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Canada's Emissions Trends

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Executive Summary

Overview

Canada is home to a rich and diverse natural environment. From clean air and water, to the conservation of our species at risk, and to protecting the health of Canadians from environmental hazards, preserving our environment is essential to our social and economic well-being.

The potential impacts of climate change are far-reaching, affecting all Canadians, our economy, infrastructure, health, the landscapes around us, and the wildlife that inhabit them. As an Arctic nation, Canada is particularly affected by the impacts of climate change.

Global greenhouse gas (GHG) emissions grew by approximately 40% between 1990 and 2011, with the bulk of the growth coming from emerging markets and developing countries. Over this period, Canada's share of total global emissions has decreased slightly and is now less than 2%.

Canada recognizes that addressing climate change requires action by businesses, consumers and governments in all countries. Climate change is a shared responsibility in Canada, and provinces and territories have been setting emissions reductions targets and taking action to address climate change according to their unique circumstances. Likewise, businesses and individual Canadians are also taking important steps to reduce emissions by using resources more efficiently and adopting new, cleaner technologies.

The Government of Canada is focused on a pragmatic approach to addressing climate change that will reduce emissions while continuing to create jobs and encourage the growth of the economy. The Government of Canada is implementing a sector-by-sector approach to regulate GHG emissions, with regulations already in place in two of the largest sources of emissions: transportation and electricity. By undertaking this regulatory agenda, Canada has strengthened its position as a world leader in clean electricity generation by becoming the first major coal user to ban construction of traditional coal-fired electricity units. In addition, regulations in the transportation sector will ensure that 2025 model-year passenger vehicles and light trucks will emit about 50% less GHGs than 2008 models. Furthermore, GHG emissions from 2018 model-year heavy-duty vehicles will be reduced by up to 23%.

Efforts by Canadians are achieving results. According to the latest *National Inventory Report*, in 2012 Canada emitted about 699 megatonnes of carbon dioxide equivalent (Mt CO_2 eq) of GHGs to the atmosphere, excluding emissions/removals from Land Use, Land-use Change and Forestry (LULUCF). Between 2005 and 2012, total Canadian GHG emissions decreased by 5.1% (37 Mt), while the economy grew by 10.6% over the same period.

Economy-wide emissions remained steady over 2010, 2011 and 2012, despite economic growth of 4.4% over that period, demonstrating continued progress in decoupling emissions and economic growth. Between 1990 and 2012, the emissions intensity of the Canadian economy decreased by 29% and Canada's per capita emissions reached a historic low of 20.1 tonnes of CO_2 eq per person, their lowest point since tracking began in 1990. Moreover, improvements in both emissions intensity and emissions per capita are expected to continue through 2020.

Overall, Canada's unique geographic, demographic and economic circumstances influence its GHG emissions profile and make addressing climate change a significant challenge. Canada has an extreme, highly variable climate that contributes to higher energy use for space heating and cooling in both commercial and residential sectors. Canada's large landmass and low population density contribute to higher transportation energy demand (and GHG emissions) per capita compared with smaller, more densely populated countries, mostly due to increased travelling distances. Despite having a small population, Canada's average population growth rate is expected to be one of the highest relative to other developed countries, at about 1% per year.

In addition to faster-than-average population growth relative to other developed countries, Canada has experienced sustained economic growth. As a natural resource–rich economy, Canada is a net exporter of agricultural commodities, energy (electricity and oil and gas) and many resource-based commodities such as pulp and paper, mined metals, and aluminum. Over the past decade, Canada's exports of energy, extracted resources and agricultural commodities as a share of Gross Domestic Product (GDP) have increased by almost 40%. Canada has the third-largest resources of crude oil in the world, and Canada's production of oil and gas is projected to rise to meet continuing global demand.

Measuring Canada's Progress on Greenhouse Gas Emissions

Under the Copenhagen Accord, Canada committed to reducing its emissions by 17% from 2005 levels by 2020.[1] As economy-wide emissions in 2005 were 736 Mt, Canada's implied Copenhagen target is 611 Mt in 2020.

Assessing progress in reducing GHG emissions is best done by comparing a "with measures" scenario against a "without measures" scenario that acts as a baseline where consumers, businesses and governments take no action to reduce emissions after 2005, Canada's base year for its Copenhagen commitment. This is the most appropriate approach, given Canada's growing economy, as it more accurately captures the real and verifiable level of effort that will be required to reduce emissions. Progress cannot be adequately measured by comparing expected future emissions against current levels, as this would not take into account factors such as the expected population and economic growth that will affect emissions between now and 2020.

Projections presented in this report under the "with current measures" scenario include actions taken by governments, consumers and businesses up to 2012 as well as the future impacts of policies and measures that were announced or put in place as of May 2014. This scenario does not include further government action and policies that are proposed or planned but not implemented. (The policies and measures modeled in this report are listed in Annex 2.)

The analysis indicates that, in a scenario where consumers, businesses and governments take no action to reduce emissions after 2005, emissions in 2020 will rise to 857 Mt. Under the "with

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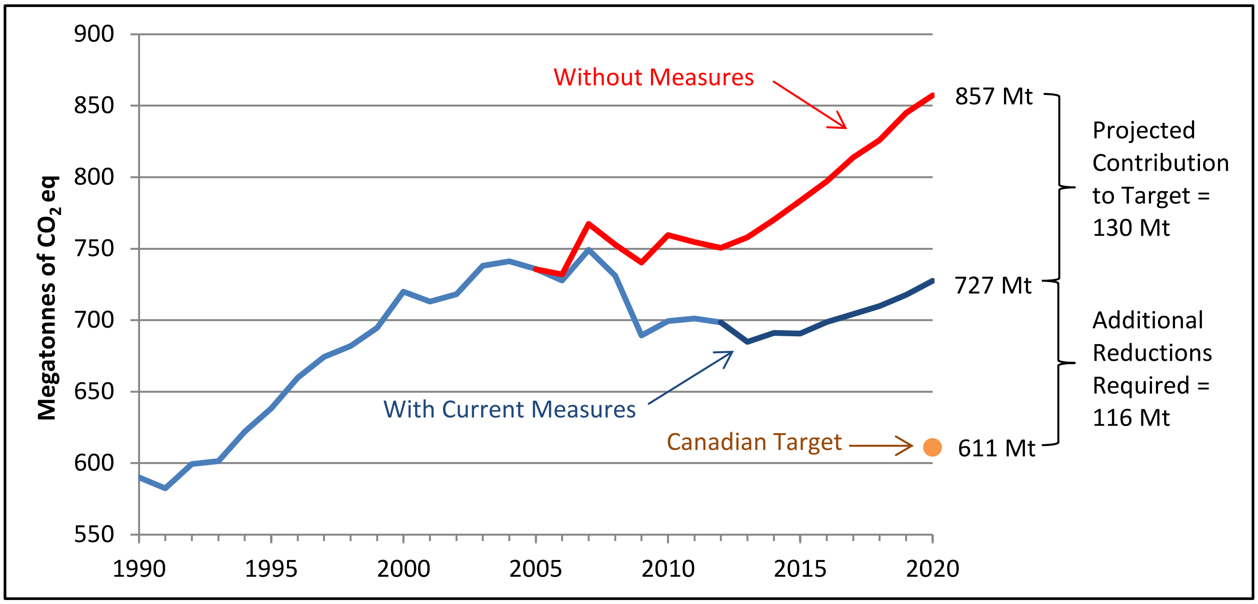
[1] Canada's Copenhagen target is 17% emission reduction by 2020 compared with 2005 levels, to be aligned with the final economy-wide emission reduction target of the United States of America in enacted legislation.

current measures" scenario that includes actions since 2005 as well as the contribution from LULUCF, Canada's GHG emissions in 2020 are projected to be 727 Mt, a total of 130 Mt less than under a "without measures" scenario. This highlights the significant expected impacts of actions made to date but also indicates the need for further efforts from all Canadians, as additional reductions of 116 Mt will be required to meet Canada's Copenhagen commitment (see Figure ES-1).

In a Spring 2012 submission to the United Nations Framework Convention on Climate Change (UNFCCC), Canada stated its intent to include the LULUCF sector in its accounting of GHG emissions towards its 2020 target, noting that emissions and related removals resulting from natural disturbances would be excluded from the accounting. It was also indicated at that time that a Reference Level or comparison against a 2005 baseline would be used for accounting. Based on these accounting approaches, the expected LULUCF contribution is 19 Mt, largely reflecting lower expected harvesting of trees in forest lands than in the past. This 19 Mt contribution is subtracted from total national emissions projections in 2020 as a credit towards reaching the target. Analysis of alternative accounting approaches remains ongoing.

Figure ES-1: Progress on Canada's 2020 Target (Mt CO_2 eq)[2]



Canada's Greenhouse Gas Emissions Projections

As shown in Table ES-1, under a scenario that includes current measures and the contribution from LULUCF, absolute emissions are projected to be 727 Mt in 2020, 1.2% below 2005 levels. Emissions from the oil and gas and buildings sectors are expected to increase, while emissions in the electricity sector are projected to decrease between 2005 and 2020. Emissions in the transportation, emissions-intensive and trade-exposed, agriculture, and waste and others sectors remain close to 2005 levels.

[2] The "With Current Measures" line includes the compliance contribution of the Land Use, Land-Use Change and Forestry (LULUCF) sector towards the Copenhagen target in every year post 2005, and therefore actual emissions (without LULUCF) would be 19 Mt higher in 2020.

Table ES-1: Change in GHG Emissions by Economic Sector (Mt CO_2 eq)

	2005	2012	2020	Change 2005 to 2020
Transportation	168	165	167	-1
Oil and Gas	159	173	204	45
Electricity	121	86	71	-50
Buildings	84	80	98	14
Emissions-intensive and Trade-exposed Industries	89	78	90	1
Agriculture	68	69	70	2
Waste and Others	47	47	46	-1
Expected LULUCF Contribution	-	-	-19	-
Total with LULUCF Contribution	**736**	**699**	**727**	**-9**

Note: Numbers may not sum to the total due to rounding.

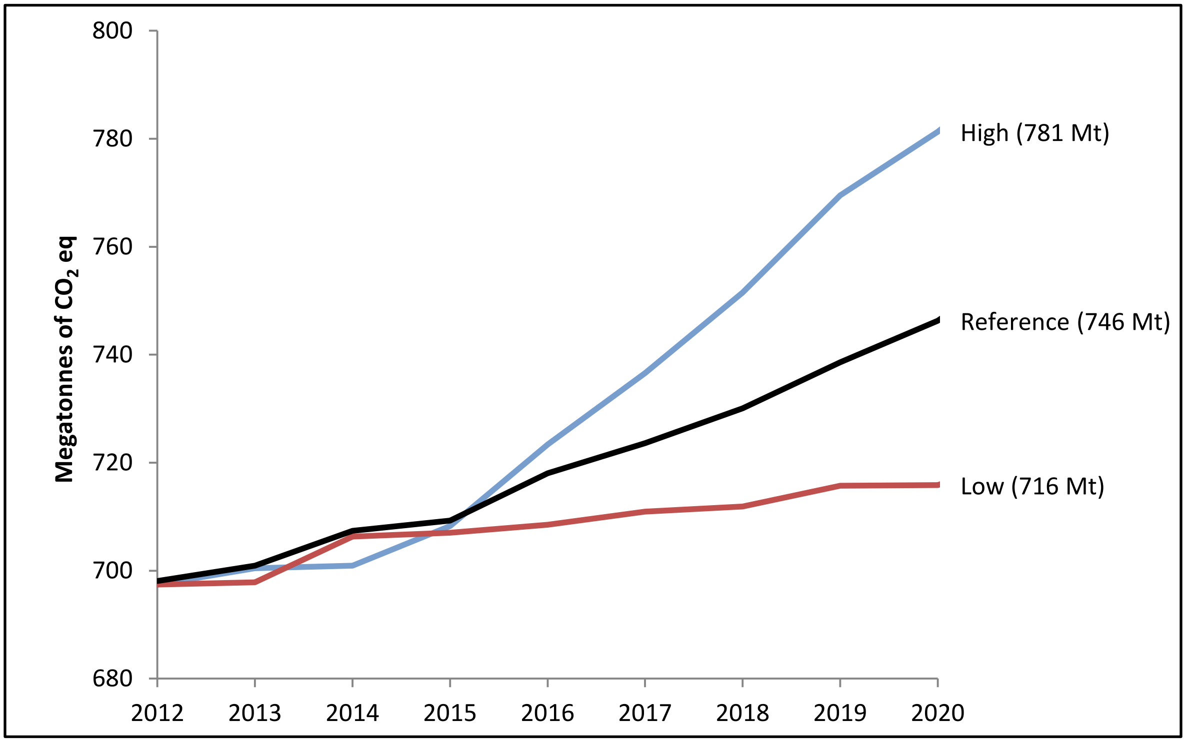
Although emissions are projected to decrease by 9 Mt between 2005 and 2020 when the contribution of LULUCF is included, GDP is expected to increase by 32% over the same period, demonstrating that economic growth and emissions growth are continuing to decouple. In addition, as population is projected to increase, per capita emissions are expected to fall to 19.7 tonnes of CO_2 eq per person in Canada in 2020, a decrease of 14% from 2005 levels.

GHG emissions projections depend on a number of economic and energy variables and are subject to significant uncertainty, especially in the longer term. Modeling estimates are subject to consultations with various industry associations, other federal departments and provincial/territorial governments. Modeling assumptions also undergo a periodic peer review process. Updates to key historical and projected energy data and drivers as well as the evolution of technology and demographics will alter the future emissions pathway.

To address the uncertainty inherent in projections, alternative scenarios that reflect different assumptions about oil and natural gas prices and production as well as different rates of economic growth have been developed. The greatest emissions are projected under a scenario aligned to the National Energy Board's high oil and gas prices with higher-than-average annual growth in GDP between 2012 and 2020 (2.7% compared with 2.2% in the reference scenario). Alternatively, the lowest emissions scenario includes slower GDP growth (average growth of 1.5% between 2012 and 2020) and the National Energy Board's low world oil and gas prices.

As shown in Figure ES-2, these scenarios suggest that the expected range of emissions in 2020 could be between 716 Mt in the lowest emissions scenario and 781 Mt in the highest emissions scenario, not including contributions for LULUCF. This 65 Mt range will continue to change over time with further government actions, technological change, economic conditions and developments in energy markets.

Figure ES-2: Range of Canada's Projected GHG Emissions (excluding LULUCF)



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Preface

Canada's Emissions Trends provides projected greenhouse gas (GHG) emissions, and supports domestic and international reporting requirements. The projections can be used to analyze the effect of different emissions abatement strategies and enables quantitative assessment of emissions reductions associated with policy measures that will arise in the future.

Environment Canada published the first *Canada's Emissions Trends* report in 2011. This is the fourth annual report.

The analysis presented in this report incorporates the most up-to-date statistics on GHG emissions and energy available at the time that the technical modeling was completed in the summer of 2014, and is based on scenarios of emissions projections using the Energy, Emissions and Economy Model for Canada.

Provincial/territorial and federal government departments were consulted during the development of the projections and were invited to provide their input.

The majority of data and assumptions used for the modeled emissions scenarios have been subject to extensive consultations. For example, the National Energy Board has extensive consultation processes in place to ensure their projections of energy demand and supply growth are robust; the data they provided to Environment Canada reflect those consultations.

As with all projections, the estimates in this paper should be seen as representative of possible outcomes that will, in the end, depend on economic, social and other factors, including future government policies.

Structure of this Report

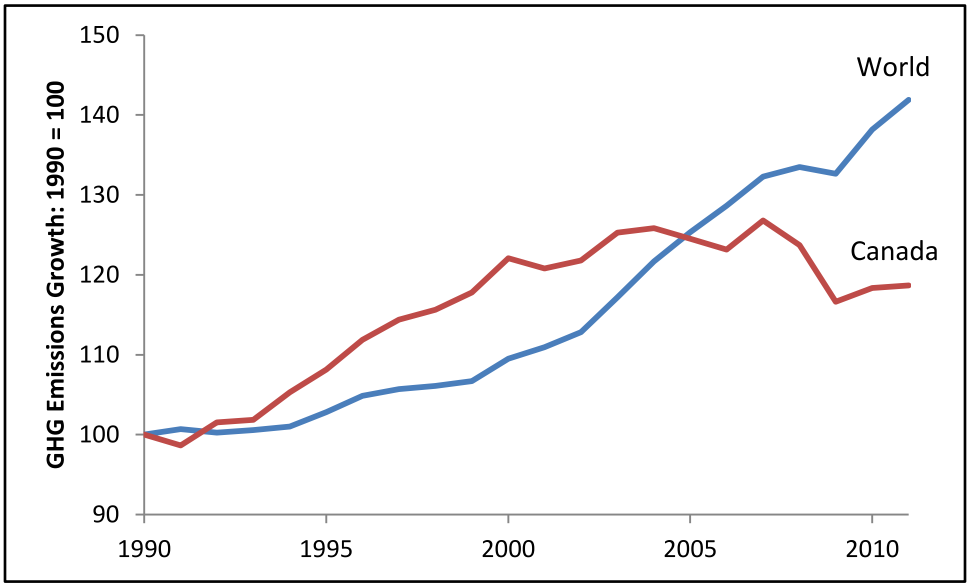
This report presents projections of GHG emissions to 2020 and is aligned to the historical data on GHG emissions provided in Canada's *National Inventory Report 1990–2012: Greenhouse Gas Sources and Sinks in Canada*. The first section, Canada's Greenhouse Gas Emissions in a Global Context, sets the stage by explaining Canada's emissions relative to other countries and the work that is under way internationally as part of the global effort to reduce emissions. The second section, Historical Greenhouse Gas Emissions by Sector, explains historical emissions trends by economic sector and provides details about the evolving trends in these sectors from 1990 to 2012. The third section, Projected Emissions Trends, provides projections of GHGs by sector to the year 2020 and explains the underlying reasons behind these sectoral trends. The fourth section, Projected Alternate Emissions Scenarios, provides a sensitivity analysis, which is also explained in further detail in Annex 3. This analysis presents possible trajectories of GHG emissions under various assumptions about the future path of energy prices and the economy. The annexes of this report provide further details on Land Use, Land-use Change and Forestry accounting, information on the key drivers of emissions used within the modeling exercise, and technical explanations of the modeling platform and changes made since last year's projections.

Canada's Greenhouse Gas Emissions in a Global Context

Canada's Share of Global Emissions

Global GHG emissions grew by approximately 40% between 1990 and 2011,[3] with the bulk of the emissions growth coming from emerging markets and developing countries. Canada's share of world cumulative emissions since 1990 has been below 2%.

