Environment Canada Environnement Canada

Canada’s Emissions Trends

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Executive Summary

Overview

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

Climate change is considered one of the most important environmental issues of our time since it will affect all of these aspects of our natural environment. Although climate change can be caused by both natural processes and human activities, scientific studies have shown that recent warming can be largely attributed to human activity, primarily the release of carbon dioxide and other greenhouse gases to the atmosphere. The potential impacts of climate change and greenhouse gas emissions are far-reaching, affecting all Canadians, our economy, infrastructure, and health, the landscapes around us, and the wildlife that inhabit them. As an Arctic nation the effects of climate change in the North will be important to Canadians. Reducing greenhouse gas emissions is everyone's responsibility and governments, businesses and consumers all have a role to play.

Most greenhouse gases have both natural and human-caused sources. However, according to the Intergovernmental Panel on Climate Change (IPCC), human-caused emissions are tipping the balance towards climate change as they disrupt the natural processes occurring in the atmosphere. Hence policy measures are focused on human-caused emissions. Likewise, all emissions in this report refer to anthropogenic (human-caused) emissions. Canada is a signatory to the United Nations Framework Convention on Climate Change (UNFCCC). Canada signed onto the Copenhagen Accord in December 2009 and committed to reduce its greenhouse gas (GHG) emissions to 17% below 2005 levels by 2020. This represents a significant challenge in light of strong economic growth: Canada's economy is projected to be approximately 31% larger (in real terms) in 2020 compared to 2005 levels.

The government's approach is to encourage strong economic growth and job creation while achieving our environmental objectives. There are encouraging signs on this front: according to the latest *National Inventory Report (NIR)*, between 2005 and 2011, Canadian GHG emissions decreased by 4.8%, while the economy grew by 8.4% over the same period. There has been an average annual decline in Canadian emissions intensity (emissions per unit of GDP) since 1990, a trend that is projected to continue through 2020. Further actions by Canadian businesses, individuals, and governments will allow us to address GHG emissions while keeping the Canadian economy strong. Canada's share of total global emissions, like that of other developed countries, will continue to decline in the face of rapid emissions growth from developing countries, particularly China and India. According to international data, Canada's carbon dioxide (CO_2) emissions from fuel combustion in 2010 accounted for 1.8% of global emissions down from 2.1% in 2005; this share is expected to decline to 1.6% in 2020.

Effective climate change mitigation requires that all countries act to reduce emissions, and, accordingly, Canada will continue to make progress towards its Copenhagen target. 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 passenger vehicles and light trucks will emit about 50% less GHGs than 2008 models once final regulations are issued. Furthermore, GHG emissions from 2018 model-year heavy duty vehicles will be reduced by up to 23 percent. Provincial and territorial governments, many of whom have set specific targets for emissions reductions, are also taking action. Likewise, businesses and individual Canadians are also taking important steps to reduce emissions.

In support of global emissions reductions, the Government of Canada, together with governments in other industrialized countries, is fulfilling its commitments under the Copenhagen Accord to help developing countries take meaningful action of their own to address climate change. Canada has fully delivered on its commitment to provide its fair share of fast-start financing: our investment of $1.2 billion in new and additional climate change financing over the last three fiscal years (2010-11, 2011-12 and 2012-2013) is Canada’s largest-ever package of support for mitigation and adaptation. We also remain committed to the goal of jointly mobilizing $100 billion per year by 2020 from public and private sources to address the needs of developing countries, in the context of meaningful mitigation actions and transparency on implementation.

This year’s *Canada’s Emissions Trends* report further demonstrates Canada’s commitment to transparency with respect to reporting on GHG emissions projections. The report goes beyond the Government of Canada’s international reporting requirements by providing greenhouse gas emissions projections on an annual basis. This year’s report will be the foundation for Canada’s 6th National Communication to the UNFCCC later in 2013, which will be subject to international assessment and review.

The projections in this year’s *Canada’s Emissions Trends* report point to significant progress that has already been achieved through actions taken by consumers, businesses and governments since 2005. Under the “with current measures” scenario, Canada’s GHG emissions in 2020 are projected to be 734 megatonnes (Mt). This is 128 Mt less than under a scenario where consumers, businesses and governments had taken no action to reduce emissions post 2005. The projections indicate that further efforts will be required in order to meet the Copenhagen target (see Figure ES-1).

Greenhouse gas emissions projections depend on a number of evolving economic and energy variables and are subject to significant uncertainty. In addition, future developments in technologies, demographics and resource-extraction will alter the future emissions pathway. Under a scenario where oil prices are assumed to be 27%

higher than in the reference case in 2020, and annual average growth in Gross Domestic Product (GDP) between 2010 and 2020 is expected to be 2.9% (compared with 2.1% in the reference scenario), emissions could reach 773 Mt[1]. Alternatively, under a scenario with slower GDP growth (average growth of 1.9% between 2010 and 2020) and lower world oil prices (29% lower than the reference case in 2020), emissions could be as low as 686 Mt.

Environment Canada uses the Energy, Environment and Economy model for Canada (E3MC), which is internationally recognized and incorporates external data from consistent sources (see Annex 4). Modeling estimates are subject to interdepartmental and provincial/territorial consultations and undergo a peer-review process. However, modeling work is inherently filled with uncertainty and projections are subject to change with updates to key energy data and drivers as well as when historical data is revised.

Progress towards the Copenhagen Target

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.

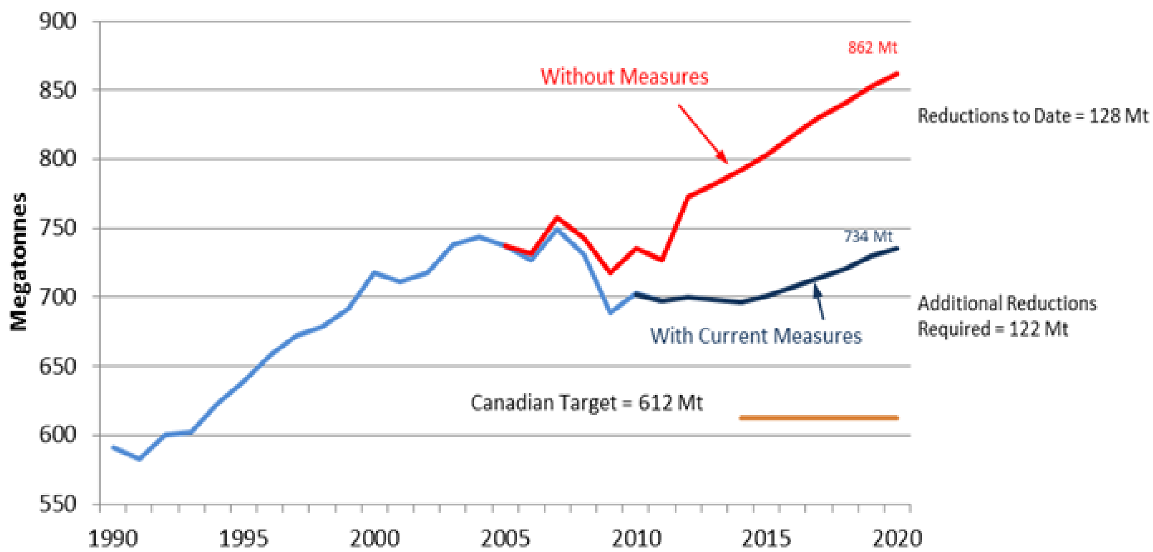
The scenario that includes current measures is then compared against this baseline scenario. In order to be included in the “with current measures” scenario, actions must be concrete or legislated, financially backed, and specific enough to add to the modeling platform as of May 2013.

This is consistent with UNFCCC guidelines for National Communications 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. Representing progress using a deviation from a “without measures” scenario is also used in modeling policy applications by agencies such as the Energy Information Administration.

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 862 Mt. This is in comparison to the “with current measures” scenario where, as a result of actions taken since 2005, emissions in 2020 are expected to be 734 Mt. This means that, taken together, actions by consumers, businesses, and federal, provincial and territorial governments have decreased emissions substantially from the “without measures” scenario (Figure ES-1).

[1] No sensitivity analysis was performed on the Land-Use Land-Use-Change and Forestry Sector. As such, emissions from this sector are assumed to be constant in all scenarios.

Figure ES 1 – Scenarios of Canadian Emissions to 2020 (Mt CO_2e)[2]



The "*Land Use, Land-Use Change, and Forestry*" (LULUCF) sector is a particularly important sector for Canada given our vast land areas. Ten percent of the world's forests are in Canada. Our managed forest covers 229 million hectares, 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*. Canada has opted for accounting approaches to GHG emissions for each subsector that take into account the unique structure of these forests and lands. These accounting approaches are seen as a scientifically credible way to measure improvements over time in this complex sector, and to a large extent are based on approaches that were internationally accepted at the UNFCCC Conference of the Parties in Durban in 2011. Based on this accounting, the contribution of LULUCF in 2020 is estimated to be 28 Mt and is added to the "with current measures" line in 2020. More detail on the LULUCF contribution is presented in Annex 1.

Government programs and measures send signals to consumers and firms which result in emissions reductions. There is an extensive list of federal and provincial/territorial measures that have been modeled, including federal policies such as the electricity performance standard for coal-fired generation, renewable fuel content regulations, light-duty vehicle GHG regulations (2011-2016 and 2017-2025), and provincial measures such as the BC carbon tax, Ontario's coal-fired electricity phase-out, Nova Scotia's cap on electricity sector emissions, Quebec's cap and trade program and carbon levy, Alberta's Specified Gas Emitters Regulation, etc.

[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 trends (without LULUCF) will be 28 Mt higher in 2020.

Taken together, these policies have and will continue to influence GHG emissions reductions, from projected levels in 2020 and beyond. Most importantly, they encourage further action by demonstrating that government policies are having a quantifiable impact on GHG emissions.

These policies (and government measures to reduce air pollutants) are also having an effect on short-lived climate pollutants (SLCPs) such as: black carbon (or soot), methane, tropospheric ozone and some hydrofluorocarbons (HFCs). Although SLCPs have relatively shorter "life-spans" in the atmosphere, they are responsible for a substantial fraction of current global warming and can have detrimental impacts on human health, agriculture and ecosystems. Action to reduce air pollutants from diesel vehicles is already reducing fine particulate matter and black carbon, and Canada's new coal-fired electricity performance standard will further reduce these emissions. The Government of Canada is committed to reducing SLCP emissions and is an active member of the Arctic Council and the Climate and Clean Air Coalition to Reduce Short-Lived Climate Pollutants, two multilateral fora that are addressing short-lived climate pollutants. Canada provided almost C$3 million as an initial donation to the Climate and Clean Air Coalition and an additional C$10 million in 2013. In May 2013, Canada assumed the chairmanship of the Arctic Council, and will co-chair negotiations for pan-Arctic arrangements to begin addressing SLCP emissions for Arctic nations.

The Government of Canada supports clean technology through a variety of programs. One of the most important initiatives is Sustainable Development Technology Canada (SDTC), an arm's-length foundation that finances and supports entrepreneurs in the development and demonstration of clean technologies. SDTC also plays a significant role in fostering collaboration and partnering among a diversity of private, not-for-profit and academic organizations – domestic and international – to strengthen Canadian clean technology capacity. Since SDTC's inception in 2001, the Government of Canada has allocated more than $1 billion in funding. Most recently, Economic Action Plan 2013 announced the allocation of $325 million over eight years to SDTC to continue support for the development and demonstration of new, clean technologies that create efficiencies for businesses and contribute to sustainable economic development. Further actions to lower emissions by federal, provincial and territorial governments will contribute to the additional reductions required for Canada to meet its commitments under the Copenhagen Accord. The Government of Canada supports the efforts of provinces and territories - many of which have GHG emissions reduction targets of their own - as well as businesses and individuals to lower their respective emissions.

Transparency and Continuous Enhancement of the Energy, Emissions and Economy Model for Canada

Canada's Emissions Trends 2013 creates scenarios of emissions projections to the year 2020 using a proven and reputable integrated energy, emissions and economy model for Canada. Having reliable projections of GHG emissions is essential for understanding Canada's emissions profile in terms of how historical trends are expected to change as we look to the future.

Future emissions are driven by factors such as the pace of expected economic and population growth, development of energy markets and their influence on prices, technological change, consumer behaviour, and policies aimed at emissions reductions. *Canada's Emissions Trends 2013* includes updates to all of these key drivers, to better reflect the most current views of their expected developments. Moreover, continued enhancement of the modeling platform is resulting in more developed and refined projections. All of these changes will improve the emissions projections and specific estimates with each update.

The 2013 *Canada's Emissions Trends* report is subject to rigorous review. The majority of data underlying the assumptions that inform the projections were developed in consultation with provinces, territories and industry and, as was done for the report in 2011, the report has been subject to a peer review process. Moreover, the highly sophisticated modeling platform is viewed as one of the leading integrated energy, emissions and economy models in North America. Sensitivity analysis is described and illustrated in Annex 3.

Economic assumptions to 2018 are based on private sector projections from Finance Canada's Private Sector Survey, June 2013. The outer years are based on the Department of Finance's longer-term fiscal projections included in their "Economic and Fiscal Implications of an Aging Population" report. Forecasts of major energy supply projects and prices forecast are taken from the National Energy Board's preliminary 2013 projections.

This analysis assumes that existing laws, regulations and policies remain unchanged over time. Programs and measures included in the modeling scenario reflect their budget profile, and are assumed to end when allocated funding sunsets. Similarly, it is assumed that there is no technological change over the projection period.

In an ongoing effort to improve the modeling platform, several changes have been made to the model over the last year. These technical refinements are described in more detail in Annex 5 and include: endogenous cogeneration building and restructuring for the oil sands; revisions to electricity demand in the oil sands; methodology changes for future oil sands production mixes; a change in the economic driver for natural gas distribution pipelines; and a new source of historical light-duty vehicle efficiencies.

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Preface

Canada's Emissions Trends 2013 provides a basis for analyzing projected greenhouse gas (GHG) emissions, and supports domestic and international reporting requirements. The projections can be used to analyze the effect of different emission abatement strategies against a consistent backdrop, and enables quantitative assessment of the emission 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 third 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 2013, and is based on scenarios of emissions projections using a detailed Energy, Emissions and Economy Model for Canada.

Provincial/Territorial and Federal government departments were consulted during the model's development and were invited to provide their input and suggestions for improvement.

The majority of data and advice received from sector experts and authorities 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 assumptions of energy demand and supply growth are robust; the input they provided to Environment Canada reflects those consultations.

In addition, these projections and reports have undergone an updated peer-review process with positive results. In the peer review, the external experts assessed the modeling methodology on its reasonableness and robustness, reviewed the sources for the key macroeconomic and energy-related assumptions, and made suggestions on how to continue improving the methodology in future rounds.

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 GHGs to the year 2020 aligned to the historical data on GHG emissions provided in Canada's *National Inventory Report* (*NIR*). The first section, Canada's GHG Emissions in a Global Context, sets the stage by explaining Canada's emissions relative to other countries and the work that is underway internationally as part of the global effort to lower emissions. The second section, Historical GHG Emissions by Sector, explains historical emissions trends by economic sector and provides details about the evolving trends in these sectors from 1990 to 2011. The third section, Projected Emissions Trends, provides projections of GHGs by sector to the year 2020 and explains the underlying reason behind these sectoral trends. The annexes of this report provide further details on LULUCF 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. Sensitivity analysis is provided under the projections section as well as in further detail in Annex 3. This analysis illustrates the plausible trajectories of GHG emissions under various assumptions about the future path of energy prices and the economy.

Note that throughout this report, table numbers may not add up due to rounding.

