenhagen Accord of 607 Mt by 2020.

Taking into account the economic drivers described above, with no major technology changes and factoring in current government measures, results in a baseline scenario whereby emissions reach 785 Mt by 2020 (or 54 Mt) above 2005 levels.

Given the uncertainty regarding the economic drivers, this scenario should be seen as one estimate within a set of possible emissions outcomes in 2020, depending on economic developments. To get a sense of the sensitivity of emissions to economic developments, emissions were calculated under a series of alternative assumptions involving relatively minor variations in assumed economic growth rates for Canada and world oil prices.

For example, under a scenario of high GDP growth, high world oil prices and no further government action, Canadian emissions could reach almost 840 Mt by 2020.

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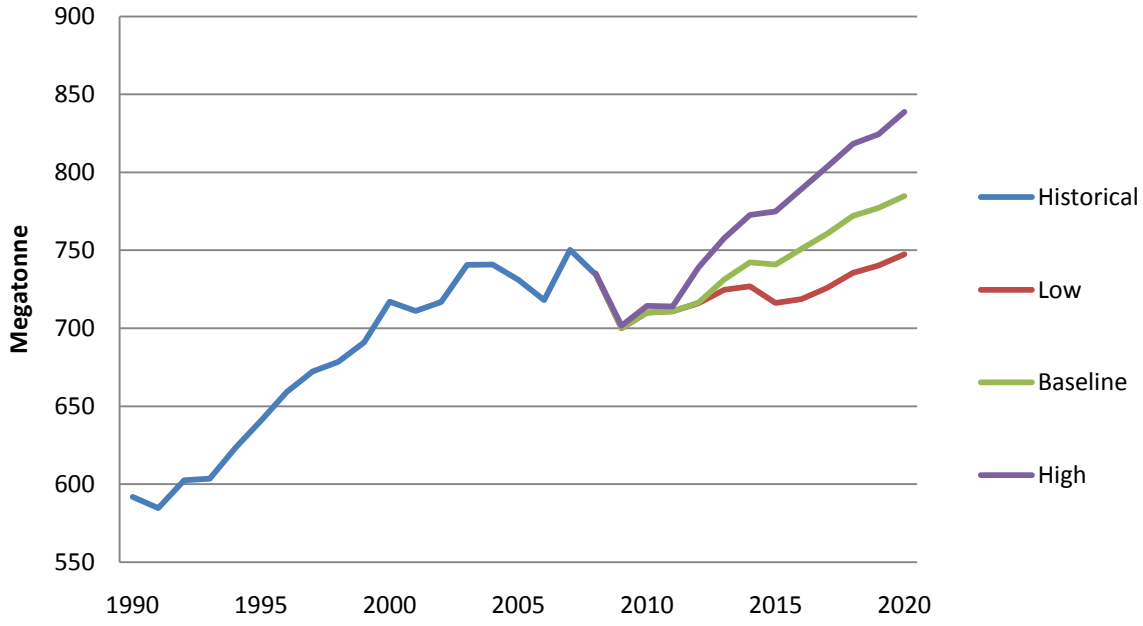
[10] For detailed information about individual key drivers, assumptions, and key response dynamics, see Annex 1.

Alternatively, with GDP growth and world oil prices below the baseline scenario assumptions, 2020 emissions could be as low as 747 Mt. Figure 3 illustrates these alternative emissions pathways. For a more detailed explanation of this sensitivity analysis, see Annex 2.

**Figure 3 Projected GHG emissions under alternative economic assumptions**




These sensitivities illustrate that Canada's emissions projections should not be interpreted as a prediction or forecast of our emissions future that will be determined by a range of as yet unknown developments in key economic drivers. Rather, the projections should be viewed as a mode of a distribution of scenarios that provides a reference point for evaluating the impact of economic and technological developments, as well as assessing the impact of existing and future government measures.

It is important to note that the projection of emissions in this scenario is based on existing government measures as of December 2010 only, and does not reflect the impact of federal measures that are under development as part of the government's plan to reduce GHG emissions to 607 Mt by 2020, nor new provincial measures that could be undertaken in the future. The impact of government measures on emissions is described in more detail in a later section.

**Table 2 Sensitivity of emissions to changes in GDP and world oil price**

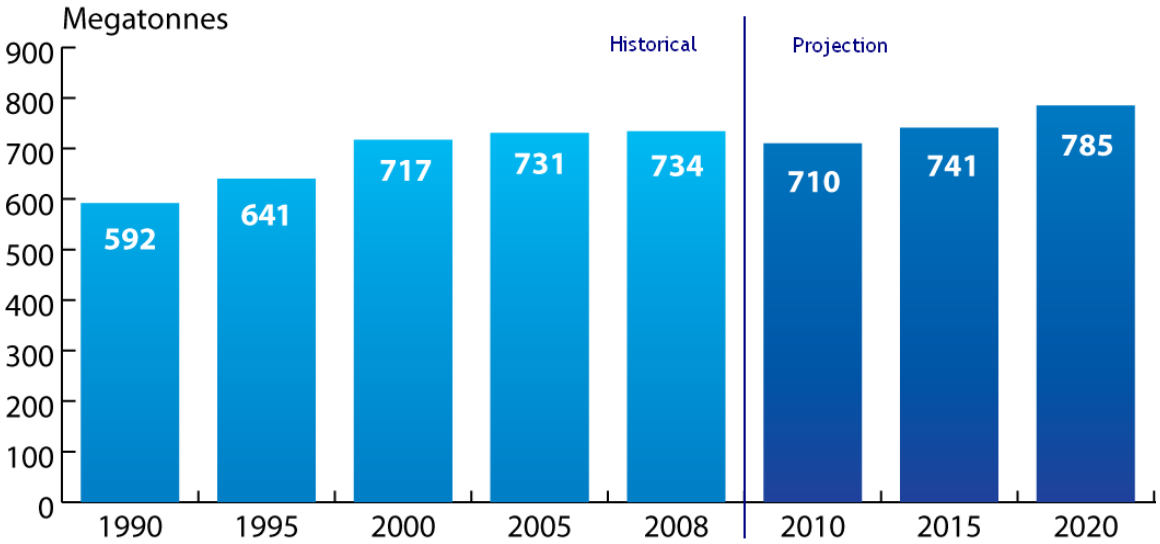
| Cases | Impact on GHG emissions relative to the reference scenario (in Mt $CO_2e$.) | |
|---|---|---|
| | **2015** | **2020** |
| Low GDP - Low World Oil Prices | 716 | 747 |
| High GDP - High World Oil Prices | 775 | 839 |
| **Baseline Scenario** | **741** | **785** |
| Sensitivity Range (including all scenarios examined – see Annex 2) | 716 – 775 | 747 - 839 |

## Baseline Scenario Trends

### National Emissions Projections

Figure 4 depicts the total projected Canadian greenhouse gas emissions in the absence of further government actions for selected years from 1990 to 2020.

**Figure 4 Total Canadian GHG emissions and projections (with no further government actions): 1990 to 2020 (Mt $CO_2e$.)**



## Emissions Projections by Sector

Emissions are estimated to have declined in 2008 and 2009 due to the global economic recession. The downturn in economic conditions contributed to a decline in emissions in major industrial sectors, including utility power generation sector and key EITE industries, such as iron and steel, smelting and refining, pulp and paper, metal mining, forestry, and chemicals and fertilizers.

As the economic recovery continues beyond 2010, total emissions are expected to begin to increase. Absent further government action, by 2020 emissions are projected to reach 785 Mt, an increase of 54 Mt from 2005.

Table 3 illustrates how the trends in each economic sector vary based on how economic drivers and government policies shape emissions in that sector. Electricity generation is the one major economic sector that is projected to reduce emissions significantly, in large part due to the combined impact of government measures to create a cleaner electricity system: Electricity emissions are projected to decline by 31 Mt (25%) between 2005 and 2020. On the other hand, increased production in the oil sands is expected to result in overall oil and gas emissions increasing by 46 Mt (30%) between 2005 and 2020.

**Table 3 GHG emissions by economic sector (Mt $CO_2e$)**

| | 2005 | 2020 | Change, 2005 to 2020 |
|---|---|---|---|
| Transportation | 164 | 180 | 16 |
| Electricity | 126 | 95 | -31 |
| Oil and Gas | 153 | 199 | 46 |
| Emissions-Intensive Trade-Exposed Industries | 80 | 81 | 1 |
| Buildings | 80 | 86 | 6 |
| Agriculture | 74 | 78 | 4 |
| Waste and Others | 54 | 66 | 12 |
| **Total** | **731** | **785** | **54** |

The following outlines in more detail projected trends in GHG emissions by sector and the economic drivers and government measures that affect them.

Transportation

Total transportation emissions are projected to increase by about 16 Mt from 164 Mt in 2005 to 180 Mt by 2020 — a marked deceleration of growth from the historical long-term trend. This deceleration is expected to occur as a result of higher gasoline and refined petroleum prices, and federal light duty vehicle emissions regulations.

Under these regulations, the fuel efficiency of passenger cars will increase by some 20 per cent. The sales-weighted fuel economy of passenger cars on the road is projected to improve from 9.7 to 7.8 litres/100 km by 2020. Likewise, emissions from freight are expected to decrease as a result of various federal, provincial and territorial programs. Under the baseline scenario, the average fuel efficiency of trucks improves from 5.8/100 tonne-km to 5.7 litres/100 tonne-km by 2020. (Note: This scenario does not incorporate the additional impact of upcoming federal regulations on heavy duty vehicles, as the specifics of these proposed regulations were still being finalized at the time the projections were prepared.)