Figure 1: GHG Emissions Growth, 1990 to 2010



Source: World Resources Institute 2014, CAIT database

Canada's share of total global emissions, like that of other developed countries, is expected to continue to decline in the face of the expected rapid emissions growth from developing countries and emerging markets such as China, India, Brazil and Indonesia. By 2005, China had overtaken the U.S. as the world's largest overall GHG emitter and in 2011 accounted for 24% of total global GHG emissions.[4]

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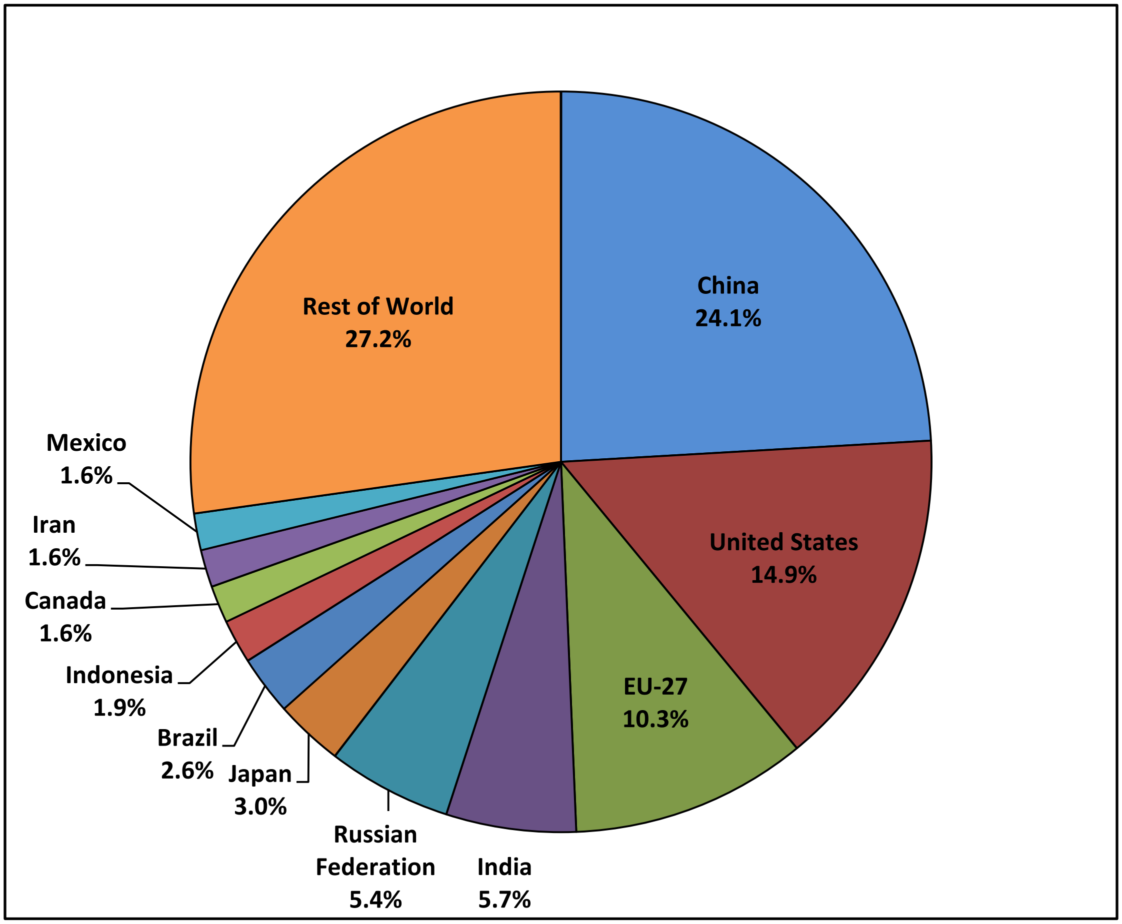
[3] World Resources Institute 2014, CAIT database

[4] World Resources Institute 2014, CAIT database

Figure 2: Breakdown of Total World Greenhouse Gas Emissions: 2011



Source: World Resources Institute 2014, CAIT database

Canada's National Circumstances

Canada is fortunate to be naturally endowed with vast expanses of land and water, abundant mineral and energy resources, and geographic variation. However, these attributes also create enormous challenges from the perspective of achieving reductions of GHG emissions in comparison with most developed countries. Canada has the largest land mass of the Organisation for Economic Co-operation and Development (OECD) countries, which creates long distances and longer travel times for both passenger and freight transportation needs. Our climate is highly variable and extreme, affecting energy demand for both winter heating and summer cooling in our residential and commercial buildings. Heating requirements for households and businesses are greater than in most other developed countries and are primarily supplied by fossil fuels. Resource extraction of minerals, fossil fuels and other energy-intensive primary resources supply increasing world demand and are a significant contributor to Canada's economic growth, but also affect Canada's emissions profile.

While Canada's population remains the smallest among the G7 countries, it is the fastest-growing, with an annual population growth rate of just over 1%. In addition, Canada has experienced sustained economic growth and ranks 11th in the world in terms of gross domestic product (GDP) on a per capita basis.[5] As a natural resource–rich economy, Canada is a significant exporter of energy and net exporter of agricultural commodities and many emissions-intensive resource-based commodities such as pulp and paper, mined metals and aluminum. Canada has an energy-intensive industrial sector, and over the past decade, industrial output has risen substantially and Canada's exports of energy, extracted resources and agricultural commodities as a share of GDP have increased by almost 40%.

Global energy demand is expected to grow by one third between 2012 and 2035, and fossil fuels are expected to remain a key component of supply for decades to come. The International Energy Agency's (IEA) 2013 World Energy Outlook reference case suggests that fossil fuels, as a share of world energy use, will decrease but still provide over three quarters of the world's energy use in 2035. Given that Canada is a key supplier and exporter of energy resources, our production of oil and gas is projected to rise to meet this demand.

Among the member countries of the IEA, Canada's energy profile is characterized by one of the highest rates of total primary energy supply[6] per unit of GDP. The IEA notes that factors driving energy consumption in Canada are a significant concentration of energy-intensive primary industries; a cold and extreme climate; a small, highly dispersed population; a high standard of living with minimal constraints on space occupation; and vast geography (which affects population density and transportation needs).[7] Canada has slightly higher-than-average rates of energy use per passenger-kilometres and ranks as one of the highest in terms of number of vehicle miles travelled per person in the IEA countries. Canada has the third-highest residential primary energy consumption per household and has among the highest energy intensities of IEA countries in the service sector (mostly due to energy use in buildings).

Despite these challenges and steady growth in energy consumption, Canada has made significant improvements. Taking into account differences in economic structure, weather and other effects, energy efficiency improved by 25% in Canada between 1990 and 2010.[8]

Emissions per Capita and Emissions Intensity

Emissions intensity, defined as GHG emissions per dollar of GDP, measures the relationship between economic activity and emissions. Although emissions are intrinsically linked to economic activity, this linkage has weakened in Canada over the past two decades due to technological and structural changes such as increases in energy efficiency and the growth of lower-emissions and service-based industries. Although GHG emissions have risen by 18% since 1990, Canada's economy grew much more rapidly, with GDP rising by 67%. As a result, the emissions intensity for the entire economy has improved considerably, declining at an

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[5] World Development Indicators: Growth of Output. 2013. World Bank.

[6] Total Primary Energy Supply includes all energy used in a country, including production, imports (minus exports) and international marine sources. Source: OECD/IEA Energy Efficiency Market Report 2013: Market Trends and Medium-Term Prospects.

[7] OECD/IEA Energy Efficiency Market Report 2013: Market Trends and Medium-Term Prospects

[8] Natural Resources Canada, Energy Efficiency Trends in Canada 1990 to 2010

average annual rate of 1.3% between 1990 and 2012, or a cumulative 29% over the entire period. Emissions intensity is expected to continue to decrease in Canada through 2020.

Per capita emissions have been decreasing significantly since 2005, when they were 22.8 tonnes of CO_2 eq per person. In 2012, emissions per capita were 20.1 tonnes of CO_2 eq per person, which is the lowest level recorded since records began in 1990.

Projections show per capita emissions are expected to decrease through 2020, falling to 19.7 tonnes of CO_2 eq per person in 2020. This reflects a projected increase in Canada's population of 17% between 2005 and 2020, compared with a projected 1.2% decrease in emissions when LULUCF is included.

International Cooperation

Effective climate change mitigation requires that all countries act to reduce emissions, and accordingly, Canada will continue to do its part. Under the United Nations Framework Convention on Climate Change, Canada signed onto the Copenhagen Accord in December 2009 and committed to reduce its GHG emissions to 17% below 2005 levels by 2020.

The Government of Canada's approach is to encourage strong economic growth and job creation while achieving its environmental objectives. Canada's economy is projected to be approximately 32% larger (in real terms) in 2020 compared with 2005 levels.

In recognition of the need for a global solution to address climate change, in 2011 Parties agreed to launch the Durban Platform for Enhanced Action negotiations under the United Nations Framework Convention on Climate Change (UNFCCC) with a view to establishing, by 2015, a new climate change agreement for the post-2020 period that is applicable to all Parties. This development was an important breakthrough for countries like Canada with a long-standing objective to establish a climate change agreement that includes all major emitters. Canada is working with UNFCCC member countries towards the establishment of a new, effective international climate change agreement.

Outside the UNFCCC, Canada is actively participating in a number of international collaborative efforts, including sectoral and regional initiatives and partnerships, that complement the formal UNFCCC negotiations and encourage concrete actions to address climate change. These include the Climate and Clean Air Coalition, the Arctic Council, the Montreal Protocol on Substances that Deplete the Ozone Layer, and the Major Economies Forum on Energy and Climate Change.

The Electricity Sector in Canada

Worldwide, carbon emissions from the generation of electricity represent 40% of global GHG emissions and are among the largest and fastest–growing sources. According to the IEA, the share of coal in electricity and heat generation emissions has also increased significantly, from 66% in 1990 to 72% in 2011, and it is projected to continue to account for the largest share of CO_2 emissions to 2040. Altering this trajectory downwards is a major global challenge.

Canada is a global leader in clean electricity. In Canada, 79% of electricity is generated from non-GHG-emitting sources (e.g., hydro, nuclear and renewables), one of the highest percentages in the world. For comparison, non-emitting sources provide less than one third of power generation for the U.S. and one fifth for China (IEA, 2013). The high level of clean generation in Canada means that emissions from electricity generation are a relatively small share of total emissions (just 12% in 2012).

Moreover, Canada's electricity intensity (electricity use per unit of GDP) is improving, dropping by roughly 12% between 2001 and 2012. A 2013 Energy Efficiency Market Report by the IEA ranked Canada tied for second among 15 IEA countries for its rate of energy efficiency improvement between 1990 and 2010.

In addition to using less electricity to produce a dollar of GDP, the emissions associated with generating a unit of electricity are decreasing. Canada's electricity sector is one of the lowest emitting, per kilowatt-hour generated, in the developed world. In 2010, Canada produced 190 grams of CO_2 per kilowatt-hour of electricity generated, which is only one third of the U.S.'s emissions intensity, one quarter of China's and less than half of the OECD average.

In 2012, the federal government introduced a tough new regulatory performance standard for coal-fired electricity generation that is scheduled to come into effect in July 2015. With this regulation, Canada became the first major coal user to ban construction of traditional coal-fired electricity generation units.

Provincial and federal government regulations have contributed to recent trends that show emissions in the electricity sector decreasing by 29% from 2005 to 2012. While Canada already has one of the cleanest systems in the world, federal and provincial governments have taken steps to make it even cleaner in the future. Provincial policies, in particular Ontario's ban on coal-fired electricity generation, renewable portfolio standards in New Brunswick and Nova Scotia, and a net zero GHG standard for new generation in British Columbia, contribute to further reductions. Emissions in the electricity sector in Canada were estimated to be 94 Mt in 1990, growing to 121 Mt in 2005 before falling to 86 Mt in 2012 (a 29% decrease), and are projected to fall to 71 Mt by 2020 (a 41% decrease).

Electricity generation is currently the third-largest source of GHG emissions in Canada but only accounts for 12% of emissions (2012). In comparison, electricity generation in the U.S. accounts for almost one third of U.S. total emissions and about half of China's emissions. The U.S. and China each produce about 20% of world generation of electricity (whereas Canada produces about 3% of global electricity), according to Natural Resources Canada. In countries such as these, where coal-fired power generation is dominant, there is significantly more scope for reducing future emissions by fuel-switching to natural gas or alternative sources of energy. In Canada, as coal-fired power is phased out under the current electricity regulations, it is projected that 85% of the utility electricity supply will be generated from non-emitting sources by 2020.

Historical Greenhouse Gas Emissions by Sector

Emissions by Activity and Economic Sector

There are several methods to categorize the sources of GHG emissions. These include the Intergovernmental Panel on Climate Change (IPCC) sectors as presented in the *National Inventory Report* (NIR), Environmental Accounts as developed by Statistics Canada and Economic Sectors as presented in this report. For the purposes of analyzing trends and policies, it is useful to allocate emissions to the economic sector from which the emissions originate. As such, this report presents emissions by "economic activity." This method of categorization is also presented in the NIR and in the *Canadian Environmental Sustainability Indicators* for comparability purposes.

Historical Emissions

Historical emissions estimates within this report are aligned to the annual NIR, which is submitted to and reviewed by the UNFCCC. This report uses data from the 2014 NIR, which contains emissions estimates to the year 2012 (the most recent available year of historical emissions data). Every year, the estimates are updated to reflect the availability of data as well as improvements and refinements to data sources and methodological techniques. For this reason, the historical emissions reported here will differ slightly from those reported in *Canada's Emissions Trends 2013*.

As shown in Table 1, from 1990 to 2005, total emissions grew from 591 Mt to 736 Mt. The majority of this increase occurred in the transportation sector, the oil and gas sector, and the electricity sector. In the transportation sector, changes in subsectors including light-duty and heavy-duty vehicles caused an increase in emissions of 40 Mt when compared with 1990 levels. Increased production and processing of oil and natural gas resulted in an increase in emissions of 58 Mt in the oil and gas sector, and the electricity sector had an increase of 27 Mt over this time period, which is mostly attributable to rising demand.

Canadian GHG emissions were stable between 2010 and 2012. In 2012, emissions were 699 Mt, 37 Mt below 2005 levels, reflecting decreases or stability in emissions in most sectors. The exception is the oil and gas sector, where emissions increased by 14 Mt. Notably, GHG emissions in the electricity sector decreased 35 Mt over the period, primarily the result of Ontario's coal generation phase-out. Compositional changes within the sectors, energy efficiency improvements, and changes to energy prices have all helped contribute to relatively stable emissions in the other sectors.

Table 1 shows historical emission levels for selected years up to 2012 for each of the major economic sectors that generate emissions. The specific gases included in the table above are: carbon dioxide (CO_2), methane (CH_4), nitrous oxide emissions (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) and sulphur-hexafluorides (SF_6), which have been converted into CO_2 eq with global warming potential values from the second Assessment Report of the IPCC.

Table 1: GHG Emissions by Economic Sector (Mt CO_2 eq) (excluding LULUCF)

Mt CO_2 eq	1990	2005	2010	2011	2012
Transportation	128	168	167	166	165
Oil and Gas	101	159	163	164	173
Electricity	94	121	99	92	86
Buildings	70	84	79	85	80
Emissions-intensive and Trade-exposed Industries	95	89	76	80	78
Agriculture	54	68	68	67	69
Waste and Others	48	47	46	47	47
National GHG Total	**591**	**736**	**699**	**701**	**699**

Note: Numbers may not sum to the total due to rounding.

Transportation

In 2012, emissions from transportation (including passenger, freight and off-road emissions) were the second-largest contributor to Canada's GHG emissions, representing 24% of overall GHGs.

Between 1990 and 2005, emissions in the transportation sector increased by 31%, from 128 Mt in 1990 to 168 Mt in 2005. This was driven by a strong period of economic growth and low oil prices from 1990 to 1999 that influenced the fleet composition and its use (e.g., more light-duty trucks in comparison with cars).

Since 2005, transportation emissions have been relatively stable, representing 165 Mt in 2012. The increasing fuel efficiency of light-duty vehicles has offset the effects of an increased population that puts more vehicles on the road and results in more kilometres (km) driven. For example, between 2005 and 2012, the sales-weighted on-road fuel efficiency for new gasoline cars has improved from 9.2 litres per 100 km to 8.4 litres per 100 km, while the sales-weighted on-road fuel efficiency for new gasoline light trucks has improved from 13.2 litres per 100 km to 11.6 litres per 100 km.

Oil and Gas

Emissions in the oil and gas sector are related to the production, transmission, processing, refining and distribution of oil and gas products. In 2012, the oil and gas economic sector accounted for the largest share of GHG emissions in Canada (25%). Emissions increased by 58 Mt over the 1990 to 2005 time period, primarily as a result of increased production across the sector.

Since 2005, GHG emissions from the oil and gas sector have increased from 159 Mt to 173 Mt in 2012, mainly due to increased oil sands production. Increased emissions from oil sands activity has been partially offset by the gradual depletion of conventional natural gas and oil resources in Canada and a decline in refining emissions. Over the 2011 to 2012 period, however, emissions from conventional light and frontier oil have increased slightly and emissions from in-situ extraction of oil sands increased by 16% due to increased production.

Electricity

As more than three quarters of the electricity supply in Canada is generated by non-GHG-emitting sources of power, the electricity sector represented 12% of total emissions in 2012, down from 16% in 2005.

Over the 1990 to 2005 period, demand for electricity rose with economic and population growth, and this increase was met with varying sources of power. Emissions from the electricity sector increased over the period, as some provinces expanded their capacity by building fossil fuel–fired power plants (primarily natural gas–fired generation) or by increasing the utilization rate of existing coal to meet growing demand. Between 2005 and 2012, emissions in this sector fell significantly as a number of coal-fired units were closed and more lower and non-emitting sources were brought online.

Emissions-intensive and Trade-exposed Industries

The emissions-intensive and trade-exposed (EITE) sector includes metal and non-metal mining activities, smelting and refining, and the production and processing of industrial goods such as chemicals, fertilizers, aluminum, pulp and paper, iron and steel, and cement.

Emissions from the EITE sector were responsible for 16% of total Canadian emissions in 1990 and fell to 11% in 2012. The decline in recent years (11 Mt from 2005 to 2012) reflects the economic downturn, technological changes such as improved emission control technologies for perfluorocarbons (PFCs) within the aluminum industry, the closure of the adipic acid plant in Ontario, and the closure of some pulp and paper facilities. Energy efficiency measures, replacement of raw materials with recycled materials, and use of unconventional fuels such as biomass and waste in production processes were also responsible for the GHG reductions over time.