Canada's GHG Emissions in a Global Context

There is currently no up-to-date international data that provides full greenhouse gas emissions projections by country. However, the International Energy Agency (IEA) reports that global carbon dioxide (CO_2) emissions from fossil fuel combustion in 2012 rose an estimated 1.4% from 2011 to 31.6 billion tonnes[3]. Although global GHG emissions are expected to continue increasing with current policies and practices, the pace of this growth appears to be slowing. The emissions growth since last year represents the second-smallest annual increase in emissions since 2003, behind only 2009 when global fossil fuel CO_2 emissions fell due to the global recession.

Box 1 – Greenhouse Gases, Carbon Dioxide, and Fuel Combustion Definitions

The most important greenhouse gases directly emitted by human activities include CO_2, CH_4, N_2O, and several other fluorine-containing halogenated substances (i.e. PFCs, HFCs, SFC). In Canada, carbon dioxide (CO_2) emissions in 2011 accounted for 79% of total greenhouse gas emissions in the National Inventory Report, with Methane (CH_4) and Nitrous Oxide (N2O) accounting for 12% and 7% of emissions respectively. Thus these three gases accounted for around 98% of total greenhouse gas emissions in Canada.

The primary source of carbon dioxide is from the combustion of fossil fuels for the purposes of energy production. This accounted for 89% of total CO_2 emissions in 2011. Carbon dioxide may also be released during the extraction of fossil fuels, the conversion of fossil fuels to other products and the production of certain industrial products, such as cement. Carbon dioxide is also emitted and absorbed in the Land Use Change and Land Use Change and Forestry (LULUCF) sector.

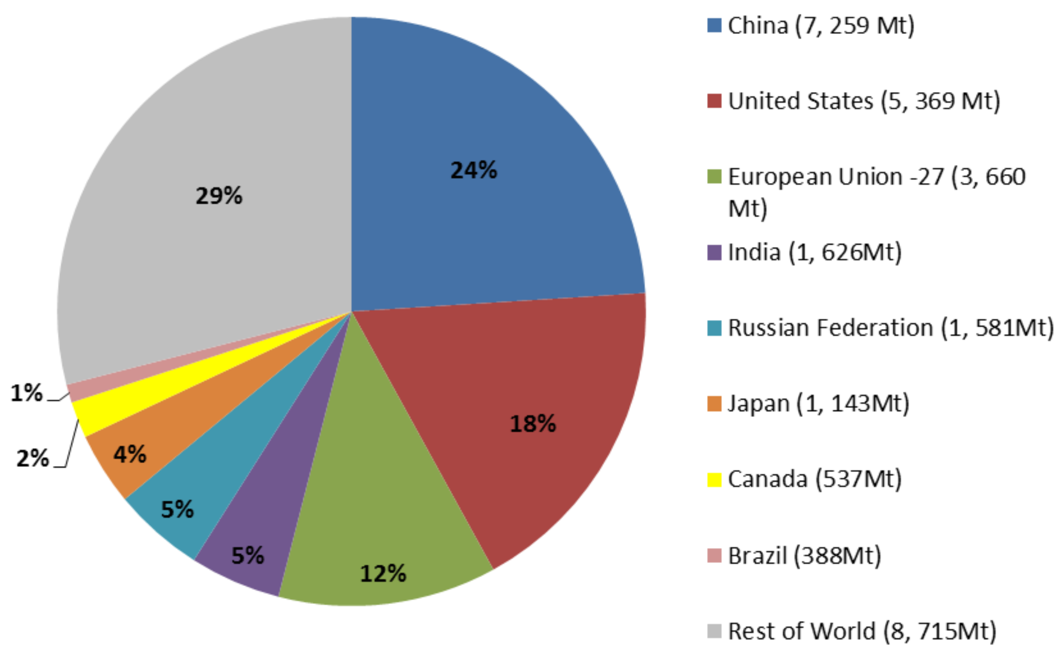
These results are reflected in the historical emissions of the two largest emitters in the world, China and the United States. CO_2 emissions from fuel combustion in the United States fell by 200 megatonnes (Mt) (3.8%) in 2012, to levels last seen in the mid-1990s. This is primarily driven by a transition away from coal power generation to natural gas in electricity generation, which is mostly driven by government policy and decreasing prices for natural gas. Although Chinese emissions grew by 300 Mt in 2012, this was among the country's smallest annual emissions growth over the past decade. The IEA explains that this is a result of China diversifying its energy sources and installing more renewable energy. In addition, European emissions fell 50 Mt in 2012 due to the economic contraction and renewable energy growth, despite an increase in coal energy use[4].

[3] World Energy Outlook Special Report: Redrawing the Energy-Climate Map

[4] http://www.eia.gov/forecasts/ieo/

According to the IEA, Canada's CO_2 emissions from fuel combustion in 2010 accounted for approximately 1.8% of global emissions. Global emissions of CO_2 from fuel combustion have increased by 44% between 1990 and 2010. Over the same period, Canadian CO_2 emissions from fuel combustion have increased by less than 24%. Canada's share of total global emissions, like that of other developed countries, will continue to decline in the face of rapid emissions growth from developing countries, particularly China and India. By 2005, China had overtaken the U.S. as the world's largest overall GHG emitter, and in 2010 accounted for 24% of total global CO_2 emissions from fuel combustion (Figure 1).

Figure 1 – Distribution of world carbon dioxide emissions from fuel combustion, 2010



Source: International Energy Agency (2012) CO_2 Emissions from Fuel Combustion 2012 – Highlights[5].
Note: Canada's emissions from fuel combustion in 2010 (537 Mt) comprises 77% of total GHG emissions from all sources in 2010.

[5] For further information see: Environment Canada (2013) Canadian Environmental Sustainability Indicators (CESI).

The United Nations Framework Convention on Climate Change (UNFCCC) is an international environmental treaty that includes over 190 countries, negotiated at the United Nations Conference on Environment and Development in 1992. The treaty's objective is to stabilize GHG concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system.

Under the UNFCCC, the Copenhagen Accord (2009), and subsequent Cancun Agreements (2010), called on all Parties to put forward 2020 mitigation pledges. As a result of these two agreements, countries representing around 80% of global GHG emissions have now put forward 2020 mitigation pledges and have committed to report on their progress in a transparent manner.

Canada signed onto the Copenhagen Accord in December 2009 and committed to reduce its GHG emissions to 17% below 2005 levels by 2020. This reduction target mirrors that of the United States, although differing industrial composition creates different challenges for the two countries. For example, 65% of utility generation in Canada is from non-emitting hydro and renewable sources, whereas the United States' electricity portfolio is predominantly from coal, which is a high-emitting fuel. Canada's ability to lower overall emissions with policies such as fuel switching for electricity generation is therefore more limited and would incur greater proportional costs.

In response to this challenge, the Government of Canada is following a sector-by-sector approach to regulatory development, which will lower emissions throughout the entire economy where it makes sense to do so, and seeking out the lowest-cost solutions. This includes support for all provincial and territorial actions to reduce emissions.

As a member of the UNFCCC, Canada submits: *National Inventory Reports* annually that detail historical GHG emissions levels since 1990; *National Communications* every four years that explain what Canada is doing to reduce emissions; and, starting in January 2014, *Biennial Reports* that illustrate emissions projections to the year 2030 by sector and gas. All of these reports are made publicly available on the UNFCCC website.[6]

Looking ahead, countries are now working towards the establishment of a new, effective international climate change agreement on the basis of the Durban Platform, adopted at the 2011 Climate Conference in South Africa. A key element of the Durban Platform is the recognition that, to be effective, all major emitters (including developed and developing countries) will need to contribute to the global effort. Negotiations on the details of the new agreement are scheduled to conclude in 2015 for implementation starting in 2020. In this context, Canada's emissions projections will be used to estimate the level of effort required to reduce emissions from the reference scenario.

[6] UNFCCC submitted reports available at: http://unfccc.int/national_reports/items/1408.php

Fast-Start Climate Financing

The Government of Canada has fully delivered on its commitment under the Copenhagen Accord to provide its share of fast-start financing, wherein developed countries agreed to collectively provide $30 billion in new and additional financial resources for the period 2010-2012. The investment of C$1.2 billion for the fiscal years 2010-11, 2011-12 and 2012-2013 (approximately $400 million in each of the three years) is Canada's largest-ever package of support for GHG mitigation and adaptation in developing countries. Our contributions to and collaborations with bilateral, multilateral, private sector and non-governmental partners are generating significant environmental benefits and paving the way for continued progress under the UNFCCC. The funds have been committed at the project level to the benefit of over 50 developing countries.

More broadly, the Government of Canada is encouraging the private sector's involvement to help developing countries achieve their climate goals. Half of the investment funds noted above will be directed towards multilateral banks for the express purpose of mobilizing private sector financing in climate-friendly projects. The Government is also funding programs to promote sustainable agriculture and address deforestation in developing countries, and has supported major initiatives that will build resilience in the most vulnerable countries to the impacts of climate change. The Government remains committed to the Copenhagen goal of jointly mobilizing $100 billion per year by 2020 from public and private sources to address the needs of developing countries, in the context of meaningful mitigation actions and transparency on implementation.

Historical GHG Emissions by Sector

Emissions by Activity and Economic Sector

There are several methods to categorize the sources of GHG emissions that arise across Canada. 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 *NIR*, which is submitted to and reviewed by the UNFCCC. This report uses data from the 2013 *NIR*, which contains emissions estimates to the year 2011. 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 2012*.

As shown in Table 1, from 1990 to 2005, total emissions grew from 591 Mt to 737 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 to 1990 levels. Expansion and adoption of new extraction technologies resulted in an increase in emissions of 61 Mt in the oil and gas sector. The electricity sector contributed to a further 27 Mt of the increase in total emissions as coal-fired units replaced nuclear units undergoing maintenance or being taken off-line, and as more fossil-fueled generation came online to meet rising demand.

Canadian GHG emissions have fallen by 35 Mt in the period 2005 to 2011, reflecting the fall in emissions in the electricity and emissions-intensive trade-exposed (EITE) industries.[7] Most other sectors saw little or no increase in GHG emissions over this period. The decline in overall emissions from the electricity sector is primarily the result of Ontario's coal generation phase-out, while the trend in the EITE sectors reflects the continued recovery from the economic recession. 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 2011 (the last available year of historical emissions numbers under the *NIR* for 2013) for each of the major economic sectors generating emissions.

[7] EITE sectors include mining activities, smelting and refining, and the production and processing of industrial goods such as chemicals, fertilizers, paper and cement.

Table 1 – GHG emissions by economic sector (Mt CO_2e) (excluding LULUCF)

Mt CO_2 equivalent	1990	2000	2005	2011
Transportation	128	155	168	170
Oil and Gas	101	150	162	163
Electricity	94	129	121	90
Buildings	70	82	84	84
Emissions Intensive & Trade Exposed Industries	93	85	87	78
Agriculture	54	66	68	68
Waste and Others	50	51	49	49
NATIONAL GHG TOTAL	**591**	**718**	**737**	**702**

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. Note that Black Carbon, a powerful short-lived climate pollutant, is not part of this analysis as it is not included under the current reporting framework of the UNFCCC.

Emissions and economic activity are intrinsically linked, although in a Canadian context their relationship has declined over the past two decades as technological improvements and regulations have been adopted and implemented in various economic sectors and relative energy prices have evolved. Emissions intensity, defined as GHG emissions per dollar of GDP, measures the relationship between economic productivity and emissions generation of that economic activity. In Canada, the relationship between total GHG emissions and total real GDP has declined at an average annual rate of 1.5% since 1990. Overall, between 1990 and 2011, economy-wide emissions intensity declined 28%.

Transportation

In 2011, emissions from transportation (including passenger, freight, and off-road emissions) were the largest contributor to Canada's GHG emissions, representing 24% of overall GHGs.

Between 1990 and 2005, emissions in the transportation sector increased 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. movement from cars to more light-duty trucks).

Since 2005, transportation emissions have been relatively stable, representing 170 Mt in 2011. The increasing fuel efficiency of light-duty vehicles has offset the effects of more vehicles on the road and more kilometres driven. For example, between 2005 and 2011, the sales-weighted on-road fuel efficiency for new gasoline cars has improved from 9.2 litres per 100 Km to 8.5 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 11.7 litres per 100 km.

Oil and Gas

Conventional oil and gas production and petroleum refining emissions are related primarily to the production, transmission, processing, refining and distribution of oil and gas products. In 2011, the oil and gas economic sector produced the second-largest share of GHG emissions in Canada (23%). Emissions from unconventional subsectors led an increase of 61 Mt over the 1990 to 2005 time period with the adoption of new extraction processes, although declines in emissions from conventional subsectors and refining offset much of this growth.

Since 2005, GHG emissions from the oil and gas sector have remained fairly consistent around 162 Mt. Increased emissions from oil sands activity has been offset by the gradual depletion of conventional natural gas and oil resources in Canada.

Electricity

In the 1990's, as economic activity was expanding across the country, electricity demand – including retail sales and direct use – was steadily increasing on average at 2.3% per year. Emissions from the electricity sector increased over this time period as some provinces expanded their capacity by building fossil-fueled generation such as natural gas or by increasing the utilization rate of existing coal units. For example, in Ontario, emissions from the electricity sector increased as nuclear plants were taken offline due to maintenance and safety issues and replaced by coal-fired plants. This growth in fossil-fuel generation drove emissions up from earlier years when domestic demand was serviced by largely emissions-free generation technologies. Post 2005, these coal-fired plants were gradually shutdown as repaired nuclear units returned to service. This change in generation mix drives the clear decline in national electricity emissions between 2005 and 2011. Alberta and Saskatchewan saw an increase in natural gas-fired generation to meet the growing demand in this time period causing their greenhouse gas emissions to rise.

Emissions-Intensive and Trade-Exposed (EITE) 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, paper and cement.

Emissions from the EITE sectors were responsible for 16% of total Canadian emissions in 1990, and fell to 11% in 2011. The decline in recent years (9 Mt decline from 2005 to 2011) reflects the economic downturn, technological changes such as improved emission control technologies for perfluorocarbons within the aluminum industry, and the closure of the adipic acid plant in Ontario. 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 remained relatively stable around the 2005 levels through to 2011. Still, since 1990 buildings have accounted for about 12% of Canada's GHG emissions in any given year. Despite a growing population and increased housing stock and commercial/institutional building stock, the stability in emissions since 2005 is attributed mainly to energy retrofits, as 40% of the floor space has seen some level of energy retrofit between 2005-2009.

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 fuel use. Emissions have remained stable over the 2005 to 2011 period at approximately 68 Mt, following an increase of 14 Mt from 1990 to 2005. Since 1990, emissions from the sector grew from 8% of Canada's total emissions to 12%. 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 (LULUCF) 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 1990 to 2011, GHG emissions from municipal solid waste landfills decreased by some 3 Mt as provincial government measures aimed at capturing landfill gas and solid waste diversion helped to slow growth from the historical period.

Projected Emissions Trends

Key Drivers Used in the Development of Emissions Projections

GHG emissions in Canada are driven by a number of factors, such as economic and population growth as well as the mix of energy supply. Projections of future emissions are greatly influenced by the underlying assumptions about the expected development of these economic drivers over time. Changing assumptions about any of these factors will alter the future path of emissions (see 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 economic projections to the year 2018 are based on the private sector projections from Finance Canada's Private Sector Survey, June 2013. The outer years (2018-2020) are based on Finance Canada's longer-term fiscal projections included in their "Economic and Fiscal Implications of an Aging Population" report. Forecasts of major energy supply projects from the National Energy Board's preliminary 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). 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 to the target established in the Copenhagen Accord.

The Land Use, Land-Use-Change and Forestry (LULUCF) sector is modeled and accounted for separately from the other sectors within this report. The expected contribution of the LULUCF sector towards the Copenhagen target is established by comparing business-as-usual emissions/removals levels in 2020 to either 2005 levels or, in the case of the managed forest, 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. As such, the expected LULUCF contribution of 28 Mt is added to emissions projections in 2020 as a credit towards the target.

