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Canada

Canada's Sixth National Report on Climate Change

2014

ACTIONS TO MEET COMMITMENTS UNDER THE UNITED NATIONS FRAMEWORK CONVENTION ON CLIMATE CHANGE

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1 Introduction

Canada is pleased to present its 6th National Communication and 1st Biennial Report on Climate Change for 2014 to meet its reporting requirements under the United Nations Framework Convention on Climate Change (UNFCCC).

Canada recognizes the importance of climate change and, as an arctic nation, is particularly affected by its impacts. To respond to this global challenge, Canada is implementing a comprehensive climate change plan, both domestically and internationally. This plan is underpinned by a strong scientific foundation and includes action on, and investments in mitigation and adaptation, as well as international engagement through a number of multilateral fora.

Since Canada's 5th National Communication in 2010, progress has been made in implementing a sector-by-sector regulatory approach to address emissions. These actions are precedent-setting: for the first time, Canada has national regulations to reduce greenhouse gas (GHG) emissions.

The Government of Canada has started with the transportation and electricity sectors—two of the largest sources of emissions in Canada. The Government of Canada has implemented regulations setting progressively more stringent standards for passenger automobiles and light-duty trucks and has introduced proposed regulations to further improve fuel efficiency and reduce GHG emissions from model years 2017 and beyond. As a result of these regulations, model year 2025 passenger vehicles and light-duty trucks will emit about 50% less GHGs and consume up to 50% less fuel than 2008 models. The Government of Canada has also taken action to regulate heavy-duty vehicles. In March 2013, the Government of Canada released final regulations that establish progressively more stringent emissions standards for heavy-duty vehicles such as full-size pick-ups, semi-trucks, garbage trucks, and buses.

The Government's coal-fired electricity regulations further strengthen Canada's position as a world leader in clean electricity production. With these regulations, Canada became the first major coal user to ban the construction of traditional coal-fired electricity generation units. This approach will foster a permanent transition towards lower- or non-emitting types of generation such as high-efficiency natural gas and renewable energy. Over the first 21 years, these regulations are expected to result in a cumulative reduction of about 214 megatonnes (Mt) GHGs, equivalent to removing some 2.6 million personal vehicles from the road per year over this period.

Building on this record, the Government of Canada is working with provinces to reduce emissions from the oil and gas sectors while ensuring Canadian companies remain competitive.

The Government of Canada has also made significant investments to begin Canada's transition to a clean energy economy and advance Canada's climate change objectives. Since 2006, the federal government has invested over $10 billion in green infrastructure, energy efficiency, the development of clean energy technologies, and the production of cleaner energy and cleaner fuels.

At the same time, climate change is a shared responsibility in Canada. Provinces and territories have been taking action to address climate change according to their unique circumstances.

In combination, these actions have been generating significant results. As a result of collective action by governments, consumers, and industry, Canada's 2020 emissions are projected to be 128 Mt lower than

they would have been under a no-action scenario. This is the equivalent of shutting down 37 coal-fired electricity generation plants. Moreover, Canada's per capita emissions are at a historic low of 20.4 tonnes of carbon dioxide equivalent (CO_2 eq) per person—their lowest level since tracking began in 1990. Canada has also demonstrated progress in decoupling emissions growth from economic growth. Since 2005, Canadian GHG emissions have decreased by 4.8%, even while the economy has grown by 8.4%.

Addressing short-lived climate pollutants (SLCPs) is also part of the Government of Canada's comprehensive climate change plan. Since the last National Communication, Canada became a founding member and large financial contributor to the Climate and Clean Air Coalition to Reduce Short-Lived Climate Pollutants (CCAC). Since its beginning in 2012, the CCAC has grown to include over 70 partners. Canada is also demonstrating leadership on addressing short-lived climate pollutants through its chairmanship of the Arctic Council (2013–2015). One of Canada's priority initiatives in this context is to advance work on addressing black carbon and methane. As part of this effort, the Arctic Council ministers agreed to establish a task force, co-chaired by Canada and Sweden, to work towards actions to reduce emissions of these pollutants. These international efforts complement the strong action Canada has taken to address SLCPs domestically, including regulations for both on-road and off-road vehicle emissions and sulphur content in gasoline and in diesel.

Beyond these efforts, Canada recognizes that the climate is changing and Canadians are experiencing its effects. Since Canada's last National Communication, Canadian governments have continued to take action to help Canadians adapt to a changing climate.

The Government of Canada is providing $148.8 million in funding over 5 years (2011–2016) to support an improved understanding of climate change and to help Canadians plan for climate impacts, including in the North. Other levels of government are making progress on impacts and adaptation issues. For example, all provinces and territories have either released adaptation strategies, or are in the process of developing them, or have integrated adaptation efforts into broader climate change action plans. Adaptation has also become an increasingly important risk management issue for the private sector. Shared adaptation priorities across jurisdictions and economic sectors include building community capacity, undertaking climate change research, and enhancing existing emergency preparedness initiatives. Continued support for adaptation decision-making by businesses, communities and Canadians contributes to effective climate risk management in Canada.

Canada's climate science is an integral part of the global effort to understand climate system behaviour, human influence on climate, and future climate change scenarios. Canada's science contributes to domestic climate change policies and decisions, and informs international bodies such as the Intergovernmental Panel on Climate Change, the Arctic Council, and the Global Methane Initiative. In May 2013, the Government of Canada provided funds for arctic research through the Natural Sciences and Engineering Research Council's Climate Change and Atmospheric Research initiative. This program supports collaborative climate change and atmospheric research, and will provide funding of more than $32 million over 5 years to 7 university-based research networks.

On the international stage, Canada is an active participant in discussions under the UNFCCC towards a new post-2020 international climate change agreement. At the 19th Conference of the Parties in Warsaw, Canada played a constructive role to help create momentum under these negotiations. Canada's leadership was also instrumental in achieving a breakthrough on an important initiative to help developing countries reduce deforestation and forest degradation, which account for nearly 15% of global GHG emissions.

Canada is also committed to working with developing countries to help them respond to the challenge of climate change. The Government of Canada fulfilled its commitment to deliver $1.2 billion of the $30 billion fast-start funding pledge made by developed countries. Issued over fiscal years 2010–2011 to 2012–2013, Canada's funding supports climate change mitigation and adaptation in developing countries. This funding is helping advance a range of climate change projects in over 60 developing countries, with a specific focus on adaptation, clean energy technology and transfer, and sustainable forests and agriculture.

In addition to Canada's engagement in the UNFCCC, the Government of Canada continues to pursue a number of collaborative international initiatives to address global climate change, including the phase-down of hydrofluorocarbons (HFCs) under the Montreal Protocol on Substances that Deplete the Ozone Layer.

Canada recognizes that climate change is a serious challenge that requires collective action by businesses, consumers and governments. The Government of Canada is focused on a pragmatic approach to addressing climate change that will reduce emissions while continuing to create jobs and encouraging the growth of the Canadian economy.

The following provides highlights of Canada's 6th National Communication and 1st Biennial Report to the NFCCC.

National Circumstances

Canada's unique geographic, demographic and economic circumstances influence its GHG emissions profile. Canada has an extreme, highly variable climate that contributes to higher energy use for space heating and cooling in both the commercial and residential sectors. Canada also has a large landmass that contributes to longer travel times and a higher demand for freight transportation.

The Canadian population remains the smallest among G8 countries but is also the fastest growing, with an annual population growth rate of just over 1%. Canada's low population density contributes to a higher energy demand (and GHG emissions) for the transportation of people and goods as compared with smaller, more densely populated countries.

In addition to its faster-than-average population growth relative to other developed countries, Canada has experienced sustained economic growth. As a natural resource-rich economy, Canada is a net exporter of agricultural products, energy (electricity and oil and gas) and many resource-based commodities such as mined metals, aluminum and pulp and paper. Over the past decade, Canada's exports of energy, extracted resources and agricultural commodities as a share of GDP have increased by almost 40%.

Canada relies on transportation for trade in the global economy. Since 1990, there has been a 33% growth in transportation emissions in Canada, an increase that was mainly driven by an increase in cross-border trade, on-road freight transportation activity and a shift in personal vehicle ownership from cars to light-duty trucks.

Canada's Greenhouse Gas Inventory

UNFCCC Annex I Parties, including Canada, are required to report annual inventories of GHG emissions and removals. Canada's National Inventory Report is prepared and submitted annually to the UNFCCC and includes estimates of CO_2 equivalent in the following six sectors: Energy, Industrial Processes, Solvent and Other Product Use, Agriculture, Waste, and Land Use, Land-use Change and Forestry (LULUCF). The most recent report is entitled *National Inventory Report: Greenhouse Gas Sources and Sinks in Canada 1990–2011*; the report's Executive Summary is available online at http://www.ec.gc.ca/ges-ghg

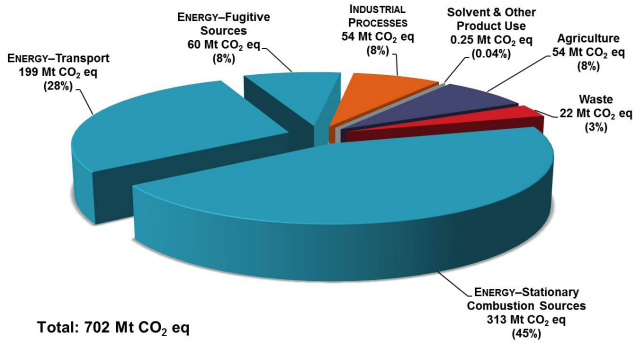

Figure 1.1 Canada's Emissions Breakdown by Sector (2011) (all sectors are consistent with the definitions provided in the IPCC 1996 Guidelines for National GHG Inventories)

In 2011, Canada emitted 702 Mt CO_2 eq[1] of GHGs to the atmosphere, excluding LULUCF estimates. The Energy Sector (comprising stationary combustion, transport and fugitive emission sources) produced the majority of Canada's GHG total emissions in 2011, at 81% or 572 Mt.

The remaining 19% of total emissions was largely generated by source within the Agriculture Sector (8% of total emissions) and Industrial Processes Sector (8%), with minor contributions from the Waste Sector (3%) and Solvent and Other Product Use Sector. Greenhouse gases in the LULUCF Sector are not included in the inventory totals, due to large annual fluctuations heavily influenced by the impact of natural disturbances on managed forest land, notably fires. In 2011, total emissions for the LULUCF Sector are estimated at about 87 Mt.

In 2011, CO_2 contributed 79% of Canada's total GHG emissions. The majority of these emissions are produced by the combustion of fossil fuels. Methane (CH_4) accounted for 13% of Canada's total emissions, largely from fugitive emissions from oil and natural gas systems, as well as activities in the Agriculture and Waste Sectors. Nitrous oxide (N_2O) emissions from activities such as agriculture soil management and transport accounted for 7% of the emissions, while perfluorocarbons (PFCs), sulphur hexafluoride (SF_6) and HFCs constituted the remainder of the emissions (slightly more than 1%).

Canada's emissions in 2011 were 111 Mt (19%) above the 1990 total of 591 Mt (Figure 1.2). Steady increases in annual emissions characterized the first 15 years of this period, followed by fluctuating emission levels between 2005 and 2008, a steep drop in 2009 and more stable values thereafter. Between 2005 and 2011, emissions decreased by 36 Mt (4.8%), primarily due to decreases from electricity generation and manufacturing industries.

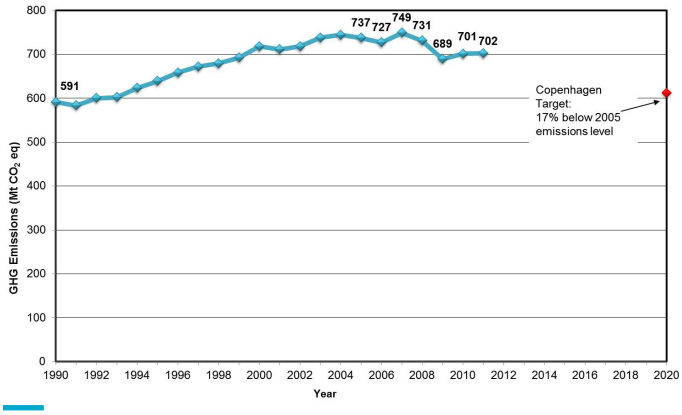

Figure 1.2 Canadian GHG Emissions Trend (1990–2011) and Copenhagen Target

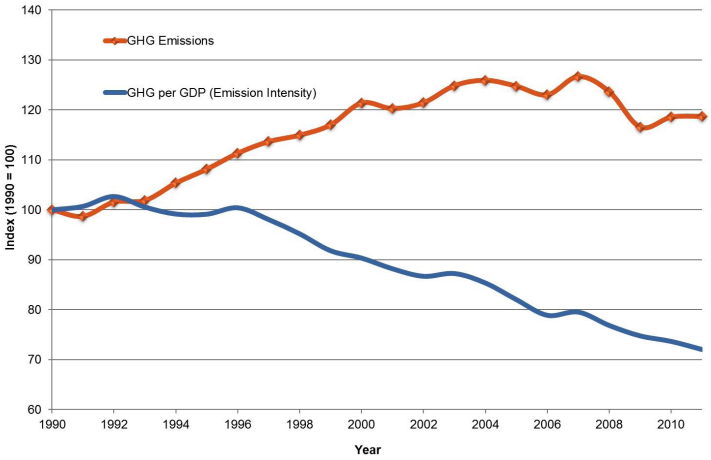

Figure 1.3 Indexed Trend in GHG Emissions and GHG Emissions Intensity (1990–2011)

Though GHG emissions have risen by 19% since 1990, Canada's economy has grown much more rapidly, with its GDP rising by 65%. As a result, the emission intensity for the whole economy (GHG per GDP) has improved considerably, dropping by 28% (Figure 1.3).

Canada has established a national system to ensure the integrity of its annual inventory. Canada's national system for the estimation of anthropogenic (i.e., human-induced) emissions from sources and removals by sinks of GHGs encompasses the institutional, legal and procedural arrangements necessary to ensure that Canada meets its reporting obligations.

The national system consists of institutional arrangements for the preparation of the greenhouse gas inventory, including formal agreements supporting data collection and estimates development; a quality assurance/quality control plan; the ability to identify key categories and generate quantitative uncertainty analysis; a process for performing recalculations for improvement of the inventory; procedures for official approval; and a working archives system to facilitate third-party review.

Policies and Measures

All levels of government in Canada are taking action to address climate change. The Government of Canada is implementing a sector-by-sector regulatory approach to reduce greenhouse gas emissions. The Government of Canada has already begun to implement this plan starting with the transportation and electricity sectors, and is now moving to address other sectors of the economy. The Government of Canada's regulatory approach is complemented by investments in clean energy technology and other non-regulatory measures that will help reduce emissions over the longer term. Provinces and territories are also taking meaningful action on climate change, and they are playing a role in several international and regional climate action plans and partnerships.

Federal Policy Making Process

While several federal departments are involved in the development and implementation of climate change programming, the Minister of the Environment is the lead minister for domestic and international climate change policies and measures within the Government of Canada. The Government of Canada uses bilateral and multilateral fora (e.g., process working groups)

to develop its sector-by-sector regulatory approach, working closely with provinces and territories, given the shared jurisdiction for the environment in the country. Federal climate change policies and measures are underpinned by key legislative instruments, the most important of which is the *Canadian Environmental Protection Act, 1999* (CEPA 1999). This act includes authorities to regulate various aspects of GHG releases, including setting the quantity or concentration of a GHG that may be released from various types of facilities, or from vehicles, engines and equipment.

Government of Canada's Sector-by-Sector Regulatory Approach

The Government of Canada's sector-by-sector regulatory approach allows Canada to maximize progress on reducing emissions while maintaining economic competitiveness by making it possible to tailor regulations to accommodate individual sector circumstances. Regulations are being designed to drive real reductions over the long term, provide regulatory certainty, spur innovation, and leverage capital stock turnover to avoid the lock-in of long-lived high-emitting infrastructure. This approach has already been implemented in the transportation and electricity sectors and the federal government is working on regulations for other sectors.

In the transportation sector, the Government of Canada has implemented GHG emission standards under CEPA 1999 for passenger automobiles and light-duty trucks for 2011–2016 model year vehicles. In 2012, proposed amendments were published to include standards for 2017 model years and beyond. With these regulations, model year 2025 passenger vehicles and light-duty trucks will emit about half as many GHGs and consume up to 50% less fuel than 2008 model year vehicles.

Canada has also taken action to regulate heavy-duty vehicles. In March 2013, the Government of Canada released regulations that establish progressively more stringent emissions standards for heavy-duty vehicles, such as full-size pick-ups, semi-trucks, garbage trucks and buses. With these tough new regulations in place, GHG emissions from 2018 model year heavy-duty vehicles will be reduced by up to 23%. Both the light- and heavy-duty standards are aligned with regulations in the United States. Other regulatory actions in the transportation sector include renewable fuels regulations, which require an average of 5% renewable fuel content for gasoline and 2% for most diesel fuels.

In the electricity sector, the federal government has introduced a performance standard for coal-fired electricity generation. The performance standard comes into force in 2015 and applies an emissions intensity limit to new coal-fired electricity generation units and to old units that have reached the end of their useful life. Over the first 21 years, these regulations are expected to result in a cumulative reduction of about 214 Mt of GHGs, equivalent to removing some 2.6 million personal vehicles from the road per year over this period.

Addressing short-lived climate pollutants is also part of the Government of Canada's comprehensive approach to addressing climate change. The federal government completed an assessment that concluded that many of Canada's measures to address greenhouse gases and air pollutants have led to reductions in emissions of short-lived climate pollutants. These include Canada's regulations to address carbon dioxide emissions from coal-fired electricity (which will reduce ozone precursor emissions and particulate matter/black carbon), as well as a suite of vehicle and fuel regulations (which have, and will continue to significantly reduce black carbon and ozone precursor emissions). Forthcoming measures to address emissions from the oil and gas sector, as well as industrial emissions requirements under Canada's new Air Quality Management System, will produce further reductions.

Cross-sectoral, Clean Energy Investments and Other Complementary Measures

The Government of Canada has also established regulations under the *Energy Efficiency Act, 1992*, to strengthen the minimum energy performance requirements for more than 40 consumer products

to date. These regulations include requirements for mandatory EnerGuide labels on major electrical household appliances and room air conditioners. The labels show how much energy a product uses compared with the range of products in its category.

The Government of Canada also recognizes the importance of clean technologies in combatting climate change. Since 2006, the federal government has invested over $10 billion in green infrastructure, energy efficiency, the development of clean energy technologies, and the production of cleaner energy and fossil fuels. This includes funds allocated to Sustainable Development Technology Canada, an arm's-length, not-for-profit foundation that finances and supports the development and demonstration of clean technologies. The federal government's investments in clean energy also include investments through the ecoENERGY Innovation Initiative to support energy technology innovation, and investments through a number of programs to support the research, development and demonstration of carbon capture and storage technologies.

The federal government's sector-by-sector approach and clean technology investments are complemented by a number of non-regulatory measures. Examples of these measures include the ecoENERGY for Aboriginal and Northern Communities program, the ecoTECHNOLOGY for vehicles program, and measures in the Land Use, Land-use Change and Forestry Sector.

Provinces and territories are also developing and implementing measures to address climate change and are playing roles on a number of international and regional climate action plans and partnerships. Table 3 of Canada's 1st Biennial Report provides details on major federal, provincial and territorial policies and measures.

Modifying Long-term Trends in GHG Emissions and Removals

Canada's GHG regulations and complementary measures by provinces and territories will reduce absolute emissions over the longer term. For example, the Government of Canada's coal-fired electricity regulations will implement a permanent shift to lower or non-emitting types of electricity generation. Along with action by provinces (e.g., Ontario coal phase-out), the regulations are expected to result in a net cumulative reduction in GHG emissions of about 214 Mt over the 2015–2035 period. Through regulatory actions in the transportation sector, GHGs from light-duty vehicles will be reduced by 92 Mt over the lifetime of 2011 to 2016 model year vehicles, and by 162 Mt over the lifetime of 2017 to 2025 model year vehicles.

Projections

The Government of Canada has developed projections of greenhouse gas emissions over the 2012 to 2030 time period. Projections are presented by greenhouse gas and by economic sector. For comparison purposes, the tables also depict historical emissions, including for 2005, which is Canada's base year for its Copenhagen target. In addition, Canada's emissions projections for selected subsectors provide significantly more detail than required by the UNFCCC. Projections for the "with current measures" scenario assume federal, provincial and territorial policies and measures announced or in place as of May 2013 and assume no further government action. Policies that are proposed or planned but not implemented are not included in these projections.

Canada associated with the Copenhagen Accord in January 2010 and committed to reduce its GHG emissions to 17% below 2005 levels by 2020. In light of strong economic growth this could be challenging. Canada's economy is projected to be approximately 31% larger (in real terms) in 2020 compared with 2005 levels. Figure 1.4 demonstrates Canada's progress towards its 2020 target.

The difference between the two scenarios represents the total effect of policies and measures by both federal and provincial and territorial Canadian governments and actions by businesses and consumers to improve their energy efficiency and emission intensity. Under

the "with current measures" scenario, Canada's GHG emissions in 2020 are projected to be 734 Mt CO_2 eq. This is 128 Mt less than under a scenario where emissions would be in 2020 if consumers, businesses and governments had taken no action to reduce emissions since 2005, highlighting the significant progress that has been achieved in lowering emissions from a business-as-usual trajectory.

The LULUCF contribution of 28 Mt of emission removals has only been estimated up to Canada's target year (2020). This is because, although business-as-usual data is available through 2030, the reference level used to measure progress in the managed forests was only constructed and negotiated to 2020. Since estimating the LULUCF contribution requires this reference level, the contribution cannot be estimated for years after 2020. It is anticipated that Canada will develop a post-2020 reference level as part of its participation in international negotiations on post-2020 treatment of the land sector in an international climate change regime under the UNFCCC.

The Government of Canada's sector-by-sector plan will continue to reduce emissions. Reducing GHG emissions, however, is everyone's responsibility and governments, businesses and consumers all have a role to play. Further actions by businesses, individuals and governments will allow Canada to address GHG emissions while keeping the Canadian economy strong.

In 2030, Canada's emissions are projected to be 815 Mt CO_2 eq, or 11% above 2005 levels, with current measures in place. Additional actions by federal or provincial/territorial governments would lower this number. Emissions are decreasing relative to population and economic growth. Per capita emissions are projected to improve through 2030, from 22.9 tonnes CO_2 eq in 2005 to 19.6 tonnes per capita in 2030—a 15% decrease from 2005 levels.

In addition, the link between growth in GDP and GHG emissions continues to weaken in Canada. There has been an average annual decline of approximately 1.5% in Canadian emissions intensity (emissions per dollar of GDP) since 1990. Emissions intensity is expected to continue to decrease through 2030, demonstrating the continued decoupling of economic and emissions growth in Canada.

GHG emission projections depend on a number of evolving economic and energy variables and are subject to significant uncertainty. In addition, future developments in technologies and resource-extraction will alter the future emissions pathway. In Canada, anticipated emissions growth is due in large part because Canada's economy is more dependent on emissions-intensive resource extraction than most other developed countries. Canada is also a major energy exporter and its oil and gas sector emissions are projected to increase significantly between now and 2030.

The Government of Canada has also provided detailed emission projections by economic sector (and subsector) as summarized in Table 1.1 below. This table illustrates how the projected trends in GHG emissions vary by economic sector.

Table 1.1 Change in GHG emissions by economic sector (Mt CO_2 eq)

	2005	2010	2011	2020	2030
Transportation	168	167	170	176	179
Oil and Gas	162	164	163	200	241
Electricity	121	99	90	82	59
Buildings	84	79	84	95	110
Emissions-Intensive & Trade-Exposed Industries	87	75	78	90	101
Agriculture	68	69	68	69	70
Waste and Others	49	48	49	50	55
Subtotal	**737**	**701**	**702**	**762**	**815**
Expected LULUCF Contribution	NA	NA	NA	−28	NE
Total	**737**	**701**	**702**	**734**	**815**

Abbreviations: NA = Not applicable, NE = Not estimated.

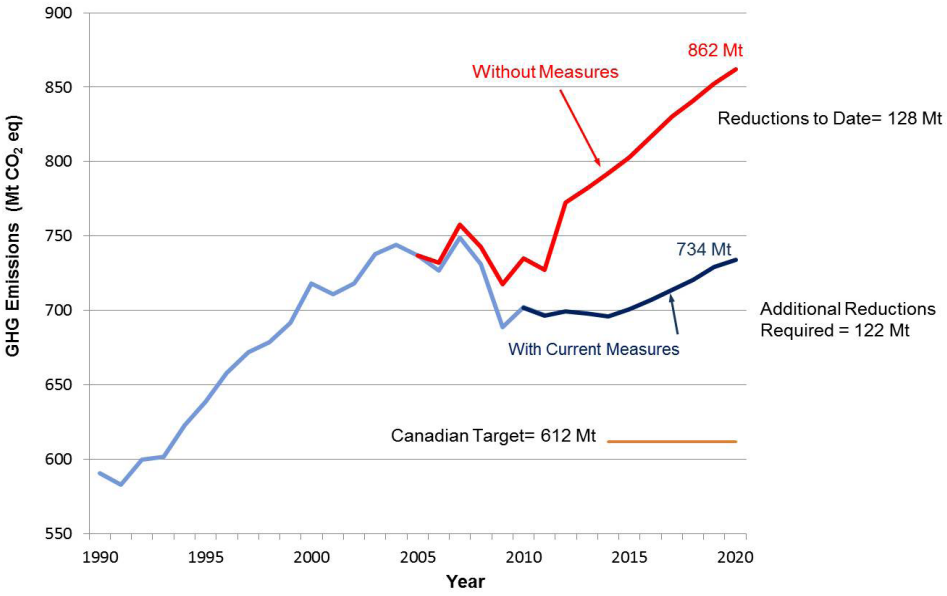

Figure 1.4 Scenarios of Canadian Emissions to 2020 (Mt CO_2 eq)*

* The "with current measures" line (post-2005) includes the compliance contribution of the LULUCF Sector towards the Copenhagen target, and therefore actual emissions trends (without LULUCF) will be 28 Mt higher in 2020.

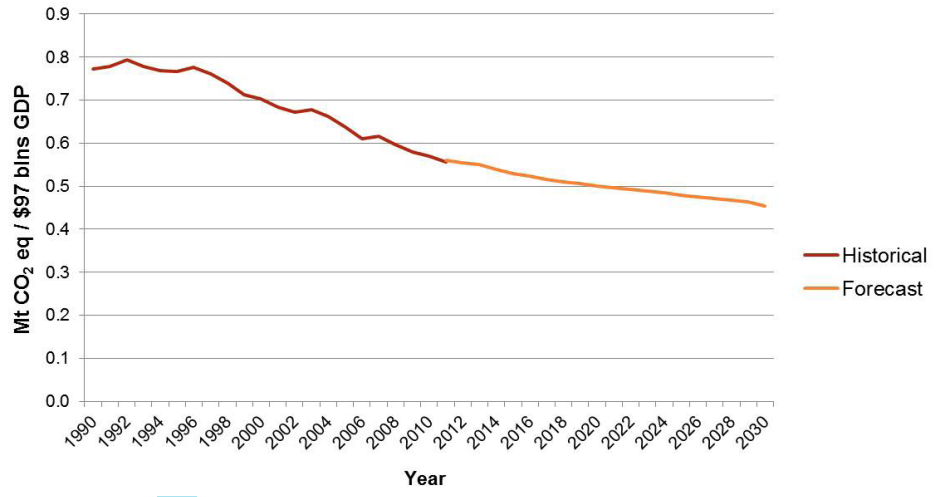

Figure 1.5 Canadian Emissions Intensity to 2030

Vulnerability Assessment, Climate Change Impacts and Adaptation Measures

Canada's climate is changing and impacts have been observed across the country. Adaptation is increasingly acknowledged as an important part of a broader response to climate change, and it is widely accepted that adaptation can help Canadians manage risks and take advantage of opportunities.

Between 1948 and 2012, the annual average surface air temperature over Canada's landmass warmed by about 1.7°C, approximately twice the global average. While warming trends are observed consistently across the country, stronger trends are found in the north and west, particularly during the winter and spring. Northern Canada (north of 60° latitude) has warmed at a rate approximately 2.5 times the global average since the late 1940s.

Although more difficult to assess, given the strong regional variability in precipitation trends and its various states (rain, freezing rain, snow, etc.), Canada has generally become wetter in recent years. Total annual precipitation in Canada has increased over the 1948–2012 period. In most of southern Canada (south of 60° latitude), there has been a decrease in snowfall and an increase in rainfall, a trend consistent with warmer temperatures.

Increases in temperature and changing precipitation patterns have led to a wide range of impacts, including reduced arctic ice cover, changes in timing and amount of surface water availability, increased evaporation contributing to lower levels in the Great Lakes, increased depth and extent of permafrost thaw, decreased quality and shorter seasons for northern ice roads, increased loss of forests due to pests and wildfires, more frequent droughts and flooding, and increased risks from food-borne diseases.

The Government of Canada renewed and expanded its focus on adaptation by investing $148.8 million in 10 adaptation programs and adopting the 2011 Federal Adaptation Policy Framework to help bring climate change issues into the mainstream of federal decision making.

Adaptation has been incorporated into more strategies and plans at the provincial and territorial levels, so that most jurisdictions now have stand-alone plans that highlight the importance of adaptation and can help focus efforts. Since 2010, for example, Quebec, Ontario, Manitoba, British Columbia and the three territories (Yukon, Northwest Territories and Nunavut) have released stand-alone adaptation strategies or action plans. Other jurisdictions continue to build from previously announced plans, are in the process of developing adaptation strategies, or are integrating adaptation considerations into broader climate change efforts.

Municipalities have taken action to prepare for a changing climate, including the development of adaptation strategies, incorporating considerations of impacts and adaptation into official plans and planning policies, and adopting measures to reduce climate-related risks.

Progress at all levels has been encouraged by new mechanisms developed to facilitate collaboration, shared learning and priority setting on adaptation research and action. These include the Adaptation Platform and the Climate Change Adaptation Community of Practice.

Canada is actively engaged in the international community to strengthen and disseminate research and science related to the impacts of climate change to ensure that adaptation actions are informed by the best available knowledge.

Building from existing efforts and past successes, Canada will continue to play a leadership role through measures such as strategic investments in adaptation for priority areas. In addition, Canada's adaptation efforts will continue to take a risk management

approach, based on the principles of collaboration and mainstreaming. To date, this approach has enabled implementation of adaptation measures across jurisdictions and economic sectors in Canada.

Finance

Over the last four fiscal years (2009–2010 to 2012–2013), Canada has provided over $1.53 billion to support climate change projects through a variety of channels and programs. This amount includes $1.2 billion in fast-start financing delivered over the last three fiscal years (2010–2011 to 2012–2013), as well as $339 million for other international assistance projects with a direct or a significant focus on climate change. Canada also provided over $204 million to support the Global Environment Facility over the last four years (fiscal years 2009–2010 to 2012–2013), of which approximately one quarter came from Canada's fast-start financing.

Canada's financial support has been provided to contribute to efforts that address climate change in developing countries, and will be delivered through a wide range of multilateral, bilateral and partnership channels. Over 60 developing countries are benefiting directly from funding delivered through Canada's bilateral channels and Canadian facilities at multilateral institutions. This number will continue to grow as multilateral banks continue to start projects with available fast-start funds from Canada. A much larger number of countries will also benefit from contributions made by Canada to multilateral trust funds such as the Global Environment Facility and the Least Developed Countries Fund.

As shown in Figure 1.6, from 2009 to 2013, the largest share of Canada's climate finance went to sub-Saharan Africa, followed by countries in Latin America and the Caribbean. Approximately 10% of financing went to global programs, for which it is not possible to estimate a geographic distribution at this time.

Canada's climate change finance is also targeting a range of climate change projects and initiatives. Canada made a $200 million contribution to the Clean Technology Fund to support the demonstration, deployment and transfer of low-carbon technologies in developing countries. This and other clean energy projects and initiatives make up 52% of Canada's climate finance. About one third of Canada's finance supported adaptation measures in vulnerable countries such as Burkina Faso, Cameroon, Haiti and Ethiopia. The remaining funding is divided among projects that are related to forests and agriculture (9%) and cross-cutting programming (7%). These estimates could change slightly over time as multilateral institutions roll out Canada's fast-start financing contributions.

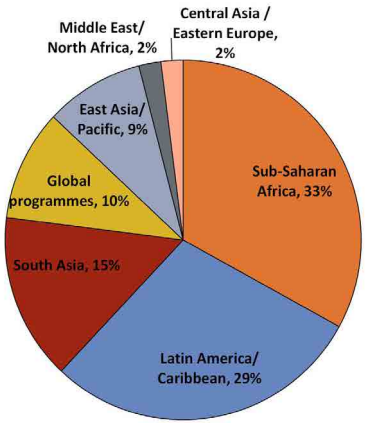

Figure 1.6 Canadian Climate Finance by Region

Technology and Capacity Building

Canada is committed to supporting the development and deployment of clean technologies to address the effects of climate change globally. Canada provides technology and capacity building support to developing country partners through bilateral and multilateral channels.

Canada has led the way in developing some important tools to advance clean energy globally, including RETScreen clean energy project analysis software and the Carbon Budget Model of the Canadian Forest Sector. The Government of Canada is committed to sharing knowledge and resources, making tools like RETScreen and the Carbon Budget Model available to international partners and providing these partners with training. Canada is also a global leader in the research, development and demonstration of carbon capture and storage technologies.

Canada works with international partners to advance clean technologies through a number of fora, including the United States-led Clean Energy Ministerial, the International Partnership on Energy Efficiency Cooperation, the Climate and Clean Air Coalition, the International Energy Agency, and the Generation IV International Forum. Bilateral cooperation with key international partners is also central to Canada's efforts to advance clean technology. Canada works with international partners to share knowledge and undertake joint science and technology activities.

Research and Systematic Observation of Climate Change

In Canada, climate system research and observation is a joint effort implemented through core government programs, academic institutions and collaborative research networks. Collectively, these efforts improve Canada's understanding of the global climate system and the influence of natural forces and human activities on climate change and variability. This enables better recognition of the potential impacts on ecosystems and society. Climate system research and monitoring in Canada provides the foundational scientific basis to guide Canadian decisions on climate change mitigation and adaptation.

Recognizing the broad and collaborative nature of climate research and monitoring in Canada, new integrated research networks involving government and university research teams were established in 2013 under the Climate Change and Atmospheric Research initiative. Seven network projects were awarded more than $32 million over 5 years to understand Earth system processes; advance weather, climate, and environmental prediction; and understand recent changes in the Arctic and cold region environments.

Canada continued its extensive climate monitoring program, including land, air, oceans and fresh water, and space-based Earth observations. Monitoring capacity was enhanced in various areas—for example atmospheric monitoring in the Arctic—through both implementation of new sites and enhanced technology. Through Canada's involvement in international organizations, agreements and commitments, climate data is collected, quality-controlled and disseminated according to international standards.

Canada is a significant contributor to the Global Climate Observing System, the Global Ocean Observing System, and the Global Terrestrial Observing System. Canada is a member of the Group on Earth Observations (now the Federal Committee on Geomatics and Earth Observations), which seeks to coordinate international efforts to build the Global Earth Observation System of Systems. Canadian monitoring priorities encompass all of the major components of the climate system: land surface, forests, cryosphere, atmosphere and oceans. The Global Climate Observing System contributes to the climate component to the Global Earth Observation System of Systems. Canada is also a participant in the international Sustaining Arctic Observing Networks initiative.

Within Canada, research on the climate system and climate change involves different scientific disciplines from a range of government and academic institutions. Canadian scientists and research programs are often linked to larger international efforts. Canadian researchers play leading roles in many international climate research bodies under the World Meteorological Organization and the Arctic Council. Canadian science and scientists made significant contributions to the Intergovernmental Panel on Climate Change's Fifth Assessment Report, as well as other internationally coordinated climate science assessments.

Education and Public Awareness

The Government of Canada recognizes that addressing the challenge of climate change will require the collective effort of all levels of government, non-governmental organizations, businesses and individual Canadians. In Canada, federal, provincial and municipal governments, as well as non-governmental organizations, have undertaken a range of activities to broaden public awareness of climate change. This includes supporting training and education to build broad support for climate change policies and encourage collective action on the part of all Canadians.

Education in Canada is under provincial jurisdiction. Climate change is taught across a range of subjects and grades, but is traditionally part of senior science and geography studies. In terms of post-secondary education, most Canadian universities provide a range of courses of study in climate science and research at both the undergraduate and graduate levels. The Government of Canada provides funding to support post-secondary research networks on climate change, including climate science and impacts. Canadian government scientists also contribute to academia by holding adjunct professorships at Canadian universities and co-supervising students.

The Government of Canada communicates information about climate change and government programs, reports and initiatives using websites and social media, including Twitter, Facebook and Flickr. Canada also participates in conferences and trade shows that highlight Government of Canada climate change initiatives and promote national and international events.

Federal government departments, provincial and municipal governments, and nongovernmental organizations act as climate change resource or information centres for Canadians, governments and businesses. For example, the Office of Energy Efficiency at Natural Resources Canada partners with a variety of stakeholders to promote energy efficiency in Canada. The Office of Energy Efficiency also offers training for Canadian consumers and businesses on the skills they need to increase energy efficiency.

Many provincial and territorial climate change strategies feature public education and awareness, ranging from general information on climate change to specific issues and adaptation activities. Activities include promoting climate change through the education system, conducting outreach to businesses and industries, and providing tools to help Canadians reduce their carbon footprint.

Canada is an active participant in a number of collaborative international initiatives and provides funding to support climate change mitigation, clean energy technology transfer, sustainable forestry and agriculture, and adaptation to climate change by the world's most vulnerable countries. Many of these initiatives include an element of capacity building through the dissemination of information and knowledge tools.

Reference

1 Greenhouse gases (e.g., methane, nitrous oxide, hydrofluoro carbons) expressed as carbon dioxide equivalent.

2 Canada's National Circumstances

2.1 Introduction

This chapter outlines national circumstances within Canada that give rise to observed trends in greenhouse gas (GHG) emission levels and removals. For the purposes of this report, Canada defines a national circumstance as a relatively inflexible characteristic of a nation, not easily shaped by government policy, which significantly influences its GHG emissions. It can also be a national characteristic, such as economic structure, that could be altered by government policy but whose alteration would need to be gradual and orderly to avoid causing the country's inhabitants undue economic harm outweighing the benefits of the corresponding GHG emissions reduction.

Overall, Canada's unique geographic, demographic, and economic circumstances influence its GHG emissions profile. For instance, Canada has an extreme, highly variable climate that contributes to higher energy use for space heating and cooling in both commercial and residential sectors compared to other industrialized countries. Canada also has a large landmass, coupled with a low population density that contributes to longer travel times and higher demand for freight transportation than in smaller and/or more densely populated countries. Canada has a resource-based economy and has seen sustained economic growth and faster than average population growth relative to other developed countries. Canada is also a net exporter of energy and has an energy intensive industrial sector.

While Canada represented only 1.6% of total global GHG emissions in 2010, it is one of the highest per capita emitters due to its size, its extreme climate, and its energy intensive, resource based economy.[1] Although Canada has the second highest GHG emissions intensity per capita among the G8 countries, since 1990 the level of emissions per unit of real gross domestic product (GDP) has fallen 28% reflecting more efficient industrial processes, a shift to a more service based economy, and lower emitting energy generation through fuel switching.[2]

Information on historical emissions trends by sector is presented in Chapter 3: Canada's Greenhouse Gas Inventory, while emissions projections by sector are presented in Chapter 5: Projections and the Total Effects of Policies and Measures.

2.2 Governance Structure

Canada is a geographically large federation composed of a central federal government, 10 provincial governments, and 3 territories. Distinct powers are assigned to the federal government and provinces based for the most part on the Canadian Constitution.

Protection of the environment is not specifically addressed under the Constitution. It has become an area of shared jurisdiction as governments have taken action according to their respective authorities. Constitutional jurisprudence continues to evolve in this area.

Federal environmental laws are based on federal constitutional powers such as international borders; international relations; trade and commerce, navigation and shipping, seacoasts and fisheries, criminal law, and the power to legislate in the national interest.

Provincial environmental laws are based on provincial constitutional powers, which include over municipalities, local works and undertakings, property and civil rights, provincially owned (public) lands and natural resources. Territorial governments exercise delegated powers under the authority of the Parliament of Canada. The devolution of powers, or the transfer of province-like responsibilities from the federal government to territorial governments, is ongoing.

Every jurisdiction has an environmental ministry or agency, but environmental responsibilities can be widely shared within each government. Within the federal government, for example, several departments and agencies have mandates that have a significant environmental component: Environment Canada, Fisheries and Oceans Canada, Natural Resources Canada, Agriculture and Agri-Food Canada, Transport Canada, Health Canada, Parks Canada Agency, and the Canadian Environmental Assessment Agency.

Natural resources, including energy, fall mainly under provincial jurisdiction. Provincial governments own the resources within their boundaries and have broad responsibility for managing resource development activities, except on some federal lands (e.g., National Parks, north of the 60th parallel, offshore) and some Aboriginal lands (e.g., lands managed by an Aboriginal government established through a land claim). Provincial governments manage resource ownership, royalties, land-use planning and allocations as well as exploration, development, conservation and use of natural resources within their boundaries.

The federal government has responsibility for interprovincial and international trade, and the National Energy Board regulates interprovincial/international pipelines (including the largest pipelines in Canada), and energy exports and imports. In terms of environmental assessment, federal environmental assessments are focused on those major projects with the greatest potential for significant adverse environmental impacts to matters of federal jurisdiction. With respect to climate change, emissions of GHGs are legislated both at the federal and provincial levels.

2.3 Addressing Climate Change in Canada

Canadian governments are addressing climate change through both mitigation and adaptation efforts.

The Government of Canada is implementing a sector-by-sector regulatory approach to reduce emissions.

The Government of Canada has already put in place regulations addressing GHG emissions from coal-fired electricity and transportation, two of the largest sources of emissions in Canada, and is working to develop regulations for other sectors.

Concurrently, provincial and territorial governments have implemented strategies to address climate change. For details on provincial and territorial measures to address GHG emissions, please see Chapter 4: Polices and Measures.

In order to limit regulatory duplication in the area of environment, the *Canadian Environmental Protection Act, 1999*, enables the federal government to enter into equivalency agreements with provinces and territories. An equivalency agreement allows the federal government to suspend the application of a federal regulation in a given province or territory, provided that the jurisdiction has an equivalent enforceable regulation in place. An equivalency agreement, therefore, provides the flexibility of allowing a province to regulate in a manner that best suits its circumstances, while still delivering GHG reductions that are at least equivalent to what would have been realized under the federal regulation. For example, a draft equivalency agreement has been developed with the Province of Nova Scotia on regulations for limiting carbon dioxide (CO_2) from coal-fired power plants.

The Government of Canada recognizes that, as a northern country, Canada will be impacted by climate change. For that reason, the Government is taking important steps to help Canadians adapt to a changing climate by providing funding to support an improved understanding of climate impacts and promote adaptation by industry and communities. For further information, please see Chapter 6: Vulnerability Assessment, Climate Change Impacts and Adaptation Measures.

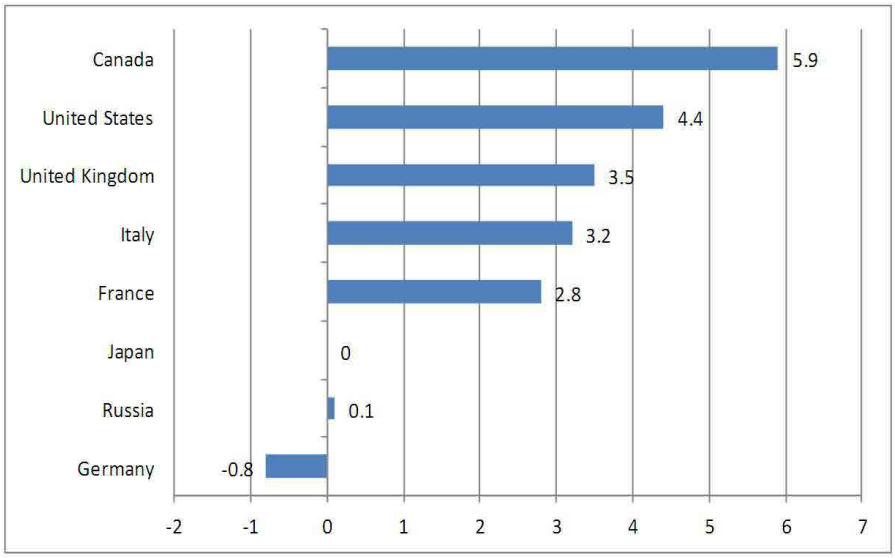

Figure 2.1 Population growth rate (in %) of G8 countries, 2006–2011
Source: Population Growth Rate (in %) of G8 Countries 2006 to 2011. The Canadian Population in 2011: Population Counts and Growth. Statistics Canada. 2012.

2.4 Population

In 2011, Canada's population was 33.5 million.[3] This is a significant growth from 27.8 million in 1990.[4] The Canadian population remains the smallest among G8 countries but the fastest growing with an annual population growth rate of just over 1%.[5] Net international migration was responsible for two-thirds of the population increase for the year ending June 2012. It is projected that there will be between 40.1 and 47.7 million people in Canada by 2036 and between 43.0 and 63.8 million by 2061.[6]

Canada's low population density contributes to higher energy demand (and GHG emissions) related to the transportation of people and goods compared to smaller, more densely populated countries.

2.5 Geographic Profile

Canada is a country of physical extremes and contrasts. Its surface area is 9,984,670 square kilometers (km^2); with land accounting for 9,093,507 km^2 and fresh water for 891,163 km^2. The country extends 5,300 km east to west, the distance between Paris and New York, and 4,600 km north to south. It is the second largest country in the world.

2.6 Climate Profile

Canada is a vast country with most of its land area located in the northern half of the northern hemisphere. Canada has a wide range of climatic conditions: Canada's Pacific coast is relatively mild year-round, while the Prairie provinces (in the central western portion of the country) have greater extremes (cold winters and warm summers).

Average annual temperatures differ considerably from region to region throughout the country. Toronto,

Ontario, located in the south of the country, has an annual average temperature of about 9°C which contrasts markedly with the −16°C annual average temperature for Resolute, Nunavut in Canada's Arctic. Halifax, Nova Scotia, on Canada's Atlantic coast, averages about 7°C, while Vancouver, British Columbia, on the Pacific coast, averages about 10°C.

Much of the country experiences four distinct seasons. Winter average temperatures in Canada typically vary from about −5 to −20°C in the south to about −30 to −35°C in the far north. Summer averages are also variable; typically 17 to 22°C in the south and 2 to 7°C in the most northern part of the country.

In most regions in Canada, summer and winter temperatures dictate both heating and cooling needs, which impact energy use. For example, Montreal, Quebec, annually experiences on average 271 cooling degree–days (when daily mean temperature is greater than 18°C) and 4,363 heating degree–days (when mean temperature is less than 18°C). [7]

Canada also has considerable regional variation in precipitation. On Canada's Pacific coast, some locations average as much as 2,000 to 3,000 millimetres (mm) a year, contrasted with the much drier Prairie provinces where some locations see as little as 200 to 400 mm a year. In the far north of Canada, precipitation totals are generally less than 200 mm a year. For example, Toronto has an average annual total precipitation of about 830 mm, while Resolute, Halifax, and Vancouver see averages of 161, 1,422 and 1,189 mm of annual total precipitation respectively.

In addition to variable temperature and precipitation, Canada also experiences extreme weather events including droughts, floods, tornadoes, snow and ice storms, and severe thunderstorms.

Canada's climate is warming. The annual average surface air temperature over the landmass has warmed by about 1.7°C, over the period 1948–2012[8]; this is approximately twice the global average. Warming trends are observed consistently across the country, although stronger trends are found in the north and west, particularly during the winter and spring. Canada's North has warmed at a rate approximately two and a half times the global average since the late 1940s. An increase in warm days, warm nights and summer days has been observed while fewer cold nights, cold days and frost days were found across the country.[9]

Precipitation trends are more difficult to assess than temperature trends, given its spatially discontinuous nature and its various states (rain, freezing rain, snow, etc.); however, Canada has generally become wetter in recent years. Total annual precipitation in Canada has increased over the period 1948–2012.[10] In most of southern Canada, there has been a decrease in snowfall and an increase in rainfall, consistent with warmer temperatures. The trends in extreme precipitation have high spatial variability and no consistent changes were found in most of the extreme precipitation indices across the country.

Because Canada's geographic position in the north increases its vulnerability to rising temperatures at rates higher than the global average, regions in Canada have been among the first in the world to observe impacts of climate change.[11]

2.7 Economic Profile

As of 2011, Canada was the world's 11th largest economy with a GDP of $1.7 trillion Canadian dollars (CAD).[12] On a per capita basis, Canada ranks 10th in the world.[13]

Between 1990 and 2011, Canadian real GDP grew by 65%.[14] At the same time, the population grew by 20.5%. This economic and population growth boosted domestic living standards and consumption considerably. In recent years, the economy has recovered steadily despite a slight contraction in 2009 with GDP growing at an average of 2.6% per year between 2010 and 2012.[15]

Canada's economy is driven by the services sector, comprising 70% of GDP in 2011.[16] Goods-producing industries, led by manufacturing, mining and oil and gas, and construction, comprise the remaining 30%. Many of Canada's goods are produced for export. In 2011, the value of total exports was $447 billion.

As a natural resource-rich economy, Canada is a net exporter of agriculture, energy (electricity and oil and gas) and many resource-based commodities such as pulp and paper, mined metals and aluminum. Over the past decade, Canada's exports of energy, extracted resources, and agricultural commodities as a share of GDP have increased by almost 40%.[17] However, because of a significant increase in manufactured imports coupled with the impact of the economic downturn, Canada has been in an overall net import position since 2009.

In the following sections details on Canada's emissions profile are presented by energy, transportation, industry, waste, building stock/urban structure, agriculture and forests.

2.8 Energy

Canada has an abundant and diversified portfolio of energy resources. In terms of hydrocarbon resources, Canada is a major global producer and exporter. Canada is also a leader in clean electricity, with 77% of its power generation coming from non-GHG emitting sources.[18]

Canada's Position in the World
- 3rd in hydroelectricity production
- 2nd in uranium production and exports3rd in oil reserves, 5th in production and 6th in exports
- 5th in natural gas production and 4th in exports

Sources: International Energy Agency, World Nuclear Association

In 2012, the energy sector accounted for over 9% of Canada's GDP in current prices (nominal GDP), and directly employed over 300,000 people.[19] Canada is also a major exporter of energy products. In 2012, Canada's exports of energy products amounted to $119 billion, or 26.2% of total domestic merchandise exports, compared to energy product imports of $54 billion, or 11.7% of Canada's total imports.[20]

Table 2.1 Canada's Energy Exports (2012)

	Total (in billions)	% exported the United States
Crude Oil and Natural Gas Liquids	$77.1	99%
Petroleum Products	$22.8	86%
Natural Gas	$8.7	100%
Electricity	$1.9	100%
Coal and Coal Products	$6.8	10%
Uranium	$1.8	12%
Total Energy	$119	90%
Energy, excluding uranium and coal	$111	96.5%
Energy as % of Domestic Exports		26.2%

Source: Energy Markets Fact Book 2013–2014. Natural Resources Canada. 2013. Ottawa.

In 2012, annual capital expenditures by the energy sector totalled $96 billion or 24.6% of total public and private investments in Canada.[21] This amount has increased substantially over the past decade, especially in the oil sands and electricity sectors. Investments in Canada's oil sands sector has increased from about $1.2 billion annually before the turn of the millennium to $25 billion in 2012.[22] In the electricity sector, capital expenditures have almost quadrupled between 2000 and 2012, from just over $6 billion to over $22 billion.[23]

Canada's provincial governments are the direct managers of most of Canada's natural resources and have responsibilities for energy resource management within their borders.

2.8.1 Energy Reserves, Production, and Trade

Three quarters of Canada's primary energy production in 2011 was in crude oil and natural gas.[24] Western Canada is a producer of crude oil and natural gas, which it exports across Canada and to the U.S. Eastern Canada imports oil and gas and has some refining stations.

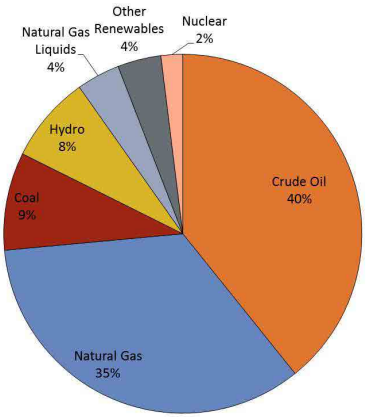

Figure 2.2 Canada's primary energy production, 2011
Source: Energy Markets Fact Book 2013–2014. Natural Resources Canada. 2013. Ottawa.

2.8.1.1 Crude Oil

Canada has 11% of the world's established reserves of crude oil, or 172 billion barrels.[25] The oil sands constitute 98% of these reserves.[26] Crude oil production in Canada has grown steadily over the past two decades, up from 1.7 million barrels per day (bbl p/d) in 1990[27] to 3.3 million bbl p/d in 2012.[28] More than half of Canada's current production comes from the oil sands.[29]

In 2012, Canada exported 72% of its annual crude oil production, with 99% of exports going to the U.S.[30] In 2012, Canadian crude oil represents about 28% of all U.S. crude oil imports, making Canada its leading foreign supplier of crude oil.[31]

2.8.1.2 Natural Gas

Canada is the 5th largest producer and 4th largest exporter of natural gas in the world.[32] Canada is part of a fully-integrated North American market where natural gas moves from supply basins to demand centers via an extensive pipeline network. As of 2012, Canada has 66.4 trillion cubic feet of proven natural gas reserves.[33]

In 2012, Canadian natural gas production averaged 13.6 billion cubic feet per day (Bcf/d).[34] Unconventional gas production, including shale and tight gas, now accounts for over 60% of Canadian production.[35] More than 60% of Canadian production in 2012 was exported to the U.S.,[36] meeting 12% of U.S. natural gas demand.[37] In 2012, Canada imported close to 3 Bcf/d[38] of natural gas, mainly from the U.S. Canada's current production of natural gas is below its mid–2000s peak of 16.6 Bcf/d[39] reflecting very low natural gas prices, and a reduced U.S. dependence on Canadian natural gas exports.

2.8.1.3 Coal

Canada ranks 11th in the world in proven coal reserves with about 6,600 million tonnes (Mt),[40] and Canada's 2012 coal production was at 67 Mt in 2012.[41] About half of the 2012 production was exported.[42] The majority of exports were destined for Asian markets, with China, Japan, and South Korea receiving 74% of total exports.[43] Canada is both an importer and an exporter of coal; however, Canada's imports of coal have declined by more than 50% since peaking in 2003.[44] In 2012, Canada imported about 10 Mt of coal, of which 83% came from the U.S.[45]

2.8.1.4 Electricity

Between 1990 and 2010, Canada's electricity production increased by 24%.[46] In 2011, Canada produced 618 terawatt-hours of electricity,[47] generated from a mix of sources. The majority of Canada's electricity is produced from non-GHG emitting sources, principally hydro (60%) and nuclear (14.3%).[48] Since 1990, renewable power production from sources other than hydro (i.e., wind, tidal, solar and biomass) has been increasing and now makes up over 3% of total production.[49] The share of electricity supply generated from coal decreased from almost 17% in 1990[50] to 11.4% in 2011.[51]

In 2012, Canada exported 58 terawatt-hours[52] of electricity to the U.S. which represents about 9% of the electricity generated in Canada in 2012[53] and about 2% of total U.S. demand.[54] In 2012, Canada imported about 11 terawatt-hours of electricity from the U.S.[55]

2.8.2 Energy Consumption

Canada's economy is becoming increasingly less energy intensive.[56] From 1990 to 2011, Canada's energy use per dollar of GDP (in constant 2002 dollars) declined 24%.[57] In that time period, Canada's GDP increased by 65% (about 2.4% per year) while energy use increased by only 27%.[58]

Over the 1990 to 2011 period, energy use on a per capita basis increase by only 2%. Canada's per capita consumption of oil products, natural gas, and electricity is higher than in most other industrialized countries,[59] reflecting the energy use of industries such as mining, pulp and paper and petroleum refining. Other key factors include long distances between communities, and a relatively cold climate.

It is worth noting, however, that the share of renewable energy of Canada's total primary energy supply is 17.1% (2010), compared to an Organisation for Economic Cooperation and Development (OECD) and world average of 7.8% and 13% respectively.[60]

2.9 Transportation

Transportation is critical to the Canadian and global economy. As a trading nation, Canada relies on a transportation sector that is globally competitive. In 2011, the transportation industry contributed 4.2% to Canada's GDP.[61]

Despite improvements in emissions intensity, transportation remains the largest source of GHG emissions in Canada (see Chapter 3: Canada's GHG Inventory). Since 1990, Canada has seen a 33% growth in transportation emissions which is mainly an increase in cross-border trade, on-road freight transportation activity and a shift in personal vehicle ownership from cars to light trucks.[62] As a result, addressing emissions in this sector is a critical part of Canada's sector-by-sector approach for reducing its GHG emissions.

2.9.1 Road Transportation

Road transportation is the largest source of passenger and freight transportation emissions, and is also the most important in terms of the value of goods traded between Canada and the U.S. Canada has more than 1 million km of 2-lane equivalent roads, roughly 38,000 km of which make up the National Highway System.[63] Canada's road network is shared by different users, including approximately 20 million light passenger vehicles, 750,000 medium and heavy trucks, 15,000 public transit buses, motorcoaches and motorcycles.[64] Between 1990 and 2011, the total number of vehicles in Canada has increased by 50%.[65]

On-road freight accounts for 31% of the transportation sector's share of GDP.[66] In 2011, over 45% of Canadian exports to the U.S. were transported by trucks, representing $149 billion, while 73.5% of imports from the U.S. ($162 billion) were similarly transported.[67] Between 1990 and 2011, emissions from on-road heavy-duty vehicles increased by 78%.[68] The growth in the domestic and cross-border freight industry is the primary driver behind increased emissions. For

example, during this period, the total number of heavy-duty vehicles on Canadian roads increased by 137%.[69]

2.9.2 Aviation

With 35,000 civil aircrafts, Canada has the second largest civil aviation aircraft fleet in the world.[70] Its commercial sector ranges from international scheduled services to small, single aircraft charter companies and business aircraft operators. In 2011, air transportation carried over 78 million passengers and 739,000 tonnes of freight.[71] Overall, air transportation represented 12% of the transportation sector's share of GDP in 2011.[72]

2.9.3 Rail

The North American rail industry is highly integrated. The primary freight firms in Canada serve as an important supply chain link for Canada's key trade corridors and gateways. The rail transportation industry generates approximately $10 billion per year, about 11% of the transportation sector's contribution to Canada's GDP, 95% of which comes from rail freight operations, with the remaining 5% coming from passenger rail services.[73]

2.9.4 Marine

Canada's marine industry is comprised of domestic marine service operators who provide both domestic and international shipping services, as well as international shipping lines calling at major Canadian ports. Canadian ports and harbors serve as vital links and gateways that facilitate domestic and international economic activities. Canada is home to more than 540 ports and more than 940 small craft and fishing harbours.