Buildings

Emissions in Canada's commercial and residential buildings increased by 14 Mt between 1990 and 2005, and then dropped 4 Mt by 2012. Still, since 1990 buildings have accounted for about 12% of Canada's GHG emissions in any given year. Despite a growing population and increased residential and commercial/institutional building stock, energy efficiency and other improvements allowed emissions to drop over the 2005 to 2012 period.

Agriculture

GHG emissions from primary agriculture in Canada consist mainly of methane (CH_4) and nitrous oxide (N_2O) from livestock and crop production systems as well as emissions from on-farm energy use. Emissions have remained stable over the 2005 to 2012 period, following an increase of 14 Mt from 1990 to 2005. Emissions and removals of carbon from land management and land-use change associated with agricultural lands are accounted for separately in the Land Use, Land-use Change and Forestry sector.

Waste and Others

Emissions from waste management and other non-emissions-intensive industrial sectors such as electric and transport equipment manufacturing remained relatively stable between 1990 and 2005. From 2005 to 2012, GHG emissions from municipal solid waste landfills decreased slightly (by 1 Mt) as provincial government measures aimed at capturing landfill gas and solid waste diversion helped to slow growth from the historical period. Non-emissions-intensive industrial subsectors included in the waste and others sector represent a wide variety of operations and include light manufacturing (e.g., food and beverage and electronics), construction and forestry.

Projected Emissions Trends

Key Drivers Used in the Development of Emissions Projections

A number of factors influence GHG emissions in Canada. Economic and population growth as well as the mix of energy supply are examples of drivers of emissions. Projections of future emissions are greatly influenced by the underlying assumptions about the expected development of economic drivers over time. Changing assumptions about any of these factors will alter the future path of emissions (see the Projected Alternative Emissions Scenarios section and Annex 3).

The approach adopted for development of the emissions scenarios presented here relies on a set of key assumptions. The short-term economic projections to the year 2018 are calibrated to private sector projections used by Finance Canada from their *Survey of Private Sector Economic Forecasters* report, June 2014. Beyond 2018, long-term key economic assumptions are based on Finance Canada's *Update of Economic and Fiscal Projections*, November 2013. Forecasts of major energy supply projects from the National Energy Board's 2013 projections were incorporated for key variables and assumptions in the model (e.g., oil and gas production and price). Under the National Energy Board's review process, supply forecasts are based on consultation with industry experts and reflect the government's most recent views regarding the evolution of Canada's energy supply sector. The projections also incorporate data from the NIR and the U.S. Energy Information Administration. For a more detailed summary of key economic data and assumptions, see Annex 2.

Government policy also has a significant impact on emissions, as do changes in behaviour by consumers and businesses. Although the modeling explicitly recognizes price-driven technological progress (e.g., known, advanced, energy-efficient technologies will become more cost-effective over time), it is virtually impossible to predict which new technologies will be developed and commercialized in the future, so no assumptions are made in this regard. Likewise, behavioural factors have been kept constant throughout the entire projection period. In this respect, the expected trend in emissions projections will be shaped by existing government measures. In reality, technological progress, behavioural shifts and future government measures must all contribute to reduce emissions.

The Land Use, Land-use Change and Forestry (LULUCF) sector is modeled and accounted for separately from the other sectors within this report. As with other sectors, key drivers of human-caused emission trends in the LULUCF sector include economic conditions, management practices and policy.

The expected contribution of the LULUCF sector towards the Copenhagen target is currently established by comparing business-as-usual emissions/removals levels in 2020 to either 2005 levels or, in the case of the managed forest sector, to a Reference Level based on an internationally accepted approach. Due to economic conditions and various management practice decisions, the LULUCF sector is expected to improve relative to the base year or Reference Levels.

Taking these drivers into account, the expected LULUCF contribution is 19 Mt, largely reflecting lower expected economic activity (i.e., harvesting) than in the past. This 19 Mt contribution is subtracted from total national emissions projections in 2020 as a credit towards reaching the target.

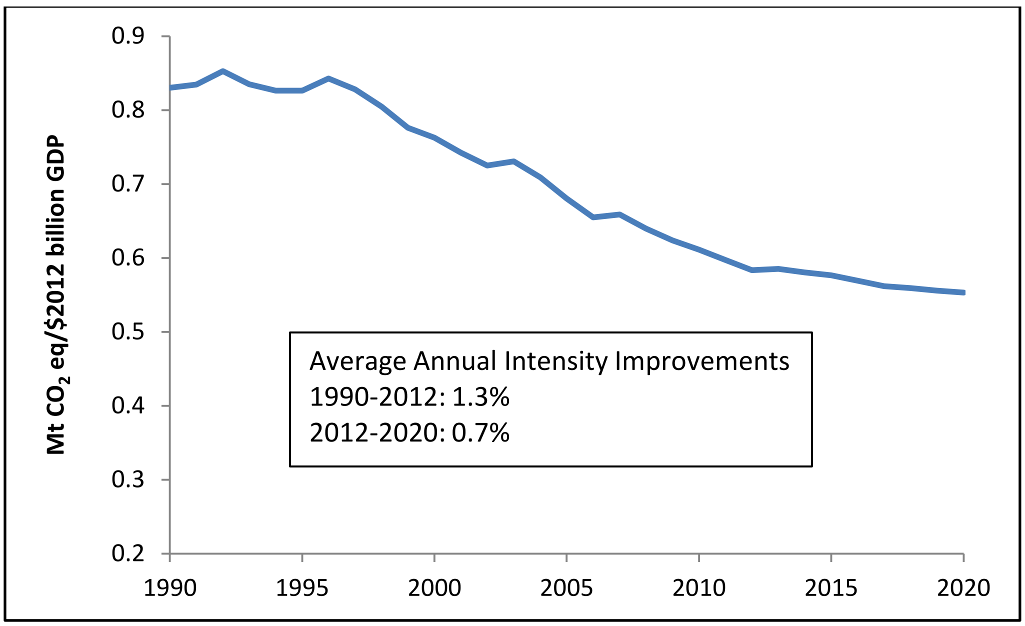
Taking into account all of the economic drivers described above, with no major technology changes and factoring in current government measures, results in a scenario whereby emissions reach 727 Mt by 2020 when the projected contribution from LULUCF is included.

Reference Scenario: Projected Trends

National Emissions Projections

Emissions and economic activity are intrinsically linked, although in a Canadian context that relationship has weakened over the past two decades as a result of structural changes, as well as behavioural and technological changes and improvements. Emissions intensity, defined as GHG emissions per dollar of GDP, measures the relationship between changes in the economy and emissions. In Canada, the relationship between total GHG emissions and total real GDP has declined at an average annual rate of 1.3% from 1990 to 2012. This trend is expected to continue but at a slower rate through 2020.

Figure 3: Canadian GHG Emissions Intensity to 2020 (excluding LULUCF)



However, given that a strong connection still remains between economic growth and GHG emissions, absolute emissions are projected to rise over the period, although at a slower rate than economic growth. As the economy grows beyond 2012 (the latest year available for historical emissions levels), total emissions are projected to increase. Absent further government action and before taking contributions from LULUCF into account, by 2020 emissions are projected to reach 746 Mt, an increase of 10 Mt from 2005. As shown in Figure 4, when the 19 Mt contribution of LULUCF is taken into account, emissions in 2020 are projected to be 727 Mt.

Progress on Reducing Emissions

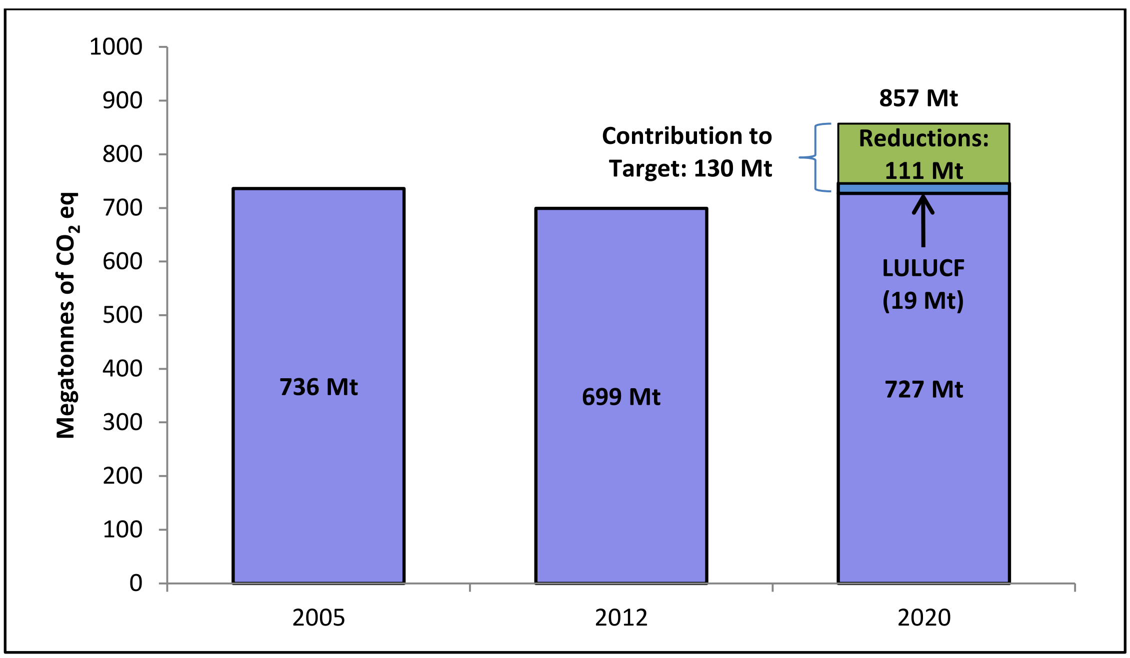
Progress in reducing GHG emissions is measured against a “without measures” scenario. This scenario, which is described in more detail in Annex 4, acts as a baseline where consumers, businesses and governments take no action post-2005 to reduce emissions.

The scenario that includes current measures is then compared against this baseline scenario. In order to be included in the “with current measures” scenario, actions must be concrete or legislated, financially backed, and specific enough to add to the modeling platform as of May 2014 (the policies and measures modeled in this report are listed in Annex 2).

This is consistent with UNFCCC guidelines for National Communication submissions, which recommend measuring the total effect of measures by taking the difference between “with measures” and “without measures” projections. Moreover, this comparison shows the level of effort required to achieve the target in 2020. This could not be captured by measuring emissions against current levels, as this would not take into account factors such as population and economic growth that will affect emissions between now and 2020.

The analysis indicates that if consumers, businesses and governments had taken no action to reduce GHG emissions after 2005, emissions in 2020 would have risen to 857 Mt. This is in comparison to the “with current measures” scenario where, as a result of actions taken since 2005 and the 19 Mt contribution from LULUCF, emissions in 2020 are expected to be 727 Mt, a total of 130 Mt less than under a “without measures” scenario (Figure 4).

Figure 4: Canadian GHG Emissions With and Without Current Measures: 2005 to 2020



Per Capita Emissions

Total GHG emissions divided by the population of Canada (per capita emissions) have decreased significantly since 2005, when they were 22.8 tonnes per person. In 2012, emissions per capita were only 20.1 tonnes per person, which is the lowest level recorded since records began in 1990.

Projections show this trend continuing through 2020, with per capita emissions expected to be 19.7 tonnes per person in 2020 (Table 2).

Table 2: Canadian GHG Emissions per Capita (excluding LULUCF)

Tonnes CO_2 eq	2005	2012	2020
Per Capita Emissions	22.8	20.1	19.7

Decomposition of Canada’s Energy-related GHG Emissions

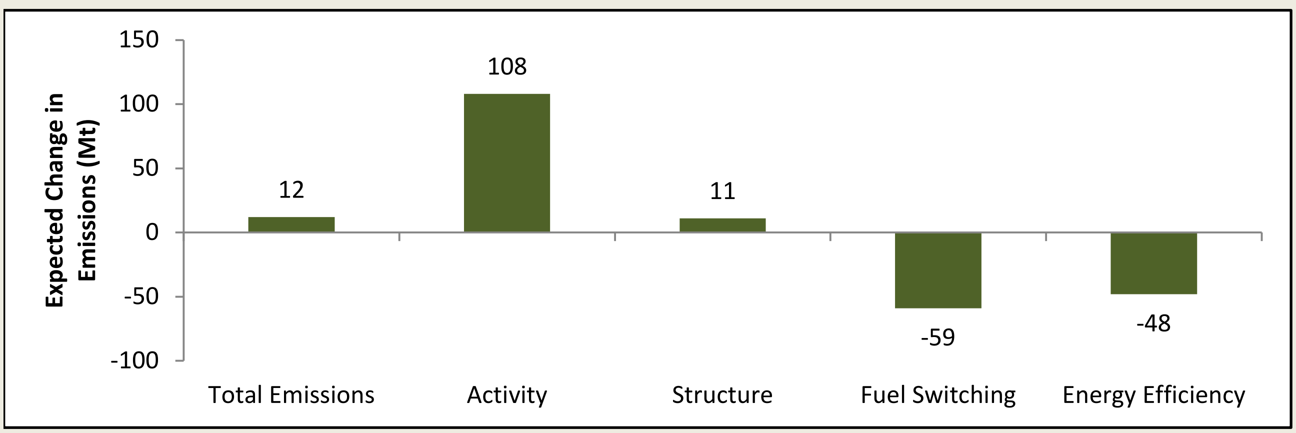
Although there is a close relationship between changes in GHG emissions and changes in the economy, the relationship has weakened since 1990 as a result of significant improvements in emissions intensity. These improvements are expected to continue into the future, largely as a result of energy efficiency improvements and the use of cleaner fuels.

To examine how different factors contributed to trends in projected emissions, a decomposition analysis of Canada’s projected combustion emissions was developed (see Annex 4 for methodology). The analysis focused on combustion emissions due to their strong link to energy use. Combustion emissions, which accounted for 72% or 532 Mt of Canada’s GHG emissions in 2005, include stationary sources such as the fuel required to heat homes and generate electricity as well as mobile sources such as light-duty and heavy-duty vehicles. Combustion emissions exclude sources such as industrial process emissions and agricultural methane. Environment Canada projects that combustion emissions are expected to grow to 544 Mt in 2020, representing increases of 12 Mt over 2005 levels.

Overall, as shown in the graph below, the analysis suggests that although economic growth and structural shifts in the economy put an upward pressure on projected combustion emissions, these factors are expected to be mostly offset by the switch to cleaner and more efficient energy use. The analysis decomposes the growth in combustion emissions into four different factors:

- The **Activity Effect** measures the impact of expected future economic growth. On its own, this growth could be expected to lead to 108 Mt of additional GHG emissions in 2020.
- The **Structural Effect** measures the change in the composition of the economy. Although there continues to be a shift towards service industries, this is dominated by the projected shift to more intensive industries such as the oil sands. As such, the impact of the projected structure of the economy would be an increase in emissions by 11 Mt in 2020.
- The **Fuel Switching Effect** measures changes in the mix of fuels. The shift to cleaner fuels such as the replacement of coal-fired electricity with other, cleaner sources is projected to have a significant impact, decreasing emissions by 59 Mt in 2020.
- The **Energy Efficiency Effect** measures changes in energy efficiency at the subsector level. The projections indicate that adopting currently available energy efficient technologies through policies, consumer responses to energy prices, and stock turnover could reduce emissions by 48 Mt in 2020.

Figure 5: Decomposition of Emissions Growth in 2020 since 2005 (excluding LULUCF)



Emissions Projections by Sector

Table 3 illustrates how the projected trends in greenhouse gas emissions vary by economic sector. This is because of the expected evolution of the key drivers of emissions in each sector, as well as various government initiatives that will affect the emissions intensity of the sector going forward. For example, the growing population in Canada affects the number of cars on the road, thus emissions from this subsector would be projected to rise. However, offsetting this trend are the Government of Canada's GHG performance standards for new vehicles, which are causing the average emissions intensity of these vehicles to decline through the projection period.

The electricity generating sector is the largest contributor to total emissions reductions, largely due to the combined impact of various government measures to create a cleaner electricity system, predominately by phasing out coal-fired generation. Electricity emissions are projected to decline by 50 Mt (41%) between 2005 and 2020. In contrast, increased production in Canada's oil sands is expected to drive a rise in emissions from the oil and gas sector of 45 Mt (28%) between 2005 and 2020.

Table 3: Change in GHG Emissions by Economic Sector (Mt CO_2 eq)

	2005	2012	2020	Change 2005 to 2020
Transportation	168	165	167	-1
Oil and Gas	159	173	204	45
Electricity	121	86	71	-50
Buildings	84	80	98	14
Emissions-intensive and Trade-exposed Industries	89	78	90	1
Agriculture	68	69	70	2
Waste and Others	47	47	46	-1
Expected LULUCF Contribution	-	-	-19	-
Total	**736**	**699**	**727**	**-9**

Note: Numbers may not sum to the total due to rounding.

Transportation

In 2012, emissions from transportation (including passenger, freight and off-road emissions) were the second-largest contributor to Canada's GHG emissions, representing 24% of overall GHGs.

In October 2010, the Government of Canada released the final *Passenger Automobile and Light Truck Greenhouse Gas Emission Regulations* (LDV1), which prescribe progressively more stringent annual emission standards for new vehicles of model years 2011 to 2016. The Government of Canada has also published proposed regulations in the *Canada Gazette* in 2014 for the second phase of action on light-duty vehicles, which contains increasingly stringent GHG emissions standards for light-duty vehicles of model years 2017 to 2025 (LDV2).

Under both phases of light-duty vehicle regulations, spanning model years 2011 to 2025, the fuel efficiency of new cars will increase by 41%, as compared with model year 2010 (and 50% compared with the 2008 model year), and the fuel efficiency of new passenger light trucks will increase by 37%. The sales-weighted fuel efficiency of new cars is projected to improve from 8.6 L/100 km in 2010 to 6.4 L/100 km in 2020 and to 5.1 L/100 km by 2025. The sales-weighted fuel efficiency of new passenger light trucks are projected to improve from 12.0 L/100 km in 2010 to 9.1 L/100 km in 2020 and to 7.6 L/100 km by 2025.

These improvements in efficiency are expected to help reduce emissions over the longer term. Total transportation emissions are projected to decrease by 1 Mt from 168 Mt in 2005 to 167 Mt by 2020. This departure from historical trends is expected to continue as a result of greater fuel efficiency in vehicles being accelerated by federal vehicle emissions regulations, despite projected increases in population and number of vehicles. Emissions are expected to further decline as the stock of existing vehicles is gradually turned over with the newer, more efficient models.