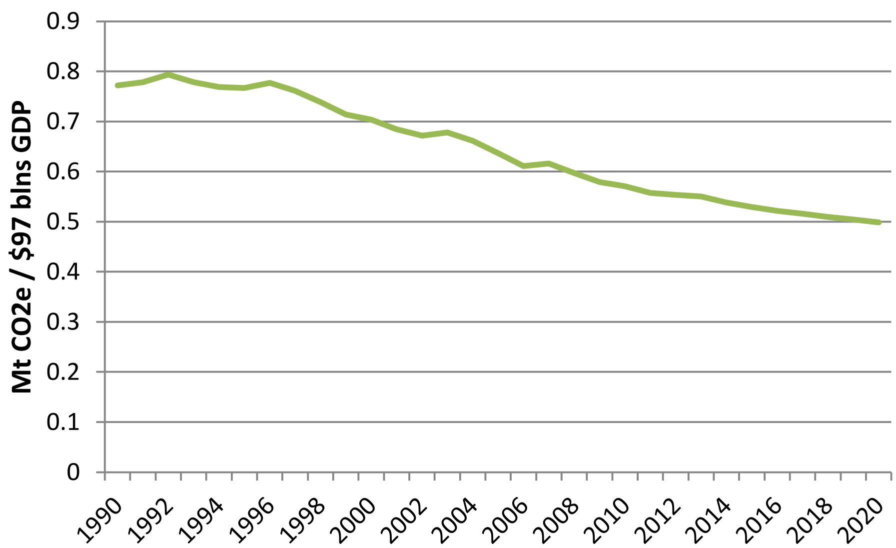
Taking into account the economic drivers described above, with no major technology changes and factoring in current government measures, results in a baseline scenario whereby emissions reach 734 Mt by 2020 when the projected contribution from LULUCF is included.

Reference Scenario: Projected Trends

National Emissions Projections

The link between growth in GDP and GHG emissions continues to weaken. There has been an average annual decline in Canadian emissions intensity (emissions per unit of GDP) of approximately 1.5% since 1990, a trend that is projected to continue through 2020 (Figure 2).

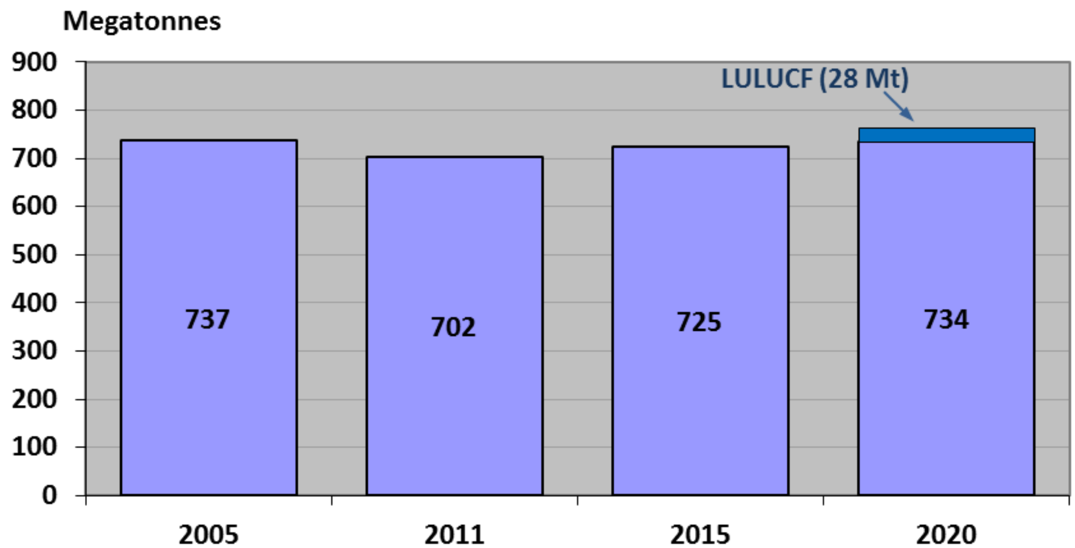
Figure 2 - Canadian Emissions Intensity to 2020



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 lower rate than economic growth. As the economy grows beyond 2011(the latest year available for historical emissions levels), total emissions are projected to increase. Absent further government action, by 2020 emissions are projected to reach 734 Mt, a decrease of 3 Mt from 2005.

Figure 3 depicts the total projected Canadian GHG emissions from 1990 to 2020 based on baseline economic projections, energy data, and current government policies.

Figure 3 – Total Canadian GHG emissions and projections (with no further government actions):2005 to 2020 (Mt CO_2e incl. LULUCF contribution applied to 2020 target)



Per Capita Emissions:

Total greenhouse gas emissions divided by the population of Canada (per capita emissions) have been decreasing significantly since 2005 when they were 22.9 tonnes of carbon dioxide equivalent (CO_2e) per person. In 2011, emissions per capita were only 20.4 tonnes of CO_2e per person, which is the lowest level recorded since records began in 1990[8].

Projections show this trend continuing through 2020. This analysis projects per capita emissions to fall to 20.1 tonnes of CO_2e per person in 2015; and down to 20.0 tonnes per person in 2020 (Table 2).

Table 2: Canadian Greenhouse Gas Emissions Per Capita[9]

Tonnes CO_2e	2005	2011	2020
Per capita emissions	22.9	20.4	20.0

[8] Emissions per capita in 2009 were also 20.4 tonnes of CO_2e per person, rising slightly to 20.5 in 2010
[9] Excluding the contribution of 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 federal greenhouse gas performance standards for new vehicles, which are causing the average emissions intensity of these vehicles to decline through the projection period compared to the long-term trend.

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 replacing coal fired generation with natural gas and hydro capacity. Electricity emissions are projected to decline by 38 Mt (31%) 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 38 Mt (23%) between 2005 and 2020.

Table 3 – Change in GHG emissions by economic sector (Mt CO2e)

	2005	2011	2020	Change, 2005 to 2020
Transportation	168	170	176	8
Oil and Gas	162	163	200	38
Electricity	121	90	82	-39
Buildings	84	84	95	11
Emissions Intensive & Trade Exposed Industries	87	78	90	3
Agriculture	68	68	69	2
Waste and Others	49	49	50	1
Expected LULUCF Contribution	N/A	N/A	-28	-28
Total	**737**	**702**	**734**	**-3**

Transportation

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 has also published proposed regulations in the *Canada Gazette* 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 (*LDV*2).

These regulations will achieve significant and sustained GHG reductions and fuel-savings benefits. By 2020, preliminary estimates suggest that Canadian regulations for model years 2011 to 2016 will lead to annual reductions of between 9 and 10 Mt in Canada. Preliminary estimates indicate that the proposed regulations for model years 2017 to 2025 will reduce GHG emissions by an additional 3 Mt in 2020, with growing reductions in subsequent years.

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 to model year 2010, 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/100km in 2010 to 6.4 L/100km in 2020, and to 5.1 L/100km by 2025. The sales-weighted fuel efficiency of new passenger light trucks are projected to improve from 12 .0 L/100km in 2010 to 9.1 L/100km in 2020, and to 7.6 L/100km by 2025.

Total transportation emissions are projected to increase from 168 Mt in 2005 to 176 Mt by 2020, a marked deceleration of growth from the historical long-term trend. This deceleration from historical trends is expected to occur as a result of higher gasoline and refined petroleum prices, and greater fuel efficiency in vehicles being accelerated by federal vehicle emissions regulations.

As depicted in Table 4, the transportation sector comprises several distinct subsectors: passenger, freight, air and others (e.g., rail and marine).[10] Each sector exhibits different trends during the projected period. For example, emissions from passenger transportation are projected to decrease by 6 Mt between 2005 and 2020, while those for ground freight and off-road are projected to grow by 13 Mt.

Although absolute emissions are expected to grow in the freight subsector, emissions are expected to decrease relative to business-as-usual levels as a result of various federal, provincial and territorial programs. The recently announced heavy-duty vehicle regulations will improve the average fuel efficiency of trucks from 2.5 litres/100 tonne-km to 2.1 litres/100 tonne-km by 2020.

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

Table 4 – Transportation: emissions (Mt CO2e)

	2005	2011	2020
Passenger Transport	96	96	90
Cars, Trucks and Motorcycles	87	88	81
Bus, Rail and Domestic Aviation	9	8	9
Freight Transport	57	61	70
Heavy-Duty Trucks, Rail	49	54	61
Domestic Aviation and Marine	8	7	9
Other: Recreational, Commercial and Residential	14	13	15
Total Emissions (Mt)	**168**	**170**	**176**

Note: In this table and all subsequent tables, numbers may not add due to rounding

Oil and Gas

Upstream Oil and Gas Production

The overall emissions intensity of oil sands production (including upgrading) has historically been decreasing over time. This trend reflects various offsetting compositional trends in the different subsectors. For example, while the emissions intensity of oil sands mining operations has been increasing since 1990 as mining operations extract deeper/poorer-quality bitumen-sand, the emissions intensity of in-situ operations and bitumen upgrading facilities have been decreasing over the same period (Figure 4).

Working against this historical trend, there are several forces that are working to drive emissions intensity up in the future for the sub-sector as a whole (e.g. declining reservoir quality, aging of existing facilities, etc.). It is therefore unclear if these historical improvements will continue. In addition, technological improvements have the potential to reduce oil sands emissions intensities. This technological potential is discussed in Box 2.

Considering the uncertainties associated with emissions intensities in the oil sands, this analysis has assumed constant emissions intensity throughout the projection period. Under a scenario where historical trends in intensities are brought forward into projections years, oil sands emissions could be some 0.5% smaller in 2020 than under the reference scenario[11]. No scenarios assuming increasing intensities were modeled under this analysis.

Under the reference case assumptions, emissions from upstream oil and gas production are estimated to grow from 109 Mt in 2005 to 144 Mt in 2020. This increase is driven by the growth in bitumen production, where emissions are expected to increase from 21 Mt in 2005 to about 76 Mt by 2020. Specifically, emissions from oil sands mining are projected to more than double over the 2005 to 2020 time period. Emissions from in situ production are expected to increase from 11 Mt in 2005 to 55 Mt in 2020. Oil sands emissions from upgrading are not included under the “upstream” categorisation but are discussed below.

Emissions from conventional crude oil production are expected to fall from 32 Mt in 2005 to 31 Mt in 2020. Emissions from natural gas production and processing are also expected to fall from about 56 Mt in 2005 to 37 Mt by 2020, but are expected to then rebound slightly in subsequent years as the price of natural gas is projected to increase in later years.

Table 5 – Upstream oil and natural gas production: emissions and drivers

	2005	2011	2020
Conventional Oil Production			
Emissions (Mt CO_2e)	32	30	31
Production (1,000 barrels/day)	1361	1262	1304
Natural Gas Production and Processing			
Emissions (Mt CO2e)	56	47	37
Production (billion cubic foot)	6984	5938	4861
Bitumen Production			
Emissions (Mt CO_2e)	21	37	76
Production (1,000 barrels/day)	1064	1743	3316

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. The emissions associated with the upgrading of oil-sands bitumen are expected to rise from 14 Mt in 2005 to 25 Mt by 2020. Further

[11] This is assuming a 5-year moving average. Under a 10-year moving average, emissions could be 10% lower than in the reference scenario.

details on emissions from oil-sands upgrading are outlined in the following section on petroleum refining and upgrading. Emissions from the production of synthetic crude oil are linked to the petroleum refining industry.

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 19 Mt in 2020.

Table 6 – Oil and gas sector: emissions by production type (Mt CO2e)

	2005	2011	2020	Absolute Change 2005 to 2020
Natural Gas Production and Processing	56	47	37	-18
Conventional Oil Production	32	30	31	-1
Conventional Light Oil Production	10	10	11	1
Conventional Heavy Oil Production	21	18	18	-2
Frontier Oil Production	2	2	2	0
Oil Sands	34	55	101	67
Bitumen In situ	11	23	55	44
Bitumen Mining	9	14	21	11
Bitumen Upgrading	14	18	25	12
Oil and Natural Gas Transmission	16	11	9	-7
Downstream Oil and Gas	24	20	19	-5
Petroleum Products	22	18	17	-6
Natural Gas Distribution	2	2	3	1
Liquid Natural Gas Production	0	0	2	2
Total	**162**	**163**	**200**	**38**

Note: numbers may not add due to rounding

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 regasified and distributed as pipeline natural gas. There is a high degree of uncertainty regarding LNG production in Canada since its potential for exportation resides in factors such as the cost/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 Boards preliminary 2013 view of expected LNG production through 2020. Greenhouse gas emissions for LNG production represent emissions from the incremental energy consumption required for LNG processes.

Petroleum Refining and Upgrading

Table 7 displays emissions associated with petroleum refining and upgrading. In the table above, the GHG emissions from upgrading bitumen into synthetic crude oil are included in the Traditional Refineries category.

There are currently 12 companies operating refineries in Canada. One refinery in Nova Scotia is expected to convert into a terminal removing its capacity from the sector. Overall, refinery production is expected to slightly increase between 2011 and 2020. GHG emissions decrease slightly over this timeframe due to improvements in energy efficiency expected at the facilities (e.g. refurbishments).

From 2005 to 2020, emissions from bitumen upgrading are projected to increase by 12 Mt, while emissions from petroleum refining are projected to decline by 5 Mt.

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

	2005	2011	2020
Traditional Refineries			
Emissions (Mt CO_2e)	22	18	17
Refined Petroleum Processed (1,000 barrels/day)	2165	2035	2143
Upgraders			
Emissions (Mt CO_2e)	14	18	26
Upgraded Products (1,000 barrels/day)	611	932	1317

Box 2: Potential Oil Sands Technology/Method Improvements

Although conventional oil production is expected to continue its historic decline, unconventional oil production from oil sands (mixtures of sand, clay and a dense petroleum product called bitumen) is projected to rise from 1.1 to 3.3 million barrels of bitumen per day between 2005 and 2020. In the absence of technological improvements in oil sands production, GHG emissions could increase by roughly 70 Mt from 2005 levels by 2020 (see Table 5). Development of new technologies has, however, reduced the emissions intensity of oil sands production over the last 20 years, and further technological advances could play an important role in mitigating GHG emissions growth from the rapidly expanding oil sands sector.

Compared to conventional methods, unconventional production from oil sands requires considerably more energy, because bitumen cannot be pumped directly out of the ground under natural conditions. In addition, depending on the extraction method, bitumen may be upgraded to synthetic crude oil (oil that has similar properties to conventionally produced crude oil). Currently there are two approaches to oil sands extraction: oil sands mining or in-situ techniques. In oil sands mining, bitumen-containing ore is dug out of the ground in a shovel-and-truck operation, and then the bitumen is separated from the associated sands using hot water. *In-situ* techniques currently involve either pumping out bitumen with sand (primary oil sands production) or pumping out bitumen after heating oil sands deposits with steam (cyclic steam stimulation and steam-assisted gravity drainage). Additional energy is used to convert bitumen to value-added petroleum products at upgraders or refineries (e.g., synthetic crude oil, diesel, gasoline).

Overall GHG emissions intensity (emissions per barrel of oil) of oil sands has fallen considerably since the start of oil sands operations in the early 1990s, with this trend dominating over the various subsectors (see Figure 4). In recent years, some efficiency improvements have plateaued as technological improvements have been negated by shifts to more energy-intensive extraction techniques and declining reservoir quality. Given the many competing factors, it is difficult to predict the future evolution of overall emissions intensity in the oil sands. For the purposes of this report, emissions intensities have been held constant for a given oil sands extraction method. However, there are several emerging technologies that have the potential to further improve intensities through reductions in energy use or carbon capture and storage. Since the majority of new production is expected to occur at new facilities rather than at facility expansion, there is an opportunity to adopt these technologies when making choices on capital investments.