In 2011, marine transportation services handled over $205 billion of Canada's international trade, and generated 2% of the transportation sector's share of GDP.[74]

2.10 Industry Profile

Canada's industrial sector is very diverse with facilities engaged in mining, manufacturing, construction and forestry. Taken together, these sectors contributed over 20% of Canada's GDP in 2011,[75] with the total value of exports for the sector representing $327 billion.[76]

Table 2.2 Emissions over the 1990–2011 period were as follows:

	1990	2000	2005	2007	2008	2009	2010	2011
	Mt CO_2 Equivalent							
Emissions-Intensive and Trade-Exposed Industries	93	85	86	89	87	73	75	79
Mining	5	6	5	7	8	7	7	8
Smelting and refining (non-ferrous metals)	17	14	12	12	12	10	10	11
Pulp and paper	15	13	9	8	7	7	6	6
Iron and steel	16	18	20	21	19	15	16	17
Cement	9	11	13	12	12	10	10	10
Lime and gypsum	3	3	3	4	3	2	3	3
Chemicals and fertilizers	28	20	24	25	26	22	23	24
Coal Production	4	2	2	3	3	3	4	4
Light manufacturing, construction & forest resources	28	29	25	24	24	21	22	23

Source: National Inventory Report 1990–2011: GHG Sources and Sinks in Canada.
United Nations Framework Convention on Climate Change. 2013.

2.11 Waste

In 2010, Canadians generated 33 million tonnes of municipal solid waste.[77] Of this total, 25% was diverted through material recovery facilities or centralized organics processing operations (i.e., recycling and composting), and 75% was sent for disposal in landfills or incineration facilities.[78] About 40% of the waste generated originated from residential sources and 60% from non-residential sources (e.g., commercial and light industrial, and construction and demolition sectors).[79]

During the period of 2000 to 2010, the quantity of municipal solid waste diverted through recycling and composting increased by 33%.[80] This increase can be attributed in part to the federal, provincial, and territorial governments working collaboratively to implement extended producer responsibility programs across Canada, a policy approach in which a producer's responsibility, physical and/or financial, for a product is extended to the post-consumer stage of a product's life cycle. To date, over 30 regulated and voluntary programs exist for a wide range of materials including beverage containers, automotive products, packaging, printed materials, and electronics.[81]

Despite this significant increase in waste being diverted from landfills, the overall quantity of municipal solid waste sent for disposal increased by 7% during the 2000 to 2010 period.[82] Between 1997 and 2009, the number of landfill gas capture systems has more than doubled, increasing from 31 to 68 facilities, resulting in 30% more landfill gas capture.[83]

2.12 Building Stock/Urban Structure

2.12.1 Residential

Between 1990 and 2011, the number of households in Canada increased by 37% (3.6 million).[84] In addition to the rise in the number of households, the average living space and the penetration rate of appliances have also increased. Despite these trends, residential energy use increased by just 13.5%[85] over the same period as homeowners switched to cleaner energy sources (such as natural gas) and energy efficient technologies.[86]

The main sources of residential energy use included natural gas, electricity, wood, heating oil, and propane. Due to Canada's relatively cold climate, space heating and water heating are the main residential energy uses (Figure 2.3).

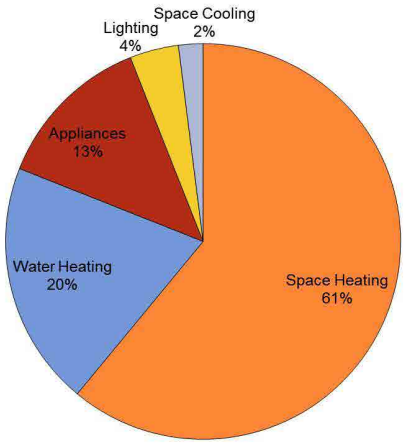

Figure 2.3 Distribution of residential energy use by end-use, 2011
Source: Natural Resources Canada. 2014. Energy Use Data Handbook, 1990–2011, Ottawa.

The amount of energy used by the residential sector to heat each square metre of living space decreased significantly between 1990 and 2011, mainly driven by energy efficiency gains. More Canadians shifted from oil to less emissions intensive natural gas as a source of home heating fuel.

The number of major appliances operated in Canada between 1990 and 2011 increased by about 47%.[87] However, the total amount of energy that households used to power major appliances decreased by 25.1% due to energy efficiency improvements.[88] Some of these improvements can be attributed to federal, provincial, and territorial government efforts to work with industry and public stakeholders to implement energy guide rating systems that help increase consumer awareness of major appliances' energy use and associated operating costs.

One of the most energy intense appliances in the household is air conditioners. The percentage of occupied floor space cooled by air conditioners has increased from 23% in 1990 to 48% in 2011.[89]

2.12.2 Commercial/Institutional

In 2011, this sector was responsible for 12% of the total energy use in Canada.[90] In the commercial/institutional sector, energy is used for space heating, cooling, lighting and water heating, as well as for operating auxiliary equipment (such as computers and servers) and motors. Space heating accounts for the largest share of energy use, with about 46%, followed by auxiliary equipment at 19%.[91] Energy usage by auxiliary equipment has risen steadily due to increasing use of new electronic technologies.

Energy efficiency efforts have reduced overall building sector energy intensity by 11% between 1990 and 2011.[92] Over the same period, the total floor space has increased by 43% while total energy consumption rose by 27%.[93] Energy consumption growth can be explained by economic growth, an increase in computerization of the work environment and an increase in the number of devices per employee.

There is a growing trend towards improving energy performance in the Canadian building stock. Between 2005 and 2009, approximately 48% of the building stocks undertook at least one energy-related renovation.[94] Furthermore, about 68% reported the presense of other energy efficiency measures, such as energy management plans or the addition of control technologies.[95] The estimated participation rate in "green"/energy rating programs, such as LEED (Leadership in Energy and Environmental Design) and BOMA BESt (Building Environmental Standards), is growing. By 2012, about 12% of the commercial and institutional building stocks were registered in these programs.[96]

2.13 Agriculture

Canada's primary agriculture sector accounts for slightly less than 2% of GDP, but it is at the heart of an agriculture and agri-food system which provides one in eight jobs, represents 8% of total GDP and places Canada as a major exporter of agriculture and agri-food products internationally.[97]

Only 5% of Canada's land mass is suitable for agricultural production. In 2011, total farm area was 65 million hectares (160 million acres). Land for crop production has been increasing over time and now represents 55% of total farmland, followed by pastures which account for slightly more than one-third.[98]

Crop production and beef farming have long been the backbone of Canada's agriculture industry. In 2011, one in three farms were engaged in grain and oilseed cropping and one in five were raising beef cattle.

In recent decades, Canadian farmers have increasingly substituted conventional tillage with no-till or conservation tillage seeding techniques. No-till practices are used on 56% of total land prepared for seeding while conservation tillage is used on 25%.[99]

2.14 Forest

Canada has 397.3 million hectares of forest, other wooded land, and other land with tree cover.[100] Forest land accounts for nearly 348 million hectares, 66% of which is considered "managed forest", where human activities affect forest carbon.[101] In 2011, the forest sector contributed $23.7 billion to national GDP, approximately 1.9% of Canada's total, and directly employed approximately 234,000 Canadians.[102]

Most of Canada's forest land, 93%, is publicly owned: 77% is under provincial or territorial jurisdiction, 16% is under federal jurisdiction, and the remaining 7% is privately owned.[103] By law, all forests harvested on public land must be successfully regenerated.[104] As of December 2012, Canada had 147.9 million hectares of forests certified as being sustainably managed under one or more of three globally recognized certification systems.[105]

Canada's vast forest ecosystems are exposed to significant natural disturbances such as fire, insects, disease and weather-related events that affect forest health and structure. A small portion of Canada's forests is also disturbed by harvesting and other human activities each year, but the area of harvest (approximately 640,000 hectares in 2011) is relatively small compared to the area of natural disturbances caused by fire and insects.[106]

For the past century, Canada's vast managed forest has been a significant carbon sink.[107] Since 2002, however, the forest has become a net source of carbon, in large part due to increased forest fires and an unprecedented insect infestation in western Canada. In spite of fire suppression efforts, the annual total area burned by wildfire in the managed forest has increased in recent years, with the area burned totalling 2.3 million hectares in 2010 and 2011.[108] Even with an integrated pest management approach, mountain pine beetle killed approximately 675 million cubic metres of pine in British Columbia between 1998 and 2009, an amount equal to 50% of the province's commercial pine.[109] It is expected that climate change (changes in temperature, precipitation and season length) will further exacerbate the impacts and increase frequency of natural disturbances.[110] Insect damage can increase the risk of wildfire and drought can stress trees, making them more susceptible to attack by insects and disease.[111]

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3 Canada's Greenhouse Gas Inventory

Canada ratified the United Nations Framework Convention on Climate Change (UNFCCC) in December 1992, and the Convention came into force in March 1994. The ultimate objective of the UNFCCC is to stabilize atmospheric greenhouse gas (GHG) concentrations at a level that would prevent dangerous interference with the climate system. In its actions to achieve its objective and to implement its provisions, the UNFCCC lays out a number of guiding principles and commitments. Specifically, Articles 4 and 12 of the Convention commit all Parties to develop, periodically update, publish, and make available to the Conference of the Parties (COP), national inventories of anthropogenic emissions by sources and removals by sinks of all GHGs not controlled by the Montreal Protocol.

Canada's National Inventory is prepared and submitted annually to the UNFCCC by April 15th, in accordance with the *"Guidelines for the preparation of national communications by Parties included in Annex I to the Convention, Part I: UNFCCC reporting guidelines on national inventories"* which include the revisions to the Land Use, Land-use Change and Forestry Sector (LULUCF) adopted by the COP at its 11th session in December 2005. The annual inventory submission consists of the *National Inventory Report* (NIR) and the Common Reporting Format (CRF) Tables.

The GHG emission and removal estimates contained within Canada's GHG Inventory are developed using methodologies consistent with the guidelines prescribed by the Intergovernmental Panel on Climate Change (IPCC). The Inventory estimates include carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), sulphur hexafluoride (SF_6), perfluorocarbons (PFCs) and hydrofluorocarbons (HFCs), in the following six IPCC sectors: Energy, Industrial Processes, Solvent and Other Product Use, Agriculture, Waste, and LULUCF.

This chapter summarizes the latest information on trends in Canada's net anthropogenic emissions from 1990 to 2011 as reported in Canada's 2013 NIR and provides a description of the factors underlying the emissions trends. The most recent report is entitled *National Inventory Report: Greenhouse Gas Sources and Sinks in Canada 1990–2011*; its Executive Summary is available online at: http://www.ec.gc.ca/ges-ghg

3.1 Canada's 2011 Greenhouse Gas Emissions

In 2011, the most recent annual dataset in this report, Canada emitted 702 megatonnes carbon dioxide equivalent (Mt CO_2 eq) of GHGs to the atmosphere, excluding LULUCF estimates. The Energy Sector (consisting of stationary combustion, transport and fugitive emission sources) produced the majority of Canada's GHG total emissions in 2011, at 81% or 572 Mt (Figure 3.1). The remaining 19% of total emissions was largely generated by sources within the Agriculture Sector (8% of total emissions) and Industrial Processes Sector (8%), with minor contributions from the Waste Sector (3%) and Solvent and Other Product Use Sector.

On an individual GHG basis in 2011, CO2 contributed 79% of Canada's total emissions (Figure 3.2). The majority of these emissions result from the combustion of fossil fuels. Methane (CH_4) accounted for 13% of Canada's total emissions, largely from fugitive emissions from oil and natural gas systems, as well as Agriculture and Waste Sectors. Nitrous oxide (N_2O) emissions from activities such as agriculture soil management and transport accounted for 7% of the emissions, while PFCs, SF_6, and HFCs constituted the remainder of the emissions (slightly more than 1%).

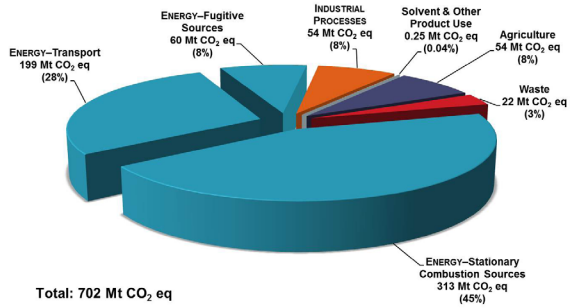

Figure 3.1 Canada's Emissions Breakdown by IPCC Sector (2011) (all sectors are consistent with the definitions provided in the IPCC 1996 Guidelines for National GHG Inventories)

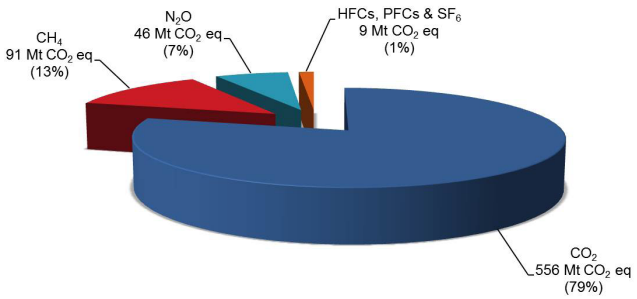

Figure 3.2 Canada's Emissions Breakdown by Greenhouse Gas (2011)

3.2 Trends in Greenhouse Gas Emissions and Removals, 1990–2011

Canada's emissions in 2011 were 111 Mt (19 %) above the 1990 total of 591 Mt (Figure 3.3). Steady increases in annual emissions characterized the first 15 years of this period, followed by fluctuating emission levels between 2005 and 2008, a steep drop in 2009 and more stable values thereafter. Between 2005 and 2011 emissions decreased by 36 Mt (4.8%), primarily due to decreases from electricity generation and manufacturing industries.

Though GHG emissions have risen by 19% since 1990, Canada's economy grew much more rapidly, with Gross Domestic Product (GDP) rising by 65%. As a result, the emission intensity for the whole economy (GHG per GDP) has improved considerably, dropping by 28% (Figure 3.4).

There have been some variations over time, however early in the period, emissions rose nearly in step with economic growth, with their paths beginning to diverge in 1995 (Figure 3.4). Since 2000, GHG emissions have started to decouple from economic growth, a shift that can be attributed to increases in efficiency, the modernization of industrial processes, and structural changes in the economy. These long-term trends have had an increased impact on emissions since the late 1990s.

Canada represented only about 2% of total global GHG emissions in 2005, although it is one of the highest per capita emitters, largely as a result of its size, climate (i.e., climate-driven energy demands), and resource-based economy. In 1990, Canadians released 21.3 tonnes (t) of GHGs per capita. In 2005, this had risen to 22.9 t of GHGs per capita; however, by 2011 it had dropped to 20.4 t of GHGs per capita (Figure 3.5).

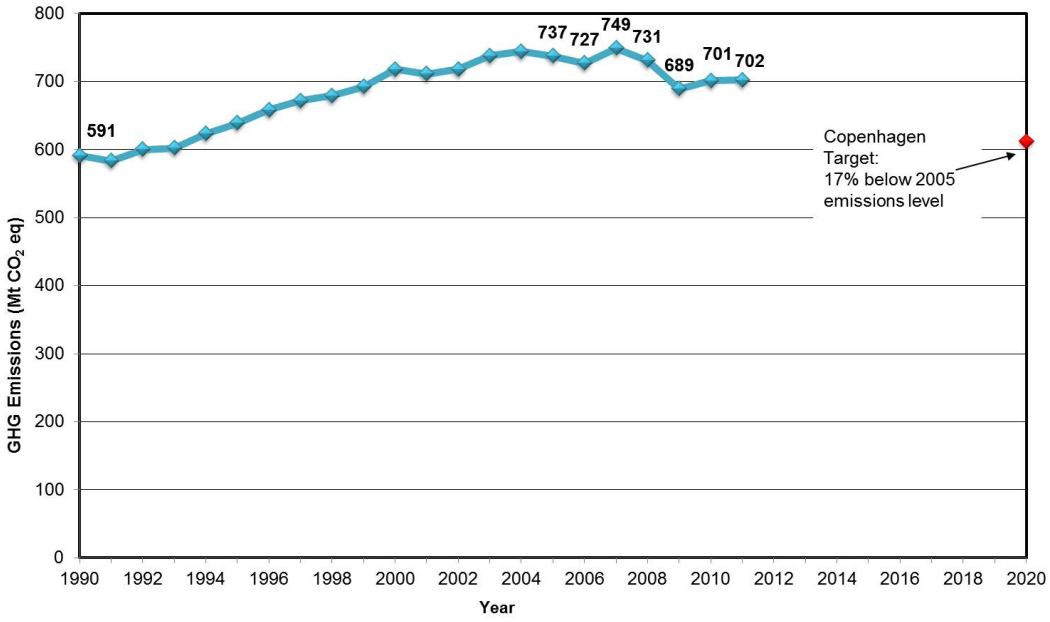

Figure 3.3 Canadian GHG Emission Trend (1990–2011) and Copenhagen Target

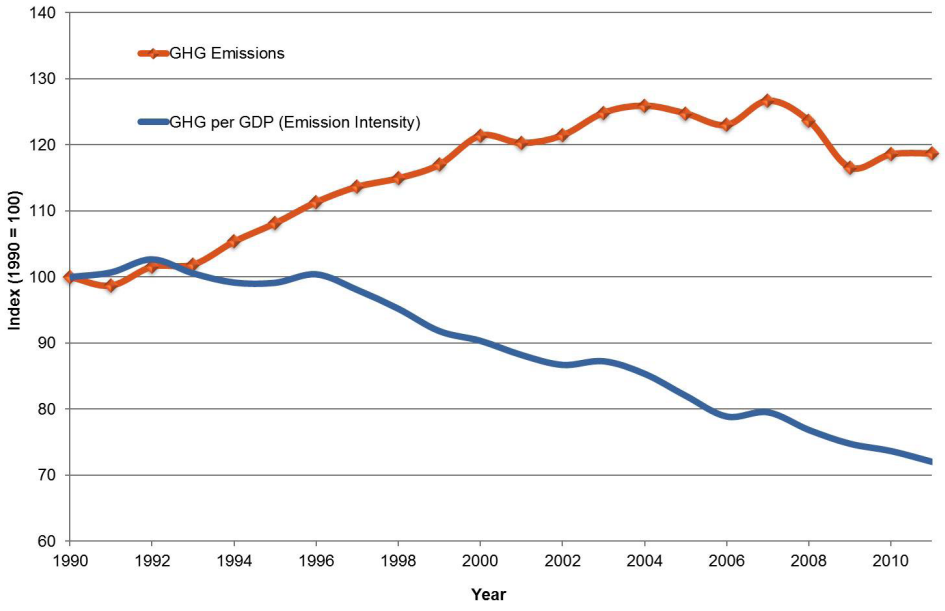

Figure 3.4 Indexed Trend in GHG Emissions and GHG Emission Intensity (1990–2011)

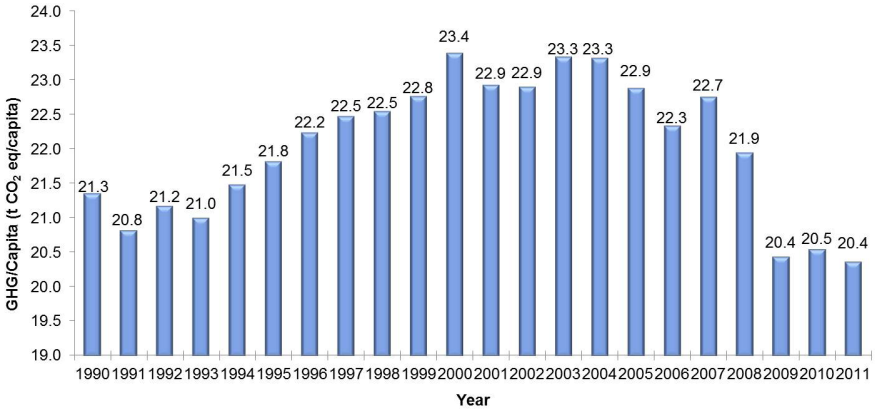

Figure 3.5 Canadian per Capita Greenhouse Gas Emissions (1990–2011)

3.3 Greenhouse Gas Trends by IPCC Sector, 1990–2011

Over the period of 1990 to 2011, total emissions in the Energy Sector grew by 103 Mt CO_2 eq (22%), by 7 Mt CO_2 eq (15%) in the Agriculture Sector, by 3 Mt CO_2 eq (16%) in the Waste Sector and by 0.1 Mt CO_2 eq (39%) in the Solvent and Other Product Use (Figure 3.6 and Table 3.1). During the same time period, emissions decreased by 1.7 Mt CO_2 eq (3%) in the Industrial Process Sector.

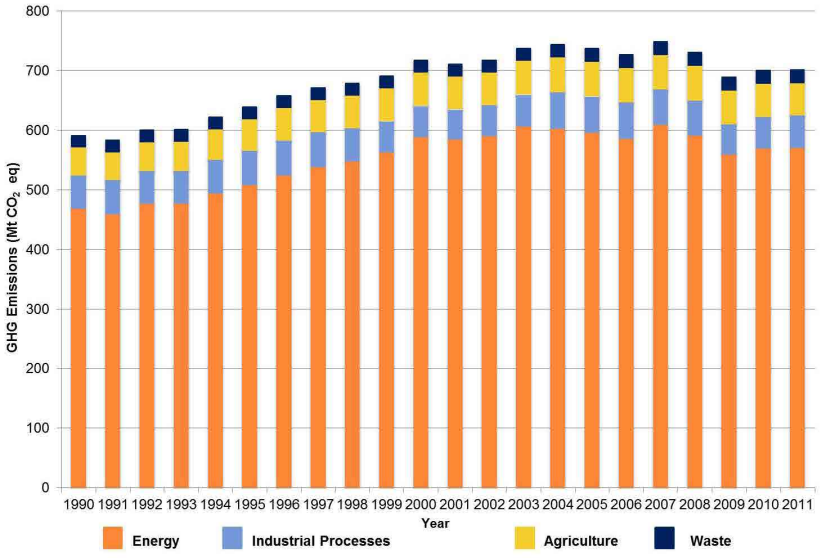

Figure 3.6 Trends in Canadian GHG Emissions by IPCC Sector (1990–2011)

Table 3.1 Canada's GHG Emissions by IPCC Sector (1990–2011)

Greenhouse Gas Categories	1990	2000	2005	2007	2008	2009	2010	2011
				Mt CO_2 equivalent				
TOTAL[1]	**591**	**718**	**737**	**749**	**731**	**689**	**701**	**702**
ENERGY	**469**	**589**	**597**	**610**	**592**	**560**	**570**	**572**
a. Stationary Combustion Sources	**281**	**346**	**341**	**352**	**336**	**315**	**316**	**313**
Electricity and Heat Generation	94	129	123	122	115	100	101	93
Fossil Fuel Production and Refining	51	67	71	72	67	67	65	62
Petroleum Refining and Upgrading	17.0	16.0	20.0	21.0	19.0	19.0	18.0	16.0
Fossil Fuel Production	34.0	51.0	51.0	51.0	47.0	48.0	47.0	45.0
Mining & Oil and Gas Extraction	6.6	12.1	18.9	28.9	30.0	31.7	35.0	36.4
Manufacturing Industries	55.8	55.6	48.6	47.6	45.1	40.3	41.1	42.7
Iron and Steel	5.0	6.1	5.6	6.0	5.8	4.3	4.4	4.4
Non-ferrous Metals	3.3	3.2	3.6	3.8	3.8	2.8	3.0	3.1
Chemical	8.2	9.4	8.3	8.7	8.8	8.8	9.9	10.2
Pulp and Paper	14.5	12.3	8.8	7.9	6.4	6.5	6.1	6.2
Cement	3.9	4.3	5.4	5.0	4.9	4.5	4.0	4.1
Other Manufacturing	21.0	20.3	17.1	16.3	15.5	13.4	13.7	14.7
Construction	1.9	1.1	1.4	1.4	1.4	1.2	1.5	1.3
Commercial & Institutional	25.7	33.3	31.9	30.2	29.6	29.4	28.0	29.9
Residential	43	45	44	47	46	44	41	44
Agriculture & Forestry	2.4	2.5	2.1	2.6	2.6	2.5	2.9	3.6
b. Transport	**146**	**180**	**193**	**195**	**194**	**186**	**196**	**199**
Civil Aviation (Domestic Aviation)	7.1	7.4	7.6	7.7	7.3	6.4	6.4	6.0
Road Transportation	97	118	130	133	132	132	134	135
Light-duty Gasoline Vehicles	45.5	42.1	40.2	40.0	39.5	39.7	40.0	39.5
Light-duty Gasoline Trucks	20.3	36.4	42.7	42.7	42.3	42.5	42.9	42.7
Heavy-duty Gasoline Vehicles	7.4	5.5	6.5	6.8	6.8	6.9	7.0	7.1
Motorcycles	0.2	0.2	0.3	0.3	0.3	0.3	0.3	0.3
Light-duty Diesel Vehicles	0.5	0.5	0.6	0.6	0.7	0.7	0.8	0.8
Light-duty Diesel Trucks	0.7	1.7	1.9	2.0	2.0	2.0	2.1	2.2
Heavy-duty Diesel Vehicles	20.0	30.9	37.6	39.5	39.2	39.0	40.2	41.8
Propane & Natural Gas Vehicles	2.2	1.1	0.7	0.8	0.9	0.8	0.8	0.8
Railways	7.0	7.0	7.0	7.0	8.0	5.0	7.0	7.0
Navigation (Domestic Marine)	5.0	5.1	6.7	6.8	6.5	6.7	7.0	6.0
Other Transportation	30	43	41	41	41	36	42	45
Off-road Gasoline	8	9	8	8	7	7	8	9
Off-road Diesel	16	23	23	24	26	23	28	30
Pipelines	7	11	10	8	7	6	6	6
c. Fugitive Sources	**42**	**63**	**63**	**63**	**62**	**59**	**59**	**60**
Coal Mining	2.0	1.0	1.0	1.0	0.9	0.9	1.0	1.0
Oil and Natural Gas	40.2	62.1	62.4	62.0	61.0	57.9	57.6	58.7
Oil	4	5	6	6	6	6	6	6
Natural Gas	11	18	19	20	20	19	19	19
Venting	20	34	32	31	31	29	28	29
Flaring	4	5	6	5	5	4	4	5
INDUSTRIAL PROCESSES	**56.0**	**52.1**	**60.5**	**59.8**	**58.5**	**50.8**	**53.3**	**54.3**
a. Mineral Products	**8.4**	**9.8**	**9.9**	**9.8**	**9.0**	**7.0**	**7.6**	**7.7**
Cement Production	5.4	6.7	7.2	7.3	6.6	5.1	5.7	5.7
Lime Production	1.8	1.9	1.7	1.6	1.5	1.2	1.4	1.4
Mineral Product Use	1.2	1.2	1.0	0.9	0.9	0.7	0.5	0.6
b. Chemical Industry	**16.0**	**8.0**	**9.3**	**7.9**	**9.4**	**7.1**	**6.5**	**7.0**
Ammonia Production	4.5	5.7	5.3	5.2	5.6	5.2	5.3	5.7
Nitric Acid Production	1.0	1.2	1.3	1.1	1.3	1.2	1.1	1.2
Adipic Acid Production	11.0	0.9	2.6	1.5	2.4	0.7	0.0	0.0
Petrochemical Production	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
c. Metal Production	**22.6**	**22.5**	**19.7**	**18.9**	**18.5**	**15.4**	**15.8**	**16.6**
Iron and Steel Production	10.2	11.5	10.2	11.1	10.7	8.0	9.0	9.9
Aluminum Production	9.3	8.2	8.2	7.3	7.4	7.2	6.6	6.6
SF_6 Used in Magnesium Smelters and Casters	3.1	2.8	1.3	0.5	0.5	0.2	0.2	0.2
d. Production and Consumption of Halocarbons and SF_6	**1.0**	**3.2**	**5.5**	**5.7**	**5.8**	**6.5**	**7.3**	**7.7**
e. Other & Undifferentiated Production	**7.6**	**8.6**	**16.0**	**17.0**	**16.0**	**15.0**	**16.0**	**15.0**
SOLVENT & OTHER PRODUCT USE	**0.18**	**0.45**	**0.38**	**0.33**	**0.34**	**0.26**	**0.24**	**0.25**
AGRICULTURE	**47**	**56**	**58**	**58**	**59**	**56**	**56**	**54**
a. Enteric Fermentation	16	20	22	21	20	19	19	18
b. Manure Management	5.7	7.0	7.5	7.2	6.9	6.7	6.5	6.4
c. Agriculture Soils	25	29	29	30	31	30	30	30
Direct Sources	14.00	15.00	15.00	16.00	17.00	16.00	16.00	16.00
Pasture, Range and Paddock Manure	2.20	3.10	3.40	3.30	3.20	3.00	2.90	2.70
Indirect Sources	9.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00
d. Field Burning of Agricultural Residues	0.21	0.12	0.04	0.04	0.05	0.04	0.03	0.03
WASTE	**19**	**20**	**21**	**21**	**21**	**21**	**22**	**22**
a. Solid Waste Disposal on Land	17	18	20	20	20	20	20	20
b. Wastewater Handling	0.8	0.9	1.0	1.0	1.0	1.0	1.0	1.0
c. Waste Incineration	0.7	0.8	0.7	0.7	0.7	0.7	0.7	0.7
LAND USE, LAND-USE CHANGE AND FORESTRY	**-62**	**-52**	**63**	**52**	**-11**	**-10**	**100**	**87**
a. Forest Land	-88	-64	54	45	-18	-15	99	83
b. Cropland	12	0	-4	-6	-7	-7	-8	-8
c. Grassland	-	-	-	-	-	-	-	-
d. Wetlands	5	3	3	3	3	3	3	3
e. Settlements	9	8	9	10	10	9	9	9

1. National totals exclude all GHGs from the Land Use, Land-use Change and Forestry Sector.

Almost all of the emission changes over the long term are attributable to six major areas: the fossil fuel (coal, oil and gas) industries[1], transport[2], electricity generation, manufacturing[3], energy consumption in commercial/institutional buildings and agriculture. The relative contribution of each of these has varied somewhat, depending on the time period. The fossil fuel industries and transport are the major drivers of the long-term trend of emissions growth. Between 1990 and 2011, these two sectors were each responsible for about one-half of the total 111 Mt growth in emissions. Major increases in oil and gas production (much of it for export), as well as a large increase in the number of motor vehicles, especially light-duty gasoline trucks (vans, sport-utility vehicles and pick-up trucks) and heavy-duty diesel vehicles (commercial transport trucks), have contributed to the significant rise in GHG emissions. In contrast, the observed emission decline in the short-term (2005–2011) has been driven by electricity generation and manufacturing. Emissions from both the commercial/institutional buildings and agriculture sectors have increased over the long-term (1990–2011) by 4.2 Mt and 7.2 Mt, respectively; however, recent trends show a decline in emissions over the short-term (2005–2011) by 2.0 Mt and 4.2 Mt, respectively.

Greenhouse gases in the LULUCF sector are not included in the inventory totals. In 2011, total emissions for the LULUCF sector are estimated at about 87 Mt.

The detailed Common Reporting Format (CRF) Tables containing Canada's GHG emissions and removals estimates between 1990 and 2011 are presented in Canada's 1st Biennial Report in Annex 1 of this document; a summary of Canada's GHG emissions and removals by IPCC Sector between 1990 and 2011 is presented in Table 3.1.

3.3.1 Energy—2011 GHG Emissions, 572 Mt

Overall, this Sector accounted for 81% of total Canadian GHG emissions in 2011. Figure 3.7 shows emissions from key components of the Energy Sector in Canada: Energy Industries[4], Manufacturing Industries and Construction, Transport, Other,[5] and Fugitive.

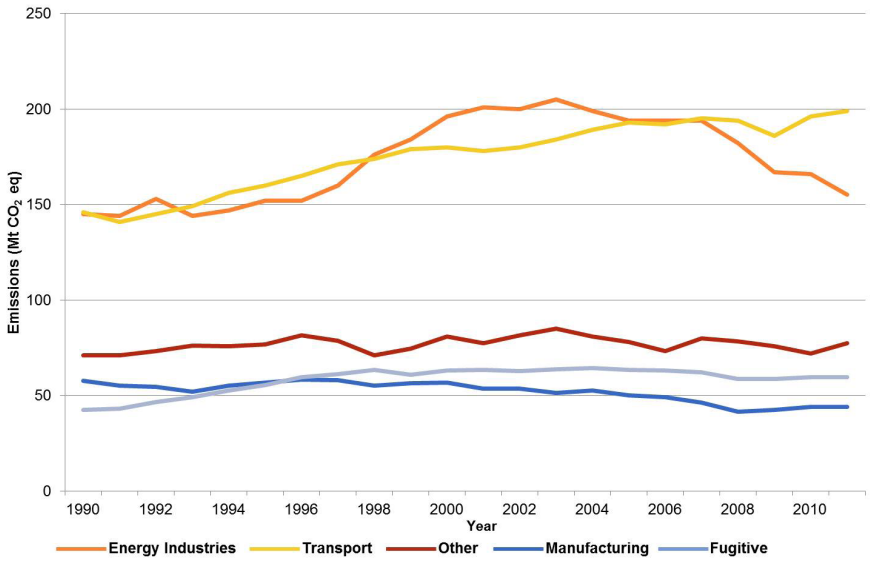

Figure 3.7 GHG Emissions from Energy by Sub-Category (1990–2011)

3.3.1.1 Energy Industries—2011 GHG Emissions, 155 Mt

The Energy Industries (which includes Electricity and Heat Generation, Petroleum Refining and Upgrading, and Fossil Fuel Production) account for the second largest portion of Canada's fuel combustion emissions after transportation (22% of Canada's total). In 2011, combustion emissions from this category totaled 155 Mt, an increase of 7% from the 1990 level of 145 Mt.

Public Electricity and Heat Generation—2011 GHG Emissions, 93 Mt

Public Electricity and Heat Generation, the main constituent of the Energy Industries, accounted for 13.3% (93 Mt) of Canada's 2011 GHG emissions (Table 3.1). Overall emissions from this category decreased 0.3% (<1 Mt) since 1990. The estimated GHG emissions from this sector do not include emissions from industrial generation; rather, these emissions have been allocated to the specific industrial sectors.

During the period from 1990 to 2011, electricity generation rose significantly. However, the amount of coal-based electricity within the generation mix grew rapidly at first and then fell (most significantly after 2004), resulting in virtually zero emissions growth.

Petroleum Refining and Upgrading—2011 GHG Emissions, 16 Mt

The Petroleum Refining and Upgrading category mainly includes emissions from the combustion of fossil fuels during the production of refined petroleum products. In 2011, GHG emissions from this category totaled approximately 16 Mt.

Fossil Fuel Production—2011 GHG Emissions, 45 Mt

The Fossil Fuel Production category encompasses emissions from stationary fuel combustion associated with the upstream oil and gas industry. In 2011, GHG emissions totaled about 45 Mt from this subsector. Between 1990 and 2011, emissions from these two categories increased by about 11 Mt, or 32%. This growth is due to increases in natural gas and oil production, particularly crude bitumen and heavy crude oil.

3.3.1.2 Manufacturing Industries and Construction—2011 GHG Emissions, 44 Mt

Emissions from the Manufacturing Industries and Construction group, not including Mining and Oil and Gas Extraction, were responsible for 6.2% of Canada's total GHG emissions in 2011, down 24% from 1990. The largest decrease was −57% in the Pulp, Paper and Print category, which can be attributed to decreased demand, fuel switching, and changes in manufacturing operations.

3.3.1.3 Transport—2011 GHG Emissions, 199 Mt

Transport is a large and diverse subsector; with 199 Mt, this sector accounted for 28% of Canada's GHG emissions in 2011. This subsector includes emissions from fuel combustion for the transport of passengers and freight in five distinct subcategories: Road Transportation, Civil Aviation (Domestic Aviation), Navigation (Domestic Marine), Railways, and Other Transportation (Off-Road and Pipelines).

From 1990 to 2011, GHG emissions from Transport—driven primarily by energy used for personal transportation—rose 36% (53 Mt), accounting for almost one half of Canada's emission growth from 1990 to 2011.

As shown in Table 3.1, the growth in Road Transport emissions is due not only to the 50% increase in the total vehicle fleet since 1990 (12% since 2005), but also to a shift in light-duty vehicle purchases from cars to trucks, which, on average, emit 44% more GHGs per kilometer. Between 1990 and 2011, the increase of 22 Mt in emissions from light-duty gasoline trucks and heavy-duty diesel vehicles reflects the trend towards the increasing use of SUVs, minivans and pickups for personal transportation and heavy-duty trucks for freight transport.

3.3.1.4 Other Energy Sectors—2011 GHG Emissions, 77 Mt

Other Energy Sectors comprise fuel combustion emissions from Commercial and Institutional buildings, Residential buildings, and Agriculture and Forestry. Overall, this subsector exhibited increases in GHG emissions of 9% from 1990 to 2011, while individual subcategories within it demonstrated a variety of changes.

GHG emissions in Commercial and Institutional buildings and facilities and Residential buildings arise primarily from the combustion of fuel to heat buildings. Fuel combustion in these two categories accounted for 10% of all GHG emissions in 2011. Emission patterns are influenced by factors such as weather, changes in energy efficiency, new home construction volumes, and increases in commercial floor space. These factors impact space heating requirements and therefore demand for natural gas, home heating oil and biomass fuels.

Trends in emissions from the Commercial and Institutional category largely accounted for the 4.2 Mt (or 6%) increase since 1990. Residential emissions fluctuate on an annual basis and overall have remained largely unchanged between 1990 and 2011.

Emissions from stationary fuel combustion in Agriculture and Forestry amounted to 3.6 Mt in 2011 (0.5 % of the total), an increase of 49% from 1990.

3.3.1.5 Fugitive Emissions from Fuels—2011 GHG Emissions, 60 Mt

Fugitive emissions from fossil fuels are the intentional or unintentional releases of GHGs from the production, processing, transmission, storage, and delivery of fossil fuels. Released gases that are combusted (flared) at oil and gas production and processing facilities are included in these fugitive emissions. In total, fugitive emissions constitute 8.5% of Canada's total GHG emissions for 2011, with Oil and Natural Gas contributing almost all the total fugitive emissions.

Fugitive emissions contributed 16% to the growth in emissions between 1990 and 2011, with a 41% increase between 1990 and 2011, from 42 to 60 Mt. Over this period fugitive emissions from Oil and Natural Gas increased by 46%, while those released in the Solid Fuels category (i.e., coal mining) decreased by 1 Mt (50%) as a result of the closing of many mines in eastern Canada.

3.3.2 Industrial Processes—2011 GHG Emissions, 54 Mt

The Industrial Processes Sector includes GHG emissions that are direct by-products of processes, including Mineral Products, Chemical Industry, Metal Production, Production and Consumption of Halocarbons and SF_6, and Other and Undifferentiated Production. The 54 Mt emitted from the Industrial Processes Sector contributed 8% to the 2011 national GHG inventory, compared with 56 Mt (9%) in 1990, a decrease of approximately 2 Mt or 3% (Figure 3.8).

This decrease in emissions is explained by significant emission reductions in adipic acid production (which generates N_2O), aluminium production (PFCs), and magnesium production (SF_6); these reductions were partly offset by growths in hydrofluorocarbon (HFC) emissions (i.e., emission from refrigeration and air conditioning), and in CO_2 emissions from the use of natural gas liquids and feedstock in the Chemical Industry and the use of lubricants (captured under the category of Other and Undifferentiated Production).

Some chemical and metal industries have made significant progress in controlling emissions over the years. For example, while increasing its production by 90% (1.4 Mt) between 1990 and 2011, the aluminium industry has succeeded in reducing its PFC emissions by 78% or 5.1 Mt CO_2 eq, largely due to technological improvements. The magnesium production industry also showed a decrease in emissions because of replacement of SF_6 with alternatives and the closure of plants over the years.

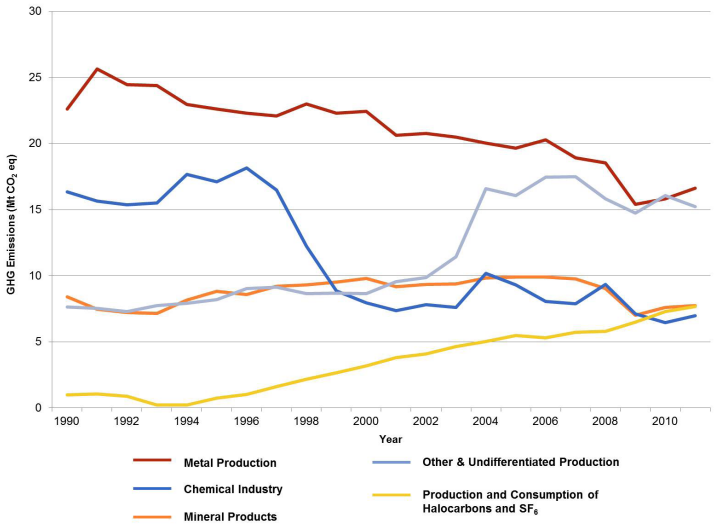

Figure 3.8 GHG Emissions from Industrial Process Sector by Sub-Category (1990–2011)

Emissions from refrigeration and air conditioning have grown by 672% (6.7 Mt CO_2 eq) since 1990; this is largely due to the displacement of ozone-depleting substances by HFCs since the Montreal Protocol came into effect in 1989. The non-energy (feedstock) use of fuels in the petrochemical industry has considerably increased over the years, justifying by and large the emission growth of 100% (7.6 Mt CO_2 eq) seen in the category of Other and Undifferentiated Production since 1990. A slight increase in emissions trends in Cement Production are largely driven by domestic and international (mainly U.S.) construction activities.

3.3.3 Solvent and Other Product Use—2011 GHG Emissions, 0.25 Mt

The Solvent and Other Product Use Sector accounts for emissions related to the use of N_2O as an anaesthetic in medical applications and as a propellant in aerosol products. The emission trends were primarily driven by the domestic demand for N_2O for anaesthetic or propellant purposes.

3.3.4 Agriculture—2011 GHG Emissions, 54 Mt

In 2011, emissions from agriculture (excluding energy use) accounted for 54 Mt or 8% of total Canadian GHG emissions, an increase of 7 Mt since 1990. N_2O accounts for about 62% of sectoral emissions and CH_4 for 38%. The two principal activities in the agricultural industry are livestock and crop production. Livestock contributed 32 Mt CO_2 eq; 18 Mt CO_2 eq from enteric fermentation and 14 Mt CO_2 eq from manure management, storage and application (56% and 44% of livestock emissions, respectively). Crop production contributed N_2O emissions during the application of synthetic nitrogen fertilizers (14 Mt CO_2 eq) and from crop residue decomposition (7.3 Mt CO_2 eq), representing 66% and 34% of crop production emissions, respectively (Table 3.2).

The main drivers of the emission trend in the Agriculture Sector are the expansion of the beef cattle and swine populations, and increases in the application of synthetic nitrogen fertilizers in the Prairies of western Canada. Beef, swine and poultry populations in Canada are 16%, 17% and 39% higher, respectively, than in 1990 and largely account for the 12% increase (from 29 to 32 Mt CO_2 eq) in emissions associated with animal production over the 1990–2011 period (Table 3.2).

Table 3.2 GHG Emissions from Agriculture by Production Systems (1990–2011)

Production System		GHG Emissions (Mt CO_2 eq)[1]							
		1990	2000	2005	2007	2008	2009	2010	2011
Livestock		**29**	**36**	**39**	**37**	**36**	**34**	**33**	**32**
	Dairy Cows	5.8	5.0	4.7	4.5	4.5	4.5	4.6	4.6
	Beef Cattle	19	25	28	27	26	25	24	23
	Swine	2.4	3.1	3.5	3.3	2.9	2.8	2.7	2.8
	Other Livestock[2]	1.5	2.1	2.3	2.3	2.3	2.2	2.2	2.2
Crop		**18**	**20**	**19**	**21**	**23**	**22**	**22**	**22**
	Synthetic Nitrogen Fertilizers	9.2	12	11	13	13	13	14	14
	Crop Residue Decomposition	7.5	7.2	7.7	7.7	9.1	8.2	8.5	7.3
	Other Management Practices[3]	1.3	0.9	0.4	0.3	0.2	0.2	0.1	0.1
Agriculture (Total)		**47**	**56**	**58**	**58**	**59**	**56**	**56**	**54**

[1]Totals may not add up due to rounding.

[2]Other livestock includes sheep, lamb, goat, horse, bison, poultry, llamas and alpacas.

[3]Other management practices includes summerfallow, conservation tillage practices, irrigation, cultivation of organic soils and field burning of crop residues.

Emission factors for beef cattle increased from 1990 to 2011 due to herd improvements that increased average live weight; an average animal now consumes more feed and also emits more GHGs. As a result, emissions from beef cattle increased at greater rates than cattle populations.

The increases in emissions from beef production were partially offset by a 28% reduction in the dairy population. Due to improved genetics and changes in feeding and/or management practices, average milk productivity per head increased by 32% and dairy quotas were attained with fewer animals, increasing industry profitability. Subsequently, emissions associated with dairy cows decreased by approximately 20% since 1990. Even though the decrease in dairy population is driving the emission decline in this category, an average cow produces more milk today than in 1990, and also emits more GHGs, as was the case with non-dairy cattle.

Emissions attributed to crop production are due mainly to either the application of synthetic nitrogen (N) fertilizers or to crop residue decomposition, which is directly proportional to crop yields. The use of synthetic nitrogen fertilizer has increased from 1.2 Mt N to 2.0 Mt N from 1990 to 2011 due mainly to a reduction in summerfallow and an intensification of cropping systems in western Canada. Major crops grown in Canada, including corn, wheat, barley, and canola, require high rates of fertilization to achieve and sustain high levels of production. As a consequence, emissions from synthetic nitrogen fertilizer consumption have increased substantially, from 9.2 Mt CO_2 eq in 1990 to 14 Mt CO_2 eq in 2011. Emission trends for the Agriculture subsectors are presented in Figure 3.9.

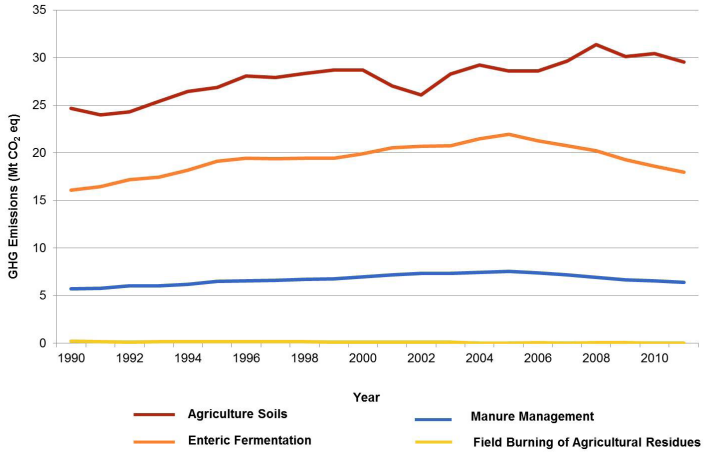

Figure 3.9 GHG Emissions Trend for Agriculture by Sub-Category (1990–2011)

3.3.5 Waste—2011 GHG Emissions, 22 Mt

From 1990 to 2011, GHG emissions from the Waste Sector increased 14%. In 2011, these emissions represented 3.1% (22 Mt) of the total national GHG emissions, close to its 1990 value (3.2% or 19 Mt). Of the 22 Mt total emissions from this sector in 2011, solid waste disposal on land, which includes municipal solid waste (MSW) landfills and wood waste landfills, accounted for 20 Mt. Methane emissions produced by the decomposition of biomass in MSW landfills were responsible for 92% of the emissions from this sector. Emissions from municipal wastewater treatment and incineration of waste (excluding emissions from incineration of biomass material) contributed 1.0 Mt and 0.69 Mt, respectively, to the total from the Waste Sector (Figure 3.10).

Methane emissions from MSW landfills increased by 18% between 1990 and 2011 (Figure 3.10) despite an increase of 81% in landfill gas capture and combustion over the same period. Approximately 349 kilotonnes (kt) CH_4 (or 7 334 kt CO_2 eq) were captured by the 68 landfill gas collection systems operating in Canada.

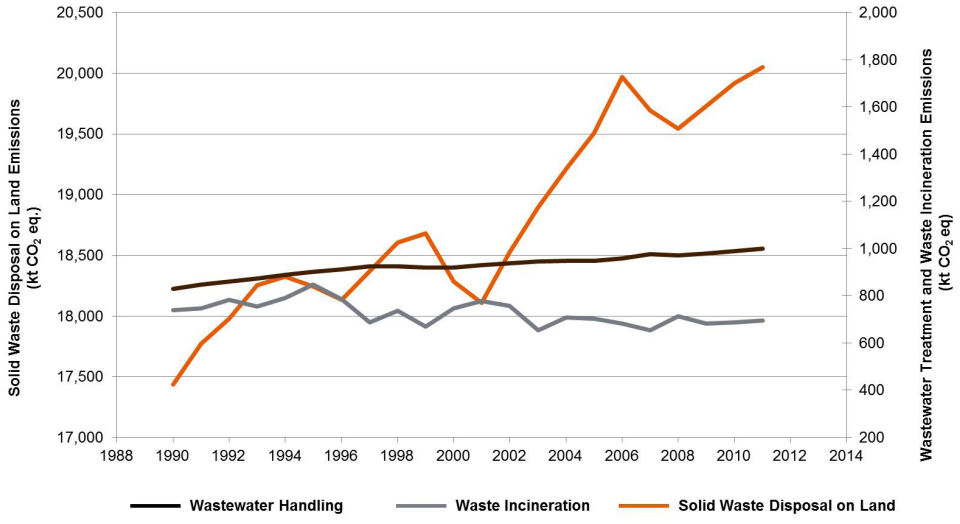

Figure 3.10 GHG Emissions from Waste (1990–2011)

Of the total amount of CH_4 collected in 2011, 51% (179 kt) was utilized for various energy purposes and the remainder was flared. From 1990 to 2011, the population growth trend (24%) exceeded that of the sector emissions (14%). The decline in the growth of emissions per capita from waste observed in the mid-1990s is directly attributable to CH_4 capture at landfills and waste diversion programs.

3.3.6 Land Use, Land-use Change and Forestry—2011 Net GHG Emissions, 87 Mt (not included in national totals)

The LULUCF Sector reports GHG fluxes between the atmosphere and Canada's managed lands, as well as those associated with land-use changes. The LULUCF UNFCCC categories include Forest Land, Cropland, Grassland, Wetlands, Settlements, and Other Land. The net LULUCF flux, calculated as the sum of CO_2 emissions and removals and non-CO_2 emissions, displayed high interannual variability over the reporting period. In 2011, this net flux amounted to emissions of 87 Mt (Figure 3.11).

In accordance with UNFCCC accounting rules, all emissions and removals in the LULUCF Sector are excluded from the national totals. GHG emissions from sources and removals by sinks are estimated and reported for four categories of managed lands: Forest Land, Cropland, Wetlands, and Settlements.

The Forest Land category includes GHG emissions from and removals by Canada's managed forests. Managed forests display the highest interannual variability of all categories and exert an overriding influence on the net sectoral GHG balance and trend (Table 3.3). The net GHG flux reflects the difference between carbon uptake by tree growth and emissions due to anthropogenic and natural disturbances, specifically forest management activities, wildfires and insect infestations. The high variability in the net flux from managed forests is associated with the immediate impact of wildfires, which alone accounted for annual emissions of between 11 Mt and 264 Mt over the period from 1990 to 2011.

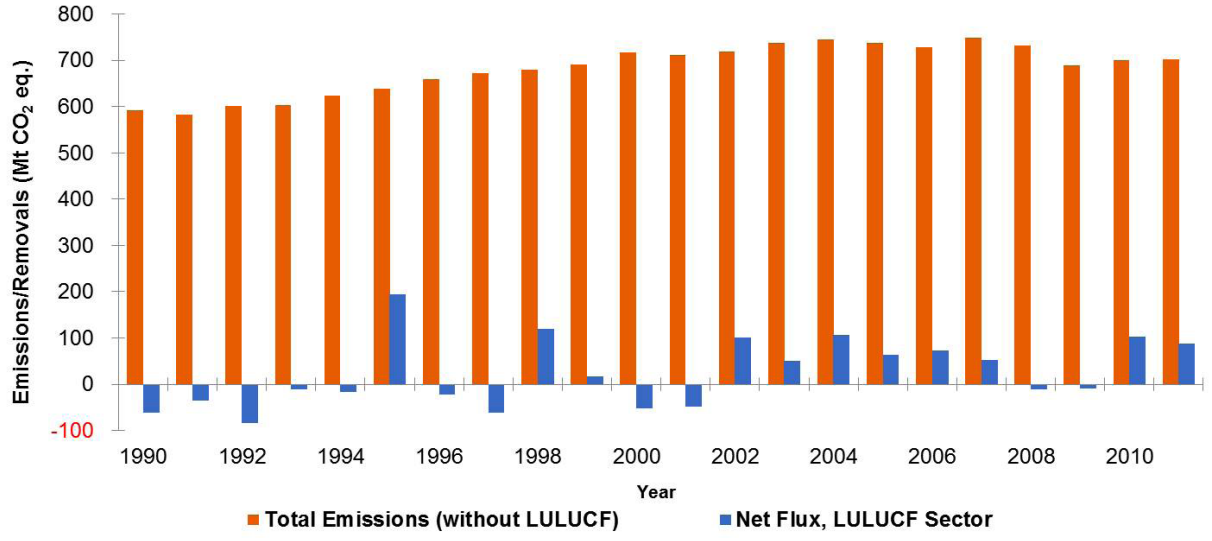

Figure 3.11 GHG Emissions from LULUCF Relative to Total Canadian Emissions (1990–2011)

Table 3.3 LULUCF Sector Net GHG Flux Estimates (1990–2011)

Sectoral Category		Net GHG Flux (kt CO2 eq)[4]							
		1990	2000	2005	2007	2008	2009	2010	2011
Land Use, Land-use Change and Forestry TOTAL[1]		**-62 000**	**-52 000**	**63 000**	**52 000**	**-11 000**	**-10 000**	**103 000**	**87 000**
a.	**Forest Land**	**-88 000**	**-64 000**	**54 000**	**45 000**	**-18 000**	**-15 000**	**99 000**	**83 000**
	Forest Land Remaining Forest Land	-87 000	-63 000	55 000	46 000	-17 000	-14 000	99 000	84 000
	Land Converted to Forest Land	-1 000	-1 000	- 900	- 900	- 800	- 800	- 700	- 700
b.	**Cropland**	**12 000**	**40**	**-4 100**	**-5 700**	**-6 500**	**-6 900**	**-7 600**	**-8 000**
	Cropland Remaining Cropland	-2 000	-7 000	-10 000	-11 000	-12 000	-12 000	-13 000	-13 000
	Land Converted to Cropland	13 000	7 000	6 000	5 700	5 300	5 500	5 300	5 300
c.	**Grassland**	**NE, NO**	**NE, NO**	**NE, NO**	**NE, NO**	**NE, NO**	**NE, NO**	**NE, NO**	**NE, NO**
	Grassland Remaining Grassland	NE	NE	NE	NE	NE	NE	NE	NE
	Land Converted to Grassland	NO	NO	NO	NO	NO	NO	NO	NO
d.	**Wetlands**	**5 000**	**3 000**	**3 000**	**3 000**	**3 000**	**3 000**	**3 000**	**3 000**
	Wetlands Remaining Wetlands	1 000	2 000	2 000	2 000	2 000	2 000	2 000	2 000
	Land Converted to Wetlands	4 000	800	1 000	700	800	800	700	700
e.	**Settlements**	**9 000**	**8 000**	**9 000**	**10 000**	**10 000**	**9 000**	**9 000**	**9 000**
	Settlements Remaining Settlements	- 100	- 200	- 200	- 200	- 200	- 200	- 200	- 200
	Land Converted to Settlements	9 000	9 000	10 000	10 000	10 000	10 000	10 000	10 000
	Forest conversion (memo item)[2]	26 000	20 000	20 000	20 000	20 000	19 000	19 000	19 000
	Grassland conversion (memo item)[2,3]	300	200	200	200	200	200	200	200

Notes:

1. Totals may not add up due to rounding. Annex 9 describes the rounding protocol.
2. Already included in land converted to cropland, land converted to wetlands, and land converted to settlements; and in cropland remaining cropland and wetlands remaining wetlands (for residual emissions post-20 years, 10 years for reservoirs).
3. Includes conversion of agricultural grassland to cropland and of tundra to settlement.
4. Negative sign indicates net removals of CO2 from the atmosphere.

NE = Not estimated, NO=Not Occuring

Important trends associated with human activities in managed forests include a 28% increase in the carbon removed in harvested wood biomass between 1990 and the peak harvest year, 2004. Since then, significant reductions in forest management activities have occurred, with a 33% decline in harvest levels in 2011, which in 2009 reached their lowest point for the 22 year period (30 Mt of carbon). This trend reflects a deep restructuring of the Canadian forest economic sector, aggravated by the consequences of the economic recession in the United States, Canada's main export market.

Note that the Forest Land estimates reflect the assumption that all carbon transferred out of forests in the form of wood products is deemed an immediate emission, i.e., the estimates do not incorporate the long-term carbon storage in Harvested Wood Products (HWP). In general, incorporating the delay in emissions due to carbon storage in commodities more accurately reflects when emissions occur. The difference in Forest Land estimates due to a more realistic HWP estimation approach is not constant over time.[6] The impact is larger at the beginning of the time series and decreases over time, which is expected since the HWP pool starts in 1990 and at that time contains no carbon from historically produced commodities. Over time, carbon accumulates in the pool of HWP in use, and so emissions from the pool increase (from 58 Mt CO_2 in 1990 to about 100 Mt CO_2 in 2011).

The Cropland subcategory includes the effect of agricultural practices on CO_2 emissions from, and removals by, arable soils and the immediate and long-term impacts of Forest and Grassland conversion to Cropland. The steady decline in emissions from Cropland is noteworthy, from 12 Mt CO_2 eq in 1990 to a net removal of 8 Mt CO_2 eq in 2011. This pattern largely

results from changing agricultural land management practices in western Canada, such as the extensive adoption of conservation tillage practices (over 13 million hectares of cropland since 1990), reduction in summerfallow by more than 68% and an increase in perennial forage crops. The net CO_2 removals due to the management of mineral soils increased from about 2.1 Mt in 1990 to 14 Mt in 2011. A decline in Forest Land conversion to Cropland has also contributed to this trend in emissions/removals.

3.4 Uncertainties

National GHG inventories strive for accuracy, completeness, comparability, transparency, and consistency. In spite of constant efforts towards these objectives, estimates will always inherently carry some uncertainty. Uncertainties in the inventory estimates may be caused by systematic model uncertainty or by random uncertainties present within the input parameters and activity data. While reducing model uncertainty requires in-depth reviews of the estimation models, random uncertainties may be reduced by improvements to the activity data, emission factors and other model parameters. The primary purpose of quantitative uncertainty information is to set priorities to improve the accuracy of future inventories and to guide decisions about which methods to use. Typically, the uncertainties associated with the trends and the national totals are much lower than those associated with individual gases and sectors.