As depicted in Table 4, the transportation sector comprises several distinct subsectors: passenger, freight, air and others (e.g., rail and marine). Each subsector exhibits different trends during the projected period. For example, emissions from passenger transportation are projected to *decrease* by 8 Mt between 2005 and 2020, while those for ground freight, off-road and other vehicles are projected to *grow* by 10 Mt over the same time period due to anticipated economic growth. As a result, net emissions remain essentially stable over the period.

Although absolute emissions are expected to grow in the freight subsector due to expected economic growth, emissions are expected to decrease relative to business-as-usual levels as a result of various federal, provincial and territorial programs. The regulations for heavy-duty vehicles will improve the average fuel efficiency of trucks from 2.3 L/100 tonne-km in 2012 to 2.2 L/100 tonne-km by 2020.

Table 4: Transportation: Emissions (Mt CO_2 eq)

	2005	2012	2020	Change 2005 to 2020
Passenger Transport	96	94	88	-8
Cars, Trucks and Motorcycles	87	85	78	-9
Bus, Rail and Domestic Aviation	9	8	9	0
Freight Transport	57	61	67	10
Heavy-Duty Trucks, Rail	49	54	59	10
Domestic Aviation and Marine	8	7	8	0
Other: Recreational, Commercial and Residential	14	11	12	-2
Total	**168**	**165**	**167**	**-1**

Note: Numbers may not sum to the total due to rounding.

Oil and Gas

Emissions from oil and gas are projected to increase by 28% (from 159 Mt to 204 Mt) over the 2005 to 2020 time frame. This is due mainly to increases in oil sands production.

Table 5: Oil and Gas Sector: Emissions by Production Type (Mt CO_2 eq)

	2005	2012	2020	Change 2005 to 2020
Natural Gas Production and Processing	**54**	**48**	**40**	**-14**
Conventional Oil Production	**32**	**30**	**29**	**-3**
Light Oil Production	9	10	9	0
Heavy Oil Production	21	18	17	-4
Frontier Oil Production	2	2	2	0
Oil Sands	**34**	**61**	**103**	**69**
Bitumen in Situ	11	26	53	42
Bitumen Mining	9	15	23	14
Bitumen Upgrading	13	20	27	14
Oil and Natural Gas Transmission	**16**	**11**	**9**	**-7**
Downstream Oil and Gas	**24**	**22**	**21**	**-3**
Petroleum Products	22	20	18	-4
Natural Gas Distribution	2	2	3	1
Liquid Natural Gas Production	**0**	**0**	**3**	**3**
Total	**159**	**173**	**204**	**45**

Note: Numbers may not sum to the total due to rounding.

Upstream Oil and Gas

Upstream oil and gas includes the extraction, production, processing and transmission of both conventional and unconventional oil and gas. This subsector represented approximately 87% of the oil and gas sector emissions in 2012. This share is expected to increase to 90% by 2020 as oil sands extraction increases significantly.

Emissions projections in the oil and gas sector are based on the National Energy Board’s assumptions of oil and natural gas prices as well as estimates of anticipated production. Under these assumptions, emissions from upstream oil and gas production are estimated to grow from 135 Mt in 2005 to 181 Mt in 2020. This increase is driven by the growth in oil sands production, where emissions are expected to increase from 34 Mt in 2005 to about 103 Mt by 2020. Specifically, emissions from oil sands mining are projected to more than double over the 2005 to 2020 time period. Even more significantly, emissions from in situ production are expected to increase from 11 Mt in 2005 to 53 Mt in 2020. The emissions associated with the upgrading of oil-sands bitumen are expected to rise from 13 Mt in 2005 to 27 Mt by 2020.

Emissions from conventional crude oil production are expected to fall from 32 Mt in 2005 to 29 Mt in 2020 as conventional reserves are depleted. Emissions from natural gas production and processing are also expected to fall from about 54 Mt in 2005 to 40 Mt by 2020. Emissions from the pipeline transport of oil and natural gas are expected to fall from about 16 Mt in 2005 to 9 Mt by 2020.

Table 6: Selected Upstream Oil and Natural Gas Subsectors: Emissions and Drivers

	2005	2012	2020
Conventional Oil Production			
Emissions (Mt CO_2 eq)	32	30	29
Production (1000 barrels/day)	1359	1311	1302
Natural Gas Production and Processing			
Emissions (Mt CO_2 eq)	54	48	40
Gross Production (billion cubic feet)	6834	5826	4861
Oil Sands			
Emissions (Mt CO_2 eq)	34	61	103
Production (1000 barrels/day)	1064	1921	3418

Downstream Oil and Gas

Emissions from the downstream subsectors are expected to remain relatively unchanged throughout the projection period. Emissions are projected to decrease from 24 Mt in 2005 to 21 Mt in 2020.

Table 7 displays emissions associated with petroleum refining, which accounted for over 90% of downstream oil and gas emissions in 2005. From 2005 to 2020, emissions from petroleum refining are projected to decline by 4 Mt.

Canadian refineries are expected to decrease their output by 4% between 2012 and 2020. However, GHG emissions are expected to decrease by 10% over this time frame due to improvements in energy efficiency expected at the facilities (e.g., refurbishments).

Table 7: Petroleum Refining: Emissions and Drivers

	2005	2012	2020
Traditional Refineries			
Emissions (Mt CO_2 eq)	22	20	18
Refined Petroleum Processed (1000 barrels/day)	2296	2193	2112

Liquified Natural Gas

Liquefied natural gas (LNG) is natural gas (predominantly methane) that has been converted to liquid form for ease of storage and transport. Canadian projects in British Columbia and eastern

Canada aim to produce LNG to sell in global markets, where it would be re-gasified and distributed as pipeline natural gas. There is a high degree of uncertainty regarding LNG production in Canada since its potential for export resides in factors such as the cost and acceptability of export terminals and pipelines on the West Coast, as well as the long-term price expectations of natural gas, both domestically and internationally. For this report, modeling assumptions have used the National Energy Board's 2013 projections of expected LNG production. GHG emissions for LNG production represent emissions from the incremental energy consumption required for liquefaction processes.

Electricity Generation

The recent downward trend in emissions from the electricity sector is expected to continue over the next decade as a result of various federal and provincial government initiatives. Emissions in the electricity sector are projected to fall by 41% between 2005 and 2020.

Several provinces have introduced measures that will contribute to the decline of emissions in the electricity sector by moving away from fossil fuel electricity generation and towards cleaner sources of power.The Government of Canada released final regulations to reduce emissions from coal-fired electricity generation in September 2012. The regulations apply a stringent performance standard to new coal-fired electricity generation units and those coal-fired units that have reached the end of their economic life. The regulations come into effect on July 1, 2015, and will facilitate a permanent transition towards lower or non-emitting types of generation such as high-efficiency natural gas and renewable energy. With this regulation, Canada became the first major coal user to ban construction of traditional coal-fired electricity generation units. Canada already boasts one of the cleanest electricity systems in the world, with three quarters of our electricity supply emitting no GHGs. These regulations further strengthen our position as a world leader in clean electricity production.

Table 8 outlines the decline in projected emissions alongside the expected increase in electricity generation through 2020.

Table 8: Electricity Sector: Emissions and Drivers

	2005	2012	2020
Emissions (Mt CO_2 eq)	121	86	71
Generation (Terawatt-hours)	553	553	590

The increase in generation expected through 2020 will be powered from various fuel sources depending on the Canadian province and available resources. Although coal usage for electricity generation is declining, the proportion of power generation from fossil fuels is expected to vary by province depending on the availability of electricity from hydro, nuclear power and non-hydro renewable energy sources such as wind.[9] Hydro-power generation is expected to increase in most Canadian provinces. On a national level, emissions from coal-fired generation are projected to decline by 46 Mt over the 2005 to 2020 time period.

[9] See Annex Table A.5 Utility Electricity Generation by Fuel.

Table 9: Electricity Generation: Emissions by Fuel Type (Mt CO_2 eq)

	2005	2012	2020	Change 2005 to 2020
Coal	97	63	51	-46
Refined Petroleum Products	11	4	3	-8
Natural Gas	14	19	16	2
Total	**121**	**86**	**71**	**-50**

Note: Numbers may not sum to the total due to rounding.

The proportion of utility electricity generation coming from wind power and other renewable sources, excluding hydro, is expected to continue to increase between 2005 and 2020. Non-hydro renewables comprised 0.3% of total utility electricity generation in 2005 and are expected to account for 7.4% of total generation by 2020. It is assumed that renewables do not generate emissions.

Emissions-intensive and Trade-exposed Industries

The EITE sector includes metal and non-metal mining activities, smelting and refining, and the production and processing of industrial goods such as chemicals, fertilizers, aluminum, pulp and paper, iron and steel, and cement.

Emissions from the EITE sector declined 11 Mt between 2005 and 2012 following a decline in pulp and paper and mining output but are projected to reach 2005 levels overall by 2020, owing to modest production growth in the recovery years of the economic downturn and continued reduction of emission intensities.

Table 10: Emissions-intensive and Trade-exposed Industries: Emissions by Subsector (Mt CO_2 eq)

	2005	2012	2020	Change 2005 to 2020
Mining	6	8	9	3
Smelting and Refining (non-ferrous metals)	14	10	12	-2
Pulp and Paper	9	6	6	-3
Iron and Steel	19	16	18	-1
Cement	13	10	11	-2
Lime and Gypsum	3	3	3	0
Chemicals and Fertilizers	25	25	32	7
Total	**89**	**78**	**90**	**1**

Note: Numbers may not sum to the total due to rounding.

Buildings

Emissions from commercial and residential buildings are projected to increase by 15% (from 84 Mt to 98 Mt) over the 2005 to 2020 time frame (excluding indirect emissions from electricity).

Table 11: Buildings: Emissions (Mt CO_2 eq)

	2005	2012	2020	Change 2005 to 2020
Residential	45	41	47	2
Commercial	40	39	51	11
Total	**84**	**80**	**98**	**14**

Note: Numbers may not sum to the total due to rounding.

Residential Sector

As shown in Table 12, GHG emissions from residential buildings (e.g., houses, apartments and other dwellings) are expected to rise steadily by 6 Mt between 2012 and 2020 (15%). Although energy intensity continues to decline in the projection period, the assumption that heating requirements will be the average of the last 10 years leads to higher space heating demand than what has been seen in recent, warmer winters.

Table 12: Residential Sector: Emissions and Drivers

	2005	2012	2020
Emissions (Mt CO_2 eq)	45	41	47
Households (millions)	12.7	14.0	15.7

Commercial Sector

GHG emissions from Canada's commercial sector are expected to reach 51 Mt in 2020, an increase of 11 Mt from 2005 (Table 13). Emissions in commercial buildings remained stable between 2005 and 2012, while floor space continued to increase due, in part, to strengthening of building energy codes and increased commitment to benchmark energy use and the undertaking of energy-related retrofits. Even with continued efficiency improvements, emissions are expected to grow due to two factors. The first is an expansion of commercial floor space (the principal driver of emissions in this subsector) as the economy continues to grow. The second is the expected increase of hydrofluorocarbons (HFCs) in refrigeration and air conditioning in the commercial sector, due to the phase-out of ozone-depleting hydrochlorofluorocarbon (HCFC) refrigerant alternatives (see box below). HFCs are among the strongest GHGs and some HFCs are up to 14,000 times more potent than carbon dioxide. This implies that even a small increase in HFC use has a significant impact on emissions. Between 2012 and 2020, emissions are projected to increase by 31% (12 Mt), while floor space is projected to increase by 14%. HFC emissions (in CO_2 eq) account for more than one third (4.1 Mt) of the projected increase in overall emissions from commercial buildings between 2012 and 2020. However, the Government of Canada has indicated the intent to regulate HFCs which will limit growth of these emissions in the future.

Table 13: Commercial Sector: Emissions and Drivers

	2005	2012	2020
Emissions (Mt CO_2 eq)	40	39	51
Floor Space (millions m^2)	634	712	813

Emissions Growth from Hydrofluorocarbons

Hydrofluorocarbons (HFCs) are human-made, non–ozone–depleting chemicals used mainly in air conditioning and refrigeration systems, foam insulation, and aerosol applications. Most of these fluorinated gases are short-lived climate pollutants and potent GHGs, and some HFCs are up to 14,000 times more potent than CO_2. Globally, use and emissions of HFCs are growing rapidly as they continue to be introduced as alternatives to ozone-depleting substances, such as hydrochlorofluorocarbons (HCFCs), which are being phased out under the Montreal Protocol, an international treaty signed in 1987 to protect the ozone layer. While HFCs currently account for about 1% of global GHG emissions, if no action is taken, they could account for up to 19% of CO_2 eq emissions by 2050, given the sustained growth in demand for refrigeration and air conditioning in buildings and motor vehicles around the world.

In Canada, total GHG emissions from HFCs were less than 1 Mt in 1990, 5 Mt in 2005 and 8 Mt in 2012. However, they are projected to increase to 15 Mt in 2020, nearly twice the current levels. Under a business-as-usual scenario, HFCs are projected to increase at a faster rate than economic growth because they are often replacing HCFCs that are being phased out. HFC emissions are projected to rise in both the transportation and building sectors from applications such as commercial refrigeration, air conditioning and insulation foam products.

For the past five years, Canada, in partnership with Mexico and the United States, has advocated to amend the Montreal Protocol to include a phase-down of HFCs. The amendment would gradually reduce the consumption and production of HFCs and control by-product emissions of HFCs globally. While the proposal has not yet been adopted by the international community, , Canada is committed to addressing HFCs and has announced that it will publish a Notice of Intent to regulate these gases. Building on the approach of integrating with our largest trading partner, the regulations will align with recently proposed United States regulations on HFCs. The regulations will apply to HFCs in bulk and to certain manufactured products containing HFCs.

Agriculture

While emissions remain relatively stable over the 2005 to 2020 period, there are a number of compositional trends in the sector. Between 2005 and 2012, increases from on-farm fuel use and crop production were offset by decreases in animal production.

In the projection period, all agriculture sub-sector emissions are projected to remain relatively stable, reaching a total of 70 Mt in 2020.

Table 14: Agriculture Sector: Emissions[10] (Mt CO_2 eq)

	2005	2012	2020	Change 2005 to 2020
On-farm Fuel Use	10	14	13	3
Crop Production	19	24	24	5
Animal Production	39	32	33	-6
Total	**68**	**69**	**70**	**2**

Note: Numbers may not sum to the total due to rounding.

Waste and Others

This sector includes a number of diverse subsectors including waste as well as other industrial sectors. Non-emissions-intensive industrial subsectors included in the Waste and Others sector represent a wide variety of operations, and include light manufacturing (e.g., food and beverage, electronics), construction and forestry. Projected reductions in waste-related emissions, mostly due to increased landfill gas capture, are expected to be offset by moderate growth in the non-emissions-intensive industrial sectors over the 2005 to 2020 time frame.

Table 15: Waste and Others: Emissions (Mt CO2 eq)

	2005	2012	2020	Change 2005 to 2020
Waste	22	21	16	-6
Coal Production	2	4	4	2
Light Manufacturing, Construction and Forest Resources	23	22	26	3
Total	**47**	**47**	**46**	**-1**

Note: Numbers may not sum to the total due to rounding.

Land Use, Land-Use Change and Forestry

LULUCF is a particularly important sector for Canada given our vast land area. Of the world's forests, 10% are in Canada. Our managed forest covers 232 million hectares,[11] more than the managed forest of the entire European Union. Canada also has 65 million hectares of total farm area, as reported in the 2011 Census of Agriculture. These managed lands can act either as a carbon sink (i.e., remove CO_2 from the atmosphere) or a GHG source (emit CO_2 and other GHGs to the atmosphere). For example, planting trees on non-forested land (afforestation) removes carbon from the atmosphere as the trees grow, but conversion of forest land to other land uses (deforestation) will emit CO_2 and other GHGs to the atmosphere due to

[10] Includes both energy and non-energy emissions, such as methane from livestock manure and ruminant animals, and nitrous oxide from fertilizer usage, crops and manure.

[11] Canada's *National Inventory Report 2014*

decomposition or burning of the biomass. LULUCF accounting represents only emissions/removals from managed lands in Canada.[12]

The contribution of the LULUCF sector towards Canada's 2020 target represents emissions/removals that result from human activities. Emissions/removals related to natural disturbances (e.g., wildfires, insect infestations such as the mountain pine beetle) are not taken into account when calculating the LULUCF contribution.[13] The LULUCF sector has been included in both the 2012 and 2013 *Emissions Trends* reports. This year, Canada continues to estimate a contribution arising from the LULUCF sector using the same general methodology, but using updated data and some methodological improvements consistent with the 2014 NIR.

In this report, the LULUCF sector includes the same four categories or subsectors as shown in the 2013 *Emissions Trends Report*:

- *Forest Land Remaining Forest Land:* all forest that is "managed" for timber (e.g., harvesting) and non-timber resources (including parks), or subject to fire protection (this amounts to 67% of all forests in Canada);
- *Cropland Remaining Cropland*: cultivated agricultural land;
- *Forest Land Converted to Other Land Categories*: permanent, human-induced conversion of forested land to other land use (to agricultural land, infrastructure, mines, etc.) where forest is not expected to re-grow;
- *Land Converted to Forest Land:* land afforested through direct human activity (planting) and where the previous land use was not forest.

Table 16 summarizes the projected emissions and removals from the LULUCF sector in 2020. The LULUCF projection estimates are modeled separately from other economic sectors and use different accounting approaches than the other sectors. Each LULUCF subsector's contribution to Canada's 2020 emissions reduction target is estimated using an accounting approach that compares projected business-as-usual 2020 emissions/removals to 2005 emissions/removals, with the exception of Forest Land Remaining Forest Land, where 2020 projected emissions/removals from this subsector are compared with a 2020 Reference Level. The methodologies used for producing these estimates are described in more detail in Annex 1 of this report.

The expected total LULUCF contribution is 19 Mt, largely reflecting lower expected harvesting of trees in forest lands than in the past. This 19 Mt contribution is subtracted from total national emissions projections in 2020 as a credit towards reaching the target.

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[12] Given that, by definition, no LULUCF activities occur on unmanaged land, countries with reporting obligations under the UNFCCC do not have to report for unmanaged lands.

[13] The impact of natural disturbances is cancelled or factored out by using the Reference Level approach. See Annex 1.