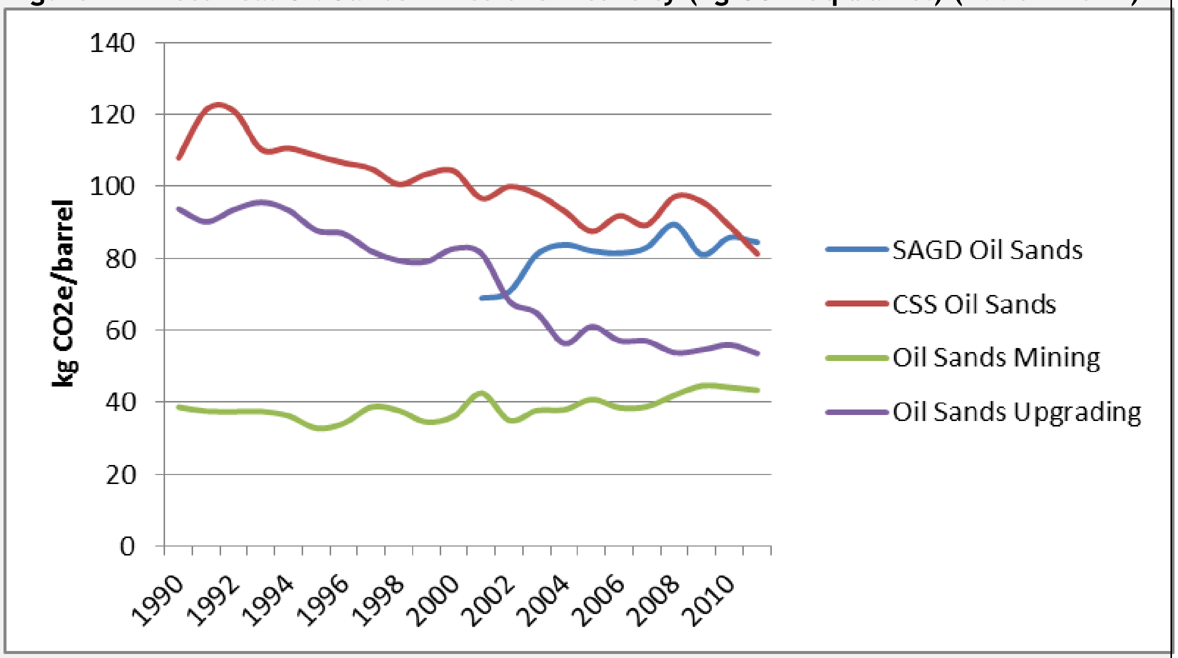
The following are examples of promising technologies that may have scope for wider use:

- Cold bitumen extraction methods would allow separation of sand from mined bitumen without the need for heat, hence reducing energy and emissions.
- Oxy-fuel steam generation optimizes the fuel oxygen mix for more efficient combustion in steam generators. The resultant waste flue gas is rich in CO_2 and thus more amenable to carbon capture and storage, where CO_2 is stored underground.
- Solvent-aided processes (SAPs) involve the co-injection of solvents along with steam

- into SAGD production wells to increase the fluidity of bitumen with less energy input.
- Infill wells are additional wells drilled between producing pairs of SAGD wells to increase production with minimal additional steam inputs.
- Partial upgrading of in-situ bitumen can be carried out to eliminate the need for diluent for transportation.

Although technological advances in oil sands extraction and processing will result in emissions intensity improvements, trends in absolute emissions will depend on the combination of emissions intensity, production levels, and the resource quality. For the projections presented in this report, a conservative approach to the penetration of these new technologies in the oil sands sector has been applied.

Figure 4 - Historical Oil Sands Emissions Intensity (kg CO2-eq/barrel) (1990 – 2011)



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 governmental initiatives. One measure expected to contribute to the decline is the federal Emissions Performance Standard for coal-fired electricity generation. In September 2012 the Government released final regulations to reduce emissions from the coal-fired electricity sector. 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. The government’s approach will foster 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 greenhouse gases. These regulations further strengthen our position as a world leader in clean electricity production.

Provincial measures that turn towards cleaner sources of power to meet electricity demand are also expected to contribute to the decline in emissions in the electricity sector. Some initiatives being undertaken include the Ontario coal phase-out which will have all coal units in the province retired by the end of 2014. As well, Nova Scotia aims to decrease greenhouse gas emissions in its electricity sector through a cap on emissions and through a renewable portfolio standard that will require 40% of electricity sales to come from renewable sources by 2020.

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	2011	2020
Emissions (Mt CO_2e)	121	90	82
Generation (Terawatt hours)	550	545	609

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 all fossil fuels is expected to vary following greater availability of electricity from hydro, nuclear power, and renewable energy sources such as wind.[12] 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 41 Mt over the 2005 to 2020 time period. This represents 6% of total Canadian emissions in 2020. However, emissions from natural gas increase over this time-period to fill in electricity generation requirements of an increasing demand as well as much of the generation that had been fueled by coal. Emissions from natural gas increase by 8 Mt over the 2005 to 2020 time period.

[12] See Annex Table A.2.5 Electricity generation by fuel.

Table 9 – Electricity generation: emissions by fuel type (Mt CO2e)

	2005	2011	2020	Absolute Change 2005 to 2020
Coal	101	69	60	-41
Refined Petroleum Products	7	2	2	-5
Natural Gas	13	19	21	8
Total	**121**	**90**	**82**	**-39**

Note: numbers may not add due to rounding

The proportion of utility electricity generation coming from wind power and other renewable sources, excluding hydro and nuclear, is expected to continue to increase from 2005 levels by 2020. Renewables comprised 0.36% of total utility electricity generation in 2005 and are expected to account for 4% of total generation by 2020. It is assumed that renewables do not generate emissions.

Emissions-Intensive and Trade-Exposed Industries

Emissions from the EITE sectors declined from 2005 levels by 2011, mostly due to the economic downturn, but are expected to reach 2005 levels again as compositional changes occur within the sector. Emissions are estimated to be at their lowest point in 2010 following a decline in pulp and paper and mining output, and subsequently follow an upward trend consistent with production growth in the cement, chemicals, and lime and gypsum subsectors.

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

	2005	2011	2020
Emissions (Mt CO_2e)	87	78	90
Gross Output of EITE sectors (1997 $billions)	129	108	123

Emissions generated by most EITE subsectors remain stable over the 2005 to 2020 projection period, owing to modest production growth and continued reduction of emission intensities. Exceptions include decreased emissions in pulp and paper as well as smelting and refining, and increased emissions from chemicals and fertilizers.

Table 11 – Emissions-intensive and trade-exposed industries: emissions by subsector (Mt CO2e)

	2005	2011	2020	Absolute Change 2005 to 2020
Mining	5	8	10	5
Smelting and Refining (Non-ferrous metals)	12	11	11	-1
Pulp and Paper	9	6	5	-4
Iron and Steel	20	17	19	0
Cement	13	10	12	-1
Lime and Gypsum	3	3	3	0
Chemicals and Fertilizers	25	24	30	5
Total	**87**	**78**	**90**	**2**

*Totals may not add up due to rounding

Buildings

Emissions from commercial and residential buildings are projected to increase by 12% over the 2005 to 2020 timeframe (excluding indirect emissions from electricity).

Residential

As shown in Table 12, GHG emissions from the residential sector (e.g., houses, apartments and other dwellings) are expected to remain relatively stable between 2005 and 2020, rising 3 Mt. This is despite an expected national increase of three million households between 2005 and 2020, a key driver of residential emissions growth. This highlights the decreasing emissions intensities in the average home which are taking place due to increasing energy costs being managed with, for example, better insulation technologies. In addition, federal and provincial measures aimed at increasing the energy efficiency of residential buildings, such as building code regulations and rebates for energy efficiency improvements are helping to improve efficiencies in this subsector.

Table 12 – Residential sector: emissions and drivers

	2005	2011	2020
Emissions (Mt CO_2e)	44	45	47
Households (millions)	12.7	13.9	15.6

Commercial Sector

GHG emissions from Canada's commercial sector are expected to reach 48 Mt in 2020, an increase of 9 Mt from 2005 (Table 13). The economic downturn led to stable emissions in this subsector between 2005 and 2011, but these are expected to grow during the projection period due to an expansion of commercial floor space (the principal driver of emissions from this subsector) as the economy continues to grow.

Table 13 – Commercial sector: emissions and drivers

	2005	2011	2020
Emissions (Mt CO_2e)	39	39	48
Floor space (millions m^2)	654	727	884

Agriculture

With respect to 2020 emissions projections, increased emissions from on-farm fuel use and crop production in the agriculture sector have been partially offset by decreased emissions from livestock production since 2005. This decrease in livestock production occurred over the 2005 to 2011 timeframe as the number of animals decreased. However, since this initial decline, there is projected to be a gradual increase in emissions in line with an estimated increase in livestock production from 2011 to 2020.

Given these compositional trends, agriculture emissions are projected to remain relatively stable reaching a total of 69 Mt in 2020.

Table 14 – Agriculture sector: emissions[13] (Mt CO2e)

	2005	2011	2020
On-Farm Fuel Use	9	14	13
Crop Production	19	22	22
Animal Production	39	32	34
Total	**68**	**68**	**69**

Waste and Others

Emissions from 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. Industry output is projected to grow moderately, leading to emissions growth of 1 Mt between 2005 and 2020.

Table 15 – Waste and Others: emissions (Mt CO2e)

	2005	**2011**	**2020**
Waste & Others			
Waste	21	22	18
Coal Production	2	4	4
Light Manufacturing, Construction & Forest Resources	25	23	29
Total Waste and Others	**49**	**49**	**50**

Land Use, Land-Use Change and Forestry

LULUCF is a particularly important sector for Canada given our vast land areas. 10% of the world's forests are in Canada. Our managed forest covers 229 million hectares, 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.

[13] 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.

A unique challenge in forecasting and accounting for LULUCF emissions and removals resides in addressing the effects of natural disturbances (e.g., wildfires, insect infestations such as the mountain pine beetle), which can result in significant variations in the annual emission and removal estimates and generally cannot be predicted for future years. The impact of natural disturbances also makes it difficult to discern the effects of improved management practices.

LULUCF emissions accounting represents only emissions/removals from managed lands. For example, the category of Forest Land Remaining Forest Land includes only the area of forests that are managed for timber and non-timber resources (including national/provincial parks) or subject to fire projection. 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-forest land, 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 greenhouse gases to the atmosphere due to decomposition or burning of the biomass.

The LULUCF projection estimates presented in the table below are modeled separately from the other sectors. Specifically, each sub-sector has been modeled by the relevant department experts. In addition, the accounting approach used to measure progress in the sector for the purpose of meeting the Copenhagen target of 17% below 2005 levels is different from the other sectors described above. These methodologies are described in more detail in Annex 1 of this report.

Table 16 - Projected emissions (+) or removals (-) from the LULUCF sector in 2020(1) (Mt CO2 eq)

(In Mt of GHG emissions/removals)	2005 Estimate/ Reference Level	2020 Projected Emissions/Removals	Expected Contribution in 2020 Emissions
Forest Land Remaining Forest Land	-107[(2)]	-133	-26
Cropland Remaining Cropland [(3)]	-10	-9	1
Forest Land Converted to Other Land Categories[(4)]	18	15[(5)]	-4
Land Converted to Forest Land	-0.9	-0.4	0.6
Total	**-100**	**-128**	**≈-28**

(1) Numbers may not add due to rounding

(2) For Forest Land Remaining Forest Land, a 2020 reference level is used for determining the contribution.

(3) Cropland remaining Cropland includes residual emissions after 20 years from forest conversion to cropland

(4) 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

(5) Differences between these values and those reported in the *NIR* are due to the inclusion here of emissions from the conversion of forest to other land after 20 years or more, except in the case of conversion of forest to cropland

Emissions by Province

Emissions vary significantly by province[14], 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 emissions.

Table 17 – Provincial and territorial GHG and per capita emissions: 2005 to 2011

	GHG Emissions (Mt CO_2e)		Per Capita Emissions (t/capita)	
	2005	**2011**	**2005**	**2011**
British Columbia	64	59	15.3	12.8
Alberta	232	246	69.8	64.5
Saskatchewan	71	74	71.5	69.7
Manitoba	21	20	17.8	15.9
Ontario	206	171	16.4	12.8
Quebec	86	80	11.3	10.0
New Brunswick	20	19	26.9	24.6
Nova Scotia	23	20	24.9	21.6
Newfoundland	2	2	15.5	15.3
Prince Edward Island	10	9	19.2	18.3
Territories	2	2	21.9	17.7
Canada	**737**	**702**	**22.9**	**20.4**

[14] While reported at the Provincial/Territorial level in Canada's Emissions Trends report, emissions associated with ammonia production as well as with the consumption of PFCs and SF6 (except for electric utilities) are only reported at the national level in Canada's National Inventory Report. As such differences in emissions totals may occur, if these totals are calculated by summing up provincial values

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, regulatory measures, and legislated renewable electricity targets.[15]

Table 18 – Provincial and territorial GHG emissions: 2005 to 2020 (Mt CO2e)

	2005	2011	2020	Change 2005 to 2020
British Columbia	64	59	64	0
Alberta	232	246	295	63
Saskatchewan	71	74	74	2
Manitoba	21	20	22	1
Ontario	206	171	177	-29
Quebec	86	80	81	-5
New Brunswick	20	19	18	-2
Nova Scotia	23	20	16	-7
Prince Edward Island	2	2	2	0
Newfoundland	10	9	10	0
Territories	2	2	2	0
LULUCF	NA	NA	-28	NA
Canada	**737**	**702**	**734**	**-3**

[15] 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.

The provinces oriented toward resources extraction and/or that are highly reliant on fossil fuels for their electricity generation (i.e., Alberta, Saskatchewan, New Brunswick and Nova Scotia) 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 in 2020, and compares them to actual emissions in 2005 and 2011. Per capita emissions are projected to fall in all provinces in 2020 relative to 2005 levels.

Table 19 – Provincial and territorial per capita emissions: 2005 to 2020

	2005	2011	2020
British Columbia	15.3	12.8	12.4
Alberta	69.8	64.5	64.9
Saskatchewan	71.5	69.7	61.2
Manitoba	17.8	15.9	15.8
Ontario	16.4	12.8	12.2
Quebec	11.3	10.0	9.4
New Brunswick	26.9	24.6	23.9
Nova Scotia	24.9	21.6	17.3
Prince Edward Island	15.5	15.3	13.0
Newfoundland	19.2	18.3	19.1
Territories	21.9	17.7	17.7
Canada	**22.9**	**20.4**	**20.0**

Projected Alternate Emissions Scenarios

Given the uncertainty regarding the key drivers of greenhouse gas emissions, the scenario presented in the previous section should be seen as one estimate within a set of possible emissions outcomes in 2020, depending on economic developments and underlying assumptions. The events that will shape emissions and energy markets cannot be anticipated in full. 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 world oil prices; and their impacts on macroeconomic growth and energy consumption[16].