The overall level of uncertainty of Canada's national inventory (without LULUCF), as reported in the most recent NIR submission (2013) lie within an uncertainty range of 674 Mt CO_2 eq to 730 Mt CO_2 eq (±4). These results are consistent with those published in previous submissions, which ranged from 3% to +6%. The Energy Sector had the lowest uncertainty, at ±3%, while the Agriculture Sector had the highest uncertainty, at ±39%. The Industrial Processes, the Solvent and Other Product Use, and the Waste Sectors had uncertainties of ±8.2, ±19 and ±34%, respectively. The emission source categories that made the largest contributions to uncertainty at the national level when LULUCF is not included were:

- Agriculture—indirect N_2O emissions from agricultural soils;
- Energy—fuel combustion—public electricity and heat combustion, CO_2;
- Energy—fuel combustion—other (off-road) transportation, N_2O;
- Waste—solid waste disposal on land, CH_4; and
- Agriculture—direct N_2O emissions from agricultural soils.

The national emission estimate including LULUCF emissions and removals of 789 Mt CO_2 eq lies within an uncertainty range of 673 Mt CO_2 eq to 905 Mt CO_2 eq (±15%). Uncertainty is high for LULUCF estimates because emissions are primarily driven by highly variable natural disturbance factors. The top five contributors influencing the national uncertainty when LULUCF is included were:

- LULUCF—forest land, CO_2;
- Agriculture—indirect agricultural soils, N_2O;
- Energy—fuel combustion—public electricity and heat combustion, CO_2;
- Energy—fuel combustion—other (off-road) transportation, N_2O; and
- Waste—solid waste disposal on land, CH_4.

3.5 National Inventory Arrangements

Canada has established a national system to ensure the integrity of its annual inventory. Canada's national system for the estimation of anthropogenic emissions from sources and removals by sinks of all GHGs not controlled by the Montreal Protocol encompasses the institutional, legal, and procedural arrangements necessary to ensure that Canada meets its reporting obligations.

The national system consists of institutional arrangements for the preparation of the inventory, including: formal agreements supporting data collection

and estimate development; a quality assurance/quality control plan; the ability to identify key categories and generate quantitative uncertainty analysis; a process for performing recalculations for improvement of the inventory; procedures for official approval; and, a working archives system to facilitate third-party review.

The national entity responsible for Canada's national inventory system is the Pollutant Inventories and Reporting Division of Environment Canada. The National Inventory Focal Point is:

Director
Pollutant Inventories and Reporting Division
Science and Risk Assessment Directorate
Science and Technology Branch
Environment Canada
10th Floor, 200 Sacré-Coeur Boulevard
Gatineau QC K1A 0H3

3.5.1 Institutional, Legal, and Procedural Arrangements

The *Canadian Environmental Protection Act, 1999* (CEPA 1999) provides the legislative authority for Environment Canada to implement a national inventory system; CEPA 1999 also provides the authority under which Environment Canada's Pollutant Inventories and Reporting Division is responsible for preparing and submitting the national inventory to the UNFCCC.[7]

Numerous organizations contribute to the development of Canada's national inventory (Figure 3.12) and the Pollutant Inventories and Reporting Division is involved in many partnerships with data providers and expert contributors in a variety of ways, ranging from informal to formal arrangements. Currently, partnerships exist between Environment Canada and other government departments such as Statistics Canada, Natural Resources Canada, Transport Canada and Agriculture & Agri-Food Canada. Environment Canada also has arrangements with industry associations and universities, collaborates with provincial and territorial governments on a bilateral basis, and will often commission specific studies to consultants or university researchers. Groups at Environment Canada other than the Pollutant Inventories and Reporting Division also contribute data on waste and waste management, residential fuel use of biomass, and emissions of SF_6, ozone and aerosol precursors.

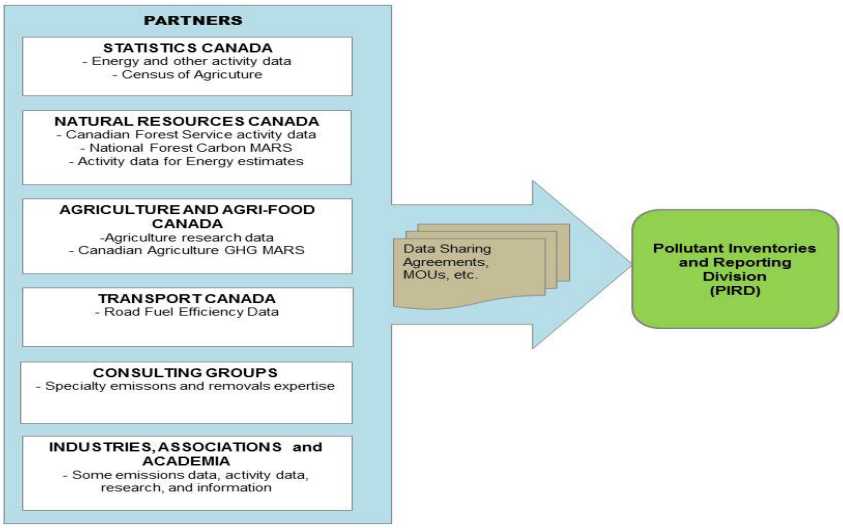

Figure 3.12 Partners of the National System

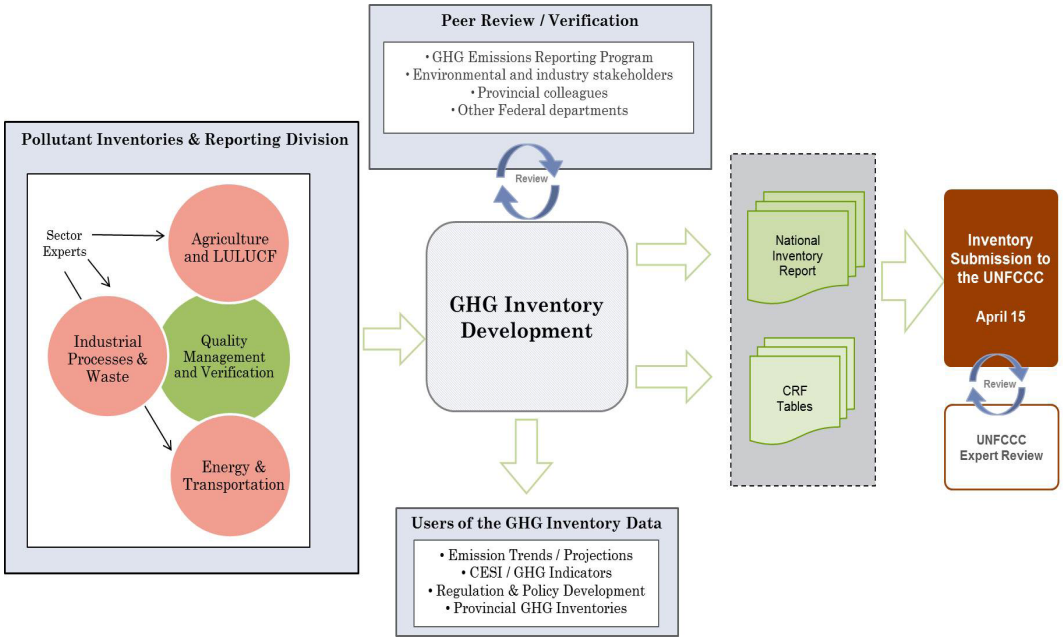

Figure 3.13 Inventory Preparation Process

3.5.2 Process for Inventory Preparation

Recognizing the need to draw on the best available technical and scientific expertise and information in accordance with good practice and international quality standards, Environment Canada has defined roles and responsibilities for the preparation of the inventory, both internally and externally, and has formalized the GHG inventory preparation process (Figure 3.13).

Canada's inventory is developed, compiled, and reported annually by Environment Canada's Pollutant Inventories and Reporting Division, with input from numerous experts and scientists across Canada. Inventory experts in the Division develop, analyze, and verify activity data, methods, emission factors, and the emission and removal estimates. Once the emission and removal estimates are complete, the Division develops, reports, and publishes the NIR and the CRF tables. The Division also manages the quality and the archiving systems, performs trend analysis, and acts as a clearinghouse for greenhouse gas information and technical guidance on greenhouse gas quantification. Moreover, the Pollutant Inventories and Reporting Division manages the Greenhouse Gas Emissions Reporting Program which requires annual reporting from facilities whose emissions exceed the reporting threshold of 50 kt CO_2 eq. The facility data collected under this program serve as an important component of the overall inventory development process in comparing and verifying the inventory estimates.

The inventory is built around a continuous process of methodological improvements, refinements, and review, according to the quality management and improvement plans. The Inventory Coordinator within the Quality Management and Verification section is responsible for preparing the inventory development schedule based on the results of the lessons-learned review of the previous inventory cycle, quality assurance/quality control follow-up, the UNFCCC review report, and collaboration with provincial and territorial governments. These feedbacks are incorporated in the inventory preparation process and the planning of methodological improvements; in any given year a number of improvements are implemented in both the preparation process and

estimation methodologies. Based on these outcomes, methodologies and emission factors are reviewed, developed, and/or refined (as appropriate).

For any given inventory reporting cycle, all methodological improvements must be implemented by the end of October. At this time, data are collected from the source agencies and are entered into spreadsheet-based emission estimation systems, databases, and/or models. Between November and January, draft estimates are calculated by the inventory experts and subsequently internally reviewed. During February, the NIR text and CRF tables are prepared according to UNFCCC guidelines. Quality control checks and estimates are signed off by sectoral managers before the report and national totals are prepared. The inventory preparation process also involves key category assessment, recalculations, uncertainty calculation, and documentation preparation.

Over the months of February and March, the compiled inventory is reviewed internally. Some components are externally reviewed by experts, government agencies, and provincial and territorial governments, after which the NIR is fully edited. Comments from the reviews are documented and, where appropriate, incorporated in the NIR and CRF, which are normally submitted to the UNFCCC electronically prior to April 15 of each year. Once finalized, the NIR is then translated and made available in French.

3.5.3 Quality Assurance and Quality Control

Quality Assurance (QA) and Quality Control (QC) and verification procedures are an integral part of the preparation of the inventory and are planned and implemented on a continuous basis to improve the transparency, completeness, accuracy, consistency and comparability of inventory estimates.

QC involves a system of routine technical activities to assess and maintain the quality of the inventory as it is being developed. QC activities are completed during each annual inventory preparation cycle and include accuracy checks on data acquisition and calculations, the use of standardized procedures for emission and removal calculations, measurements, estimating uncertainties, archiving information, and reporting. QC activities also include technical reviews of categories, activity data, emission factors, other estimation parameters, and methods. QA is a planned system of review procedures conducted by independent experts and is performed independently from QC procedures. QA reviews help to ensure that the inventory represents the best possible estimates of emissions and removals given the current state of scientific knowledge and data availability, and supports the effectiveness of the QC program.

The documentation of QA/QC procedures is at the core of the national system. Standard checklists are used for the consistent, systematic documentation of all QA/QC activities in the annual inventory preparation and submission and the checklists are archived along with other procedural and methodological documentation, by inventory category and by submission year. The Pollutant Inventories and Reporting Division also coordinates QA/QC activities with outside agencies and organizations providing activity data and/or developing GHG emission and removal estimates for Environment Canada.

In addition to QA/QC procedures performed by the Division, the inventory is also reviewed on an annual basis. Initial checks of the April submission are performed by the UNFCCC in May and June and a more in-depth review by an Expert Review Team comprised of international experts and coordinated by the UNFCCC, takes place in September.

3.5.4 Key Categories

A *key category* is one that is prioritized within the national inventory system because its estimate has a significant influence on a country's total inventory of direct GHG emissions in terms of the absolute level of emissions (level assessment), the trend in

emissions from the base year to the current year (trend assessment), or both. As much as possible, two important inventory aspects of key categories should receive special consideration:

- Preferential use of detailed, higher-tier methods; and
- Additional attention with respect to QA/QC.

For the 2013 GHG inventory, level and trend key category assessments were performed according to the Tier 1 approach, as presented in the IPCC Good Practice Guidance.[8,9] The emission and removal categories used for the key category assessment generally follow those in the CRF and the LULUCF CRF; however, they have been aggregated in some cases and are specific to the Canadian inventory.

Major key categories based on the level and trend assessments (including LULUCF) are the fuel combustion categories (Stationary Combustion—Gaseous, Liquid and Solid Fuels, Road Transportation, and Off-road Transport), and the LULUCF category Forest Land Remaining Forest Land.

3.5.5 Process for Recalculations of Estimates

The UNFCCC requires all Annex I Parties to continually improve their national greenhouse gas inventories. Environment Canada consults and works jointly with key federal and provincial partners along with industry stakeholders, research centres and consultants on a continuous basis to improve the quality of the underlying variables and scientific information used in the compilation of the national inventory. As new information and data become available and more accurate methods are developed, previous estimates are updated to provide a consistent and comparable trend in emissions and removals. As such, recalculations are expected to occur annually, reflecting the principle of continuous improvement. The nature, rationale and impact of these recalculations are documented in the NIR and associated CRF tables. Recalculations occur for any number of reasons, including:

- Correction of errors detected by quality control procedures;
- Incorporation of updates to activity data, including changes in data sources;
- Reallocation of estimates to different categories (although this will only affect sub-totals);
- Refinements of methodologies and emission factors;
- Inclusion of categories previously not estimated (which improves inventory completeness); and
- Implementation of recommendations from UNFCCC reviews.

As appropriate, Environment Canada revises and recalculates the emission and removal estimates for all years in the inventory, as good inventory preparation practice requires that methodological improvements and updates be applied to the entire time series of annual estimates (i.e., from 1990 to the most recent year reported). A consistent time series is required to avoid confounding a methodological change with an actual change in GHG emissions or removals.

Annex I Summary GHG Estimates from Common Reporting Format (CRF) Tables

For purposes of consistency, the CRF tables (Tables 1051 to 1055) have been adapted such that emissions/removals of all gases are treated in a similar manner when comparing totals with and without LULUCF. Due to rounding, values presented in Chapter 3: Canada's GHG Inventory may differ slightly from the values presented below:

Table A.1 Emissions Trends (CO_2) 1990–2011

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011
	(Gg)									
1. Energy	**425,363.31**	**453,252.01**	**524,581.14**	**532,080.64**	**522,051.36**	**545,509.50**	**529,726.01**	**501,501.96**	**510,574.37**	**511,466.86**
A. Fuel Combustion (Sectoral Approach)	413,901.84	438,534.73	508,575.85	516,510.25	505,696.41	529,899.56	513,828.51	486,761.84	496,029.12	496,447.85
1. Energy Industries	142,311.03	148,974.80	193,046.66	190,442.71	184,026.10	190,831.48	178,333.38	163,020.73	162,908.31	151,834.10
2. Manufacturing Industries and Construction	63,604.18	64,513.94	67,950.44	68,056.67	68,788.39	76,870.03	75,462.04	72,285.20	76,775.62	79,580.81
3. Transport	139,058.13	151,482.44	169,732.80	182,490.40	182,184.93	185,670.09	184,765.38	178,378.84	187,022.25	190,083.66
4. Other Sectors	68,760.58	73,429.27	77,715.87	75,431.34	70,589.91	76,400.04	75,152.13	72,993.11	69,244.25	74,880.87
5. Other	167.92	134.28	130.08	89.14	107.08	127.93	115.59	83.97	78.69	68.41
B. Fugitive Emissions from Fuels	11,461.47	14,717.28	16,005.28	15,570.38	16,354.94	15,609.93	15,897.50	14,740.12	14,545.25	15,019.01
1. Solid Fuels	NA,NE	NA,NE	NA,NE	NA,NE	NA,NE	NA,NE	NA,NE	NA,NE	NA,NE	NA,NE
2. Oil and Natural Gas	11,461.47	14,717.28	16,005.28	15,570.38	16,354.94	15,609.93	15,897.50	14,740.12	14,545.25	15,019.01
2. Industrial Processes	**33,442.46**	**37,288.62**	**39,528.16**	**46,376.39**	**49,210.38**	**48,630.99**	**46,296.21**	**40,060.62**	**42,953.34**	**43,651.45**
A. Mineral Products	8,392.68	8,830.32	9,807.95	9,896.17	9,917.97	9,759.19	9,047.20	7,018.41	7,613.50	7,738.58
B. Chemical Industry	4,510.01	5,291.39	5,731.80	5,345.25	5,541.57	5,186.22	5,596.81	5,226.70	5,303.37	5,749.81
C. Metal Production	12,907.61	14,974.75	15,349.05	15,053.40	16,298.18	16,195.92	15,838.22	13,051.65	13,974.46	14,927.03
D. Other Production	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
E. Production of Halocarbons and SF_6										
F. Consumption of Halocarbons and SF_6										
G. Other	7,632.16	8,192.16	8,639.35	16,081.58	17,452.67	17,489.65	15,813.98	14,763.86	16,062.02	15,236.02
3. Solvent and Other Product Use	IE,NA	IE,NA	IE,NA	IE,NA	IE,NA	IE,NA	IE,NA	IE,NA	IE,NA	IE,NA
4. Agriculture										
A. Enteric Fermentation										
B. Manure Management										
C. Rice Cultivation										
D. Agricultural Soils										
E. Prescribed Burning of Savannas										
F. Field Burning of Agricultural Residues										
G. Other										
5. Land Use, Land-Use Change and Forestry[(2)]	**-67,017.60**	**163,187.33**	**-54,626.85**	**53,493.77**	**61,822.44**	**41,332.70**	**-17,885.65**	**-19,900.55**	**84,031.09**	**68,694.38**
A. Forest Land	-92,390.82	147,589.49	-65,904.78	45,548.73	54,433.69	34,736.71	-24,080.51	-24,846.80	79,790.72	65,022.70
B. Cropland	11,372.68	4,336.84	-158.51	-4,283.29	-5,248.97	-5,837.25	-6,715.84	-7,123.49	-7,760.16	-8,149.32
C. Grassland	IE,NA,NE,NO	IE,NA,NE,NO	IE,NA,NE,NO	IE,NA,NE,NO	IE,NA,NE,NO	IE,NA,NE,NO	IE,NA,NE,NO	IE,NA,NE,NO	IE,NA,NE,NO	IE,NA,NE,NO
D. Wetlands	5,272.94	3,220.32	3,174.63	3,066.00	3,012.98	2,816.41	2,865.38	2,795.25	2,692.26	2,668.72
E. Settlements	8,727.59	8,040.67	8,261.80	9,162.32	9,624.74	9,616.83	10,045.31	9,274.48	9,308.27	9,152.27
F. Other Land	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO
G. Other	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE
6. Waste	**507.26**	**575.52**	**533.17**	**497.98**	**485.66**	**469.02**	**505.82**	**487.34**	**491.45**	**495.66**
A. Solid Waste Disposal on Land	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
B. Waste-water Handling										
C. Waste Incineration	507.26	575.52	533.17	497.98	485.66	469.02	505.82	487.34	491.45	495.66
D. Other	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
7. Other ***(as specified in Summary 1.A)***	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**
Total CO_2 emissions including net CO_2 from LULUCF	**392,295.43**	**654,303.48**	**510,015.61**	**632,448.78**	**633,569.84**	**635,942.22**	**558,642.39**	**522,149.36**	**638,050.26**	**624,308.34**
Total CO_2 emissions excluding net CO_2 from LULUCF	**459,313.03**	**491,116.15**	**564,642.46**	**578,955.01**	**571,747.40**	**594,609.51**	**576,528.04**	**542,049.92**	**554,019.16**	**555,613.97**

IE=Included elsewhere, NA=Not applicable, NE=Not estimated, NO=Not occurring

Note: All footnotes for this table are given at the end of Table A.5

Table A.2 Emissions Trends (CH_4) 1990–2011

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011
	(Gg)									
1. Energy	1,681.83	2,154.27	2,496.83	2,525.37	2,534.45	2,501.75	2,431.68	2,323.32	2,322.46	2,353.07
A. Fuel Combustion (Sectoral Approach)	211.79	215.20	258.93	250.29	245.94	246.81	238.90	227.06	228.01	227.06
1. Energy Industries	76.41	81.25	117.58	111.41	107.91	109.55	101.84	94.54	92.41	89.41
2. Manufacturing Industries and Construction	2.51	2.77	3.10	3.60	3.59	3.68	3.49	3.26	3.27	3.28
3. Transport	32.02	35.37	35.40	32.80	31.20	30.99	29.09	27.45	28.04	29.75
4. Other Sectors	100.84	95.80	102.85	102.47	103.23	102.58	104.47	101.79	104.30	104.62
5. Other	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
B. Fugitive Emissions from Fuels	1,470.04	1,939.07	2,237.89	2,275.08	2,288.51	2,254.95	2,192.78	2,096.26	2,094.44	2,126.00
1. Solid Fuels	104.69	74.22	46.16	47.71	41.98	46.12	44.69	41.02	48.25	47.33
2. Oil and Natural Gas	1,365.34	1,864.85	2,191.74	2,227.37	2,246.53	2,208.82	2,148.09	2,055.24	2,046.19	2,078.67
2. Industrial Processes	**4.72**	**3.86**	**4.22**	**3.39**	**3.36**	**3.38**	**3.06**	**2.63**	**2.65**	**2.65**
A. Mineral Products	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
B. Chemical Industry	4.72	3.86	4.22	3.39	3.36	3.38	3.06	2.63	2.65	2.65
C. Metal Production	IE,NA,NE	IE,NA,NE	IE,NA,NE	IE,NA,NE	IE,NA,NE	IE,NA,NE	IE,NA,NE	IE,NA,NE	IE,NA,NE	IE,NA,NE
D. Other Production										
E. Production of Halocarbons and SF_6										
F. Consumption of Halocarbons and SF_6										
G. Other	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
3. Solvent and Other Product Use										
4. Agriculture	**896.30**	**1,047.80**	**1,091.66**	**1,199.04**	**1,165.44**	**1,133.44**	**1,100.74**	**1,050.54**	**1,016.30**	**986.82**
A. Enteric Fermentation	767.20	909.96	947.19	1,044.82	1,013.67	987.58	963.13	918.42	885.87	856.34
B. Manure Management	122.05	132.08	140.41	152.82	150.26	144.66	136.07	130.59	129.43	129.54
C. Rice Cultivation	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO
D. Agricultural Soils	NA,NE	NA,NE	NA,NE	NA,NE	NA,NE	NA,NE	NA,NE	NA,NE	NA,NE	NA,NE
E. Prescribed Burning of Savannas	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
F. Field Burning of Agricultural Residues	7.06	5.77	4.07	1.40	1.51	1.20	1.54	1.52	1.01	0.93
G. Other	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
5. Land Use, Land-Use Change and Forestry	**158.49**	**899.68**	**71.50**	**270.00**	**320.27**	**304.24**	**200.48**	**295.45**	**562.94**	**545.54**
A. Forest Land	140.65	888.83	60.59	257.40	308.40	292.65	188.34	284.16	551.83	535.12
B. Cropland	13.09	6.34	5.68	5.07	4.89	4.99	4.55	4.92	4.86	4.83
C. Grassland	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO
D. Wetlands	0.31	0.01	NO	1.50	0.15	NO	0.47	0.51	0.46	NO
E. Settlements	4.44	4.50	5.23	6.03	6.82	6.59	7.12	5.85	5.80	5.59
F. Other Land	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
G. Other	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE
6. Waste	**845.85**	**884.99**	**884.71**	**943.05**	**965.25**	**952.25**	**945.40**	**954.14**	**963.39**	**969.96**
A. Solid Waste Disposal on Land	830.36	868.86	870.77	928.85	950.86	937.72	930.71	939.35	948.44	954.87
B. Waste-water Handling	15.04	15.76	13.87	14.11	14.30	14.43	14.58	14.68	14.84	14.98
C. Waste Incineration	0.46	0.37	0.07	0.09	0.09	0.10	0.11	0.11	0.11	0.12
D. Other	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
7. Other *(as specified in Summary 1.A)*	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**
Total CH_4 emissions including CH_4 from LULUCF	**3,587.21**	**4,990.61**	**4,548.92**	**4,940.85**	**4,988.78**	**4,895.06**	**4,681.37**	**4,626.08**	**4,867.74**	**4,858.04**
Total CH_4 emissions excluding CH_4 from LULUCF	**3,428.71**	**4,090.93**	**4,477.42**	**4,670.85**	**4,668.51**	**4,590.82**	**4,480.88**	**4,330.63**	**4,304.80**	**4,312.50**

IE=Included elsewhere, NA=Not applicable, NE=Not estimated, NO=Not occurring

Note: All footnotes for this table are given at the end of Table A.5

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011
	(Gg)									
1. Energy	**27.43**	**33.22**	**40.19**	**39.43**	**37.48**	**37.79**	**36.79**	**32.74**	**34.81**	**34.58**
A. Fuel Combustion (Sectoral Approach)	27.33	33.10	40.07	39.31	37.35	37.67	36.66	32.60	34.67	34.45
1. Energy Industries	2.81	2.98	3.90	3.97	3.87	3.97	3.91	3.65	3.84	3.69
2. Manufacturing Industries and Construction	2.00	2.22	2.48	2.86	2.83	2.93	2.80	2.64	2.71	2.76
3. Transport	20.26	25.48	31.14	29.97	28.21	28.21	27.37	23.82	25.64	25.39
4. Other Sectors	2.26	2.42	2.56	2.50	2.44	2.55	2.58	2.50	2.48	2.61
5. Other	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
B. Fugitive Emissions from Fuels	0.10	0.11	0.12	0.12	0.12	0.12	0.13	0.14	0.14	0.13
1. Solid Fuels	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO
2. Oil and Natural Gas	0.10	0.11	0.12	0.12	0.12	0.12	0.13	0.14	0.14	0.13
2. Industrial Processes	**37.87**	**37.87**	**6.90**	**12.61**	**7.91**	**8.50**	**11.93**	**5.87**	**3.58**	**3.78**
A. Mineral Products	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
B. Chemical Industry	37.87	37.87	6.90	12.61	7.91	8.50	11.93	5.87	3.58	3.78
C. Metal Production	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
D. Other Production										
E. Production of Halocarbons and SF_6										
F. Consumption of Halocarbons and SF_6										
G. Other	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
3. Solvent and Other Product Use	0.58	0.69	1.45	1.22	1.06	1.05	1.10	0.84	0.78	0.80
4. Agriculture	**90.02**	**98.92**	**105.57**	**106.27**	**106.04**	**109.16**	**114.47**	**109.91**	**110.55**	**107.10**
A. Enteric Fermentation										
B. Manure Management	10.19	12.07	12.92	13.99	13.68	13.44	13.17	12.64	12.31	11.85
C. Rice Cultivation										
D. Agricultural Soils	79.65	86.70	92.54	92.24	92.32	95.69	101.27	97.23	98.21	95.22
E. Prescribed Burning of Savannas	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
F. Field Burning of Agricultural Residues	0.18	0.15	0.11	0.04	0.04	0.03	0.04	0.04	0.03	0.02
G. Other	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
5. Land Use, Land-Use Change and Forestry	**6.65**	**37.83**	**3.01**	**11.36**	**13.48**	**12.80**	**8.43**	**12.43**	**23.68**	**22.96**
A. Forest Land	5.89	37.37	2.55	10.83	12.97	12.30	7.91	11.95	23.21	22.50
B. Cropland	0.59	0.30	0.27	0.25	0.24	0.24	0.23	0.24	0.24	0.24
C. Grassland	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO
D. Wetlands	0.01	0.00	NO	0.06	0.01	NO	0.02	0.02	0.02	NO
E. Settlements	0.16	0.16	0.19	0.22	0.26	0.25	0.27	0.22	0.22	0.21
F. Other Land	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
G. Other	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
6. Waste	**2.38**	**2.70**	**2.71**	**2.76**	**2.75**	**2.76**	**2.81**	**2.78**	**2.81**	**2.84**
A. Solid Waste Disposal on Land										
B. Waste-water Handling	1.66	1.84	2.03	2.10	2.12	2.17	2.15	2.16	2.19	2.21
C. Waste Incineration	0.72	0.85	0.69	0.66	0.63	0.59	0.66	0.62	0.63	0.63
D. Other	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
7. Other *(as specified in Summary 1.A)*	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**
Total N_2O emissions including N_2O from LULUCF	**164.92**	**211.21**	**159.83**	**173.64**	**168.72**	**172.07**	**175.53**	**164.58**	**176.22**	**172.06**
Total N_2O emissions excluding N_2O from LULUCF	**158.27**	**173.39**	**156.82**	**162.28**	**155.24**	**159.27**	**167.10**	**152.15**	**152.54**	**149.10**

IE=Included elsewhere, NA=Not applicable, NE=Not estimated, NO=Not occurring

Note: All footnotes for this table are given at the end of Table A.5

Table A.4 Emissions Trends (HFCs, PFCs and SF_6) 1990–2011

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011
	(Gg)									
Emissions of HFCs[3] - (Gg CO_2 equivalent)	**767.25**	**479.41**	**2,936.12**	**5,296.47**	**5,105.86**	**5,483.71**	**5,550.65**	**6,306.34**	**7,072.55**	**7,526.83**
HFC-23	0.07	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
HFC-32	NA,NO	0.00	0.00	0.01	0.04	0.06	0.07	0.09	0.11	0.12
HFC-41	NA,NO	NA,NE,NO	IE,NA,NO	IE,NA,NO	IE,NA,NO	IE,NA,NO	IE,NA,NO	IE,NA,NO	IE,NA,NO	IE,NA,NO
HFC-43-10mee	NA,NO	NA,NE,NO	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
HFC-125	NA,NO	0.02	0.18	0.36	0.33	0.34	0.39	0.46	0.52	0.57
HFC-134	NA,NO	NA,NE,NO	IE,NA,NO	IE,NA,NO	IE,NA,NO	IE,NA,NO	0.00	0.00	0.00	0.00
HFC-134a	NA,NO	0.28	1.42	2.26	2.32	2.62	2.44	2.64	2.96	3.06
HFC-152a	NA,NO	0.00	0.26	0.64	0.30	0.18	0.13	0.32	0.66	0.83
HFC-143	NA,NO	NA,NE,NO	IE,NA,NO	IE,NA,NO	IE,NA,NO	IE,NA,NO	IE,NA,NO	IE,NA,NO	IE,NA,NO	IE,NA,NO
HFC-143a	NA,NO	0.01	0.14	0.33	0.28	0.28	0.32	0.38	0.42	0.46
HFC-227ea	NA,NO	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
HFC-236fa	NA,NO	NA,NE,NO	IE,NA,NO	IE,NA,NO	IE,NA,NO	IE,NA,NO	IE,NA,NO	IE,NA,NO	IE,NA,NO	IE,NA,NO
HFC-245ca	NA,NO	NA,NE,NO	IE,NA,NE,NO	IE,NA,NE,NO	IE,NA,NE,NO	IE,NA,NO	IE,NA,NE,NO	IE,NA,NE,NO	IE,NA,NE,NO	IE,NA,NE,NO
Unspecified mix of listed HFCs[4] - (Gg CO_2 equivalent)	NA,NO	NA,NE,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO
Emissions of PFCs[3] - (Gg CO_2 equivalent)	**6,538.83**	**5,489.59**	**4,311.08**	**3,317.26**	**2,583.90**	**2,193.70**	**2,252.32**	**2,171.97**	**1,607.49**	**1,450.89**
CF_4	0.91	0.76	0.59	0.46	0.36	0.30	0.31	0.30	0.22	0.20
C_2F_6	0.07	0.06	0.05	0.04	0.03	0.02	0.02	0.02	0.02	0.02
C_3F_8	NA,NE,NO	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
C_4F_{10}	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO
c-C_4F_8	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	0.00	0.00	0.00	0.00
C_5F_{12}	NA,NE,NO	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
C_6F_{14}	NA,NE,NO	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Unspecified mix of listed PFCs[4] - (Gg CO_2 equivalent)	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO
Emissions of SF_6[3] - (Gg CO_2 equivalent)	**3,392.20**	**2,395.56**	**3,051.86**	**1,492.14**	**1,595.90**	**771.98**	**683.95**	**393.06**	**462.24**	**415.29**
SF_6	0.14	0.10	0.13	0.06	0.07	0.03	0.03	0.02	0.02	0.02

IE=Included elsewhere, NA=Not applicable, NE=Not estimated, NO=Not occurring

Note: All footnotes for this table are given at the end of Table A.5

Table A.5 Emissions Trends Summary (CO_2 equivalent) 1990–2011

GREENHOUSE GAS EMISSIONS	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011
	CO_2 equivalent (Gg)									
CO_2 emissions including net CO_2 from LULUCF	392,295.43	654,303.48	510,015.61	632,448.78	633,569.84	635,942.22	558,642.39	522,149.36	638,050.26	624,308.34
CO_2 emissions excluding net CO_2 from LULUCF	459,313.03	491,116.15	564,642.46	578,955.01	571,747.40	594,609.51	576,528.04	542,049.92	554,019.16	555,613.97
CH_4 emissions including CH_4 from LULUCF	75,331.34	104,802.77	95,527.37	103,757.79	104,764.35	102,796.18	98,308.76	97,147.64	102,222.51	102,018.82
CH_4 emissions excluding CH_4 from LULUCF	72,002.96	85,909.47	94,025.84	98,087.81	98,038.65	96,407.19	94,098.57	90,943.19	90,400.78	90,562.54
N_2O emissions including N_2O from LULUCF	51,126.25	65,475.92	49,546.19	53,829.90	52,302.00	53,340.78	54,415.48	51,019.46	54,629.21	53,338.12
N_2O emissions excluding N_2O from LULUCF	49,065.08	53,749.55	48,613.73	50,308.15	48,124.33	49,373.88	51,802.20	47,165.70	47,287.06	46,221.70
HFCs	767.25	479.41	2,936.12	5,296.47	5,105.86	5,483.71	5,550.65	6,306.34	7,072.55	7,526.83
PFCs	6,538.83	5,489.59	4,311.08	3,317.26	2,583.90	2,193.70	2,252.32	2,171.97	1,607.49	1,450.89
SF_6	3,392.20	2,395.56	3,051.86	1,492.14	1,595.90	771.98	683.95	393.06	462.24	415.29
Total (including LULUCF)	**529,451.29**	**832,946.73**	**665,388.23**	**800,142.33**	**799,921.85**	**800,528.58**	**719,853.55**	**679,187.83**	**804,044.25**	**789,058.29**
Total (excluding LULUCF)	**591,079.35**	**639,139.72**	**717,581.11**	**737,456.83**	**727,196.04**	**748,839.98**	**730,915.73**	**689,030.17**	**700,849.29**	**701,791.22**

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011
	CO_2 equivalent (Gg)									
1. Energy	469,186.20	508,788.47	589,473.78	597,336.61	586,892.94	609,761.78	592,195.74	560,441.65	570,137.09	571,601.41
2. Industrial Processes	55,978.49	57,472.54	52,054.26	60,461.41	61,018.70	59,787.20	58,545.80	50,805.78	53,262.13	54,271.29
3. Solvent and Other Product Use	178.71	212.58	449.60	378.00	329.36	326.32	341.62	260.49	241.97	247.40
4. Agriculture	46,728.50	52,669.69	55,650.44	58,122.92	57,345.56	57,641.84	58,602.62	56,134.71	55,612.85	53,924.99
5. Land Use, Land-Use Change and Forestry[5]	-61,628.06	193,807.01	-52,192.87	62,685.50	72,725.80	51,688.60	-11,062.19	-9,842.34	103,194.97	87,267.07
6. Waste	19,007.45	19,996.44	19,953.02	21,157.90	21,609.48	21,322.84	21,229.94	21,387.55	21,595.25	21,746.13
7. Other	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Total (including LULUCF)[6]	**529,451.29**	**832,946.73**	**665,388.23**	**800,142.33**	**799,921.85**	**800,528.58**	**719,853.55**	**679,187.83**	**804,044.25**	**789,058.29**

IE=Included elsewhere, NA=Not applicable, NE=Not estimated, NO=Not occurring

(1) The column "Base year" should be filled in only by those Parties with economies in transition that use a base year different from 1990 in accordance with the relevant decisions of the COP. For these Parties, this different base year is used to calculate the percentage change in the final column of this table.

(2) Fill in net emissions/removals as reported in table Summary 1.A. For the purposes of reporting, the signs for removals are always negative (-) and for emissions positive (+).

(3) Enter actual emissions estimates. If only potential emissions estimates are available, these should be reported in this table and an indication for this be provided in the documentation box. Only in these rows are the emissions expressed as CO_2 equivalent emissions.

(4) In accordance with the UNFCCC reporting guidelines, HFC and PFC emissions should be reported for each relevant chemical. However, if it is not possible to report values for each chemical (i.e. mixtures, confidential data, lack of disaggregation), this row could be used for reporting aggregate figures for HFCs and PFCs, respectively. Note that the unit used for this row is Gg of CO_2 equivalent and that appropriate notation keys should be entered in the cells for the individual chemicals.

(5) Includes net CO_2, CH_4 and N_2O from LULUCF.

References

1 "Fossil fuel industries" comprise the sum of the subsectors of Mining and Oil and Gas Extraction, Fossil Fuel Production and Refining, Pipelines (Transportation) and Fugitive Releases.

2 The "Transport" subsector refers to Transportation minus Pipelines.

3 "Manufacturing" includes the Manufacturing Industries subsector (in the Energy Sector) and the Industrial Processes Sector.

4 The "Energy Industries" is a Common Reporting Format subsector, required to be reported on by the UNFCCC. "Energy Industries" includes Electricity and Heat Generation, Petroleum Refining and Upgrading, and Fossil Fuel Production. This is the "fossil fuel industries" (referred to in section 3.3), plus Electricity and Heat Generation, minus Fugitive releases.

5 "Other" includes Residential, Commercial and Institutional buildings, and Agriculture and Forestry.

6 Environment Canada. 2013. National Inventory Report: Greenhouse Gas Sources and Sinks in Canada, 1990–2011. Part 1, Chapter 7 (Table 7–5), p. 178. Available online at: http://www.ec.gc.ca/ges-ghg

7 Canada. 1999. Canadian Environmental Protection Act, 1999. S.C., 1999, c. 33. Canada Gazette. Part III, vol. 22, no. 3. Available online at http://www.gazette.gc.ca/archives/p3/1999/index-eng.html

8 Intergovernmental Panel on Climate Change. 2000. Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories. Available online at www.ipccnggip.iges.or.jp/public/gp/english/

9 Intergovernmental Panel on Climate Change. 2003. Good Practice Guidance for Land Use, Land-use Change and Forestry. Available online at www.ipcc-nggip.iges.or.jp/public/gpglulucf/gpglulucf.htm

4 Policies and Measures

4.1 Overall Policy Context

The Policies and Measures chapter outlines climate change mitigation actions taken by the Government of Canada, as well as key actions by provincial and territorial governments.

In the context of the Copenhagen Accord of 2009, and the subsequent Cancun Agreements of 2010, Canada committed to reduce its national greenhouse gas (GHG) emissions by 17% from 2005 levels by 2020.

As its contribution to meeting this target, the Government of Canada's climate change plan involves regulating GHG emissions on a sector-by-sector basis. The Government of Canada has already begun to implement this climate change plan starting with two of the largest sources of GHG emissions in this country—the transportation and electricity sectors. Building on this record, the Government of Canada is working with provinces to reduce emissions from the oil and gas sectors while ensuring Canadian companies remain competitive.

Provincial and territorial governments are also taking meaningful action on climate change according to their own circumstances (see section 4.5).

4.2 Policy Making Process

Within the Government of Canada, the Minister of the Environment is the lead minister for domestic and international climate change policies. Natural Resources Canada, Transport Canada and other federal departments are also involved in the development and implementation of climate change policies and measures.

As previously described in Chapter 2: National Circumstances, the environment is an area of concurrent jurisdiction in Canada and governments have taken action according to their respective authorities. Aside from a few exceptions, natural resources, including energy, are under provincial jurisdiction.

It is within this context that Canadian federal, provincial and territorial governments have adopted action plans to address climate change. These plans include legislative and regulatory measures, tax measures, fiscal mechanisms, incentives to reduce GHG emissions, as well as measures to address climate change impacts and adaptation.

The Government of Canada uses both bilateral and multilateral fora to develop its sector-by-sector regulatory approach. Working groups with provinces and territories have been established for several sectors (e.g., iron and steel, and chemical and fertilizers sectors).

4.2.1 Description of Inter-Jurisdictional Decision-Making Bodies

Most federal departments have direct links with their counterparts in provinces or with provincial departments with related interests. Federal-provincial meetings happen throughout the year at all levels, from the working level through to Ministerial level.

Federal/Provincial/Territorial Ministers with common interests or portfolios are often organized in councils such as the Canadian Council of Fisheries and Aquaculture Ministers and the Canadian Parks Ministers' Council. These councils meet on a regular basis, ensuring sharing of information and best-practices.

Federal/Provincial/Territorial discussions related to climate change could take place under the following councils:

- The Canadian Council of Ministers of the Environment;

- The Canadian Council of Forest Ministers; and
- The Energy and Mines Ministers' Conference.

Detailed descriptions of these councils can be found in Canada's 5th National Communication.

4.2.2 Federal Legislative Instruments

4.2.2.1 *The Canadian Environmental Protection Act, 1999*

The *Canadian Environmental Protection Act, 1999* (CEPA 1999) allows the Government of Canada to take action to protect the environment and human health in order to contribute to sustainable development. The Act includes authorities to regulate various aspects related to releases of greenhouse gases, including setting the quantity or concentration of a greenhouse gas that may be released from various types of facilities, or from vehicles, engines and equipment. Under these authorities, regulatees may be required to maintain records and conduct sampling or monitoring, and then report these results and compliance information to the Minister of the Environment.

While regulations made under CEPA 1999 apply across the country, there are provisions in CEPA 1999 that allow for avoidance of overlap and duplication between the federal and provincial, territorial or Aboriginal governments (as defined under CEPA 1999). If a province, territory or Aboriginal government has a regulation in place that is equivalent to one made under certain authorities in CEPA 1999, an agreement with that jurisdiction and the federal government can be concluded. The Governor-in-Council can then choose to make an order declaring that the federal regulation will not apply in that jurisdiction. A draft equivalency agreement has been developed with the Province of Nova Scotia on regulations for limiting carbon dioxide (CO_2) from coal-fired power plants.

4.2.2.2 *The Energy Efficiency Act, 1992*

The *Energy Efficiency Act, 1992* gives the Government of Canada the authority to promote energy efficiency; to make and enforce regulations that prescribe standards and labelling requirements for energy-using products and products that affect energy use that are imported to Canada or shipped across provincial borders for lease or sale; and to collect data on energy use. Pursuant to the *Energy Efficiency Act, 1992*, Canada's *Energy Efficiency Regulations* came into effect in 1995. Since then, the Regulations have been amended a number of times to introduce new performance standards on products used in homes and businesses in Canada.

Stringency levels and other aspects of the energy efficiency standards are reported annually in Natural Resources Canada's *Improving Energy Performance in Canada: Report to Parliament under the Energy Efficiency Act*. To monitor compliance with the Regulations, Natural Resources Canada captures information from energy efficiency reports and import documents. The department confirms that all products entering Canada meet the required energy performance levels and can take action in the event of non-compliance.

4.2.2.3 *Canada Shipping Act, 2001*

Given the global nature of the marine transportation sector, standards for shipping are generally made at the international level. The International Maritime Organization is the United Nations' specialized agency that sets global standards for safety and security of shipping and to prevent pollution by vessels. Transport Canada leads the Government of Canada's participation at the International Maritime Organization, which is active in developing standards and approaches to limit or reduce air pollutant and greenhouse gas emissions from international shipping.

Transport Canada administers the *Canada Shipping Act, 2001,* which includes provisions that promote the protection of the marine environment from navigation and shipping activities. The *Canada Shipping Act, 2001* and its regulations are the instruments that implement the International Maritime Organization's energy efficiency and emissions standards in Canada.

4.2.2.4 *Aeronautics Act*

Similar to the shipping sector, standards for air transportation are generally made at the international level. The International Civil Aviation Organization is the United Nations' agency that sets global standards for safety and security of aviation and to prevent pollution by aircraft. The International Civil Aviation Organization is active in developing standards and approaches to limit or reduce air pollutant and greenhouse gas emissions from international aviation. Transport Canada leads the Government of Canada's participation in the International Civil Aviation Organization.

The *Aeronautics Act* and its regulations are Canada's primary instruments for implementing International Civil Aviation Organization environmental standards and practices in Canada.

4.2.2.5 *Railway Safety Act*

The *Railway Safety Act* ensures the safe operation of railways and provides the legislative basis for developing regulations governing rail safety, security and some aspects of the environmental impacts of rail operations in Canada. The *Railway Safety Act* provides the authority for Transport Canada to develop regulations, rules and standards that apply to federally regulated railroads.

4.3 Federal Monitoring and Reporting Mechanisms

The Government of Canada's 2013–2016 Federal Sustainable Development Strategy provides an integrated picture of federal actions to achieve environmental sustainability, including Canada's economy-wide target to reduce its total GHG emissions by 17% from 2005 levels by 2020.

Meeting Canada's 2020 target for GHG emissions is also supported through the federal Strategic Environmental Assessment process, which requires Government of Canada departments and agencies to consider the potential environmental impacts of their proposed policies, plans, and programs, and to assess these impacts on the Federal Sustainable Development Strategy goals and targets, including Canada's GHG emission reduction target.

Progress towards meeting Canada's 2020 target is monitored and reported on through a number of fora. As mentioned in the previous chapter, Canada's *National Inventory Report* (NIR) is submitted annually to the United Nations Framework Convention on Climate Change (UNFCCC) and is a source of information on total historical GHG emissions levels for the country.

Canada's annual *Emissions Trends Report* presents projections of greenhouse gas emissions in Canada to the year 2020 and explains how efforts of federal, provincial and territorial governments, consumers and businesses are having an impact on greenhouse gas emissions. Progress towards meeting Canada's 2020 target is also reported through Canadian Environmental Sustainability Indicators website, and is one of over 30 environmental indicators reported on in Canada's 2012 *Federal Sustainable Development Strategy Progress Report*. As well, additional GHG emissions data is collected through the Facility GHG Reporting Program, which provides a more precise picture of the sources and amounts of GHG emissions from Canada's largest emitters. This GHG tracking program applies to all facilities that emit the equivalent of 50,000 tonnes or more of GHGs in carbon dioxide equivalent (CO_2 eq) units per year.

4.4 Federal Policies and Measures and their Effects

Per the UNFCCC guidelines, the Policies and Measures chapter generally focuses on actions implemented since Canada's 5th National Communication in 2010. Priority has been given to those policies and measures that have the most significant impact in affecting Canada's GHG emissions. To provide additional context, information

is also included on key supporting and complementary Government of Canada measures such as investments in clean energy technologies and initiatives that may be of interest to international audiences. Given the shared jurisdiction for climate change in Canada, the chapter also includes information on the most important provincial and territorial policies and measures.

Table 3 in Canada's 1st Biennial Report (see Annex I of this report) provides more detailed information on the most significant federal, provincial, and territorial policies and measures, including emissions reductions estimates where available.

4.4.1 Regulations under the Sector-By-Sector Approach

The Government of Canada is implementing a sector-by-sector regulatory approach as its contribution to reduce GHG emissions towards Canada's Copenhagen Accord target. The sector-by-sector approach makes it possible to tailor regulations to accommodate sector circumstances, integrating environmental and economic considerations. Regulations are being designed to drive real reductions over the long-term, provide regulatory certainty, drive innovation, and leverage capital stock turnover to avoid lock-in of long-lived high-emitting infrastructure. This approach allows Canada to maximize progress on reducing emissions while maintaining economic competitiveness.

4.4.1.1 Transportation Sector

Light-Duty Vehicle Regulations

On October 13, 2010, the Government of Canada published the *Passenger Automobile and Light Truck Greenhouse Gas Emission Regulations* under CEPA 1999. These Regulations impose increasingly stringent annual GHG emission standards to passenger automobiles and light trucks for the 2011 to 2016 model years. The Regulations provide allowances for improvements not captured during conventional emission testing such as improvements to air-conditioning systems and innovative technologies that have a measurable CO_2 reduction. They also provide flexibility for alternative energy vehicles such as electric and plug-in hybrid electric vehicles.

In 2012, proposed amendments were published to include new increasingly stringent standards for passenger automobiles and light trucks of model years 2017 and beyond. Once the amendments are finalized in 2014, they will build on the Regulations already in place by continuing to establish stringent GHG emission standards for these vehicles. Passenger automobiles and light trucks make up about 13% of Canada's total GHG emissions and it is expected that the cumulative actions will see GHG emissions from 2025 model vehicles fall by up to 50% compared to 2008 model year vehicles. Canada worked closely with the U.S. to develop the Regulations which are aligned with U.S. Environment Protection Agency (EPA) standards.

Heavy-Duty Vehicle Regulations

On March 13, 2013, the *Heavy-Duty Vehicle and Engine Greenhouse Gas Emission Regulations* were published under CEPA 1999. They will apply increasingly stringent emissions standards to new on-road heavy-duty vehicles and engines in Canada for 2014 to 2018 model years that are either imported or manufactured in Canada. These Regulations will reduce emissions from the full range of new on-road heavy-duty vehicles such as full-size pickup trucks, semi-trucks, buses and vocational vehicles such as garbage trucks. These Regulations also provide flexibility to comply with the progressively more stringent emission standards on the basis of "averaging" under the CO_2 emission credit system requirements. To conform to annual requirements, manufacturers can choose the most cost-effective technologies, most of which are readily available. These include aerodynamic devices, high efficiency engines, low rolling resistance tires, weight reductions, and other technology options.

These Regulations will complement the *Passenger Automobile and Light Truck Greenhouse Gas Emission Regulations*. Canada worked closely with the U.S. to develop the Regulations which are aligned with

U.S. EPA standards. It is expected that by 2018, GHG emissions from 2018 model year heavy-duty vehicles will be reduced by up to 23%.

Renewable Fuels Regulations
Canada's national *Renewable Fuels Regulations* require petroleum fuels producers and importers to have an average 5% renewable fuel content for gasoline (as of December 15, 2010), and 2% renewable fuel content in diesel fuel (as of July 1, 2011).

Marine Vessel Fuel Efficiency Regulations
On May 8, 2013, the Government of Canada amended its *Vessel Pollution and Dangerous Chemicals Regulations* to set standards for increased fuel efficiency of marine vessels. These Regulations implement the energy efficiency requirements negotiated under the International Maritime Organization's *International Convention for the Prevention of Pollution from Ships*. The Regulations apply to all ships above 400 gross tonnes. All ships are required to maintain a Ship Energy Efficiency Management Plan that details plans for optimizing fuel efficiency. Additionally, new ships on international trade routes must meet Energy Efficiency Design Index requirements that phase in increasing efficiency targets from 2015 to 2025.

New Canadian ships that serve domestic trade within Canada are currently exempt from the Energy Efficiency Design Index requirements. A technical review found that when the international Energy Efficiency Design Index standard is applied to Canadian ships on domestic service, which are smaller and use shorter routes, the results would reduce the energy efficiency of Canadian ships and increase their CO_2 emissions. The technical review recommended ways to apply the Energy Efficiency Design Index to yield the intended results; Transport Canada plans to implement adjusted domestic Energy Efficiency Design Index standards in the future. Nevertheless, both existing and new Canadian ships must still maintain a Ship Energy Efficiency Management Plan.

Aviation Regulations
The Government of Canada is participating in the development of a new global CO_2 standard for airplanes at the International Civil Aviation Organization. Canada plans to adopt the standard once it has been finalized and approved by the International Civil Aviation Organization.

4.4.1.2 Electricity Sector

Canada's electricity sector is already one of the cleanest in the world, and the Government of Canada has taken steps to make it even cleaner by introducing a tough new regulatory performance standard for coal-fired electricity generation. On September 12, 2012, the Government of Canada published in final form the *Reduction of Carbon Dioxide Emissions from Coal-fired Generation of Electricity Regulations*. The Regulations apply a stringent emissions intensity limit (performance standard) to new coal-fired electricity generation units and to old units that have reached the end of their useful life. The Regulations will ensure that coal-fired electricity generation in Canada operates as cleanly as high efficiency natural gas-fired electricity generation and that no new high-emitting coal-fired electricity units will be built in Canada.

Under the Regulations, the performance standard is set at the emissions intensity level of 420 tonnes CO_2/gigawatt hours (GWh). The standard will address emissions of CO_2 from the combustion of coal, coal derivatives (e.g., syngas) and petroleum coke (petcoke), and from all fuels burned in conjunction with any of the preceding fuel, except for biomass. The Regulations also contain flexibilities to maintain the integrity of the electricity system while still achieving the environmental objective of emission reductions.

The performance standard provisions of the Regulations come into force on July 1, 2015. Any new units commissioned after that date will need to meet the performance standard. In 2020, the first old units will be subject to the performance standard, resulting, in that year, in an estimated emissions reduction

of 3 megatonnes (Mt) CO_2 eq. The Regulations, in addition to other measures and commitments made by industry and provinces, particularly Ontario's mandated cessation of coal-fired electricity generation by the end of 2014, are projected to reduce emissions of carbon dioxide from this sector by 41 Mt below 2005 levels by 2020. This constitutes a 33% reduction in GHG emissions from electricity generation for the year 2020. Significant further reductions will occur in subsequent years. Over the first 21 years, the Regulations are expected to result in a cumulative reduction of about 214 Mt of GHGs, equivalent to removing some 2.6 million personal vehicles from the road per year over this period. In addition to contributing to Canada's climate change objectives, this measure will help improve air quality for Canadians.

4.4.1.3 Oil and Gas Sector

The Government of Canada is working with provinces to reduce emissions from the oil and gas sectors while ensuring Canadian companies remain competitive.

4.4.1.4 Emissions-Intensive and Trade-Exposed Sectors

Environment Canada is developing sector-specific regulatory approaches for other major-emitting industrial sectors.

Emissions-Intensive and Trade-Exposed Industries are broadly characterized as having relatively high emissions per unit produced and exporting a significant portion of their production. These sectors face global competition for market share and have limited ability to pass on costs. As a result, approaches for these sectors must be carefully calibrated to maintain economic competitiveness. Canada classifies the following sectors as Emissions-Intensive and Trade-Exposed Industries: fertilizers (including potash) and chemicals, aluminum/alumina, iron and steel, pulp and paper, cement, base metals smelting, iron ore pelletizing, and lime.

4.4.1.5 Cross-Sectoral Measures

Regulations under the *Energy Efficiency Act*

Regulations under the *Energy Efficiency Act* have now been established for more than forty products, including major household appliances, water heaters, heating and air-conditioning equipment, automatic icemakers, dehumidifiers, dry-type transformers, electric motors, commercial refrigeration and some lighting products.

Natural Resources Canada regularly amends the Regulations to strengthen the minimum energy performance requirements for prescribed products when the market has achieved a higher level of efficiency. The Regulations are also amended to add new products, harmonize minimum energy performance requirements with those of other jurisdictions (e.g., provinces, territories and the U.S.), and update testing methodologies and labelling requirements.

With the introduction of Canada's Energy Efficiency Regulations, placing an EnerGuide label on major electrical household appliances and room air conditioners became mandatory. The label on a product shows how much energy a product uses within the range of products within its category, allowing customers to consider the most energy-efficient choice.

4.4.2 Federal Investments in Clean Energy Technology

The Government of Canada also recognizes the importance of clean technologies for achieving sustainable economic prosperity, while creating a healthier environment. The Government is committed to supporting clean technologies and has made significant investments to transition Canada to a clean energy economy and advance Canada's climate change objectives. Since 2006, the Government has invested over $10 billion in green infrastructure, energy efficiency, the development of clean energy technologies, and the production of cleaner energy and cleaner fuels. Some of these programs include the

ecoENERGY Technology Initiative, ecoENERGY for Renewable Power, the Clean Energy Fund, and the Pulp and Paper Green Transformation Program. A complete list of all relevant measures is provided in Table 3 of Canada's 1st Biennial Report in Annex I of this report.

The Government is also supporting investments in clean energy technologies through tax measures (e.g., the accelerated capital cost allowance for clean energy generation and conservation equipment) and through reforms to its approach to supporting business innovation, including taking a more whole-of-government approach to innovation support, improving coordination and focus for its programs, and strengthening research and development partnerships between academia and industry.

4.4.2.1 Sustainable Development Technology Canada

Sustainable Development Technology Canada (SDTC) is an arm's-length, not-for-profit foundation established through the *Canada Foundation for Sustainable Development Technology Act* (2001) that finances and supports the development and demonstration of clean technologies. The organization reports to Parliament on an annual basis through the Minister of Natural Resources. SDTC manages funds endowed by the Government of Canada and provided under authority of the Minister of Natural Resources and the Minister of the Environment, the most notable being the Sustainable Development Tech Fund.

The Sustainable Development Tech Fund was established in 2001 to support the development and demonstration of new sustainable development technologies with a focus on addressing issues related to climate change, clean air, clean water and clean soil. The Government of Canada has allocated a total of $915 million to this fund, including an injection of $325 million in Budget 2013. To date, the Sustainable Development Tech Fund has allocated $592 million to support 245 projects across Canada, leveraging an additional $1.5 billion, mostly from industry. It has a strong presence in the Canadian clean technology sector and has served as an important catalyst to foster innovative collaborations. One example of a project under this fund is N-Solv Corporation' Bitumen Extraction Solvent Technology. Funding for this project is being used to demonstrate a low-temperature in-situ production technology for bitumen reserves using a pure, condensing solvent. The N-Solv technology is targeted to produce 85% fewer greenhouse gas emissions than current in-situ processes and will reduce the consumption of process water to zero.

SDTC is partnering with Export Development Canada, Canada's export credit agency, to further develop Canada's international capabilities in the clean technology sector by addressing barriers to success for Canadian clean technology firms. Export Development Canada supports projects or transactions involving later-stage SDTC companies by deploying its range of products, including bonding, guarantees, financing and political risk insurance. SDTC in turn shares with Export Development Canada its assessment of technology risks and its assessment of the capacity of portfolio companies to perform in international markets.

While environmental outcomes are an indirect, long-term objective of the organization (the primary objective being to build the capacity of Canadian clean technology entrepreneurs), SDTC-supported projects have yielded environmental benefits, including greenhouse gas emissions reductions. It is projected that SDTC's efforts will have resulted in a total cumulative GHG reduction of 135.8 Mt CO_2 eq (global) by 2020. As of 2012, completed projects are estimated to have yielded a total of 2.1 Mt CO_2 eq.

4.4.2.2 ecoENERGY Innovation Initiative

The ecoENERGY Innovation Initiative is investing up to $268 million over five years (2011–2016) in renewable energy and clean energy technologies. The initiative's objective is to support energy technology innovation to produce and use energy more cleanly and efficiently.

The program will help in the search for long-term solutions to reducing and eliminating GHGs and air pollutants from energy production and use.

The initiative consists of two separate funding streams: one for research and development projects and one for demonstration projects. A portion of the funding from the ecoENERGY Innovation Initiative program is provided to federal researchers and laboratories to continue research and development work.

Activities funded under the program are in five strategic priority areas:

- Energy Efficiency
- Clean Electricity and Renewables
- Bioenergy
- Electrification of Transportation
- Unconventional Oil and Gas

4.4.2.3 Carbon Capture and Storage

Canada has invested heavily in the research, development, and demonstration of carbon capture and storage technologies. Canada's federal and provincial governments have invested over $1.8 billion in funding for carbon capture and storage. Federal funding is provided through a number of programs such as the Clean Energy Fund, the ecoENERGY Innovation Initiative, and the ecoENERGY Technology Initiative. With four large-scale demonstration projects either operational or proceeding with construction, Canada remains a global leader in advancing carbon capture and storage. Canada is also an active member in a number of multilateral initiatives which include a focus on the further development of improved, cost-effective carbon capture and storage technologies such as the Carbon Sequestration Leadership Forum, the Carbon Capture Use and Storage Action Group of the Clean Energy Ministerial, the Global Carbon Capture and Storage Institute, and the Canada–U.S. Clean Energy Dialogue.