Table 16: Projected Emissions (+) or Removals (-) from the LULUCF Sector in 2020[(a)] (Mt CO_2 eq)

(In Mt of GHG Emissions/Removals)	2005 Emissions/ 2020 Reference Level	2020 Projected Emissions/Removals	Expected Contribution in 2020
Forest Land Remaining Forest Land	-115.1[(b)]	-133.8	-18.7
Cropland Remaining Cropland[(c)]	-10.0	-8.0	2.0
Forest Land Converted to Other Land Categories[(d)]	17.3[(e)]	14.8	-2.5
Land Converted to Forest Land	-0.9	-0.4	0.6
Total	**-108.7**	**-127.4**	**≈-19**

(a) Numbers may not sum to the total due to rounding.

(b) For Forest Land Remaining Forest Land, a 2020 Reference Level is used for determining the contribution.

(c) Cropland Remaining Cropland includes residual emissions after 20 years from forest conversion to cropland.

(d) Includes all emissions from the conversion of Forest Land to other categories, except residual emissions 20 years or more after the forests are converted to cropland.

(e) Differences between these values and those reported in Canada's 2014 NIR are due to the inclusion of emissions from the conversion of forest to other land after 20 years or more for all categories except the conversion of forest to cropland.

Forest Land Remaining Forest Land is expected to contribute a net sink or removal of 18.7 Mt (rounded to 19 Mt) towards the 2020 target, the largest contribution of all the LULUCF subsectors. The most important driver of human-caused emissions on forest lands is the volume of wood harvested. When trees are harvested, much of the carbon that was stored in the trees is removed from the forest and transferred to harvested wood products. The carbon stored in the harvested wood products is then released into the atmosphere over the course of several years or decades as wood products are discarded, decay in landfills, or are burned in woodstoves, etc. Meanwhile, the dead biomass left in the forest after the harvest releases carbon as it decomposes, although at the same time new trees begin to re-grow, removing carbon from the atmosphere.

The 18.7 Mt contribution represents the impact of human activities on GHGs emitted from Canada's forests, driven primarily by the trends in harvesting. Harvest levels are projected to be lower in the period to 2020 than they were in the recent past, leading to anticipated reductions of human-caused emissions compared with historical levels, hence the contribution towards the target. As a result of the global economic recession, harvest levels in 2009 reached their lowest point since 1975, representing a 43% decline since the peak year of 2004.[14] Harvest levels have now started recovering but are expected to remain below average historical levels between now and 2020.

Beyond the pace of economic recovery for the forest sector, a number of additional factors are expected to influence harvest levels to 2020. First, the market for harvested wood products is experiencing structural changes. For example, while sales of lumber are recovering, the demand for pulp and paper products is being affected by a long-term shift towards electronic

[14] National Forestry Database Program, www.nfdp.ccfm.org

media. Second, some provinces have revised their policy frameworks for forest management, including harvesting. While the primary goal of provincial and territorial forest management policies is not climate change mitigation, these policies can impact emissions/removals. For example, Quebec's *Sustainable Forest Development Act*,[15] which came into force in 2013, and Ontario's forest tenure reform, based on the 2011 *Forest Tenure Modernization Act*,[16] will both have effects on forest management and hence on forest emissions/removals.

Cropland Remaining Cropland[17] is expected to provide a net source of 2 Mt of emissions in 2020. Soil carbon sequestration in Canada has increased from a rate of 1 Mt CO_2 eq per year in 1990 to 10 Mt CO_2 eq per year in 2005 and is still 10 Mt in 2012 (NIR 2014). This increase has been driven by several factors such as increased uptake of no-till, reduced use of summerfallow and changing crop patterns. Estimates indicate that the rate of sequestration is expected to decline from 10 Mt to 8 Mt CO_2 eq per year from 2012 to 2020 as a result of the soil sink approaching equilibrium and limited scope for additional practice adoption, thus creating a net source of 2 Mt in 2020. For example, on most of the land where no-till makes economic sense, that practice is already in use, and it is assumed that there will be little additional uptake. Also, a significant portion of the land already in no-till will have been in that practice for 20 years or more by 2020 and therefore approaching or at equilibrium. The rate of sequestration is expected to continue decreasing after 2020.

Forest Land Converted to Other Land Categories provides a net sink of 2.5 Mt in 2020. Current forest conversion rates in Canada are estimated at 46 000 hectares per year, down from 52 000 in 2005 and from the rate of 64 000 hectares per year observed in 1990. Overall, forest conversion emissions are projected to decline slightly in 2020 relative to 2005. The drivers of forest conversion in Canada are varied. In 2005, the largest driver was agriculture followed by resource extraction, urban and industrial expansion, hydroelectric development, and transportation (see Figure A.1 in Annex 1). By 2020, resource extraction is projected to surpass agriculture as the largest driver of land conversion, due to the expansion of the oil and gas industry.

Land Converted to Forest Land has a minor effect on the LULUCF contribution, providing a small net source of 0.6 Mt in 2020. Given the low levels of new forest creation, it is not possible to identify any trends in the activity except that it appears to be lower than in the 1990s.

The projected 19 Mt contribution of the LULUCF sector to achieving the 2020 target may change as subsector projections are refined over time as a result of further analysis, new data, updated projections or a change in accounting approaches. Actions aimed at reducing emissions or increasing removals in this sector could also change this projected estimate.

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[15] Ministère de l'Énergie et des Ressources naturelles, www.mern.gouv.qc.ca/english/forest/understanding

[16] Ontario Ministry of Natural Resources and Forestry, www.mnr.gov.on.ca/en/Business/Forests/2ColumnSubPage/STDPROD_091533.html

[17] The land categories where changes were examined for estimating emissions beyond 2011 were land in annual cropping, forage production and summerfallow.

Emissions Projections by Province

Emissions vary significantly by province, driven by diversity in population size, economic activities and resource base, among other factors. For example, provinces where the economy is oriented more toward resource extraction will tend to have higher emission levels whereas more manufacturing or service-based economies tend to have lower emissions levels. Electricity generation sources also vary, with provinces that rely on fossil fuels for their electricity generation having higher emissions than provinces that rely more on hydroelectricity. Table 17 shows the provincial/territorial distribution of emissions in absolute terms as well as their per capita (tonnes/capita) emissions.

Table 17: Provincial and Territorial GHG and per Capita Emissions: 2005 to 2012

	GHG Emissions (Mt CO_2 eq)		Per Capita Emissions (t/capita)	
	2005	**2012**	**2005**	**2012**
Newfoundland and Labrador	10	9	19.2	16.6
Prince Edward Island	2	2	15.6	13.4
Nova Scotia	23	19	24.6	20.1
New Brunswick	20	16	26.9	21.7
Quebec	86	78	11.3	9.7
Ontario	207	167	16.5	12.5
Manitoba	21	21	17.8	16.9
Saskatchewan	71	75	71.6	68.8
Alberta	232	249	69.8	64.0
British Columbia	62	60	14.8	13.2
Territories	2	2	23.0	17.9
Canada	**736**	**699**	**22.8**	**20.1**

Note: Numbers may not sum to the total due to rounding.

Table 18 displays projected provincial and territorial GHG emissions from 2005 to 2020. The projected emissions reflect a diversity of economic factors and government measures to reduce GHG emissions. These include public education campaigns, energy efficiency and renewable electricity programs, greening government operations, carbon taxes or levies (e.g., British Columbia, Alberta and Quebec), regulatory measures, and legislated renewable electricity targets.[18] All of the provincial and territorial governments (except Nunavut) have announced their own GHG reduction targets. These are described in Table A.8 of Annex 2.

[18] Although provincial and territorial governments have announced a diverse range of measures, only measures that could be readily modeled or have an announced regulatory or budgetary dimension were modeled. Aspirational goals and targets that were not supported by measurable, real and verifiable actions were not included.

Table 18: Provincial and Territorial GHG Emissions: 2005 to 2020 (Mt CO_2 eq)

	2005	2012	2020	Change 2005 to 2020
Newfoundland and Labrador	10	9	8	-2
Prince Edward Island	2	2	2	0
Nova Scotia	23	19	15	-8
New Brunswick	20	16	16	-4
Quebec	86	78	80	-6
Ontario	207	167	170	-37
Manitoba	21	21	23	2
Saskatchewan	71	75	73	2
Alberta	232	249	287	55
British Columbia	62	60	69	7
Territories	2	2	2	0
LULUCF	-	-	-19	-
Canada	**736**	**699**	**727**	**-9**

Note: Numbers may not sum to the total due to rounding.

The provinces oriented toward resource extraction and/or that are highly reliant on fossil fuels for their electricity generation (i.e., Alberta, Saskatchewan and New Brunswick) have per capita emissions above the national average. The provinces highly reliant on hydroelectricity or less emission-intensive sources for their electricity generation (i.e., Quebec, British Columbia, Ontario, Newfoundland and Labrador, and Manitoba) have per capita emissions below the national average.

Table 19 displays projected provincial and territorial per capita GHG emissions to 2020 and compares them with actual emissions in 2005 and 2012. Per capita emissions are projected to fall in all provinces in 2020 relative to 2005 levels.

Table 19: Provincial and Territorial per Capita GHG Emissions: 2005 to 2020 (t/capita)

	2005	2012	2020
Newfoundland and Labrador	19.2	16.6	16.0
Prince Edward Island	15.6	13.4	12.1
Nova Scotia	24.6	20.1	15.9
New Brunswick	26.9	21.7	21.3
Quebec	11.3	9.7	9.4
Ontario	16.5	12.5	11.5
Manitoba	17.8	16.9	16.6
Saskatchewan	71.6	68.8	62.9
Alberta	69.8	64.0	65.3
British Columbia	14.8	13.2	13.7
Territories	23.0	17.9	18.5
Canada	**22.8**	**20.1**	**19.7**

Projected Alternate Emissions Scenarios

Given the uncertainty regarding the key drivers of GHG emissions, the scenario presented in the previous section should be seen as one estimate within a set of possible emissions outcomes in the projection period, as events that will shape emissions and energy markets cannot be fully anticipated. In addition, future developments in technologies, demographics and resources cannot be foreseen with certainty. The variation in these complex economic and energy variables implies that modeling results are most appropriately viewed as a range of plausible outcomes. Environment Canada addresses this uncertainty via modeling and analysis of alternative cases that focus on variability in two key factors: future economic growth projections; and the evolution of oil and natural gas prices and production as per National Energy Board high and low scenarios. These assumptions are presented in Table 20 and Table 21 below.

Table 20: Economic Growth Assumptions from 2012 to 2020

Assumption	Low	Reference	High
Average Annual GDP Growth Rate	1.5%	2.2%	2.7%

Table 21: Oil and Gas Price Assumptions in 2020

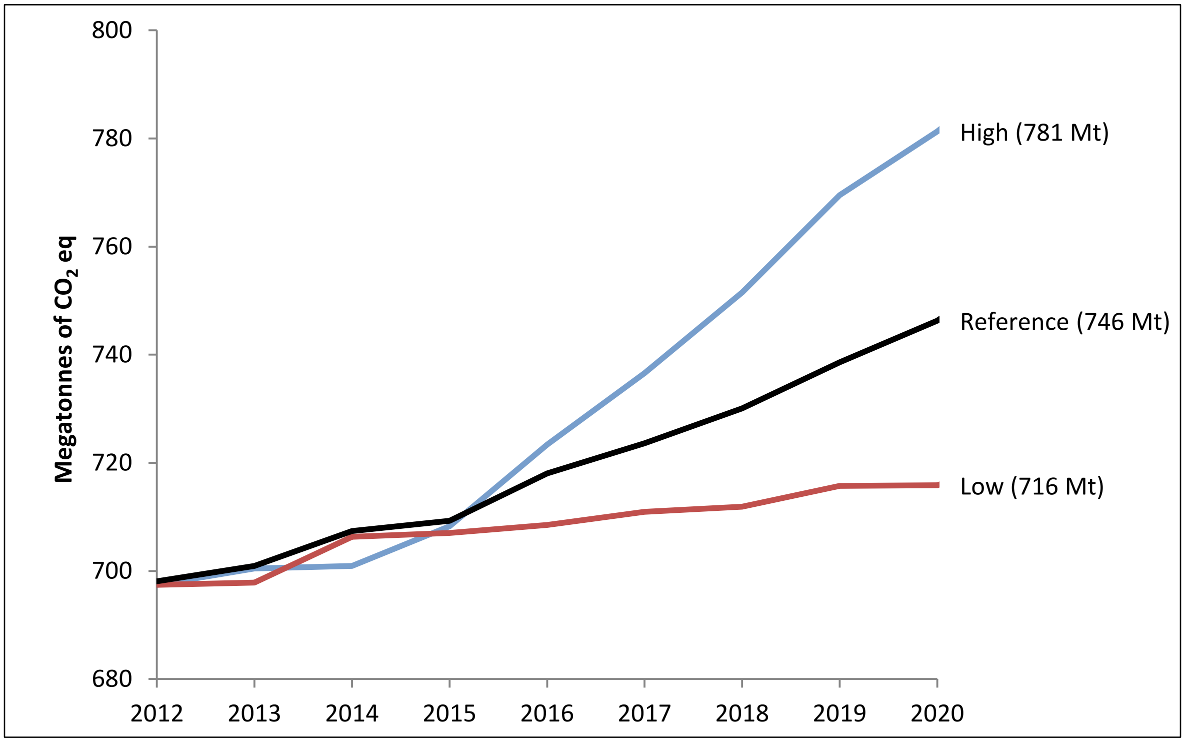
Assumption	Low	Reference	High
Crude Oil Price: WTI (2012 C$/bbl)	72	102	132
Natural Gas Price: Henry Hub (2012 C$/GJ)	3.30	4.72	6.04

The most extreme results of varying economic growth and world oil/natural gas price assumptions are presented in Figure 6. Under the scenario with the highest emissions, emissions could reach 781 Mt by 2020 (excluding the contributions from LULUCF). Alternatively, in the low emissions case, 2020 emissions could be as low as 716 Mt (excluding LULUCF).

The range in total projected emissions from all scenarios rises as we extend our projection further into the future. As a result of the assumptions made about the growth in Canadian GDP and future oil and natural gas price and production, the range is roughly 65 Mt in 2020.

These sensitivities illustrate that Canada’s emissions projections should not be interpreted as a precise estimate of our emissions because, as outlined above, actual emissions will be determined by a range of as yet unknown developments in key drivers. Rather, the projections should be viewed as one plausible outcome for future emissions that provides a reference point for evaluating the impact of economic and technological developments, as well as assessing the impact of future government measures.

Figure 6: Projected GHG Emissions Under Alternative Economic Assumptions



It is important to note that the projection of emissions in this report is based on existing government measures as of the spring of 2014 only and does not reflect the impact of further federal, provincial or territorial measures that are under development or that could be undertaken in the future. Likewise, specific federal, provincial and territorial targets are not directly modeled in these scenarios.

Table 22: Sensitivity of GHG Emissions to Changes in GDP and Price (excluding LULUCF) in Mt CO_2 eq

	2020	**Change 2005 to 2020**
Slow GDP, Low World Oil Prices	716	-20
Fast GDP, High World Oil Prices	781	45
Baseline Scenario	747	10
Sensitivity Range (including all scenarios examined, see Annex 3)	**716 to 781**	**-20 to 45**

Annex 1: The Contribution of the Land Use, Land-use Change and Forestry Sector and Modeling Methodologies

Importance of the Land Use, Land-use Change and Forestry Sector

The United Nations Framework Convention on Climate Change has recognized the important role of the Land Use, Land-use Change and Forestry sector in addressing climate change. The LULUCF sector involves GHG fluxes between the atmosphere and Canada's managed lands, as well as those associated with land-use change.

Allowing countries to get "credits" for reductions of emissions from their land sector and/or increased removals provides an incentive to take the GHG impacts of human activities on the landscape into consideration when making land management decisions. Similarly, allotting "debits" for their land sector emission increases and/or reduced removals also provides an incentive.

As mentioned earlier in this report, the LULUCF sector includes the same four categories as shown in the 2013 *Emissions Trends Report*:

- *Forest Land Remaining Forest Land*: all forest that is "managed" for timber (e.g., harvesting) and non-timber resources (including parks), or subject to fire protection;
- *Cropland Remaining Cropland*: cultivated agricultural land;
- *Forest Land Converted to Other Land Categories*: permanent, human-induced conversion of forested land to other land use (to agricultural land, infrastructure, mines, etc.) where forest is not expected to re-grow; and
- *Land Converted to Forest Land:* land afforested through direct human activity (planting) and where the previous land use was not forest.

Over the last two decades, important changes have occurred in land management practices in Canada that have reduced GHG emissions or enhanced their removals from the atmosphere. For example, farmers have increasingly adopted no-till practices and reduced field area under summerfallow, which contribute to a higher rate of soil carbon sequestration. Beneficial management practices have also been adopted by the forestry sector, primarily through provincial policies and/or regulations in their areas of jurisdiction. Although these policies and regulations are aimed broadly at improving sustainability in the sector, they can also reduce GHG emissions and increase sequestration. They include increase in protected forest areas for conservation and biodiversity purposes; relatively more reliance on tree planting as opposed to natural regeneration; increasing use of improved seed stock for tree planting; and more and faster rehabilitation of harvest roads and landings. Recently, economic factors have had a large impact on the forest sector: it experienced a 43% decline in harvest levels between the peak year of 2004 and 2009, resulting in the lowest harvest since 1975, although harvests have recovered somewhat since 2009.

LULUCF Subsector Modeling Methodologies

The accounting approaches that Canada uses are largely consistent with the rules developed at the 2011 UNFCCC 17th Conference of the Parties in Durban, South Africa. Each subsector's contribution to Canada's 2020 target is estimated by comparing projected business-as-usual 2020 emissions/removals to 2005 emissions/removals, with the exception of Forest Land Remaining Forest Land, where 2020 projected emissions/removals are compared with a 2020 Reference Level based on historical data. The Reference Level approach has been internationally agreed to and is currently seen as the most scientifically credible approach to account for emissions and removals from Canada's managed forests, considering Canada's inventory methodology and forest structure.

Consistent with these accounting approaches, LULUCF projections have been modeled separately from the other sectors. Each LULUCF subsector has been projected using a different model/methodology as determined by the relevant federal government department subsector experts. Environment Canada, in partnership with Natural Resources Canada and Agriculture and Agri-Food Canada, develops and periodically updates projections of business-as-usual emissions and removals (i.e., in the absence of new policies aimed at contributing to mitigation) to 2020 for each subsector. Estimates for emissions and removals associated with management of Wetlands, Grasslands and Settlement land (other than those associated with forest conversion) have not been included, as data collection and modeling work are under development.

The Government of Canada's work to analyze alternative accounting approaches is ongoing, and changes to the accounting approach may be made in the future. In particular, there remains uncertainty with respect to future approaches that may be included under a post-2020 climate change agreement.

Further detail on Canadian emissions trends and methodologies used are provided for each of the subsectors below.