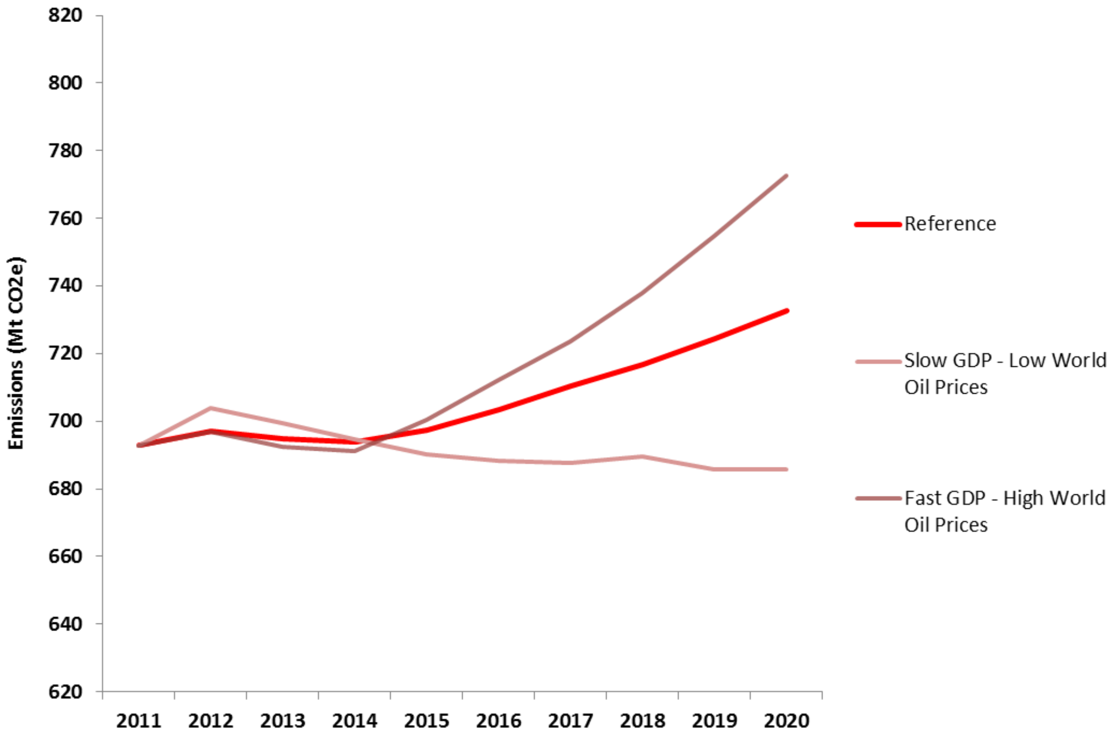
The reference case presented in the above emissions projections section has an average annual GDP growth rate of 2.1% between 2010 and 2020, and a world oil price of $102/bbl ($US) in 2020. In the most extreme alternative "high/fast" scenario, the average annual GDP growth rate is 2.9% over the period with an assumed world oil price of $130/bbl ($US) in 2020. In contrast, the most conservative scenario, integrating slow GDP growth and low world oil prices, the average annual GDP growth rate is 1.9% with an assumed world oil price of $72/bbl ($US) in 2020. Annex 3 outlines additional scenarios used to explore uncertainty in the 2013 *Emissions Trends* projections.

The most extreme results of varying economic growth and world oil price assumptions are presented in Figure 5. Under the Fast GDP-High World oil Prices scenario, emissions could reach almost 773 Mt by 2020, including the contributions from LULUCF. Alternatively, in the Slow GDP-Low World oil Prices case, 2020 emissions could be as low as 686 Mt.

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 world oil price, in 2020 the range is roughly 87 Mt.

[16] No sensitivity analysis was performed on the Land-Use Land-Use-Change and Forestry Sector. As such, emissions from this sector are assumed to be constant in all scenarios.

Figure 5 – Projected GHG emissions under alternative economic assumptions



These sensitivities illustrate that Canada's emissions projections should not be interpreted as a precise prediction or forecast 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.

It is important to note that the projection of emissions in this report is based on existing government measures as of the spring of 2013 only, and does not reflect the impact of further federal/provincial/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 20 – Sensitivity of emissions to changes in GDP and world oil price

(Mt CO2e)

Cases	2020	Change 2005 to 2020
Slow GDP – Low World Oil Prices	686	-51
Fast GDP – High World Oil Prices	773	36
Baseline Scenario	734	-3
Sensitivity Range (including all scenarios examined – see Annex 3)	686 to 773	-51 to 36

Box 3: Short-Lived Climate Pollutants

Short-lived climate pollutants (SLCPs) include black carbon (or soot), methane, tropospheric ozone and some hydrofluorocarbons (HFCs). Reducing SLCPs has multiple benefits for human health, agriculture and ecosystems, and also has the potential to reduce the rate of near-term warming expected under climate change, because of SLCPs' short lifetime in the atmosphere. Reducing SLCP emissions can help slow the rate of near-term warming, both globally and in sensitive regions such as the Arctic.

Black carbon is a component of fine particulate matter ($PM_{2.5}$), which is produced during the burning of biomass and fossil fuels. Black carbon stays in the atmosphere for only several days to weeks, whereas CO_2 has an atmospheric lifetime of more than 100 years. Methane is another potent GHG and SLCP: the global warming potential used within this analysis of methane is 21, with an atmospheric lifetime of only 12 years. Due to the potency of these short-lived pollutants, taking action to reduce these emissions can have relatively rapid impacts on slowing the rate of climate change in the near term.

Although the climate impacts and mitigation actions for methane (CH4), HFCs and tropospheric ozone have been understood for some time, black carbon has only recently become a focus of attention for policy makers, and significant work has been done to identify its source. Black carbon is produced under various circumstances: open biomass burning, residential biofuel burned with traditional technologies (e.g., woodstoves), stationary and mobile diesel engines, industrial processes, and fossil fuel combustion (including gas flaring).

Canada's policies on GHGs under the sector-by-sector approach, and its new Air Quality Management System, are having an impact on SLCPs. For example, the performance standards for coal-fired electricity generation are expected to reduce particulate matter ($PM_{2.5}$) (and thus black carbon), as are the air pollution regulations for light- and heavy-duty diesel vehicles, in combination with low-sulphur-fuel standards.

Canada is a founding partner of the Climate and Clean Air Coalition to Reduce Short-Lived Climate Pollutants, launched with the United Nations Environment Programme in February 2012. In 2013, Canada pledged a further $10 million in addition to its initial contribution of $3 million USD. Canada is engaged with several initiatives under the Coalition that will lower SLCPs.

Canada is also engaged in other international fora and agreements to address SLCPs. These include the Gothenburg Protocol, which was recently amended to include actions that will reduce black carbon; and the Arctic Council, where negotiations for a new pan-Arctic arrangement to reduce emissions of black carbon and methane commence under Canada's chairmanship. The Arctic Council has also produced mitigation recommendations and is involved in scientific monitoring and modeling work in the Arctic, as well as demonstration projects.

Table A.1.2 – Select Short Lived Climate Pollutants

killotonne	1990	1995	2000	2005	2010	2015	2020
CH4	3,425	4,089	4,474	4,670	4,310	4,280	4,042
HFCs	0.590	0.369	2.259	4.072	5.435	7.868	9.985
Black Carbon*	79	75	63	57	50	42	37

* Excluding open and natural sources.
*Black Carbon emissions inventories and projections are still under development. These estimates are highly preliminary.
*2011 is the last year of historical data for CH4 and HFCs; the last year of historical data for Black Carbon is 2007
*Black carbon emissions from flaring in production processes from the oil and gas, industry and waste sectors, may not be fully reflected in these emissions trends.
*Further analysis is needed to determine the impact of government policies on black carbon emissions going forward (compared to how they affect particulate matter).

Annex 1: The Land Use, Land-Use Change and Forestry Sector

Importance of the LULUCF Sector

The United Nations Framework Convention on Climate Change (UNFCCC) has recognized the important role of the land use, land-use change and forestry (LULUCF) sector in addressing climate change. The LULUCF sector involves greenhouse gas (GHG) fluxes between the atmosphere and Canada's managed lands, as well as those associated with land-use change. Globally, land use and land-use change was responsible for an estimated net carbon flux to the atmosphere of 1.14 GtC on average per year over the 1990 to 2009 period, which comprised 12.5% of total anthropogenic carbon emissions over the same period.[17]

Globally, data suggest an overall decreasing trend in land-use change emissions particularly since 2000. Emissions from land-use change were 36% of the total human emissions in 1960, 18% in 1990, and 9% in 2011. "The implementation of new land policies, higher law enforcement to stop illegal deforestation, and new afforestation and regrowth of previously deforested areas could all have contributed to this decline"[18].

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 as a result of 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 carbon emissions and increase sequestration. They include: relatively more reliance on tree planting as opposed to natural regeneration; more use of improved seed stock for tree planting; more and faster rehabilitation of harvest roads and landings; and adjustments in management practices to reduce soil compaction. 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 recovered somewhat in 2010 and 2011[19].

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[17] Houghton RA, House, JI, Pongratz J and others. 2012. Carbon emissions from land use and land-cover change. *Biogeosciences*, 9, 5125–5142.
[18] http://www.globalcarbonproject.org/carbonbudget/12/hl-full.htm
[19] National Forestry Database Program, www.nfdp.ccfm.org.

Accounting for the LULUCF Sector

At the 2011 UNFCCC Climate Conference in Durban, South Africa, countries agreed on rules for LULUCF accounting to be used by developed countries in the second commitment period of the Kyoto Protocol (i.e. 2013-2020). Challenges related to natural disturbances had been the subject of considerable technical work and acknowledging that natural disturbances are out of human control, it was agreed in the Durban rules that the impacts of natural disturbances can be removed in accounting for forests. The rules also included improved accounting of emissions from harvested wood products, and specified the use of Reference Levels for accounting for Forest Management.

Changes from Canada's Emissions Trends 2012

The 2012 *Emissions Trends Report* represented a key milestone for Canada as it included the LULUCF sector for the first time. This year, Canada continues to estimate a similar contribution arising from the LULUCF sector but sources of change in the estimates should be noted.

- Changing the classification system away from *activity based accounting* (e.g. forest management) towards the accounting approach used in our National Inventory Report (e.g. forest land remaining forest land). There are only slight differences between these two sets of classifications.

- *Updated data and methodological improvements*. Projections have been remodelled to take into account updated information and improved modeling consistent with the 2013 *NIR*.

- *Change in the treatment of harvested wood products from Forest Conversion to Other Land Categories*. The model used in the 2012 Emissions Trends Report included delayed emissions from long-term carbon storage in wood products resulting from forest conversion. However, the approach to calculating emissions from wood products is currently being refurbished. Therefore, an instant oxidation approach consistent with that used in the NIR was adopted for this year's report.

- *Technical corrections to the Reference Level*. The Reference Level used for the managed forest (Forest Land Remaining Forest Land) has been updated, reflecting a process of technical correction outlined in the Durban LULUCF agreement[20].

Because of these changes, the UNFCCC category estimates reported this year will differ somewhat from the estimates for the Kyoto Protocol activities reported last year.

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

Subsector Analysis

Environment Canada, in partnership with Natural Resources Canada and Agriculture and Agri-Food Canada, has undertaken research and analysis over the past two years to develop preliminary projections of LULUCF emissions and removals. Updated projections of business-as-usual emissions and removals (i.e. in the absence of new policies that contribute to mitigation) have been estimated to 2020 for each subsector and will be updated periodically in the future. It should be noted that 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.

Table A.1.1 – Projected emissions (+) or removals (-) from the LULUCF sector in 2020[(1)]

(In Mt of GHG emissions/removals)	2005 Estimate/ Reference Level	2020 Projected Emissions/Removals	Expected Contribution in 2020 Emissions
Forest Land Remaining Forest Land	-107[(2)]	-133	-26
Cropland Remaining Cropland [(3)]	-10	-9	1
Forest Land Converted to Other Land Categories[(4)]	18	15[(5)]	-4
Land Converted to Forest Land	-0.9	-0.4	0.6
Total	-100	-128	≈-28

(1) Numbers may not add due to rounding

(2) For Forest Land Remaining Forest Land, a 2020 reference level is used for determining the contribution.

(3) Cropland remaining Cropland includes residual emissions after 20 years from forest conversion to cropland

(4) 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

(5) Differences between these values and those reported in the *NIR* are due to the inclusion here of emissions from the conversion of forest to other land after 20 years or more, except in the case of conversion of forest to cropland

Each 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 are compared to a 2020 Reference Level. As noted earlier, the Reference Level is an internationally accepted approach, one that is seen as a scientifically-credible approach to account for emissions and removals from managed forests.

The Durban agreement for LULUCF included Canada's proposed Reference Level for the 2013 to 2020 period[21]. As Canada's target is focused on the single year of 2020, it is the 2020 value from the Reference Level time series that is used here (using the technically-corrected Reference Level discussed above). Use of the Reference Level approach allows factoring out of highly variable natural disturbance impacts, in accordance with the process agreed at the UNFCCC 17th Conference of the Parties in Durban, South Africa.

Canada's work to analyze alternative accounting approaches is ongoing, and changes to the accounting approach may be made in future *Emissions Trends* reports. In particular, there remains uncertainty with respect to future approaches that may be included under a new climate change agreement that would be applied after 2020. For example, the United States uses a net-net approach to accounting for LULUCF emissions/removals where the sector is added into the national total in both the base and target year just like the other economic sectors.

Subsector Emissions Trends and Methodologies

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

- **Forest Land Remaining Forest Land.** As per Table A.1.1, this subsector dominates the expected LULUCF contribution in 2020. Harvesting is the human activity with the most impact on emissions in this subsector. As already noted, harvest levels reached a 35-year low in 2009 before recovering somewhat in 2010 and 2011. However, current projections suggest that harvests will remain below the recent average historical level used in estimating the Reference Level. The projected value for the Forest Land Remaining Forest Land contribution in 2020 is derived by using these projected harvests to determine the expected sink in 2020 and comparing that to the Reference Level. Both the projected sink in 2020 and the Reference Level are derived using an assumption of no natural disturbances from 2012 onward except a low background level expected to occur every year.

- **Land Converted to Forest Land.** Given the low levels of new forest creation, it is not possible to identify any trends in the activity except that recent new forest

[21] Canada's submission on its reference level for 2013-2020 is described in a submission to the UNFCCC at http://unfccc.int/bodies/awg-kp/items/5896.php.

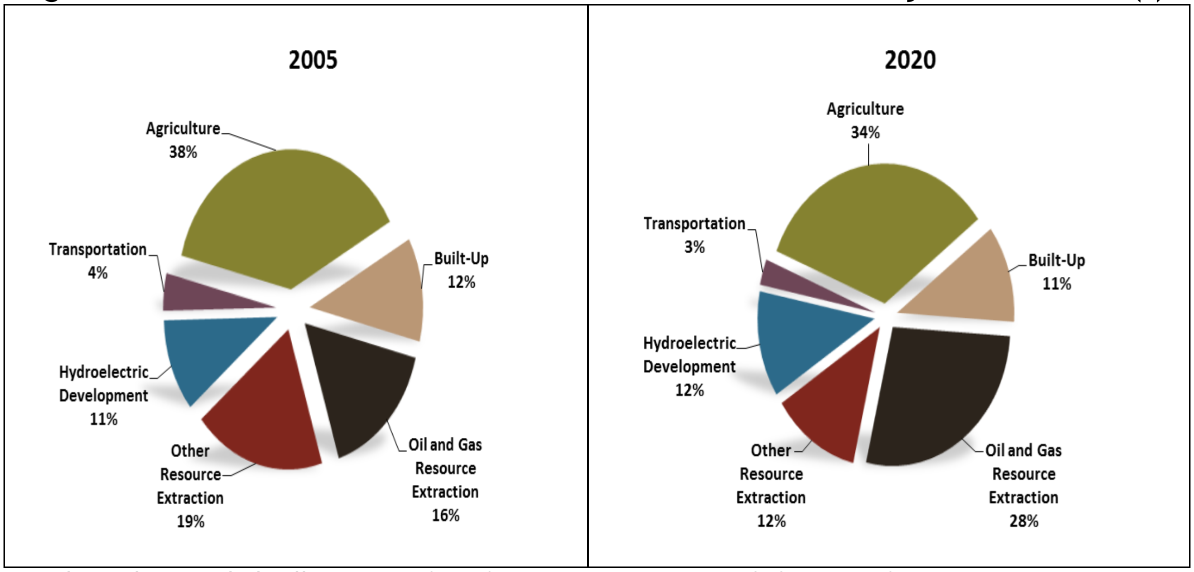
creation appears to be lower than in the 1990s. Data on creation of new forests for 2009 to 2011 are not available. Therefore it was assumed that the 2000 to 2008 average rate in each ecozone in each province would be the business-as-usual rate in the future, totaling about 2,700 ha per year for Canada as a whole. 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.