As depicted in Table 4, the transportation sector is comprised of several distinct sectors – passenger, freight and air and others (e.g., rail and marine)[11]. Each sector exhibits different trends and responds to a very different mix of technological options. For example, emissions from passenger transportation are projected to decrease by 5 Mt between 2005 and 2020, while those for ground freight and off-road are projected to grow by 18 Mt.

[11] There are many alternative approaches for treating and grouping the transportation activities. For example, passenger transportation could be included in the residential sectors. Likewise, moving of industrial freight could be included with each industry.

**Table 4 Transportation: emissions and drivers**

| | 2005 | 2008 | 2010 | 2020 |
|---|---|---|---|---|
| *Ground Passenger* | | | | |
| Emissions (Mt $CO_2e$) | 78 | 78 | 79 | 73 |
| kg $CO_2$ eq./100 km – Average Gasoline Vehicle | 24 | 23 | 22 | 19 |
| *Ground Freight and Offroad* | | | | |
| Emissions (Mt $CO_2e$) | 78 | 84 | 80 | 96 |
| kg $CO_2$ eq./100 km – Average Diesel Truck | 70 | 64 | 63 | 63 |
| *Air and Other Emissions (Mt $CO_2e$)* | *8* | *9* | *9* | *11* |
| **Total Emissions (Mt)** | **164** | **171** | **168** | **180** |

Oil and Gas

Upstream Oil and Gas Production

Absent further government action, emissions from upstream oil and gas production, including pipelines but excluding refining and upgrading[12], are estimated to grow from 120 Mt in 2005 to 142 Mt in 2020. This increase is primarily driven by the growth in bitumen production, where emissions are expected to increase from 16 Mt in 2005 to about 52 Mt by 2020.

Over this same period, emissions from conventional crude oil production are expected to fall from 31 Mt in 2005 to 22 Mt in 2020, while those from natural gas production and processing are expected to fall from about 53 Mt in 2005 to 52 Mt by 2020.

Emissions from the pipeline transport of oil and natural gas are expected to fall from about 20 Mt in 2005 to 16 Mt by 2020 (Table 5). The emissions associated with the

[12] Includes natural gas, conventional light and heavy crude oil, and in situ bitumen from oil sands.

upgrading of oil-sands bitumen[13] are expected to rise from 14 Mt in 2005 to 40 Mt by 2020. Further details on emissions from oil-sands upgrading are reported in the section below dealing with the refining industry.

**Table 5 Oil and gas sector: emissions by production type (Mt $CO_2e$)**

| | 2005 | 2008 | 2010 | 2020 | Absolute Change 2005 to 2020 |
|---|---|---|---|---|---|
| **Natural Gas** | **53** | **53** | **47** | **52** | **-1** |
| Light Oil | 9 | 11 | 10 | 8 | -1 |
| Heavy Oil | 21 | 17 | 18 | 12 | -9 |
| Offshore | 1 | 1 | 2 | 2 | 1 |
| **Total Conventional Oil** | **31** | **29** | **30** | **22** | **-9** |
| Oil sands – Bitumen In situ | 9 | 16 | 19 | 34 | 25 |
| Oil sands – Bitumen Mining | 7 | 8 | 9 | 18 | 11 |
| Oil sands – Bitumen Upgrading | 14 | 16 | 21 | 40 | 26 |
| **Total Oil sands** | **30** | **40** | **49** | **92** | **62** |
| **Petroleum Refining** | **19** | **19** | **18** | **17** | **-2** |
| **Pipelines** | **20** | **17** | **15** | **16** | **-4** |
| **Total** | **153** | **158** | **159** | **199** | **46** |

[13] By UNFCC convention, emissions from the production of synthetic crude oil are linked to the petroleum refining industry.

**Table 6 Upstream oil and natural gas production: emissions and drivers**

| | 2005 | 2008 | 2010 | 2020 |
|---|---|---|---|---|
| *Conventional Oil Production* | | | | |
| Emissions (Mt $CO_2e$) | 31 | 29 | 30 | 22 |
| Production (1,000 barrels/day) | 1,359 | 1,352 | 1,239 | 909 |
| *Natural Gas Production and Processing (including Pipelines)* | | | | |
| Emissions (Mt $CO_2e$) | 73 | 70 | 62 | 68 |
| Production (billion cubic foot (BCF)) | 6,820 | 6,316 | 5,537 | 6,204 |
| *Bitumen Production* | | | | |
| Emissions (Mt $CO_2e$) | 16 | 24 | 28 | 52 |
| Production (1,000 barrels/day) | 1,063 | 1,322 | 1,689 | 3,122 |

Petroleum Refining and Upgrading

Table 7 displays emissions associated with petroleum refining and upgrading. As noted above, the greenhouse gas emissions from upgrading bitumen into synthetic crude oil are included in the petroleum refining industry. From 2005 to 2020, emissions from bitumen upgrading are projected to increase by 26 Mt, while emissions from petroleum refining are projected to decline by 2 Mt.

**Table 7 Petroleum refining and upgrading sector: emissions and drivers**

| | 2005 | 2008 | 2010 | 2020 |
|---|---|---|---|---|
| *Traditional Refineries* | | | | |
| Emissions (Mt $CO_2e$) | 19 | 19 | 18 | 17 |
| Refined Petroleum Processed (1,000 barrels/day) | 2,114 | 2,047 | 1,974 | 2,157 |
| *Upgraders* | | | | |
| Emissions (Mt $CO_2e$) | 14 | 16 | 21 | 40 |
| Upgraded Products (1,000 barrels/day) | 612 | 730 | 975 | 1,917 |

Electricity Generation

Emissions from electricity generation and distribution have historically increased over time as a result of the need to increase generating output to supply a growing economy. However, emissions from this sector are now declining, and that trend is expected to continue over the next decade. Between 2005 and 2020, electricity generation emissions are expected to decrease by 31 Mt, from 126 Mt in 2005 to 95 Mt in 2020, primarily as a result of the federal Emissions Performance Standard for coal-fired electricity generation, as well as provincial measures to shift away from coal as a fuel source and measures to encourage the development of renewables.

**Table 8 Electricity sector: emissions and drivers**

| | 2005 | 2008 | 2010 | 2020 |
|---|---|---|---|---|
| Emissions (Mt $CO_2e$) | 126 | 120 | 107 | 95 |
| Generation (TWh) | 608 | 620 | 629 | 734 |

Against a backdrop of decreasing coal power usage, fossil fuel generation is expected to vary with the availability of electricity from hydro, nuclear and renewable power sources such as wind. Hydro power generation is expected to increase throughout

Canada, although the growing demand for electricity in Alberta is expected to continue being met primarily through increased generation from coal and natural-gas-fuelled power plants[14]. On a national level, electricity generation from natural gas, a relatively cleaner form of energy, is expected to more than double between 2005 and 2020.

**Table 9 Electricity generation: emissions by fuel type (Mt $CO_2e$)**

| | 2005 | 2008 | 2010 | 2020 | Change 2005 to 2020 |
|---|---|---|---|---|---|
| Coal | 98 | 96 | 78 | 55 | -43 |
| Refined Petroleum Products | 9 | 5 | 3 | 5 | -4 |
| Natural Gas | 18 | 17 | 24 | 33 | 15 |
| Non-combustion | 1 | 2 | 2 | 2 | 1 |
| **Total** | **126** | **120** | **107** | **95** | **-31** |

The proportion of utility electricity generation coming from wind power and other renewable sources (other than hydro and nuclear) increases in the 2005 to 2020 period, starting at only about 0.6 per cent in 2005 and reaching six per cent of total generation by 2020. These forms of electricity generation are assumed to be emissions free.

Emissions-Intensive and Trade-Exposed Industries

As shown in Tables 10 and 11, emissions in the emissions-intensive trade-exposed (EITE) industries (which includes, among others, pulp and paper, cement, iron and steel - Table 11 provides the full list of these industries) are expected to experience modest growth as the economy recovers in 2010 and onwards. By 2020 emissions are projected to slightly surpass 2005 levels, at 81 Mt.

[14] Note that two new coal fired plants are assumed to be constructed with carbon capture capabilities: one in Saskatchewan (Boundary Dam 3) and the other in Alberta (Keephills 3).

**Table 10 Emissions-intensive and trade-exposed industries: emissions and drivers**

| | 2005 | 2008 | 2010 | 2020 |
|---|---|---|---|---|
| Emissions (Mt $CO_2e$) | 80 | 76 | 66 | 81 |
| Gross Output of EITE sectors (1997 $billions) | 101 | 100 | 85 | 118 |

Emissions remain virtually constant over the 2005 to 2020 projection period in most of the EITE subsectors, owing to modest growth and continued improvements in emission intensities. Emissions are expected to decrease in the pulp and paper subsector as a result of the long-term decline in production already underway in this area.

**Table 11 Emissions-Intensive and trade-exposed industries: emissions by subsector (Mt $CO_2e$)**

| | 2005 | 2008 | 2010 | 2020 | Absolute Change 2005 to 2020 |
|---|---|---|---|---|---|
| Iron Ore Mining | 2 | 2 | 1 | 2 | 0 |
| Non-Metal Mining | 3 | 3 | 4 | 4 | 1 |
| Pulp and Paper | 7 | 5 | 4 | 3 | -4 |
| Cement | 12 | 11 | 11 | 12 | 0 |
| Lime & Gypsum | 3 | 3 | 3 | 3 | 0 |
| Chemicals and Fertilizers | 26 | 26 | 23 | 26 | 0 |
| Iron and Steel | 15 | 15 | 11 | 18 | 3 |
| Aluminium | 9 | 8 | 7 | 10 | 1 |
| Base Metal Smelting | 3 | 3 | 2 | 3 | 0 |
| **Total** | **80** | **76** | **66** | **81** | **1** |

Buildings

Residential

As shown in Table 12, greenhouse gas emissions from the residential sector (e.g., houses, apartments and other dwellings) are expected to increase by 4 Mt between 2005 and 2020, rising to 46 Mt overall.