The Government of Canada provided, in 2008, $240 million for SaskPower's Boundary Dam carbon capture and storage project, which is set to begin commercial operations in 2014. Once operational, the project will capture up to 1 Mt CO_2 annually from a coal-fired power plant in southern Saskatchewan.

4.4.3 Other Federal Complementary Measures

To complement the regulations under the sector-by-sector approach, and in addition to investments in clean energy technologies mentioned above, the Government of Canada has also put in place a number of non-regulatory measures such as programs targeting energy efficiency and the transportation sector. Moreover, the Government has also introduced measures to enhance the neutrality of the tax system across sectors by phasing out certain tax preferences for the oil and gas and mining sectors (including coal mining). The Government of Canada's conservation efforts also support Canada's climate change objectives by protecting natural heritage features that perform an important carbon-storage function. An example is the six-fold expansion of the Nahanni National Park Reserve which will protect key boreal forest ecosystems.

A cross-section of measures is outlined below for the purposes of illustration. A complete list of relevant measures is provided in Table 3 of Canada's 1st Biennial Report in Annex I of this report.

4.4.3.1 ecoENERGY for Aboriginal and Northern Communities Program

The ecoENERGY for Aboriginal and Northern Communities Program is investing $20 million over five years (2011–2016) to support Aboriginal and northern communities, including off-grid communities, to reduce GHG emissions through the integration of proven renewable energy technologies such as residual heat recovery, biomass, geothermal, wind, solar and small hydro. The program provides funding support for the design and construction of renewable energy projects integrated with community buildings, and for the feasibility stages of larger renewable energy projects, thereby displacing natural gas, coal, and diesel generation of electricity and heat.

The program works collaboratively with communities, federal departments, provincial/territorial governments, utilities and other stakeholders to improve project development opportunities and to increase the uptake of renewable energy technologies in Aboriginal communities and in the North.

4.4.3.2 ecoENERGY Efficiency program

The ecoENERGY Efficiency program is investing $195 million between 2011 and 2016 to improve energy efficiency in Canada—at home, at work, and on the road. Operating in the residential, commercial and institutional, industrial, and transportation sectors, these efforts will: make the housing, building, and equipment stock more energy-efficient through regulations, codes, and standards; make energy performance more visible in all sectors through labelling, benchmarking, training, and information sharing to affect behaviour change; and make industry and vehicle operations more efficient though energy management standards, practices, and training. Improving energy efficiency will contribute to a cleaner environment, reducing GHG emissions while saving Canadians money and making the most of Canada's natural resources.

An example of Natural Resources Canada activity under this program is the *National Energy Code for Buildings* (Code) 2011, which placed Canada on a comparable footing with other countries in energy-efficient building construction. Code 2011 is 25% more stringent than the previous code. Twelve Canadian provinces and territories are adopting Code 2011, or adapting it to their circumstances, and one territory published guidelines that exceed it.

4.4.3.3 Clean Transportation Initiatives

The Government of Canada undertakes research and provides economic incentives to support the adoption of low-emission technologies and practices in the transportation sector. For example, Transport Canada's Shore Power Technology for Ports Program and Truck Reservation System Program provide funding for the deployment of Marine Shore Power technologies and intelligent transportation systems, respectively, at ports.

Transport Canada also tests, evaluates, and provides expert technical information on the environmental and safety performance of advanced light-duty vehicle and heavy-duty vehicle technologies through its ecoTECHNOLOGY for Vehicles Program. The program shares technical findings to inform the development of vehicle emissions regulations; to guide the proactive development of new or revised safety regulations, standards, codes, and guidelines; and to support the development of non-regulatory industry codes and standards to help integrate new vehicle technologies in Canada.

Transport Canada also supports the reduction of GHGs from the transportation sector through agreements with industry. For example, Canada's Action Plan to Reduce Greenhouse Gas Emissions from Aviation is a comprehensive voluntary approach that includes all segments of the Canadian aviation sector, from airlines and airports to air traffic navigation and aircraft manufacturers. The Action Plan sets an aspirational goal to improve fuel efficiency from a 2005 baseline by an average annual rate of at least 2% per year until 2020. The Action Plan forms the basis for the Government of Canada's response to the International Civil Aviation Organization's Assembly Resolution A37-19, which encouraged Member States to submit national action plans by June 2012, setting out measures each state is taking or will take to address international aviation emissions.

With respect to the rail sector, Transport Canada is working under the framework of the Canada–U.S. Regulatory Cooperation Council on a joint voluntary approach with the U.S. Environmental Protection Agency on the development of potential strategies to reduce greenhouse gas emissions from locomotives.

4.4.4 Land Use, Land-use Change and Forestry (LULUCF) Sector

LULUCF is an important sector given Canada's significant share of global forest cover and the central role of agriculture in different regions of the country. Over the last two decades, important changes have occurred in land management practices in Canada that have reduced CO_2 emissions or enhanced their removals from the atmosphere. For example, farmers have increasingly adopted no-till practices and reduced summer fallow practices, thereby increasing the rate of soil carbon sequestration. Improved practices have also been adopted by the forestry sector, primarily as a result of provincial policies and/or regulations. Although these policies and regulations are aimed broadly at improving sustainability in the sector, they can also reduce carbon emissions and increase sequestration. Improved practices 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 adjustment in management practices to reduce soil compaction. Additional information and data on the LULUCF sector can be found in Chapter 3: Canada's Greenhouse Gas Inventory.

4.4.5 Addressing Short-Lived Climate Pollutants

A key element of Canada's approach to climate change includes addressing short-lived climate pollutants such as black carbon, methane and hydrofluorocarbons. Due to their short life span, reducing short-lived climate pollutants can achieve more immediate climate benefits, particularly in the North, as well as important health benefits. To this end, Canada is taking action domestically and internationally to reduce short-lived climate pollutants. For example, Canada is a founding member of, and active participant in the Climate and Clean Air Coalition, a voluntary international framework for concrete action to accelerate efforts to reduce short-lived climate pollutants. Since its launch in February 2012, the Coalition has grown to include over 70 member countries and non-government partners.

In addition, Canada is the current Chair of the Arctic Council (2013–15). During Canada's Chairmanship, a new Task Force, co-chaired by Canada and Sweden, will work towards actions to reduce emissions of black carbon and methane.

Within Canada, measures in place already contribute to reducing short-lived climate pollutants. These include regulations concerning on-road vehicle and engine air pollutants, off-road diesel engine emission air pollutants, sulphur in gasoline and diesel regulations, and regulations to limit air pollution from marine shipping in Canadian coastal waters. Additional regulatory measures (e.g., GHG regulations for coal-fired electricity generation) will further reduce these emissions.

4.5 Provincial and Territorial Polices and Measures and their Effects

4.5.1 Provinces

Recognizing that Canada's Copenhagen target is a national target that is meant to be achieved through the actions of all levels of government, businesses, and individual Canadians, actions are being taken by more than just the federal government. Provinces and territories are playing a role in several international and regional climate action plans and partnerships. For example:

- British Columbia, Manitoba, Ontario, and Quebec are, along with California, members of the Western Climate Initiative, a collaboration of jurisdictions working together to identify, evaluate, and implement emissions trading policies to tackle climate change at a regional level. Members have set a regional greenhouse gas emissions reduction target of 15% below 2005 levels by 2020.
- British Columbia, Ontario, and Quebec are members of the International Carbon Action Partnership. The Partnership is comprised of public authorities and governments that have established or are actively pursuing carbon markets through mandatory cap and trade systems with absolute caps. At this time,

however, British Columbia and Ontario have not established cap and trade systems.
- All Canadian provinces and territories now participate in the Climate Registry, a continental-wide, sub-national effort to develop a common reporting system.
- New Brunswick, Nova Scotia, Prince Edward Island, and Newfoundland and Labrador are all signatories to the New England Governors/Eastern Canadian Premiers Climate Change Action Plan. This plan includes a voluntary commitment to reduce regional greenhouse gas emissions to 1990 levels by 2010, 10% below 1990 levels by 2020, and recognizes a long term 2050 target for reductions of 75–85% below 2001 levels. The plan has identified energy demand, electricity, and transportation as key sectors for emissions reduction.
- New Brunswick, Nova Scotia, Prince Edward Island, and Newfoundland and Labrador, have signed the Atlantic Energy Framework for Collaboration. This agreement is designed to increase cooperation on energy development to achieve a more sustainable, reliable, and secure energy supply. This cooperation aims to enable the region to more fully develop its renewable energy resources.
- Ontario, New Brunswick, and Quebec are observers of the Regional Greenhouse Gas Initiative, a cooperative effort by ten Northeast and Mid-Atlantic States to limit greenhouse gas emissions. The Regional Greenhouse Gas Initiative is the first mandatory, market-based CO_2 emissions reduction program in the United States.

4.5.1.1 Newfoundland and Labrador

In August 2011, Newfoundland and Labrador released an updated Climate Change Plan called *Charting Our Course*, which built on the province's 2005 Action Plan. The 2011 Action Plan sets out 75 commitments for action across the economy and reaffirms a commitment to reduce greenhouse gas emissions to 10% below 1990 levels by 2020, and 75–85% below 2001 levels by 2050. Data released in 2013 indicated that the province came close to its 2010 target. This data also showed that significant progress has been made over the past decade: GHG emissions in 2010 were 18% below peak GHG emissions in 2002.

The 3,000 megawatts (MW) Lower Churchill Project is one of the largest renewable energy projects in North America. Phase One of the project (the 824 MW Muskrat Falls development) was formally sanctioned in 2012. Once this development becomes operational in 2017, 98% of Newfoundland and Labrador's energy will come from renewable clean sources, ensuring a reliable, competitively-priced supply of power for development in the province, with the surplus exported to markets in North America. Muskrat Falls will enable Newfoundland and Labrador to displace an estimated 1.2 Mt of GHG emissions annually from its oil-fired thermal generating station in Holyrood which accounts for over 10% of the province's current greenhouse gas emissions.

Since 2007, the provincial government has set out a number of energy efficiency initiatives. These include residential energy audit and rebate programs, a number of which were cost shared with the federal government. Commercial and industrial rebate programs and energy audits are being implemented through the two electrical utilities. This will be complemented by new actions in the province's 2011 Energy Efficiency Action Plan, *Moving Forward*. These include a requirement that new buildings constructed with provincial funding be built sustainably and strive to attain Leadership in Energy and Environmental Design silver status, and energy audits be conducted on existing government buildings.

Newfoundland and Labrador is taking action in its energy intensive sectors. For example, through the regulatory agency responsible for overseeing the offshore oil sector, the province has adopted the World Bank's voluntary standard for gas flaring.

Newfoundland and Labrador is also providing support to business, non-governmental organizations, and

municipalities to reduce GHGs emissions in the province. The Newfoundland and Labrador Green Fund is a three year $25 million program that is cost-shared with the federal government to support a wide range of climate change and energy efficiency-related initiatives ($23 million is funded by the federal government and $2 million by the provincial). Investments through the Green Fund are expected to result in an annual reduction of approximately 200,000 tonnes CO_2 eq. Projects include energy efficiency projects, small scale wind turbines, biofuels, and waste methane capture at the Robin Hood Bay Regional Waste Management Facility in St. John's.

4.5.1.2 Prince Edward Island

Prince Edward Island (P.E.I.) released a Strategy for Reducing the Impacts of Global Warming in 2008. Goals include reducing GHG emissions, enhancing carbon sinks, improving adaptation to climate change, and increasing public awareness. P.E.I. seeks to reach a target of reducing GHG emissions to at least 10% below 1990 levels by 2020.The Strategy outlined 47 action items focused on energy efficiency and conservation, renewable energy, transportation, agriculture, adaptation, public education and awareness, and government leadership.

Achievements under the Strategy include:

- P.E.I. has reduced by over 20%, since 2001, the amount of CO_2 eq emitted per MW hour of electricity use.
- Biomass heating facilities are now operational in seven large government facilities (schools, hospitals, etc.) across the province. Recent contracts will see similar heating systems established in another 13 facilities.
- Work continues on the drafting of a provincial building code and associated energy standards under the *National Energy Code for Buildings* to create energy-efficient construction. An implementation date of early-to-mid 2014 is anticipated.
- Since 2009, the Province has contributed $7.5 million toward a series of programs designed to improve energy efficiency in private homes and businesses.

P.E.I's Energy Accord was released in November 2010 and took effect in March 2011. The Accord is a five-year energy strategy developed by P.E.I. in partnership with the Maritime Electric Company Limited. Its goals are to lower and stabilize electricity rates and increase P.E.I.'s reliance on locally owned wind power. The Accord contains a number of initiatives, including support for an additional 40 MW in wind generation (once installed, 33% of the province's electricity supply will come from wind generation) and the establishment of a provincial Commission on the Future of Electricity.

4.5.1.3 Nova Scotia

Nova Scotia has an economy-wide GHG emission target of at least 10% below 1990 levels by 2020. Nova Scotia's key initiatives to meet its emission reduction targets include:

- A mandatory declining cap on greenhouse gas emissions for Nova Scotia Power, starting from 10.2 Mt in 2009 and declining to 4.5 Mt in 2030. This cap is regulated under the *Environmental Act* and the *Greenhouse Gas Emissions Regulations*.
- Under the *Environmental Goals and Sustainable Prosperity Act 2007, Green Economy Act 2012*, and *Renewable Electricity Regulations*, Nova Scotia committed to a target of meeting 25% of electricity needs from renewable sources by 2015 and 40% by 2020.
- A Community Feed-in Tariff Program to support the local development of renewable energy projects.
- A Sustainable Transportation Strategy launched in April 2013 with funding of $6 million to support a range of activities including public transit fleet efficiency, land use planning, and active transportation.
- Increasing overall provincial energy efficiency by 20% over current levels by 2020.
- Support for the development of biomass/biofuels.

In September 2012, the Nova Scotia government and the Government of Canada published the draft *Agreement on Equivalency of Federal and Nova Scotia Regulations for the Control of Greenhouse Gas*

Emissions from Electricity Producers. This agreement establishes that Nova Scotia regulations on GHG emissions from electricity producers are equivalent in effect to regulations from the federal government and, therefore, the latter does not apply in Nova Scotia. Nova Scotia amended its GHG regulations to require additional reductions for the period from 2021 to 2030 in September 2013.

4.5.1.4 New Brunswick

New Brunswick 2007–2012 Climate Change Action Plan was completed in 2012. The province is currently renewing its Climate Change Action Plan and remains committed to the 2020 target of 10% below 1990 levels. In its 2011–2012 Progress Report, New Brunswick projected that it was on track to meet its 2012 target of returning to 1990 GHG emissions levels.

New Brunswick's Air Quality Regulations set the context for all industrial sectors operating in the province and include an industrial approvals program which generally incorporates facility level emission caps, mitigation requirements, as well as monitoring and reporting programs, and compliance enforcement.

New Brunswick's new Oil and Gas Rules address air emissions and require the reporting and management of greenhouse gas emissions. The Government of New Brunswick plans to extend this requirement to other large industrial sectors such as pulp and paper and electricity generation.

In 2011, New Brunswick adopted the New Brunswick Energy Blueprint energy policy. Key policies that encourage continued reductions in GHG emissions include support for: biomass, an electricity efficiency plan, energy efficiency building code standards, and minimum efficiency levels for appliances and equipment. Total GHG reductions resulting from the Blueprint are projected to reach 1.3 Mt when fully implemented in 2020. New Brunswick also adopted the Renewable Portfolio Standard in 2006 and expanded it, requiring that by 2020, 40% of in-province electricity sales come from renewable energy.

After a refurbishment project started in 2008, the Point Lepreau Nuclear Generating Station re-entered into service in November 2012. With the re-introduction of nuclear power into the grid, approximately 65% of the province's electricity production comes from non-emitting energy sources. Point Lepreau itself supplies 30% of the province's electricity.

In 2005, New Brunswick established Efficiency New Brunswick as a Crown Corporation. Since 2005, Efficiency New Brunswick programs have invested $58.6 million to help make homes and businesses more energy efficient, and leveraged $307 million in private sector efficiency investments. This has reduced GHG emissions by 326,000 tonnes per year and generates over $50 million per year in energy cost savings.

4.5.1.5 Quebec

Quebec's approach with respect to climate change is based on four complementary policies: an energy strategy, a climate change action plan, a mass transit strategy, and a strategy aimed at developing Quebec industry and green technologies.

Quebec's energy strategy for 2006–2015 (May 2006)

Quebec's energy strategy for 2006–2015 is mainly centered on the development of renewable energy (hydroelectric power, wind energy, and biomass energy), along with more efficient use of all types of energy. The energy strategy lists energy savings targets for the main types of energy for 2015:

- 2 million tonnes of oil equivalent for petroleum products;
- 350 million cubic meters for natural gas; and
- 11 terawatts per hour for electricity.[1]

The strategy also includes:

- Developing a portfolio of hydroelectric projects totalling 4,500 MW by 2015.

- Successfully completing, over five years, new wind energy projects totalling 3,000 MW in order to attain the 4,000 MW target for 2015.

A new energy strategy is under development and should be made public by 2015.

The 2013–2020 Climate Change Action Plan
Quebec's 2013–2020 Climate Change Action Plan was adopted in June 2012, following the 2006–2012 Climate Change Action Plan.

Under the plan, the government has allocated close to $3 billion over 8 years to contribute to Quebec's goal to reduce GHG emissions by 25% below 1990 levels by 2020. The plan includes 30 priorities and measures pertaining to various sectors such as energy, freight and passenger transportation, manufacturing, buildings, technological innovation, and adaptation to the impacts of climate change.

One of the key elements of the action plan is a GHG emission cap-and-trade system that came into force in January 2012, and for which the first compliance period began in January 2013. The sectors implicated are electricity generation and distribution along with major industrial facilities. In 2015, the system will be expanded to include fuel and fossil fuels used notably in the transportation, buildings, and small and medium sized business sectors. Quebec and California are scheduled to formally link their cap-and-trade systems in January 2014. The Quebec government will hold its first cap-and-trade auction on December 3rd, 2013, and a joint auction with California in the spring of 2014.

The 2013–2020 Climate Change Action Plan also includes measures aimed at:
- Promoting mass and alternative transit by improving services, developing infrastructure, and facilitating sustainable choices.
- Greening vehicles in Quebec through the use of vehicles that are more energy-efficient (electric and plug-in hybrid electric) and better maintained.
- Optimizing the logistics of passenger and freight transportation and improving the efficiency of land, marine, rail, and air transport.
- Improving the carbon footprint and energy efficiency of Quebec companies.
- Promoting the use of renewable energy and energy efficiency in residential, commercial, and institutional buildings.
- Supporting innovation and research, and the development, demonstration, and marketing of technologies aimed at reducing GHG emissions.

In 2007, Quebec adopted a carbon levy that affects about 50 large emitters such as producers, distributors, and refiners of energy derived from fossil fuels. The carbon levy generates revenues of $200 million per year, which are used to fund various government measures related to climate change. The carbon levy will be gradually replaced by the Quebec cap-and-trade system.

2006–2012 Quebec Public Transit Policy
Launched in 2006, the Quebec Public Transit Policy aimed to increase public transit services by 16% and ridership by 8% by 2012. The policy exceeded the target objectives in 2012, with services and ridership increasing by 21% and 11% respectively in Quebec.

Public consultation on a future sustainable mobility policy took place in May–June 2013. The policy is expected to be implemented in 2014 and will cover the following areas:
- Land-use planning and transportation
- Public transit governance and funding
- Electrification of transportation and environment
- Regional, rural and interurban transportation
- Specialized transit for handicapped transit users or those with reduced mobility

4.5.1.6 Ontario

Ontario's policies and measures to address climate change mitigation are outlined in the Climate Change Action Plan. Released in 2007, the plan set province-

wide emission reduction targets and outlined a range of initiatives to reduce GHG emissions and support a sustainable, clean, low-carbon economy. Specifically, the Climate Change Action Plan includes a set of short-term (6% below 1990 levels by 2014), medium-term (15% below 1990 levels by 2020), and long-term (80% below 1990 levels by 2050) targets for reducing Ontario's GHG emissions. The Climate Change Action Plan is updated through regular reports describing the province's progress on existing and new initiatives.

Green Energy, Conservation and Efficiency
Most of Ontario's progress in emissions reductions has been achieved through the phase-out of coal-fired electricity generation. Since 2003, Ontario has shut down 11 of 19 coal units across five generating stations. With six more units to be shut down at the end of 2013, one year ahead of schedule, the province is on track to end coal-fired electricity generation by the end of 2014. The Ontario government estimates that this policy will reduce GHG emissions from the electricity sector by approximately 30 Mt from 2003 levels. Ontario is replacing coal-fired generation with increased conservation and cleaner energy sources like natural gas, nuclear, solar and wind.

Other actions include:

- Investments of $2 billion in conservation programs between 2006 and 2011 resulting in 216 MW of demand savings and 605 GW per hour energy savings in 2011.
- New regulation passed in 2011 that will require Ontario's broader public sector (e.g., municipalities, universities, colleges, schools, and hospitals) to demonstrate leadership in energy conservation by reporting annually on energy use and greenhouse gas emissions starting in 2013.
- Installing over 4.7 million smart meters which track electricity use of homes or businesses and help Ontarians make more informed decisions about their electricity consumption.

Transportation
The 25-year Big Move Regional Transportation Plan adopted in 2008 aims to improve regional transportation, bolster global competitiveness, protect the environment, and enhance the quality of life in the Greater Toronto and Hamilton Area. To date, $16 billion has been committed and projects with committed funding are underway.

Ontario's electric vehicle program provides incentives or plug-in electric vehicles, including grants of $5,000–$8,500, supporting a vision of 1 in 20 vehicles driven in Ontario to be electric by 2020.

Land Use and Stewardship
Ontario's Provincial Policy Statement is the provincial framework for land use planning and development policies, and guides municipalities when creating their planning policies and in their decision-making related to planning. The Provincial Policy Statement addresses the need to reduce GHG emissions through policies that promote efficient use and management of land and infrastructure, protection of the environment, and wise use of resources. This includes the promotion of compact development, increased use of public transit and other non-motorized methods of transport, and encouraging land use patterns and forms of settlement based on higher densities and on mixed uses.

Ontario's Greenbelt, established in 2005, is composed of 1.8 million acres of protected prime agricultural land and environmentally sensitive areas in southern Ontario. Implemented through municipal official plan policies, this plan plays a role in greenhouse gas emissions reductions by curbing urban sprawl, preserving agricultural land, protecting agricultural soils, forests, wetlands and watersheds, and promoting trails, parklands and open spaces by protecting natural features (trees, plants, and grass) that perform an important carbon-storage function.

Agriculture and Waste
The Environmental Farm Plan is a voluntary program that enables farmers to learn and implement best management practices that can provide economic and environmental benefits. Practices under the plan that support the reduction of greenhouse gas emissions include manure management, feed efficiency and livestock management, nutrient management planning, precision agriculture, farm energy audits, and farm energy and water conservation measures.

The Ontario Ethanol Growth Fund has helped create an industry with domestic production that is currently at 885 million litres per year, projected to grow to over one billion litres per year. This initiative has created over 300 skilled jobs in rural Ontario, generated over $635 million in capital investment, and continues to contribute to improved air quality in Ontario. Ontario has seven ethanol facilities in place.

4.5.1.7 Manitoba

In June 2012, Manitoba released Tomorrow Now, a new eight-year strategic plan, for public comment. The plan foresees the modernization of the *Sustainable Development Act* and the release of an updated climate change action plan, as well as a comprehensive energy strategy, including a 43% increase in hydro power output from 2012 levels in the next 15 years.

The *Manitoba Climate Change and Emissions Reductions Act* received Royal Assent in July 2008 with an initial target to reduce emissions to an amount that is at least 6% less than Manitoba's total 1990 emissions by 2012. Between 2000 and 2011, Manitoba's emissions decreased by seven percent amidst a 9.6% increase in its population and 78% growth in its economy during the same period.

As legislated under the *Manitoba Climate Change and Emissions Reductions Act*, Manitoba achieved its interim GHG emissions reduction target to stabilize emissions at 2000 levels by 2010. Manitoba has fully implemented its 2008–2012 climate change plan, with over 60 actions carried out across multiple sectors. Sectors covered by the plan include energy, transportation, agriculture, municipalities, businesses, and public sector operations.

Manitoba GHG emissions reduction programs include:
- Setting a provincial energy savings target of 842 MW of electricity by 2017. In addition, the government has committed to developing 1000 MW of wind power over the next decade, as well as expanding renewable power production through hydroelectric, geothermal, solar, and biomass power production.
- Introducing a coal-reduction strategy including a tax on coal emissions that came into effect in January 2012 that provides capital support for coal-reliant industries to convert to cleaner energy and support for developing biomass.
- Committing $3 billion over 10 years for the Clean Energy Transfer Initiative to promote enhancements to the east-west power grid to sell hydro power to other jurisdictions.
- Expanding energy efficiency through new building codes and standards; programs for homeowners, low-income housing, businesses and farms; and promoting energy efficient appliances.
- Implementing a provincial biofuels mandate.
- Phasing down the Brandon coal-fired generating station for use in emergency circumstances.
- Requiring large landfills to capture methane gas.

In November 2012, Manitoba released the Clean Energy Strategy which outlines actions to harness water, wind, solar, and biomass resources within the province. Priorities include:
- Expanding development of hydroelectricity generation and transmission.
- Expanding energy efficiency programs and standards.
- Ensuring affordable utility rates.
- Expanding alternative renewable energy sources (wind, geothermal, biomass, biofuels, electric vehicles).
- Reducing reliance on fossil fuels.

4.5.1.8 Saskatchewan

Saskatchewan is taking action to reduce its level of GHG emissions. The *Management and Reduction of Greenhouse Gases Act*—a key piece of legislation in Saskatchewan's approach to climate change—received Royal Assent in 2010 and was amended in April 2013. The Act provides for:

- Creation of an Office of Climate Change in the Ministry of Environment.
- Regulation of major GHG emitters.
- Provincial carbon price for regulated emitters.
- The Saskatchewan Technology Fund to collect carbon compliance payments from large emitters to invest in low-emitting technologies to reduce GHG emissions.
- A Climate Change Foundation to promote research and development of low carbon technologies, adaptation, and public education and awareness.
- Performance agreements with large emitters to reduce GHG emissions outside of regulated activities and with non-regulated emitters in the agriculture, transportation, commercial, and residential building sectors.

Green Initiatives

The Government of Saskatchewan committed $70 million to the Go Green Fund over four years, beginning in 2008. The Go Green Fund currently manages 20 contracts with Saskatchewan businesses, organizations, and communities. Funding has supported household energy efficiency and water conservation programs, such as the Energy Efficiency for New Homes Program and small scale renewable energy initiatives in Saskatchewan, including solar, wind, and biomass through the Net Metering Program. Examples of Go Green Fund projects include:

- Saskatchewan Government Insurance Green Vehicle Rebates program
- Provincial climate change program
- Aquistore carbon capture and storage project through the Petroleum Technology Research Centre
- Green energy programs including Solar Heating Initiative for Today and Municipal Energy Efficiency
- High level wind energy storage project with Cowessess First Nations and the Saskatchewan Research Council

Carbon Capture Storage

Saskatchewan is currently engaged in a number of Carbon Capture and Storage Initiatives including the following examples.

The International Energy Agency Greenhouse Gas Weyburn-Midale CO_2 Monitoring and Storage Project was launched in 2000 and has studied carbon dioxide injection and storage into two depleted oilfields in south-eastern Saskatchewan. The end result was the publication of a Best Practice manual in 2012 and a scientific publication in June 2013 to recommend best practices for the geological storage of carbon dioxide in a depleted oil reservoir. Approximately 8500 tonnes CO_2 per day are captured from a coal gasification facility—owned by the Dakota Gasification Company located in Buelah, North Dakota. The gas is compressed to a liquid phase and transported via a 320 kilometer pipeline to the Weyburn and Midale oil fields for injection. This is the first time that a man-made source of CO_2 has been used for enhanced oil recovery.

The Boundary Dam Integrated Carbon Capture and Storage Demonstration Project will see Unit #3 at a coal-fired power plant located in Estevan rebuilt as the first commercial-scale power plant equipped with a fully-integrated carbon capture and storage system. Operations are expected to begin in 2014. The Boundary Dam project will reduce carbon dioxide emissions by up to 1 Mt a year.

Aquistore is an independent research and monitoring project to demonstrate that storing liquid CO_2 deep underground (in a brine and sandstone water formation), is a safe, workable solution to reduce greenhouse gases. Aquistore is located in south-eastern Saskatchewan near Estevan. Aquistore will serve as the storage site for the world's first commercial post-

combustion CO_2 capture, transportation, utilization, and storage project form a coal-fired electrical generating station. The project is expected to store 300,000 tonnes CO_2 by 2014.

4.5.1.9 Alberta

Alberta was the first province to regulate GHG emissions from large industry. As of July 1, 2007, companies that emit more than 100,000 tonnes CO_2 eq are required to reduce their emissions intensity by 12%, using a baseline based on past emissions between 2003–2005. These Regulations apply to just over 100 facilities that make up about 50% of Alberta's emissions. Regulated facilities have four compliance options to achieve their reduction requirement: improve the GHG intensity of their operations; buy emissions performance credits from other regulated facilities that achieve reductions beyond their requirement; buy Alberta-based offsets; or pay $15 per tonne CO_2 eq to the Climate Change and Emissions Management Fund that is used to support development and application of clean energy technologies.

As of 2013, the Regulation covers 106 facilities from 15 industrial sectors and has resulted in a cumulative:

- 40 Mt of emissions avoided (20 Mt in facility reductions and 20 Mt through carbon offsets).
- $398 million paid to the Climate Change and Emissions Management Fund with $182 million allocated to 48 clean energy projects.

In July 2008, Alberta announced its Climate Change Action Plan with an objective to reduce greenhouse gas emissions by 50 Mt from a 'business as usual' scenario by 2020 and by 200 Mt by 2050. Alberta is currently working on renewing this strategy to ensure policies and programs are in place to meet the targets. The Government of Alberta will be investing $2 billion into the Green Transit Incentives Program, a program providing capital funding assistance for sustainable public transit infrastructure.

In April 2008, the province created the Alberta Carbon Capture and Storage Development Council to develop a roadmap for implementing carbon capture and storage. Alberta is investing $1.3 billion in two major capture and storage projects, the Shell Quest and Alberta Trunk Line projects, expected to store 2.8 Mt CO_2 a year by 2016.

The Government of Alberta implemented a Renewable Fuels Standard in April 2011, to accelerate the use of fuels derived from renewable sources. The Renewable Fuels Standard requires an average of 2% renewable content in diesel fuel and 5% renewable alcohol in gasoline. The renewable fuel content must have at least 25% less GHG emissions than the equivalent petroleum fuel on a life-cycle basis. The Renewable Fuels Standard is expected to reduce greenhouse gas emissions by at least 1 Mt annually.

In April 2011, Alberta extended and expanded its Bioenergy Producer Credit Program until 2016. The program has been in place since 2006 and provides incentives to develop bioenergy products to support implementation of the Renewable Fuel Standards and the development of new technologies and facilities that use non-food crops, waste biomass and wood fibre for fuel, power and heat.

Since 2005, the Government of Alberta has been purchasing ECOLOGO certified electricity (or Green Power) generated from local, renewable sources to supply government-owned buildings and operations.

4.5.1.10 British Columbia

The 2008 Climate Action Plan took the first step for achieving a legislated GHG reduction target of 33% below 2007 emissions levels by 2020. A broad-based revenue-neutral carbon tax was introduced in 2008 as a core economic policy to support the Province's GHG reduction targets. The carbon tax applies to emissions from the combustion of fossil fuels and is currently at a rate of $30 per tonne. The B.C. Government has committed to maintain that rate for five years or until

other jurisdictions implement similar measures. Since 2008, the carbon tax generated a cumulative $3.7 billion in revenues which were returned to British Columbians through personal, small business, and corporate income tax cuts, as per the legal requirement.

Carbon neutrality for the entire public sector was achieved in 2010, 2011 and 2012. To reach this goal, the British Columbia public sector has reduced direct emissions and has invested to date almost $60 million in carbon offsets through the Pacific Carbon Trust, a Crown Corporation established in 2008 to deliver B.C. based GHG offsets and support the growth of B.C's low-carbon economy.

The B.C. Climate Action Charter commits signatory local governments to measure and report on emissions, achieve carbon neutral corporate operations by 2012, and work toward compact, energy efficient communities. As of June 2013, 182 of 190 local governments had signed the Charter. Participating governments have their carbon tax payments fully refunded annually to support regional reduction initiatives. Other actions include:

- A $14 billion Provincial Transit Plan designed to expand transit services to communities and increase ridership.
- The LiveSmart BC Efficiency Incentive Program which invested $110 million from 2008 to 2013, helping over 75,000 homeowners reduce their energy bills by 15%–28%, and providing assistance to over 10,000 small businesses to reduce a total of $6 million/year in energy bills.

British Columbia's commitment to taking action on climate change is enshrined in legislation. Several pieces of climate action legislation are currently in force:

- *Greenhouse Gas Reductions Targets Act*: Setting greenhouse gas reduction targets for the Province and mandating the provincial government become carbon neutral in 2010.
- *Greenhouse Gas Reduction (Cap and Trade) Act*: Though B.C. is not pursuing a cap and trade system at this time, the Reporting Regulation under the Act is in effect, providing foundational data for emissions reductions and policy development. The Regulation requires industrial facilities emitting over 10,000 tonnes CO_2 eq to report their GHG pollution each year to the Province, which is then posted publically.
- *Clean Energy Act*: Increases provincial commitments to conservation and development of clean energy resources including wind, solar, tidal and hydro power.
- *Renewable and Low Carbon Fuel Requirements Act*: Requires 5% renewable content in gasoline and 4% renewable content in diesel, and a minimum 10% reduction in carbon intensity of transportation fuels by 2020.

Clean Energy and Innovation in British Columbia

Making the transition to a clean energy economy is a cornerstone of British Columbia's climate action plan. British Columbia's Energy Plan: A Vision for Clean Energy Leadership (2007), British Columbia's *Clean Energy Act* (2010) and other initiatives have been adopted to reduce emissions from the energy sector and foster innovation including through carbon capture and sequestration for coal-fired electricity and a commitment to generate at least 93% of energy from clean or renewable sources.

The Clean Energy Vehicle Program, announced in 2011, which provides purchase incentives for approved clean energy vehicles (plug-in electric, extended range electric, hydrogen, and compressed natural gas). Incentives have been extended until March 31, 2014. The program also includes aggressive charging infrastructure deployment. B.C. continues to have one of the highest clean energy vehicle adoption rates in Canada on a per capita basis.

These measures and commitments have allowed British Columbia to be on track to meet its 2012 target of reducing GHG emissions by 6% below 2007. By 2011,

B.C. had seen emissions reductions relative to 2007 of 5.8%, putting it within reach of its 2012 interim target. Between 2007 and 2011 B.C. has seen greater reductions in per capita fossil fuel sales than the Canadian average. Researchers at the University of Ottawa are attributing at least a portion of this reduction to the Revenue Neutral Carbon Tax.[2]

4.5.2 Territories

Beyond the measures outlined below, in 2011, Canada's three northern territories released the Pan-Territorial Adaptation Strategy and the Pan-Territorial Renewable Energy Inventory, outlining the impacts of climate change and proposing strategies for collaborative actions and at the same time supporting-specific initiatives to meet each jurisdiction's unique challenges.

4.5.2.1 Yukon

The Yukon Government Climate Change Action Plan was released in February 2009. The Action Plan recognizes many actions already underway and sets out 33 priority actions the Yukon Government undertakes in support of enhancing knowledge and understanding of climate change, adapting to climate change, reducing GHG emissions and leading Yukon action in response to climate change. A key initiative was the creation of the Climate Change Secretariat. The Secretariat provides corporate leadership on climate change within Yukon government. The Action Plan commits to annually report internal emissions through the Climate Registry, a 20% reduction of greenhouse gas emissions from government operations by 2015, and carbon neutral government operations by 2020.

In September 2012, Yukon government released a progress report which, in addition to updating on work that has been completed since 2009, outlines sector-specific targets for emission reductions within transportation, building, electricity, and industrial sectors. Highlights of completed actions include:

- Adoption of GreenHome energy efficiency standards for all new construction completed by the Yukon Housing Corporation.
- Implementation of a policy where fuel economy is a major factor when purchasing vehicles, helping to reduce emissions from the government fleet.
- Initiation of pilot projects to demonstrate home and commercial energy efficiency and new heating technologies.
- Completion of a transportation analysis to inform actions to reduce emissions in the transportation sector.

Yukon released its Energy Strategy in January 2009. The Strategy considers how to best meet Yukon's energy needs while balancing environmental and economic objectives for the Territory. The Energy Strategy proposes goals, long-term strategies and short-term actions for electricity, renewable energy, energy efficiency/conservation and oil and gas. Key initiatives related to climate change include:

- Increasing total renewable energy generation in the territory by 20% by the year 2020.
- Increasing territorial energy efficiency by 20% by the year 2020.
- Developing/implementing industry best management practices for GHG emissions.
- Promoting energy efficient products.

4.5.2.2 Northwest Territories

Since 2001, when the first Northwest Territories Greenhouse Gas Strategy was first prepared, the Government of the Northwest Territories has taken a coordinated approach to responding to climate change concerns. The updated Greenhouse Gas Strategy for the Northwest Territories: 2011–2015 was released in December 2011 with a goal to stabilize greenhouse gas emissions to their 2005 level by 2015. The Strategy emphasizes renewable energy development, increased collaboration with the other territories, a transportation policy, and community engagement, while recognizing that the territory faces rising emissions with increased economic development.

The territorial government is investing to support continuous improvements in energy efficiency for

homeowners and communities and upgrades to the energy performance of existing government facilities. New facilities developed by the Government of the Northwest Territories must meet the requirements of the Good Building Practice for Northern Facilities 2009 guidebook so they meet an energy performance benchmark of 25% above the *Model National Energy Code for Buildings* 1997.

The use of residual heat recovered from diesel-electric generators in district heating systems is being expanded in communities and new systems are being installed and will provide opportunities for greater use of biomass heat in future years.

The territorial government also supports energy planning in all communities. Some, like the City of Yellowknife have already adopted their own emission targets and are well into implementation.

The 2012–2015 Northwest Territories Biomass Energy Strategy specifies 15 actions with the aim of increasing the use of biomass fuels for space heating, ensure sustainable consumption, achieve life cycle greenhouse gas emissions reductions, and create economic benefits. The Strategy builds on the progress achieved in the implementation of the 2010 Northwest Territories Biomass Energy Strategy, and complements actions under the 2011–2015 Greenhouse Gas Strategy.

The 2012–2017 Solar Energy Strategy outlines nine actions to promote the use of solar energy technologies, including: providing energy information and workshops to the private and public sector, establishing a Government of the Northwest Territories Interdepartmental Solar Energy Committee, installing solar panels on public buildings, developing a comprehensive program to connect solar systems to the electricity grid while continuing to support off-grid solar applications, setting up solar systems to replace up to 20% diesel consumption in communities, and expand solar potential to replace 75% consumption, and developing a Solar Energy Monitoring Program.

4.5.2.3 Nunavut

In April 2012, the Nunavut Climate Change Centre was launched to provide current climate change information relevant to the territory's residents. It also assists the government in monitoring the implementation of the territory's climate adaptation strategy.

In June 2011, Nunavut released Upagiaqtavut—Setting the Course, Impacts and Adaptation in Nunavut, which provides a framework and sets strategic objectives for climate change adaptation in Nunavut, building on commitments of its 2003 Climate Change Strategy. Key objectives include: identifying new and innovative partnership opportunities with federal, provincial and territorial governments, communities and other organizations; strengthen monitoring of climate change impacts in Nunavut; integrate climate change considerations into all government decision making, land use planning, environmental assessments, and emergency planning.

The Nunavut government has also produced Inuit Qaujimajatuqangit of Climate Change in Nunavut, a territory-wide examination of Inuit traditional knowledge with respect to climate change.

Nunavut released an energy strategy in 2006. One of its major goals is to reduce dependency on imported fuel through conservation and development of renewable energy sources. Virtually all fuel used for heating and electricity is imported, and the territory spends about 20% of its budget on purchasing, selling and subsidizing fuel.

4.6 How Policies and Measures are Modifying Long-Term Trends in Greenhouse Gas Emissions and Removals

Canada's actions on climate change at all levels of government are modifying longer-term trends in GHG emissions, contributing to reductions into the future.

The Government of Canada's sector-by-sector regulatory approach involves setting regulatory performance standards for equipment and facilities to generate reductions in absolute GHG emissions over the long term. The regulations are designed to maintain competitiveness vis-à-vis major trading partners and drive investments in new clean energy technologies and industries. They are also designed to be stringent but flexible to stimulate innovation and are predictable to provide investment certainty, which encourages longer-term investments in energy efficiency, clean energy technologies and non-emitting electricity generation.

For example, the Government of Canada's regulations to reduce carbon dioxide from coal-fired electricity generation will implement a permanent shift to lower or non-emitting types of generation and will achieve significant reductions beyond the 2020 horizon. Combined with actions being undertaken by provinces (e.g., Ontario coal phase out) the regulations are expected to result in a net cumulative reduction in GHG emissions of about 214 Mt from 2015 to 2035.

Similarly, Canada's regulations to reduce emissions from vehicles will have significant impacts on emissions after 2020. For example, 2025 passenger vehicles and light trucks will emit about half as many GHGs as 2008 models. The light duty vehicle Regulations will reduce greenhouse gas emissions by 92 Mt over the lifetime of the vehicles produced in the model years 2011 to 2016 and 162 Mt of reductions over the lifetime of 2017 to 2025 model years.

Canada is one of the leading investors in carbon capture and storage technology in proportion to its economy. Federal and provincial governments are making significant investments towards carbon capture and storage projects. For example, the SaskPower Boundary Dam Project in Estevan, Saskatchewan, will be the world's first commercial scale power plant with a fully integrated carbon capture and storage system. Disseminating the knowledge and shared learning generated from these projects is also a key priority for Canada, and is critically important in moving towards global deployment of carbon capture and storage.

Additional actions by provinces, territories and municipalities in their areas of jurisdiction will modify long-term trends in GHG emissions and removals. These actions include policies and measures related to mass transit, the energy efficiency of built environment, urban planning and addressing urban sprawl, and other land-use planning measures to protect natural features that perform important carbon-storage functions.

References

1 The energy savings target for electricity in the Quebec Energy Strategy 2006–2015 is 8 terrawatts per hour for 2015. This target was then revised to 11 terrawatts per hour under the 2007–2010 Energy Efficiency and New Technology Master Plan.

2 For example: Rivers, Nicholas and Schaufele, Brandon, Salience of Carbon Taxes in the Gasoline Market (June 10, 2013). Available at SSRN: http://ssrn.com/abstract=2131468 or http://dx.doi.org/10.2139/ssrn.2131468

5 Projections and the Total Effect of Policies and Measures

5.1 Introduction

This chapter provides projections of greenhouse gas (GHG) emissions through 2030, aligned to Canada's historical emissions from 1990 to 2011 as presented in Canada's 2013 *National Inventory Report* (NIR) and Chapter 3: Canada's Greenhouse Gas Inventory of this report. The projections are presented by gas and by sector as well as selected subsectors. The sectors are aligned to the same sectoral categorisation as in the Policies and Measures chapter of this report—as recommended in the United Nations Framework Convention on Climate Change (UNFCCC) guidelines. A description of how this method of categorisation maps to Intergovernmental Panel on Climate Change (IPCC) sectors is provided below.

Projections presented in this report represent a "with current measures" scenario and include actions taken by governments, consumers and businesses up to 2011 as well as the future impacts of policies and measures that were announced or put in place as of May 2013. The policies and measures modeled in this section are listed in Annex 1 of this chapter and are described in more detail in Chapter 4: Policies and Measures. It should be noted that the sum of emission reductions associated with individual policies and measures in Table 3 of the Biennial Report will not be equivalent to the overall projected emission reductions of policies and measures in this chapter due to the interaction effects between measures and the different modeling approaches being used.

For the purposes of presenting progress to Canada's 2020 target, the "with current measures" scenario is compared to a "without measures" projection that assumes no action taken after 2005, Canada's target base year. The difference between the two scenarios represents the total effect of policies and measures by both federal and provincial Canadian governments as well as actions by businesses and consumers. Under the "with current measures" scenario, Canada's GHG emissions in 2020 are projected to be 734 megatonnes (Mt) carbon dioxide equivalent (CO_2 eq). This is 128 Mt less than under a scenario where emissions would be in 2020 if consumers, businesses and governments had taken no action to reduce emissions since 2005, highlighting the significant progress that has been achieved at lowering emissions from a business-as-usual trajectory.

Canada has chosen not to include a "with additional measures" scenario at this time, as further regulatory and other actions by federal, provincial and territorial governments remain under development. As such, policies that may be proposed or planned but are not yet implemented are not included in this chapter's projections.

5.2 Comparing Activity Sector Categories to Economic Sectors

Canada's GHG projections are derived using a detailed bottom-up simulation model where energy data is allocated to individual subsectors using the North American Industrial Classification System. These subsectors are then aggregated into the economic sectors presented in this report. Considering that Gross Domestic Product (GDP) and relative energy prices are a key driver of GHG emissions in most sectors, macroeconomic models are the primary tool for generating emissions projections in Canada. This method of energy and emissions allocation is essential for identifying possible impacts from current and future policies and measures implemented in a particular sector.

According to the National Communication reporting guidelines, Parties have the flexibility to present their policies, measures and projections according to sectoral categories that are appropriate to their own national circumstances. Canada has chosen to use

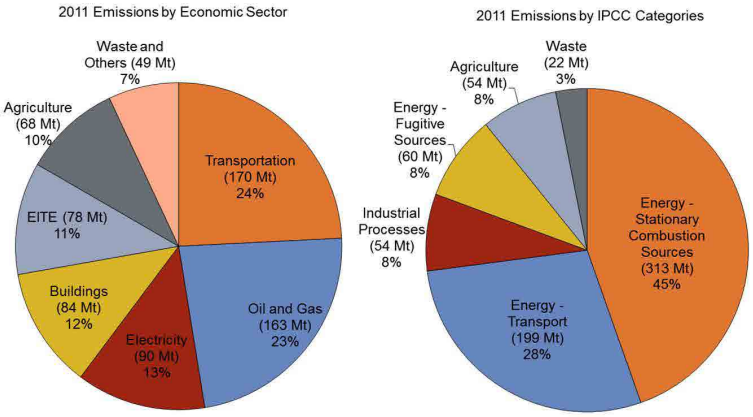

Figure 5.1 Total Canadian 2011 GHG emissions (702 Mt CO_2 eq)—Methods of Categorisation

economic sectors in our Biennial Report and National Communication as these categories more accurately reflect the drivers of emissions than the IPCC activity based sectoral categories. This approach is used in *Canada's Emissions Trends*, an annual publication that provides projections of GHG emissions to the year 2020. It is also presented in Canada's NIR along with GHG emissions categorised under the IPCC reporting requirements by activity sectors such as emissions from energy use, fugitive emissions, transportation emissions, and emissions from industrial processes.

Figure 5.1 shows the distribution of 2011 emissions on an IPCC activity basis versus an economic sector basis. Some adjustments that are made to estimate economic sector emissions include:

- Reallocating off-road transportation emissions related to farming (primarily farm tractors and other mobile machinery) to the Agriculture Sector instead of transportation.
- Reallocating off-road transportation emissions related to mining operations from transportation to the Oil and Gas Sector and the Emissions-Intensive and Trade-Exposed (EITE)[1] Industry Sector.
- Reallocating emissions related to pipeline operations to the Oil and Gas Sector.
- Reallocating some of the industrial process emissions to the Buildings Sector.

In addition, stationary combustion emissions under the IPCC categorisation are allocated across economic sectors, as appropriate. Almost all industrial process and fugitive emissions under these processes are aligned with the economic sector that generates them (primarily in the EITE and Oil and Gas Sectors). In addition, emissions from landfills are included in the Waste and Others Sector.

Table 5.1 GHG Emissions by Economic Sector (Mt CO_2 eq) from 1990 to 2011

	1990	1995	2000	2005	2010	2011
Transportation	128	137	155	168	167	170
Oil and Gas	101	124	150	162	164	163
Electricity	94	98	129	121	99	90
Buildings	70	76	82	84	79	84
Emissions-Intensive & Trade-Exposed Industries	93	94	85	87	75	78
Agriculture	54	61	66	68	69	68
Waste and Others	50	49	51	49	48	49
NATIONAL GHG TOTAL	591	639	718	737	701	702

5.3 Historical Emissions Trends

Although historical emissions have been described in detail in Chapter 3: Canada's Greenhouse Gas Inventory, a brief summary of historical trends by economic sector is provided here.[2]

As shown in Table 5.1, from 1990 to 2005, total emissions grew from 591 Mt to 737 Mt. The majority of this increase occurred in the Transportation, Oil and Gas, and Electricity Sectors. In the Transportation Sector, population and economic growth were primary drivers of a 40 Mt increase in emissions over this period. As production increased and Canada's oil sands industry developed, emissions in the Oil and Gas Sector increased 61 Mt. The Electricity Sector[3] contributed to a further 27 Mt of the increase in total emissions as more fossil-fueled power generation came online to meet rising demand.

Canadian GHG emissions fell by 35 Mt from 2005 to 2011, driven mostly by reductions in the Electricity and EITE Sectors. Emissions in most other sectors were stable over the period. The decline in emissions from the Electricity Sector is primarily the result of Ontario's coal-fired electricity generation phase-out, while the trend in the EITE Sector reflects the impacts of the economic recession and the subsequent recovery. 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.

Emissions are intrinsically linked to economic activity, although in Canada this linkage has weakened over the past two decades due to technological and structural changes such as increases in energy efficiency and the growth of lower-emissions and service-based industries. Emissions intensity, defined as GHG emissions per dollar of GDP, measures the relationship between economic activity and emissions generation. In Canada, emissions intensity has declined at an average annual rate of 1.5% between 1990 and 2011, or a cumulative 28% over the entire period.

5.4 GHG Emissions Projections by Economic Sector and Gas

5.4.1 National Emissions Projections

GHG projections depend on a number of evolving variables and are subject to significant uncertainty. In addition, developments in technology, demographics and resource extraction will alter the future emissions pathway. In this chapter, emissions are projected to 2030 with comparisons made to 2005, Canada's base year for its Copenhagen target. Projections are based on policies and measures in place as of May 2013 and assume no further government action. Where applicable, historical emissions for 2010 and 2011 (the most recent year for which historical emissions are available) are also shown. Projections are based on Environment Canada's Energy, Environment and Economy Model for Canada (E3MC) which is internationally recognized and incorporates external data from consistent sources.

5.4.2 Emissions Intensity

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. Emissions intensity is expected to continue to decrease through 2030 (Figure 5.2).

However, given that a connection still remains between economic growth and GHG emissions, under a "with current measures" scenario, absolute emissions are projected to rise over the period, although at a rate slower than economic growth. Before taking into account any further action by federal, provincial, and territorial governments, by 2020 emissions are projected to reach 734 Mt, a decrease of 3 Mt from 2005. By 2030 emissions are projected to reach 815 Mt, an increase of 11% over 2005 levels. However, GDP is expected to increase by 59% over the same period, demonstrating the continued decoupling of economic and emissions growth. In addition, actual emissions in 2030 will be lower if federal, provincial and territorial governments take additional measures.

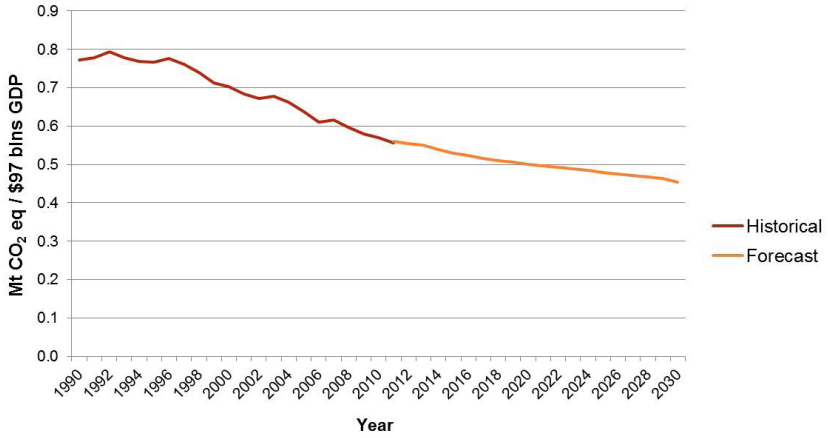

Figure 5.2 Canadian Emissions Intensity (1990 to 2030)

Of note, the Land Use, Land-use Change and Forestry (LULUCF) contribution has only been estimated up to our target year (2020). This is because although data is available through 2030, the Reference Level used to measure progress in the managed forests was only constructed and negotiated to 2020. Since estimating the LULUCF contribution requires this Reference Level, the contribution cannot be estimated for years after 2020. It is anticipated that Canada will develop a post-2020 Reference Level as part of its participation in international negotiations on post-2020 treatment of the land sector in an international climate change regime under the UNFCCC.

5.4.3 Per Capita Emissions

Total GHG emissions divided by the population of Canada (per capita emissions) have been decreasing significantly since 2005 when they were 22.9 tonnes CO_2 eq per person. In 2011, emissions per capita were only 20.4 tonnes CO_2 eq per person, which is the lowest level recorded since records began in 1990.

Projections show per capita emissions to continue to decrease through 2030 as per capita emissions are projected to fall to 20.0 tonnes CO_2 eq per person in 2020 and to 19.6 tonnes per person in 2030 (Table 5.2). This reflects a projected increase in Canada's population of 29% between 2005 and 2030, while emissions are projected to increase by only 11%.

Table 5.2 Canadian GHG Emissions Per Capita*

	2005	2010	2011	2015	2020	2030
Per Capita Emissions (t CO_2 eq)	22.9	20.5	20.4	20.1	20.0	19.6

* Excluding the contribution of LULUCF.

5.4.4 Emissions by Gas

Total Canadian GHG emissions over the projection period are presented by gas in Tables 5.3 and 5.4, in their native gaseous forms and in CO_2 eq respectively.

CO_2 emissions are projected to rise throughout the projection period to 2030 increasing by 6% between 2005 and 2020, and by an additional 7% between 2020 and 2030. On a CO_2 eq basis, CO_2 represented 79% of total Canadian GHG emissions in 2005. By 2020, CO_2 emissions are projected to represent 80% of total emissions. By 2030 this share is expected to increase slightly to 81%.

Given that CO_2 emissions comprise roughly 80% of total GHG emissions, the trends in CO_2 emissions follow the same growth trends as GHG emissions.

Table 5.3 Total Canadian Emissions Projections by Gas, Excluding LULUCF Emissions (kilotonne (Kt)—natural form) from 1990 to 2030

	1990	1995	2000	2005	2010	2011	2015	2020	2030
CO_2	459,028	490,973	564,021	578,709	553,786	555,467	575,390	614,199	656,171
CH_4	3,424	4,089	4,474	4,669	4,308	4,316	4,300	4,067	4,119
N_2O	158	173	157	162	153	149	153	157	165
HFCs	1	0	2	4	5	6	8	10	14
PFCs	1	1	1	0	0	0	0	0	0
SF_6	0	0	0	0	0	0	0	0	0

Between 2005 and 2030, CO_2 emissions are projected to rise in every economic sector of Canada with the exception of the Electricity Sector where CO_2 emissions are projected to fall by 32% between 2005 and 2020, and by a further 28% between 2020 and 2030. Total methane (CH_4) emissions have increased in Canada since 1990. Between 1990 and 2005, emissions increased by 36% due to increasing activity in the Agriculture and Oil and Gas Sectors. Between 2005 and 2020, this long term trend is projected to reverse as emissions are expected to fall by 13% reflecting decreasing CH_4 emissions in both the Agriculture and the Oil and Gas Sectors. Fugitive CH_4 emissions from conventional oil production are expected to decline due to decreasing production as a result of depletion of reserves. Between 2020 and 2030, CH_4 emissions are projected to remain almost constant in all Canadian economic sectors.

Nitrous oxide (N_2O) emissions, which decreased slightly between 2005 and 2010, are projected to remain relatively stable over the projection period. N_2O emissions arise primarily from the Agriculture Sector.

Hydrofluorocarbons (HFCs) have been increasingly used in the last decade or so in refrigeration and air conditioning systems as an alternative to ozone damaging hydrochlorofluorocarbons, commonly referred to as HCFCs that are being phased out under the Montreal Protocol. However, HFCs are also potent GHGs with long atmospheric lifetimes and are projected to triple by 2030 from relatively low levels in 2010, increasing at a faster rate than economic growth due to the current lack of cost-effective substitutes to HCFCs. HFC emissions are projected to rise in the Transportation and Building Sectors from mobile air-conditioning and refrigerants respectively.

Perfluorocarbons (PFCs) and sulphur-hexafluorides (SF_6) are projected to decrease substantially over the projection period. The main releases of these gases into the environment occur during the manufacture of semi-conductors, refrigeration equipment and the production of aluminium as well as other industrial processes such as in the magnesium industry. Reductions are anticipated from voluntary measures in the aluminum industry and other sectors.

Table 5.4 converts the above information into CO_2 eq with global warming potential values from the second Assessment Report of the IPCC and provides emissions totals including and excluding LULUCF emissions.

Table 5.4 Total Canadian Emissions Projections by Gas in CO_2 eq, Including and Excluding LULUCF Emissions (Mt CO_2 eq) from 1990 to 2030

	1990	1995	2000	2005	2010	2011	2015	2020	2030
CO_2 incl LULUCF	296	590	443	563	607	594	458	484	512
CO_2 excl LULUCF	459	491	565	579	554	555	575	614	656
CH_4 incl LULUCF	75	105	96	104	102	102	92	87	88
CH_4 excl LULUCF	72	86	94	98	90	91	90	85	86
N_2O incl LULUCF	51	66	50	54	54	53	48	50	52
N_2O excl LULUCF	49	54	49	50	47	46	47	49	51
HFCs	1	1	3	5	7	8	10	13	19
PFCs	7	6	4	3	2	2	2	2	2
SF_6	3	2	3	2	0	0	0	0	0

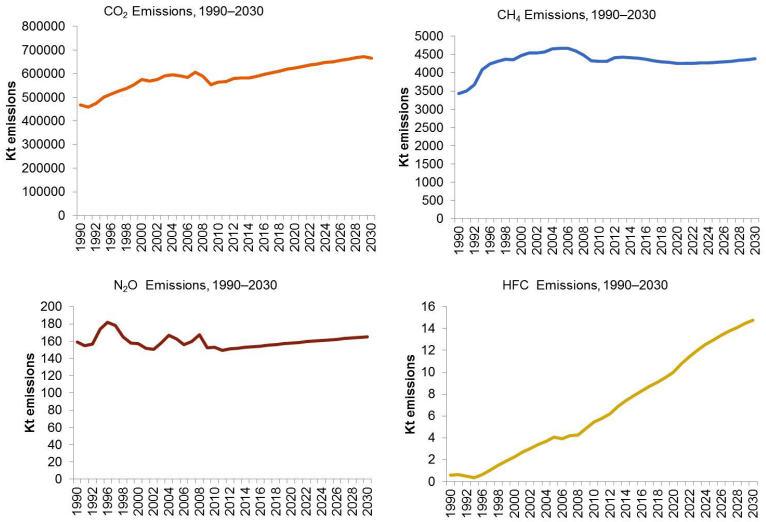

Figure 5.3 Total Canadian Emissions by Gas, 1990–2030: CO_2, CH_4, N_2O, HFC

5.4.5 Emissions Projections by Sector

Table 5.5 illustrates how the projected trends in GHG emissions vary by economic sector. This is a result of the expected evolution of the key drivers of emissions in each sector, as well as various government and other initiatives vary by sector. For example, in the Transportation Sector, the growing population in Canada affects the number of cars on the road, thus emissions from the passenger transportation subsector are projected to rise. However, offsetting this trend are the Federal Government's GHG performance standards for new vehicles which are causing the average emissions intensity of all vehicles to decline through the projection period. For the Electricity Sector, emissions are expected to fall, largely due to the combined impact of various government measures to create a cleaner electricity system, predominately by replacing coal fired generation with lower-emitting natural gas and non-emitting sources.