- **Cropland Remaining Cropland**[22]**.** Soil carbon sequestration in Canada has increased from a rate of 2 Mt CO_2e per year in 1990 to 13 Mt CO_2e per year in 2011 (*NIR*, 2013). 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 to 9 Mt CO_2e from 2011 to 2020 as a result of the soil sink approaching equilibrium and limited scope for additional practice adoption. For example, on most of the land where using 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.** Current forest conversion rates in Canada are estimated at 46,000 hectares per year, down from 64,000 hectares per year in 1990. Part of the emissions due to forest conversion occurs immediately upon the conversion event, while the remaining emissions take place over subsequent years and decades and are related to the rate of decay of forest material. Forest conversion emissions are projected to decline slightly to 2020 relative to 2005. The circumstances surrounding forest conversion activities in Canada are extremely varied and involve a wide range of economic drivers (agriculture, urban expansion, resource extraction Figure A.1.1). As such, future reports projections will be adjusted as a result of revised conditions for each of these sectors.

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

Figure A.1.1 - Main Drivers of Forest Conversion in 2005 and Projected for 2020 (*)



(*) These charts include all emissions from forest conversion since 1970, except for conversion to harvested peat sites (Peatlands) included in historical estimates for 2005 but not available for the projections to 2020.
Note that the “Built-up” section includes Industrial and commercial buildings, urban and municipal expansion, and recreation.

Contribution of the LULUCF Sector to 2020 Projected Emissions

On the basis of current estimates, the projected contribution of the LULUCF sector to achieving the 2020 target is 28 Mt CO_2e. This estimated contribution 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 will count towards attaining the Copenhagen target.

As the Government of Canada works towards achieving its climate change objectives, it will consider, along with its provincial and territorial partners, policy actions to achieve further mitigation results from the LULUCF sector. Key LULUCF activities in Canada with potential for increasing mitigation benefits through reducing emissions or increasing removals include changing forest management practices, increasing afforestation, decreasing forest conversion, and enhancing agricultural practices that sequester carbon. In addition to climate change mitigation, such efforts could positively impact other environmental or economic objectives. For example:

- Many farm practices provide multiple benefits. In addition to increasing soil organic carbon levels, no-till can improve moisture retention and reduce the risk of soil erosion.

- Converting one hectare of forest emits on average approximately 300 tonnes of CO_2e; policies aimed at reducing forest conversion would have climate change benefits and could also address other environmental issues, such as biodiversity conservation.

Annex 2: Baseline Data and Assumptions

Key Economic Drivers 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 key assumptions and drivers are set out in this section. They include:

- Economic growth projections (Gross Domestic Product)
- Real disposable personal income projections
- Consumer price index projections
- Household formation projections
- Labour force projections
- World oil price projections
- Natural gas price projections
- Other energy price projections
- Energy production and supply projections
- Major energy investment outlooks
- Major electricity supply projects (outlook)
- Emissions Factors

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. Alternative cases are explored in the sensitivity analysis in Annex 3.

Historical data on gross domestic product and disposable personal income are provided from Statistics Canada. Consumer price index and population demographics are also produced by Statistics Canada while historical emissions data are provided by the *NIR*. The economic projections to the year 2018 are calibrated to private sector projections from Finance Canada's Private Sector Survey, June 2013.[23] The outer years (2019-2020) are guided by Finance Canada's longer-term fiscal projections included in their "Economic and Fiscal Implications of an Aging Population" report[24].

Forecasts of major energy supply projects from the National Energy Board's preliminary 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

Canadian real GDP in 2011 was an estimated C$1.6 trillion. [25] The economic projections to the year 2018 are calibrated to Finance Canada's Private Sector Survey from the June 2013 update. The outer years (2019-2020) are guided by Finance Canada's longer-term fiscal projections included in their "Economic and Fiscal Implications of an Aging Population" report.

The Canadian economy grew by 1.4% per year over 2005 through 2011 and this growth is expected to continue at a slightly higher pace into the future, as the annual rate of growth in real GDP increases to 2.1% from 2011 to 2020.

Table A.2.1 – Macroeconomic assumptions: 1990-2020 average annual growth rates (%)

	1990-2005	2005-2011	2011-2020
Gross Domestic Product	2.8%	1.4%	2.1%
Consumer Price Index[26]	2.1%	1.9%	1.8%

[23] Department of Finance Canada (2013): *June 2013: Department of Finance Private Sector Survey*. Web-site http://www.fin.gc.ca/pub/psf-psp/2013/2013-06-eng.asp, accessed 10 Sep 2013.
[24] http://www.fin.gc.ca/pub/eficap-rebvpc/eficap-rebvpc-eng.pdf
[25] Source: Statistics Canada CANSIM Table 380-0064: Gross domestic product, expenditure-based http://www5.statcan.gc.ca/cansim/a26?lang=eng&retrLang=eng&id=3800064&paSer=&pattern=&stByVal=1&p1=1&p2=-1&tabMode=dataTable&csid= retrieved on 9 Sep 2013 (GDP in chained 2007 dollars; annual average of seasonally-adjusted data).
[26] The consumer price index (inflation) in the macroeconomic model is a function of the disaggregated price components of personal consumption. The projection targets the mid-point of the Bank of Canada's target of 1 to 3 percent inflation throughout the projection. However, due to the fact that inflation is endogenous, rates do not equal 2 percent in each year but do converge to an average of 2 percent after 2015.

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 1.2% annually between 2011 and 2020, an improvement over the 0.3% average annual growth during the period between 2005 and 2011.

Population Dynamics and Demographics

The population size and its characteristics (e.g., age, sex, education, household formation, among others), have important impacts on energy demand. Canada's overall population is projected to grow on average at an annual rate of 1.1% between 2011 and 2015, and by 1.1% per year between 2011 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 1.3% per year between 2011 and 2020.

- *Labour force*. This is expected to have a decelerating growth rate, reflecting the aging population. Its annual average growth rate was on average 1.3% per year between 2005 and 2011, and is projected to slow to 0.8% per year between 2011 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. 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 most directly related to the WTI crude oil price at Cushing, Oklahoma, which is the underlying physical commodity market for light crude oil contracts for the New York Mercantile Exchange (NYMEX). The increase in North American supply and the resulting transportation bottleneck at Cushing have created a disconnect between the WTI and Brent crude oil, an often quoted international light oil benchmark. 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 (preliminary expectations 2013). According to the Board, the world crude oil price for WTI is projected to increase slightly from about US$80 per barrel of oil (bbl) in 2010 to about US$102/bbl in 2020. A higher price scenario, in which 2020 prices are US$130/bbl, is used for the sensitivity analysis in Annex 3. Under the higher price case, GHG emissions are expected to be lower.

Figure A.2.1 – Crude oil price: WTI, and Alberta Heavy

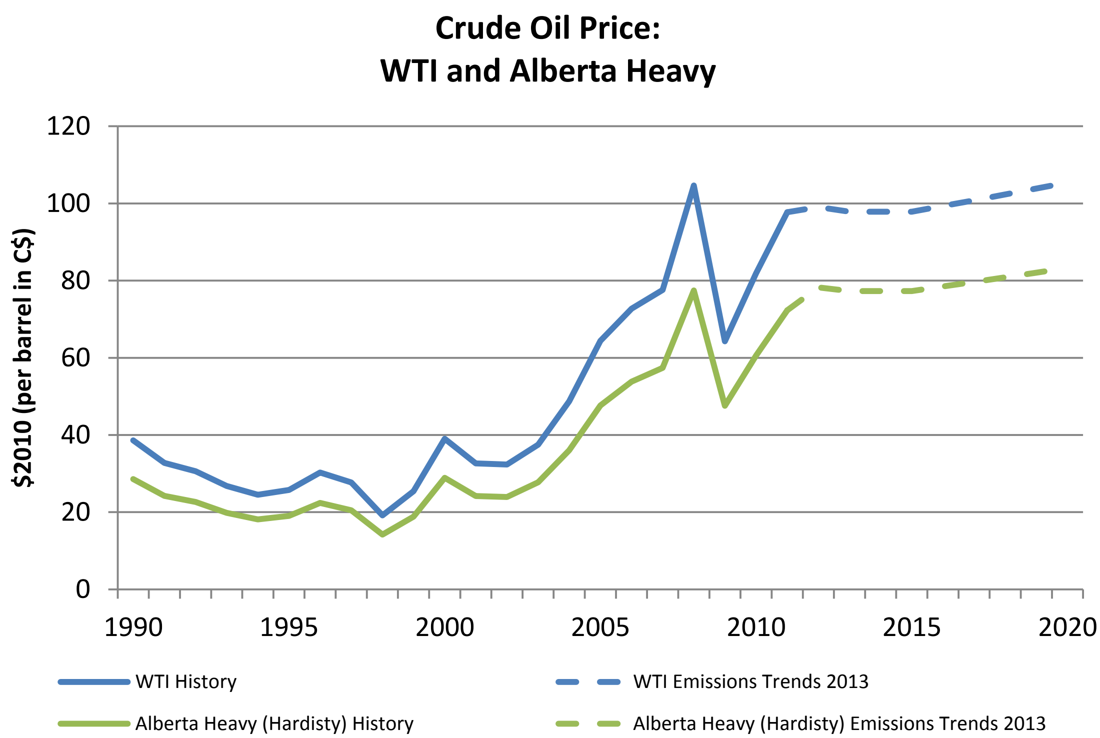


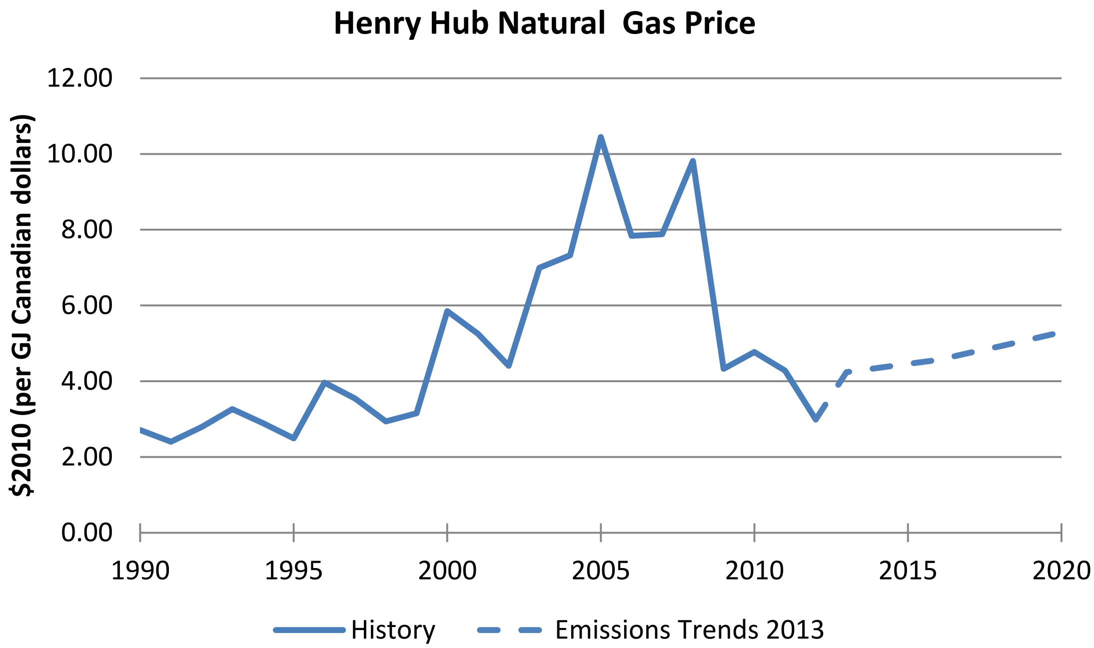
Figure A.2.1 shows crude oil prices for light crude oil (WTI) and Heavy oil. Historically the price of heavy oil / bitumen (Alberta Heavy) has followed the light crude oil price (WTI) at a discount of 50% to 60%. However, in 2008 and 2009 the differentials between the prices of light and heavy crude 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 Resources Conservation Board 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%.[27]

As shown in Figure A.2.2, the Henry Hub price for natural gas in Alberta (the benchmark for Canadian prices) declined in 2010 to about four Canadian dollars per gigajoule (GJ). In the projection, it begins to recover to reach about C$5.30 per GJ by 2020, still well below its peak of over C$10 in 2005. This reflects the National Energy Board's assumption that major pipeline expansions such as Mackenzie and Alaska pipelines may not occur before 2020 due to low natural gas prices.

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

Figure A.2.2 – Henry Hub natural gas price (C$/GJ)



Energy Production

National Energy Board preliminary 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 2010 to 2020 oil sands in situ production will increase more than fivefold and oil sands mining production will increase by more than 100% (see Table A.2.2).

Table A.2.2 – Crude oil production

Thousand Barrels Per Day	2005	2011	2020
Crude and Condensates	**1534**	**1410**	**1441**
Conventional Heavy	511	556	612
Conventional Light	526	428	432
C5 & condensates	173	148	137
Frontier Light (offshore + northern	324	277	260
Oil Sands	**1064**	**1743**	**3315**
Oil Sands – Primary	150	211	243
Oil Sands – In-situ	286	640	1794
SAGD	82	374	1467
CSS	204	266	328
Oil Sands Mining	628	892	1278
Total Production (gross)	**2597**	**3153**	**4756**

Table A.2.3 illustrates oil sands supply composition. 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 (A.1.3) from Alberta is projected to increase from about 862 000 barrels per day (bp/d) in 2011 to about 1.2 million (bp/d) by 2020. Synthetic crude oil from Saskatchewan is projected to increase slightly to 76 000 (bp/d). Non-upgraded bitumen will increase from 697 000 (bp/d) in 2011 to 1.8 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.2.3 - Oil Sands Disposition

Thousand Barrels Per Day	2005	2011	2020
Synthetic	610	932	1317
Non-upgraded Bitumen	368	697	1817
Oil Sands (net)	**979**	**1,630**	**3,133**
Own use	85	114	182
Oil Sands (gross)	**1,064**	**1,743**	**3,316**

Projections show gross natural gas production will decline to some 4.9 billion cubic feet in 2020, as new production and non-conventional sources such as shale gas and coal-bed methane come to market[28] but do not quite offset conventional declines. The shale gas growth rate is projected to be 16% per year between 2011 and 2020 (National Energy Board –preliminary estimates 2013).

Table A.2.4 - Natural Gas production

Billion Cubic Feet	2005	2011	2020
Supply			
Gross Production	6984	5938	4861
Own-use Consumption	722	629	781
Marketable Gas	6262	5309	4081
Imports	346	1148	828
Total Supply	6608	6456	4908
Liquid Natural Gas Production	0	0	550

[28] For the purposes of this document, shale gas development has been included under natural gas production (but not separately identified). As more data and information on likely shale gas production trends become available, consideration will be given to modeling shale gas separately.

Taking into account these provincial/territorial utility expansion plans, plus additional units forecast to be built by the Energy, Emissions and Economy Model for Canada (E3MC) to meet growth in electricity demand, aggregate electricity generation is also expected to increase substantially, by about 12% from 2011 to 2020, with fuel mix changes as generation increases. As Table A.2.5 illustrates, the proportion of generation coming from wind power and other renewable sources is expected to increase from 2005 to 2020, starting at only about 0.3% in 2005 and reaching 4.5% of total generation by 2020. In addition, the proportion of natural-gas-fired generation is projected to be 60% greater than 2005 levels.

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 increase 60% over its 2005 levels by 2020 because of its appeal as a relatively cleaner source of power generation and a reliable means to cover peak loads. The lower natural gas price 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 9.5% in 2020.

Table A.2.5 – Electricity generation by fuel, terawatts per hour (TWh)

	2005	2011	2020
Coal and Petroleum Coke	97	66	58
Refined Petroleum Products	12	2	3
Natural Gas	25	37	40
Hydro	327	342	397
Nuclear	87	88	84
Other Renewables	2	10	28
Total Generation	550	545	609

Emissions Factors

Table A.2.6 provides a time-averaged estimate of carbon dioxide equivalent emissions emitted per unit of energy combusted 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.