Forest Land Remaining Forest Land

Provided by the Canadian Forestry Service of Natural Resources Canada

A Reference Level approach is used to measure changes in GHGs in the Forest Land Remaining Forest Land (hereafter, the managed forest) category. This approach measures countries' progress in reducing forest emissions or increasing forest removals that can be attributed to changes in human activities/practices (e.g., harvesting, fertilization) over time, as the Reference Level approach allows factoring out of highly variable natural disturbance impacts.

The Reference Level is a baseline or expected business-as-usual scenario. This Reference Level scenario was established in 2011 by making assumptions about the human activities (primarily harvesting) that were expected to take place in the future in the forest if no additional policies were implemented and if the economic drivers remained similar to what they had been in the past. Under the Durban LULUCF agreement, once the Reference Level scenario is established, these underlying assumptions cannot be changed. The GHG emissions/removals resulting from these assumptions then can be calculated based on the state of the forest (e.g., the GHG impact of harvesting a hectare of forest in coastal British Columbia is different from harvesting a hectare of boreal forest in Ontario due to the differences in forest density, age and tree species).

The human activity that has the most impact on Canada's forest emissions/removals is harvesting. Consequently, the core assumption underlying the Reference Level is the harvest volume: first, it assumes that harvest rates recover progressively between 2010 and 2012 from the low level in 2009 that resulted from the economic recession; then, it assumes that harvests each year from 2013 to 2020 will be the same as the average historical harvest volume for 1990–2009. This was considered the best estimate of Canada's business-as-usual harvest level for the period 2013–2020 at the time when Canada established its Reference Level in 2011.[19]

The projected 2020 contribution is estimated by comparing the GHG impacts of the Reference Level scenario with those of a second scenario based on the currently expected future harvest and other management activities. Updated harvest projections to 2020 were obtained from provincial and territorial governments in February 2014. The accounting contribution arises primarily from the difference in harvest level assumptions between the Reference Level and this updated future harvest scenario. As the Reference Level scenario and the updated harvest scenario differ only with regard to the level of human activities that they assume, the GHG impact of natural processes (i.e., carbon that is removed/emitted when trees naturally grow and die) and of natural disturbances (e.g., wildfire, insect infestations) are meant to cancel out when these two scenarios are compared to calculate the contribution.

All estimates for the managed forest (and for Land Converted to Forest Land, discussed below) were derived using Canada's National Forest Carbon Monitoring Accounting and Reporting System. The system uses forest inventory data from the provinces and territories as well as from the National Forest Inventory, and includes detailed information on natural disturbance. Natural Resources Canada developed and maintains the Carbon Budget Model of the Canadian Forest Sector (CBM-CFS3), a forest carbon dynamics estimation tool fully consistent with the IPCC inventory guidelines. Emissions from harvested wood products are calculated using the Carbon Budget Modelling Framework for Harvested Wood Products. With the CBM-CFS3 as its core, the system provides annual estimates of GHG emissions and removals affected by forest management, natural disturbances and land-use change. This is the same system as the one used to produce forest-related emission/removal estimates from 1990 to 2012 for Canada's 2014 National Inventory Report.

To produce the managed forest projections for 2020, the models are run to 2020 for both the Reference Level scenario and the scenario based on the currently expected future harvest and other management activities. Historical data on natural disturbances up to 2012 are included in the two scenarios; however, because future natural disturbances are unknown and unpredictable, the analysis for each scenario assumes no natural disturbances would occur from 2013 onward, apart from a minimum level of wildfire expected to occur every year (based on more than 50 years of historical data). Projected emissions from harvested wood products use the same general approach as used in managed forest estimates for the 2014 NIR, i.e., the pool of harvested wood products is assumed to start in 1990, with emissions occurring over time.

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[19] A full description of Canada's Reference Level assumptions is available in a submission to the UNFCCC at unfccc.int/bodies/awg-kp/items/5896.php.

Forest Land Converted to Other Land Categories

Provided by Science and Risk Management Directorate, Environment Canada

Emissions associated with forest conversion to other land use are reported in Canada's 2014 NIR under the LULUCF sector. Forest conversion is not a LULUCF category under UNFCCC reporting requirements, since it overlaps with the subcategories of land converted to cropland, land converted to wetlands and land converted to settlements; it is nevertheless reported as a memo item in the annual inventory submission. Emissions reported in this document are consistent with values reported in the NIR and are derived using identical data and methodology.

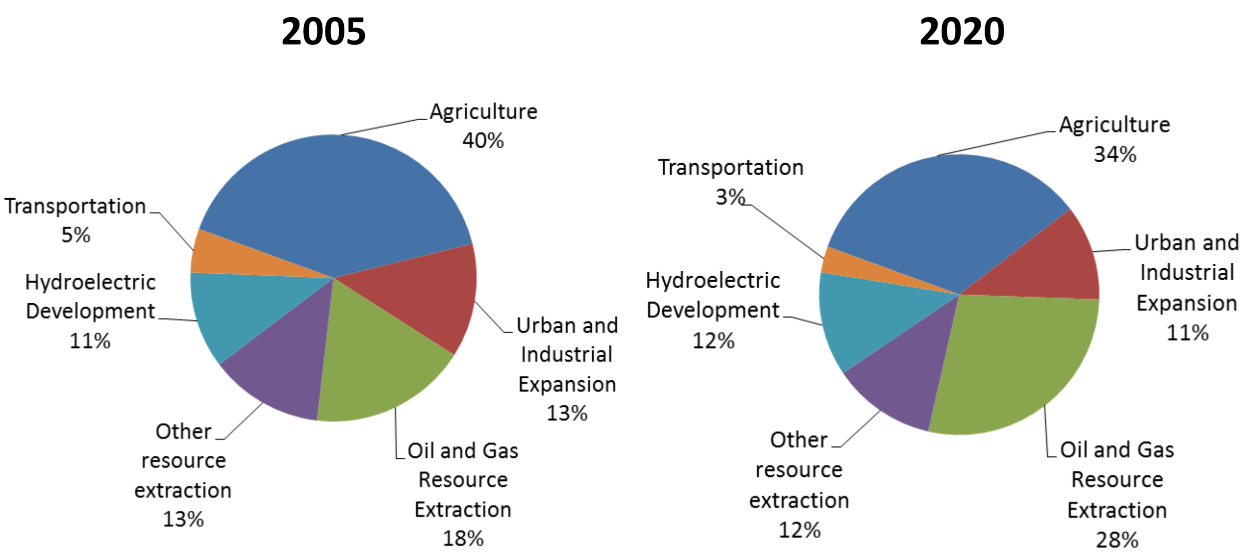
Historical estimates for forest land conversion are based on an earth observation sampling approach with resulting emissions calculated using the Carbon Budget Model of the Canadian Forest Sector. These estimates take into account land conversion activity from 1970 to 2012 and are developed for the specific activity (driver) that initiated the land conversion and by end land-use category (cropland, wetlands, settlements). Specific drivers include agriculture, urban and industrial expansion, hydroelectric development, transportation, oil and gas, and other resource extraction including mining, forestry roads and peat extraction.

The projected estimates for forest conversion are based on a business-as-usual scenario of forest conversion activity for the 2013 to 2020 period, using the best available knowledge of drivers, policies and practices, as documented in the NIR.

Emission estimates for projected forest conversion are developed using an empirical model; model parameters were derived by driver and ecological region based on the relationship between areas converted and resulting emissions as were reported in the NIR submissions for the years 2011 and 2012. All emission estimates for forest conversion use an instantaneous oxidation approach to represent the conversion of forest to harvested wood products, which is in keeping with the approach used for the development of estimates for Canada's 2014 NIR.

The drivers of forest conversion in Canada are varied. In 2005, the largest driver was agriculture, followed by resource extraction, urban and industrial expansion, hydroelectric development, and transportation (Figure A.1). By 2020, resource extraction is projected to surpass agriculture as the largest driver of land conversion, due to the expansion of the oil and gas industry.

Figure A.1: Relative Contribution of Main Drivers of GHG Emissions from Forest Conversion in 2005 and Projected for 2020*



*For the specified year, the charts include all emissions from forest conversion since 1970, with the exception of conversion to harvested peat sites (Peat Extraction), which are included in historical estimates for 2005 but not available for the projections to 2020.

Note that the Urban and Industrial Expansion section includes industrial and commercial buildings, urban and municipal expansion, and recreation.

Cropland Remaining Cropland

Provided by Agriculture and Agri-Food Canada (AAFC)

AAFC generated estimates for Cropland Remaining Cropland by using two models: the Canadian Regional Agricultural Model (CRAM) and the Canadian Agricultural Greenhouse Gas Monitoring Accounting and Reporting System (CanAG-MARS). CRAM was used to estimate the resource use patterns in the agriculture sector, which were then fed into CanAG-MARS to provide corresponding estimates of emissions/removals from Cropland Remaining Cropland.

CRAM is an economic model maintained by AAFC that provides a detailed characterization of agricultural activities in Canada. It is a static partial equilibrium model of the Canadian agriculture sector, which operates by maximizing consumer and producer surplus. CRAM's features include coverage of all major cropping activities, livestock production and some processing, detailed provincial and/or sub-provincial breakdown of activities, and a detailed breakdown of cropping production practices including choice of tillage regime, use of summerfallow and stubble.

CRAM is directly calibrated to the 2011 Census of Agriculture, and all resource use patterns are the same as what is reported in the Census for that year. As CRAM is a static model, it does not provide any information on how the agriculture sector changes over time. In order to estimate future resource use patterns, a 2020 baseline was created where CRAM was aligned to the crop and livestock production estimates from AAFC's 2014 Medium Term Outlook (MTO). The

2014 MTO provides a 10-year estimate of crop and livestock production from 2013 to 2023 based on the expected economic conditions that will impact the agriculture sector in Canada over that time period.

The CanAG-MARS model is maintained by AAFC, which reports on GHG sources and sinks resulting from changes in land use and land management practices in Canada's agricultural sector. The estimation procedure follows a Tier 2 methodology under IPCC Good Practice Guidance for LULUCF. The model quantifies the annual change in soil organic carbon associated with land use or land management changes.

The amount of organic carbon retained in soil represents the balance between the rate of primary production (carbon transfer from the atmosphere to the soil) and soil organic carbon decomposition (carbon transfer from the soil to the atmosphere). How the soil is managed can determine whether the amount of organic carbon stored in soil is increasing or decreasing. The estimation procedure is based on the premise that changes in soil management influence the rate of soil carbon gains or losses for a period of time following a land management change. If there was no change in land management, then soil organic carbon is assumed to be at equilibrium and the change in carbon stock is deemed to be zero.

Carbon emissions and removals on mineral soils are estimated by applying country-specific, spatially disaggregated carbon emission and removal factors multiplied by the relevant area of land that undergoes a management change. The carbon factor represents the rate of change in soil carbon per unit area for each land management change as a function of time since the land management change occurred.

The 2011 and 2020 resource use patterns generated within CRAM were combined with activity data from past census periods dating back to 1951. Within the CanAG-MARS model, activity data is annualized assuming a constant rate of change between census periods and projection years. The data is linked to soil landscapes, and annual changes in land activities are estimated through a set of rule-based mechanisms. Factors are applied to the area of current and past land use or land management change activities to generate GHG emissions/removals for each inventory year.

Residual emissions occurring 20 years after the conversion of forest land to cropland were provided by Environment Canada, as AAFC does not have the capacity to estimate some components of this, such as the decay of woody biomass. These estimates were combined with the estimates generated by CRAM and CanAG-MARS to produce the final estimated Cropland Remaining Cropland emissions.

Land Converted to Forest Land

Provided by the Canadian Forestry Service of Natural Resources Canada

Projections were based on average historical rates of land being afforested as reflected in the NIR. As no new information is available, projections have not been updated from those published in the *Emission Trends Report 2013*. For that report, projections were based on the assumption that the 2000–2008 historical average provided the best representation of the business-as-usual scenario in each province, given that 2000–2008 is the most recent period for which afforestation activity data is available. This business-as-usual rate in the future totals about 2700 hectares per year for Canada as a whole. Data on creation of new forests for 2009–

2012 are not available. Given the low levels of new forest creation, it is not possible to identify any trends in the activity, except that new forest creation appears to be lower than in the 1990s. Improvements in the data may be possible, as there are indications that some creation of new forest during the 2000s has not yet been reflected in the GHG inventory. Thus, the rate of new forest creation in the last decade may be underestimated.

Annex 2: Baseline Data and Assumptions

Baseline Data and Assumptions

Many factors influence the future trends of Canada's GHG emissions. These key factors include the pace of economic growth, as well as Canada's population and household formation, energy prices (e.g., world oil price and the 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 certain key drivers (e.g., world oil price, the pace of economic growth) 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 and key drivers are listed in this annex. Alternative cases are explored in the sensitivity analysis in Annex 3.

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 GHG emissions.

Historical data on GDP and disposable personal income are provided by Statistics Canada. Consumer price index and population demographics are also produced by Statistics Canada, while historical emissions data are provided by the 2014 NIR. The economic projections to the year 2018 are calibrated to Finance Canada's June 2014 Private Sector Survey.[20] The outer years (2018 to 2020) are based on Finance Canada's longer-term fiscal projections included in their Economic and Fiscal Implications of an Aging Population report.[21]

Forecasts of major energy supply projects from the National Energy Board's 2013 projections were incorporated for key variables and assumptions in the model (e.g., oil sands production, large hydro-capacity expansions, nuclear refurbishment and additions). The National Energy Board is an independent federal agency that regulates international and interprovincial aspects of the oil, gas and electric utility industries. The U.S. Energy Information Administration's outlook on key parameters is also taken into account in the development of energy and emissions trends.

Economic Growth

The Canadian economy grew by 1.5% per year over 2005 through 2012, a period that includes the 2009 global recession. Real GDP growth is expected to average 2.2% per year from 2012 to 2020. In line with the Bank of Canada's target, the annual inflation rate is expected to be approximately 2% per year throughout the projection.

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[20] Department of Finance Canada (2013). *June 2013: Department of Finance Private Sector Survey*. Website www.fin.gc.ca/pub/psf-psp/2013/2013-06-eng.asp, accessed 10 Sep 2013.

[21] www.fin.gc.ca/pub/eficap-rebvpc/eficap-rebvpc-eng.pdf

Table A.1: Macroeconomic Assumptions, 1990–2020 Average Annual Growth Rates

Assumption	1990–2012	2012–2020
Average Annual GDP Growth Rate	2.4%	2.2%
Average Annual Population Growth Rate	1.0%	1.1%
Average Annual Labour Force Growth Rate	1.3%	0.6%

The growth in the labour force and changes in labour productivity influence the changes in Canada's real GDP. Labour productivity is expected to increase by an average of 1.0% annually between 2012 and 2020, an improvement over the 0.4% average annual growth during the period between 2005 and 2012. The increase in productivity is attributed to an expected rise in capital formation and contributes to the growth in real disposable personal income, which is expected to increase by an average of 1.8% per year between 2012 and 2020.

Population Dynamics and Demographics

The population size and its characteristics (e.g., age, sex, education, household formation) have important impacts on energy demand. Canada's overall population is projected to grow on average at an annual rate of 1.1% between 2012 and 2020.

Major demographic factors that can have measurable impacts on energy consumption are summarized below:

- Household formation: This is the main determinant of energy use in the residential sector. The number of households is expected to increase on average by 1.4% per year between 2012 and 2020.
- Labour force: This is expected to have a decelerating growth rate, reflecting the aging population. Its annual average growth rate was 1.3% per year between 2005 and 2012, and is projected to slow to 0.6% per year between 2012 and 2020.

World Crude Oil Price

A major factor in projected GHG emissions is the assumption about future world oil prices, since this drives the level of production of oil. Canada is a price taker in crude oil markets, 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 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. The increase in North American supply and the resulting transportation bottleneck at Cushing have created a disconnect between the WTI price of crude oil and the Brent price of crude oil. As such, the North American oil market is currently being priced differently from the rest of the world.

The emissions outlook's reference case is anchored by the world oil price assumptions developed by the National Energy Board (NEB). According to the NEB, the world crude oil price for WTI is projected to increase slightly from about $96 Canadian dollars (2012 C$) per barrel of oil (bbl) in 2012 to about C$102/bbl in 2020. The NEB's higher price scenario, in which 2020 prices are C$132/bbl, is used for the sensitivity analysis in Annex 3.

Figure A.2: Crude Oil Price: WTI and Alberta Heavy (2012 C$/bbl)

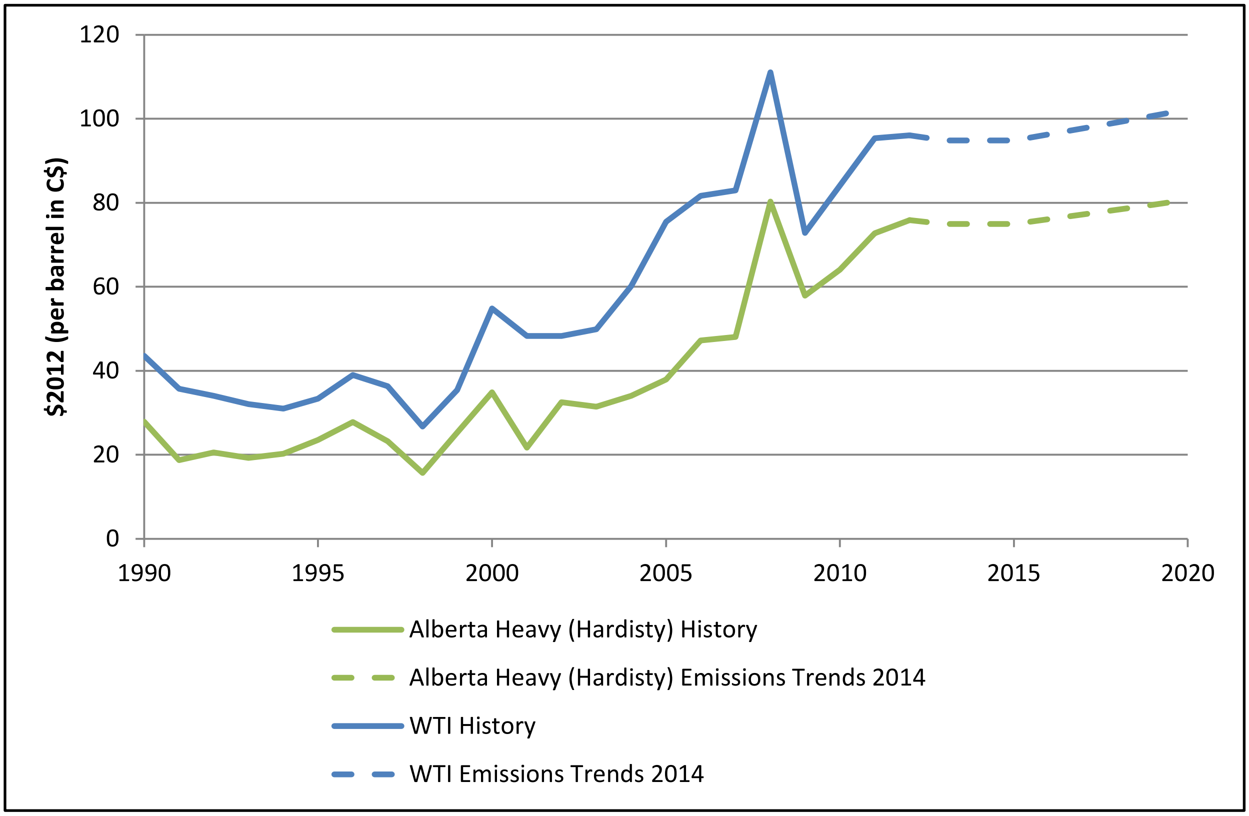

Figure A.2 shows crude oil prices for light crude oil (WTI) and heavy oil. Historically, the price of heavy oil/bitumen (Alberta Heavy) has followed the light crude oil price (WTI) at a discount of 50% to 60%. However, in 2008 and 2009 the differentials between the prices of light and heavy crude oils ("bitumen/light-medium differential") narrowed significantly owing to a global shortage of heavier crude oil supply. The bitumen/light-medium differential averaged 22% over the 2008 to 2009 period, compared with 44% over the five-year average from 2003 to 2007.