The number of households, which is a key driver of growth in residential sector emissions, is expected to increase by 2.8 million from 2005 to 2020 but residential emissions are almost flat throughout this period. This is largely due to federal and provincial measures aimed at increasing the energy efficiency of residential buildings (e.g., building code regulations and incentives/rebates for energy efficiency improvements).

**Table 12 Residential sector: emissions and drivers**

| | 2005 | 2008 | 2010 | 2020 |
|---|---|---|---|---|
| Emissions (Mt $CO_2e$) | 42 | 43 | 44 | 46 |
| Households (Millions) | 12.8 | 13.4 | 13.8 | 15.6 |

Commercial

Greenhouse gas emissions from the commercial sector are expected to increase by 2 Mt from 2005 to 2020 to 40 Mt (Table 13), mainly as a result of expansion of commercial floor space. As in the residential sector, emissions growth in the commercial sector is significantly dampened by federal and provincial measures incorporated into this analysis, such as building code regulations, energy efficiency standards, and other programs.

**Table 13 Commercial sector: emissions and drivers**

| | 2005 | 2008 | 2010 | 2020 |
|---|---|---|---|---|
| Emissions (Mt $CO_2e$) | 38 | 36 | 36 | 40 |
| Floor space (Millions $m^2$) | 654 | 700 | 732 | 902 |

Agriculture

The agriculture sector produces emissions of three greenhouse gases: carbon dioxide, methane and nitrous oxide. Carbon dioxide comes from fossil fuel combustion in farm machinery and losses in soil organic matter. Methane comes from livestock manure and ruminant animals. Nitrous oxide comes from fertilizer usage, crops and manure.

While agriculture contributes some 10% of Canadian GHG emissions, it also has major potential for present and future carbon sequestration through practices such as " no-till" cultivation; and strategies to manage and capture emissions from livestock manure could help reduce overall emissions, while having the potential to provide a renewable source of electricity generation.

**Table 14 Agriculture sector: emissions (Mt $CO_2e$)**

| | 2005 | 2008 | 2010 | 2020 |
|---|---|---|---|---|
| **Agriculture** | | | | |
| Fuel Combustion | 12 | 13 | 12 | 14 |
| Non-Energy[15] | 62 | 63 | 63 | 64 |
| **Total – Agriculture** | **74** | **76** | **75** | **78** |

Waste and Others

This sector includes emissions from waste management as well as from non-emissions-intensive industrial sectors.

Emissions from waste management come from three sources: emissions from the decomposition of solid waste in landfill sites, emissions from waste in water and incineration of solid wastes. These emissions represent 3 percent of total GHG emissions. For these emissions, population and households are the main drivers. Provincial measures aimed at recycling and emissions capture from landfill sites are projected to help keep emissions growth below the growth in population and household formation.

[15] Includes emissions not related to energy use such as methane from livestock manure and ruminant animals and nitrous oxide from fertilizer usage, crops and manure.

Emissions from other industrial sectors represent a wide variety of operations and include construction, forestry as well as light-manufacturing facilities (e.g. food and beverage, and electronics). These industries are projected to grow significantly in the future, leading to expected emissions growth of 8 Mt between 2005 and 2020.

**Table 15 Waste and Others: emissions (Mt $CO_2e$)**

| | 2005 | 2008 | 2010 | 2020 |
|---|---|---|---|---|
| **Waste** | | | | |
| Solid Waste | 20 | 21 | 21 | 24 |
| Waste Water and Incineration | 1 | 1 | 1 | 1 |
| **Total – Waste** | **21** | **22** | **22** | **25** |
| | | | | |
| **Others** | | | | |
| Light Manufacturing | 27 | 27 | 27 | 34 |
| Construction | 4 | 4 | 4 | 5 |
| Forestry | 2 | 2 | 2 | 2 |
| **Total – Others** | **33** | **33** | **33** | **41** |
| | | | | |
| **Total Waste and Others** | **54** | **55** | **55** | **66** |

# Government Measures and GHG Emissions

Canada's target of reducing greenhouse gas emissions 17 per cent below 2005 levels by 2020 requires that emissions decline to 607 Mt by 2020.

So far, federal and provincial governments have taken significant measures to reduce emissions. Existing federal initiatives include fuel efficiency regulations for light-duty vehicles, renewable fuels standards, and the Emissions Performance Standard for coal-fired electricity. Provinces and territories have also taken action within their respective jurisdictions, through a wide range of measures. Some notable examples include: British Columbia's carbon tax, Alberta's industrial regulations, Nova Scotia's regulation of electricity GHG emissions, Ontario's phase-out of coal-fired electricity and Quebec's carbon levy. Additional details on these existing federal and provincial measures are provided in Annex 1.

The baseline scenario for GHG emissions takes into account the impact of these existing measures on emissions.

Figure 5 indicates that these existing measures would limit GHG emissions in 2020 to about 785 Mt. It shows that significant progress in reducing 2020 emissions has been achieved by existing measures. Without government measures, emissions in 2020 would be 65 Mt higher, and would reach 850 Mt. Each level of government has contributed in roughly equal measure to the overall reduction in emissions to date.

**Figure 5 Baseline Emissions Scenario with and without Government Actions**

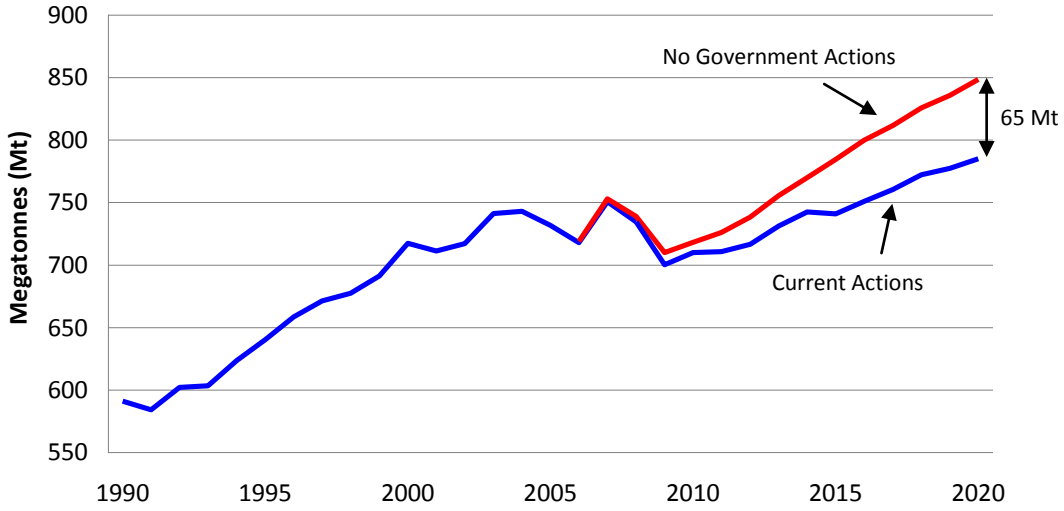
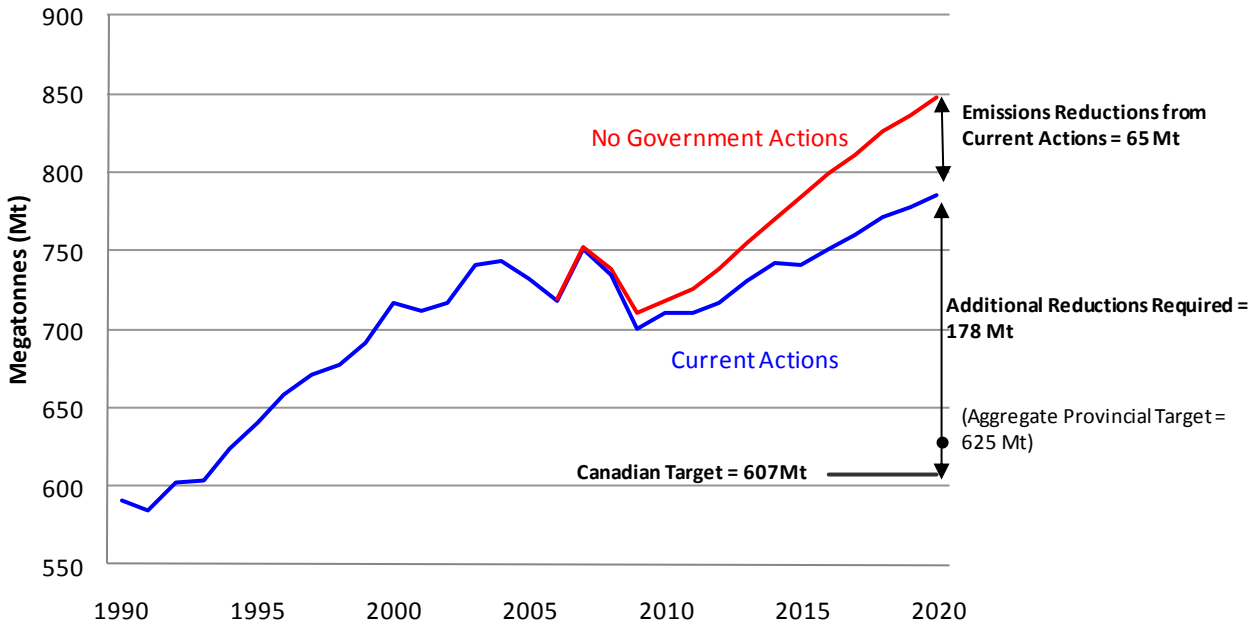



Figure 6 shows that the reduced emissions including current measures are still higher than Canada's target of 607 Mt, and further federal and provincial measures are required in order to generate the additional 178 Mt in emission reductions needed to achieve that objective.