The model uses these factors to determine the level of carbon dioxide equivalent emissions arising from each unit of fuel in the list below.

Table A.2.6 – Mass of carbon dioxide equivalent emissions emitted per quantity of energy combusted for various fuels

Fuel	CO_2 eq. Emitted (gram per mega joule (g/MJ))
Aviation Gasoline	73.37
Biodiesel	8.30
Biomass	4.63
Coal	90.81
Coke	7.63
Coke Oven Gas	36.77
Diesel	74.06
Ethanol	4.32
Gasoline	68.61
Heavy Fuel Oil	74.49
Jet Fuel	68.86
Kerosene	67.42
Landfill Gases/Waste	19.46
Light Fuel Oil	70.41
LPG	60.62
Natural Gas	49.90
Natural Gas Raw	66.13
Petroleum Coke	84.65
Still Gas	47.94

Federal, Provincial and Territorial Measures

The analysis includes existing federal, provincial and territorial measures to reduce GHG emissions. All levels of government are taking action on emissions while balancing their economic objectives. The Government of Canada supports all actions by provinces and territories as well as individual Canadians and businesses. In addition, the Government is taking action of its own and following its sector-by-sector approach to regulatory development.

Since 2006, the Government of Canada has invested more than $10 billion to reduce GHG emissions and support clean energy technologies through investments in green infrastructure, energy efficiency, clean energy technologies and the production of cleaner energy and fuels. These include expenditures through the ecoENERGY initiatives, Clean Energy Fund, Green Infrastructure Fund, Public Transit Tax Credit, Marine Shore Power Program, biofuels and bioproducts initiatives and programs, National Vehicle Scrappage Program, and the National Renewable Diesel Demonstration Initiative, to name just a few.

In addition, regulations are being enacted to reduce emissions from key sources, and joint initiatives and investments have been undertaken with the provinces and territories to assist them in addressing their unique challenges and to facilitate coordinated approaches.

Table A.2.7 below identifies the major federal, provincial and territorial measures that are included in the *Canada's Emissions Trends*' reference case. It includes federal measures that have been implemented or announced in detail as of May 2013. Where program funding is set to end, the projections assume that the impacts of these programs, other than those embodied in consumer behaviour and long-lived assets, cease when the approved funding terminates.

The analysis also includes existing provincial and territorial measures. Environment Canada involves provinces and territories in extensive consulations 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 2013 have been included wherever possible.

Although the emissions outlook's baseline scenario 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.

The following are select federal government measures that have been included in the baseline scenario:

1. <u>Performance standard for coal-fired electricity generation:</u> In June 2010, the Government of Canada announced its intention to regulate coal-fired electricity generation. The regulations impose a performance standard on new coal-fired electricity generation units, and on units that have reached the end of economic life. The new regulations, which are scheduled to take effect in 2015, will encourage electric utilities to transition towards lower- or non-emitting types of generation. The proposed regulations send a critical signal to industry in advance of capital stock turnover, which is expected to be significant. By affecting current capital investment decisions, these regulations will prevent the building of higher-emitting facilities in the future. The gradual phase-out of old and dirty coal units is expected to significantly reduce emissions from the electricity generation sector and improve air quality for all Canadians.

2. *Passenger Automobile and Light Truck Greenhouse Gas Emission Regulations*: In October 2010, the Government published its final *Passenger Automobile and Light Truck Greenhouse Gas Emission Regulations*, which establish progressively stringent standards, harmonized with the United States, for GHG emissions from new cars and light trucks for the 2011 to 2016 model years. The Government also published a *Notice of Intent* for Phase 2 of the regulations in order to develop more stringent GHG emissions standards for light-duty vehicles of model years 2017 to 2025.

3. *Renewable Fuels Regulations*: In 2006, as part of the Renewable Fuels Strategy, the Government of Canada announced its intention to regulate an annual average renewable fuel content of 5% in gasoline by 2010, and, in a second phase, a 2% requirement for renewable content in diesel fuel by 2011.

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

Table A.2.7. – GHG Measures reflected in projections (in place May 2013)

Provincial/Territorial Measures	Federal Measures
Alberta - Specified Gas Emitters Program (SGER) British Columbia - BC Carbon Tax - Renewable Fuels tax exemptions for minimum ethanol and biodiesel content - BC Emissions Offsets Regulations - Landfill Gas Management Regulation Manitoba - Renewable Fuels provincial tax credit/exemption for minimum ethanol content Nova Scotia - Nova Scotia Renewable Portfolio Standard for electric generation - Electric Demand-Side Management policies for Nova Scotia - Solid Waste Management Resources Management Strategy Ontario - Ontario Residential Electric 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 Quebec - Renewable Fuels tax reimbursement/income tax credit - Quebec and California WCI Cap and Trade system - Quebec's Carbon Levy - Landfill Gas Regulation (Règlement sur l'enfouissement et l'incinération de matières résiduelles) Saskatchewan - Renewable fuels distributor tax credit for ethanol produced and consumed in the province	- Performance standard for coal-fired electricity generation - Residential Building Code changes for energy efficiency (EnerGuide-80 or R-2000 level) applying to all provinces - Renewable Fuel Content Regulation - Adoption of the National Energy Code for Building of Canada 2011, or its equivalent, by all provinces and territories, except North-West-Territories, by 2016 - Commercial appliance efficiency improvements (excludes lighting) - Residential appliance efficiency improvements. Includes refrigeration, freezers, range and dryers - Industry Expansion of CIPEC (Canadian Industry Program for Energy Conservation) including ISO and 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) Regulation for greater stringency on GHG emissions from heavy-duty truck vehicle years 2014 to 2018 - The Pulp and Paper Green Transformation Program (PPGTP), to improve environmental performance of mills including GHG emissions reductions. The program ended in 2012 but resulted in on-going 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 Program

Canadian provinces and territories have committed to taking action on climate change through various programs and regulations. Environment Canada's modeling does not include the emissions reduction targets of provinces. Only concrete actions and measures (that have already been implemented) to reach these targets are included in emissions projections. Table A.2.8 lists the emissions reductions targets announced by each province or territory for illustrative purposes.

Table A.2.8. – Announced GHG reduction targets of provincial/territorial governments

Province / Territory	Target
British Columbia	33% below 2007 by 2020 and 80% below 2007 by 2050
Alberta	50 Mt below BAU by 2020 and 200 Mt below BAU by 2050
Saskatchewan	20% below 2006 by 2020
Manitoba	15% below 2005 by 2020 and 50% to 80% below 2005 by 2050
Ontario	15% below 1990 by 2020 and 80% below 1990 by 2050
Quebec	20% below 1990 by 2020
New Brunswick	10% below 1990 by 2020
Nova Scotia	10% below 1990 by 2020
Newfoundland	10% below 1990 by 2020
Prince Edward Island	10% below 1990 by 2020 and 75% to 85% below 1990 levels in the long term
Nunavut	No Territorial target announced
Yukon	20% below 2009 by 2015 and carbon neutral by 2020
Northwest Territories	No Territorial target announced

Annex 3: Alternate Emissions Scenarios

Emissions projections depend on a number of economic and energy projections which make them subject to uncertainty. Emissions projections are more appropriately viewed as a range of plausible outcomes as reasonable variations are made to these key drivers. In addition, 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
- The evolution of world oil prices and their impacts on macroeconomic growth and energy consumption

Table A.3.1 outlines the range of variations in these uncertainties compared to reference levels. The fast and slow GDP extremes were derived by applying the assumptions from the 2013 Annual Energy Outlook by the 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.3.1 – Sensitivity analysis – Extreme projections for Economic Growth and Oil Prices (2020)

	Slow/Low	Reference	Fast/High
GDP (Chain-Weighted 1997 $s, Bns)	1480	1520	1630
World Oil Price (2010 US$/bbl)	72.34	102.34	130.40

In the reference case, the world oil price is projected to grow from $79/bbl in U.S. dollars ($US) in 2010 to $102/bbl ($US) in 2020. A higher-price scenario, in which 2020 prices are $130/bbl ($US), is used alone and in combination with different GDP growth assumptions. A low-price scenario is also included where the world oil price remains fairly stable at $72/bbl ($US) after 2015 through 2020. These high and low oil price extremes were provided by the National Energy Board as the probability range of future energy prices used within their analysis.

Figure A.3.1 illustrates how differing price and GDP growth assumptions might impact Canadian GHG emissions through 2020. Under the scenarios that affect only one driver independently of the other, GHG emissions in 2020 range from 718 Mt to 749 Mt, under the low world oil price and fast GDP growth cases respectively.

Figure A.3.1 – Projected GHG emissions under full range of alternative economic assumptions (independent changes to variables)

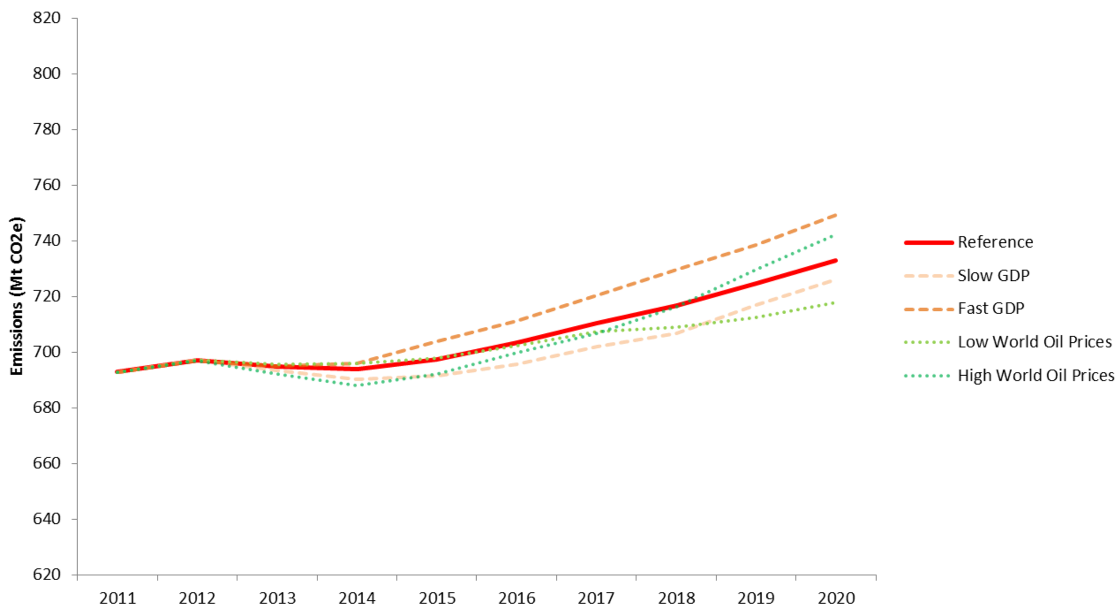
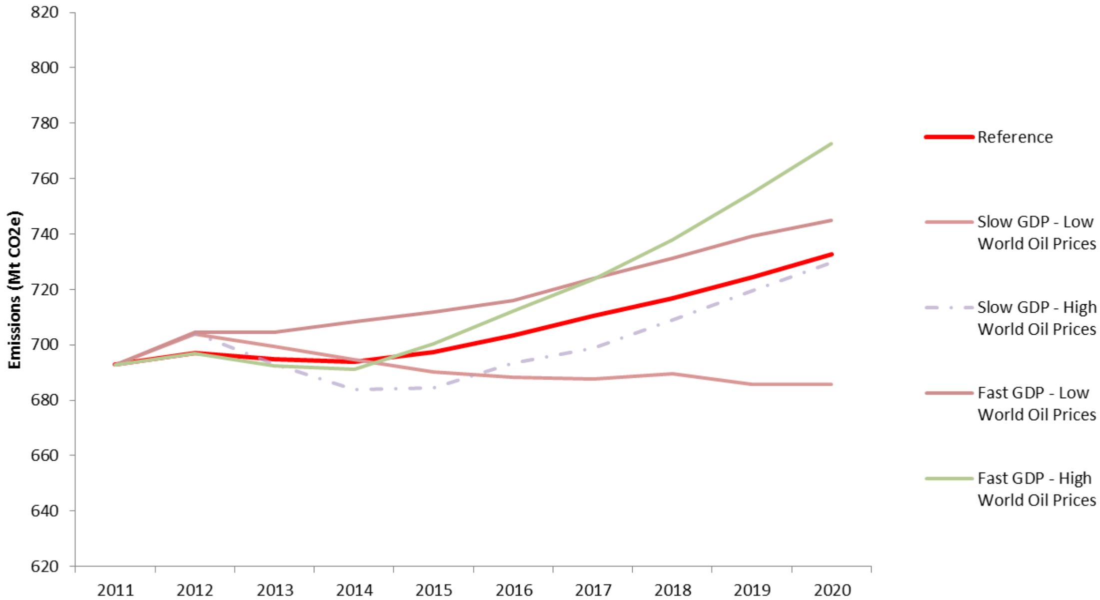


Figure A.3.2 illustrates how differing price and GDP growth assumptions in combination, might impact Canadian GHG emissions through 2020. Under the fast and high scenario which combines high world oil prices with fast growth in GDP emissions could reach 773 Mt including the contribution from LULUCF[29]. Alternatively, under a scenario with slower GDP growth (average growth of 2.0% between 2010 and 2020) and lower world oil prices (29% lower than the reference case in 2020), emissions could be as low as 686 Mt.

[29] No sensitivity analysis was performed on the Land-Use Land-Use-Change and Forestry Sector. As such, emissions from this sector are assumed to be constant in all scenarios.

Figure A.3.2 – Projected GHG emissions under full range of alternative economic assumptions (combined changes to variables)



GHG emissions in the fast-GDP-growth scenario are about 11% higher in 2020 than 2010 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 prices, emissions could be 16% higher than 2010 levels by 2020. Expected growth of the economy is the primary driver of expected emission growth. Any variation in this path will lead to a different set of projections about expected future emissions. Table A.3.2 quantifies the results of the full range of emissions alternatives illustrated in the above figure.

Table A.3.2 – Sensitivity analysis – Change in GDP and/or world oil /natural gas prices

Cases	GHG emissions (in Mt CO2 eq – Including LULUCF)	
	2020	Change, 2005 to 2020
Slow GDP	726	-11
Fast GDP	749	12
Low World Oil Prices	718	-19
High World Oil Prices	742	5
Slow GDP - Low World Oil Prices	686	-51
Slow GDP - High World Oil Prices	730	-7
Fast GDP - Low World Oil Prices	745	8
Fast GDP - High World Oil Prices	773	36
Reference	734	-3
Sensitivity Results	686 to 773	-51 to 36

The growth in emissions is expected to slow down as the world price of oil increases since overall economic activity would decline as the price of oil rose. However, the increase in price drives higher production in the oil and gas sectors which partially offsets this effect. Emissions from the oil and gas sector in the high world oil price case rise by 71 Mt from 2010 to 2020; whereas they only rise by 48 Mt in the low price scenario.

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

As noted, the oil sands sector displays the fastest growth in emissions, but it also displays the greatest range of uncertainty about future emissions depending on the assumptions used. Emissions could rise by as much as 74 Mt – or as little as 58 Mt – over the 2005 to 2020 period. The baseline scenario projects that oil sands emissions would increase by 67 Mt.

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 world oil price, in 2020 the range is roughly 87 Mt.

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 or imminently pending as of May 2013.

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

The emissions projections have been developed in line with generally recognized best practices. 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. Finally, the methodology used to develop the projections and underlying assumptions has been subject to peer review by leading external experts on economic modeling and GHG emissions projections, as well as vetted with key stakeholders.

The approach to developing Environment Canada's *Emissions Trends Report* 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 Environment Canada's National Inventory Report. For these projections, the most recent historical data available were for 2011.

Environment Canada's projections and historical data in the *NIR* are aligned, based on economic sector.