Table 5.5 GHG emissions by Economic Sector (Mt CO_2 eq) from 2005 to 2030

	2005	2010	2011	2015	2020	2030
Transportation	168	167	170	174	176	179
Oil and Gas	162	164	163	177	200	241
Electricity	121	99	90	84	82	59
Buildings	84	79	84	89	95	110
Emissions-Intensive & Trade-Exposed Industries	87	75	78	82	90	101
Agriculture	68	69	68	69	69	70
Waste and Others	49	48	49	50	50	55
Subtotal	737	701	702	725	762	815
Expected LULUCF	NA	NA	NA	NE	−28	NE
Total	737	701	702	725	734	815

Abbreviations: NA = Not applicable; NE = Not estimated.

5.4.5.1 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., from cars to 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 an increased population putting more vehicles on the road and resulting in more kilometres (km) driven. For example, between 2005 and 2011, the sales-weighted on-road fuel efficiency for new gasoline cars improved from 9.2 litres (L) per 100 km to 8.5 L/100 km, while the sales-weighted on-road fuel efficiency for new gasoline light trucks improved from 13.2 L/100 km to 11.7 L/100 km.

In October 2010, the Government of Canada released the final *Passenger Automobile and Light Truck Greenhouse Gas Emission Regulations,* 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 contain increasingly stringent GHG emissions standards for light-duty vehicles of model years 2017 to 2025.

These regulations will achieve significant and sustained GHG reductions and fuel-savings benefits. By 2020, it is estimated that Canadian regulations for model years 2011 to 2016 will lead to annual reductions of between 9 and 10 Mt. Preliminary estimates indicate that the proposed regulations for model years 2017 to 2025, once finalized, will reduce GHG emissions by an additional 3 Mt in 2020, increasing to 18 Mt by 2030, as these new efficient vehicles replace the existing stock.

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 50% compared to the 2008 model year), and the fuel efficiency of new passenger light trucks will increase by 37%. The sales-weighted fuel efficiency of new cars is projected to improve from 8.6 L/100 km in 2010 to 6.4 L/100 km in 2020, and to 5.1 L/100 km by 2025. The sales-weighted fuel efficiency of new passenger light trucks are projected to improve from 12.0 L/100 km in 2010 to 9.1 L/100 km in 2020, and to 7.6 L/100 km by 2025.

Total transportation emissions are projected to increase from 168 Mt in 2005 to 176 Mt by 2020, a marked deceleration of emissions growth in the sector due to the projected increased fuel-efficiency of on-road vehicles. This deceleration from historical trends is expected to continue as a result of greater fuel efficiency in vehicles being accelerated by federal vehicle emissions regulations, despite projected increases in population and number of vehicles.

Emissions are projected to increase by only 3 Mt between 2020 and 2030 as the stock of existing vehicles is gradually overturned with the newer, more efficient models.

As depicted in Table 5.6, the Transportation Sector comprises several distinct subsectors: passenger, freight, air and others (e.g., rail and marine). Each subsector exhibits different trends during the projection period. For example, emissions from passenger transportation are projected to decrease by 16 Mt between 2005 and 2030, while those for ground freight, off-road and other vehicles are projected to grow by 24 Mt over the same time period due to anticipated growth in GDP. Note that although absolute emissions are projected 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 L/100 tonne-km to 2.1 L/100 tonne-km by 2020.

Table 5.6 Transportation: Emissions by Subsector (Mt CO_2 eq) from 2005 to 2030

	2005	2010	2011	2015	2020	2030
Passenger Transport	96	97	96	95	90	80
Cars, Trucks and Motorcycles	87	88	88	86	81	70
Bus, Rail and Domestic Aviation	9	8	8	8	9	10
Freight Transport	57	60	61	66	70	81
Heavy-Duty Trucks, Rail	49	52	54	58	61	71
Domestic Aviation and Marine	8	8	7	8	9	10
Other: Recreational, Commercial and Residential	14	11	13	14	15	18
Total Emissions	168	167	170	174	176	179

5.4.5.2 Oil and Gas

Emissions in the Oil and Gas Sector are related to the production, transmission, processing, refining and distribution of oil and gas products. In 2011, the Oil and Gas Sector produced the second largest share of GHG emissions in Canada (23%). Emissions increased 61 Mt over the 1990 to 2005 time period, primarily as a result of the development of the unconventional oil and gas industry.

Since 2005, GHG emissions from the Oil and Gas Sector have remained fairly consistent around 162 Mt. Increased emissions from unconventional oil sands activity have been offset by the gradual depletion of conventional natural gas and oil resources in Canada and a decline in refining emissions.

Upstream Oil and Gas Production

Upstream oil and gas includes the extraction, production and processing of both conventional and unconventional oil and gas. This subsector represented approximately 70% of the Oil and Gas Sector in 2011 and this share is expected to increase to 74% by 2030 as oil sands extraction increases significantly.

In general, extracting oil from oil sands via an "in situ" method (e.g., using in-ground techniques to separate the oil from the sand) is more emissions intensive than the more traditional mining methods. However, within the oil sands sector, the overall emissions intensity of upstream oil production has been decreasing over time, as declining intensity from increasingly energy efficient in-situ operations more than offsets increasing intensity of oil sands mining operations (which are extracting deeper/poorer-quality bitumen-sand).

Working against this historical trend, there are several forces that are driving emissions intensity up in the oil sands subsector (e.g., declining reservoir quality, aging of existing facilities, shift from mining to more emissions-intensive in situ etc.). It is therefore unclear if these historical improvements in emissions intensity will continue. On the other hand, technological improvements have the potential to reduce oil sands emissions intensities. This technological potential is discussed in Text Box 5.1.

Box 5.1 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 5.8). 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 (CSS) and steam-assisted gravity drainage (SAGD)). 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 5.4). 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, 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.

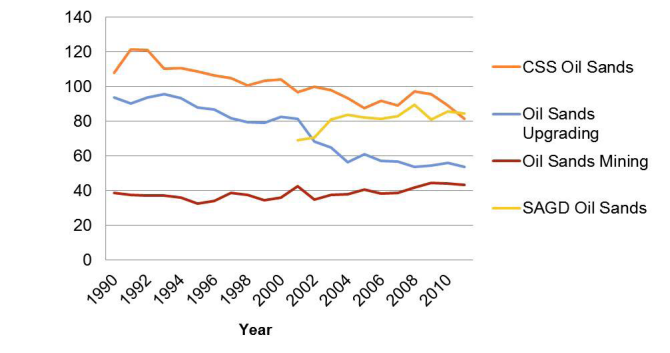

Figure 5.4 Historical Oil Sands Emissions Intensity (kilograms CO_2 eq/ barrel) 1990–2011

Considering the uncertainties associated with emissions intensities in the oil sands, the modelled projections have assumed constant emissions intensity throughout the projection period. Alternatively, under a scenario where historical trends in intensity reductions continue, oil sands emissions could be 10% lower in 2020 than under the reference scenario assuming a 10-year moving average.

Emissions projections in the Oil and Gas Sector are based on the National Energy Board's preliminary projections of oil and natural gas prices as well as preliminary estimates of anticipated production. Under the assumptions made for this report, emissions from upstream oil and gas production are estimated to grow from 109 Mt in 2005 to 144 Mt in 2020 and 177 Mt in 2030. 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 and 107 Mt by 2030. Specifically, emissions from oil sands mining are projected to more than double over the 2005 to 2020 time period and almost triple over the 2005 to 2030 time period. Even more significantly, emissions from in situ production are expected to increase from 11 Mt in 2005 to 55 Mt in 2020 and 82 Mt in 2030.

Emissions from conventional crude oil production are expected to fall from 32 Mt in 2005 to 31 Mt in 2020, and decrease further to 22 Mt in 2030 as conventional reserves are depleted. Emissions from natural gas production and processing are also expected to fall from about 56 Mt in 2005 to 37 Mt by 2020, but then rebound slightly in 2030 (to 48 Mt) as the production of natural gas is projected to increase in later years due an anticipated increase in price.

Table 5.7 Upstream Oil and Natural Gas Production: Emissions and Drivers

	2005	2010	2011	2015	2020	2030
Conventional Oil Production						
Emissions (Mt CO_2 eq)	32	29	30	36	31	22
Production (1,000 barrels/day)	1361	1228	1262	1459	1304	891
Natural Gas Production and Processing						
Emissions (Mt CO_2 eq)	56	49	47	40	37	48
Production (billion cubic feet)	6984	5873	5938	5029	4861	6318
Bitumen Production						
Emissions (Mt CO_2 eq)	21	35	37	51	76	107
Production (1,000 barrels/day)	1064	1614	1743	2338	3316	4567

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 but then increase to 12 Mt in 2030 due to the increased production and distribution of natural gas over this time period. The emissions associated with the upgrading of oil sands bitumen are expected to rise from 14 Mt in 2005 to 26 Mt by 2020 and 29 Mt by 2030. Further 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 but then increase to 21 Mt in 2030.

Liquified natural gas (LNG) is natural gas (predominantly methane) that has been converted to liquid form for ease of storage and transport. Canadian projects in British Columbia and eastern Canada aim to produce LNG to sell in global markets, where it would be re-gasified and distributed as pipeline natural gas. There is a high degree of uncertainty regarding LNG production in Canada since its potential for export resides in factors such as the cost and acceptability of export terminals and pipelines on the West Coast, as well as the long term price expectations of natural gas, both domestically and internationally. For this report, modeling assumptions have used the National Energy Board's preliminary projections of expected LNG production through 2030. GHG emissions for LNG production represent emissions from the incremental energy consumption required for LNG processes.

Table 5.8 Oil and Gas Sector Emissions by Production Type (Mt CO_2 eq) from 2005 to 2030

	2005	2010	2011	2015	2020	2030
Natural Gas Production and Processing	56	49	47	40	37	48
Conventional Oil Production	32	29	30	36	31	22
Conventional Light Oil Production	10	10	10	13	11	7
Conventional Heavy Oil Production	21	18	18	22	18	12
Frontier Oil Production	2	2	2	2	2	2
Oil Sands	34	52	55	73	101	137
Bitumen In situ	11	11	23	36	55	82
Bitumen Mining	9	14	14	16	21	25
Bitumen Upgrading	14	18	18	21	25	28
Oil and Natural Gas Transmission	16	11	11	10	9	12
Downstream Oil and Gas	24	22	20	19	19	21
Petroleum Products	22	20	18	17	17	18
Natural Gas Distribution	2	2	2	2	3	3
Liquid Natural Gas Production	0	0	0	0	2	4
Total	162	164	163	177	200	241

Note: numbers may not add due to rounding.

Petroleum Refining and Upgrading

Table 5.9 displays emissions associated with petroleum refining and upgrading. As noted above, the GHG emissions from upgrading bitumen into synthetic crude oil are included in the Traditional Refineries category. From 2005 to 2020, emissions from bitumen upgrading are projected to increase by 12 Mt, while emissions from traditional petroleum refining are projected to decline by 6 Mt. Over the longer term to 2030, emissions are expected to remain constant in traditional refineries through 2030 whereas they are expected to increase by a further 3 Mt in in upgrading.

Table 5.9 Petroleum Refining and Upgrading Sector Emissions and Drivers

	2005	2010	2011	2015	2020	2030
Traditional Refineries						
Emissions (Mt CO_2 eq)	22	20	18	17	17	17
Refined Petroleum Processed (1,000 barrels/day)	2165	2113	2035	2136	2143	2282
Upgraders						
Emissions (Mt CO_2 eq)	14	18	18	21	26	29
Upgraded Products (1,000 barrels/day)	611	865	932	1064	1317	1513

Canadian refineries are expected to increase their output by 16% between 2011 and 2030. However, GHG emissions actually decrease over this timeframe due to improvements in energy efficiency (e.g., refurbishments).

5.4.5.3 Electricity Generation

As more than three quarters of the electricity supply in Canada is generated by non-GHG emitting sources of power, the Electricity Sector only comprised 13% of total emissions in 2011.

Historically over the 1990 to 2005 period, demand for electricity rose and this increase in demand was being met with varying sources of power. Emissions from the Electricity Sector increased over this time period as some provinces expanded their capacity by building fossil fuel-fired power plants or by increasing the utilization rate of existing coal units in place of nuclear plants, as was done in the province of Ontario. In addition, other provinces increased their natural gas-fired generation to meet growing demand. Post-2005, emissions in this sector are projected to fall significantly as coal-fired units will have been closed and more lower and non-emitting sources will have been brought online.

The recent downward trend in emissions from the Electricity Sector is expected to continue over the next decade as a result of various federal and provincial governmental initiatives. Emissions in the Electricity Sector are projected to fall by 32% between 2005 and 2020 and by a further 28% between 2020 and 2030.

Several provinces have introduced significant measures to move away from fossil fuel electricity generation to cleaner sources of power and will contribute to the decline in emissions in the Electricity Sector. In particular, Ontario's coal-fired generation phase-out will have all coal units in the province retired by the end of 2014. As well, Nova Scotia aims to decrease 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.

In addition, the Federal Government released final regulations to reduce emissions from the coal-fired electricity generation in September 2012. The regulations apply a stringent performance standard to new coal-fired electricity generation units and those coal-fired units that have reached the end of their economic life. The regulations come into effect on July 1, 2015 and will facilitate a permanent transition towards lower or non-emitting types of generation such as high-efficiency natural gas and renewable energy. With this regulation, Canada became the first major coal user to ban construction of traditional coal-fired electricity generation units.

Table 5.10 outlines the decline in projected emissions alongside the expected increase in electricity generation through 2030.

Table 5.10 Electricity Sector: Emissions and Drivers

	2005	2010	2011	2015	2020	2030
Emissions (Mt CO_2 eq)	121	99	90	84	82	59
Generation (terawatt hours)	550	523	545	573	609	685

The increase in electricity generation expected through 2030 will be powered from various fuel sources depending on the Canadian province and available resources. Although coal usage for electricity generation is declining, the proportion of power generation from fossil fuels is expected to vary by province depending on the availability of electricity from hydro, nuclear power, and non-hydro renewable energy sources such as wind.[4] 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 75 Mt over the 2005 to 2030 time period. Emissions from natural gas are expected to increase by 16 Mt over the period in this sector, as natural gas replaces coal in electricity generation and meets requirements of increasing overall demand.

Table 5.11 Electricity Sector Emissions by Fuel Type (Mt CO_2 eq) from 2005 to 2030

	2005	2010	2011	2015	2020	2030
Coal	101	80	69	62	60	26
Refined Petroleum Products	7	3	2	3	2	3
Natural Gas	13	16	19	18	21	29
Total	121	99	90	84	82	59

The proportion of utility electricity generation coming from wind power and other renewable sources, excluding hydro and nuclear, is projected to increase between 2005 and 2030. Non-hydro renewables comprised 0.36% of total utility electricity generation in 2005 and are expected to account for 4.4% of total generation by 2030. It is assumed that renewables do not generate emissions.

5.4.5.4 Emissions-Intensive and Trade-Exposed Industries

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

Emissions from the EITE Sector were responsible for 16% of total Canadian emissions in 1990, and fell to 11% in 2011. The decline (9 Mt) reflects the economic downturn, technological changes such as improved emission control technologies for perfluorocarbons (PFCs) 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.

Emissions from the EITE Sector are expected to reach 2005 levels again by 2020 and increase by 11 Mt between 2020 and 2030. Emissions are estimated to have been at their lowest point in 2010 following a decline in pulp and paper and mining output, but then began to recover following an upward trend consistent with production growth anticipated in the fertilizer, cement, chemicals, and lime and gypsum subsectors.

Table 5.12 EITE Industries: Emissions and Drivers

	2005	2010	2011	2015	2020	2030
Emissions (Mt CO_2 eq)	87	75	78	82	90	101
Gross Output of EITE sectors (1997 $billions)	129	104	108	115	123	137

Emissions generated by most EITE subsectors are projected to be near 2005 levels by 2020, owing to modest production growth in the recovery years of the economic downturn, and continued reduction of emissions intensities. Exceptions include decreased emissions in pulp and paper, and increasing emissions from mining, chemicals and fertilizers as several new plants are expected to be built.

Over the 2020 to 2030 timeframe a number of subsectors are projected to increase. For example, the chemicals and fertilizers subsector is projected to demonstrate growing emissions which are projected to rise by 17%. Mining emissions are projected to increase by 30% over the period, while emissions from cement

increase by 17%.This reflects expected increases in production while the energy efficiency of the subsectors increase more slowly.

Table 5.13 EITE Industries' Emissions by Subsector (Mt CO_2 eq) from 2005 to 2030

	2005	2010	2011	2015	2020	2030
Mining	5	7	8	9	10	13
Smelting and Refining (Non-ferrous metals)	12	10	11	11	11	12
Pulp and Paper	9	6	6	6	5	5
Iron and Steel	20	16	17	17	19	20
Cement	13	10	10	11	12	14
Lime and Gypsum	3	3	3	3	3	3
Chemicals and Fertilizers	25	24	24	26	30	35
Total	87	75	78	82	90	101

5.4.5.5 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, energy efficiency improvements are helping to keep emissions stable.

Emissions from commercial and residential buildings are projected to increase by 12% over the 2005 to 2020 timeframe, and then by an additional 17% over the 2020 to 2030 timeframe (excluding indirect emissions from electricity).

Residential

As shown in Table 5.14, GHG emissions from the residential buildings (e.g., houses, apartments and other dwellings) are expected to remain relatively stable between 2005 and 2020, rising 3 Mt, before increasing by another 4 Mt between 2020 and 2030. This is despite an expected national increase of 4.4 million households between 2005 and 2030, 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 better technologies and practices. In addition, federal and provincial measures aimed at increasing the energy efficiency of residential buildings, such as building code regulations, rebates for energy efficiency improvements and voluntary housing energy efficiency standards are helping to improve efficiencies in this subsector.

Table 5.14 Residential Subsector: Emissions and Drivers

	2005	2010	2011	2015	2020	2030
Emissions (Mt CO_2 eq)	44	41	45	45	47	51
Households (millions)	12.7	13.7	13.9	14.7	15.6	17.1
Tonnes per household	3.46	2.99	3.23	3.06	3.01	2.98

Commercial

GHG emissions from Canada's commercial buildings are expected to reach 48 Mt in 2020, an increase of 9 Mt from 2005. Emissions continue to rise from 2020 to 2030 increasing by an additional 11 Mt (Table 5.15). Emissions in the commercial subsector remained stable between 2005 and 2011 while floor space continued to increase due, in part, to strengthening of building energy codes, an increased commitment to benchmark energy use and undertaking of energy-related retrofits. Even with continued efficiency improvements, emissions are expected to grow due to two factors: an expansion of commercial floor space (the principal driver of emissions from this subsector) as the economy continues to grow; and the expected increase of HFCs in refrigeration and air conditioning for the commercial sector, due to the phase-out of ozone-depleting HCFC refrigerant alternatives. As HFCs[5] have an average global warming potential that is up to 1900 times more potent than CO_2, even a small increase in HFC use has a significant impact on emissions. Between 2020 and 2030, emissions are projected to increase by 23%, while floor space increases by 26%.

Table 5.15 Commercial Subsector: Emissions and Drivers

	2005	2010	2011	2015	2020	2030
Emissions (Mt CO_2 eq)	39	38	39	44	48	59
Floor space (millions square meters)	654	719	727	789	884	1118

5.4.5.6. Agriculture

GHG emissions from primary agriculture in Canada consist mainly of methane and nitrous oxide from livestock and crop production systems as well as emissions from on-farm energy use. Emissions have remained stable over the 2005 to 2011 period at approximately 69 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 LULUCF Sector.

While emissions remain stable over the 2005 to 2030 period, there are a number of compositional trends in the sector. Between 2005 and 2011, increases in on-farm fuel use were offset by decreases in animal projection. However, this trend reverses in the projection period as animal production is expected to increase and fuel use is expected to decrease through improved farm management practices.

Given these compositional trends, agriculture emissions are projected to remain relatively stable, reaching a total of 69 Mt in 2020 and 70 Mt in 2030.

Table 5.16 Agriculture Sector Emissions by Subsector (Mt CO_2 eq) from 2005 to 2030

	2005	2010	2011	2015	2020	2030
On-Farm Fuel Use	9	13	14	14	13	10
Crop Production	19	22	22	22	22	23
Animal Production	39	33	32	33	34	37
Total Agriculture	68	69	68	69	69	70

5.4.5.7 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.

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. Emissions from these various subsectors are projected to remain relatively stable over the 2005 to 2020 timeframe increasing slightly in the 2020 to 2030 timeframe.

Table 5.17 Waste and Others Emissions by Subsector (Mt CO_2 eq) from 2005 to 2030

	2005	2010	2011	2015	2020	2030
Waste	21	22	22	20	18	18
Coal Production	2	4	4	4	4	3
Light Manufacturing, Construction & Forest Resources	25	22	23	26	29	34
Total Waste and Others	49	48	49	50	50	55

5.4.5.8 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.

LULUCF emissions accounting represents only emissions/removals from managed lands in Canada. 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 (i.e., 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 GHGs to the atmosphere due to decomposition or burning of the biomass.

Very little information is available on management practices on Canadian agricultural grassland, and it is unknown whether grazed land is improving or degrading. While there are no detailed comprehensive activity data for Canadian agricultural grassland, there is no evidence to suggest that current management practices are degrading grasslands. Work is ongoing to determine to what extent management of grasslands can impact GHG emissions. Wetland information is also incomplete, with little information on the wetland areas subject to forest or agricultural management practices. The methodology for creating projections is still under development.

Finally, in settlements remaining settlements, urban trees contribute very little to the national GHG budget. Estimates for 2011 indicate modest removals of less than 0.2 Mt CO_2 eq. Therefore, these have been left out of projections analysis until more robust estimation and projection methods are developed.

While GHG emissions from the LULUCF Sector are included in Canada's annual NIR, the sector was left out of projections provided in Canada's 5th National Communication and was not included in the updated projections provided to the Expert Review Team during the May 2011 review. 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) that can result in significant variations in the annual emission and removal estimates and generally cannot be predicted for future years. As a result, the effects of natural disturbances cannot be included in projection estimates because they cannot be reasonably predicted, apart from a low level of background fire expected to occur every year and residual effects from past events. The impact of natural disturbances, when included in annual estimates of GHG emissions from the LULUCF sector, also makes it difficult to discern the effects of improved management practices.

The LULUCF projection estimates presented in the table below are modeled separately from the other sectors. Specifically, each subsector has been modeled by the experts in the relevant departments of the Federal Government.

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

Table 5.18 LULUCF Emissions by Subsector (Mt CO_2 eq) from 1990 to 2030

	1990	1995	2000	2005	2010	2011	2015	2020	2030
Forest Land Remaining Forest Land	−181	116	−130	−14	68	54	−120	−133	−147
Cropland Remaining Cropland	−2	−4	−7	−10	−13	−13	−10	−9	−6
Forest Land Converted to Other Land Categories	26	19	18	18	17	17	15	15	12
Land Converted to Forest Land	−1.0	−1.0	−1.0	−0.9	−0.7	−0.7	−0.5	−0.4	−0.4
Total LULUCF	−158	130	−120	−7	72	57	−115	−128	−142

Note: estimates up to and including 2011 include natural disturbances; estimates for 2015 and beyond are projections and exclude the impacts of natural disturbances except for a low background level expected to occur every year. Numbers may not add due to rounding.

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. Under this approach, the contribution of LULUCF in 2020 is estimated to be 28 Mt. This approach is described in detail in Annex 2 of this chapter.

Table 5.19 Projected Emissions (+) or Removals (−) from the LULUCF Sector in 2020[a]

(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[b]	−133	−26
Cropland Remaining Cropland[c]	−10	−9	1
Forest Land Converted to Other Land Categories[d]	18	15[e]	−4
Land Converted to Forest Land	−0.9	−0.4	0.6
Total	−100	−128	−28

[a] Numbers may not add due to rounding.
[b] For Forest Land Remaining Forest Land, a 2020 reference level is used for determining the contribution.
[c] Cropland remaining Cropland includes residual emissions after 20 years from forest conversion to cropland.
[d] Includes all emissions from the conversion of Forest Land to other categories, except residual emissions 20 years or more after the forests are converted to cropland.
[e] Differences between these values and those reported in 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.

5.4.5.9 Foreign Passenger and Foreign Freight

Emissions from Foreign Passenger and Foreign Freight Sectors are not included in the national total consistent with UNFCCC reporting guidelines.

Emissions from the Foreign Passenger and Foreign Freight Sectors comprise total Canadian fuel sold to ships. Emissions are expected to increase 20% between 2005 and 2030 as the number of foreign transportation vehicles and number of kilometers traveled increases. The short-term drop in emissions in 2011 can be primarily attributed to the global economic slowdown and its effect on foreign fuel consumers.

Table 5.20 Fuel Sold to Ships Emissions by Subsector (Mt CO_2 eq) from 2005 to 2030

	2005	2010	2011	2015	2020	2030
Foreign Passenger	8	8	8	9	10	12
Foreign Freight	5	4	3	3	4	4
Total Foreign	13	12	11	12	13	16

Table 5.21 Provincial and Territorial GHG and Per Capita Emissions from 2005 to 2011

	GHG Emissions (Mt CO_2 eq)	GHG Emissions (Mt CO_2 eq)	GHG Emissions (Mt CO_2 eq)	Per Capita Emissions (t/capita)	Per Capita Emissions (t/capita)	Per Capita Emissions (t/capita)
	2005	2010	2011	2005	2010	2011
Newfoundland and Labrador	10	9	9	19.2	18.3	18.3
Prince Edward Island	2	2	2	15.5	14.0	15.3
Nova Scotia	23	20	20	24.9	21.3	21.6
New Brunswick	20	18	19	26.9	24.3	24.6
Quebec	86	80	80	11.3	10.1	10.0
Ontario	206	175	171	16.4	13.2	12.8
Manitoba	21	20	20	17.8	16.2	15.9
Saskatchewan	71	73	74	71.5	70.1	69.7
Alberta	232	241	246	69.8	64.5	64.5
British Columbia	64	60	59	15.3	13.2	12.8
Territories	2	2	2	21.9	18.8	17.7
Canada	737	701	702	22.9	20.5	20.4

Table 5.22 Provincial and Territorial GHG Emissions (Mt CO_2 eq) from 2005 to 2030

	2005	2010	2011	2015	2020	2030
Newfoundland and Labrador	10	9	9	10	10	10
Prince Edward Island	2	2	2	2	2	2
Nova Scotia	23	20	20	19	16	15
New Brunswick	20	18	19	19	18	16
Quebec	86	80	80	80	81	84
Ontario	206	175	171	170	177	189
Manitoba	21	20	20	21	22	24
Saskatchewan	71	73	74	78	74	66
Alberta	232	241	246	265	295	320
British Columbia	64	60	59	60	64	85
Territories	2	2	2	2	2	3
LULUCF	NA	NA	NA	NE	-28	NE
Canada	737	701	702	725	734	815

Abbreviations: NA = Not applicable; NE = Not estimated.

5.5 Emissions by Province[6]

Emissions vary significantly by province, driven by diversity in population size, economic activities and resource base, among other factors. For example, provinces where the economy is oriented more toward resource extraction will tend to have higher emissions 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 5.21 shows the provincial/territorial distribution of emissions in absolute terms as well as their per capita (t/capita) emissions.

Table 5.22 displays projected provincial and territorial GHG emissions from 2005 to 2030. 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 (i.e., British Columbia, Alberta and Quebec), regulatory measures, and legislated renewable electricity targets.[7]

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 5.23 displays projected provincial and territorial per capita GHG emissions out to 2030 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 and to continue to fall in most provinces out to 2030.

Table 5.23 Provincial and Territorial Per Capita Emissions (t/capita) from 2005 to 2030

	2005	2010	2011	2015	2020	2030
Newfoundland and Labrador	19.2	18.3	18.3	20.0	19.1	20.2
Prince Edward Island	15.5	14.0	15.3	14.1	13.0	11.3
Nova Scotia	24.9	21.3	21.6	20.0	17.3	15.5
New Brunswick	26.9	24.3	24.6	24.4	23.9	21.0
Quebec	11.3	10.1	10.0	9.6	9.4	9.1
Ontario	16.4	13.2	12.8	12.2	12.2	12.1
Manitoba	17.8	16.2	15.9	15.9	15.8	15.6
Saskatchewan	71.5	70.1	69.7	69.2	61.2	48.6
Alberta	69.8	64.5	64.5	64.0	64.9	59.3
British Columbia	15.3	13.2	12.8	12.3	12.4	14.6
Territories	21.9	18.8	17.7	19.4	17.7	23.1
Canada	22.9	20.5	20.4	20.1	20.0	19.6

5.6 Assessment of Aggregate Effect of Policies and Measures

Canada associated with the Copenhagen Accord in January 2010 and committed to reduce its GHG emissions to 17% below 2005 levels by 2020. In light of strong economic growth this could be challenging: Canada's economy is projected to be approximately 31% larger (in real terms) in 2020 compared to 2005 levels. The Government of Canada's approach is to encourage strong economic growth and job creation while achieving Canada's environmental objectives.

Progress in reducing GHG emissions is measured against a "without measures" 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 is 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 electric-generation energy use resulting from non-policy driven factors, including nuclear refurbishment or historical weather-related fluctuations in hydroelectric dam capacities are included in the "without measures" scenario. Oil sands emissions are derived using 2005 emissions intensities. Agriculture emissions from livestock and crop production are maintained at reference scenario levels throughout the entire projection period. 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.

The difference between this baseline scenario and the "with current measures" scenario presented in this report represents the total effect of policies and measures by both federal and provincial Canadian governments and actions by businesses and consumers. Through actions of governments, consumers and businesses, emissions are projected to be 128 Mt less in 2020 than under a scenario where no action to reduce emissions had been taken since 2005, highlighting the significant progress that has been achieved at lowering emissions from a business-as-usual trajectory (Figure 5.5).

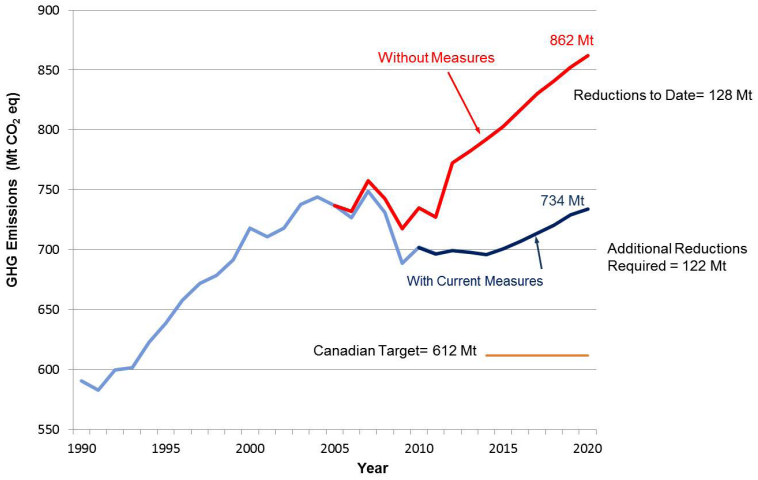

Figure 5.5 Scenarios of Canadian Emissions to 2020 (Mt CO_2 eq)*

* The "with current measures" line (post-2005) includes the compliance contribution of the LULUCF Sector towards the Copenhagen target, and therefore actual emissions trends (without LULUCF) will be 28 Mt higher in 2020.

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).

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.

Please see Annex 2 of this chapter for a discussion on the contribution of LULUCF towards Canada's Copenhagen target.

Annex 1 Baseline Data and Assumptions

Key Economic Drivers and Assumptions

Table 5A.1 Summary of Key Assumptions Used in Base Case Development and Projection Analysis from 1990 to 2030

	Historical		Projected	
Key Underlying Assumptions	1990	2011	2020	2030
Oil Price (C$2010/bbl)	$38.63	$97.73	$105.42	$110.82
Natural Gas Price (C$2010/GJ)	$2.71	$4.28	$5.29	$6.34
Real GDP Chain-Weighted ($1997)*	0.2%	2.5%	1.6%	1.7%
Real GDP per capita ($1997)*	−1.3%	1.3%	0.6%	0.9%
Consumer Price Index (1992=100)*	4.8%	2.9%	2.2%	2.1%
Population*	1.5%	1.2%	1.0%	0.8%
Population of driving age (18–75)*	1.5%	1.3%	0.7%	0.6%
Labour Force*	1.3%	0.9%	0.7%	0.5%

*Annual growth rate
Abbreviations: C$ = Canadian dollars, bbl = Barrels, GJ = Gigajoule, Kt CO_2 eq = Kilotonne of carbon dioxide equivalent, GDP = Gross domestic product.

Baseline Data and Assumptions

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

In constructing the emissions projections, Environment Canada developed alternative views of changes in certain key drivers (e.g., world oil price, the pace of economic growth) that result in a range of plausible emissions growth trajectories. The baseline emissions projections scenario represents the mid-range of these variations, but remains conditional on the future path of the economy, world energy markets and government policy. The assumptions and key drivers are listed in this section. Alternative cases are explored in the sensitivity analysis in Chapter 5 Annex 3.

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

Historical data on GDP and disposable personal income are provided from Statistics Canada. Consumer price index and population demographics are also produced by Statistics Canada while historical emissions data are provided by the *National Inventory Report*, 2013 (NIR 2013). The economic projections to the year 2018 are calibrated to Finance Canada's June 2013 Private Sector Survey.[8] The outer years (2018–2030) are based on Finance Canada's longer-term fiscal projections included in their "Economic and Fiscal Implications of an Aging Population" report.[9]

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 Board is an independent federal agency that regulates international and interprovincial aspects of the oil, gas and electric utility industries. The U.S. Energy Information Administration's outlook on key parameters is also taken into account in the development of energy and emissions trends.

Economic Growth

The Canadian economy grew by 1.4% per year over 2005 through 2011, a period that includes the 2009 global recession. Real GDP growth is expected to average 2.1% per year from 2011 to 2020, and 1.6% from 2020 to 2030.

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 1.4% annually between 2011 and 2020, an improvement over the 0.3% average annual growth during the period between 2005 and 2011. The increase in productivity is attributed to an expected rise in capital formation, and contributes to the growth in real disposable personal income, which is expected to increase by an average of 1.6% per year between 2011 and 2020.

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, slowing to 1.0% per year between 2015 and 2020, and further slowing to 0.9% between 2020 and 2030.

Table 5A.2 Macroeconomic Assumptions, 1990–2030 Average Annual Growth Rates

	1990–2005	2005–2011	2011–2020	2020–2030
Gross Domestic Product	2.8%	1.4%	2.1%	1.6%
Consumer Price Index*	2.1%	1.9%	1.8%	1.9%

* The consumer price index 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% inflation throughout the projection. However, due to the fact that inflation is endogenous, rates do not equal 2% in each year.

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 and by an average of 0.9% per year between 2020 and 2030.
- Labour force: This is expected to have a decelerating growth rate, reflecting the aging population. Its annual average growth rate was 1.3% per year between 2005 and 2011, and is projected to slow to 0.8% per year between 2011 and 2020 and then further slow to 0.6% between 2020 and 2030.

World Crude Oil Price

A major factor in projected GHG emissions is the assumption about future world oil prices since this drives the level of production of oil. Canada is a price taker in crude oil markets as its shares of world oil production and consumption are not large enough (4% and 2%, respectively) to significantly influence international oil prices. West Texas Intermediate (WTI) crude oil is used as an oil price benchmark. North American crude oil prices are determined by international market forces and are most directly related to the WTI crude oil price at Cushing, which is the underlying physical commodity market for light crude oil contracts for the New York Mercantile Exchange. The increase in North American supply and the resulting transportation bottleneck at Cushing have created a disconnect between the WTI price of crude oil and the Brent price of crude oil. As such, the North American oil market is currently being priced differently from the rest of the world.

The emissions outlook's reference case is anchored by the world oil price assumptions developed by the National Energy Board. According to the Board, the world crude oil price for WTI is projected to increase slightly from about $82 Canadian dollars (C$) per barrel of oil (bbl) in 2010 to about C$105/bbl in 2020 and rise further to C$111/bbl in 2030. A higher price scenario, in which 2020 prices are C$136/bbl and 2030 prices are C$142/bbl is used for the sensitivity analysis in Annex 3 of this Chapter. Under the higher price scenario, GHG emissions are expected to be lower.

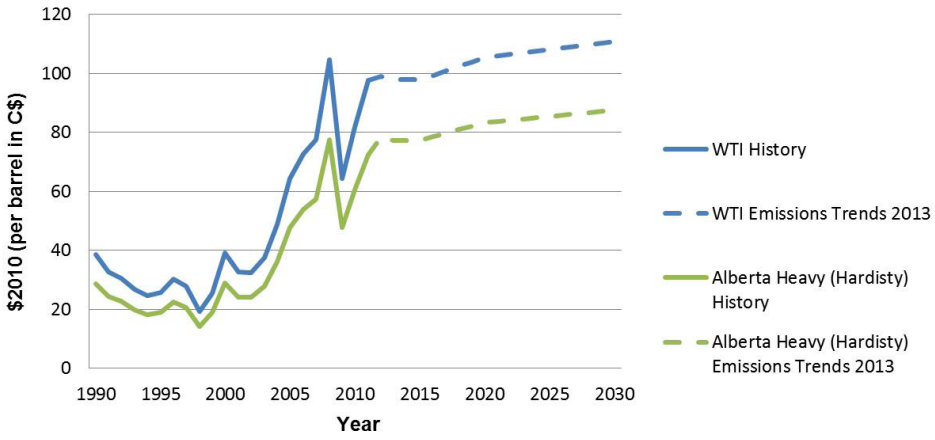

Figure 5A.1 Crude Oil Price: WTI and Alberta Heavy (C$ 2010/bbl)

Figure 5A.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%.[10]

As shown in Figure 5A.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 and then C$6.26 per GJ by 2030, 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.

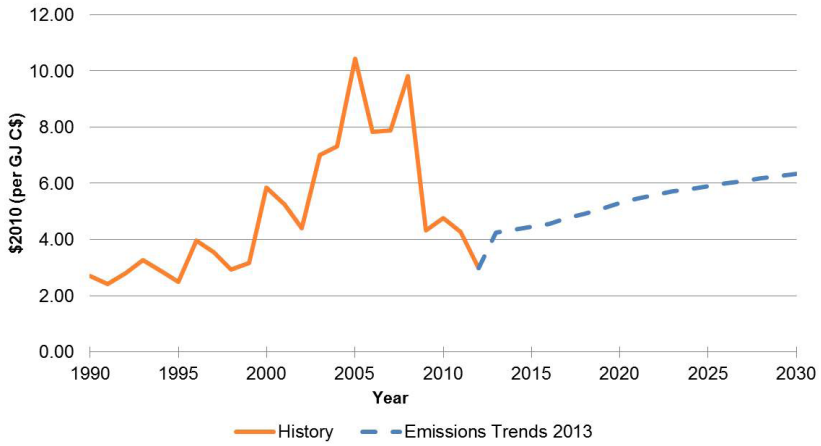

Figure 5A.2 Henry Hub Natural Gas Price ($C 2010/GJ)

Table 5A.3 Crude Oil Production in thousands barrels per day

	2005	2010	2011	2015	2020	2030
Crude and Condensates	1534	1380	1410	1592	1441	1029
Conventional Light	511	512	556	707	612	414
Conventional Heavy	526	425	428	523	432	290
C5 & condensates	173	152	148	133	137	138
Frontier Light (offshore + north)	324	291	277	229	260	187
Oil Sands	1064	1614	1743	2338	3315	4567
Oil Sands—Primary	150	194	211	243	243	243
Oil Sands—In-situ	286	563	640	1093	1794	2725
Steam Assisted Gravity Drainage	82	319	374	805	1467	2360
Cyclic Steam Stimulation	204	244	266	288	328	364
Oil Sands Mining	628	857	892	1003	1278	1599
Total Production (gross)	2597	2994	3153	3930	4756	5596

Energy and Electricity Production

National Energy Board 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 2030 oil sands in situ production will increase nearly fivefold and oil sands mining production will nearly double (see Table 5A.3) with further increases out to 2030.

Table 5A.4 illustrates oil sands disposition. There are two main products from oil sands production: synthetic crude oil (or upgraded bitumen) and non-upgraded bitumen, which is sold as heavy oil. Synthetic crude oil production is projected to increase from about 932,000 barrels per day (bbl p/d) in 2011 to about 1.3 million bbl p/d by 2020 and then to about 1.5 million bbl p/d by 2030. Non-upgraded bitumen will increase from 697,000 bbl p/d in 2011 to 1.8 million bbl p/d by 2020 and then to 2.8 million bbl p/d by 2030. 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 5A.4 Oil Sands Disposition in thousands barrels per day

	2005	2010	2011	2015	2020	2030
Synthetic	610	932	932	1064	1317	1513
Non-upgraded Bitumen	368	700	697	1127	1817	2844
Oil Sands (net)	979	1632	1,630	2191	3,133	4356
Own-use	85	111	114	147	182	210
Oil Sands (gross)	1,064	1743	1,743	2338	3,316	4,567

Projections show gross natural gas production will decline to some 4.9 trillion cubic feet (TCF) in 2020, as new production and non-conventional sources such as shale gas and coal-bed methane come to market[11] but do not quite offset conventional declines. These new sources of natural gas production increase output to 6.3 TCF by 2030.

Table 5A.5 Natural Gas Production in billion cubic feet

	2005	2010	2011	2015	2020	2030
Supply						
Gross Production	6984	5873	5938	5029	4861	6319
Own-use Consumption	722	503	629	664	781	1122
Marketable Gas	6262	5370	5309	4365	4081	5197
Imports	346	828	1148	828	828	828
Total	6608	6198	6456	5193	4908	6024
Liquid Natural Gas production	0	0	0	0	550	1100

Table 5A.6 Electricity Generation by Fuel, terawatts per hour

	2005	2010	2011	2015	2020	2030
Coal and Petroleum Coke	97	76	66	59	58	28
Refined Petroleum Products	12	3	2	4	3	4
Natural Gas	25	29	37	36	40	69
Hydro	327	321	342	357	397	456
Nuclear	87	86	88	92	84	97
Other Renewables	2	9	10	25	28	30
Total Generation	550	523	545	573	609	685

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

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 26% from 2011 to 2030, with fuel mix changes as generation increases. As Table 5A.6 illustrates, the proportion of generation coming from wind power and other non-hydro renewable sources is expected to increase from 2005 to 2030, starting at only about 0.4% in 2005 and reaching 4.4% of total generation by 2030. Importantly, though, the proportion of natural-gas-fired generation in 2030 is projected to be triple 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 substantially by 2030 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 4.1% in 2030.

Emissions Factors

Table 5A.7 provides a rough estimate of carbon dioxide equivalent emissions emitted per unit of energy consumed by fossil fuel type. These numbers are estimates based on latest available data based on Intergovernmental Panel on Climate Change (IPCC) methodology. Specific emission factors can vary slightly by year, sector, and province.

Table 5A.7 Mass of CO_2 eq Emissions Emitted Per Quantity of Energy for Various Fuels

Fuel	CO_2 eq. Emitted [grams 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
Liquefied Petroleum Gas	60.62
Natural Gas	49.90
Natural Gas Raw	66.13
Petroleum Coke	84.65
Still Gas	47.94

Federal, Provincial and Territorial Measures

Table 5A.8 identifies the major federal, provincial and territorial measures that are included when modeling the reference case. This includes federal measures that have been implemented or announced in detail as of May 2013. Where program funding is set to end, the projections assume that the impacts of these programs, other than those embodied in consumer behaviour, cease when the approved funding terminates. The analysis also includes existing provincial and territorial measures. Environment Canada involves provinces and territories in extensive consultations to ensure their initiatives are accounted for in analysis and modeling of emissions trends. For the purposes of this report, provincial/territorial measures announced and fully implemented as of May 2013 have been included wherever possible.

Although the reference case includes existing measures that have been implemented or announced in detail, it does not take into account the impact of broader strategies or future measures within existing plans where significant details are still under development. These policies still under the development will be included in subsequent projections as their details become finalised. Canada has chosen not to include a "with additional measures" scenario at this time, since upcoming measures are still being analysed at both the provincial and federal levels.

Note also that the modeled polices and measures in Table 5A.8 will not match the full list of measures included in the previous chapter of this report. This is because the economic modeling will only account for measures that have been fully funded, legislated or where sufficiently detailed data exists that make them possible to add to the modeling platform.

Table 5A.8 GHG Measures Reflected in Projections (in place May 2013)

Provincial/Territorial Measures	Federal Measures
Alberta • Specified Gas Emitters Program	• Electricity Performance Standard for Coal Fired Generation
British Columbia • B.C. Carbon Tax • Renewable fuels tax exemptions for minimum ethanol and biodiesel content • B.C. Emissions Offsets Regulations • Landfill Gas Management Regulation	• Residential Building Code changes for energy efficiency (EnerGuide-80 or R-2000 level) applying to all provinces • Renewable Fuel Content Regulation
Manitoba • Renewable fuels provincial tax credit/exemption for minimum ethanol content	• Adoption of the *National Energy Code for Buildings* of Canada 2011 or its equivalent, by all provinces and territories, except Northwest Territories, by 2016
Nova Scotia • Renewable Portfolio Standard for electric generation • Electric demand-side management policies • Solid Waste Management Resources Management Strategy	• Commercial appliance efficiency improvements (excludes lighting) • Residential appliance efficiency improvements. Includes refrigeration, freezers, ranges and dryers
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	• Industry Expansion of Canadian Industry Program for Energy Conservation including International Organization for Standardization (ISO) and Canadian Standards Association (CSA) certification programs • Light Duty Vehicles 1 (LDV-1) GHG emissions standards for the light-duty vehicle model years 2011 to 2016 • Light Duty Vehicles 2 (LDV-2) GHG emissions standards increases stringency for model years 2017 to 2025
Quebec • Renewable fuels tax reimbursement/income tax credit • Quebec and California cap and trade system • Quebec's Carbon Levy • Landfill Gas Regulation	• 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, to improve environmental performance of mills including GHG emissions reductions. The program ended in 2012 but will result in on-going emission reductions
Saskatchewan • Renewable fuels distributor tax credit for ethanol produced and consumed in the province	• 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 emissions reduction modeling does not take these generalized targets into consideration in the emissions projections modeling within this report. Instead, individual policies that are brought forward as methods to attain the provincial targets may be included in the modeling platform if they meet the criteria discussed above. Table 5A.9 lists the emissions reductions targets announced by each province or territory.

Table 5A.9 Announced GHG Reduction Targets of Provincial/Territorial Governments

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

Annex 2 The Contribution of the Land Use, Land-use Change and Forestry Sector

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.[12]

Each subsector's contribution to Canada's 2020 emissions reduction target is estimated using an accounting approach that compares projected estimates for 2020 emissions/removals to 2005 emissions/removals, with the exception of Forest Land Remaining Forest Land, where 2020 projected estimates for emissions/removals are compared to a 2020 Reference Level[13] (see Table 5.19). The Reference Level approach is currently seen as the most scientifically-credible approach to account for emissions and removals from Canada's managed forests considering Canada's inventory methodology and forest structure.

The Durban agreement for Land Use, Land-use Change and Forestry (LULUCF) included Canada's proposed Reference Level for the 2013 to 2020 period.[14] 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. Canada's work to analyze alternative accounting approaches is ongoing, and changes to the accounting approach may be made in future.

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_2eq. 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. 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. Actions aimed at reducing emissions or increasing removals in this sector will also change this measurement.

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 5.19, 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 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 hectares per year for Canada as a whole.
- **Cropland Remaining Cropland.**[15] Soil carbon sequestration in Canada has increased from a rate of 2 Mt CO_2 eq per year in 1990 to 13 Mt CO_2 eq 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_2 eq 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 5A.3). As such, future projections will be adjusted as a result of revised conditions for each of these sectors.

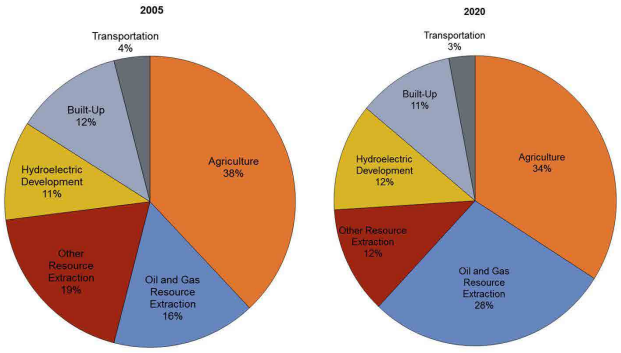

Figure 5A.3 Main Drivers of Forest Conversion in 2005 and Projected for 2020*

* 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.

Annex 3 Modeling and Methodological Differences from Canada's 5th National Communication

Canada's 5th National Communications included projections of GHG to the year 2012 in-line with our reporting requirements under the Kyoto Protocol Implementation Act (KPIA), which are no longer applicable. Canada's reporting obligations under the United Nations Framework Convention on Climate Change (UNFCCC) now require preparing emission projections to 2020 and 2030. The projections in this report use the same model as Canada used for the 5th National Communications—the E3MC model—as well as the same modeling methodology. Differences arise through updated input data (e.g., historical GHG emissions, gross domestic product (GDP), etc.), updated assumptions about domestic and international evolving energy markets, and the inclusion of current government measures. Of particular importance is that projections in the 5th National Communication included the expected impact of the Clean Air Regulatory Agenda that was ultimately not implemented. This 6th National Communication report includes new provincial and federal government measures (e.g., Federal Electricity Performance Standard for coal fired generation).

During the expert review process by the UNFCCC in 2011, Canada submitted *Canada's Emissions Trends Report 2011*[16] which was subsequently publicly released and contained its national GHG projections to 2020. Differences in modeling and economic assumptions used in the development of the projections submitted during the 2011 review process versus the development of this year's submissions are outlined below. These modeling and assumption adjustments impact historical and projected emissions data as highlighted in various sections of the report. Select adjustments 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. Previously, inefficient facilities were assumed to increase production into the future in order to meet increased demand. 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. Energy intensity was increased substantially and calibrated to an IHS Cambridge Energy Research Associates report resulting in an approximate increase of 3 Mt in primary oil sands emissions.
- Improvements in the transportation sector include an update to data sources and a refinement of efficiency assumptions. The new source originates from mandatory manufacturer reporting as required under the light-duty vehicle regulations starting in model year 2011. The degradation factor for converting lab-tested to on-road fuel efficiency has been changed from 85% to 80%.
- 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 using 2011 census data, affecting future livestock production projections.
- The Emission-Intensive and Trade-Exposed 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 with Environment Canada's engineers and sector specialists.
- 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. Projects that have been placed on hold due to economic circumstances have been taken out of the reference case.

Canada acknowledges the important role of the LULUCF Sector in addressing climate change and, as in the 2012 *Emissions Trends Report*, has placed a focus on this sector in the development and analysis of emissions projections to 2020. Some estimates in LULUCF contributions have changed due to the following technical adjustments implemented in 2013:

- Classification of LULUCF subsectors has changed in order to maintain alignment between our LULUCF accounting and our Inventory reporting to the UNFCCC. Forest Management is replaced by "Forest Land Remaining Forest Land"; Cropland Management is replaced by "Cropland Remaining Cropland"; Deforestation is replaced by "Forest Land Converted to Other Land Categories"; and Afforestation is replaced by "Land Converted to Forest Land". As noted in the LULUCF section of Chapter 5: Projections and the Total Effects of Policies and Measures, this has implications for land-use change reporting.
- Projections have been remodeled to take into account updated information and improved modeling consistent with Canada's most recent (2013) NIR. New sources of information include the 2011 Census of Agriculture and updated historical data on harvests, fire and insect infestations.
- Reference Level used for the managed forest (Forest Land Remaining Forest Land) has been updated from Canada's original Reference Level included in the Durban Agreement to, reflect the updated data and methodologies used to produce the NIR 2013, and the shift to accounting based on Forest Land Remaining Forest Land. The impact of this technical correction on the Reference Case is primarily due to the inclusion of the actual level of natural disturbances that occurred in the years 2010 and 2011.

Annex 4 Alternate Emissions Scenarios

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

In Table 5A.10, the emissions outcomes of these alternative cases are presented independently and in various combinations. These alternative cases explore the interaction of energy markets and economic growth, and their impact on emissions, under a range of assumptions.

Under a scenario where oil prices are assumed to be 27% higher than in the reference case in 2020 and annual average growth in GDP between 2010 and 2020 is expected to be 2.6% (compared with 2.2% in the reference scenario), emissions could reach 773 Mt CO_2 eq including the contribution from LULUCF in 2020.[17] 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 CO_2 eq including the LULUCF contribution in 2020.

In the baseline scenario, 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. These high and low oil price extremes were provided by the National Energy Board as the probable range of future energy prices used within their analysis.

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

Figure 5A.4 illustrates how differing price and GDP growth assumptions in various combinations might impact Canadian GHG emissions through 2020.

GHG emissions in the fast-GDP-growth scenario are about 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 5A.10 quantifies the results of the full range of emissions alternatives illustrated in the above figure.

Table 5A.10 Sensitivity Analysis: Change in GDP and/or World Oil/Natural Gas Prices in Mt CO_2 eq with LULUCF in 2020

Cases	GHG Emissions in 2020	GHG Emissions Change Between 2005 and 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	36 to −51

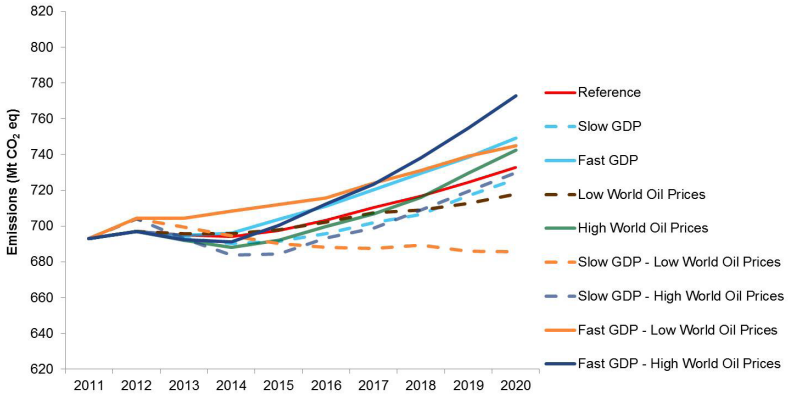

Figure 5A.4 Projected GHG Emissions Under Full Range of Alternative Economic Assumptions (excluding LULUCF)

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 Sector which generally 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.

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.

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.

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 oil sands emissions would increase by 67 Mt.

Annex 5 Methodology for Development of Emissions Scenarios

The scenarios developed to support Environment Canada's GHG emissions projections derive from a series of plausible assumptions regarding, among others, population and economic growth, prices, demand and supply of energy, and the evolution of energy efficiency technologies. The projections also assume no further government actions to address GHG emissions beyond those already in place as of May 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 Canada's GHG emissions projections involves two main features:

- Using the most up-to-date statistics on GHG emissions and energy use, and sourcing key assumptions from the best available public and private expert sources.
- Developing scenarios of emissions projections using a detailed, proven Energy, Emissions and Economy Model for Canada (E2MC).

Up-to-date Data and Key Assumptions

Each year, Environment Canada updates its models using the most recent data available from Statistics Canada's *Report on Energy Supply and Demand in Canada* and Canada's NIR. For these projections, the

most recent historical data available were for 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). Projections are based on the latest energy and economic data, with key modeling assumptions aligned with Government of Canada views:

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

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

The Without Measures Scenario

In 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 belonging to 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 E3MC model.

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, CH_3 and N_2O) by sector and by province.

Figure 5A.5 shows the general structure of E3MC. The component modules of E3MC represent the individual supply, demand, and conversion sectors of domestic energy markets, and also include the macroeconomic module. In general, the modules interact through values representing the prices of the energy delivered to the consuming sectors and the quantities of end-use energy consumption.

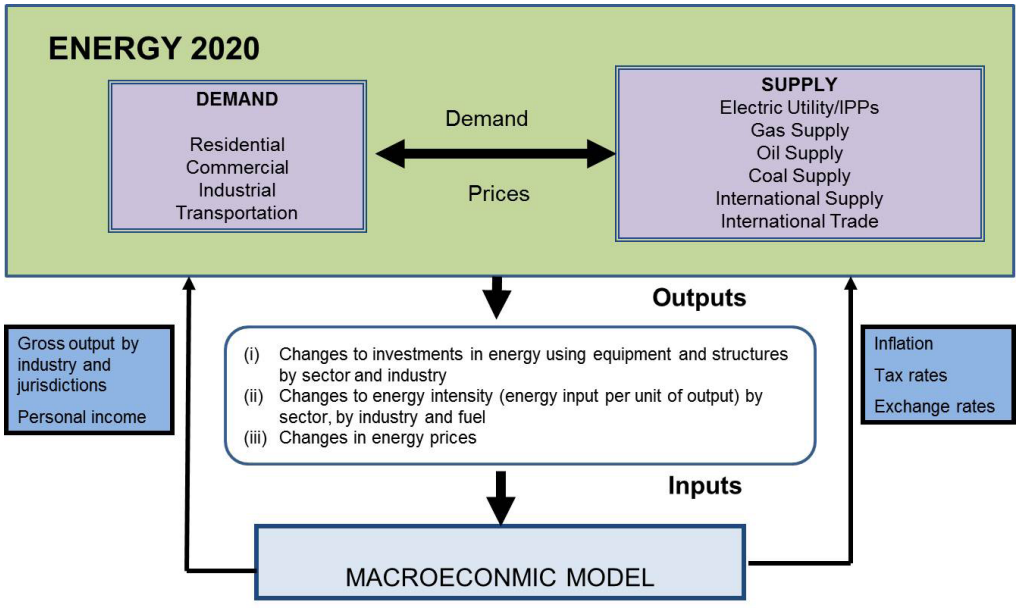

Figure 5A.5 Energy, Emissions and Economy Model for Canada

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.[18] All of these structures work to simulate the rebound effect. In the example above, the impact of extra kilometres that may be driven as a result of improved fuel efficiency is automatically netted out of the associated emissions-reduction estimates.

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

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

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

Taken as a whole, the E3MC model provides a detailed representation of technologies that produce goods and services throughout the economy, and can simulate, in a realistic way, 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.

Annex 6 Land Use, Land-use Change and Forestry 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 subsector 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 2013 NIR 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 were 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 were developed are 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 NIR.