The 65 MT in reductions by 2020 from existing federal and provincial measures represent about one quarter of the reductions needed to achieve the target of 607 Mt by 2020. At the same time, each province in Canada has adopted emissions reduction targets for their respective jurisdictions (a list of targets is available in Annex 1). Adding up provincial government targets for GHG emissions across the country results in an aggregate provincial target for GHG emissions of 625 Mt in 2020. This aggregate provincial target is only slightly higher than the Canadian target of 607 Mt.

More work is required to achieve the reductions required to meet the Canadian target, and more work is also required to meet the aggregate provincial target. At the federal level work is underway that will lead to additional reductions. As the government advances additional measures under its climate change plan, future emission reductions will continue to accumulate, thereby pushing projected emissions in 2020 down to the levels required to meet the 2020 target. For example this scenario includes the impact of light-duty vehicle regulations for model years 2011 to 2016, but the impact of the second phase of light-duty vehicle regulations starting in 2017, and heavy-duty vehicle regulations starting in 2014, have not yet been included. Once the details of these measures have been announced and they are taken into account in the baseline scenario, projected emissions in 2020 will decline further below the projected levels shown here. Similarly, once additional measures in other sectors and additional provincial actions are announced and taken into account, projected emissions in 2020 will decline further.

**Figure 6 Scenarios of Canadian Emissions to 2020 (Mt $CO_2e$)**



# ANNEX 1:

## Baseline Data and Assumptions

### Key Economic Drivers and Assumptions

Economic assumptions are based on the Government of Canada's short-term economic outlook contained in Finance Canada's October 2010 Update of Economic and Fiscal Projections. Long-term economic projections were developed using *The Informetrica Macro-Economic Model* (TIM) and are tuned to productivity growth projections developed in consultation with Finance Canada officials and Statistics Canada's population growth projections. With respect to major energy supply project assumptions, Environment Canada typically adopts either the National Energy Board or Natural Resources Canada's view regarding the evolution of Canada's energy supply sector. For the emissions outlook in this report, forecasts of major energy supply projects are based on consultation with Natural Resources Canada, as their assumptions reflect their most recent views regarding the evolution of Canada's energy supply sector.

Many factors influence the future trends of Canada's greenhouse gas emissions. These key factors include the pace of foreign and domestic economic growth as well as its composition, population and household formation, energy prices (e.g., world oil price and price of refined petroleum products, regional natural gas prices, and electricity prices), technological change, and policy decisions. Varying any of these assumptions could have a material impact on the emissions outlook.

In constructing the emissions projections, Environment Canada developed alternative views of changes in key drivers (e.g., world oil price, the pace of economic recovery) that result in a range of plausible emissions growth trajectories. The baseline emissions projections scenario represents the mid-range of these variations, but remains conditional on the future path of the economy, world energy markets and government policy. The assumptions used about key drivers are listed in this section. Alternative cases are explored in the sensitivity analysis in Annex 2 of the paper.

The emissions projections baseline scenario is designed to incorporate the best available information about economic growth as well as energy demand and supply into the future. The projections capture the impacts of future production of goods and services in Canada on greenhouse gas emissions.

Economic projections were developed using *The Informetrica Limited Macroeconomic Model* (TIM), with the economic assumptions calibrated to Finance Canada's October 2010 Update of Economic and Fiscal Projections for the period 2010-2014. The longer-term projections are tuned to productivity growth projections developed in consultation with Finance Canada officials and Statistics Canada's population growth projections.

Similarly, forecasts of major energy supply projects (e.g., oil sands production, large hydro capacity expansions, nuclear refurbishments) from Natural Resources Canada were used; these forecasts are based on consultations with experts and reflect the

most recent views regarding the evolution of Canada's energy supply sector. The projections also incorporate data from the National Greenhouse Gas Emissions Inventory, the National Energy Board, and the U.S. Energy Information Administration for the latest information on key parameters.

## Economic Growth

Canadian real gross domestic product (GDP) in 2008 was an estimated $1,100 billion ($1997). This represents an average annual real GDP growth rate of about 2.7 per cent over the 16 previous years.

The short-term economic outlook underlying the emissions reference case is grounded in the GDP growth forecast contained in Finance Canada's October 2010 Update of Economic and Fiscal Projections. The Department of Finance regularly surveys private sector economic forecasters on their views on the outlook for the Canadian economy. The economic forecasts reported in this fiscal update, and which form the basis of the department's fiscal forecasts, are based on a survey from September 2010 and includes the views of 15 private sector economic forecasters[16].

The Canadian economy is expected to show strong growth of about 2.6 per cent per year following the end of the recession until 2014. This growth is expected to continue at a slightly slower pace into the future, as annual rate of growth in real GDP decreases to approximately 2.2 per cent in the period 2014 to 2020.

**Table A1.1 Macroeconomic assumptions: 1990-2020 average annual growth rates (%)**

| | 1990-2008 | 2008-2010 | 2010-2020 |
|---|---|---|---|
| **Gross Domestic Product in $97** | 2.7% | -0.7% | 2.4% |
| **Industrial Gross Output in $97** | 2.5% | -1.1% | 2.6% |
| **Real Disposable Personal Income in $97** | 2.3% | 1.7% | 2.1% |
| **Consumer Price Index** | 2.1% | 0.6% | 2.7% |

[16] In October 2010, the Department of Finance released an Update of Economic and Fiscal Projections. Based on the September "Consensus Forecast", the pace of economic growth for 2010 was more robust than the projected pace underlining the budget (2.6% vs. 3.0%). Despite the higher growth for 2010, the average pace of growth for the 2010-2014 period is comparable to the growth under Budget 2010.

Gross output, which is a proxy for industrial production, is also projected to show significant growth. It is expected to increase by about 13 per cent by 2015 and 27 per cent by 2020, relative to 2008 levels.

The growth in the labour force and changes in labour productivity influence the changes in Canada's real gross domestic product (GDP). For example, the slowing growth in the labour force contributes to a reduced GDP growth rate after 2014. The deceleration of the GDP growth rate is, however, not as pronounced as that of the labour force, as labour productivity is expected to increase owing to higher capital formation. Labour productivity is expected to increase on average by one per cent per year between 2008 and 2020.

## Population Dynamics and Demographics

The population size and its characteristics (e.g., age, sex, education, household formation, among others), and their evolution through time, have important impacts on energy demand. Canada's overall population is projected to grow on average at an annual rate of one percent between 2008 and 2015, slowing to 0.9 per cent between 2015 and 2020. Major demographic factors that can have measurable impacts on energy consumption are summarized below in the three following variables:

- *Household formation*. This is the main determinant of energy use in the residential sector. Households are expected to increase on average by 1.4 per cent per year between 2008 and 2015, by 1.1 per cent between 2015 and 2020.

- *Labour force*. This is expected to have a decelerating growth rate, reflecting the aging population. Its annual average growth rate is expected to be 0.9 per cent for the period ending in 2020.

- *Population of driving age*. This is an important factor in determining gasoline and diesel consumption. It is expected to increase on average by 1.2 per cent per year between 2008 and 2015, by 0.9 per cent between 2015 and 2020.

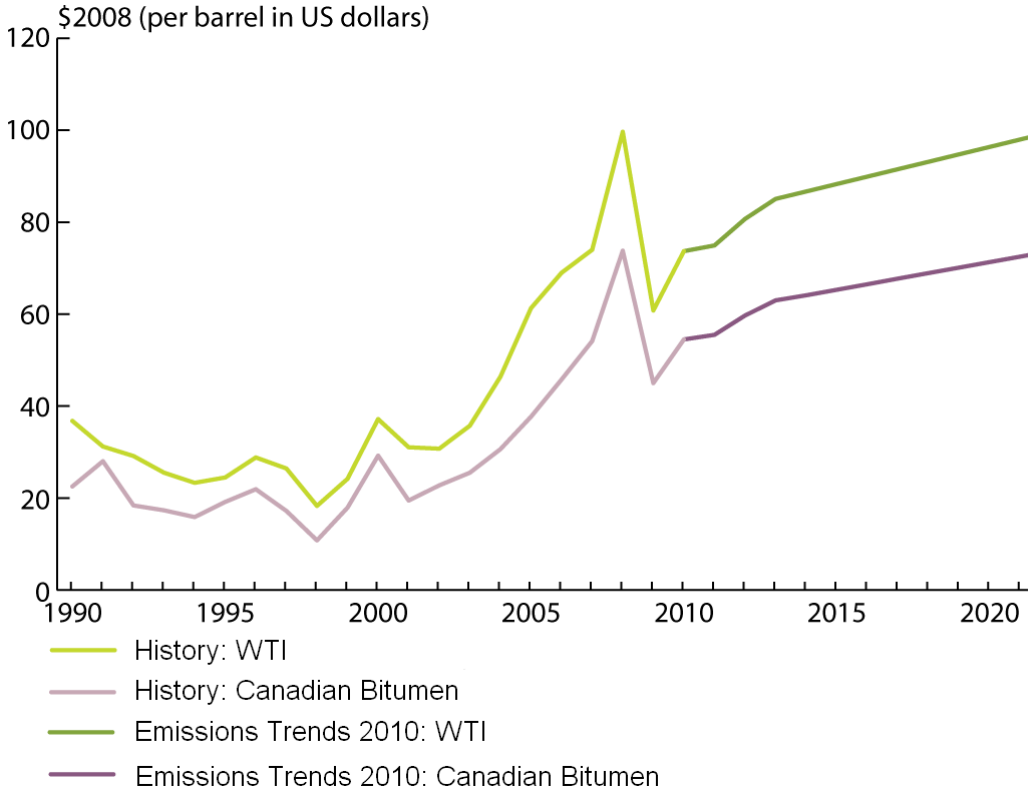
## World Crude Oil Price

A major factor in projected greenhouse gas emissions is the assumption made about future world oil prices. With respect to crude oil prices Canada is a price taker, as its shares of world oil production and consumption are not large enough (4% and 2% respectively) to significantly influence international oil prices. West Texas Intermediate (WTI) crude oil is used as an oil price benchmark. North American crude oil prices are determined by international market forces and are most directly related to the WTI crude oil price at Cushing, which is the underlying physical commodity market for light crude oil contracts for the New York Mercantile Exchange (NYMEX).