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

- National Energy Board preliminary 2013 views on energy prices and large-scale energy projects
- Economic growth from private sector projections from Finance Canada's Private Sector Survey, June 2013
- 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 2013, the "without measures" 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 2011, 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 oil sands emissions are derived from 2005 emissions intensities. Exogenous agriculture emissions from livestock and crop production are maintained at reference scenario levels throughout the entire projection period. All other sectors (Transportation, Oil and Gas, Buildings, Emissions – Intensive and Trade Exposed Industries, and Waste and Others) are derived from the highest of either the 2005 or 2011 emissions intensity, subject to a limit of no greater than 30% more than the value in 2011.

Energy, Emissions and Economy Model for Canada

The projections presented in this chapter were generated from Environment Canada's Energy, Emissions and Economy Model for Canada, also known as E3MC.

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, 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.

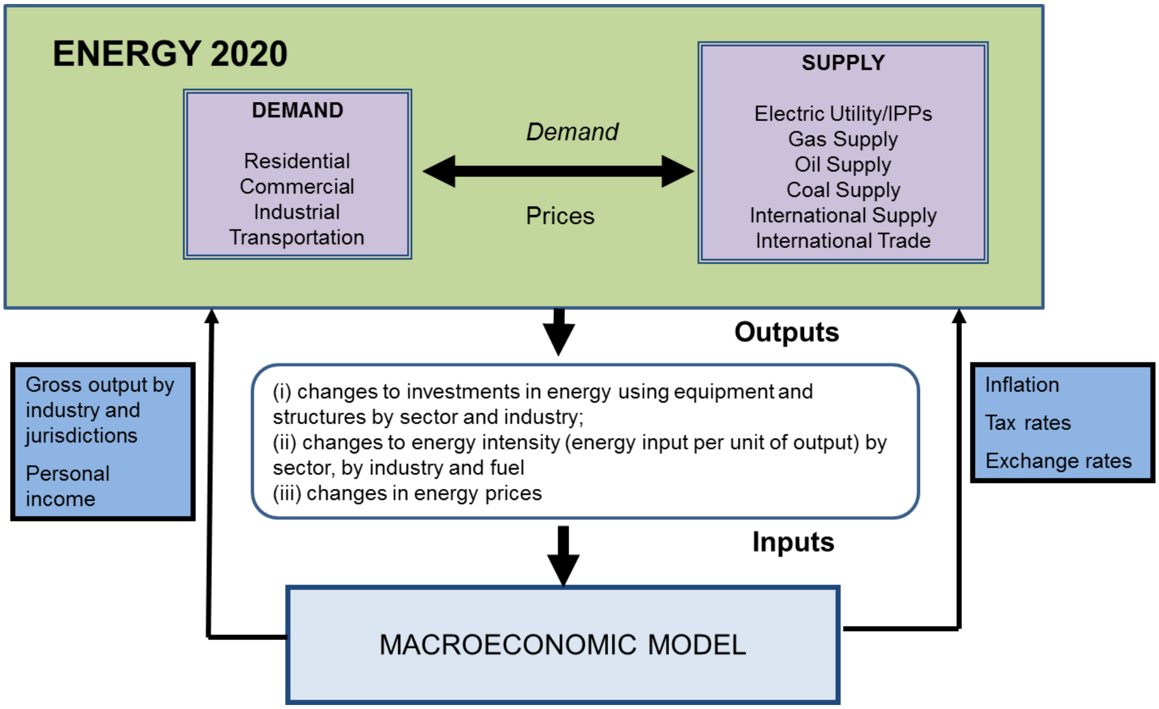
- The in-house macroeconomic model is used to examine consumption, investment, production, and trade decisions in the whole economy. It captures the interaction among industries, as well as the implications for changes in producer prices, relative final prices, and income. It also factors in government 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, methane and nitrous oxide) by sector and by province.

Figure A.4.1 shows the general structure of E3MC. The component modules of E3MC represent the individual supply, demand, and conversion sectors of domestic energy markets, and also include the macroeconomic module. In general, the modules interact through values representing the prices of the energy delivered to the consuming sectors and the quantities of end-use energy consumption.

Figure A.4.1 – Energy, emissions and economy model for Canada



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

Treatment of Interaction Effects

Estimates of the net impact of government measures incorporated 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.[30] 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

[30] 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.

accounts for emissions in the electricity generation sector as well as for emissions in the consumer demand sectors. As the electricity sector reduces its emissions intensity, policies designed to reduce electricity demand in the consumer sectors will cause less of an emissions reduction. The natural gas and oil supply sectors similarly respond to the demands from the consumer sectors, including the demands for refined petroleum products for transportation. The model also simulates the export of products by supply sectors.

Taken as a whole, the E3MC model provides a detailed representation of technologies that produce goods and services throughout the economy, and can simulate, in a realistic way, capital stock turnover and choices among technologies. The model also includes a representation of equilibrium feedbacks, such that supply and demand for goods and services adjust to reflect policy. Given its comprehensiveness, E3MC covers all the 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 traveled. In each period, capital stocks are retired according to an age-dependent function (although the retrofitting of unretired stocks is possible, if warranted by changing economic conditions). Demand for new stocks grows or declines depending on the initial exogenous forecast of economic output (i.e., a forecast that is external to the model and not explained by it) and the subsequent interplay of energy supply–demand with the macroeconomic module. A model simulation iterates between energy supply–demand and the macroeconomic module until there is a convergence. The global convergence criterion is set at 0.1% 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.

LULUCF MODELING METHODOLOGY

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 Government department sub-sector experts.

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 National GHG Inventory (Environment Canada, 2013) under the LULUCF sector. Emissions for Forest conversion is not a LULUCF reporting category, 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 from forest conversion to all land categories are estimated using a consistent approach, further described in this section.

Historical estimates for forest land conversion where developed based on an earth observation sampling approach with resulting emissions impacts calculated using the Carbon Budget Model of the Canadian Forest Sector. These estimates take into account activity extending back to the 1970's and up to 2011 and were developed by driver (agriculture, built-up, hydroelectric development, non-renewable and renewable resource extraction-(mining and oil and gas), renewable resource extraction, transportation and hydroelectric reservoirs) and end land use categories (cropland, wetlands, settlements).

The projected estimates for forest conversion where developed asare based on a business-as-usual (BAU) scenario of forest conversion activity for the 2011 - 2020 period, using the best available knowledge of drivers, policies and practices. The sampling and estimations for both historical and BAU are based on a sub- provincial ecological stratification spatial framework taking into consideration regional conditions and factors.

Emission estimates for projected forest conversion were 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 reported in the most recent NIR submission. 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 2013 National Inventory Submission.

Forest Land Remaining Forest Land and Land Converted to Forest Land projections

Canada's National Forest Carbon Monitoring, Accounting and Reporting System

- Provided by Canadian Forest Service, Natural Resources Canada

Canada's National Forest Carbon Monitoring Accounting and Reporting System builds on information in the National Forest Inventory and on additional provincial and territorial forest inventory information. Natural Resources Canada developed and maintains the Carbon Budget Model of the Canadian Forest Sector, a Tier 3 forest carbon dynamics estimation tool fully consistent with the IPCC inventory guidelines. With the Carbon Budget Model of the Canadian Forest Sector as its core model, the system provides annual estimates of greenhouse gas emissions and removals as affected by forest management, natural disturbances, and land-use change. Natural Resources Canada, in collaboration with the Canadian Space Agency uses remote sensing and other data to monitor the area annually disturbed by wildfires, and maintains a deforestation monitoring program to estimate the area annually affected by conversion of forest to non-forest land uses in both the managed and unmanaged forest area.

This system has been in place since 2006 and is described in detail in Canada's 2013 National Inventory Report. The system is used to produce the projections shown here, using assumptions about human activities in the future. This ensures that the projections are fully consistent with historical emission estimates.

For Forest Land Remaining Forest Land (FLFL), projections are based on the same methodologies used for the production of FLFL estimates for NIR2013. As noted above, harvesting is the human activity with the greatest impact on this subsector. Because future harvest levels are unknown, Canada has based its projection on the latest available business-as-usual harvest projections from provincial and territorial governments. Additionally, as the effects of future disturbances are unknown, Canada has assumed no natural disturbances would occur from 2012 onward, apart from a low, background level of wildfire expected to occur each year (based on more than 50 years of historical data). Projected emissions from harvested wood products use the same assumptions as used in FLFL estimates for the 2013 National Inventory Report, i.e. that the pool of harvested wood products starts in 1990, with emissions occurring over time.

As described above, the projected contribution from FLFL for accounting purposes is derived using a Reference Level approach. The Reference Level approach is an internationally accepted and scientifically-credible approach to account for emissions and removals from managed forests. The Reference Level value Canada submitted to the UNFCCC in 2011 has been updated, reflecting a process of technical correction outlined in the Durban LULUCF agreement,[31] as well as a shift to the use of UNFCCC inventory categories (i.e. Forest Land Remaining Forest Land, as opposed to Forest Management). The technical correction ensures that the Reference Level reflects the latest updated data and methodological improvements consistent with 2013 National Inventory Report, and is methodologically consistent with the projection for FLFL. 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 and 2011: these impacts were not known in 2011 when the Reference Level was first derived. However, it is important to note that key assumptions about management originally used in deriving the Reference Level - such as those related to harvest rates - cannot be changed. In particular, the Reference Level was derived using the assumption that the historical average harvest rate in 1990-2009 would occur in 2013-2020, after recovery from the recent major downturn in the forest sector. This assumption has not been changed.

For Land Converted to Forest Land, projections were based on average historical rates, consistent with the estimates reported in the 2013 National Inventory Report. As noted above, there is limited information available on LFL in recent years, so projections were based on the assumption that the 2000-2008 historical average provided the best representation of business-as-usual in the future.

Cropland Remaining Cropland

- Provided by Agriculture and Agri-Food Canada (AAFC)

AAFC generated estimates for Cropland remaining Cropland (CLCL) 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 estimates the resource use patterns in the agriculture sector which were then fed into CanAG-MARS to provide estimates of emissions/removals from cropland remaining cropland.

CRAM is an economic model maintained by AAFC which provides a detailed characterization of agriculture 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

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

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 2013 Medium Term Outlook (MTO). The 2013 MTO provides a 10 year estimate from 2012 to 2022. Since estimates for crop and livestock production levels are not available for 2030 the 2020 production levels were held constant out to 2030.

The CanAG-MARS is model 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 (GPG) for LULUCF. The model quantifies the annual change in soil organic carbon (SOC) associated with land use or land management changes (LUMC). The amount of organic carbon retained in soil represents the balance between the rate of primary production (C transfer from the atmosphere to the soil) and soil organic carbon (SOC) decomposition (C 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 (LMC). If there was no change in land management, then SOC 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 C per unit area for each LMC as a function of time since the land management change.

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 LUMC activities to generate GHG emissions/removals for each inventory year. Since activity data for 2030 was held constant at 2020 levels, GHG data reported for 2030 reflect emissions/removals associated with changes in land management activities up to and including the 2020 projection year.

Residual emissions from forest land converted 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 and provide the final estimated CLCL emissions.

Annex 5: Technical Changes since *Emissions Trends Report 2012*

The projections presented in this chapter were developed using the Energy, Emissions and Economy Model for Canada (E3MC). While the methodology used to create these projections has not changed since publication of the 2011 and 2012 *Emissions Trends* reports, some technical improvements have been made. Specific changes are outlined below.

Improvements in the oil and gas sectors include the ability to more accurately model energy demand and unit characteristics of cogeneration units, as well as updates to intensity and production expectations:

- Addition of endogenous cogeneration build for oil sands:
    - Originally, only known cogeneration units were included in the forecast exogenously; no additional cogeneration had been assumed. Now, in addition to exogenously specified cogeneration units, the model builds additional endogenous units to satisfy the demands of the oil and gas sector. In 2011, according to the Energy Resources Conservation Board, oil sands sectors generated about 1.25 times more electricity than they consumed and sold the surplus electricity to the grid. Under the current assumption, the current ratio of generated to consumed electricity is being held constant in the forecast.
- Restructuring of the oil sands cogeneration units:
    - Demands of industrial sectors consist of end-use demands and cogeneration demands. Originally, cogeneration demands included demand for fuels used to generate steam and electricity in cogeneration units, while end-use demands included all other demands. An update permitted end-use demands to include all fuel used to produce steam, and cogeneration demands to include only incremental fuel used to generate electricity.
    - Heat rates (i.e., fuel consumption per unit of electricity generation) of the cogeneration units were originally very high, because they were accounting for fuel used to generate both steam and heat. Now that cogeneration demands only include incremental fuel used to generate electricity, the heat rates of cogeneration units have been reduced considerably. For example, originally the heat rates were in the range of 12,000 to 18,000, whereas now they are in the range of 4000 to 6000.
- Electricity demands of the oil sands:
    - Assumptions regarding electricity demands by oil sands sectors have been changed upwards using report by the Canadian Energy Research Institute to be more consistent with Alberta's Energy Resources Conservation Board (ERCB) data in history. In the forecast, we took the electricity intensity in the last historical year and flattened the trend in

    - the future, reducing the previous 27% projected rise to a more probable growth rate.
- New oil sands production mix:
    - Previously, inefficient facilities were assumed to increase production into the future in order to meet increased demand. This increased the sector's average energy intensity and emissions profile, which proved to be an incorrect assumption. A revision to the production method now holds existing facilities' production constant at the 2011 level and allocates new production to a generic new facility.
- Primary oil sands intensity:
    - Energy intensity was significantly increased and calibrated to an IHS CERA report. This resulted in an approximate increase of 3 Mt in primary oil sands emissions.
- Change of economic driver for natural gas distribution pipelines from Natural Gas Production to Natural Gas Distribution to better reflect the volume of fuel usage and emissions from pipelines.
- Closure of Nova Scotia refinery in 2013 to reflect conversion to a terminal. Analysis of other refineries that converted to terminals suggests a significant decrease of emissions to near-zero from those facilities.

Improvements in the transportation sector include an update to data sources and a refinement of efficiency assumptions:

- New source of historical light-duty vehicle efficiencies.
    - The new source originates from mandatory manufacturer reporting as required under the light-duty vehicle regulations starting in model year 2011. Earlier years originate from a database constructed by Transport Canada (since transferred to Environment Canada) consisting of manufacturer-reported sales-weighted data.
- The degradation factor for converting lab-tested to on-road fuel efficiency has been changed from 85% to 80%. That is, on-road fuel efficiencies are assumed to be 80% as efficient as the lab-tested number.

Changes in the agriculture sector reflect revised emissions data and fuel use assumptions:

- Updates to the exogenous agriculture module were provided by Agriculture and Agri-Food Canada (AAFC), whose model projects emissions from observed costs and activity levels. AAFC's model was updated with 2011 census data, affecting future livestock production projections.

The emissions-intensive trade-exposed (EITE) sector modeling was updated based on consultation with experts, and included some refinements in fuel and emissions allocation:

- Industrial gross output projections for select subsectors have been revised based on consultation within Environment Canada, specifically with an internal team of engineers and sector experts.

- Reallocation of all natural gas used in ammonia production from the petrochemicals sector to the fertilizers sector.
- Revision of allocation of undifferentiated emissions among EITE sectors.

Improvements in the electricity sector incorporated updated historical data and a revised outlook on future projects:

- The adjustment to historical data included adding previously missing units and correcting fuel usage for existing units.
- Online dates for projects were changed where applicable.
    - Deerland Peaking Station's commissioning date has been moved from 2013 to 2015.
- Projects that have been placed on hold due to economic circumstances have been taken out of the reference case.
    - The Swan Hills project in Alberta has been put on hold due to the low price of natural gas. The company has indicated that the project will be revisited once prices are higher.
    - Ontario has less wind coming online in the future due to a renegotiation of a contract with Samsung.
- New major projects added since last year include Saskatchewan's Battleford natural gas station (260 megawatts).

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