Alberta's Energy Regulator expects the bitumen/light-medium differential to average 26% over the forecast period, compared with the five-year average of 36% and the 2009 average of 17%.[22]

As shown in Figure A.3, the Henry Hub price for natural gas in Alberta (the benchmark for Canadian prices) declined in 2010 to about C$4 per gigajoule (GJ). In the projection, it begins to recover to reach about C$4.72 per GJ by 2020, well below its peak of over C$9 in 2005. This reflects the NEB's assumption that major pipeline expansions such as the Mackenzie and Alaska pipelines may not occur before 2020 due to low natural gas prices.

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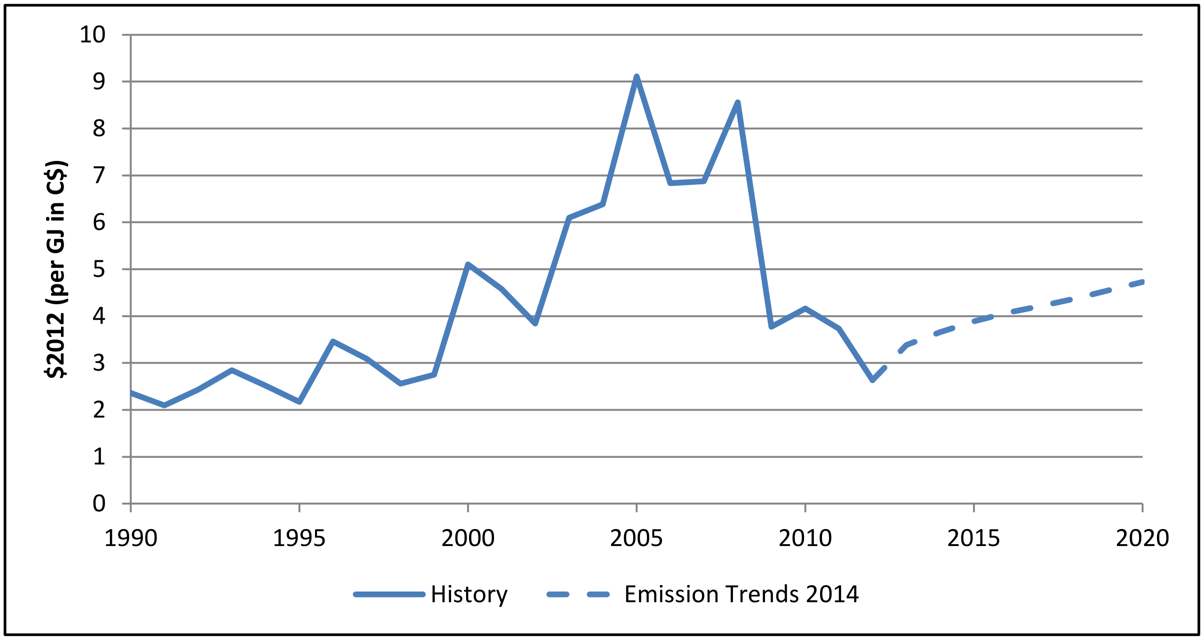
[22] www.aer.ca/data-and-publications/statistical-reports/st98

Figure A.3: Henry Hub Natural Gas Price (2012 C$/GJ)



Energy and Electricity Production

Oil and Gas

NEB projections show that both natural gas and conventional oil production will decrease over time as a result of declining supply, although the projected increase in production from oil sands operations will more than compensate for this decline. As such, under assumed prices and absent further government policy actions, it is expected that from 2012 to 2020 oil sands in situ production will more than double (see Table A.2).

Table A.2: Crude Oil Production in Thousands of Barrels per Day

Thousand Barrels per Day	2005	2012	2020
Crude and Condensates	**1532**	**1462**	**1405**
Conventional Heavy	524	451	431
Conventional Light	511	649	612
C5 and Condensates	173	150	103
Frontier Light (offshore + northern)	324	211	259
Oil Sands	**1064**	**1921**	**3418**
Oil Sands: Primary	150	245	249
Oil Sands: in Situ	286	750	1731
Steam-assisted Gravity Drainage	82	491	1406
Cyclic Steam Stimulation	204	259	325
Oil Sands Mining	628	925	1438
Total Production (gross)	**2596**	**3382**	**4823**

Note: Numbers may not sum to the total due to rounding.

Table A.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 is projected to increase from about 959 000 barrels per day (bp/d) in 2012 to about 1.3 million bp/d by 2020. Non-upgraded bitumen will increase from 851 000 bp/d in 2012 to 1.9 million bp/d 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 A.3: Oil Sands Disposition in Thousands of Barrels per Day

Thousand Barrels per Day	2005	2012	2020
Synthetic	611	959	1347
Non-upgraded Bitumen	370	851	1904
Oil Sands (net)	**981**	**1810**	**3250**
Own Use	83	111	168
Oil Sands (gross)	**1064**	**1921**	**3418**

Note: Numbers may not sum to the total due to rounding.

Projections show gross natural gas production will decline to some 4.9 trillion cubic feet (TCF) in 2020, as new production and non-conventional sources such as shale gas and coal-bed methane come to market[23] but do not quite offset conventional declines.

[23] 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 modeling shale gas separately.

Table A.4: Natural Gas Production in Billion Cubic Feet

Billion Cubic Feet	2005	2012	2020
Supply			
Gross Production	6834	5826	4861
Own-use Consumption	618	718	605
Marketable Gas	6215	5108	4256
Imports	332	1106	1231
Total Supply	**6547**	**6213**	**5487**
Liquid Natural Gas Production	**0**	**0**	**548**

Note: Numbers may not sum to the total due to rounding.

Electricity

The projections in this report reflect plans by provincial and territorial utilities with respect to key electricity capacity expansions. In addition, additional units are built endogenously by the model to meet growth in electricity demand. Aggregate electricity generation is expected to increase, by 6.7% from 2012 to 2020, with fuel mix changes as generation increases. As Table A.5 illustrates, the proportion of generation coming from wind power and other non-hydro renewable sources is expected to increase from 2005 to 2020, starting at only about 0.3% in 2005 and reaching 7.5% of total generation by 2020.

Government actions, such as the introduction of the Electricity Performance Standard, will cause fuel switching in the overall electricity generating portfolio. As noted above, it is expected that natural gas-fired generation will continue to increase because of its appeal as a relatively cleaner source of power generation and a reliable means to cover peak loads. The lower price of natural gas also makes it an attractive choice. Coal and petroleum coke generation are projected to fall from 18% of the generation in the Canadian portfolio in 2005 to 9.0% in 2020.

Table A.5: Utility Electricity Generation by Fuel, Terawatt-hours

Terawatt-hours (TWh)	2005	2012	2020
Coal and Petroleum Coke	98	64	53
Refined Petroleum Products	12	3	2
Natural Gas	28	40	33
Hydro	327	345	379
Nuclear	87	89	79
Other Renewables	2	12	44
Total Generation	**553**	**553**	**590**

Note: Numbers may not sum to the total due to rounding.

Emissions Factors

Table A.6 provides a rough estimate of CO_2 eq emissions emitted per unit of energy consumed by fossil fuel type. These numbers are estimates based on latest available data based on IPCC methodology. Specific emission factors can vary slightly by year, sector and province.

Table A.6: Mass of CO_2 eq Emissions Emitted per Quantity of Energy for Various Fuels

Fuel	CO_2 eq Emitted (g/MJ)
Aviation Gasoline	73.37
Biodiesel	8.31
Biomass	4.59
Coal	90.87
Coke	6.82
Coke Oven Gas	36.79
Diesel	74.08
Ethanol	2.81
Gasoline	68.50
Heavy Fuel Oil	74.58
Jet Fuel	68.82
Kerosene	67.41
Landfill Gases/Waste	65.92
Light Fuel Oil	70.43
Liquified Petroleum Gas	60.61
Natural Gas	49.88
Natural Gas Raw	66.03
Petroleum Coke	84.35
Still Gas	47.86

Federal, Provincial and Territorial Measures

Table A.7 identifies the major federal, provincial and territorial measures that are included when modeling the reference case. This includes federal measures that have been implemented or announced in detail as of May 2014. 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 involves provinces and territories in extensive consultations to ensure their initiatives are accounted for in analysis and modeling of emissions trends. For the purposes of this report, provincial/territorial measures announced and fully implemented as of May 2014 have been included wherever possible.

Although the reference case includes existing measures that have been implemented or announced in 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. Policies still under development will be included in subsequent projections as their details become finalized.

Economic modeling only accounts for measures that have been fully funded, legislated or where sufficiently detailed data exists that make it possible to add to the modeling platform. In addition, due to the interactive effects between federal and provincial/territorial measures, it is not possible to accurately split aggregate emissions reductions into federal, provincial or territorial measures.

Canadian provinces and territories have committed to taking action on climate change through various programs and regulations. Environment Canada's emissions reduction modeling does not take these generalized targets into consideration in the emissions projections modeling within this report. Instead, individual policies that are brought forward as methods to attain the provincial targets may be included in the modeling platform if they meet the criteria discussed above. Table A.8 lists the emissions reductions targets announced by each province or territory.

Table A.7: GHG Measures Reflected in Projections (in place May 2014)

	Provincial/Territorial Measures
Alberta	• Specified gas emitters regulation (assumed to be renewed)
British Columbia	• B.C. carbon tax • Renewable fuels tax exemptions for minimum ethanol and biodiesel content • B.C. emissions offsets regulation • Landfill gas management regulation
Manitoba	• Renewable fuels provincial tax credit/exemption for minimum ethanol content
Nova Scotia	• Renewable portfolio standard for electricity generation • Electricity demand-side management policies • Solid waste management resources management strategy • Capping GHG emissions from the electricity sector
Ontario	• Ontario residential electricity peak savings (time-of-use pricing) • Ontario feed-in tariff program • Provincial commercial building code changes for process efficiency improvements • Landfill gas regulation (O. Reg. 216/08 and 217/08) • Ontario coal phase-out program • Ontario Power Authority contracted capacity (March 2014) • Ontario's greener diesel mandate (April 2014)
Quebec	• Renewable fuels tax reimbursement/income tax credit • Quebec and California cap and trade system • Quebec's carbon levy • Landfill gas regulation
Saskatchewan	• Renewable fuels distributor tax credit for ethanol produced and consumed in the province

Federal Measures
• Electricity performance standard for coal-fired generation • Residential building code changes to incorporate energy efficiency for adoption by provinces across Canada • Renewable fuel content regulation • Adoption of the National Energy Code for Buildings of Canada 2011 or its equivalent, by all provinces and territories, except Northwest Territories, by 2016 • Commercial appliance efficiency improvements (excludes lighting) • Residential appliance efficiency improvements, includes refrigeration, freezers, ranges and dryers • Industry expansion of Canadian industry program for energy conservation including International Organization for Standardization (ISO) and Canadian Standards Association (CSA) certification programs • Light duty vehicles 1 (LDV-1) GHG emissions standards for the light-duty vehicle model years 2011 to 2016 • Light duty vehicles 2 (LDV-2) GHG emissions standards increases stringency for model years 2017 to 2025 • Heavy duty vehicles (HDV) GHG emissions standards for heavy-duty vehicle model years 2014 to 2018 • The pulp and paper green transformation program, to improve environmental performance of mills including GHG emissions reductions; the program ended in 2012 but will result in ongoing emission reductions • Public transit subsidy income tax credit for transit passes and subsidy to all levels of government to improve public transit service in communities, includes standards for renewable fuels • Incandescent lighting phase-out

Table A.8: Announced GHG Reduction Targets of Provincial/Territorial Governments

Province/Territory	Target
Newfoundland and Labrador	20% below 2005 by 2020 and 75% to 85% below 2001 by 2050
Prince Edward Island	10% below 1990 by 2020 and 75% to 85% below 2001 by 2050
Nova Scotia	10% below 1990 by 2020 and 80% below 2009 for emissions from human sources
New Brunswick	10% below 1990 by 2020 and 75% to 85% below 2001 by 2050
Quebec	20% below 1990 by 2020
Ontario	15% below 1990 by 2020 and 80% below 1990 by 2050
Manitoba	15% below 2005 by 2020 and 80% below 2005 by 2050
Saskatchewan	20% below 2006 by 2020
Alberta	50 Mt by 2020 below business-as-usual and 200 Mt by 2050 below business-as-usual
British Columbia	33% below 2007 by 2020 and 80% below 2007 by 2050
Yukon	Government operations are carbon neutral by 2020
Northwest Territories	Cap emissions increase at 66% over 2005 by 2020
Nunavut	No territorial target announced

Annex 3: Alternate Emissions Scenarios

Emissions projections depend on a number of economic and energy variables, which make them subject to uncertainty, and thus most appropriately viewed as a range of plausible outcomes. Future developments in technologies and the rate of resource extraction cannot be foreseen with certainty. Typically, these key uncertainties are addressed through examining alternative cases. The sensitivity analysis presented here focuses on two key uncertainties: future economic growth, and the evolution of oil and natural gas price and production.

In Table A.9, the emissions outcomes of these alternative cases are presented independently and in various combinations. These alternative cases explore the interaction of energy markets and economic growth, and their impact on emissions, under a range of assumptions.

Under a scenario where oil and gas prices are assumed to be 29% higher than in the reference case in 2020, and annual average growth in GDP between 2012 and 2020 is expected to be 2.7% (compared with 2.2% in the reference scenario), emissions could reach 781 Mt CO_2 eq (not including the contribution from LULUCF) in 2020.[24] Alternatively, under a scenario with slower GDP growth (average growth of 1.5% between 2012 and 2020) and lower world oil and gas prices (29% lower than the reference case in 2020), emissions could be as low as 716 Mt CO_2 eq, (not including the LULUCF contribution) in 2020.

Assumptions

The fast and slow GDP growth extremes were derived by applying the assumptions from the 2013 *Annual Energy Outlook* by the U.S. Energy Information Agency for fast and slow economic growth for population and productivity in the macroeconomic framework of the model. Also applied were high and low population growth assumptions for Canada, based on impacts derived from Statistics Canada's 2010 population growth projections for high and low population growth. The fast and slow GDP growths were then solved endogenously within the model.

Table A.9: Economic Growth and Population from 2012 to 2020

Assumption	Low	Reference	High
Average Annual GDP Growth Rate	1.5%	2.2%	2.7%
Average Annual Population Growth Rate	0.8%	1.1%	1.3%

Oil and gas prices and production for all scenarios are based on projections from the National Energy Board. In the baseline scenario, the world oil price is projected to grow from $96/bbl (barrel of oil) in 2012 real Canadian dollars (2012 C$) in 2012 to $102/bbl in 2020. The natural gas price is also predicted to increase in the baseline scenario from the 2012 value of $2.63/GJ to $4.72/GJ (per gigajoule) in 2020.

[24] No sensitivity analysis was performed on the LULUCF sector. As such, emissions from this sector are assumed to be constant in all scenarios.

Table A.10: Oil and Gas Price and Production in 2020

Assumption	Low	Reference	High
Crude Oil Price: WTI (2012 C$/bbl)	72	102	132
Crude Oil Price: Alberta Heavy (2012 C$/bbl)	57	81	104
Crude Oil Production (1000 bbl/day)*	4188	4721	5282
Natural Gas Price: Henry Hub (2012 C$/GJ)	3.30	4.72	6.04
Natural Gas Production (billion cubic feet)	3611	4861	5781

* Numbers are not including C5 and condensates.

The high price scenario sees prices of $132/bbl (2012 C$) for oil and $6.04/GJ for natural gas in 2020. Crude oil and natural gas production are both increased (by 11% and 19% in 2020, respectively) under the high price scenario relative to the baseline forecast. This scenario is used alone and in combination with different GDP growth assumptions.

A low price scenario is also included, where the world oil price drops to $72/bbl (2012 C$) by 2020, and the natural gas price increases more slowly to $3.30/GJ in 2020. Crude oil and natural gas production see relative decreases of 11% and 26% in 2020 under the low price scenario. The low price scenario is similarly combined with different GDP growth assumptions.

These high and low cases for oil and natural gas prices were provided by the National Energy Board as the probable range of future energy prices used within their analysis.

Figure A.4 illustrates how differing price and GDP growth assumptions in various combinations might impact Canadian GHG emissions through 2020.

GHG emissions in the fast-GDP-growth scenario are about 7% higher in 2020 than 2012 levels. 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. When combined with high oil and gas prices, emissions could be 10% higher than 2012 levels by 2020. Expected growth of the economy is the primary driver of expected emissions growth. Any variation in this path will lead to a different set of projections about expected future emissions. Table A.11 quantifies the results of the full range of emissions alternatives illustrated in Figure A.4.