WTI crude has an American Petroleum Institute gravity[17] (API) of 40 degrees and a sulphur content of less than 0.5 per cent.

The emissions outlook's reference case is anchored by the world oil price assumptions developed by Natural Resources Canada. According to Natural Resource Canada, the world crude oil price for WTI is projected to rebound following the global recession, decreasing slightly from about US$100/bbl in 2008 to about $US96/bbl in 2020. A higher price scenario, in which 2020 prices are $US186/bbl, is used for sensitivity analysis. Under the higher price case, greenhouse gas emissions are expected to be higher.

**Figure A1.1 Crude Oil Price: WTI and Canadian Bitumen**



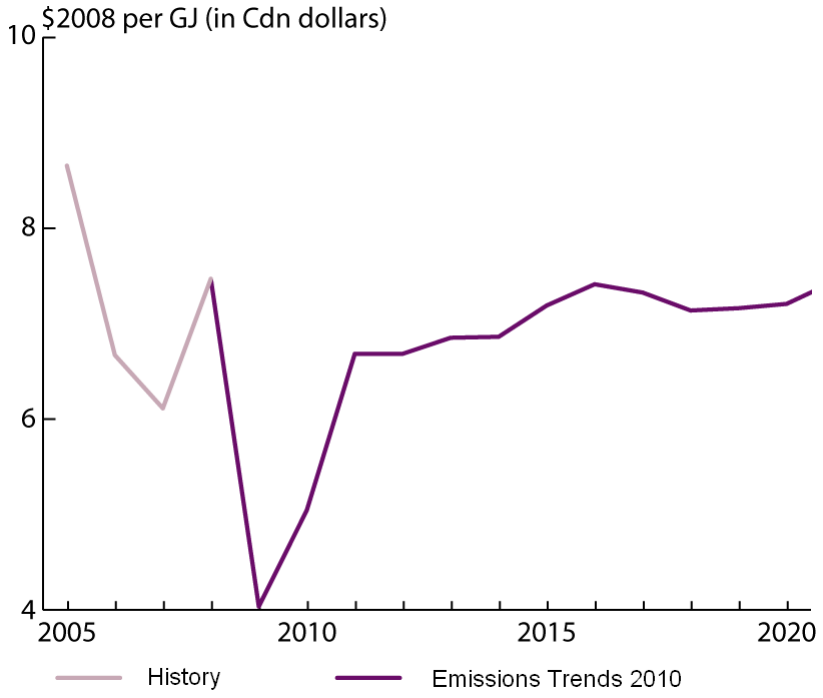

As shown in Figure A1.1, historically the price of heavy oil/bitumen has followed the light crude oil price (WTI), but at a discount of between 50 and 60 per cent. However, in 2008 and 2009 the differentials between the prices of light and heavy crude oils narrowed significantly owing to a global shortage of heavier crude oil supply. The bitumen/light-medium differential averaged 22 per cent over the 2008 to 2009 period, compared with 44 per cent over the five-year average from 2003 to 2007.

[17] API gravity is a measure of how heavy or light a petroleum liquid is compared to water

Alberta's Energy Resources Conservation Board expects the bitumen/light-medium differential to average 26 per cent over the forecast period, compared with the five-year average of 36 per cent and the 2009 average of 17 per cent.[18] Using this price difference, the bitumen price is decreasing slightly from about US$86/bbl in 2008 to about $US71/bbl in 2020.

As shown in Figure A1.2, the wellhead price for natural gas in Alberta (the benchmark for Canadian prices) declines in 2009 to about four Canadian dollars per gigajoule (GJ), and then begins to recover to reach 7.2 Canadian dollars per GJ by 2020. This reflects Natural Resource Canada's assumptions regarding pipeline expansions (e.g., Mackenzie and the Alaska pipelines).

**Figure A1.2** Wellhead Natural Gas Price in Alberta




## Energy Production

Historically, growth has occurred in all areas of oil and gas production, with over half the growth coming from natural gas production. However, our projections show that both natural gas and conventional oil production will decrease over time as a result of declining supply, but that the increase in production from oil sands operations will more than make up for this decline. As such, under assumed prices and absent further government policy actions, it is expected that from 2008 to 2020 oil sands in situ production will almost triple and oil sands mining production will more then double,

[18] http://www.ercb.ca/docs/products/STs/st98_current.pdf

while light oil production will drop 30 percent over the same period (see Table A1.2, below).

**Table A1.2 Change in crude oil production**

| Thousand Barrels Per Day | 2008 | 2010 | 2020 |
|---|---|---|---|
| Crude and Condensates | | | |
| Conventional Heavy | 361 | 371 | 234 |
| Conventional Light | 632 | 583 | 454 |
| C5 & condensates | 152 | 133 | 149 |
| Frontier Light (offshore + northern) | 360 | 286 | 220 |
| Oil Sands – Primary | 178 | 178 | 184 |
| Oil Sands – In-situ | 422 | 599 | 1,152 |
| *SAGD* | 174 | 313 | 858 |
| *CSS* | 248 | 286 | 294 |
| Oil Sands Mining | 723 | 913 | 1,786 |
| **Total Production (gross)** | **2,828** | **3,063** | **4,179** |

Table A1.3 illustrates oil sands disposition. There are two main products from oil sands production: synthetic crude oil (or upgraded bitumen) and non-upgraded bitumen, which is sold as heavy oil. Synthetic crude oil production (Table A1.3) from Alberta is projected to increase from about 660,000 barrels per day in 2008 to about 1.8 million barrels per day by 2020. Synthetic crude oil from Saskatchewan is projected to increase modestly from 70,000 barrels per day in 2008 to 85,000 per day in 2020. Non-upgraded bitumen will increase from 571,000 barrels per day in 2008 to 1.1 million barrels per day by 2020. This non-upgraded bitumen is either sold as heavy oil to Canadian refineries or transported to U.S. refineries for upgrading to refined petroleum products.

**Table A1.3 Change in oil sands disposition**

| Thousand Barrels Per Day | 2008 | 2010 | 2020 |
|---|---|---|---|
| Synthetic – Alberta | 660 | 905 | 1,832 |
| Synthetic – Saskatchewan | 70 | 70 | 85 |
| Non-upgraded Bitumen | 571 | 670 | 1,113 |
| Own use | 22 | 45 | 92 |
| **Oil Sands (net)** | **1,301** | **1,645** | **3,030** |

Natural gas production (Table A1.4) is expected to decline modestly over the forecast period, from 6.2 trillion cubic feet (TCF) in 2008 to about 5.4 TCF in 2010. Projections will increase to some 6.1 TCF in 2020, as new production and non-conventional sources such as shale gas and coal-bed methane come to market[19].

**Table A1.4 Change in natural gas production**

| Billion Cubic Feet | 2008 | 2010 | 2020 |
|---|---|---|---|
| Supply | | | |
| Gross Production | 6,188 | 5,425 | 6,078 |
| Own-use Consumption | 532 | 501 | 532 |
| Marketable Gas | 5,656 | 4,924 | 5,546 |
| Imports | 427 | 427 | 427 |
| **Total Supply** | **6,083** | **5,351** | **5,973** |

[19] For the purposes of this document, shale gas development has been included under natural gas production. As more data and information on likely shale gas production trends become available, consideration will be given to modelling shale gas production projections separately.

The emissions outlook reflects plans by provincial and territorial utilities with respect to key electricity capacity expansions.

Taking into account these provincial utility expansion plans, plus additional units forecast to be built by Environment Canada's Energy, Emissions and Economy Model for Canada (E3MC) to meet growth in electricity demand, aggregate electricity generation is also expected to increase substantially, by about 17 per cent from 2008 to 2020, with fuel mix changes as generation increases. Table A1.5 describes, based on assumed policy support, that the proportion of generation coming from wind power and other renewable sources is expected to increase from 2005 to 2020, starting at only about 0.6 per cent in 2005 and reaching six per cent of total generation by 2020. Importantly, though, the proportion of natural gas-fired generation is projected to more than double from its 2005 levels.

Government actions, such as the introduction of the Electricity Performance Standard, will cause fuel switching in the overall generating portfolio. As noted above, it is expected that natural gas-fired generation will more than double from its 2008 levels by 2020, because of its appeal as a relatively cleaner source of power generation and a means to cover peak loads. Coal and petroleum coke generation fall from 17 per cent of the generation in the Canadian portfolio to eight per cent in 2020.

**Table A1.5 Electricity generation by fuel**

| TWh | 2008 | 2010 | 2020 |
|---|---|---|---|
| Coal and Petroleum Coke | 104 | 82 | 60 |
| Refined Petroleum Products | 5 | 3 | 4 |
| Natural Gas | 23 | 42 | 65 |
| Hydro | 377 | 381 | 447 |
| Nuclear | 91 | 90 | 88 |
| Other Renewables | 3 | 12 | 44 |
| **Total Generation** | **603** | **610** | **708** |

## Emissions Factors

Table A1.6 provides a rough estimate of carbon dioxide emitted per unit of energy consumed by fossil fuel type. These numbers are only estimates, as specific emission factors can vary slightly by year, sector, and province.