Forest Land Remaining Forest Land and Land Converted to Forest Land

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 NIR. 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 NIR 2013. 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 projected harvest estimates 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 NIR, 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,[19] 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 NIR, 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 NIR. As noted above, there is limited information available on Land Converted to Forest Land 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 estimate 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 breakdown of activities and a detailed breakdown of cropping production practices including choice of tillage regime, use of summer fallow 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 a 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 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 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 to provide the final estimated CLCL emissions.

Annex 7 Further Sources

Environment Canada produces two products that report on greenhouse gas emissions.

1. *National Inventory Report*
   The NIR provides Canada's historical emissions starting in 1990. The Report fulfills Canada's obligations as a signatory to the UNFCCC, to prepare and submit an annual national greenhouse gas inventory covering anthropogenic emissions by sources and removals by sinks. The Report is prepared with input from numerous experts and scientists across Canada.

2. *Canada's Emissions Trends*
   Canada's Emissions Trends is a projection of greenhouse gas emissions tos the year 2020, at the national, provincial and sector level. The report is used to for a variety of purposes, including supporting climate change policy development. The projections are generated by an in-house integrated energy, economy and environment modeling platform, peer-reviewed by external experts.

   Environment Canada draws also upon the National Energy Board's *Energy Outlook* as a basis for its oil and gas sector modeling. The Outlook contains comprehensive energy supply and demand expectations to 2030 and includes scenarios for all energy commodities including oil, natural gas, natural gas liquids and electricity. Further, the Board provides data on energy prices, factors affecting prices and the deliverability of natural gas. Data and projections from the National Energy Board are incorporated into the exogenous oil and gas module in E3MC.

References

1 EITE subsectors include mining activities, smelting and refining, and the production and processing of industrial goods such as chemicals, fertilizers, pulp & paper, aluminum, iron & steel and cement.

2 Canada's NIR 2013 provides historical emissions by IPCC sector and by economic sector.

3 For purposes of modeling emissions projections, Environment Canada defines the electricity sector as consisting of electricity production from power plants whose primary purpose is to sell electricity to the grid (i.e., to the public. This is as per the North American Industry Classification System code that begins with "22"). This definition does not necessarily include all electricity production in Canada (e.g., does not include industrial electricity generation that is not sold to the grid).

4 See Annex Table 5A.6 Electricity generation by fuel.

5 For its projections of HFCs, Environment Canada assumes emissions arise from the total HFC bank (i.e., bulk imports plus net product imports); projected emission rates from the total bank of HFCs is assumed to remain unchanged from the historical rates over the last three years; and bulk imports of HFCs and net product imports of HFCs are assumed to grow at the rate of population growth. The commercial buildings and transportation sectors account for the largest majority of HFC use, although recycling of refrigerants and prevention of leaks has improved considerably.

6 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 SF_6 (except for electric utilities) are only reported at the national level in Canada's NIR. As such differences in emissions totals may occur, if these totals are calculated by summing up provincial values.

7 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 in the projections.

8 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.

9 http://www.fin.gc.ca/pub/eficap-rebvpc/eficap-rebvpc-eng.pdf

10 http://www.ercb.ca/docs/products/STs/st98_current.pdf

11 For the purposes of this document, shale gas development has been included under natural gas production. As more data

and information on likely shale gas production trends become available, consideration will be given to modeling shale gas separately.

12 National Forestry Database Program, www.nfdp.ccfm.org

13 In accordance with the process agreed at the UNFCCC 17th Conference of the Parties in Durban, South Africa.

14 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

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

16 Canada's first Emissions Trends report was released in 2011. http://www.ec.gc.ca/Publications/default.asp?lang=En&xml=E197D5E7-1AE3-4A06-B4FC-CB74EAAAA60F

17 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.

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

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

6 Vulnerability Assessment, Climate Change Impacts and Adaptation Measures

6.1 Introduction

Canada's climate is changing and impacts have been observed across the country. The economic impacts of these changes are difficult to assess, but are likely significant.[1]

Adaptation helps manage risks associated with a changing climate. It involves making adjustments in decisions and activities because of observed or expected changes in climate, in order to moderate harm or take advantage of new opportunities. Examples of adaptation measures include the development of different building standards for areas where heavier snowfall is expected or limiting development in coastal areas where sea level is projected to rise.

Adaptation is a shared responsibility, with roles for all levels of government, the private sector, communities, and individuals. Recognition of this responsibility is reflected in the commitments to address climate change adaptation by federal and provincial/territorial governments, and adaptation plans and implementation at the municipal level. A growing number of organizations in the private sector are also taking steps to prepare for a changing climate.

Since the publication of Canada's 5th National Communication, an increase in adaptation research and activities in Canada is evident. Understanding of the potential impacts, as well as the adaptation process, has improved, more groups are involved in adaptation discussions, and a number of adaptation measures have been implemented. Adaptation is increasingly acknowledged as an important part of a broader response to climate change, and it is widely accepted that adaptation can help manage risks and take advantage of opportunities.

This chapter provides an overview of advances in understanding climate change impacts and progress on adaptation in Canada since 2010. It includes a brief description of impacts in Canada and examples of their consequences, and outlines key government policies, strategies, and frameworks related to adaptation. It also provides an overview of domestic adaptation measures and highlights Canada's work on this issue within the international community.

Key developments since 2010

The Government of Canada renewed and expanded its focus on adaptation by investing $148.8 million over five years in 10 adaptation programs and adopting the Federal Adaptation Policy Framework (2011) to help bring climate change issues into the mainstream of federal decision-making.

Adaptation has been incorporated into more strategies and plans at the provincial and territorial level, so that most jurisdictions now have stand-alone plans which highlight the importance of adaptation and can help focus efforts.

Municipalities have taken action to prepare for a changing climate, including the development of adaptation strategies, incorporating considerations of impacts and adaptation into official plans and planning policies, and adopting measures to reduce climate-related risks.

Progress at all levels has been encouraged by new mechanisms developed to facilitate collaboration, shared learning, and priority-setting on adaptation research and action. These include the Adaptation Platform and the Climate Change Adaptation Community of Practice.

Canada is actively engaged in the international community to strengthen and disseminate research and science related to the impacts of climate change to ensure that adaptation actions are informed by the best available knowledge.

6.2 Canada's Changing Climate

Climate change impacts in Canada are well documented in several reports (for example, *From Impacts to Adaptation,*[2] in press; Climate Change 2007: Synthesis Report;[3] *Paying the Price: The Economic Impacts of Climate Change for Canada*[4]). This section illustrates some of these impacts by providing regional and sectoral examples as they relate to temperature increases and altered precipitation patterns.

6.2.1 Temperature and Precipitation

Between 1948 and 2012, the annual average surface air temperature over Canada's landmass has warmed by about 1.7°C, approximately twice the global average.[5] While warming trends are observed consistently across the country, stronger trends are found in the north and west, particularly during the winter and spring.[6] Northern Canada (defined from a meteorological monitoring perspective as north of 60° latitude) has warmed at a rate approximately two-and-a-half times the global average since the late 1940s. An increase in warm days and warm nights has been observed while fewer cold nights, cold days, and frost days have been observed across the country.[7]

Although more difficult to assess given the strong regional variability in precipitation trends and its various states (rain, freezing rain, snow, etc.), Canada has generally become wetter in recent years. Total annual precipitation in Canada has increased over the period 1948–2012.[8] In most of southern Canada (south of 60° latitude), there has been a decrease in snowfall and an increase in rainfall, consistent with warmer temperatures. The trends in extreme precipitation have varied across the country and no consistent changes have been observed.[9]

Increases in temperature and changing precipitation patterns have led to a wide range of impacts, including reduced Arctic ice cover, changes in timing and amount of surface water availability, increased evaporation contributing to lower levels in the Great Lakes, increased depth and extent of permafrost thaw, shorter seasons and decreased quality of northern ice roads, increased loss of forests due to pests and wildfires, more frequent droughts and flooding, and increased risks from food-borne diseases (Figure 6.1).[10]

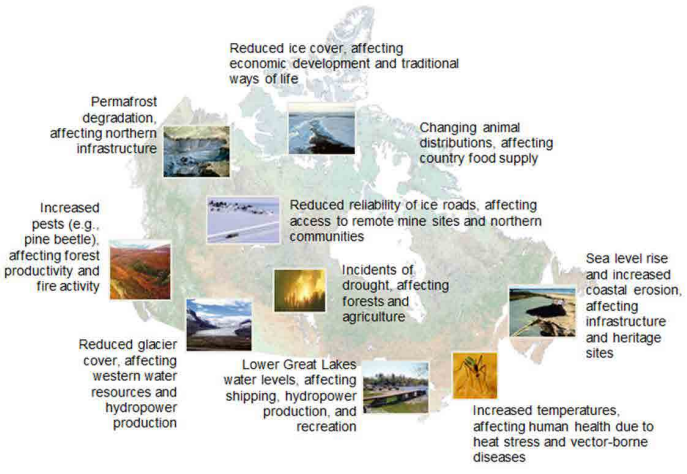

Figure 6.1 Examples of climate change impacts in Canada

6.2.2 Extreme Events

All regions of Canada have experienced extreme weather events. While it is difficult to attribute individual incidents of extreme weather to climate change, it is expected that the frequency and severity of extreme weather events—including heat waves, droughts, and floods—will change as a result of climate change.

Insured losses for weather-related claims in Canada have been near or above $1 billion in each year from 2009 to 2012. In 2011, insured losses hit $1.7 billion, while insured losses in 2012 totalled $1 billion. Insurance claims resulting from water and wind damage caused by severe weather make up more than half of all property insurance claims in Canada, and are now responsible for more claims than damages caused by fire.[11]

Extreme weather events can cause disruptions to critical infrastructure, including water treatment and distribution systems, energy generation and transmission, and transportation systems. This can lead to increased maintenance and insurance costs, decreased productivity due to damaged transportation services and infrastructure, and rebuilding costs.

For example, in a two-hour period on July 8, 2013, 126 millimetres of rain fell in the Greater Toronto Area, the amount of average precipitation the region receives for the month of July. According to the Insurance Bureau of Canada, this was one of the most expensive natural disasters in Ontario, with estimated insured property losses of more than $850 million.[12] In June 2013, heavy rainfall in parts of Alberta led to catastrophic flooding that affected several communities in the southwestern portion of the province.[13] 32 states of local emergency were declared, and more than 100,000 people were displaced throughout the region. The Government of Alberta estimated that the cost of the flooding would likely exceed $5 billion.[14]

6.2.3 Arctic Sea Ice

Changes in sea ice in the Canadian Arctic resulted in record low ice coverage in both the northern and southern routes of the Northwest Passage in September 2012 with less than half of the September average.[15] Reductions in Arctic sea ice could lead to new opportunities for mining exploration and development in northern Canada, including improved access to resources and new transportation options.[16] However, there are also challenges associated with operating in the Arctic environment, including issues related to environmental safeguards, marine navigation hazards, access to uncharted and poorly charted or sensitive areas, and poor weather forecasting.

6.2.4 Permafrost

Permafrost temperatures have risen by up to 2°C over the last 20–30 years,[17] and the southern limit of permafrost has retreated northward; for example by 130 kilometres during the past 50 years in northern Quebec.[18] Warming permafrost and increased thaw depth have a number of negative consequences for northern Canada, including increased settlement and reduced ground strength under infrastructure projects, changes in drainage leading to expansion or loss of wetlands and lakes, risks to existing waste containment, and increased erosion rates.

6.2.5 Coastal Zones

Climate change-related risks to coastal areas in Canada include coastal inundation, increased storm-surge flooding, and shoreline erosion. These impacts are primarily related to changes in sea level, sea ice cover, and the frequency and severity of storms, and additionally will be highly variable on regional and local scales. Coastal waste sites, as well as archaeological and heritage sites, are becoming increasingly exposed, threatening contamination of people and wildlife and loss of cultural resources. Contaminated marine resources may also become an issue for some coastal Inuit and First Nations communities that depend on marine resources for food, impacting their health, food and cultural security, and cost of living. Large coastal

cities such as Vancouver may be impacted by rising sea levels.[19]

6.2.6 Transportation Infrastructure

Changing temperature and precipitation patterns are affecting transportation infrastructure across the country. In southern areas, extreme heat contributes to increased pavement deterioration and buckling of railway lines.[20] In northern Canada, warmer winters and resulting permafrost degradation affect the viability of seasonal roads and airport runways. Coastal infrastructure is also negatively affected by changing sea levels and increased storminess while operations on inland waterways are affected by lower water levels. These changes will impact the costs associated with maintaining and operating transportation infrastructure.

6.2.7 Agriculture

For agriculture, climate change impacts may result in longer and warmer growing seasons that allow higher-value, warmer-weather crops to be grown, as well as longer grazing seasons for livestock.[21] However, increased temperatures could also have negative impacts on agriculture, including decreased water availability in some regions, impaired livestock health and productivity, reduced dairy production, and reduced crop production.[22] In addition, there will likely be new pests, invasive species and diseases, and more severe outbreaks of current ones.[23]

6.3 Building the Knowledge Foundation

Knowledge of climate change impacts and the potential for associated risks is the foundation for organizations to protect assets and resources and to strengthen planning and decision-making. The development of programs, policies, and actions related to climate change impacts and adaptation are commonly informed by research and different types of assessments, including vulnerability, risk, and science assessments. Efforts in Canada concerning impacts and adaptation assessment have not been limited to vulnerability assessment, though a number of sectoral or site-specific vulnerability assessments have been undertaken, some of which are highlighted in section 6.6 of this chapter.

Since Canada's 5th National Communication, more Canadian governments have completed some form of climate change assessment focusing on their own organization or specific sector. These research and assessment activities have contributed to the development of decision-support tools and have revealed lessons learned that have supported the advancement of adaptation. Expanding the knowledge base continues to be an important part of understanding the process of adaptation, as well as implementation of specific adaptation measures in Canada.

Natural Resources Canada published a national-scale scientific assessment on the impacts of climate change in Canada in 2008, titled *From Impacts to Adaptation: Canada in a Changing Climate*.[24] Through a regional approach, this assessment highlighted adaptation actions to minimize risks and take advantage of opportunities associated with a changing climate, with a focus on human and managed systems. Since its publication, it has served as an authoritative reference to inform adaptation decision-making at various levels (e.g., national, regional, sectoral).

Natural Resources Canada is developing an update to this report, to be released in 2014. While the 2008 assessment took a regional approach, the update takes a sector-based approach which focuses on natural resources (e.g., forestry, mining, and energy), food production, industry, the natural environment and biodiversity, human health, and infrastructure. In addition to this report, sectoral assessments focused on marine coasts, transportation, and mining will be completed by 2016.[25]

Federal departments have undertaken assessments to identify climate change risks and adaptation measures in their areas of responsibility, including Fisheries and Oceans Canada (2005), Health Canada (2008),

Aboriginal Affairs and Northern Development Canada (2010), and Natural Resources Canada (2010).[26] Fisheries and Oceans Canada began a new risk assessment process in 2011, examining where its own infrastructure is most vulnerable to changing conditions.[27] The information gathered through this exercise will inform decision-making on, for example, incorporating sea level rise considerations into new breakwater designs and dredging needs arising from increased sedimentation and erosion.

Provinces have also undertaken climate risk assessments. For example, the Province of Alberta has undertaken a climate risk assessment process for selected departments based on the direct or indirect interface of their core business functions with current or potential future climate impacts. Adaptation strategies have been developed for each of these departments as part of the process, and the results of the risk assessment process are informing the development of a provincial climate change adaptation strategy. The Government of Nova Scotia has also undertaken climate risk assessments with a particular emphasis on coastal and inland flood-risks, erosion hazards, and the impact on infrastructure (e.g., dykelands, railways, roads, culverts, bridges, and buildings). New flood risk and vulnerability assessments are continuing through the province's new Flood Mitigation Framework (2013).[28]

Several sector-specific assessments have also been conducted. For example, the Government of Yukon completed a multi-year infrastructure risk and vulnerability assessment of Yukon government buildings in areas where permafrost is thawing.[29] In addition to identifying infrastructure adaptation strategies, this assessment also created an inventory of permafrost information to facilitate and encourage cooperative and collaborative permafrost-related work and research activities.

Assessments are often the first stage of municipal adaptation planning processes. In this context, several Canadian guidebooks have been produced that describe the steps municipalities can take to assess and manage climate change risks.[30] For example, the Government of Alberta developed the *Climate Change Adaptation Framework Manual* (2010)[31] to help government and non-government organizations anticipate and prepare for the economic and ecological impacts of climate change. The Government of Newfoundland and Labrador also developed *7 Steps to Assess Climate Change Vulnerability in Your Community*[32] (2013), which is suitable for non-experts and for communities with limited resources. Natural Resources Canada has also compiled case studies of land use planning tools for local adaptation, which includes examples from communities of varying sizes and from all regions of Canada.[33]

Peel Public Health (Ontario) conducted a climate change and health vulnerability assessment and produced the report *Health Vulnerability to Climate Change: Assessing Exposure, Sensitivity, and Adaptive Capacity in the Region of Peel* (2013).[34] The results suggest that Peel's existing programs will not be sufficient to address future health risks resulting from a changing climate, such as increases in temperature-related illnesses and deaths, and worsening respiratory and cardiovascular conditions as a result of reduced air quality. The report establishes baseline information about climate-related impacts to human health in the Region of Peel which will contribute to the implementation of the Region of Peel Adaptation Strategy.[35]

Assessments are also important elements of adaptation planning in First Nations and northern communities. For example, in 2012, the Jean Marie River First Nation, in the Northwest Territories, assessed the community's vulnerability to permafrost degradation. The initiative provides the community with a practical tool for decision-making and a map of geological hazards which may assist land use planning. The community of Atlin, in northern British Columbia, also assessed its vulnerability to changing climate conditions, a process which led to its *Climate Change*

Adaptation Plan (2011).[36] Financial support for these projects was provided by Aboriginal Affairs and Northern Development Canada's Climate Change Adaptation Program.

6.4 Setting Direction: Adaptation Policies, Plans, and Frameworks

As the impacts of climate change have become increasingly apparent and previous investments in adaptation research, awareness, and capacity building efforts in Canada have led to tangible results, actions to address adaptation have become more formalized. They can be seen in adjustments made in existing plans, policies, and procedures to adapt to a changing climate, and through the creation of stand-alone adaptation plans and strategies.

6.4.1 Federal

The federal government has continued to make strategic investments in climate change impacts and adaptation that focus on priority areas such as human health and well-being, northern and vulnerable communities, and economic competitiveness. Efforts to better understand climate and climate change, and to develop tools to support adaptation decision-making across Canada, have also continued and are ongoing.

Canada's 5th National Communication highlighted the federal government's 2007 investment of $85.9 million in six programs which encouraged and supported provinces, territories, municipalities, and professional organizations to take action to adapt to climate change. These programs laid a foundation by strengthening the knowledge base, building capacity in national and regional adaptation planning, and engaging practitioners such as planners and engineers.

In 2011, the Government of Canada renewed its domestic climate change adaptation funding with an investment of $148.8 million in 10 programs over five years.[37] Six programs built on their previous investments by broadening their reach to address emerging issues and engaging the private sector. Four programs were added to address new priorities, focusing on transportation, fisheries, parks, and northern infrastructure. Examples of Government of Canada actions include:

- Environment Canada continues to provide updated information about observed and projected changes in climate, as well as climate change scenarios;
- Natural Resources Canada has established a national Adaptation Platform, whose participants have collaborated to advance adaptation in several areas such as coastal management and economics (discussed in further detail in section 6.5);
- The Standards Council of Canada and Aboriginal Affairs and Northern Development Canada are working to ensure that building codes and standards are effective in addressing climate-related risks to northern infrastructure design, planning, and management;
- Transport Canada is working to develop and evaluate tools, technologies, and best practices to enhance the resilience of existing and future northern transportation infrastructure and operations to climate change;
- Fisheries and Oceans Canada is developing new science knowledge to support the development of adaptation tools and strategies that will enable the integration of climate change considerations into the delivery of the Department's programs and policies;
- Parks Canada Agency is working with partners to reduce the potential impacts of climate-driven changes on ecological integrity and traditional lifestyles in Canada's Arctic national parks by mapping and developing ecological inventories, and monitoring select northern national parks;
- Health Canada is expanding its Heat Alert and Response Systems program, disseminating heat and health related guidelines and information, and supporting the development of health adaptation plans and information tools in northern First Nations and Inuit communities;

- The Public Health Agency of Canada is providing the public health system with information and tools to prevent and mitigate the occurrence of disease; and
- Aboriginal Affairs and Northern Development Canada is extending its funding program to support Aboriginal and northern communities in assessing the risks associated with climate change and developing adaptation plans to address them.

These investments were guided by the Federal Adaptation Policy Framework,[38] which was adopted by the federal government in 2011. The Framework provides direction on adaptation and a basis for increased coordination of federal adaptation activities. It establishes a clear role for the federal government focused on generating and sharing information and knowledge to inform adaptation decision-making, building the capacity of Canadians to take action, and integrating—or mainstreaming—climate change considerations into federal policies, planning, and operations.

6.4.2 Provincial and Territorial

All provinces and territories have made progress on impacts and adaptation issues, and have either released (or are in the process of developing) adaptation strategies or have integrated adaptation efforts into broader climate change action plans. This section focuses on jurisdictions that have released stand-alone adaptation strategies or action plans since the release of Canada's 5th National Communication on Climate Change in 2010. Therefore, Quebec, Ontario, Manitoba, British Columbia and the three territories (Yukon, Northwest Territories, and Nunavut) are highlighted below.

Prior to 2010, the four Atlantic Provinces (New Brunswick, Nova Scotia, Prince Edward Island, and Newfoundland and Labrador) released a joint adaptation strategy (2008). In 2009, Alberta released the first phase of its provincial adaptation strategy, which focused on risk assessment and capacity building. While not a specific or stand-alone adaptation plan, Saskatchewan's Water Security Agency's Plan (2013–2014) identifies opportunities to advance adaptation to ensure sustainability of surface and ground water supplies and reducing risks associated with flooding, drainage, and drought.

These strategies and plans reflect the growing importance of adaptation among provincial and territorial governments. Some of the shared priorities across jurisdictions include building community capacity, funding climate change adaptation research, enhancing existing emergency preparedness initiatives, and strengthening urban and rural land use planning processes.[39]

6.4.2.1 Quebec

The Government of Quebec published its 2013–2020 Climate Change Adaptation Strategy,[40] which serves as an update to its 2006–2012 strategy. Adaptation actions completed under the first strategy include assessments and research related to permafrost, coastal erosion,[41] and forestry,[42] as well as the incorporation of climate change considerations into various management plans. Quebec's updated strategy sets out a broad plan to strengthen the province's resilience to climate change. It defines the government's strategic directions and objectives in four priority areas: (1) the well-being of residents and communities; (2) the continuity of economic activity; (3) the safety and durability of buildings and infrastructure; and (4) the maintenance of ecological services. The strategy builds on initiatives introduced in the 2006–2012 strategy, including, for example, integrating adaptation into new policies and legislation and taking adaptation into account in decisions on land use and urban planning. The strategy is supported by a $200 million investment in Quebec's 2012–2013 budget.[43]

6.4.2.2 Ontario

The Government of Ontario developed Climate Ready: Ontario's Adaptation Strategy and Action Plan (2011)[44] which outlines the province's strategy and actions to address climate change impacts over

a four year period (2011–2014). The strategy helps support the Ontario government and partners to prepare for risks and opportunities resulting from climate change in the province. It identifies impacts from climate change on various sectors and suggests specific courses of action, such as promoting water conservation, developing guidance for storm-water management, and mainstreaming adaptation into provincial policies and programs. The province also published Ontario's Biodiversity Strategy (2011),[45] which includes several initiatives to assess species and ecosystem vulnerability to climate change and integrate this information into decision-making. Two additional documents, Biodiversity: It's In Our Nature (2012)[46] and A Practitioner's Guide to Climate Change Adaptation in Ontario's Ecosystems (2011),[47] were also developed to assist natural resource managers to identify ways that climate change risks can be integrated into decision-making processes.

6.4.2.3 Manitoba

In 2012, the Government of Manitoba launched its Climate Change Adaptation Pathway[48] which defines the strategic direction of its adaptation efforts. The Pathway consists of three inter-related phases: (1) government and province-wide risk assessments; (2) a provincial adaptation strategy; and (3) action planning. An interdepartmental Climate Change Adaptation Working Group has been established to foster shared understanding of climate risks, as well as current and planned adaptation initiatives, and to provide a forum for effective adaptation decision-making and collaboration going forward across government and within Manitoba.

6.4.2.4 British Columbia

The Government of British Columbia developed Preparing for Climate Change: British Columbia's Adaptation Strategy (2010)[49] to ensure that knowledge and resources are available and used efficiently and directed to key sectors and decision-makers, relevant government programs participate, and stakeholders and the public recognize that adaptation is an important part of addressing climate change. The overall objective of the strategy is to help British Columbia maintain sustainable communities and green economic development in the face of a changing climate. To date, the province has developed adaptation planning tools for decision-makers, including Preparing for Climate Change: An Implementation Guide for Local Governments in British Columbia (2012).[50] This guide was designed to assist local government officials, staff, planners, and others to plan and take action to increase the resilience of their communities to the impacts of climate change. Supporting this Guide, the Pacific Climate Impacts Consortium, a regional climate service centre, developed Plan2Adapt,[51] a website that generates maps describing projected future climate conditions for British Columbia.

6.4.2.5 Yukon, Northwest Territories, and Nunavut

In 2011, the three territorial governments jointly released the Pan-Territorial Adaptation Strategy: Moving Forward on Climate Change Adaptation.[52] Recognizing their common interest in reducing risks to northern infrastructure, economies, human health and safety, ecosystems, and traditional cultures, this strategy identifies a series of actions, including: (1) collaborating with other governments in Canada and across the circumpolar North to share knowledge and develop cooperative activities; (2) enhancing community resilience by supporting vulnerability and risk assessments and adaptation planning, and by providing information, training, and tools; and (3) mainstreaming adaptation into government operations and decision-making.

6.4.3 Municipal

Given their responsibilities related to infrastructure, municipal governments have a history of engagement on climate change with a focus on adaptation.[53] Actions have often been triggered by observed damages from past extreme weather events and through policy initiatives from higher levels of government, including significant federal support for research and capacity building (adaptation tools, training, pilot projects) and

provincial requirements to develop adaptation plans and strategies.[54]

Several Canadian cities have stand-alone adaptation strategies. For example, Vancouver published its Climate Change Adaptation Strategy (2012),[55] in which many of the proposed actions focus on increasing understanding of anticipated challenges and integrating climate change into planning, design, and emergency management. These actions are intended to guide the way Vancouver builds and maintains streets, sewers, building infrastructure, parks, and green spaces to ensure they are resilient to climate change.

Municipalities have also released plans to address specific challenges. For example, Edmonton developed the Urban Forest Management Plan (2012)[56] in response to serious threats to the city's urban tree canopy from drought, insect infestations, disease, storms, and climate change. It includes a review of existing planting strategies, which has led Edmonton's Forestry Unit to test the use of different tree species, such as red maples, and alternative tree watering techniques.[57]

Climate change adaptation has been incorporated directly into municipal official plans, which are formal planning documents that set out the long-term vision, goals, and objectives for the development of municipalities. In 2010, Iqaluit, the capital of Nunavut, became one of the first Canadian communities to integrate climate change adaptation into its formal planning processes.[58] The plan includes five priority vision statements, two high-level objectives, details on the climate change issues of concern to the community, and priority adaptation actions related to municipal infrastructure. Adaptation is also included in the official plan for the City of Ottawa. The plan notes the City will consider impacts and adaptation when completing environmental management and sub-watershed plans, ensure development avoids potential natural hazards from extreme weather events, and reduce the urban heat island effect.[59]

In addition to specific adaptation plans or strategies, municipal governments in Canada use a variety of practices to address climate change risks and opportunities, including the adoption and enforcement of bylaws and changes to policies and procedures that take a changing climate into consideration. For example, in the Halifax Regional Municipality, City Council passed a bylaw for the downtown Halifax waterfront in 2009 prescribing a 2.5 metre threshold above the ordinary high water mark for ground floor elevations of new developments to address risks related to storm surges and sea level rise.[60]

6.5 Fostering Effective Collaboration

Collaboration continues to be a fundamental mechanism for advancing adaptation in Canada. Many examples of adaptation presented in this chapter stem from effective cooperation and collaboration between different groups, including various levels of government, academia, and industry. In recognition of this, a number of collaborative initiatives have been developed since 2010, building on existing efforts.

As outlined in Canada's 5th National Communication on Climate Change, Natural Resources Canada established the Regional Adaptation Collaborative program[61] to foster collaboration amongst decision-makers from government, communities, professional organizations, and the private sector to: (1) advance adaptation on common priorities; (2) focus on regional priorities; and (3) draw on existing knowledge and expertise to advance adaptation across all regions of Canada. Six entities were established, each of which focused on the adaptation priorities of a specific region of Canada (Atlantic, Quebec, Ontario, the Prairies, British Columbia, and northern Canada).

The program delivered an extensive collection of adaptation-related products including:

- An online compendium of water and adaptation information to enable decision-makers from across

Canada to access the latest information on water resource management in a changing climate;
- Flood risk assessments to support flood risk management strategies for communities in Atlantic Canada;
- Permafrost maps to inform land use planning as well as adaptation guidance for municipal decision-makers in villages in northern Quebec (Nunavik);
- Adaptation plans to address floods and droughts in the Prairies;
- Guidelines for sea dykes and coastal flood hazard land use in British Columbia; and
- Vulnerability assessments of the mining sector and associated infrastructure in northern Canada (Nunavut).

The Regional Adaptation Collaborative entities continue to operate in conjunction with a new collaboration mechanism launched in 2012.[62] Natural Resources Canada formed—and leads—the Adaptation Platform,[63] a program that brings together decision-makers from industry associations, professional organizations, federal, provincial, and territorial governments, as well as other relevant organizations, to address shared adaptation priorities. It aims to enhance the competitiveness of regions and industries by providing a structure to bring together knowledge, capacity, and financial resources from across Canada to produce information and tools that are needed to understand and adapt to the effects of a changing climate. Through cost shared projects funded under thematic working groups, such as coastal management, economics, and measuring progress, practical tools and information are developed and the results shared broadly.

Complementary to the Adaptation Platform, the Climate Change Adaptation Community of Practice[64] supports the efforts of Canadian provinces and territories to incorporate climate change adaptation into planning and policies through the transfer of knowledge across jurisdictions. It is an interactive portal that provides a space for researchers and practitioners from across Canada to come together to ask questions, generate ideas, share knowledge, and communicate with others working on climate change adaptation. Launched in 2010, this initiative stemmed from an idea of the Council of the Federation, a provincial and territorial forum, which endorsed the creation of such a virtual community in 2008. The knowledge exchange and communication that take place during webinars and forums demonstrate how the Community of Practice helps form new relationships and connect adaptation practitioners from across Canada.

6.6 Implementing Adaptation Measures

Current adaptation efforts in Canada have been built upon a foundation of previous activities and investments, and in many cases are extensions of ongoing initiatives. Adaptation continues to be undertaken in Canada to achieve a range of goals, such as increasing capacity to adapt, improving resilience to specific climate events (especially extreme events), and enhancing ability to thrive under different climate conditions.

As previously noted in this chapter, all levels of government, as well as community groups and industry, are actively engaged in adaptation. Recent government approaches to facilitate climate change adaptation reveal a strong orientation toward applied research, development of decision-aiding tools, and support for adaptation planning at local and regional levels.

This section presents a series of illustrative examples of domestic adaptation measures within specific sectors, chosen to reflect the breadth and range of adaptation occurring across the country, focusing on new initiatives.

6.6.1 Natural Environment

Parks and protected areas conserve both terrestrial and aquatic biodiversity by helping to protect native species' gene pools, and by reducing the effects from non-climatic stressors such as habitat loss and

fragmentation. They also form core areas needed for the long-term conservation of biodiversity within broader landscapes, and provide an opportunity to apply ecosystem-based approaches to climate change adaptation.

A number of ongoing efforts are contributing to the maintenance and protection of healthy, resilient ecosystems and biodiversity in Canada. *The Canadian Parks and Protected Areas: Helping Canada Weather Climate Change* report, for example, outlines some of the actions that provinces and territories are taking on natural environments and protected areas in the context of a changing climate.[65]

Canadian jurisdictions are expanding their systems of parks and protected areas as part of their overall approach to climate change adaptation.[66] For example, the Government of Saskatchewan has partnered with environmental organizations to secure a significant amount of natural landscape to connect fragmented patches of habitat to enhance biodiversity conservation and facilitate climate change adaptation.[67]

Assisted migration trials and habitat connectivity models are important to the active management of species that migrate slowly. The Government of Alberta is currently conducting a pilot project which examines biodiversity connectivity, species vulnerability, and migration in relation to climate change. The Government of Nova Scotia has taken steps to include biodiversity connectivity, species vulnerability, and ecosystem migration and adaptation when selecting which provincial areas to protect under its Parks and Protected Areas Plan (2013).[68]

A number of additional investments will support adaptation through enhancements to Canada's environmental monitoring infrastructure and related research and services. In 2010, the Government of Canada invested $26.5 million over five years (2010–2015) for the establishment of Arctic marine meteorological areas, including extensive enhancements to the federal government's Arctic environmental monitoring infrastructure and delivery of marine meteorological services.[69]

6.6.2 Natural Resources

Climate change impacts on the forestry, mining, and energy sectors have already been observed, impacting the viability of the sector and increasing the need to advance planning to anticipate climate changes.

All levels of government in Canada have invested in the development of scientific information and tools for adaptation in the forestry sector. In 2011, the Government of Canada invested $5 million in a Canadian Forest Service (Natural Resources Canada) initiative, named Forest Change, to provide information and tools to support decisions on adaptation and enhance forest sector competitiveness in a changing climate.[70] Since 2008, the Canadian Council of Forest Ministers has focused on developing tools and knowledge to adapt sustainable forest management to a changing climate through the use of vulnerability assessments.[71] The goal of the initiative has been to assist members of Canada's forest sector in their efforts to incorporate climate change considerations into all aspects of sustainable forest management.

Efforts are underway to identify and implement adaptation best practices in the mining sector. Natural Resources Canada partnered with the Government of Nunavut to develop and publish Good Environmental Practices for Northern Mining and Necessary Infrastructure (2012),[72] which focuses on best practices for mining infrastructure in Nunavut with respect to climate change adaptation. Manitoba, Saskatchewan, and Quebec are currently undertaking a collaborative project with the International Institute for Sustainable Development that seeks to understand how existing mining policies, other than environmental assessment policies, can act as drivers or barriers to effective adaptation action in the mining sector.[73]

Adaptation is also an important risk management issue for energy production and transmission given the challenges climate change poses for the sector. Adaptive management and non-structural adaptation approaches, such as updating management policies on a regular basis, allow producers to capitalize on the impacts of climate change on hydrologic regimes. For example, BC Hydro developed a comprehensive climate change strategy which included adaptation actions such as collaborative research on impacts, a corporate climate risk assessment, and practical changes that help to manage climate risks operationally.[74] BC Hydro also identified climate change impacts on assets and infrastructure. As a result, BC Hydro modified its maintenance regimes and design standards for transmission lines to increase their resilience to wind and ice loads.[75]

6.6.3 Water Resources

Water is frequently identified as one of the most important cross-cutting climate change adaptation issues in Canada, from the perspective of quantity, quality, and availability. As such, efforts have been made to continue to build the knowledge base and the capacity to address the challenges of water resource management and adaptation.

Natural Resources Canada partnered with the Government of Ontario to provide decision-makers from across Canada access to the latest information on water resources management in a changing climate through an online compendium of water and adaptation material.[76] Other jurisdictions have also taken steps to support the implementation of adaptation measures in the water resources sector. For example, the Government of Quebec produced a hydro-climatic atlas that depicts the anticipated impacts of climate change on the St. Lawrence River system.[77] Nova Scotia examined the impact of climate change on saltwater intrusion into coastal groundwater aquifers and produced a province-wide groundwater vulnerability map.[78] Alberta has conducted hydro-climatic variability studies in the South and North Saskatchewan River Basins to understand how climate variability impacts water demand and supply.[79]

The Canadian Council of Ministers of the Environment, comprised of environment ministers from the federal, provincial, and territorial governments, has developed a suite of tools to address climate change adaptation from a water resource management perspective. These include, for example, guidance to assist the development of climate change vulnerability assessments of water quantity and water quality at a watershed scale,[80] evaluating water monitoring networks to support adaptation needs,[81] and a reference document focused on valuation of water.[82]

The provinces of Alberta, Manitoba, and Saskatchewan, along with the federal government, developed the Prairie Regional Adaptation Collaborative[83] program to work on climate change-related challenges in water resources management, including water supply and demand, drought, and excess moisture resulting in potential flooding in vulnerable communities. The three provinces worked together to conduct studies on different watersheds to understand current and projected impacts of climate change on water resources.[84] For example, the Hydro-climatic Variability: South Saskatchewan River Basin project examined the amplification of climate extremes and departures from average conditions (excessive moisture and drought) to provide insight into how water levels will fluctuate to inform adaptation planning and decision-making.[85]

The Northern Climate ExChange of the Yukon Research Centre has partnered with Yukon Energy Corporation, the University of Alberta, and the Yukon Geological Survey to develop predictive tools to improve understanding of the amount and timing of water flow in the upper Yukon River watershed, and the implications on downstream energy production. It is anticipated that Yukon Energy Corporation will be able to use this information to increase the efficiency of its hydroelectric generating operations. This project will

also provide the corporation with tools to help predict, plan for, and adapt to climate change.[86]

From a water infrastructure perspective, Canadian cities have begun to implement adaptation measures to separate storm and sanitary systems to reduce the flow of storm water into waste water systems.[87] For example, the City of Toronto has increased monitoring and maintenance of its culvert system.[88] Other flood-prone communities in Ontario, including Cambridge and Milton, are performing economic assessments of the implications of climate change for drainage infrastructure design.[89] In addition, Transport Quebec and Quebec City have taken steps to make structural changes by requiring culverts to be over-designed to account for changes in the frequency and intensity of rain events as a result of future climate conditions.[90]

6.6.4 Coastal Zone Management

Coastal zone management is a shared responsibility between jurisdictions in Canada. Federal, provincial, territorial, municipal, and Aboriginal governments all play a role in managing coastal areas, and by extension, in reducing risks to Canada's coasts and adjacent land and waters. A number of activities are underway that contribute to adaptation in this context.

Natural Resources Canada provides geoscience expertise to reduce risks and highlight opportunities to inform adaptation solutions for coastal vulnerabilities and infrastructure. In order to better predict future marine and coastal conditions, Fisheries and Oceans Canada is integrating enhanced research into adaptation tools that could be used at all levels of government. For example, the Canadian Hydrographic Service is working to improve the accuracy of information on water levels to help determine the risks of future sea level rise and increases in storm surge severity.[91]

Building from increased awareness and the availability of decision-support tools, communities have begun to implement adaptation plans and measures. The City of Halifax has implemented adaptation measures to reduce the risk of sea level rise and flooding, where planners have created a risk assessment database containing information on the vulnerability of harbour front properties. Halifax Regional Municipality has also passed an updated municipal planning strategy and land use bylaw for the downtown Halifax waterfront, prescribing a 2.5 metre threshold above the ordinary high water mark for ground floor elevations of new developments.[92]

Several municipalities have employed land use planning tools (see text box below), maps, and other landscape visualizations to illustrate the nature and extent of the changes expected in local climates, the severity of projected impacts, and what possible adaptation responses might look like.[93] The University of British Columbia's Collaborative for Advanced Landscape Planning[94] sea level rise visualization project highlighted risks associated with increased coastal flooding and potential adaptation options in the City of Delta.[95] The Government of Newfoundland and Labrador initiated a project in 2011 to map and identify vulnerable coastlines, establish a coastal monitoring network, and develop underlying data to support enhanced land use planning and management. The Government of Quebec has also developed coastal erosion risk maps to assist with community adaptation decision-making.[96]

Land use planning tools have been used by several municipalities to facilitate adaptation to climate change impacts. For example, in Beaubassin-est, a small coastal community in southeast New Brunswick vulnerable to the impacts of sea level rise and storm surge flooding, Council passed an updated zoning bylaw to enhance protection of new construction in the community's coastal zone in March 2011. This update implemented a minimum height standard for buildings to enhance protection of new construction in the community's coastal zone. The bylaw identifies a sea level rise "protection zone" in which the minimum ground floor

elevation of any new building must be at least 1.43 metres above the current 1-in-100 year flood mark. Rather than restrict development outright, the zoning bylaw imposes stricter building requirements on developers. This update to the bylaw was based on the best available scientific understanding of sea level rise for the area and a high resolution digital map that the community commissioned to help identify potential flood levels.

Collaborative efforts to address adaptation challenges in the context of coastal zone management are also underway. Collaboration has broadened public engagement and raised awareness about the impacts of climate change on Canada's coasts, as has been the case with the Storm Surge Forecast System Information Portal for British Columbia,[97] the Coastal Monitoring initiative in Newfoundland and Labrador,[98] and the King Tide Photo Initiative (British Columbia).[99]

6.6.5 Municipalities and Infrastructure

Municipal infrastructure has been an important area of focus for adaptation in Canada. This is in part due to the long-lived nature of infrastructure and the known benefits of early and planned adaptation measures as well as the need to respond to extreme weather events. Municipal infrastructure has also been the focus of a significant body of impacts and adaptation research, while many municipalities view adaptation as an extension of their efforts on sustainability. Capacity building projects have been undertaken by Engineers Canada and the Canadian Institute of Planners to inform, train, and provide tools for engineers and planners to address adaptation in their work.[100]

The Public Infrastructure Engineering Vulnerability Committee's (PIEVC) Protocol[101] has been used to assess the risks to infrastructure in more than 25 case studies across Canada, focusing on infrastructure for water supply, storm and waste water, transportation, and buildings. The results of these assessments have been used in planning, design, and operation of existing infrastructure. More recently, it was used to assess the resilience of a planned upgrade to the Sandy Point Sewage Treatment Plant in Nova Scotia in 2011. This case study is unique in that the PIEVC Protocol was applied at the pre-design stage of the project, rather than conducting the assessment after the infrastructure had been constructed.

Other municipal awareness raising and capacity building efforts have emerged. The Federation of Canadian Municipalities developed a website to promote adaptation action among its members and works to enhance the exchange of experiences in implementing adaptation through sessions at its national conferences.[102] The International Council for Local Environmental Initiatives (ICLEI) Canada developed an adaptation guidebook[103] and online workbook for communities, as well as companion documents targeted at specific topics.[104] Through its Building Adaptive and Resilient Communities program,[105] ICLEI Canada has provided training and support to communities on risk assessment and the adaptation planning process. Through Natural Resources Canada's Regional Adaptation Collaborative program (see section 6.5 of this chapter), a number of community-focused products were developed and disseminated to help communities adapt to climate change. As part of this work, case studies of adaptation actions were developed and shared between communities.[106]

The lifespan and durability of infrastructure is closely linked to climate and weather, and Canada's large seasonal changes in weather and diversity in climatic conditions have implications for infrastructure planning and maintenance. Recent flooding (for example, the Alberta[107] and Toronto[108] events referenced earlier in this chapter) has highlighted the vulnerability of Canada's infrastructure to extreme events.

Much of the infrastructure in northern Canada is dependent upon permafrost, which under normal conditions provides stable surfaces for buildings and pipelines, contains wastes, stabilizes shorelines, and provides access to remote communities in the winter.[109] As permafrost thaws and degrades, infrastructure built

upon it may become damaged or lose its structural integrity. Jurisdictions and organizations operating in northern Canada have taken steps to manage these risks and adapt to changing permafrost conditions. For example, the Standards Council of Canada and Aboriginal Affairs and Northern Development Canada are working to ensure the ability of codes, standards, and related instruments to address the climate risks of northern infrastructure design, planning, and management (e.g., thermosyphon-supported foundations, effects of permafrost degradation on existing buildings, changing snow loads, and community drainage).[110] Other products developed include permafrost maps to inform land use planning, a review of climate hazard-related mapping and vulnerability assessments of the built environment in northern Canada,[111] and adaptation guidance for municipal decision-makers in villages in northern Quebec.[112]

While the impact of permafrost degradation on infrastructure is an issue limited to northern Canada, common climate change and infrastructure challenges remain across all Canadian regions. Environment Canada is collaborating with the Canadian Commission on Building and Fire Codes to update and improve more than 6,000 specific climatic design values used in the *National Building Code of Canada* and developing specific products to address critical needs of the engineering and construction communities.[113]

6.6.6 Agriculture and Food Production

A changing climate presents the Canadian food system with a number of opportunities as well as risks.

Agricultural programs in Canada are guided by the Federal-Provincial-Territorial Growing Forward 2 Policy Framework.[114] This five-year policy framework, signed by the federal, provincial, and territorial governments, focuses on innovation, competitiveness, and market development. It also provides cost-shared funding with the provinces and territories to farmers to ensure a competitive and resilient sector that can adapt to changing conditions. Under Growing Forward 2, three new, broad federal programs (i.e., AgriInnovation,[115] AgriCompetitiveness,[116] and AgriMarketing[117]) are aimed at generating market-based economic growth in the agricultural sector. Through these programs, farmers can access information and funding to address on-farm risks, including those that may be exacerbated by climate change.

The Government of Canada undertakes research to inform adaptation decision-making in the agriculture sector in Canada. This includes, for example, research on current and future weather trends, as well as efforts to improve weather forecasting. These efforts contribute to the development of decision-support tools and practices for farmers to adapt to climate change, including optimizing land use and production, variety selection, and breeding for new climatic conditions. Other levels of governments and research organizations contribute to agricultural adaptation in Canada as well.

The Government of Quebec, for example, has developed an agro-climatic atlas[118] that conveys current and future climatic impacts on crops and agricultural systems. The atlas and its interactive maps were designed to help the farming sector manage climate-related risks and opportunities and support long-term planning. Ouranos, a private non-profit organization in Quebec that provides regional climate simulations, is also examining how to support climate change adaptation strategies in the Quebec agricultural sector. Ouranos is focusing on providing sector stakeholders with tools for making strategic choices in planning agricultural activities in order to better manage the risks and opportunities related to climate change.[119]

The Government of Saskatchewan, in conjunction with the Prairie Adaptation Research Collaborative, developed the SaskAdapt Self-Assessment Tool to help individuals and communities in Saskatchewan evaluate decisions about adapting to climate change.[120] It can assist in incorporating climate change into future planning by providing a process for helping to decide

what actions should be taken to better prepare for climate change.

6.6.7 Human Health and Well-being

Government authorities at the federal, provincial, territorial, and municipal levels are taking action to prepare for climate change health impacts by generating knowledge, including health risks in climate change plans, and mainstreaming climate change considerations into a range of health policies and programs.

The Public Health Agency of Canada generates knowledge and tools, including risk maps, surveillance methods, and guidance documents for federal, provincial, and territorial public health decision-making and action on emerging vector-borne zoonoses (diseases and infections transmissible from vertebrate animals to humans) in Canada.[121] It is currently developing a risk assessment framework for quantitative analyses of impacts of climate change on infectious diseases transmitted through food and water. This will improve the management of future risks from climate-related enteric (gastrointestinal) diseases.

Public health and emergency management officials are also taking action to raise awareness of climate change impacts and the need for adaptation, and are providing information and tools to help address current and projected future vulnerabilities. Recognizing the need for effective communication to health service providers and the public to manage health risks from extreme heat events, Health Canada developed the *Communicating the Health Risks of Extreme Heat Events: Toolkit for Public Health and Emergency Management Officials* (2011).[122] The toolkit is based on best communication practices for addressing health risks associated with extreme heat events and is intended for use by health and emergency officials who are developing or updating heat-health communication strategies.

An expanded range of measures and tools to adapt to the health impacts of climate change, including vulnerability assessment guidelines, and vulnerability mapping, among others, are available to public health and emergency management officials in Canada. To help communities develop effective adaptation measures to address heat-health risks, Health Canada also recently published the *Heat Alert and Response Systems to Protect Health: Best Practices Guidebook* (2012).[123] The Guidebook provides guidance on developing, communicating, and evaluating heat alert and response systems. The guidebook also outlines examples of preventative action in reducing urban heat.

Rosemont-La Petit-Patrie is a central borough in Montreal, Quebec that is very densely built, resulting in a pronounced urban heat island effect. In April 2011, the borough Council revised its comprehensive zoning bylaw to include four regulatory measures aimed at tackling urban heat islands: (1) when replacing an existing roof or constructing a new building, the owner must install either a green roof or a highly reflective roof; (2) for all new parking lots of 10 or more spaces, at least 15% of the area must be open ground landscaped with plants, bushes, and trees; (3) all new paving materials must meet a minimum specified surface reflectivity rating; and (4) when constructing a new building, at least 20% of the building site must remain open ground and be landscaped with plants, bushes, and trees. These four measures apply to all public and private property throughout the borough. More than 300 permits for reflective roofs were issued in the first year after the bylaw was passed.[124]

Provincial-scale Heat Alert and Response Systems are currently being developed in the provinces of Manitoba and Alberta. The Government of Quebec has also developed an interactive tool that allows the public to identify urban heat and cooling islands along with the surface temperature for the most densely populated areas in southern Quebec.[125] At the municipal level, the City of Toronto has implemented its own heat-health warning and alert system which determines when the

Medical Officer of Health should declare a heat or extreme heat alert. Once a heat alert is declared, key response partners, community agencies, and the public are notified and hot weather response activities are implemented (e.g., public cooling centres).[126]

6.7 Contributing to International Initiatives

Canada works with the international community to strengthen and disseminate research and science surrounding the impacts of climate change to ensure that adaptation actions are informed by the best available knowledge. Canada is also assisting developing countries, in particular those that are the most vulnerable to the impacts of climate change, through development assistance, multilateral instruments, and partnerships with non-governmental and international organizations in order to increase their resilience to climate change.[127] For example, from 2010–2013, the Government of Canada allocated approximately 15% of Canada's $1.2 billion fast-start commitment to multilateral and bilateral partners for adaptation-related projects.[128] Some of these projects benefited from tools developed under Canada's domestic adaptation activities, including the application of the PIEVC Protocol to infrastructure assessments in Costa Rica and Honduras, for example. More information on Canada's fast-start financing can be found in Chapter 7: Financial Resources and Transfer of Technology.

6.7.1 Research and Science

Canada is leading and participating in a number of climate-related fora and initiatives that contribute to adaptation decision-making. For example, in 2013, Canada is presiding over the World Meteorological Organization (WMO), which is responsible for the oversight and implementation of the Global Framework for Climate Services (GFCS). Canada also contributes to Intergovernmental Panel on Climate Change Working Groups I and II on an ongoing basis. These and other climate and climate change-related research efforts are outlined in more detail in Chapter 8: Research and Systematic Observation of Climate Change.

Climate services, which can be broadly defined to include activities that deal with generating and providing information on past, present, and future climate, can assist all countries in preparing for climate change. The GFCS is being implemented globally, regionally, and nationally. Canada is currently the second largest donor, targeting initiatives such as the development of a Regional Climate Centre in the Arctic. The GFCS will enable better adaptation to climate change through the development and incorporation of science-based climate information and prediction into planning, policy, and practice at all scales and by supporting capacity development and better dissemination of scientific information, in particular in the most vulnerable countries.

6.7.2 Regional and Bilateral Collaboration

Regionally, Canada is collaborating with the U.S. and Mexico on the North American Climate Services Partnership, formed in 2011. This Partnership focuses on advancing data sharing, information communication, climate prediction, and capacity development among seven areas including the North American Seasonal Forecast System and the Great Lakes.

Canada is also engaged in climate change adaptation work through the Arctic Council. Canadian scientists and researchers contributed to the Arctic Biodiversity Assessment and the Arctic Ocean Acidification report that have advanced the understanding of the range and extent of impacts of climate change in the Arctic region. In addition, Canada continues to play a role in the Adaptation Actions for a Changing Arctic project. Initiated in 2012, this project consists of three components aimed at enabling more informed, timely, and responsive adaptation decision-making in a rapidly changing Arctic. Canada led the first two components of this initiative, which assess Arctic Council reports that contribute to and inform adaptation decisions, and provide a compendium of existing national, regional,

and local adaptation efforts in the circumpolar North. Canada is also engaged in the final component which will provide an integrated assessment of all relevant drivers of change in the Arctic, scheduled to be delivered in 2017. Finally, during Canada's 2013–2015 Chairmanship, the Council will be developing a mechanism that will facilitate the active exchange of Arctic-related adaptation information.

As an example of bilateral collaboration, Health Canada and the U.S. Centers for Disease Control and Prevention entered into an agreement in 2011 to establish a North American Working Group on Climate Change and Human Health. The goal of the Working Group is to foster cross-border relationships and increase adaptive capacity in North America in the area of climate change and health. Areas of focus have included climate change and infectious diseases, coordinating adaptation across international borders, and raising awareness of climate change and health issues in North America.

6.7.3 Development Assistance, Multilateral Instruments and International Aid Partnerships

Beyond financial contributions, Canada continues to support international organizations and initiatives that strengthen understanding and disseminate knowledge related to climate change in the most vulnerable countries by providing expert engagement, scientific advice, and capacity development.

Canada's development assistance promotes action on climate change by integrating environmental sustainability into its development programming and is supporting projects specifically aimed at reducing vulnerability to climate change. The integration of environmental sustainability considerations across all of its development policies and programming is currently driven by both policy and regulatory requirements. The International Development Program of the Department of Foreign Affairs, Trade and Development has a Policy for Environmental Sustainability (1992),[129] and in 2009, environmental sustainability was announced as a cross-cutting theme and is integrated across international assistance priorities.[130]

As reported in Chapter 7: Financial Resources and Transfer of Technology, Canada continues to support international climate change adaptation with a variety of partners and multilateral instruments, such as a $20 million contribution to the Global Environment Facility and the Least Developed Countries Fund in 2010.[131] While recognizing that public finance is important to support international adaptation actions, Canada is also partnering with multilateral organizations to finance projects that catalyze private sector investments in climate change adaptation. The International Development Research Centre is also exploring ways to enhance private sector investment for adaptation through its Private Finance Advisory Network. Canada also works closely with the Organisation for Economic Co-operation and Development and other international partners to improve the integration of environmental considerations into development planning and decision-making, especially through strategic environmental assessment.

6.8 Conclusion

A wide range of impacts have been experienced across Canada and are likely to be exacerbated as climate continues to change in the future, increasing the need for adaptation.

Governments have developed adaptation strategies and policy frameworks, and have been facilitating climate change adaptation through the establishment of collaborative mechanisms to enable applied research, development of decision-support tools, and sharing of adaptation experiences. Sectors with the greatest sensitivity and exposure to climate and weather, such as infrastructure and natural resources (e.g., forestry and hydroelectricity), are taking actions to actively adapt to climate change impacts.

A number of adaptation activities have been documented since Canada's 5th National Communication. These measures are built upon a foundation of previous activities, including climate science, impacts and adaptation research and science assessments (including regional and sectoral assessments), and capacity-building and awareness raising efforts (particularly among vulnerable populations and professional groups).

Building from existing efforts and past successes, Canada will continue to play a leadership role through measures such as strategic investments in adaptation that focus on priority areas. In addition, Canada's adaptation efforts will continue to take a risk management approach, based on the principles of collaboration and mainstreaming. To date, this approach has enabled implementation of adaptation measures across jurisdictions and economic sectors in Canada.

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7 Financial Resources and Transfer of Technology

7.1 Introduction

Canada provides a variety of support to efforts that address climate change in developing countries, delivered through a wide range of multilateral, bilateral and partnership channels.

In line with its commitments under the Copenhagen Accord and the Cancun Agreements, Canada significantly scaled-up its financial support to address climate change during the fast-start financing period, which is covered by this report. Canada's contribution to, and collaboration with, bilateral, multilateral, private sector and non-governmental partners has generated significant environmental benefits and is paving the way for continued progress within, and outside the United Nations Framework Convention on Climate Change (UNFCCC). The financial resources section of this chapter (7.2) highlights some key initiatives the Government of Canada has supported since the 5th National Communications to the UNFCCC. Table 7.2 and 7.3 also present a summary of Canadian climate finance delivered from 2009–2010 to 2012–2013.

The Government of Canada is actively engaged in the development and deployment of clean technologies through a range of multilateral and bilateral channels: efforts are focused on areas including developing technical tools to support clean energy innovation, supporting energy efficiency, sustainable forest management and carbon capture and storage. Section 7.3 of this chapter highlights key examples of Canada's recent efforts to advance clean technology globally.

7.2 Financial Resources

This section presents a summary of the financial support provided by Canada since its last National Communication to the UNFCCC and highlights some of the key initiatives that received support from Canada. It focusses on all initiatives supported by Canada that have had as objective or result the achievement of climate benefits and have contributed significantly to the advancement of the UNFCCC's ultimate goals. Where known, private financing mobilized by this support is indicated.

Over the last four fiscal years (2009–2010 to 2012–2013), Canada provided over $1.54 billion[1] to support climate change projects through a variety of channels and programs (see figure 7.1). This amount includes $1.2 billion in fast-start financing delivered over the last three fiscal years (2010–2011 to 2012–2013), as well as $350 million[2] of international assistance projects with a direct or a significant focus on climate change.

The $1.54 billion we are reporting on includes $55.35 million of fast-start financing that was used to increase our contribution to the Global Environment Facility (GEF), bringing Canada's total contribution to the GEF to over $204 million over the last four years (See table 7.2). The amounts for Canada's GEF contribution have not been further broken down by focal area due to the complexity of doing so within the broader GEF trust fund. Detailed information on Canada's support to the GEF can be found at section 7.2.4.

7.2.1 New and Additional Resources

Canada's provision and mobilization of financial support is in line with its obligation under the UNFCCC to provide new and additional resources as part of its overall support to help developing countries implement actions to address climate change.

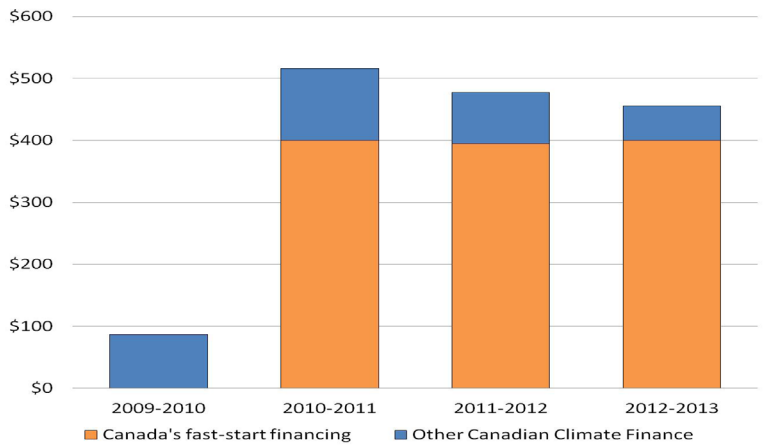

Figure 7.1 Canadian Climate Finance Programming for Fiscal Years 2009–2010 to 2012–2013 (Not including contributions to the Global Environment Facility)

Canada's fast-start financing effort is the prime example of Canadian support that is fully new and additional. Canada provided $1.2 billion in support to projects that were above and beyond what was planned prior to the Copenhagen Accord.

Over the past four years, Canada also responded to priorities identified by bilateral partners in the context of ongoing and long-standing development partnerships that include addressing climate change issues as part of objectives set by its partners. For this support, it is not possible to determine a simple definition under which this programming is new and additional or not, nor is it necessary to do so given the importance of seeking to mainstream climate change results in country-driven programming.