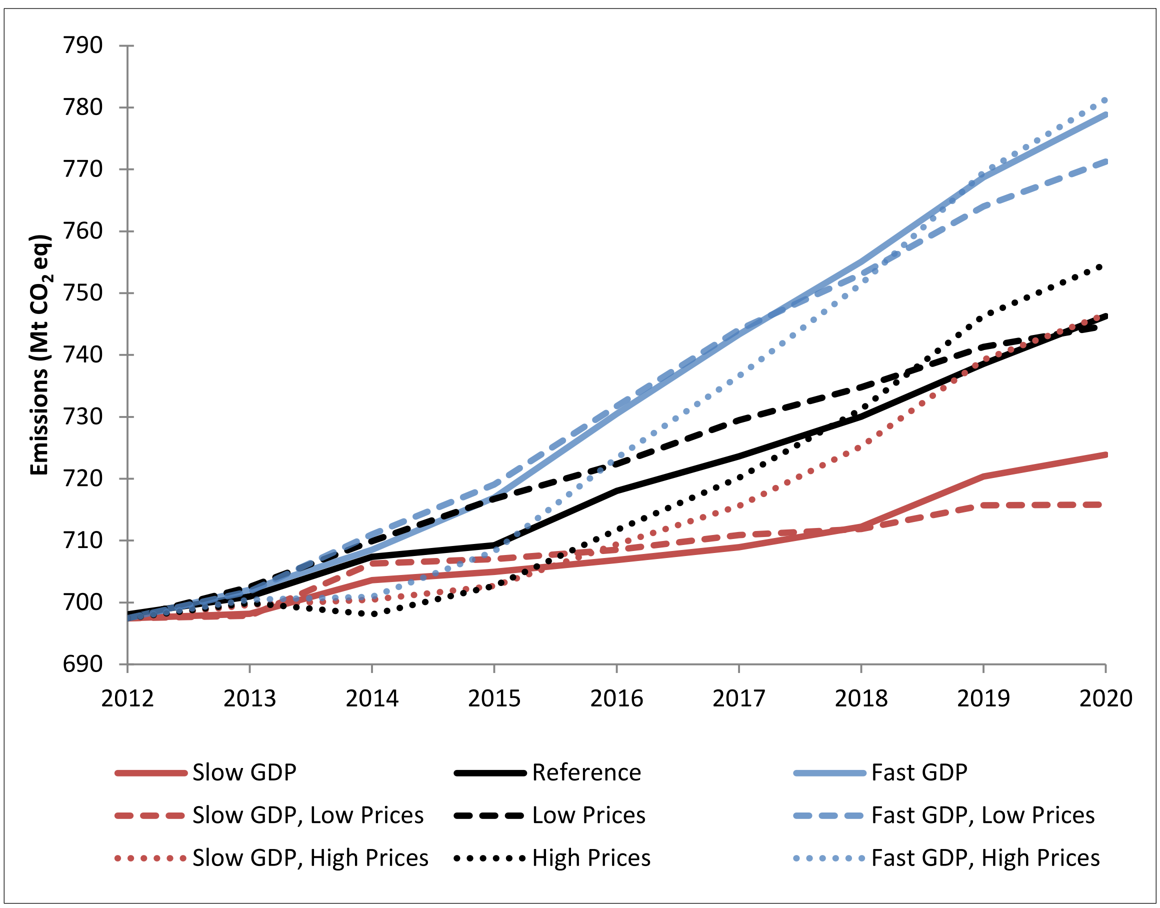
The growth in emissions is expected to slow down as energy prices increase and consumers are provided with a greater incentive to make more efficient choices. However, the increase in price also drives higher production in the oil and gas sector, which generally offsets this effect. Emissions from the oil and gas sector in the high world oil and gas prices case rise by 52 Mt from 2012 to 2020, whereas they rise by only 4 Mt in the low price scenario.

The range in total projected emissions from all scenarios rises as we extend our projection further into the future. As a result of the assumptions made about the growth in Canadian GDP and the future evolution of oil and natural gas price and production, the range is roughly 65 Mt in 2020.

Table A.11: Sensitivity Analysis Summary for 2020 in Mt CO_2 eq (excluding LULUCF)

Scenarios	2020	Change between 2005 and 2020
Slow GDP	724	-12
Fast GDP	779	43
Low World Oil and Gas Prices	745	9
High World Oil and Gas Prices	755	19
Slow GDP, Low World Oil and Gas Prices	716	-20
Slow GDP, High World Oil and Gas Prices	747	11
Fast GDP, Low World Oil and Gas Prices	771	35
Fast GDP, High World Oil and Gas Prices	781	45
Reference	746	10
Sensitivity Range	**716 to 781**	**-20 to 45**

Figure A.4: Projected GHG Emissions Under Full Range of Alternative Economic Assumptions (excluding LULUCF)



Annex 4: 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, 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 GHG emissions beyond those already in place as of May 2014.

The emissions projections presented in this report cannot be viewed as a precise estimate 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. They incorporate IPCC standards for estimating GHG emissions across different fuels and processes, rely 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 apply an internationally recognized energy and macroeconomic modeling framework in the estimation of emissions and economic interactions. Projections and underlying assumptions in this year's *Canada's Emission Trends* report have been through a consultation process with key stakeholders, while a more detailed examination of methodological approaches is performed periodically by leading external experts on economic modeling and GHG emissions projections.

The approach to developing Canada's GHG emissions projections involves two 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.

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 and Demand in Canada* and Canada's NIR. For these projections, the most recent historical data available were for 2012. Environment Canada's projections and historical data in the NIR are aligned, based on economic sector definitions.

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

- National Energy Board views on energy prices and large-scale energy projects
- Economic growth from Finance Canada's June 2014 Private Sector Forecaster Survey and November 2013 Update of Economic and Fiscal Projections
- Statistics Canada's population growth projections

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 production levels.

The Without Measures Scenario

In 2014, the “without measures” or no programs scenario has been fully remodeled to take into account all of the structural changes occurring within the model and also to update assumptions about key drivers. Moreover, a refined methodology is being used to ensure that the drivers are being reflected in accordance with the description of the scenario.

The “without measures” scenario is constructed by beginning the model’s forecasting mode in 2006, configured to exclude any government policies implemented after 2005. Historical macroeconomic data are used between 2006 and 2012, and wholesale energy prices throughout the entire projection period are kept the same as those used in the reference scenario. Changes in electricity-generation-sector energy use resulting from non-policy-driven factors, including nuclear refurbishment or historical weather-related fluctuations in hydroelectric dam capacities, are reflected in the “without measures” scenario. Exogenous agriculture emissions from livestock and crop production are maintained at reference scenario levels throughout the entire projection period. All other sectors belonging to transportation, oil and gas, buildings, emissions-intensive and trade-exposed industries, and waste and others are derived from the higher of either the 2005 or 2012 emissions intensity, subject to a limit of no greater than 30% more than the value in 2012.

Logarithmic-mean Divisia Approach Used in Box Entitled “Decomposition of Canada’s Energy-related GHG Emissions”

Since the late 1970s, researchers have been using decomposition analysis to help explain changes in energy and GHG emissions. The analysis is based on the identity presented below:[25]

$$\mathrm{E} = A \bullet \frac{E}{A} = \sum_i A \bullet \frac{a_i}{A} \bullet \frac{e_i}{a_i} = \sum_i A \bullet S_i \bullet I_i$$

Where:

- E = Emissions
- A = Total Activity
- a_i = Activity of subsector i
- e_i = Emissions of subsector i
- S_i = Structural Effect i
- I_i = Intensity Effect i

[25] Natural Resources Canada, Improving the Factorization Methodology in Energy Efficiency Trends in Canada 1990 to 2005, July 2007. For simplicity, this analysis does not use the rolling base year approach that has been adopted by Natural Resources Canada.

The Total Activity Effect (A) is generally a measure of economic growth. The measures of activity vary from sector to sector. For example, for the residential sector, activity is measured in terms of floor space, while in the industrial sector, it is generally measured in terms of gross output. The Structural Effect (S_i) measures the change in the composition of the economy, such as the shift from goods-producing to service-producing industries. The Intensity Effect (I_i) measures changes in emissions intensity at the subsector level. This variable will capture the impact of changes in fuel mix as well as energy efficiency improvements.

There are a number of methodologies that can be used to decompose the identity, each with pros and cons. The methodology that has been used here is the logarithmic mean Divisia index (LMDI) method that is used by Natural Resources Canada as well as other international experts. The main benefits of this approach as described by Ang (2004)[26] are:

- Relatively simple mathematical application
- Additivity across subsectors
- No residual

Using the LMDI method, the decomposition of the change in GHG emissions over time or from two cases can be defined by the following equations:

$$E_1 - E_0 = \sum_i \frac{e_{i1} - e_{i0}}{\ln\left(e_{i1}/e_{i0}\right)} \bullet (\ln A_1 - \ln A_0) \quad \text{Activity Effect}$$

$$+ \sum_i \frac{e_{i1} - e_{i0}}{\ln\left(e_{i1}/e_{i0}\right)} \bullet (\ln \frac{a_{i1}}{A_1} - \ln \frac{a_{i0}}{A_0}) \quad \text{Structural Effect}$$

$$+ \sum_i \frac{e_{i1} - e_{i0}}{\ln\left(e_{i1}/e_{i0}\right)} \bullet (\ln \frac{e_{i1}}{a_{i1}} - \ln \frac{e_{i0}}{a_{i0}}) \quad \text{Emission Intensity Effect}$$

Energy, Emissions and Economy Model for Canada

The projections presented in this annex were generated from Environment Canada's Energy, Emissions and Economy Model for Canada (E3MC).

E3MC has two components: Energy 2020, which incorporates Canada's energy supply and demand structure, and the in-house macroeconomic model of the Canadian economy.

Energy 2020 is an integrated, multi-region, multi-sector North American model that simulates the supply of, price of, 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,

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[26] Ang, B.W., Decomposition analysis for policymaking in energy: which is the preferred method?, Energy Policy, 2004, vol. 32, issue 9, pages 1131-1139.

energy prices, GHG emissions, investment costs and possible cost savings from measures, in order to identify the direct effects stemming from GHG reduction measures. The resulting savings and investments from Energy 2020 are then used as inputs into the macroeconomic model.

The in-house macroeconomic 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, the macroeconomic model 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 macroeconomic 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.

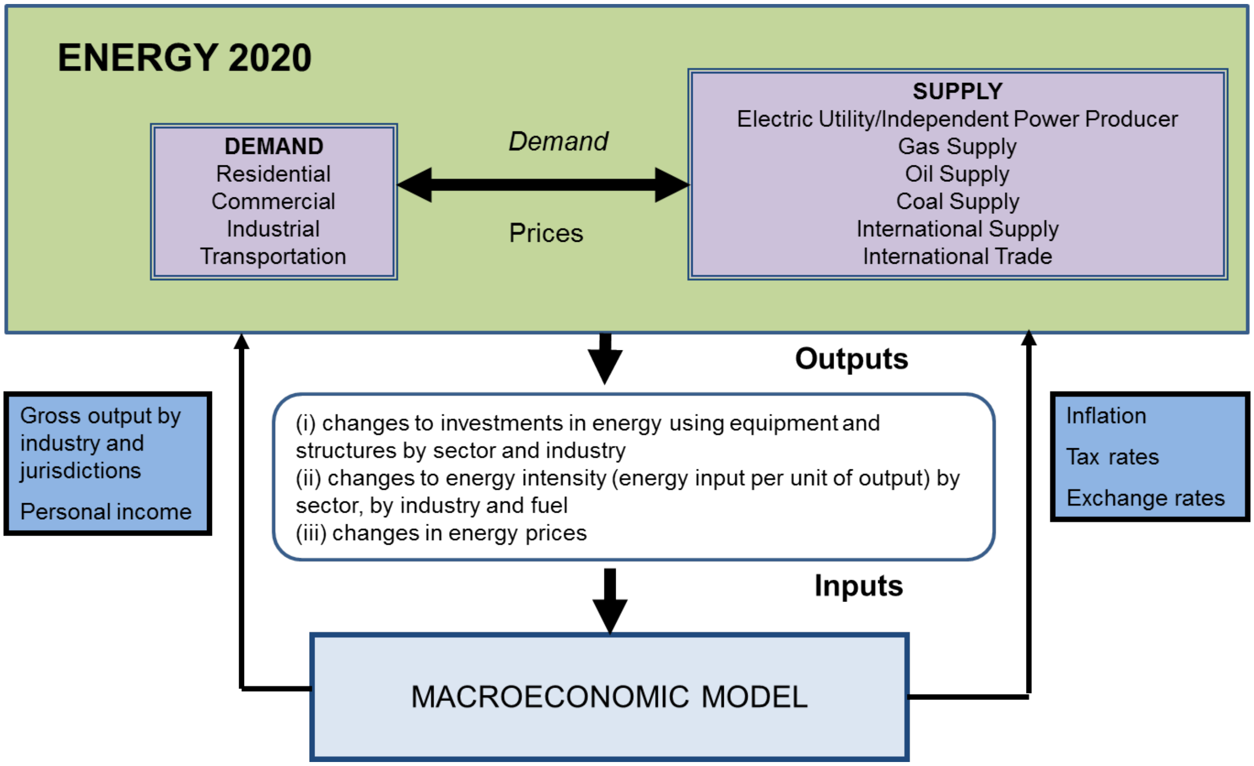
E3MC develops projections using a market-based approach to energy analysis. For each fuel and consuming sector, the model balances energy supply and demand, accounting for economic competition among the various energy sources. This ensures consistent results among the sectors and regions. The model can 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 GHG emissions (such as CO_2, CH_3 and N_2O) by sector and by province.

Figure A.5 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.

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 GHG emissions, are determined based on many assumptions that influence the overall size and growth rate of the economy.

Figure A.5: Energy, Emissions and Economy Model for Canada



Treatment of Interaction Effects

Estimates of the net impact of government measures incorporated into the modeling scenarios need to take into account major interaction and behavioural affects. The analytical approach permitted by E3MC addresses these key modeling challenges:

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, for example, 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 occur 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% and 20% 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 time frames.[27] All of 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 is 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 these impacts in order 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 consistent manner. The model includes 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, meaning that 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,

[27] 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.

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 GHG 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-kilometres travelled. 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% 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 5: Technical Changes Since Emissions Trends Report 2013

The following changes were implemented to provide better estimates of energy and emissions:

- Allocation of a portion of producer consumption of electricity reported by Statistics Canada to industrial/institutional sectors after accounting for 7% transmission line loss;
- Balancing of supply and demand of electricity for historic model input;
- Better alignment to sectoral-level electricity generation and flow data (inputs, exports and inter-regional flows) reported by Statistics Canada;
- Addition of renewable industrial generation from hydroelectricity and landfill gas;
- Addition of missing wind electricity generation units;
- Re-allocation of some utility-owned cogeneration units to their respective industrial/institutional sectors;
- Better reconciliation of sectoral and unit level electricity data;
- Evolution of Ontario's electricity sector based on the province's Long Term Energy Plan (December 2013);
- Addition of Ontario's Greener Diesel regulation (April 2014);
- Allocation of some projected carbon capture and storage offsets to Fertilizers and Petroleum Products sectors (Alberta Carbon Trunk Line Initiative);
- Used conversion factors from the National Energy Board rather than the Alberta Energy
- Regulator to convert modeled oil and gas production outputs from energy to volumetric values for reporting in the Emissions Trends Report. This change does not affect modeled emissions but ensures consistency in volumetric amounts reported in Emissions Trends Reports and NEB publications;
- Improved assumptions for HFC emission projections:
    - Changed the economic driver for the projection from population to GDP in order to better reflect the tendency for increased use of refrigeration and air conditioning in a growing economy;
    - Included a new assumption around the emissions of HFCs at the time of equipment decommissioning.
- Improved assumptions for passenger transportation device efficiencies: modeling of light duty vehicle regulations was modified for the years 2016 through 2025 to better reflect the composition of the Canadian passenger fleet.
- Changed energy consumption assumption for the liquid natural gas production sector. Previously, we assumed a ratio of one third of liquid natural gas production powered by electricity from the grid and two thirds powered by natural gas for compression. To be more consistent with the currently proposed projects, we have changed this ratio to 5:95. Fuel consumption assumptions are as follows: electricity, 280 MW to produce 1 billion cubic feet of liquid natural gas per day; natural gas, 11% of natural gas feed is assumed to be consumed in the process.
- The contribution of LULUCF has decreased from 28 Mt in the 2013 Emissions Trends Report to 19 Mt, mainly because the projected contribution of the Forest Land Remaining Forest Land category has been revised downward by 7 Mt. This change results from a variety of factors:

- *Updated historical data and methodological improvements*: projections for Forest Land Remaining Forest Land have been remodeled to take into account updated information and improved modeling consistent with data and methods used for the 2014 NIR. In particular, data and methodology improvements in producing forest estimates for the NIR resulted in a decrease of 3 Mt in the projected contribution. The updated historical data and methodological improvements are incorporated into the Reference Level, reflecting a process of "technical correction" outlined in the Durban LULUCF agreement.[28] While the forest management assumptions underlying the Reference Level scenario must not change once established, technical corrections can be made to ensure that the Reference Level reflects historical data and modeling improvements consistent with the latest NIR. The component of the technical correction with the greatest impact on the Reference Level value is inclusion of the impacts of fire and insect infestations in 2010, 2011 and 2012: these impacts were not known in 2011 when the Reference Level was first derived. Given that the natural disturbance data are included in both the Reference Level and the updated future harvest scenario, the impact of these natural disturbances are meant to cancel out when these two values are compared to calculate the contribution, meaning that the contribution reflects only the effect of changes in human activities.
- *Updated harvest projection*: the updated future harvest projections developed by provinces and territories show that harvest levels to 2020 are expected to be higher than what was projected last year, while still remaining below the Reference Level's harvest assumptions (i.e., average historical level for 1990–2009). Accordingly, the projected contribution of the Forest Land Remaining Forest Land category has been revised downward by a further 4 Mt.

- The projected contribution of Cropland Remaining Cropland has also been revised and now shows a debit that is 1 Mt higher than estimated last year. Two drivers explain why the rate of sequestration is slightly lower in this year's estimates compared with the 2013 estimates, both related to changes in resource use. The first is that there is more summerfallow being used in 2020 relative to the previous estimate. The second is that there is less forage production in 2020 relative to the previous estimate, as future growth in the beef sector is not anticipated to be as strong as previously projected.
- The projected contribution of forest conversion has also been revised downward, by about 1 Mt. This decrease is due to recalculations over the period 1990–2011 that result mainly from changes in the allocation of areas converted to peat extraction. The previous assumption that all land converted to peat extraction came from forest land was changed based on geospatial analysis that identified that only 5% of land converted can be considered forest. These changes resulted in a decrease in the estimated value of emissions for the base year 2005 by 1.2 Mt. These recalculations are explained in detail in sections 7.6.1.5 and 7.8.4 of the 2014 NIR.

[28] Decision 2/CMP.7, Annex paragraphs 14-15, unfccc.int/resource/docs/2011/cmp7/eng/10a01.pdf#page=11.

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