**Table A1.6 Mass of carbon dioxide emitted per quantity of energy for various fuels**

| Fuel name | $CO_2$ eq. emitted ($g/10^6$ J) |
|---|---|
| Natural gas | 49.7 |
| Liquefied petroleum gas | 61.0 |
| Non-marketable natural gas | 66.5 |
| Propane | 59.8 |
| Aviation gasoline | 69.6 |
| Automobile gasoline | 67.6 |
| Kerosene | 67.3 |
| Light fuel oil | 70.3 |
| Heavy fuel oil | 74.0 |
| Tires/tire-derived fuel | 80.8 |
| Wood and wood waste | 0[20] |
| Coal (bituminous) | 88.1 |
| Coal (subbituminous) | 91.6 |
| Coal (lignite) | 92.4 |
| Petroleum coke | 86.4 |
| Coal (anthracite) | 97.6 |

[20] While the emissions intensity of burning wood is 81.26, biofuels such as wood can be considered carbon-neutral since carbon dioxide was absorbed from the atmosphere as the trees were growing.

## Federal, Provincial and Territorial Measures

Domestically, since 2006, a range of instruments have been deployed to combat climate change. Significant investments have been made in renewable energy, incentives have been put in place to accelerate the development and deployment of green technologies and practices, regulations are being enacted to reduce emissions from key sources, and joint initiatives and investments have been undertaken with the provinces and territories to assist them in addressing their unique challenges and to facilitate coordinated approaches.

Table A1.7 below identifies the major federal, provincial and territorial measures that are included in the Emissions Outlook's Reference Canada. It includes federal measures that have been implemented or announced in detail as of November 2010. Where program funding is set to end, the projections assume that the impacts of these programs, other than those embodied in consumer behaviour, cease when the approved funding terminates.

The analysis also includes existing provincial and territorial measures: Environment Canada monitors provincial/territorial initiatives, and strives to take them into account in its analysis and modeling (for the purposes of this report, provincial measures announced and fully implemented as of March 31, 2010 have been included wherever possible).

While the emissions outlook's baseline scenario includes those existing measures that have been implemented or announced in specific detail, it does not take into account the impact of broader strategies or future measures within existing plans where significant details are still under development.

The federal government's climate change plan involves the development of measures to address emissions on a sector by sector basis, and some measures under development as part of this plan have not yet been included in the baseline scenario: for example, the government has committed to regulate the emissions of heavy duty vehicles starting in 2014, but the details of the regulations are being finalized, so it is not yet included.

Similarly, broad provincial policy initiatives such as the B.C. Energy Plan, Manitoba's Beyond Kyoto plan, and provincial announcements associated with regional emissions trading regimes (e.g., Western Climate Initiative) are not taken into account in the baseline scenario.

Some of the key existing federal measures that have been taken into account in the baseline scenario include:

1. Performance Standard for Coal-Fired Electricity Generation – In June 2010, the Government announced its intention to regulate for coal-fired electricity generation. The proposed regulations will impose a performance standard on new coal-fired electricity generation units and those units that have reached the end of economic life. The new regulations, which are scheduled to take effect in 2015, will encourage electric utilities to transition towards lower- or non-emitting types of generation. The proposed regulations send a critical signal to industry in

advance of expected significant capital stock turnover. By affecting capital investment decisions now, the regulations will help avoid a legacy of higher-emitting facilities being built. The gradual phase-out of old and dirty coal units is expected to significantly reduce emissions from the electricity generation sector and improve air quality for all Canadians.

2. Passenger Automobile and Light Truck Greenhouse Gas Emission Regulations – In October 2010, the Government published its final *Passenger Automobile and Light Truck Greenhouse Gas Emission Regulations*, which establish progressively stringent standards, harmonized with the U.S., for GHG emissions from new cars and light trucks for the 2011 to 2016 model years. The Government has also signaled its intent to continue working with the U.S. on the development of progressively more stringent standards for new cars and light trucks of the 2017 and later model years.

3. Renewable Fuels Regulations – In 2006, as part of the Renewable Fuels Strategy, the Government of Canada announced its intention to regulate an annual average renewable fuel content of five per cent in gasoline by 2010, and in a second phase, a two percent requirement for renewable content in diesel fuel and heating oil by 2011. The first phase of the Strategy concerning gasoline came into force December 15, 2010. When fully implemented, the Strategy's two regulatory requirements combined with provincial regulations will ensure a total volume of renewable fuel that will reduce annual greenhouse gas emissions by up to four Mt --about the equivalent of taking one million vehicles off the road.

4. Energy efficiency regulations, codes and standards for buildings and homes – The Government continues to update and strengthen energy efficiency standards for products under the *Energy Efficiency Act* and is working with provinces to update the National Energy Code for Buildings. These actions, combined with targeted incentive programs, have proven to be effective at reducing energy use and GHG emissions in this sector.

For detailed information about existing federal measures see the May 2010 Environment Canada report, "A Climate Change Plan for the Purposes of the *Kyoto Protocol Implementation Act.*"

## Table A1.7 Measures covered by the projections

| Provincial/Territorial Measures[21] | Federal Measures[22] |
|---|---|
| • Ontario Coal Phase Out<br>• Ontario Feed-In-Tariff Energy Efficiency Standards<br>• B.C. Carbon Tax<br>• Alberta's Industrial Regulations<br>• Quebec's Carbon Levy<br>• Nova Scotia's Cap on Electricity Sector GHG Emissions<br>• Building Code Regulations<br>• Various energy efficiency standards and rebates across provinces | • Passenger Automobile and Light-Duty Truck Emissions Regulations<br>• Electricity Performance Standards<br>• Strengthened Energy Efficiency Standards<br>• Renewable Fuels Content Regulation (5% ethanol)<br>• ecoENERGY for Renewable Power<br>• ecoENERGY Retrofit Initiative<br>• ecoENERGY for Buildings and Houses<br>• ecoENERGY for Industry<br>• ecoFreight Program<br>• ecoTechnology for Vehicles Program<br>• ecoENERGY for Fleets<br>• ecoMobility |

[21] Environment Canada is continually researching new provincial/territorial initiatives. Very recent provincial/territorial measures may not be incorporated in this report. New initiatives will continue to be included in our analysis as information becomes available.

[22] For detailed information about specific Federal government regulatory and other policy initiatives see the following:

"A Climate Change Plan for the Purposes of the *Kyoto Protocol Implementation Act 2010.*"
http://www.climatechange.gc.ca/default.asp?lang=En&n=4044AEA7-1

Light duty trucks: http://www.ec.gc.ca/default.asp?lang=En&n=714D9AAE-1&news=3C7732ED-B2B7-4E45-8A54-A495500E58DB

Quality Fuels: http://www.ec.gc.ca/default.asp?lang=En&n=714D9AAE-1&news=AA10549F-E7DA-4568-8F35-B20BE581FCBC

Energy Efficiency: http://www.ec.gc.ca/default.asp?lang=En&n=714D9AAE-1&news=A1966AC2-3E88-44D3-AE52-79482FB5B583

Electricity Performance standards: http://www.ec.gc.ca/default.asp?lang=En&n=714D9AAE-1&news=E5B59675-BE60-4759-8FC3-D3513EAA841C

**Federal Measures (contd)**

- Public Transit Tax Credit
- ecoENERGY for Renewable Heat
- ecoAUTO Rebate Program
- ecoENERGY for Personal Vehicles Initiative
- National Vehicle Scrappage Program
- Marine Shore Power Program
- Renewable Fuels Development
- ecoENERGY for Biofuels Initiative
- ecoAGRICULTURE Biofuels Capital Initiative
- Technology Development and Deployment
- ecoENERGY Technology Initiative

**Table A1.8 Announced 2020 GHG Reduction Targets of Provincial governments (only announced and implemented measures under these targets are included in projections)**

| Province/Territory | Target |
|---|---|
| British Columbia | 33% below 2007 |
| Alberta | 50 Mt below BAU |
| Saskatchewan | 20% below 2006 |
| Manitoba | 15% below 2005 |
| Ontario | 15% below 1990 |
| Quebec | 20% below 1990 |
| New Brunswick | 10% below 1990 |
| Nova Scotia | 10% below 1990 |
| Newfoundland[23] | 10% below 1990 |
| Prince Edward Island[19] | 10% below 1990 |

[23] 19, Under the auspices of the Conference of New England Governors and Eastern Canadian Premiers (NEG-ECP) partnership, the four Atlantic provinces committed to a regional goal of achieving 10% below 1990 levels by 2020. Prince Edward Island and Newfoundland have not established their own official provincial emissions reduction targets, so the common NEG-ECP target is applied to them for the purposes of this analysis.

# ANNEX 2:

## Alternate Emissions Scenarios

Emissions projections are subject to uncertainty, and are most appropriately viewed as a range of plausible outcomes. Many of the events that shape emissions and energy markets cannot be anticipated. In addition, future developments in technologies, demographics, and resources cannot be foreseen with certainty. Typically, these key uncertainties are addressed through alternative cases.

The sensitivity analysis presented here focuses on two key uncertainties:

- The growth of the economy
- The evolution of world oil prices and their impacts on macroeconomic growth and energy consumption

The emissions outcomes of these alternative cases are presented as stand-alone and in combinations in Table A2.1.

**Table A2.1 Sensitivity analysis – change in GDP and/or world oil price**

| Cases | GHG emissions (in Mt $CO_2$ e.) | |
|---|---|---|
| | **2015** | **2020** |
| Low GDP | 733 | 768 |
| High GDP | 754 | 810 |
| Low World Oil Prices | 726 | 764 |
| High World Oil Prices | 764 | 817 |
| Low GDP - Low World Oil Prices | 716 | 747 |
| High GDP - High World Oil Prices | 775 | 839 |
| Baseline Scenario | 741 | 785 |
| Sensitivity Results | 716 - 775 | 747 - 839 |

The higher GDP case assumes stronger economic growth in the goods producing sector. By 2020, Canadian GDP in the high GDP case is some 29 per cent higher than 2008 levels, compared with 25 per cent higher in the baseline scenario.