7.2.2 Geographic Distribution

The geographic distribution of Canada's climate finance support over the reporting period has been estimated (see Figure 7.2). However, these estimates could evolve over the next years as financing provided to multilateral banks rolls out at the project level.

It is currently estimated that, over the period covered by fiscal years 2009/10–2012/13, 33% of Canadian climate finance flowed to sub-Saharan Africa, 29% to Latin America and the Caribbean, 15% to South Asia, 9% to East Asia and the Pacific, 2% to the Middle East and North Africa, and 2% to developing countries in Central Asia and Eastern Europe. 10% was allocated to global programs for which it is not possible to estimate a geographic distribution at this time.

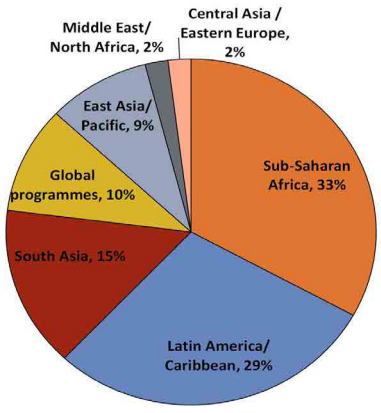

Figure 7.2 Canadian Climate Finance by Region

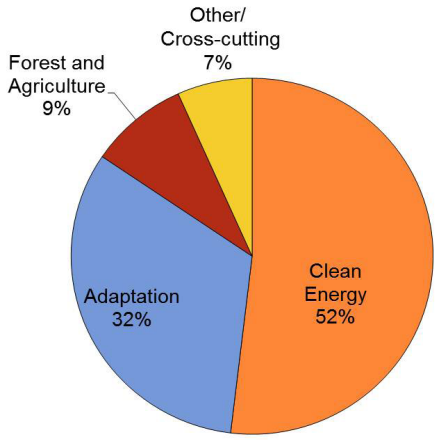

Figure 7.3 Canadian Climate Finance by Priority Area (estimated total)

East Asia and the Pacific, 2% to the Middle East and North Africa, and 2% to developing countries in Central Asia and Eastern Europe. 10% was allocated to global programs for which it is not possible to estimate a geographic distribution at this time.

Over 60 developing countries are benefiting directly from funding delivered through Canada's bilateral channels and Canadian facilities at multilateral institutions, and this number will grow as these facilities continue to make project commitments with available Canadian fast-start funds. A much larger number of countries will also benefit from contributions made by Canada to multilateral trust funds such as the GEF and the Least Developed Country Fund.

7.2.3 Sectorial Distribution

Canada's support is primarily focused on three broad areas: adaptation by the poorest and most vulnerable countries, clean energy, and forests and agriculture.

As shown by Figure 7.3, it is currently estimated that 52% of Canada's climate finance delivered over the reporting period will support clean energy projects and initiatives, 32% will go to adaptation projects, 9% for projects related to forests and agriculture, and 7% for cross-cutting programming. Once again, these estimates could change slightly over time as multilateral institutions roll out our fast-start financing contributions.

Table 7.1 Financial Contributions to Multilateral Institutions and Programmes

Institution or Programme	Contribution (millions of CAD)			
Adaptation by the Poorest and Most Vulnerable Countries	2009–2010	2010–2011	2011–2012	2012–2013
Caribbean Development Bank—Community Disaster Risk Reduction Program†			10.00	4.50
International Network for Bamboo and Rattan†				0.49
Least Developed Countries Fund†		20.00		
United Nations Development Programme—Canadian Climate Adaptation Facility†				16.50
World Bank—Pilot Program for Climate Resilience†	15.00			
World Food Programme—MERET—Ethiopia†		15.00		

Table 7.1 Financial Contributions to Multilateral Institutions and Programmes (continued)

Institution or Programme	Contribution (millions of CAD)			
Adaptation by the Poorest and Most Vulnerable Countries	2009–2010	2010–2011	2011–2012	2012–2013
World Meteorological Organization—Global Framework for Climate Services†				6.14
World Meteorological Organization—Haiti Weather Services†				6.50
World Bank – Productive Safety Net Programme—Ethiopia*		34.00		
World Food Programme—Food for Asset Building—Ethiopia*	3.00			
World Food Programme—Cambodia*			4.00	
World Food Programme—Productive Safety Net Programme—Ethiopia*	35.50	40.55	17.50	

Institution or Programme	Contribution (millions of CAD)			
Clean Energy	2009–2010	2010–2011	2011–2012	2012–2013
Asian Development Bank—Canadian Climate Fund for the Private Sector in Asia†				82.39
Clean Technology Fund†			100.00	100.00
Global Alliance for Clean Cookstoves†			0.60	1.30
Inter-American Development Bank—Canadian Climate Fund for the Private Sector in the Americas†			200.00	50.00
International Finance Corporation—Canada Climate Change Programme[a]†		276.83 14.72 #		60.28 #
United Nations Environment Programme—Climate and Clean Air Coalition†				13.00
Institution or Programme	Contribution (millions of CAD)			
Forests and Agriculture	2009–2010	2010–2011	2011–2012	2012–2013
CGIAR Research Program on Climate Change, Agriculture and Food Security†	5.50			
Congo Basin Forest Fund†			20.00	
Forest Carbon Partnership Facility—Carbon Fund†			5.00	
Forest Carbon Partnership Facility—Readiness Fund†		40.00		
International Center for Tropical Agriculture†				0.50
International Fund for Agricultural Development†			19.85	
World Bank—Bio Carbon Fund†		4.50		

Table 7.1 Financial Contributions to Multilateral Institutions and Programmes (continued)

Institution or Programme	Contribution (millions of CAD)			
Cross-cutting	2009–2010	2010–2011	2011–2012	2012–2013
United Nations Development Programme—Mexico†				2.50
United Nations Environment Programme—Climate Technology Centre and Network†				2.50
UNFCCC Supplementary Fund†			0.65	1.00
UNFCCC Trust fund for Participation†		1.00		
Sub-total—Contribution targeting the Rio Conventions as a 'principal objective'†	20.05	357.33	356.10	287.32
Sub-total—Contribution targeting the Rio Conventions as a 'significant objective'*	38.50	74.55	21.50	0.00
Sub-total—Other climate finance #	0.00	14.72	0.00	60.28
Total	**58.55**	**446.60**	**377.60**	**347.60**

Legend:	†	Contribution targeting the Rio Conventions as a 'principal objective'	*	Contribution targeting the Rio Conventions as a 'significant objective'	#	Other climate finance excluding official development assistance

[a] The initial commitment to the International Finance Corporation (IFC)-Canada Climate Change Program in fiscal year (FY) 2010–11 was $291.55 million. In FY2012–13, $75 million was transferred to the Catalyst Fund and $60.28 million of new fast-start resources were contributed. These transactions resulted in a final funding level of $271 million for the IFC-Canada Climate Change Program, and $75 million to the Catalyst Fund.

7.2.4 Financial Support to the Global Environment Facility

Canada continued to support climate change activities through its assessed and regular contributions to the Global Environment Facility (GEF). Canada also used $18.5 million in each year of fast-start financing to increase annual payments to the 5th replenishment of the GEF, bringing total contributions over 2009–2010 to 2012–2013 to $204.6 million, and Canada's total contributions to the GEF's 5th replenishment (2010–2014) to $238 million, a more than 50% increase over the 4th Replenishment. More information on Canada's GEF contribution is shown in 7.2 below.

Table 7.2 Contributions to the Global Environment Facility

	Contribution (millions of CAD)[a]			
	2009–2010	2010–2011	2011–2012	2012–2013
Global Environment Facility	33.94	58.58	54.75	57.29

[a] Canada received a discount for accelerated payment for its GEF-5 contribution. Thus, Canada's GEF-5 paid-in contribution (CAD $216.6 million) and recorded contribution (CAD $238.4 million) slightly differ. This table displays paid-in contributions.

7.2.5 Adaptation by the Poorest and Most Vulnerable Countries

Over the last four years, Canada has delivered on its promise to scale up support for adaptation by vulnerable countries by providing over $480 million to bilateral and multilateral partners and to non-governmental organizations from 2009–2010 to 2012–2013. Canada's adaptation support was delivered to over 50 countries in Africa, Asia and Latin America and the Caribbean.

For example, Canada and the United Nations Development Programme (UNDP) worked collaboratively to establish the Canadian Climate Adaptation Facility, which will help local populations to build more resilient agricultural practices, strengthen their infrastructure, diversify their sources of livelihood and improve their food security. The $16.5 million Canadian facility at the UNDP is focusing on the poorest and most vulnerable populations in six countries in Africa, South East Asia and the Caribbean.

Canada has also provided support to the World Meteorological Organization with a $13.6 million contribution to projects aimed at enhancing the

availability of modern weather services for vulnerable countries. Of this amount, $6.5 million was disbursed to support work in collaboration with other international partners to rebuild a weather and climate warning service in Haiti following the devastating earthquake of 2010 that destroyed this capability. An additional $7.1 million provided support for the Global Framework for Climate Services, which aims to enhance resilience in social, economic and environmental systems to climate variability and climate change.

The Canada Fund for African Climate Resilience delivered $23.2 million in partnership with non-governmental and educational organizations to substantially improve and increase food security and economic growth and reduce the impacts of climate change through adaptation measures in Africa. The support, focusing on projects in eight countries (Burkina Faso, Cameroon, Democratic Republic of Congo, Ghana, Ethiopia, Rwanda, Senegal and Tanzania), will prevent or reduce the impact of climate change on future economic growth and food security in these countries. More information on projects that received support through this fund can be found in table 7.3.

Canada's International Development Research Centre (IDRC) is one of the leading institutions worldwide that supports research related to adaptation in developing countries. Canada has provided over $80 million to IDRC to support bilateral and global research on how best to adapt to the impacts of climate change in Africa, Asia, and Latin America and the Caribbean. In Asia, and Latin America and the Caribbean, research will contribute to solutions for managing the water-related impacts of climate change such as flooding, melting glaciers, rising sea-levels, and more frequent and intense storms. In Africa, researchers are investigating population health vulnerabilities to vector-borne diseases, looking at how to manage scarce water resources to safeguard agricultural production, and assessing the feasibility of different adaptation strategies to inform African governments' response to climate change.

7.2.6 Clean Energy

Over the last four years, Canada has worked collaboratively with a number of multilateral organizations to diversify its support for clean energy in developing countries.

For example, Canada made a $200 million contribution to the Clean Technology Fund (CTF) of the World Bank's Clean Investment Funds to support the demonstration, deployment and transfer of low carbon technologies in developing countries. CTF investment plans are tailored to a country's needs so that they can be integrated into national development objectives and serve as programmatic organizing frameworks for the activities of actors across institutions, stakeholder groups, and sectors. The CTF Trust Fund Committee committed these and other recent contributions to the investment plans of Chile, India and Nigeria.

Canada has also made a $2.5 million fast-start financing contribution to support the UNEP in implementing the Climate Technology Centre and Network (CTCN). The CTCN will provide tailored advice and technical assistance to developing countries to support the implementation of technology actions for mitigation or adaptation objectives. Canada's contribution will support start-up costs of the Centre and specific capacity-building activities, and facilitate private sector engagement, given its important role in the technology transfer process. With a seat on the CTCN advisory board, Canada is taking an active interest in the development of this key institution.

Canada, along with Bangladesh, Ghana, Mexico, Sweden, the United States, and the United Nations Environment Programme, launched the Climate and Clean Air Coalition (CCAC) in February 2012. The CCAC is a new international voluntary initiative seeking to reduce Short-Lived Climate Pollutants. Canada has delivered $13 million of its fast-start financing to support the CCAC and its implementation of projects of benefit to developing country Partners. Reducing emissions of short-lived climate pollutants is part of Canada's overall

international climate change strategy, and provides an opportunity to make near-term progress on climate change while providing air quality and health benefits, and reducing greenhouse gas (GHG) emissions.

The use of clean cook stove technologies can prevent severe burns, premature deaths, while avoiding deforestation and contribute to climate change mitigation. This is why Canada has provided $1.9 million of fast-start financing to support the Global Alliance for Clean Cookstoves. Since its launch by the U.S. in 2010, the Global Alliance has raised the visibility of the issue of household energy pollution, and mobilized hundreds of bilateral, non-profit, academic, U.N., corporate, and foundation partners in pursuit of an ambitious clean cooking agenda. The Global Alliance has also conducted comprehensive clean cookstoves and fuels market assessments in sixteen countries, and raised millions of dollars to support critical life-saving and life-changing initiatives in some of the globe's poorest countries.

Between 2007 and 2011, Canada also supported the Asia Pacific Partnership on Clean Development and Climate (APP). The APP enhanced partnerships between the public and private sectors, promoted best practices and technologies across a range of key sectors, and deepened cooperation among its seven partner countries. Between 2008 and 2011, Canada invested $13.02 million in 35 APP projects within the energy-intensive energy supply sectors, which offered the greatest potential to address climate change and air pollution challenges. Canada's investment was matched by a $99.32 million investment from public and private sector partners.

7.2.7 Forests and Agriculture

Canada's financial resources for climate change were also delivered to a number of multilateral organizations to support sustainable agriculture and forest management in developing countries.

For example, the Forest Carbon Partnership Facility Readiness Fund supports capacity building and technical assistance for developing countries. Canada's $40 million contribution to the Readiness Fund supports countries in building national capacity to address the problem of deforestation and forest degradation. The Forest Carbon Partnership Facility (FCPF) provides technical and financial assistance to 36 developing countries engaged in Reduction of Emissions from Deforestation and Degradation (REDD+). As of June 2013, the FCPF has allocated $121.6 million to REDD+ countries. This includes grant agreements representing firm commitments of approximately $42.5 million, out of which $9.7 million have been disbursed in grant to countries.

The Congo Basin in Central Africa is home to one-quarter of the world's tropical forests. This vast area is critical for regional and global ecological services as it acts as a carbon sink and catchment basin. The Congo Basin countries are the home to nearly 100 million people, of which some of the world's poorest people, many of whom depend on the forest for their livelihoods. As such, sustainable management of the Congo Basin is key to improving living conditions while minimizing the impact on the local and global environment. Canada committed $20 million to the African Development Bank as the Administrator of the Congo Basin Forest Fund to help local communities in forest zones secure sustainable livelihoods and reduce GHG emissions, therefore alleviating poverty while maximizing carbon storage. Canada also provided $2 million to the Congo Basin Forest Partnership to support technical assistance to working groups on climate change, forestry governance, biodiversity, and desertification in the Congo basin region.

Canada made a $19.85 million contribution to the International Fund for Agricultural Development-Adaptation for Smallholder Agriculture Program. Launched in 2012, the program is working with developing countries to increase knowledge and investments in climate-smart agriculture. For example, to cope with recurrent flooding in Bangladesh, the program will contribute to the development of

integrated food production systems with alternative rice varieties in rehabilitated swamp forests, and to the development of the capacity of rural institutions to manage climate risk.

Canada has also provided $4.5 million fast-start financing to the BioCarbon Fund of the World Bank. This fund is dedicated to helping developing countries take part in the Clean Development Mechanism's Afforestation/Reforestation activities, and to opening the Clean Development Mechanism by contributing to an assessment of how carbon assets from forestry can be formed by developing methodologies and capacity building.

7.2.8 Mobilising Private Sector Investments

The majority of financing for climate change will come from private sector sources, scaled up climate-focused investment will be a key part of scaled up action on climate change. There are a number of potential barriers to facilitating sufficient private investment, and therefore Canada is actively contributing to international efforts to better understand opportunities for mobilizing private investment.

A large portion of Canada's climate financing over the reporting period was provided to multilateral organizations such as the International Finance Corporation, the Inter-American Development Bank and the Asian Development Bank for the establishment of Canadian facilities targeting the mobilization of climate friendly private-sector investment in developing countries. The first two facilities, at the International Finance Corporation and Inter-American Development Bank, are fully operational and are showing results on the ground.

Projects supported by these Canadian facilities are expected to generate significant environmental benefits and contributed to leveraging investment from the public and private sectors. As of September 2013, out of the $684 million provided to multilateral financial institutions through our fast-start financing, direct project investments using approximately $110 million of the Canadian funding provided has been approved, helping to mobilize over $1050 million of public and private sector investment and contributing to achieving annual GHG emission reductions of over 675 kilotonnes carbon dioxide equivalent (Kt CO_2 eq). These facilities achieve an incremental benefit by providing support to projects with measurable, positive climate impacts that require some financing on concessional terms to be viable.

Table 7.3 Bilateral and Regional Financial Contributions

Fiscal Year 2009–2010

Recipient Country	Description	Funding Area (in millions of CAD)					
		Energy	Other Vulnerability Assessments	Capacity Building	Coastal Zone Management	Forestry	Agriculture
Africa, Asia, Latin America and the Caribbean, and the Middle East*	Support for the Canadian International Food Security Research Fund.						0.18
Africa*	Support for the African Model Forest Initiative through the International Model Forest Network.					1.41	
Africa, Asia*	Support to IDRC for adapation and climate resilience research			7.75			
Asia Pacific#	Support for clean energy projects through the Asia Pacific Partnership.	11.80					
Bolivia*	Building capacities in community-based eco-development and environmental health in connection with water and sanitation.			0.25			
Caribbean countries*	Supporting natural disasters management capacities in national governments and local communities.			1.28			
Costa Rica, Dominican Republic, Honduras*	Helping communities restore degraded forests and addressing livelihood issues of local landowners in areas with high levels of rural poverty.			0.15			
Ethiopia, Philippines, Jamaica*	Advancing sustainable economic growth and development in urban regions.			0.23			
Haiti*	Supporting the rehabilitation of the Artibonite River watershed.			2.03			
Honduras*	Promoting sustainable agriculture and natural resource management practices.			0.17			
Indonesia*	Enhancing the livelihood security and well-being of vulnerable coastal communities.				0.50		
Latin America*	Support for the Latin American Energy Organization.	0.50					
Nigeria†	Supporting effective climate change governance.			1.52			
Peru*	Supporting the development of sustainable management policies and programs.			0.10			

Table 7.3 Bilateral and Regional Financial Contributions (continued)

Recipient Country	Description	Funding Area (in millions of CAD)					
		Energy	Other Vulnerability Assessments	Capacity Building	Coastal Zone Management	Forestry	Agriculture
Philippines†	Supporting the improvement of enabling policies and strategic environment for disaster risk reduction.			1.00			
Western Africa*	Support for climate change adaptation and capacity building.			0.01			
Senegal, Tanzania, South Africa*	Increasing the capacity of local communities to develop integrated long-term sustainability plans.			0.13			

Legend:	†	Contribution targeting the Rio Conventions as a 'principal objective'	*	Contribution targeting the Rio Conventions as a 'significant objective'	#	Other climate finance excluding official development assistance (ODA)

Fiscal Year 2010–2011

Recipient Country	Description	Funding Area (in millions of CAD)					
		Energy	Capacity Building	Other Vulnerability Assessments	Coastal Zone Management	Forestry	Agriculture
Africa, Asia, Latin America and the Caribbean, and the Middle East*	Support for the Canadian International Food Security Research Fund.						7.04
Africa*	Support for the African Model Forest Initiative through the International Model Forest Network.					1.75	
Africa†	African Adaptation Research Centers Program support (launch costs, communications, research information service to partners, institutional risk assessments, economic analysis training, adaptation finance consultancy).		1.25				
Africa, Asia*	Support to the International Development Research Centre for adaptation and climate resilience research.		8.28				
Asia Pacific#	Support for clean energy projects through the Asia Pacific Partnership.	1.20					
Benin†	Strengthening economic skills and climate change adaptive capacity.		0.78				

Table 7.3 Bilateral and Regional Financial Contributions (continued)

Recipient Country	Description	Funding Area (in millions of CAD)					
		Energy	Capacity Building	Other Vulnerability Assessments	Coastal Zone Management	Forestry	Agriculture
Benin, Bolivia, Burkina Faso, Ethiopia, Honduras, Mali, Nepal, Senegal, East Timor*	Support for the Unitarian Service Committee Seeds of Survival Programme (2010–2015).		1.53				
Bolivia*	Building capacities in community-based eco-development and environmental health in connection with water and sanitation.		0.13				
Burkina-Faso†	Irrigation and climate information.		1.28				
Caribbean countries*	Supporting natural disasters management capacities in national governments and local communities.		1.60				
Congo Basin Region*	Supporting a fair and sustainable management of natural resources in Congo Basin countries.		0.29				
Costa Rica, Dominican Republic, Honduras*	Helping communities restore degraded forests and addressing livelihood issues of local landowners in areas with high levels of rural poverty.			0.04			
Cuba*	Enhancing municipal environmental management practices and the quality of life of the communities in coastal zones.				0.10		
Egypt†	Establishing the Alexandria Research Centre for Adaptation to Climate Change.		1.16				
Ethiopia†	Reduce population health vulnerability and increase resilience to vector-borne tropical diseases.			7.35			
Ethiopia, Kenya, Sudan, Tanzania†	Enhancing climate change adaptation in agriculture and water resources in the Greater Horn of Africa.		1.34				
Ethiopia, Philippines, Jamaica*	Advancing sustainable economic growth and development in urban regions, consistent with the countries' national development agendas.		0.68				
Ghana†	Climate change adaptation research and capacity development in Ghana.		1.40				

Table 7.3 Bilateral and Regional Financial Contributions (continued)

Recipient Country	Description	Funding Area (in millions of CAD)					
		Energy	Capacity Building	Other Vulnerability Assessments	Coastal Zone Management	Forestry	Agriculture
Haiti†	Supporting the improvement of local response to climate change impacts, and reducing vulnerability to natural disasters.			4.90			
Haiti*	Supporting the rehabilitation of the Artibonite River watershed.		1.90				
Honduras*	Enhancing food security through improved agricultural productivity, diversity and the promotion of sustainable natural resource management practices.		5.93				
Indonesia*	Enhancing the livelihood security and well-being of vulnerable coastal communities on the west coast of South Sulawesi.				0.99		
Kenya†	Enhancing climate change adaptation research capacity in Kenya's agriculture sector.		1.12				
Latin America*	Support for the Latin America Energy Organization.	0.03					
Lesotho, Malawi, Swaziland†	From research to policy: linking climate change adaptation to sustainable agriculture in southern Africa.		1.50				
Mali*	Supporting the development and rehabilitation of the agricultural irrigation infrastructure.			0.50			
Nigeria†	Supporting effective climate change governance.		1.17				
Peru*	Supporting the development of sustainable management policies and programs.		0.04				
Philippines*	Improving the investment climate for sustainable economic growth.		1.40				
Vietnam†	Supporting the implementation of the National Target Program on climate change.			4.45			
Western Africa*	Support for climate change adaptation and capacity building.		0.06				

Legend:	†	Contribution targeting the Rio Conventions as a 'principal objective'	*	Contribution targeting the Rio Conventions as a 'significant objective'	#	Other climate finance excluding ODA

Table 7.3 Bilateral and Regional Financial Contributions (continued)

Fiscal Year 2011–2012

Recipient Country	Description	Funding Area (in millions of CAD)					
		Energy	Capacity Building	Other Vulnerability Assessments	Coastal Zone Management	Forestry	Agriculture
Africa, Asia, Latin America and the Caribbean, and the Middle East*	Support for the Canadian International Food Security Research Fund.						12.23
Africa*	Support for the African Model Forest Initiative through the International Model Forest Network.					2.72	
Africa, Asia*	Support to the International Development Research Center for adaptation and climate resilience research		16.10				
Asia, Latin America, and the Caribbean†	Adaptation Research initiatives support (launch costs, communications, research information services to partners, institutional risk assessments, economic analysis training, adaptation finance consultancy)		1.34				
Argentina†	Adapting to water stress in Comahue Region of Argentina.		1.26				
Barbados, Trinidad and Tobago, Jamaica, Guyana, Grenada†	Sustainable water management under climate change in small island states of the Caribbean.		1.50				
Benin, Bolivia, Burkina Faso, Ethiopia, Honduras, Mali, Nepal, Senegal, East Timor*	Support for the Unitarian Service Committee—Seeds of Survival Programme (2010–2015).		2.09				
Bolivia†	Strengthening local capacity for adaptation to climate change in the Bolivian Altiplano.		1.08				
Bolivia*	Building capacities in community-based eco-development and environmental health in connection with water and sanitation.		0.43				
Cambodia†	Improving water governance and climate change adaptation in Cambodia.		1.50				
Cambodia, Ghana, Kenya, Mozambique, Zimbabwe*	Providing improved food and economic security for communities who are among the poorest and most vulnerable people in their societies.		1.38				
Caribbean countries*	Supporting natural disasters management capacities in national governments and local communities.		2.04				

Table 7.3 Bilateral and Regional Financial Contributions (continued)

Recipient Country	Description	Funding Area (in millions of CAD)					
		Energy	Capacity Building	Other Vulnerability Assessments	Coastal Zone Management	Forestry	Agriculture
Chile†	Vulnerability and adaptation to climate variability and change in the Maipo Basin, central Chile.		1.30				
Chile, Colombia, Dominican Republic, Mexico†	Supporting the development of policy frameworks and projects for waste management, including a series of measures for the whole waste stream that will reduce emissions of short-lived climate pollutants such as black carbon and methane.	0.45					
China†	Water resources and adaptation to climate change in North China Plains and Poyang Lake Region in China.		1.50				
China, Nepal, Pakistan†	Building effective water governance in the Asian Highlands.		1.53				
Colombia, Mexico†	Providing technical advice to countries to help them flesh out establish implementable mitigation actions in the oil and gas sector, including actions that will significantly reduce emissions of short-lived climate pollutants, notably black carbon and methane.	1.10					
Congo Basin Region*	Supporting a fair and sustainable management of natural resources in Congo Basin countries.			0.50			
Congo Basin Region†	Support for the Congo Basin Forest Partnership.		0.14				
Costa Rica, Dominican Republic, Honduras*	Helping communities restore degraded forests and addressing livelihood issues of local landowners in areas with high levels of rural poverty.		0.05				
Costa Rica, Guatemala, Nicaragua†	Adapting community-based water supply in Central America to a changing climate.		1.48				
Cuba*	Enhancing municipal environmental management practices and the quality of life of the communities in coastal zones.				0.07		
Dominican Republic, Guatemala†	Water security and climate change in Central America and the Caribbean.		1.49				
Ethiopia*	Increasing agricultural productivity for smallholder farmers.		1.50				

Table 7.3 Bilateral and Regional Financial Contributions (continued)

Recipient Country	Description	Funding Area (in millions of CAD)					
		Energy	Capacity Building	Other Vulnerability Assessments	Coastal Zone Management	Forestry	Agriculture
Ethiopia, Philippines, Jamaica*	Advancing sustainable economic growth and development in urban regions, consistent with the countries' national development agendas.		1.44				
Haiti†	Support for climate change adaptation and local risks management.		2.93				
Haiti*	Supporting the rehabilitation of the Artibonite River watershed.			0.19			
Honduras†	Building capacity to assess infrastructure vulnerability.		0.15				
Honduras*	Enhancing food security through improved agricultural productivity, diversity and the promotion of sustainable natural resource management practices.		4.59		0.11		
India†	Adapting to climate change in urbanizing watersheds .		1.50				
Indonesia*	Enhancing the livelihood security and well-being of vulnerable coastal communities on the west coast of South Sulawesi.				1.30		
Latin America and the Caribbean*	Improving capacities for energy planning and regulation across countries in the region.		0.21				
Mali*	Supporting the development and rehabilitation of the agricultural irrigation infrastructure.		0.04				
Mexico*	Commission for Environmental Cooperation.	0.34					
Nicaragua*	Supporting sustainable economic growth in rural areas and increase access to safe, nutritious food for poor communities.		1.10				
Nigeria†	Supporting effective climate change governance.		0.61				
Peru, Costa Rica, Mexico†	Providing technical advice to countries to help them flesh out implementable mitigation actions in the housing sector.	0.50					
Philippines*	Improving the investment climate for sustainable economic growth.		0.70				
Thailand†	Supporting inland aquaculture and climate change adaptation.		1.23				

Table 7.3 Bilateral and Regional Financial Contributions (continued)

Recipient Country	Description	Funding Area (in millions of CAD)					
		Energy	Capacity Building	Other Vulnerability Assessments	Coastal Zone Management	Forestry	Agriculture
Thailand†	Improving flood management planning.		1.43				

Legend:	†	Contribution targeting the Rio Conventions as a 'principal objective'	*	Contribution targeting the Rio Conventions as a 'significant objective'

Fiscal Year 2012–2013

Recipient Country	Description	Funding Area (in millions of CAD)					
		Energy	Capacity Building	Other Vulnerability Assessments	Coastal Zone Management	Forestry	Agriculture
Africa, Asia, Latin America and the Caribbean, and the Middle East*	Support for the Canadian International Food Security Research Fund.						10.08
Africa*	Support for the African Model Forest Initiative through the International Model Forest Network.					3.16	
Africa, Asia*	Support to the International Development Research Centre for adaptation and climate resilience research.		16.05				
Africa, Latin America and the Caribbean*	Support to the World Resources Institute for capacity building in tracking climate finance.		0.15				
Benin, Bolivia, Burkina Faso, Ethiopia, Honduras, Mali, Nepal, Senegal, East Timor*	Support for the Unitarian Service Committee Seeds of Survival Programme (2010–2015).		2.21				
Bolivia*	Building capacities in community-based eco-development and environmental health in connection with water and sanitation.		0.71				
Burkina Faso†	Improving food security through the sustainable development of agriculture.			2.50			
Cambodia, Mozambique, Ghana, Kenya, Zimbabwe*	Providing improved food and economic security for communities who are among the poorest and most vulnerable people in their societies.		0.73				
Caribbean countries*	Supporting natural disasters management capacities in national governments and local communities.		2.10				

Table 7.3 Bilateral and Regional Financial Contributions (continued)

Recipient Country	Description	Funding Area (in millions of CAD)					
		Energy	Capacity Building	Other Vulnerability Assessments	Coastal Zone Management	Forestry	Agriculture
Cameroon†	Increasing the access to sufficient, nutritious and safe food, and the economic well-being of produces in model forests and improving climate resilience capacities.		2.72				
Chile†	Supporting the development of a nationally appropriate mitigation action proposal based on atmospheric carbon capture by soils and support for research on climate change adaptation.		0.33				
Chile, Colombia, Mexico, Dominican Republic†	Supporting the development of policy frameworks and projects for waste management, including a series of measures for the whole waste stream that will reduce emissions of short-lived climate pollutants such as black carbon and methane.	2.70					
Chile, Kenya, Mexico†	Building the capacity of protected-area agencies to enhance the resilience to climate change of ecosystems and local communities that depend on them.		3.30				
Colombia†	Implementation of an environmental education program for risk management to support climate change adaptation.		0.32				
Colombia, Mexico†	Providing technical advice to countries to help them flesh out establish implementable mitigation actions in the Oil and Gas sector, including actions that will significantly reduce emissions of short-lived climate pollutants, notably black carbon and methane.	1.90					
Congo Basin Countries†	Capacity building in 10 countries located in the Congo Basin Region to help identify and develop nationally appropriate mitigation actions.		0.78				
Congo Basin Region†	Support for the Congo Basin Forest Partnership		1.86				
Congo Basin Countries*	Supporting a fair and sustainable management of natural resources in Congo Basin countries.			0.5			

Table 7.3 Bilateral and Regional Financial Contributions (continued)

Recipient Country	Description	Funding Area (in millions of CAD)					
		Energy	Capacity Building	Other Vulnerability Assessments	Coastal Zone Management	Forestry	Agriculture
Cuba*	Enhancing municipal environmental management practices and the quality of life of the communities in coastal zones and strengthening local capacities to implement industrial agricultural techniques that reduce the need for imported energy and resources.		0.60		0.04		
Democratic Republic of Congo†	Reducing poverty and increasing food self-sufficiency.			1.75			
Ethiopia†	Increasing economic, social and ecological resilience of smallholder Ethiopian farmers to climate change and increasing the food security of Ethiopian households.		1.81	1.87			
Ethiopia*	Increasing agricultural productivity for smallholder farmers and supporting market-led approach to development for increased food consumption and higher incomes.			5.34			
Ethiopia, Bolivia, Mali, Ghana*	Improving livelihood security and resilience.		1.11				
Ethiopia, Philippines, Jamaica*	Advancing sustainable economic growth and development in urban regions, consistent with the countries' national development agendas.		0.87				
Ghana†	Implementing measures to ensure sustainable access to food and livelihoods.		2.08				
Ghana†	Increasing resilience of the vulnerable households to climate change.		2.10				
Ghana*	Supporting climate resilient agriculture capacity building for smallholder farmers.		1.00				
Guatemala†	Reducing socio-environmental vulnerability to climate change.		0.66				
Haiti†	Strengthening adaptive capacities to address climate change threats.		0.50				
Haiti*	Supporting the rehabilitation of the Artibonite River watershed in the border zone between Haiti and the Dominican Republic.			0.48			

Table 7.3 Bilateral and Regional Financial Contributions (continued)

Recipient Country	Description	Funding Area (in millions of CAD)					
		Energy	Capacity Building	Other Vulnerability Assessments	Coastal Zone Management	Forestry	Agriculture
Honduras†	Building capacity to assess infrastructure vulnerability.		0.60				
Honduras*	Enhancing food security through improved agricultural productivity, diversity and the promotion of sustainable natural resource management practices.		2.74		0.13		
Indonesia*	Enhancing the livelihood security and well-being of vulnerable coastal communities on the west coast of South Sulawesi.				1.33		
Indonesia, Cambodia, Laos, Philippines, Thailand, Vietnam*	Reducing the impact of disasters on vulnerable populations in Southeast Asia by providing support to governments and civil society to manage and reduce disaster risk.			2.61			
Latin America and the Caribbean*	Improving capacities for energy planning and regulation across countries in the region.		0.17				
Mexico†	Providing technical support for GHG emission inventory.		0.13				
Nicaragua*	Supporting sustainable economic growth in rural areas and increase access to safe, nutritious food for poor communities.			2.05			
Peru†	Climate change adaptation integration in the poorest communities.		0.30				
Peru, Costa Rica, Mexico†	Providing technical advice to countries to help them flesh out implementable mitigation actions in the Housing sector.	3.00					
Rwanda†	Increasing access to sufficient, nutritious and safe food among those most vulnerable to climate change.		2.24				
Senegal†	Reducing poverty by improving the ability to adapt to climate change.		3.02				
Tanzania†	Improving market-led agricultural production and market and processing knowledge.		3.11				

Legend:	†	Contribution targeting the Rio Conventions as a 'principal objective'	*	Contribution targeting the Rio Conventions as a 'significant objective'

7.3 Transfer of Technology

Clean technologies are critical to achieving long-term low-carbon growth, particularly in emerging economies that are projected to be the source of large GHG increases into the future. Canada is committed to a broad range of actions to advance clean technologies globally, including support for domestic research and development, science and technology (S&T) cooperation with international partners and building capacity in developing countries. Some examples are outlined below.

7.3.1 Developing and Sharing Knowledge and Tools

Canada is leading the way in developing software tools for innovative clean energy project analysis, modelling and simulation. The RETScreen Clean Energy Project Analysis Software is the world's foremost clean energy decision-making software. It can be used worldwide to evaluate the effects of various types of renewable-energy and energy-efficient technologies. Used by more than 377,000 people around the world, RETScreen has been directly responsible for over $8 billion in user savings globally. By virtue of enabling clean energy, the software indirectly contributes to a substantial reduction in greenhouse gas emissions, a reduction conservatively estimated at 20 megatonnes (Mt) CO_2 eq per annum. It is also estimated that RETScreen has facilitated the installation of at least 24 gigawatts of installed clean energy capacity worldwide with a value of approximately $41 billion. Canada continues to enhance and strengthen the RETScreen software. A number of new resources have been added over the last four years, including: the RETScreen Plus Energy Performance Analysis Module to help users monitor, analyse, and report key energy performance data to facility operators; and the RETScreen Clean Energy Policy Toolkit to practically assist countries in developing clean energy policies.

Canada has also developed the Carbon Budget Model of the Canadian Forest Sector (CBM-CFS3). This forest carbon accounting software, developed by the Canadian Forest Service, helps forest managers meet criteria and indicator reporting requirements for sustainable forest management and forest certification, and understand how their actions affect the net carbon balance of their forest estate. It is a stand and landscape-level modeling framework that simulates the dynamics of all forest carbon stocks required under the UNFCCC and can be applied to assess carbon emission implications of REDD+ strategies. Canada makes the CBM-CFS3 available free of charge, and has run training workshops in Canada that included forest managers from Russia, Madagascar, Uganda, Thailand, Philippines, Mexico, China and Korea. Preliminary versions of the model interface and documentation are available in French, Spanish and Russian, and bilateral projects with forest management agencies are also ongoing with Russia, Mexico, Poland, Korea, and China. The Joint Research Centre of the European Union has applied the model to 25 E.U. countries, while worldwide over 1000 people in 57 countries have used the software.

The Department of Natural Resources has supported Engineers Canada to lead the development of a standardized methodology tool to assess the engineering vulnerability of infrastructure in a changing climate in Canada. After testing in Canada, the tool was introduced at a regional workshop in Brazil in 2010. Since then, it has been successfully applied in two infrastructure risk assessments: the City of Limon sewage collection and treatment system in Costa Rica, and an assessment of highway bridges in Honduras. The successful application of the tool in Limon led to an agreement with Costa Rica's College of Architecture and Engineering to licence use of the tool in that country.

With four large-scale demonstration projects either operational or proceeding with construction, Canada remains a global leader in the research, development, and demonstration of carbon capture and storage (CCS) technologies. These projects include the Shell Quest project at an oil sands upgrader in Alberta ($120 million in federal funding, $745 million from the Government of Alberta); the SaskPower Boundary Dam project at a

coal-fired power plant in Saskatchewan ($240 million in federal funding, $1 billion from SaskPower—a utility owned by the Government of Saskatchewan), the Enhance Energy Alberta Carbon Trunk Line project in Alberta ($63.2 million in federal funding, $495 million from the Government of Alberta); and the existing Weyburn-Midale commercial enhanced oil recovery operations run by Cenovus Energy and Apache Canada. In addition to investing heavily in CCS, Canada is also an active member in a number of multilateral initiatives focused on advancing CCS development and deployment such as the Carbon Sequestration Leadership Forum, the Carbon Capture Use and Storage Action Group of the Clean Energy Ministerial, the Global CCS Institute, and the Canada-U.S. Clean Energy Dialogue.

7.3.2 Engaging Multilaterally

The International Energy Agency is a key platform through which Canada works with international partners to facilitate clean technology cooperation. Canada participates in 27 of the Agency's 40 implementing agreements to encourage technology collaboration. These agreements form the framework for facilitating initiation, implementation, monitoring and review of collaborative Research and Development (R&D) between developed and emerging economies in renewable energy, energy end use, buildings, transportation, fossil fuels, and nuclear fusion. Canada provides over $1 million annually to the International Energy Agency, with additional funds for targeted agreements.

Canada supports the work of the Climate Technology Initiative (CTI), which operates as an Implementing Agreement under the International Energy Agency, bringing countries together to foster international co-operation in the accelerated development and diffusion of climate-friendly and environmentally sound technologies and practices. Through the CTI, Canada also supports the CTI's Private Financing Advisory Network (PFAN). CTI–PFAN uses limited public funds to mobilize private sector investment in clean technologies in developing countries, thereby helping to bridge the gap between investments and clean energy businesses.

The Clean Energy Ministerial is a high-level process focused on clean technology to address climate change. Canada works through the Clean Energy Ministerial with 22 other governments, including major emerging economies, with the goal of facilitating the transition to a global clean energy economy. The Ministerial advances this goal through high-level dialogue, technical cooperation through clean energy initiatives, and engagement with the private sector. Its focus on collaboration, including with the private sector, makes it a valuable forum through which Canada pursues its capacity building and technology transfer objectives.

Canada is an active participant in four of the Clean Energy Ministerial technical initiatives: the Carbon Capture, Use and Storage Action Group; the International Smart Grids Action Network; the Global Superior Energy Performance Partnership (GSEP); and the Super-Efficient Equipment and Appliance Deployment Initiative (SEAD). Canada's participation in these initiatives, and its provision of expertise and in-kind support to their work, will contribute to global GHG reductions through energy efficiency improvements or promoting clean energy supply.

Both GSEP and SEAD are also initiatives under the International Partnership for Energy Efficiency Cooperation (IPEEC). IPEEC provides a forum for dialogue and action between key global energy users on energy efficiency, and promotes information exchange on best practices. Beyond its participation in GSEP and SEAD, Canada participates in IPEEC's Executive and Policy Committees and has been the Policy Committee Chair since May 2012.

The Generation IV International Forum is an international treaty-supported R&D collaboration that is working to develop and promote advanced generation (Generation IV) nuclear-based clean

energy systems. Canada's participation in collaborative R&D through the Forum facilitates the development of leading edge technology and knowledge through sharing of confidential and protected data, resources and infrastructure, shared training of highly qualified people, and through the undertaking of collaborative research. Canada provides funding of approximately $4 million annually to support its contributions to the Generation IV International Forum collaborative R&D, as well as in-kind support from Canadian national labs and participating university partners.

The International Model Forest Network is a global learning network of 60 member Model Forests around the world, which together cover more than 100 million hectares. Canada has hosted the International Model Forest Network Secretariat since its inception in 1995, and works with international partners to advance the sustainable management of forest-based landscapes through the Model Forest approach. Since 2010 Canada has provided targeted support for climate change initiatives in Model Forests which focused on: forest management through reforestation and applied research on climate change impacts on forests; capacity building through research extension and communications activities to increase awareness of the need to adapt to the impacts of climate change; and the development and ground-truthing of policy options based on research conducted in Model Forests. Canada's financial contribution to the Network since 2010 totalled more than $15 million, the bulk of which was provided in the form of contributions to African recipients.

Canada led the development of the Global Early Warning System for Wildland Fire under the Global Observation of Forest Cover and Landcover Dynamics Fire Implementation Team. Operational since May 2011, early warning information is produced daily and made available through the Global Fire Monitoring Centre. This system contributes to the Global Multi-Hazard Early Warning System evolving under the auspices of the United Nations International Strategy for Disaster Reduction. Canada is collaborating with the European Commission's Joint Research Centre to enhance the current system. Regional early warning products using more detailed local data are also in development through collaboration with partner agencies in Africa and Southeast Asia.

7.3.3 Working with Bilateral Partners

Bilateral cooperation with key international partners forms a central part of Canada's efforts to advance clean technology. Selected details of key partnerships with emerging economies are outlined below.

Canada and China engage and collaborate on climate change through the Canada–China Climate Change Working Group, which is supported by a Memorandum of Understanding on Climate Change Cooperation signed in 2009. The Canada–China Climate Change Working Group meets annually to discuss areas of mutual interest and explore knowledge exchange opportunities. In 2012 Canada hosted a successful adaptation workshop in Vancouver through the Working Group, which focused on knowledge exchange to enhance China's capacity to address adaptation issues.

Canada has an S&T agreement with China, which is an important platform to accelerate research in priority areas, including clean energy technologies. In addition, Canada's Department of Foreign Affairs, Trade and Development, in partnership with key stakeholders in Canada and China, launched a joint funding opportunity in 2013 to support industrial-academic collaborative R&D in the domain of clean automobile transportation.

Canada has an S&T Agreement with India to facilitate cooperative S&T activities between the two countries in fields of common interest, including alternate energy and sustainable environmental technologies. Canada and India have also signed a Joint Statement recognizing the importance of environmental management and sustainable development and also cooperate through the India–Canada Forum on Environmental Cooperation.

Canada supports technology transfer and capacity building activities with Mexico through practical cooperation on climate change, notably including the Canada–Mexico Partnership. Through its fast-start financing, Canada has also been able to partner with Mexico to build capacity in emissions reporting, as well as to develop long-term sectoral mitigation strategies that support national priorities in three industrial sectors—waste management, oil and gas, and housing. Canada and Mexico are currently working to support the reduction of climate change vulnerability and the adaptation of vulnerable populations in Mexico ($2.5 million). An additional project ($1 million) is aimed at climate change adaptation and supporting the restoration of protected areas in Mexico.

More specifically, Canada and Mexico work together on Carbon Budget Modeling. The collaboration seeks to improve the capacity for GHG reporting and to develop policy-relevant analyses of the implications of various REDD+ strategies on future forest carbon balances and GHG emissions. The partnership has resulted in joint research on the application, testing and advances to the scientific and technical development of the CBM-CFS3 to Mexico (referred to in Section 7.3.1), and in capacity-building activities such as training of Mexican scientists. In addition to this support for Mexico, Canada also provided over $9 million in fast-start finance to support sector specific mitigation projects in Africa, Latin America and the Caribbean.

These innovative projects provided an opportunity for developing countries to develop and adopt climate mitigation actions appropriate to their own circumstances. For example, $3.5 million was disbursed to support Mexico, Costa Rica and Peru in developing an approach to implement Nationally Appropriate Mitigation Actions in the housing sector. Low-carbon housing roadmaps are now being developed in these countries. Canada also provided $2.6 million to support Mexico, Colombia, Chile and the Dominican Republic in the development and implementation of mitigation actions in the solid waste sector.

References

1 All figures are in Canadian dollars unless otherwise stated.

2 Including over $100 million of contributions made to projects with a primary focus on climate change [i.e., marked as targeting the Conventions as a 'principal objective' under the Organization for Economic Cooperation and Development, Development Assistance Committee (OECD/DAC) Rio markers], and over $236 million to projects that included a significant climate change component (i.e. marked as targeting the Conventions as a 'significant objective' under the OECD/DAC Rio markers). Canada has not included every contribution reported as targeting the Conventions as a 'significant objective' under the OECD/DAC Rio markers to ensure this report focusses on the most relevant contributions to climate action. For example, core contributions made to multilateral organizations are not reported on in this report.

8 Research and Systematic Observation of Climate Change

8.1 Introduction

In Canada, climate system research and observation is a joint effort that is implemented through core government programs, academic institutions, and collaborative research networks. Collectively, these efforts improve our understanding of the global climate system and the influence of natural forces and human activities on climate change and variability. This enables better recognition of the potential impacts on global ecosystems and human society. Climate system research and monitoring in Canada provides the foundational scientific basis to guide Canadian decisions on climate change mitigation and adaptation. Chapter 6: Vulnerability Assessment, Climate Change Impacts and Adaptation Measures presents a discussion of research and other activities in Canada related to climate change impacts, adaptation, and vulnerabilities.

This chapter presents a summary of research and systematic observation activities of climate change in Canada. Moreover, it outlines specific changes and progress subsequent to the 2010 publication of Canada's 5th National Communication on Climate Change. The emphasis of this chapter is on long-term research and monitoring programs within Canada, which are typically led by Government of Canada departments. However, recognising the vast and collaborative nature of climate research and monitoring in Canada, various examples of academic and consortium-based programs, as well as cooperative research networks, are also presented.

8.2 Funding and Priorities

8.2.1 Overview

In Canada the essential infrastructure for climate system research and systematic observations programs is provided, in large part, by the federal government. Integrated research teams within the federal government provide the climate-related scientific information needed to serve Canadians. This includes providing direct information through published research results, data, and climate services, and through sound advice to policy makers. Federal government research and observation activities are complemented by those of the Canadian academic community, which has a stronger focus on enquiry driven science. Productive partnerships have been established between the two communities and both continue to make substantial contributions to Canadian and international programs. The following sections highlight some of the key organisational and funding mechanisms for climate research and systematic observations within Canada.

8.2.2 Funding within the Government of Canada

Research and systematic observation of the climate system is the shared responsibility of multiple departments within the Government of Canada. As such, funding for these programs is embedded within annual departmental budget allocations. In addition to these core programs (such as Environment Canada's climate research program), the Government of Canada funds targeted initiatives to enhance climate-related research and monitoring beyond the core programs and to initiate specific projects (see examples in 8.2.3).

8.2.2.1 Clean Air Agenda

In March 2007, the Government of Canada implemented the Clean Air Agenda and in 2011, funding was renewed through to 2016. The aim of the Clean Air Agenda is to address climate change and air pollutants at the domestic, continental, and international level. Programs across 11 Government of Canada departments and agencies are organized around five themes: the Clean Air Regulatory Agenda, Clean Energy, Clean Transportation, International Actions, and Adaptation. Of these, the Clean Air Regulatory Agenda and

Adaptation themes are most directly aligned with climate system research and monitoring.

The Clean Air Regulatory Agenda supports the scientific research, monitoring, and atmospheric modelling necessary to assess and develop Canada's regulatory approach to reducing greenhouse gas (GHG) emissions. The Adaptation theme is designed to help Canadians adapt to climate change. Programs under this theme provide a wide breadth of outcomes, from providing scientific knowledge on the climate system (through research, monitoring, and modelling) to targeted regional and sector-based adaptation programs.

8.2.2.2 Canadian Space Agency Programs

Government Related Initiatives Program

The Canadian Space Agency contributes to environmental monitoring and science by coordinating space programs and policies of the Government of Canada. The Government Related Initiatives Program assists federal departments in integrating space-borne Earth Observation data in their operations. The Program is organised around three themes: Environment; Resources and Land Use Management; and Security and Foreign Policy.

Initiatives under the Environment theme include developing and deploying technologies and applications that provide information about the current state and evolution of the climate, the quality of the air and the water, as well as the biodiversity of the country and the planet. Space-based observations are particularly useful for monitoring changes in the physical, chemical, and biological aspects of the Earth and for supporting climate research because of the global nature of the climate system.

Earth Observation Application Development Program

The Earth Observation Application Development Program (EOADP) addresses the needs of the industry. Projects supported under the Environment theme of the Earth Observation Application Development Program are focused on enhancing the understanding and monitoring of key parameters and processes of the Earth, atmosphere, oceans, cryosphere, and biosphere systems and how these are inter-related. A specific focus of recent projects has been the demonstration of new capabilities and monitoring applications using data from the RADARSAT-2 satellite, which was launched in 2007.

8.2.2.3 Program of Energy Research and Development

The Program of Energy Research and Development is a federal program managed by Natural Resources Canada and involves the participation of 13 federal departments and agencies. Funding is provided to federal departments and agencies to deliver programs targeted toward sustainable energy research and development. Government of Canada departments and agencies collaborate with universities, the private sector, provincial and municipal governments, and international organisations to deliver their respective research and development programs under this initiative. While the Program covers a broad range of sustainable energy-related research projects, certain departments focus on research related to environmental and climate-related implications. For example, Environment Canada manages funding for projects that look at the environmental aspects of energy production and use and Natural Resources Canada, in collaboration with the University of Ottawa, re-activated a series of permafrost monitoring stations with funding support from this Program.

8.2.3 Research Granting Agencies and Funded Initiatives in Canada

In Canada there are three main granting agencies that administer funding to a wide variety of programs among Canadian universities. These are the Natural Sciences and Engineering Research Council (NSERC), the Canadian Institutes of Health Research and the Social Sciences and Humanities Research Council. NSERC is concerned with administering funds to most science-based projects and therefore, is the

most closely-linked of the three granting agencies to climate research programs. Its core role is to support university research and training in the fields of science and engineering. The Council fulfills its mission by awarding scholarships and research grants through peer-reviewed competition, and by building partnerships among universities, colleges, governments, and the private sector. A number of climate-related research initiatives and networks in Canada are funded by NSERC.

8.2.3.1 Climate Change and Atmospheric Research Grants

NSERC's Climate Change and Atmospheric Research initiative was announced in 2012. Research projects funded through the Climate Change and Atmospheric Research grants involve interpreting Earth system processes; advancing weather, climate and environmental prediction; and understanding recent changes in the Arctic and cold region environments. In 2013, seven research teams were awarded grants totalling more than $32 million over five years to support climate change and atmospheric research at Canadian post-secondary institutions. The teams are comprised of university and government researchers, and partner organisations. Through such collaboration the teams will undertake seven projects:

- Network on Climate and Aerosols: Addressing Key Uncertainties in Remote Canadian Environments
- Research related to the Polar Environment Atmospheric Research Laboratory: Probing the Atmosphere of the High Arctic
- Canadian Arctic GEOTRACES Program: Biogeochemical and Tracer Study of a Rapidly Changing Arctic Ocean
- Canadian Sea Ice and Snow Evolution Network
- Ventilation, Interactions and Transports Across the Labrador Sea
- Canadian Network for Regional Climate and Weather Processes
- Changing Cold Regions Network

8.2.3.2 Networks of Centers of Excellence

Created in 1989, the Networks of Centers of Excellence program is an integral part of the Government of Canada's Innovation Strategy. It connects nation-wide and multidisciplinary research partnerships with industrial expertise and strategic investment. All programs funded by this initiative are large-scale, academic-led, virtual research centres that bring together multi-disciplinary partners from academia, industry, government, and not-for-profit organisations. The Networks of Centers of Excellence initiative is supported by the three major Canadian federal granting agencies, as well as by two government departments: Health Canada and Industry Canada. There are currently two Networks of Centers of Excellence initiatives that are directly related to climate research and monitoring: ArcticNet and the Marine Environmental Observation Prediction and Response Network.

ArcticNet

The first two phases of ArcticNet took place from 2003–2011, and were discussed in the 5th National Communication report. Since 2011, the third phase of ArcticNet was launched, which focuses on four main themes: coastal marine ecosystems, coastal terrestrial ecosystems, Inuit health and adaptation, and industrial development in the North. This integrated research offers a unique multi-disciplinary and cross-sectorial environment to train specialists. To date, there are over 145 ArcticNet researchers from 30 Canadian universities, 8 federal and 11 provincial agencies and departments collaborate with research teams in various countries.

Marine Environmental Observation Prediction and Response Network

Established in 2012, the Marine Environmental Observation Prediction and Response (MEOPAR) Network aims to address issues related to human activity in marine environments and the effects that marine hazards have on human activities in coastal areas. With funding of approximately $25 million from

2012–2017, the team of Canadian researchers involved in this network use research and observations to help reduce Canada's vulnerability and exposure to hazards and enable quicker response times in cases of marine emergencies. The long term objective is to develop disaster and risk reduction tools and put forward adaptation measures for Canada to better manage ocean influences on coastal environments. This is achieved through both new and existing partnerships with organisations including academia, governmental departments, non-governmental departments, and industries such as insurance and oil and gas.

8.2.3.3 Canada Research Chairs

The Canada Research Chair program aims to achieve research excellence in engineering and the natural sciences, health sciences, humanities, and social sciences by funding academic positions at universities in Canada. The Program is funded by NSERC of Canada and managed by a steering committee that reports to the Minister of Industry. Funding of Tier I and Tier II Chairs supports established and emerging researchers in faculty positions at Canadian universities. The Program spans a wide range of research areas and as of July 2013, there were four Canada Research Chairs contributing directly to climate research in Canada; one each at the Université du Québec à Montréal, the University of Toronto, McGill University, and the University of British Columbia.

8.2.3.4 Canada Excellence Research Chairs

The Canada Excellence Research Chair Program was launched in 2008, with the first group of Canada Excellence Research Chairs announced in May 2010. Supported by Canada's three major federal granting agencies, the Program funds world-renowned researchers to establish research programs at Canadian universities with up to $10 million over seven years. Canada Excellence Research Chairs are selected through a rigorous multi-level peer review process. Four priority research areas have been identified, which align with the Government of Canada's Science and Technology Strategy:

- Environmental Sciences and Technologies;
- Natural Resources and Energy;
- Health and Related Life Sciences and Technologies; and
- Information and Communications Technologies.

Among the first group of Canada Excellence Research Chairs, there are three positions that directly support academic research related to the climate system; one each at the University of Saskatchewan, the University of Manitoba, and Dalhousie University. Another Canada Excellence Research Chairs competition is expected to launch in 2015.

8.2.4 Other Initiatives

8.2.4.1 International Polar Year

International Polar Year was a large, international research campaign organised by the World Metrological Organisation (WMO) and the International Council for Science. It involved thousands of researchers from 62 countries whose research focused on the Arctic and Antarctic. Canada played a significant role in the International Polar Year and Canadian research focused on two important scientific challenges for Canada's northern regions: climate change impacts and adaptation and the health and well-being of northern communities. Canada's participation included 52 projects involving Canadian government and university researchers, students, and community partners from Canada's North. As part of its commitment to the International Polar Year initiative, the Government of Canada provided $156 million in funding over five years (2006–2011) to implement an innovative Arctic program for scientific research, data collection and management, northern training and capacity building, and public education opportunities.

In the intervening years since the field research campaigns concluded, the extensive International Polar Year data has continued to generate new scientific publications and led to new scientific knowledge on the Arctic climate. In April 2012, Canada hosted the final International Polar Year conference in Montreal. The

five day conference brought together over 2,000 people to review and assess the research results from International Polar Year projects. The journal Climatic Change published a special issue[1] in 2012 of Canadian science results from International Polar Year projects.

8.2.4.2 Beaufort Regional Environmental Assessment

The Beaufort Regional Environmental Assessment, launched in 2011, is a four year, multi-stakeholder initiative that is sponsoring regional environmental and socio-economic research to assist in preparing the federal government and local communities to respond to new investments in oil and gas in the Beaufort Sea. The parties supporting this proposal are partners from the Inuvialuit Settlement Region, territorial and federal governments, the oil and gas sector, and academia. This program will help ensure governments, Inuvialuit, and industry are better prepared for oil and gas exploration and development in the offshore by building upon the regional information base for the Beaufort Sea.

This is done through the implementation of a research program and groups addressing key regional issues including cumulative effects assessment, information management, regional waste management, oil spill preparedness and response, socio-economic indicators, and climate change. This will support effective and efficient regulatory decision-making by providing the necessary scientific and socio-economic information to all stakeholders.

8.2.4.3 Canadian Foundation for Climate and Atmospheric Sciences

The Canadian Foundation for Climate and Atmospheric Sciences was established in 2000 with funding from the Government of Canada. The Foundation operated as an autonomous granting agency until 2012, during which time it acted as the main funding body in Canada for university-based research on climate and atmospheric sciences. Nine major research networks funded by the Foundation completed their activities in 2011 and published final reports to document new scientific understanding, legacy data sets, and modelling capabilities generated from the research investments. During the last year of the Foundation's federal mandate in 2011–2012, grants were awarded to 12 projects and research consortia to build on previous achievements. In 2010, the Foundation published *The Sky's the Limit, Ten Years of Achievements*, which highlighted the scientific achievements of the Foundation-supported research networks and projects.[2] Many of the projects and initiatives started under the Canadian Foundation for Climate and Atmospheric Sciences program have found new funding sources to continue the work, most notably under NSERC's Climate Change and Atmospheric Research initiative.

8.3 Systematic Observation

8.3.1 Overview

Systematic climate observations are essential for understanding the mean states of various climate components over time, the natural variability around these means, detecting changes in the means and extremes, and attributing these changes to specific causes. Observations can also help elucidate the processes by which components of the climate system interact and the sensitivity of these processes to natural and anthropogenic forcing. Climate research incorporates observations into climate system models through mathematical equations, thus making the prediction of changes and the long-term projections of future climates possible.

The long-term systematic collection, quality assurance, and dissemination of climate system data in Canada is primarily the responsibility of the federal government, and arises from a broad spectrum of program obligations. Through Canada's involvement in international organisations, agreements, and commitments, climate data is collected, quality controlled, and disseminated according to international standards.