By 2020, Canadian GDP in the low GDP case is some 21 per cent higher than 2008 levels, compared with 25 per cent higher in the baseline scenario.

In the baseline scenario, the world oil price is projected to grow from $70/bbl ($US) in 2010 to $96/bbl ($US) in 2020. A higher price scenario, in which 2020 prices are $US186/bbl, is used alone and in combination with different GDP growth assumptions. A low price scenario is also included where the world oil price remains fairly stable at $US52/bbl after 2015.

Greenhouse gas emissions in the "high-GDP/high oil price" scenario are about 18 per cent higher in 2020 than 2010 levels. This compares with 11 per cent higher in the baseline scenario over the same period. As economic activity increases, there will unquestionably be a higher demand for energy and a corresponding increase in emissions. In contrast, emissions are expected to be much lower if the Canadian economy grows at a slower pace. Emissions could be as little as 5 per cent higher than 2010 levels by 2020, compared with 11 per cent higher in the baseline scenario. Expected growth of the economy is the primary driver of expected emission growth. Any variation in this path will lead to a different set of projections about expected future emissions.

The growth in emissions is expected to slow down as the world price of oil increases since overall economic activity would decline as the price of oil rose. However, the increase in price drives higher production in the oil and gas sectors, resulting in increased emissions from this sector in the high world oil price case, where emissions rise by 129 Mt from 2010 to 2020; whereas they only rise by 75 Mt in the baseline scenario and by 37 Mt in the low price scenario.

The range in projected emissions from all scenarios rises as we extend our projection further into the future. The strong assumptions made about the growth in Canadian GDP and the future world oil price can alter 2020 emission projections by up to 92 Mt.

Under all scenarios over the forecast period, emissions are expected to grow the fastest in oil sands extraction and upgrading. Electricity generation and the conventional oil and gas sectors are projected to see an emissions decrease. Emission changes in the transportation sector show a deceleration from the long-term growth trend in all scenarios.

Emissions from the electricity sector could decrease by as much as 33 Mt—or as little as 26 Mt—over the 2005 to 2020 projection period, depending on the assumptions used. The baseline scenario projects that electricity emissions would fall by 31 Mt.

The oil sands sector displays the fastest growth in emissions, but it also displays the greatest range of uncertainty about future emissions depending on the assumptions used. Emissions could rise by as much as 76 Mt—or as little as 28 Mt—over the 2005 to 2020 period. The baseline scenario projects that oil sands emissions would increase by 36 Mt.

# ANNEX 3:

## Methodology for Development of Emissions Scenarios

The scenarios developed to support Environment Canada's GHG emissions projections derive from a series of plausible assumptions regarding, among others, the level of continuing population and economic growth, prices, demand and supply of energy, and the evolution of energy efficiency technologies. The projections also assume no further government actions to address greenhouse gas emissions beyond those already in place or imminently pending as of November, 2010.

The emissions projections presented in this report cannot be viewed as a forecast or prediction of emissions at a future date. Rather, this report presents a simple projection of the current structure and policy context into the future, without attempting to account for the inevitable but as yet unknown changes that will occur in government policy, energy supply, demand and technology, or domestic and international economic and political events.

The emissions projections have been developed in line with generally recognized best practices. It incorporates IPCC standards for estimating greenhouse gas emissions across different fuels and processes, relies on outside expert views and the most up-to-date data available for key drivers such as economic growth, energy prices, and energy demand and supply, and applies an internationally recognized energy and macroeconomic modelling framework in the estimation of emissions and economic interactions. Finally, the projections and underlying assumptions have been subject to peer review by leading external experts on economic modelling and greenhouse gas emissions projections, as well as vetted with key stakeholders.

The approach to developing Environment Canada's Emissions Trends involves three main features:

- Using the most up-to-date statistics on GHG emissions and energy use, and sourcing key assumptions from the best available public and private expert sources
- Developing scenarios of emissions projections using a detailed, proven Energy, Emissions and Economy Model for Canada
- Consulting with industry experts on detailed results, and engaging external experts for peer review of overall results and methodologies

### Up-to-date Data and Key Assumptions

Each year, Environment Canada updates its models using the most recent data available from Statistics Canada's Report on Energy Supply-Demand and Environment Canada's National Inventory Report. For these projections, the most recent historical data available were for 2008.

In addition to the most recent historical information, the projections are based on expert-derived expectations of key drivers (e.g. world oil price). These assumptions are based on the latest energy and economic data, with key modeling assumptions aligned to Government of Canada views:

- Economic growth from Finance Canada's October 2010 Update of Economic and Fiscal Projections
- productivity growth projections estimated in consultation with Finance Canada officials,
- Statistics Canada's population growth projections,
- National Energy Board and/or Natural Resources Canada's (NRCan) views on energy prices and large scale energy projects).

Even with the benefit of external expert assumptions, there is considerable uncertainty surrounding energy price and economic growth assumptions, particularly over the medium- to long-term. As such, a range of emissions is presented representing a series of sensitivity analyses. These cases were based on high and low GDP growth as well as high and low oil prices and productions levels.

## Energy, Emissions and Economy Model for Canada

The projections presented in this chapter were generated from Environment Canada's Energy, Emissions and Economy Model for Canada, also known as E3MC. This represents a departure from previous reports, which were based on projections developed by Natural Resources Canada. Although the modeling structure used to generate the emissions forecast is different, the methodological approach is similar.

E3MC has two components: Energy 2020, which incorporates Canada's energy supply and demand structure, and The Informetrica Model (TIM), a macroeconomic model of the Canadian economy.

- Energy 2020 is an integrated, multi-region, multi-sector North American model that simulates the supply, price and demand for all fuels. The model can determine energy output and prices for each sector, both in regulated and unregulated markets. It simulates how such factors as energy prices and government measures affect the choices that consumers and businesses make when they buy and use energy. The model's outputs include changes in energy use, energy prices, greenhouse gas emissions, investment costs and possible cost savings from measures, which are used to identify the direct effects stemming from greenhouse gas reduction measures. The resulting savings and investments from Energy 2020 are then used as inputs into TIM.
- The Infometrica Model is used to examine consumption, investment, production, and trade decisions in the whole economy. It captures the interaction among industries, as well as the implications for changes in producer prices, relative final

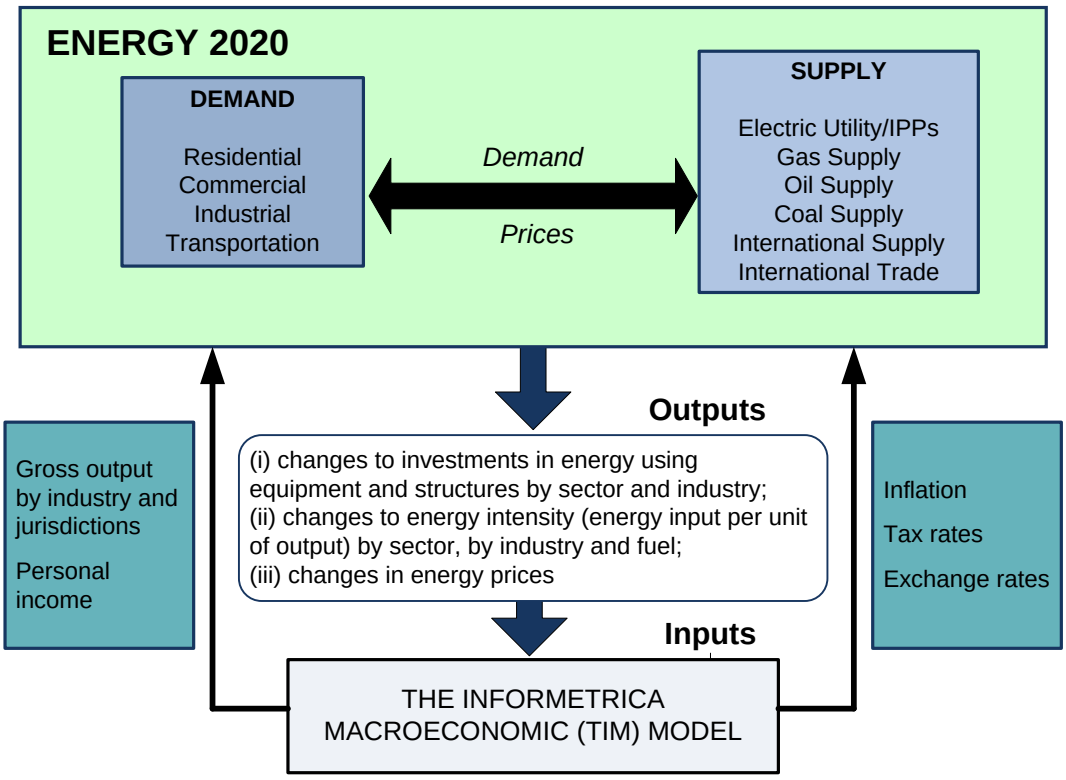
prices, and income. It also factors in government fiscal balances, monetary flows, and interest and exchange rates. More specifically, TIM incorporates 133 industries at a provincial and territorial level. It also has an international component to account for exports and imports, covering about 100 commodities. The model projects the direct impacts on the economy's final demand, output, employment, price formation, and sectoral income that result from various policy choices. These, in turn, permit an estimation of the effect of climate change policy and related impacts on the national economy.

E3MC develops projections using a market-based approach to energy analysis. For each fuel and consuming sector, the model balances energy supply and demand, accounting for economic competition among the various energy sources. This ensures consistent results among the sectors and regions. The model can be operated in a forecasting mode or an analytical mode. In forecasting mode, the model generates an annual energy and emissions outlook to 2050. In analytical mode, it assesses broad policy options, specific programs or regulations, new technologies or other assumptions.

The model's primary outputs are tables showing energy consumption, production and prices by fuel type, year and region. The model also identifies many of the key macroeconomic indicators (e.g., GDP or unemployment) and produces a coherent set of all greenhouse gas emissions (such as carbon dioxide, methane, and nitrous oxide) by sector and by province.

Figure A3.1 shows the general structure of E3MC. The component modules of E3MC represent the individual supply, demand, and conversion sectors of domestic energy markets and also include the macroeconomic module. In general, the modules interact through values representing the prices of the energy delivered to the consuming sectors and the quantities of end-use energy consumption.

**Figure A3.1 Energy, emissions and economy model for Canada**




To develop this projection of energy use and related emissions, it was necessary to provide a view of the Canadian economy to 2020. The level and composition of energy supply and demand, and the resulting greenhouse gas emissions, are determined based on many assumptions that influence the overall size and growth rate of the economy.

### *Treatment of Interaction Effects*

Estimates of the net impact of government measures incorporated in the modelling scenarios need to take into account major interaction and behavioural affects. The analytical approach permitted by E3MC addresses these key modeling challenges, namely additionality, free ridership, rebound effects, and policy-interaction effects.

- *Additionality*. This issue relates to the question of what would have happened without the initiative in question. Problems of additionality arise when the stated emissions reductions do not reflect the difference in emissions between equivalent scenarios with and without the initiative in question. This will be the case if stated emissions reductions from an initiative have already been included in the reference case—emissions reductions will effectively be double-counted in the absence of appropriate adjustments. The E3MC model controls for additionality by basing its

structure on incremental or marginal decision-making. The E3MC model assumes a specific energy efficiency or emission intensity profile at the sector and end-use point (e.g., space heating, lighting, or auxiliary power). Under the E3MC modeling philosophy, if the initiative in question were to increase the efficiency of a furnace, only the efficiency of a new furnace would be changed. The efficiency of older furnaces would not change unless those furnaces are retired and replaced with higher efficiency ones. As such, any change in the model is incremental to what is reflected in the business-as-usual assumptions.

- *Free ridership.* A related problem, free ridership, arises when stated reductions include the results of behaviour that would happen regardless of the policy. This can occur when subsidies are paid to all purchasers of an item (e.g., a high efficiency furnace), regardless of whether they purchased the item because of the subsidy. Those who would have purchased the product regardless are termed free riders. In the E3MC model, the behaviour of free riders has already been accounted for in the reference case. Thus their emissions are not counted toward the impact of the policy. Instead, the E3MC model counts only the incremental take-up of the emissions-reducing technology.

- *The rebound effect*. This describes the increased use of a more efficient product resulting from the implied decrease in the price of its use. For example, a more efficient car is cheaper to drive and so people may drive more. Emissions reductions will generally be overestimated by between 5 per cent and 20 per cent unless estimates account for increased consumption because of the rebound effect. Within the model, we have mechanisms for fuel choice, process efficiency, device efficiency, short-term budget constraints, and cogeneration, which all react to changes in energy and emissions costs in different timeframes.[24] All these structures work to simulate the rebound effect—in the example above, the impact of extra kilometres that may be driven as a result of improved fuel efficiency are automatically netted out of the associated emissions reduction estimates.

- *Policy interaction effects.* This describes impacts on the overall effectiveness of Canada's emissions-reduction measures when they interact with each other. A policy package containing more than one measure or policy would ideally take into account this impact to understand the true contribution that the policy package is making (in this case, to emission reductions).

E3MC is a comprehensive and integrated model focusing on the interactions between sectors and policies. In the demand sectors, the fuel choice, process efficiency, device efficiency, and level of self-generation are all integrally combined in a

24 A shift in energy prices will cause cogeneration to shift in the short to medium term, device efficiency to adjust over the short to mid-term, process efficiency to adjust in the mid term, and fuel choice to react in the mid- to long-term. The actual adjustment times depend on the particular sector.

consistent manner. The model has detailed equations to ensure that all the interactions between these structures are simulated with no loss of energy or efficiency. For example, the electric generation sector responds to the demand for electricity from the energy demand sectors, so any policy to reduce electricity demand in the consumer sectors will impact the electricity generation sector. The model accounts for emissions in the electricity generation sector as well as for emissions in the consumer demand sectors. As the electricity sector reduces its emissions intensity, policies designed to reduce electricity demand in the consumer sectors will cause less of an emissions reduction. The natural gas and oil supply sectors similarly respond to the demands from the consumer sectors, including the demands for refined petroleum products for transportation. The model also simulates the export of products by supply sectors.

Taken as a whole, the E3MC model provides a detailed representation of technologies that produce goods and services throughout the economy and can simulate, in a realistic way, capital stock turnover and choices among technologies. The model also includes a representation of equilibrium feedbacks, such that supply and demand for goods and services adjust to reflect policy. Given its comprehensiveness, E3MC covers all the greenhouse gas emissions sources, including those unrelated to energy use.

### *Simulation of capital stock turnover*

As a technology vintage model, E3MC tracks the evolution of capital stocks over time through retirements, retrofits, and new purchases, in which consumers and businesses make sequential acquisitions with limited foresight about the future. This is particularly important for understanding the implications of alternative time paths for emissions reductions.

The model calculates energy costs (and emissions) for each energy service in the economy, such as heated commercial floor space or person-kilometre traveled. In each period, capital stocks are retired according to an age-dependent function (although the retrofitting of unretired stocks is possible, if warranted by changing economic conditions). Demand for new stocks grows or declines depending on the initial exogenous forecast of economic output (i.e., a forecast that is external to the model and not explained by it) and the subsequent interplay of energy supply–demand with the macroeconomic module. A model simulation iterates between energy supply-demand and the macroeconomic module until there is a convergence. The global convergence criterion is set at 0.1 per cent between iterations. This convergence procedure is repeated for each year over the simulation period.

The E3MC model simulates the competition of technologies at each energy service node in the economy based on a comparison of their cost and some technology-specific controls, such as a maximum market share limit in cases where a technology is constrained by physical, technical, or regulatory means from capturing all of a market. The technology choice simulation reflects the financial costs as well as the consumer and business preferences, revealed by real-world technology acquisition behaviour.

### *Model Limitations*

While E3MC is a sophisticated analytical tool, no model can fully capture the complicated interactions associated with given policy measures between and within markets or between firms and consumers. Unlike computable general equilibrium models, however, the E3MC model does not fully equilibrate government budgets and the markets for employment and investment. That is, the modeling results reflect rigidities such as unemployment and government surpluses and deficits. Furthermore, the model, as used by Environment Canada, does not generate changes in nominal interest rates and exchange rates, as would occur under a monetary policy response to a major economic event.

# ANNEX 4:

## Comparison with the Latest National Inventory Report

Canada's Emissions Trends presents a projection of greenhouse gas emissions to the year 2020 which were constructed using Environment Canada's integrated energy, economy and environment modeling platform.

Canada's Emission Trends provides a detailed breakdown of emissions by economic sector as well as a description of assumptions sector by sector. It provides all the details related to the summary of emissions projections published on January 28th on the Government of Canada's website:
http://www.climatechange.gc.ca/default.asp?lang=En&n=DC025A76-1

The technical work for Canada's Emissions Trends was completed in December 2010. The projections were aligned to the most recent data available at that time. For example, the economic projections are calibrated to those used by Finance Canada in the fall 2010 Fiscal Update. As another example, Statistics Canada's 2010 population growth projections are used within the modeling work. The projections also incorporate 2010 data from the National Energy Board and the U.S. Energy Information Administration.

The Emission Trends report makes extensive use of the National Greenhouse Gas Emissions Inventory. It therefore reflects the historical emissions data that were available at the time i.e., the 2010 National Inventory Report. The 2010 National Inventory provides GHG data up to 2008. Thus, all subsequent years are considered projection years.

Since the modeling work in this Emissions Trends report was completed in December 2010, Environment Canada has released the 2011 National Inventory Report (May 2011), which includes greenhouse gas data up to 2009. In Canada's National Inventory Report, greenhouse gas emissions are categorized by emitting activity whereas this Emissions Trends report allocates emissions on the basis of the economic sector from which they originate. For a comparison of the two alternative methods see page 15 of this report.

The new data in the 2011 National Inventory Report confirmed that emissions significantly declined between 2008 and 2009 as projected in this Emissions Trends report. The Trends report projected aggregate Canadian emissions to fall from 735 Mt in 2008 to 700 Mt in 2009. NIR data show that emissions fell slightly more to 690 Mt in 2009.

The new National Inventory Report also made slight revisions to previous years for greenhouse gas emissions at the national and provincial levels. This was due to updates in underlying 2008 data collection and slight methodological improvements. The following table illustrates the small differences in Canadian greenhouse gas emission levels:

**Table A4.1 Comparison with Latest National Inventory Report**

| Mt $CO_2e$ | 2005 | 2006 | 2007 | 2008 | 2009[25] |
|---|---|---|---|---|---|
| 2010 NIR/ Canada's Emissions Trends | 731 | 718 | 750 | 734 | 700 |
| 2011 NIR | 731 | 719 | 748 | 732 | 690 |
| Difference | 0 | 1 | 2 | 2 | 10* |

Environment Canada has started its annual update of greenhouse gas emissions projections. The information in the 2011 National Inventory Report will be incorporated into the update along with the most recent data available from other government agencies as discussed on page 19 of this report.

[25] * No data for 2009 was provided in the 2010 National Inventory Report. Data presented here is a projection from this Emissions Trends Report.