Canada is a significant contributor to the Global Climate Observing System, the Global Ocean Observing System, and the Global Terrestrial Observing System. Canada is a member of the Group on Earth Observations, which seeks to coordinate international efforts to build a Global Earth Observation System of Systems. The Canadian Group on Earth Observations has identified several specific national priorities for such observations, including soil moisture monitoring, modelling and forecasts; integrated planning of monitoring networks and environmental data; and sustained Arctic monitoring programs. The Global Climate Observing System contributes the climate component to the Global Earth Observation System of Systems. Canada is also a participant in the international Sustaining Arctic Observing Networks initiative.

8.3.2 Monitoring Networks

8.3.2.1 Atmosphere

Surface Weather and Climate

Environment Canada's national ground-based weather, climate, upper air, and meteorological marine observation networks follow well-defined operating standards and procedures in accordance with the climate monitoring principles and standards of the Global Climate Observing System and related programs. Network spatial densities and station distributions are relatively stable, with lower densities in the sparsely populated northern regions. To address these spatial gaps, Environment Canada is making it a strategic priority to transform its monitoring capabilities in collaboration with other federal departments and levels of government in Canada, as well as the private sector. This Canadian Network of Networks initiative will address the diverse needs of public and private sector groups for high quality weather, water, and climate data that are managed on a foundation that is efficient, collaborative, and sustainable.

The Surface Weather Network involves approximately 808 fully automated stations. Canada also contributes to the international Voluntary Observing Ship Climate Project through its Automated Volunteer Observing Ships. The Canadian moored buoy network, with 52 buoys located in the Atlantic and Pacific oceans and in inland waters, contributes hourly observations to the Global Telecommunication System, following Data Buoy Cooperation Panel and WMO guidelines. In addition to these networks, the Environment Canada drifter buoy network provides marine observations from most of the data sparse areas in the Arctic, north Atlantic, and north Pacific oceans. In 2012, under the Environment Canada Arctic METAREA service expansion, the drifter buoy network was expanded through Environment Canada's deployment of 23 drifter buoys in the Arctic. Environment Canada also contributes to the Global Drifter Program by upgrading approximately 20 drifter buoys with barometers every year.

Within this broader atmospheric monitoring program, Environment Canada operates two climate change surface networks—the Canadian Reference Climate Stations Network and the daily Climatological Network. The Canadian Reference Climate Stations Network consists of approximately 300 stations, of which 86 are included in the Global Surface Network. In addition to monitoring the Global Climate Observing System Surface Essential Climate Variables, the Canadian Global Surface Network stations also measure and report atmospheric pressure, wind speed and direction, humidity, and snow on ground on hourly and synoptic reporting frequencies. The Reference Climate Stations Network is primarily intended for determining climate trends on regional and national scales. It was initially established by identifying and designating stations with continuous high quality observations of 30 plus years in duration. The resulting network was a mixture of automated stations, human-based aviation weather observing sites, and daily temperature and precipitation climatological stations operated by volunteers and co-operating agencies. Since 2000, Environment Canada has been converting about 10% of these stations per year to a standardised auto-station configuration.

Environment Canada and the U.S. National Oceanic and Atmospheric Administration (NOAA) have a bilateral agreement to coordinate standards, procedures, equipment, and measurement programs between the Canadian Reference Climate Stations and the U.S. Climate Reference Network. The objective is to establish and maintain an integrated North American climate reference network.

The daily Climatological Network currently consists of approximately 480 sites where observations of temperature (minimum and maximum), precipitation (rainfall or snowfall), and snow depth are recorded once or twice daily. Ongoing modernisation of automated data collection and quality assurance/quality control protocols continues to improve data quality and collection efficiency. For example, Environment Canada has developed data entry systems (one internet-based and one telecommunications-based) to allow observers to submit their observations in near real-time.

Upper Air Networks

Canada maintains 31 of the approximately 1,300 upper air radiosonde stations and five of the estimated 171 Global Climate Observing System Upper Air Network (GUAN) stations operating under the global World Weather Watch/Global Observing System program. The Canadian GUAN stations are located at Alert, Goose Bay, Moosonee, Fort Smith, and Cambridge Bay.

At the radiosonde stations, balloon borne radiosondes are released twice daily to measure and simultaneously transmit data on temperature, humidity, and pressure to automated ground systems. Wind direction and speed are determined by using Global Positioning System technology to track the radio signal transmitted by the radiosonde.

Upper air observations from the Canadian upper air radiosonde network are supplemented through initiatives such as the Canadian Aircraft Meteorological Data Relay program. About 10,000 observations of wind and temperature are generated daily by a fleet of about 27 aircraft operated by a contract air carrier in Canada. These observations translate into roughly 1,400 soundings per week from 30 Canadian airports. Nav Canada also provides the Canadian Aircraft Meteorological Data Relay program data from two unscheduled aircraft used for flight inspection that visit each of the Canadian terminals one to two times per year. The quality of the data is monitored in near-real-time by the Canadian Meteorological Centre before the data are used in the Canadian Meteorological Centre's national data assimilation system and distributed internationally.

Atmospheric Composition

Environment Canada operates the long term observations network for atmospheric measurements of CO_2 and other GHGs (CH_4, CO, N_2O, and SF_6). The stations are located to provide regional scale information on GHG emissions from local and regional natural (forests, wetlands) and non-natural (coal, oil and gas, agriculture, waste) sources. As of July 2013, there were 15 measurement sites located in coastal, interior, and Arctic regions in Canada. A major focus of the GHG measurement program since the 5th National Communication has been to enhance the regional coverage in Canada's North. This includes the addition of three monitoring sites in the Northwest Territories and Nunavut to complement the long-term observation record at Alert, Nunavut. Environment Canada's Global Atmosphere Watch Observatory at Alert is one of three WMO Global GHG inter-comparison sites.

Measurements of aerosol chemistry and microphysics are conducted at four sites in Canada. The Alert and Whistler sites are more comprehensively instrumented for aerosol measurements (particle size distributions, light scattering and absorption, refractory black carbon concentrations, near real-time submicron particle chemistry, filters for inorganics and elemental carbon and organic carbon). Aerosol instrumentation at the East Trout Lake and Egbert sites consists of light scattering and absorption as well as filters for inorganics

and elemental carbon/organic carbon ratios. Aerosol observations contribute to improved understanding of biogenic and biomass source influences, trans-Pacific and Arctic atmospheric transport behaviour, and industrial/urban influences on regional scales.

Stratospheric ozone measurements support Canada's international obligations, as it is party to the Montreal Protocol on substances that deplete the ozone layer, and is also party to the Vienna Convention on the protection of the ozone layer. More specifically, total ozone column measurements are being taken to study ozone trends, monitor the recovery of the ozone layer as well as polar ozone depletion events, such as those that occur naturally over the Antarctic every spring time. In addition, total ozone measurements by the Brewer network are used by modellers to generate ultraviolet forecasts, which are then validated by Brewer ultraviolet measurements. Surface ozone measurements are also made at 15 regionally-representative sites across Canada by the Canadian Air and Precipitation Monitoring Network, a regional-scale network that measures air and precipitation chemistry across the country. The data are collected and reported as hourly averages and analysed to establish the status and trends of regional-scale surface ozone within Canada.

Environment Canada uses two main methods to monitor stratospheric ozone, the Brewer Spectrophotometer method measures the total thickness of the ozone layer several times per hour and the ozonesonde method measures the vertical concentration profile of ozone in the troposphere and the stratosphere on a weekly basis. There are ten sites that monitor stratospheric ozone using Brewer Spectrophotometers: Alert, Eureka, Resolute, Churchill, Goose Bay, Edmonton, Kelowna, Saturna, Regina, and Toronto. There are eight sites using ozonesondes: Alert, Eureka, Resolute, Churchill, Goose Bay, Edmonton, Yarmouth, and Kelowna. The majority of ozonesonde stations are co-located with the Brewer stations.

Environment Canada operates the AEROCAN (AEROsol CANada) network, a sun photometer and sky-scanning radiometer network of 20 sites across Canada as a part of the global AERONET (Aerosol Robotic Network) network. The objective of AEROCAN is to acquire data on aerosol optical properties, e.g., aerosol optical depth, and derive aerosol characteristics such as size distribution and mass. Aerosol radiative forcings are one of the largest uncertainties in climate change studies. AEROCAN provides data that can be used for aerosol optical depth trend analysis, optical properties characterisation, and for validation of satellite retrievals.

Data management among Environment Canada's atmospheric composition measurement networks adheres to principles set out by the WMO Global Atmosphere Watch Program. Ozone, GHG, and aerosols data are reported to the relevant the WMO World Data Centers. The World Ozone and Ultraviolet Radiation Data Center is operated by Environment Canada and located in the city of Toronto. GHG and aerosols data are also archived in the Canadian National Atmospheric Chemistry Database and Analysis System. Canada's participation in these national and international data archives ensures open access to the first-order data collected under the various monitoring programs.

8.3.2.2 Oceans

Fisheries and Oceans Canada is responsible for the collection and management of data on the physical, chemical, and biological variables describing the climate of the oceans that surround Canada. This includes the Northeast Pacific, Northwest Atlantic, Hudson Bay, the Beaufort Sea, the Arctic Archipelago, and the Labrador Sea. Observations are made by ship, moored and floating buoys, and remote sensing. The rescue of historical data has continued to be a significant initiative over the past few years. Collaborations are established with other government departments and agencies to include oceanographic

activities for which the responsibility falls outside Fisheries and Oceans Canada.

Canada's Oceans Action Plan articulates a vision and mission for Canadians focused on safe and accessible waterways, healthy and productive aquatic ecosystems, and sustainable fisheries and aquaculture. The Oceans Action Plan is based on the principles of international leadership, sovereignty and security, integrated oceans management, health of the oceans, and advancements in oceans science and technology. Ocean monitoring is a crucial requirement for achieving the goals of this Plan.

Pacific and Atlantic Ocean Monitoring

The Atlantic Zone Monitoring Program includes a network of six stations sampled bi-weekly, 13 seasonal cross-shelf sections sampled one to two times annually, and fisheries resource surveys. A section across the Labrador Sea is sampled annually for temperature, salinity, oxygen, nutrients, carbon system variables, chlorofluorocarbons, and microbial, phytoplankton, and zooplankton abundance and production. It is an important ocean monitoring program for climate research because each year it samples the water masses that contribute to the Atlantic branch of the ocean's thermohaline circulation. Since 2006, a few stations have been added to the offshore end of the Atlantic Zone Monitoring Program Halifax section to provide annual downstream sampling of these same variables. Similarly, the Pacific Line, which is surveyed three times per year for temperature, salinity, O_2, CO_2, chlorophyll, nutrients, and zooplankton, is a cornerstone of long-term observations of the effects of climate variability and change on ocean ecosystems.

Satellite data images are captured by Fisheries and Oceans Canada at receiving stations at the Bedford Institute of Oceanography—Atlantic Region and the Institute of Ocean Sciences—Pacific Coast. Sea-surface temperatures images are derived from Advanced Very High Resolution Radiometer on the U.S. NOAA series of polar orbiting weather satellites and at Resolute, Canada. Both the Pacific Coast and the Resolute datasets are transmitted to L'Institue Maurice Lamontagne for analysis. Chlorophyll concentration images are produced from SeaWifs data collected on the ORBView-2 satellites. Primary Production images are derived from the semi-monthly composites of chlorophyll concentration and temperature. On-line archives of imagery are available from both institutes.

Fisheries and Oceans Canada's Integrated Science Data Management Branch acquires, archives, processes, and disseminates all real-time surface drifter data that are distributed on the Global Telecommunications System as well as delayed mode data acquired from other sources. The reports are processed to remove duplicates and quality control routines are applied to the reported measurements. As a designated Responsible National Oceanographic Data Centre, Fisheries and Oceans Canada partners with the Atlantic Oceanographic and Meteorological Laboratory in the US to provide long term archive facilities for the Global Drifter Center data. Observed Essential Climate Variables are surface and subsurface water temperatures, air pressure and pressure tendency, surface and subsurface salinity, and surface currents.

Canada also contributes to the international Argo program, which now has over 3,000 profiling submersible floats in the world's oceans and provides ongoing coverage of global ocean temperature and salinity variability. The Argo Program also provides a unique dataset for the development and testing of assimilative ocean circulation models, modern temperature–salinity climatology for the global ocean, and time series of variability in heat and freshwater storage and transports, used for analysis of the dominant patterns and modes of coupled atmosphere–ocean variability. Canada's contribution to the Argo program to date has included deployment of over 250 ocean floats in the northwest Atlantic and northeast Pacific Oceans.

Arctic Ocean Observations
The Arctic Ocean observations programs include through-flow monitoring in key straits of ocean current through full depth, ice drift, temperature and salinity at the seabed, and acoustic backscatter from zooplankton. In addition, there is monitoring of the pack ice in the Beaufort Sea by instruments on sub-sea moorings.

Sea Levels
Fisheries and Oceans Canada also has responsibility for monitoring sea levels through the use of the Atlantic and Pacific National Sea Level Network of coastal stations.

Ocean Observations Data Management
National coordination and integrity across the various Fisheries and Oceans Canada monitoring programs, through the National Science Data Management Committee, ensures common protocols for both observation and data archiving. Integrated Science Data Management manages and archives ocean data collected by Fisheries and Oceans Canada, or acquired through national and international programs in ocean areas adjacent to Canada. The Integrated Science Data Management also assembles, processes, quality controls, and distributes large volumes of climate related data, as a data centre for the major international climate research programs. Systematic observation of ecosystem state variables provides the data required to test scientific conjectures on the propagation of climate signals through linked components of the ocean's biota and physical environment.

8.3.2.3 Cryosphere

Sea Ice
Environment Canada's Canadian Ice Service observes sea ice conditions on a daily basis in the ice-encumbered waters within and adjacent to Canada's exclusive economic zone, including the Great Lakes and Saint Lawrence River. The RADARSAT satellite mission is the primary observing platform, with over 7,000 Synthetic Aperture Radar images analysed annually. Radar data is augmented with visual and infrared satellite images. Aircraft reconnaissance is conducted in shipping areas for visual confirmation of satellite observations. Along Canada's east coast, these also provide iceberg surveillance.

The sea ice information gathered through these observations and analyses, in addition to improving the safety of navigation, provide invaluable data for climate studies. Environment Canada produces charts of sea ice distribution on a weekly basis, which are used for ice climate purposes. These charts have been digitised back to 1968, and are available freely on the Canadian Ice Service website. The weekly charts are also sent to the World Data Center for Glaciology, which is co-located with the United States National Snow and Ice Data Center in Boulder, Colorado. Environment Canada produced three 30-year climatic ice atlases for Northern Canada Waters, the East Coast of Canada, and the Great Lakes. Each of these represents a statistical compilation of regional ice charts for 1980–2010. The Canadian Ice Chart Digital Archive and graphing tools available on the Canadian Ice Service website can be used to analyse sea ice variability, trends, and current departure from normal. A data rescue project to digitise additional sea ice cover charts from 1959 has been completed and digitisation of the historical Polar Continental Shelf Project ice charts is planned.

Environment Canada also produces daily charts of iceberg distribution along the East Coast of Canada. Fisheries and Oceans Canada programs include the monitoring of sea ice draft and drift with moored buoys, and the use of helicopter-borne sensors to collect sea ice thickness data for use in joint research projects with Environment Canada's Canadian Ice Service. Iceberg aerial reconnaissance is conducted over Canada's east coast waters in conjunction with the International Ice Patrol. Flight frequency depends upon the area, with the iceberg limit monitored weekly. Areas inside the limit, up to southern Labrador, are monitored monthly.

Using a newly-developed ice tracking algorithm for deriving ice motion from sequential RADARSAT

images, a series of studies examining ice fluxes through the Canadian Arctic Archipelago have been undertaken within Environment Canada. Environment Canada's ice chart data is also currently being used in the development and validation of various sea ice and ice–atmosphere–ocean models.

An automated sea ice analysis system has been running operationally since March 2011. The three-dimensional variational data assimilation system provides an analysis of sea ice concentration on a 5 km grid every six hours. The analysis domain covers all marine ice-covered areas of North America and the two MET/NAVAREAS in the Arctic for which Canada has responsibility. Assimilated data include Environment Canada ice charts, lake ice manual analyses, and ice concentrations derived from satellite passive microwave observations and from scatterometer satellite observations.

Lake and River Ice

Dates of freeze-up and break-up of ice cover on lakes and rivers are a useful indicator of climate change, being well correlated with air temperature during the transition seasons, and are an important ecological indicator. There are Global Climate Observing System requirements for daily observations of ice conditions in spring and fall for selected large lakes and several hundred medium-sized lakes distributed across middle and high latitudes. There are also associated needs for the selection of a set of the Global Climate Observing System reference lakes for assessing long-term variability, development of methods for merging in situ and remotely sensed information on this parameter, and for a central or several regional archive(s) of information.

Canada has contributed significantly to the Global Climate Observing System in this area. In situ observations exist at several hundred Canadian lake and river sites for various periods. A volunteer "Icewatch" program provides lake and river ice reports for about 85 locations across Canada. Thickness measurements are now also being recorded at 65 weather stations across Canada. Satellite-based methods have also demonstrated excellent potential and monitoring for large Arctic lakes has already been implemented using passive microwave observations. This record is being extended back in time using the available satellite record. Environment Canada began weekly monitoring of ice extent on small lakes in 1995, using the U.S.NOAA's Advanced Very High Resolution Radiometer and RADARSAT imagery, providing lake ice coverage information for numerical weather prediction models. Canadian researchers are currently working on a project to develop an operational method for mapping freeze-up and break-up dates over large areas of Canada using Synthetic Aperture Radar and optical data from the ENVISAT satellite.

Snow on Ground

Canada's national snow on ground in situ measurement program involves a composite of inputs including automatic and staffed stations that are part of Environment Canada's Reference Climate Stations, surface weather, volunteer climate observing network, and reports from contracted aviation service providers. Effort is underway to improve measurement of snow depth and derivation of snowfall from auto-stations. Environment Canada produces a daily global snow depth analysis based on real-time observations from synoptic and hourly meteorological reports. Improving the resolution of the analysis continues to be an area of focus.

Environment Canada has made progress in developing satellite passive microwave capabilities for deriving snow water equivalent information over western and sub-Arctic regions of Canada. Weekly satellite snow water equivalent maps are generated each winter for the Canadian Prairies region and provided to a number of operational agencies in support of flood forecasting, hydropower production, and other water resource management activities. Environment Canada has also developed capabilities to assimilate satellite derived information on snow cover fraction

and water equivalent with the Canadian Land Data Assimilation System in support of enhanced numerical weather prediction. Natural Resources Canada has produced daily snow cover derived from the U.S. NOAA's Advanced Very High Resolution Radiometer observations since 1982.

Permafrost

Permafrost monitoring is an important priority for Canada; one third of the permafrost regions of the northern hemisphere lie within Canada and 50% of Canadian land mass is covered by the permafrost zone. Through in situ observations, active layer and permafrost thermal states are measured. At most thermal sites, ground temperatures are measured to a 20 meter depth. At active layer monitoring sites, regular measurements are also taken of the depth of the soil layer above the permafrost that freezes and thaws annually.

The 5th National Communication provided a detailed description of efforts led by Natural Resources Canada between 2004 and 2011 to enhance the monitoring network. Through new funding programs including the Northern Energy Development Initiative for the Mackenzie Valley and the federal government's International Polar Year program, this network has now been increased to about 190 active layer and/or thermal monitoring sites, with observation periods ranging from a few to over 20 years. Maintenance of this permafrost monitoring network continues to rely on short term funding projects that involve many agencies and institutions.

The collaborative Thermal State of Permafrost project led by Natural Resources Canada, the University of Ottawa, and Carleton University and supported by the federal International Polar Year program was Canada's major permafrost contribution to International Polar Year. Major achievements included establishment of new monitoring sites in the Yukon Territory, northern Manitoba, and in six communities in the Baffin Region. Additional support received from Aboriginal Affairs and Northern Development Canada facilitated further site establishment in Nunavut communities in collaboration with the Nunavut Government, to address gaps in the western portion of the Territory. Support from the Program for Energy Research and Development and collaboration with University of Ottawa facilitated re-activation of monitoring sites in 2011–2012 along the Alaska Highway Corridor that were initially established in the late 1970s.

The approximately 190 thermal sites and eight active layer monitoring sites now included in the Canadian permafrost network contribute to the Global Terrestrial Network for Permafrost, established by the International Permafrost Association under the WMO and the Global Climate Observing System. Natural Resources Canada continues to play a leadership role in the coordination of the Global Terrestrial Network for Permafrost. Their website, through which summary data and information are disseminated, was originally established and maintained by Natural Resources Canada but during 2013 it will be transferred to European partners. Summary datasets from 69 long-term Canadian sites are posted on the website. Data from active layer sites are submitted annually to the Circumpolar Active Layer Monitoring Program within the Global Terrestrial Network for Permafrost and posted on the website hosted by George Washington University.

Glaciers

In Canada, some 200,000 km^2 of glacier cover is found in the Western Cordillera region and in the Arctic Islands and exhibits a wide range of glacier-climate settings.

Canada's Glacier–Climate Observing System is delivered through a multi-lateral initiative of collaborative monitoring and research coordinated by Natural Resources Canada and involving other federal departments and agencies, as well as universities. Glacier–climate observations are derived from the in situ measurements of a network of reference glaciers in

the Western and Northern Cordillera and the Canadian Arctic Archipelago. Both aircraft and satellite-based remote sensing are applied in a multi-scale/multi-mode fashion to generate regional perspectives of land ice and its responses to climate variations.

Mass balance measurements were initiated for some glaciers and ice caps in Canada during the late 1950s and early 1960s. Data and supporting metadata on Canada's reference glacier measurements are submitted to the World Glacier Monitoring Service. Digital data are stored in the World Glacier Inventory and are accessible through a website located at the U.S. National Snow and Ice Data Center. Records from 28 mass balance programs are archived internationally at the National Snow and Ice Data Center and records from 24 are archived at the World Glacier Monitoring Service. These records are also maintained at Natural Resources Canada.

Currently, 15 of the Canadian reference sites contribute to the Global Climate Observing System Global Terrestrial Network for Glaciers, with seven of these reporting Essential Climate Variables at protocol intervals to the World Glacier Monitoring Service.

In addition to the monitoring of reference glaciers, work at various levels of frequency and intensity is ongoing in various regions of the country. For example, with the prospect of some of Canada's smaller reference glaciers in more southern mountainous regions (e.g., the Peyto Glacier) becoming drastically reduced in area, work was initiated in 2010 to augment existing observing and assessment in the region to include larger icefield settings such as the Columbia Icefield, Wapta Icefield, and the Illecillewaet Neve and their outlet glaciers.

Efforts to develop multi-agency hydrological observatories are supported by an NSERC grant for Canada's initiative under the Climate Change and Atmospheric Research—Changing Cold Regions Network. An example of such an initiative has also been developed within the Columbia River Basin to support immediate water resource management needs. These efforts are supported by the Columbia Basin Trust—Water, British Columbia Hydro, and an enhanced observing period using a combination of academic, government, and private sector capacity.

Overall, the current observing capacity with respect to glaciers in Canada exhibits a basic level of regional, thematic/stakeholder, and climatic coverage; noting that the levels of effort and the frequency and types of observations vary considerably from site to site.

8.3.2.4 Terrestrial Systems

Responsibility for systematic observation of the terrestrial sector in Canada is shared among multiple departments and programs. The work includes multiple networks and involves both ground-based and satellite-based observing platforms.

Hydrometric Monitoring

Environment Canada is responsible for the collection, interpretation, and dissemination of standardised water level and river discharge data and information in Canada. The data are collected under a national program jointly administered under federal–provincial and federal–territorial cost-sharing agreements. It operates over 2,400 hydrometric stations and publishes the data annually in the national HYDAT archive database. Station metadata are stored in the national HYDEX database. The present network is fully digital and over 1,600 stations transmit data in near real-time. Similar to the ground-based national meteorological networks, the hydrometric program is well established, with defined standards and operating procedures. The data are published annually and made available in an online archive database. In support of the Global Terrestrial Network for Rivers, Canada provides data from discharge stations located at or near the mouth of large rivers.

Most of the hydrometric stations are located in the southern half of the country where the population

and economic activities are the greatest. As a result, the adequacy of the hydrometric network to describe hydrologic characteristics, both spatially and temporally, decreases significantly in the north.

Modernisation of the hydrometric monitoring system is ongoing. All stations are equipped with digital data loggers and the goal of 100% near real-time reporting is progressively being achieved. Hydroacoustic technologies have been introduced to facilitate the measurement of velocity profiles. In the previous few years, the data acquisition and production components have been modernised with the development and implementation of the hydrometric workstation.

Forests

Natural Resources Canada's National Forest Inventory provides ongoing monitoring of Canada's forests. The National Forest Inventory is a collaborative effort of federal, provincial, and territorial governments from across Canada. The Inventory monitors a network of 20,000 sampling points across Canada. A 20 km by 20 km grid is used in southern Canada with less intensive sampling in northern Canada. Detailed ground measurements are taken at a subset of the National Forest Inventory plots. The ongoing 10-year re-measurement cycle provides a continuous record of forest change. The re-measurement strategy is designed for flexibility, alignment with jurisdictional inventory activities, and integration with other relevant forest information products.

The National Forest Inventory provides national and regional scale estimates of above-ground forest biomass. Since 2010, it has developed updated national estimates and released new tools for calculating biomass estimates for individual trees or for stands of merchantable or non-merchantable size trees for any species or forest type found in Canada. Updated biomass estimation models are being embedded in the Carbon Budget Model of the Canadian Forest Sector. The Carbon Budget Model of the Canadian Forest Sector and National Forest Inventory biomass calculation tools are available through the National Forest Information System.

Natural Resources Canada is engaged in several research and development initiatives in partnership with the Canadian Space Agency to develop improved monitoring of forest biomass stocks and stock changes. Special focus is being placed on improving mapping and monitoring for Canada's remote northern forests, where traditional forest inventory techniques are impractical or prohibitively expensive. New techniques are being developed to use very high spatial resolution satellite data and airborne Light Detection And Ranging (LiDAR) to monitor forests. New techniques are also being developed to produce plot-like datasets using LiDAR that can be used to extend the relatively sparse existing ground plot networks for linking with broader coverage remote sensing products, such as Landsat, to provide detailed, large area characterisations of forest biomass and other forest attributes. At the national scale, statistical imputation techniques are being developed to combine the information from National Forest Inventory photo-plots with information from remote sensing and other geospatial datasets to produce maps at moderate resolution of forest biomass and composition.

Agricultural Soils and Vegetation and Agroclimate

Agriculture and Agri-Food Canada and Environment Canada are partners in the operation of a soil temperature network of 28 stations. Agriculture and Agri-Food Canada has played a leadership role in advancing soil moisture monitoring by use of satellite microwave data to assess surface moisture conditions and by the development of a small in situ network to determine rooting zone moisture conditions. The data is important to Environment Canada's land surface assimilation modelling and the US National Aeronautics and Space Administration's (NASA) calibration and validation of satellite moisture assessment systems. A broad spectrum of other Canadian agricultural databases exists, ranging from detailed characterisations of physical and chemical properties of soil to the location and extent of various land use activities and vegetation types.

Agriculture and Agri-Food Canada has implemented annual monitoring of agricultural land use, and is developing land use change information from this land use inventory. Agriculture and Agri-Food Canada is also working with Environment Canada and Natural Resources Canada to develop a terrestrial monitoring framework for Canada.

Agriculture and Agri-Food Canada has developed new tools and indices to enhance its monitoring of drought conditions on Canada's agricultural landscapes. A system to automate reporting of agroclimate impacts has become operational and is used to validate extent, location, and severity of drought and other extreme climate events on agriculture. Agriculture and Agri-Food Canada has also developed Canadian versions of two important drought indices used by the U.S., in order to increase homogeneity of drought assessment across North America as part of Agriculture and Agri-Food Canada's role as Canadian lead in the North American Drought Monitor. Agriculture and Agri-Food Canada has contributed to the enhancement of climate monitoring networks in the Prairies and Atlantic Canada and, with Environment Canada and the private sector, has helped establish the Community Cooperative Rain, Hail, and Snow project in Canada to increase community participation in monitoring.

8.3.3 Space-based Observations

8.3.3.1 Canadian Satellites and Missions

SCISAT-1 Atmospheric Chemistry Experiment

Launched in August 2003, the primary goals of the SCISAT-1 Atmospheric Chemistry Experiment mission include understanding chemical and dynamical processes in the stratosphere and upper troposphere, particularly in the Arctic; exploring the relationship between atmospheric chemistry and climate change; and measuring aerosols and clouds to reduce the uncertainties in their effects on the global energy balance. Data on the distribution and concentration of a large number of ozone depleting substances, many of which are powerful GHGs, provide valuable information on the depletion/recovery of the ozone layer.

RADARSAT

RADARSAT-1 was launched in 1995. Until March 2013, it provided valuable information for use in environmental monitoring and natural resource management, particularly over the Canada's North. Its successor, RADARSAT-2, was launched in 2007. RADARSAT-2 provides a high resolution, enhanced repeat imaging capacity, shortened programming and processing-delivery timelines, superior data storage and more precise measurements than its predecessor.

RADARSAT Constellation Mission

The Canadian Space Agency initiated the development of the RADARSAT Constellation Mission to ensure C-Band Synthetic Aperture Radar data continuity for RADARSAT users. Once implemented, the RADARSAT Constellation Mission will provide complete coverage of Canada's land and oceans, offering an average daily revisit, as well as daily access to 95% of the world to Canadian and international users. Government funding for this mission was confirmed in January 2013 and satellite launches are scheduled for 2018.

8.3.3.2 Canadian Instruments aboard International Satellites and Missions

CLOUDSAT

CLOUDSAT, launched in 2006, is a NASA satellite to which the Canadian Space Agency contributed important radar subsystems. CLOUDSAT uses a Cloud Profiling Radar to provide three-dimensional data of clouds, which contribute to improving our understanding of how clouds influence the weather and their effect on climate.

Measurements Of Pollution In The Troposphere (MOPITT)

Launched in December 1999 on board NASA's Terra satellite, the MOPITT instrument was funded by the Canadian Space Agency. The instrument continuously scans the Earth's atmosphere to make long-term measurements of CO concentrations. The objectives of MOPITT are to extend the 13-year record of tropospheric CO, show paths of transport for

atmospheric pollution, and provide a proxy to aid in constraining the retrieval of tropospheric CO_2.

Optical Spectrograph and InfraRed Imaging System (OSIRIS)
Launched in 2001, Canada's OSIRIS instrument, onboard the Swedish satellite Odin, captures detailed vertical profile measurements of ozone concentration and the formation of ozone holes over the poles. This mission contributes to understanding of how human activities and volcanic emissions affect the atmospheric environment.

New InfraRed Sensor Technology (NIRST)
NIRST is a demonstration instrument on board the 4th Argentinian science application satellite, which was built and launched in 2011 in collaboration with NASA. The instrument makes use of new Canadian thermal detector technology and was developed to monitor temperatures of the ocean surface and record high temperature events such as forest fires and volcanic eruptions. Such data are important for improving estimates of emissions from biomass fires.

Surface Water and Ocean Topography
Surface Water and Ocean Topography is a joint mission of NASA and the Centre National d'Etudes Spatiales in France, with a contribution from the Canadian Space Agency. The main goal of the hydrological component of the mission is to obtain the first global inventory of freshwater storage and its change on a global spatial scale and at sub-monthly, seasonal, and annual time scales. The Canadian Space Agency contribution to the mission is the provision of the Enhanced Interaction Klystron, a critical component of the Ka-band Radar Interferometer which is the core instrument on this mission.

8.3.3.3 Canadian Involvement in International Missions

In addition to the Canadian initiatives listed sections 8.3.3.1 and 8.3.3.2, Canadian researchers are involved in internationally-led Earth observation missions. As a cooperating member of the European Space Agency (ESA), Canada participates directly in ESA programs, activities, and decision-making. Canada shares many of ESA's objectives for the Living Planet program, which promotes the use of satellite data to broaden the understanding, preservation, and management of the Earth and its environment.

Canadian researchers sit on science advisory groups for missions led by NASA, ESA, and the Japan Aerospace Exploration Agency. They contribute expertise and establish collaborations to make use of international space activities for Canadian climate-related applications.

8.4 Research

8.4.1 Overview

Within Canada, research on the climate system and climate change involves different scientific disciplines from a range of government and academic institutions. The key federal departments involved in such research are Environment Canada, Fisheries and Oceans Canada, Natural Resources Canada, and Agriculture and Agri-Food Canada. Environment Canada is primarily responsible for providing the foundational scientific understanding of the climate system, with other federal departments carrying out discipline-specific research. Government activities are frequently undertaken in close collaboration with other science-based institutions, primarily within the university community. Many Canadian research programs are also linked to larger international efforts. Climate research in Canada contributes to increasing the understanding of the carbon cycle (and other biogeochemical cycles), analysis of climate trends and variability, climate change detection and attribution studies, understanding the physical processes that govern climate system dynamics, and developing advanced global and regional climate models to project future climate change. Results inform assessment of past and future climate change impacts on the Canadian environment, economy, and society.

8.4.2 Trends and Variability

Climate analysis makes use of climate observations (physical and chemical), proxy data, and climate model outputs over a variety of time and space scales in order to investigate the past, present, and possible future characteristics and behaviour of the climate system. Topics of investigation include analysis of trends, temporal and spatial variability, extremes, and the detection and attribution of climate change. Long-term research on understanding Canadian climate trends and variability is primarily shared among multiple departments of the Government of Canada. Paleoclimate analysis in Canada is primarily undertaken by the academic research community.

8.4.2.1 Atmosphere

Climate Data Analysis and Research

Environment Canada maintains an active research focus on climate trend and variability analysis on all time and spatial scales. Research on the development of statistical techniques is undertaken to produce high quality homogenised historical climate data, indices, and metadata bases for a wide range of climate variables including gridded data products and marine hindcast data bases. This includes the development of statistical downscaling techniques, concentrating on climate change detection and attribution research, particularly for climate extremes (e.g., temperature and precipitation). These data products are used in climate trend and variability analyses and climate impact studies.

The goal is to characterise and understand natural climate variability and anthropogenic climate change so past and future changes in the climate can be placed in their proper context. This research is conducted with both observed data (including extensive archives of instrumental and analysed climate data) and climate models of past, present, and future climates. A related goal is to investigate the relationship between atmospheric circulation and weather and climate extremes. Particular attention is on assessing and understanding trends in the Canadian and global climate with respect to extreme events, and investigation and explanation of climate anomalies.

Homogenised climate data analysis and research includes the development of climate monitoring products. Ongoing work to develop homogenised monthly climate data for temperature, precipitation, and wind has resulted in national gridded time series of monthly climate anomalies (temperature, precipitation, pressure, and wind) dating back to the early 1900s. These data are also included in the collaborative production of a North American gridded dataset for global and regional climate model validation. Since 2010, these time series have been updated and improved, using new and better methods for data validation and correction. Environment Canada's methods and computer programs for homogenisation of climate data and calculation of extremes are freely available (provided via Environment Canada's climate research website) and have been widely used around the world.

Expertise is also applied to the design of optimal climate observing networks in Canada as well as to develop guidance for proper consideration of climate change in infrastructure design. Environment Canada's climate data analysis research provides specialised climatic design information on climate extremes (e.g., temperature, precipitation, wind, and waves) to support development of building codes and standards. This information is based on past and present observed climate data and uses future climate scenario information and statistical downscaling techniques (for extremes) to guide development of infrastructure codes and standards with respect to potential impacts of future climate change.

The Climate Trends and Variations Bulletin is an informational product based on adjusted and homogenised Canadian climate data. Environment Canada produces five Bulletins each year and provides the product on its website. The bulletin summarises recent national and regional climate information and presents it in an historical context.

8.4.2.2 Oceans

Marine Ecosystems

The oceanography and climate science research program of Fisheries and Oceans Canada encompasses analysis, process, and modelling research of the oceans and their marine ecosystems. This includes variability in physical and chemical oceanographic properties and in biological distributions and production from bacterioplankton to fish. Ocean regions of interest are the Northeast Pacific, Northwest Atlantic, Hudson Bay, and the Arctic. Observations from Fisheries and Oceans Canada monitoring programs, remote sensing, and field programs are used to provide state-of-the-ocean descriptions for these regions and historical ocean climate variability. The field programs involve moored measurements and annual surveys, and are carried out with international programs such as the international Arctic-Subarctic Ocean Flux program in the Arctic Ocean. In recent years, Fisheries and Oceans Canada has started Climate Change Science and Ecosystem Research Initiatives to focus collaborative research on issues such as ocean acidification and hypoxia, and on regional ecosystems and climate change impacts.

Ocean Climate

Interactions between the oceans, sea ice, snow pack, and the atmosphere are a fundamental part of the Earth's global climate system. Understanding the role of oceans in global climate and the impacts of climate change on aquatic ecosystems is of critical importance to Canada, which borders three inter-connected oceans.

Ocean temperatures can affect the growth and survival of marine life and the availability of the preferred and tolerated thermal habitats for various species. Changes in climate may also affect stock productivity and the sustainable harvest rates. Fishing could also exacerbate the impacts of temperature changes by decreasing stock resilience or increasing the variability in abundance and, therefore, the risks of a stock collapse. Consequently, knowledge of the physical state of Canada's oceans is the cornerstone of advice provided by Fisheries and Oceans Canada.

Canada's State of the Oceans Report 2012 presents highlights from regional reports on five Large Ocean Management Areas, which are geographic regions within Canada's three oceans. This research has documented warming surface waters, changes to O_2 levels, and changes to freshwater inputs, all of which are relevant to understanding aquatic ecosystem and marine navigation impacts.

8.4.2.3 Cryosphere

Environment Canada and Natural Resources Canada share the lead within the federal government for analysing the state of the Canadian cryosphere. The Canadian Cryospheric Information Network is a partnership among the Government of Canada, Canadian academia, and the private sector to manage research data and enhance awareness and access to information and data on the Canadian cryosphere.

Snow and Ice

In 2007, at Canada's request, the WMO Congress requested the Inter-commission Task Group on the International Polar Year to establish an ad-hoc expert group to explore the feasibility of creating a Global Cryosphere Watch system to promote sustained polar/cryosphere observations and the development of an authoritative information database on past, present, and future changes of our global snow and ice resources. The initiative is now a full program under the WMO. Canada continues to support the implementation of the Global Cryosphere Watch Program through participation of scientists in the Program's Working Groups and Expert Teams. In 2013, Environment Canada hosted a workshop in support of a proposed Snow Watch Group initiative under the Global Cryosphere Watch Program.

Environment Canada carries out research on variability and change in the physical processes within the cryosphere and the role of these changing processes in the climate system. This involves reporting on trends and causes based on analysis of existing data (collected both by Environment

Canada and other research partners). Additionally, research focuses on making improvements to snow–ice surface/atmosphere processes in the Canadian Land Surface Scheme model, which contributes to global and regional climate model development. Environment Canada's research also contributes to improved characterisation of solid precipitation (snow/ice) for weather forecasting, climate analyses, and characterisation of current and future water availability in the Canadian Arctic and other regions in Canada.

Permafrost

Natural Resources Canada is the primary Government of Canada department responsible for conducting permafrost-related research. Data collected over the last 20–30 years through the permafrost monitoring network is used to characterise recent trends and variability in permafrost conditions across the Canadian Arctic.

A major achievement of the International Polar Year project was an updated quantification of trends in permafrost temperature across the Canadian North for a range of ecoregions from the boreal forest to the tundra and polar desert. Data collected and analysed since the 5th National Communication show that permafrost continues to warm across the Canadian permafrost region. The rate of permafrost warming varies regionally, ranging from less than 0.2°C per decade in the warm ice-rich permafrost of the central and southern Mackenzie Valley (in the Northwest Territories) to about 0.6°C per decade in the cold permafrost at Alert, Nunavut. Investigations of permafrost–climate linkages, as part of the International Polar Year project, are improving understanding of the factors affecting the spatial variability of permafrost response to a changing climate. This analysis effort is also advancing understanding of the spatial and thermal characteristics of mountain permafrost including the role of vegetation and elevation in permafrost–climate relationships.

Glaciers

Natural Resources Canada conducts research on Canada's glaciers and collaborates and partners with researchers from other Canadian and international government departments and universities. This includes formal collaborative networks such as the Changing Cold Regions Network (under the Climate Change and Atmospheric Research initiative) and the Canadian Rockies Hydrological Observatory. Additionally, the private sector (e.g., hydro-power) is also involved in this field of research.

In Canada, glaciers and ice caps are found in the Western Cordillera region and in the Arctic Islands. Formal mass balance studies in Western Canada began in 1965 at the inception of the International Hydrological Decade led by the United Nations Educational, Scientific, and Cultural Organisation. These studies grew from a variety of casual and professional observations dating back to as early as 1896. They were, and continue to be, centered on the role of glaciers in the hydrological cycle and water resources for human and natural systems. Recent efforts have demonstrated that the role of glaciers in regulating stream flow may be in decline as the result of significant area-wide reductions in glacier cover fueled by significantly negative mass balance forcing and even signs of acceleration.

Research activities also address temporal context through documenting or back-casting neo-glacial variations for certain reference glacier mass balance sites. The most notable examples of this are the Peyto Glacier (modeled back to 1673) and the Castle Creek Glacier (northern Canadian Rocky Mountains), which has the longest reconstructed continuous record of annually resolved glacier recession for a North American glacier (1959–2007).

Glacier mass balance measurements in the Canadian High Arctic began in 1959. These measurements are used to investigate synoptic scale glacier mass balance loss, which contributes to research on the hydrologic

processes by which these glaciers contribute to global sea level rise.

The addition of remote sensing technologies in both regions has enabled integration of aircraft and satellite altimetry observations with in situ mass balance and snow accumulation records to validate satellite-based records and provide a more robust historical record. An extensive database review is underway for the period 1995–present for reference site mass balance data to distinguish a climate or reference mass balance from a true or hydrological mass balance.

8.4.2.4 Forests

Natural Resources Canada supports a comprehensive, multidisciplinary, and growing climate change research agenda that integrates the biophysical and social sciences, links them to policy, and places a strong emphasis on knowledge exchange. Natural Resources Canada's carbon and impacts and adaptation science is delivered with the end goal of providing knowledge and tools to members of Canada's forest sector to enable them to make informed adaptation and mitigation decisions.

Ongoing research efforts are aimed at improving the understanding of climate change impacts on forest growth and mortality rates using long-term data from permanent sample plots. Work is also ongoing to improve the spatial detail and resolution of national forest carbon monitoring and change estimation procedures.

National Forest Inventory information is being used together with other biophysical and socio-economic data to generate indicators of climate change-related forest change, an effort taking place under the Forest Change initiative of Natural Resources Canada. These indicators are selected on the basis of sensitivity to climate change, relevance to decision support, and feasibility of development and update, and are reported through a web-based tracking system.

Natural Resources Canada's carbon science research agenda is designed to develop scientific knowledge, modelling, reporting, and policy advice on the management of forest carbon and GHG fluxes. This work also makes a large contribution to improved understanding and representation of the carbon cycle in climate projections. Natural Resources Canada develops scientific knowledge about the key natural determinants of changes in forest carbon/GHG balances across various scales and the impacts of management. This knowledge contributes to reducing uncertainty about the impact of key natural influences on carbon dynamics and estimates of carbon stock changes and GHG emissions: natural disturbances, forest growth, soils/decomposition, inter-annual variability, and climate change.

A comprehensive review of assisted migration was published as a five-paper special issue[3] of the Forestry Chronicle. Several jurisdictions and companies are using this knowledge to evaluate and adjust their current policies and practices, and guide future research in this field.

The "Blueprint for Forest Carbon Science in Canada 2012–2020" document coordinated by Natural Resources Canada is meant to serve as a guide for research and for the tasks of coordination and integration of Canadian forest carbon science. It discusses:

- The overarching forest carbon policy issues that are expected to be important for governments and the forest sector to 2020;
- The forest carbon science questions, and the research priorities to address these questions, that are expected to be of greatest relevance for policy to 2020; and
- The science approaches, infrastructure, and partnerships needed to make progress in addressing these research priorities.

Canadian Wildland Fire Information System

The Canadian Wildland Fire Information System creates daily fire weather and fire behaviour maps

year-round and hot spot maps throughout the forest fire season, generally between May and September. The scientific basis for the Canadian Wildland Fire Information System is the Canadian Forest Fire Danger Rating System, which is a national system for wildland fire danger developed by Natural Resources Canada. The foundation of the Canadian Forest Fire Danger Rating System is the Fire Weather Index, which contains numerical rankings of relative wildland fire potential, and the Fire Behaviour Prediction system, which provides quantitative estimates of the potential fire spread rate, fuel consumption, and fire intensity under different conditions.

Fire Weather Index values are calculated using standard weather measures. Currently Fire Weather Index values are calculated using approximately 1,800 weather stations. Other information that is collected and maintained includes data on fire locations; both in the form of satellite imagery derived hotspots and calculated fire perimeters. The wealth of data on fire weather, fire behaviour, and fire locations provides an important source of information on how the conditions in Canada's forests have changed over the last few decades.

Climate Impacts on Productivity and Health of Aspen

Trembling aspen (*Populus tremuloides*) is the most abundant tree species in Canada's boreal forest, where it is important both ecologically and commercially. Concerns about climate-related dieback of aspen forests in the 1990s prompted the establishment of Climate Impacts on Productivity and Health of Aspen, a regional research and monitoring study that includes a network of 180 plots across west-central Canada. This study is aimed at understanding and forecasting the effects of drought, insects, and other factors on the productivity and health of aspen forests under a changing climate. The work includes annual assessments of damage by insects and diseases, analyses of long-term changes in aspen growth from tree rings and ground plots, and mapping of aspen dieback through remote sensing. A key component of this research is the development and application of user-friendly indicators of soil moisture for historical analyses and mapping of drought severity. Climate Impacts on Productivity and Health of Aspen was initiated by Natural Resources Canada in 2000 and has continued through partnerships with collaborators from provincial forest management agencies, Environment Canada, university research groups, the Canadian Carbon Program, and others.

8.4.3 Greenhouse Gas Sources and Sinks

8.4.3.1 Agricultural Ecosystems

Since the 5th National Communication, Agriculture and Agri-Food Canada has focused significant research resources on environmental issues such as climate change, and GHG mitigation and adaptation. Specific research activities include:

- Understanding nitrogen and carbon dynamics in relation to GHG emissions and removals in agricultural systems;
- Understanding and evaluating the influence of agricultural land management on soil carbon reservoirs, crop selection on N_2O release, and animal husbandry practices on CH_4 release;
- Modelling climate impacts on crop biomass production and net GHG emissions and removals;
- Modelling of global change impacts to understand how various policy and biophysical drivers will influence agricultural land use and land management systems;
- Examining the impacts of climate change, climate variability, and water resources on annual crop production potential;
- Assessing water and nutrient management in an era of scarce resources; and
- Identifying climate trends and their relationship to changes in land use and land management.

Agriculture and Agri-Food Canada has continued research and development of agri-environmental indicators and associated metrics that measure the environmental performance of the agriculture sector,

including annual GHG emissions and removals from agriculture. This work is currently funded under the Sustainable Science and Technology Advancement initiative of Agriculture and Agri-Food Canada's *Growing Forward 2* policy framework and builds on work from the National Agri-Environment Health Analysis and Reporting Program and the National Carbon and Greenhouse Gas Accounting and Verification System. Agriculture and Agri-Food Canada is continuing to make improvements to Holos, a farm-level software tool for estimating the mitigation potential of changes in agricultural practices and working with industry and provincial partners to ensure it meets the needs of the sector.

Canada is one of the founding members of the Global Research Alliance on Agricultural Greenhouse Gases, an international network of more than 30 member-countries, devoted to collaboration in agricultural research on GHG mitigation and beneficial management practices for farmers in Canada and around the world. At its launch, Canada announced that it would invest $27 million towards the Global Research Alliance.

The Agricultural Greenhouse Gas Program represents Canada's initial contribution to the Global Research Alliance on Agricultural Greenhouse Gases and will provide Canadian farmers with technologies to manage their land and livestock in a way that will mitigate GHG emissions. This five year, $27 million federally funded program runs from September 1, 2010 to August 31, 2015. The objective of the Agricultural Greenhouse Gas Program is to enhance the understanding and accessibility of agricultural technologies; Beneficial Management Practices (agricultural practices aimed at reducing the environmental impact of farming activities on the landscape); and processes that can be adopted by farmers to mitigate GHG emissions.

8.4.3.2 Forest Ecosystems

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 compliant with the Intergovernmental Panel on Climate Change (IPCC) reporting guidelines. With the Carbon Budget Model of the Canadian Forest Sector as its core model, the System provides annual estimates of annual GHG 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.

Over 400 analysts have been trained in the use of the model, and training workshops have included participants from over 20 countries. Application of the model has reduced the uncertainties regarding the net carbon balance from the forest sector, and provided a clear demonstration of the impacts of large-scale natural disturbances, forest management, and land-use change on GHG emissions and removals. In addition to supporting the annual reporting of GHG balances in Canada, the Carbon Budget Model of the Canadian Forest Sector is also used in national-scale analyses of mitigation options through measuring changes in forest management and in the use of harvested wood products for long-lived products or bioenergy.

8.4.3.3 Ocean systems

Fisheries and Oceans Canada's research programs seek an understanding of the processes that control the flux of carbon into and out of ocean systems, assessing the potential and verifiability of measures to enhance oceanic carbon uptake. The primary objective of this ocean processes climate research is "getting the carbon right" by reducing the uncertainties. The

communication of such information to policy makers is important as a scientific basis for the international discussions regarding ocean based carbon sequestration programs. The key scientific questions being addressed are whether the oceans will continue to sequester CO_2, whether the oceans can sequester an even larger fraction of CO_2 emissions through purposeful fertilisation, and the pathways to ocean acidification and the effect acidification has on ocean life. Making progress in this area requires the integrated approach of observations and model development from local to global scales.

8.4.3.4 Observation-based Approaches to Carbon Source Estimation

The increase in regional-scale GHG observations, increasing availability of space-based GHG observations, and application of atmospheric transport models have enabled the development of inversion methods to provide independent verification of reported GHG emissions. These observations-based estimates contribute to monitoring natural and anthropogenic GHG sources and sinks. Canada is building its capacity to monitor sources and sinks at regional scales using atmospheric observations and inverse modelling through two approaches. Work was initiated in 2011 by Environment Canada on a Carbon Assimilation System, working closely with researchers at the University of Toronto and with funding support from the Canadian Space Agency. Development work is focused on CO_2 at global scales, with the intention to move to a regional domain and CH_4 simulation. The second approach is the development of methods to integrate atmospheric models and surface in situ GHG observations to characterise regional-scale source influences on CH_4.

8.4.4 Climate Processes

Climate process research addresses both the physical and chemical processes by which the climate system functions. These issues include, but are not limited to the role of clouds, oceans, sea ice, permafrost, and land surface processes in the climate system, as well as the function of forests, agriculture, wetlands, and oceans in the global carbon, water, and energy cycles. Improved understanding of these processes contributes to development of higher resolution climate projections, which are used to support climate adaptation. Expertise in this area is concentrated primarily within universities and Government of Canada departments where there are collaborative research relationships with academia.

8.4.4.1 Land and Cryosphere

Much of the research with respect to cryospheric processes within the climate system has been led by Environment Canada and Natural Resources Canada. New satellite capabilities for retrieval of snow cover information have been developed and validated through intensive field campaigns in northern Canada involving ground-based measurements and aircraft remote sensing. Environment Canada's cold climate processes research has led to the implementation of improved process information on energy and water cycles in climate models through the development, testing, and enhancement of the Canadian Land Surface Scheme model. This includes research on snow cover variability and evaluation of the simulation of snow cover using regional climate models. Part of the ongoing effort towards climate model development within Environment Canada includes enhancing the representation of snow, soil, and vegetation in the Canadian Land Surface Scheme model, which is being incorporated into Environment Canada's climate models.

Environment Canada is also involved in the generation of snow cover change scenarios for the Canadian Arctic and evaluation of the representation of Arctic snow in the Canadian Regional Climate Model and Coupled Model Inter-comparison Project—Phase 5 model runs. This work is part of a project under ArcticNet, which is being led by the Ouranos Climate Consortium.

Canadian universities are also active in climate process research, with various programs having a particular sector and/or geographic focus with respect to land processes and biogeochemical cycling. For example,

researchers at McGill University study Earth System science and land surface processes, including focus on biogeochemistry and carbon cycling. The University of Saskatchewan also has areas of study focused on carbon and nitrogen cycling with a particular focus on agricultural soils. A research group at the University of British Columbia studies carbon cycling and energy exchange with a particular focus on exchange between the atmosphere and forest systems.

8.4.4.2 Oceans

Research teams have been investigating the storage and transport of heat, freshwater, and carbon in the North Atlantic, North Pacific, and Arctic Oceans through field expeditions, data analysis, and model simulations. These studies have provided better knowledge of the transports through the Canadian Arctic Archipelago in recent decades, the production of intermediate-depth water masses in the Labrador Sea, and the linkages of these processes to the larger scale circulation in the North Atlantic. This is important since Arctic outflows and Labrador Sea water play important roles in the strength of the global oceanic thermohaline circulation, which is expected to be an important factor to climate impacts in Canada and Europe. Researchers from Fisheries and Oceans Canada are involved in three of the seven network projects funded under NSERC's Climate Change and Atmospheric Research initiative.

8.4.4.3 Biophysical Sensitivities

A subcomponent of climate process research seeks to improve understanding of the biophysical sensitivities of systems to climate and climate change. Research on the biophysical aspects of sensitivity is one component of determination of vulnerability, which is defined as the degree to which a system is susceptible to, or able to cope with the effects of climate, including extremes. Research on the biophysical sensitivities of both unmanaged and managed resources to changes in climate is conducted mainly by federal departments through a mixture of core funding and funding from other programs such as the Lake Winnipeg Basin Initiative and the Program of Energy Research and Development.

Environment Canada's Water and Climate Impact Research Centre, jointly established with the University of Victoria, conducts a national, interdisciplinary program of ecosystem-based research in the aquatic sciences, which includes research on hydrological and ecosystem processes that contribute to our understanding of the biophysical sensitivities and vulnerabilities of freshwater systems to climate variability and change. The program focuses on identifying, quantifying, and modelling hydrologic and ecological impacts of climate change and variability. Major activities related to biophysical sensitivities include:

- Developing suitable indicators of hydrological and ecological response;
- Detecting and predicting trends in key hydrologic variables, water resources, and aquatic systems sensitive to hydroclimatic extremes and variability; and
- Determining and modelling how climatic alterations affect hydrologic, geochemical, and ecological processes at local and regional scales.

A special focus is also placed on sensitive aquatic systems, such as the bellwether systems identified in the Arctic, or highly valued water resources that are under increasing stress from synergistic effects of resource extraction/consumption and climate variability.

Much of the work on biophysical sensitivities to climate variability and change conducted by Environment Canada and its partners is regional in nature. In northern and western Canada, researchers have examined the sensitivity of transboundary waters to changes in extreme events such as floods and low flows, including an assessment of changes to the controlling atmospheric circulation patterns. Researchers are also examining past trends and variability in hydro-climatology and constructing future climatic scenarios

of hydroclimatic conditions from both global and regional circulation models.

In the Athabasca River basin, the hydrology, hydro-climatology, sediment/bitumen transport, and hydro-ecological flow needs under both current and future climate regimes are being addressed.

In the Prairies, past trends and variability in extreme drought and excessive moisture conditions and their impacts on Prairie lake levels and the water quality of Lake Winnipeg have been examined. In addition, hydrologists are monitoring water balances in wetlands and generating hydrological models that can be used to analyse and predict the impacts of climate change and land use change.

Climate change impact studies are being conducted in the Great Lakes, e.g., by examining the trends of atmospheric and limnological variables and modelling the impact of projected climate change scenarios on the hydrodynamics and water quality in the Great Lakes. Scenarios of future climate change also suggest lower water levels in the future for the Great Lakes–Saint Lawrence system—a consequence of particular concern for coastal ecosystems such as wetlands, and human activities such as recreation and shipping. Under the International Joint Commission Upper Great Lakes Study there are also several projects on coupled land, lake, and atmosphere modelling. One of these, led by Environment Canada, seeks to develop a fully coupled hydrological land, lake, and atmospheric prediction system, which makes it possible to simulate the Great Lakes water level dynamics on daily to decadal time scales, as well as forecast water levels on weekly to seasonal time scales. This model will provide improved numerical guidance for managing the levels of the Great Lakes in a changing climate.

In the Arctic, Environment Canada has led an assessment of climate change impacts on Arctic freshwater ecosystems and hydrology, and on river flow to the circumpolar Arctic Ocean. In the Mackenzie Delta region specifically, scientists are analysing the role of climate in catastrophic lake drainage, and analysing peak spring water level to determine climate-related variability and change in the spring breakup flood. They are also working to improve models for climate change impact prediction; establishing surface energy balance over heterogeneous terrain and comparing with tower and aircraft estimates; and conducting analysis of the heat and mass exchanges of lakes.

8.4.4.4 Atmospheric Physics and Chemistry

Environment Canada carries out research in atmospheric physics and chemistry with the goal of better representing these processes in climate models. This involves a wide range of parameterisations, particularly in terms of improving the representation of clouds, aerosols, and radiation in Environment Canada's climate models. Atmospheric physics and chemistry research includes both tropospheric and stratospheric processes linking to other components of the Earth system (e.g., land, ocean, cryosphere, and the carbon cycle).

Researchers from Environment Canada and Fisheries and Oceans Canada collaborate with Canadian university partners on Climate Change and Atmospheric Research network initiatives related to atmospheric physics and chemistry: The "Network on Climate and Aerosols: Addressing Key Uncertainties in Remote Canadian Environments" project studies the sources, sinks, and climatic impacts of atmospheric aerosol particles in remote Canadian environments. "Research related to the Polar Environment Atmospheric Research Laboratory: Probing the Atmosphere of the High Arctic" studies the Canadian high Arctic atmospheric composition using measurements from the Polar Environment Atmospheric Research Laboratory at Eureka, Nunavut.

In the longer term, research will address the effects of short-lived climate pollutants on climate and future air quality by improving the accuracy of simulated radiative forcings and climate on regional scales.

Parameterisations for chemistry, aerosols, and clouds will be developed and tested by Environment Canada. Atmospheric physics development will also address the need for improved parameterisations of subgrid-scale processes related to three-dimensional inhomogeneities in layer and convective clouds since they have important implications for calculations of radiation, precipitation, and mixing in climate models.

8.4.5 Climate Modelling and Applications

Climate modelling research in Canada is undertaken in federal government research facilities, universities, and by regional climate modelling consortia. Canadian scientists are also extensively engaged in research collaborations with international colleagues, working on projects to improve the representation of various physical processes in global and regional climate models. For example, Canadian scientists play an important leadership role in international climate research coordination and assessment bodies, such as the World Climate Research Program and the IPCC.

As part of the development and evaluation of climate models, scientists gain insights and improved understanding of the climate system and the influence of human activities on climate. This is achieved through application of global and regional models, individually and as part of multi-model ensemble or model inter-comparison projects.

8.4.5.1 Ocean Modelling

Fisheries and Oceans Canada, Environment Canada, and National Defence Canada are collaborating under the Canadian Operational Network of Coupled Environmental PredicTion Systems Memorandum of Understanding to develop an operational global coupled atmosphere–ocean–ice data assimilation and prediction system suitable for data reanalysis, hindcasts, nowcasts, and forecasts. This will:

- Advance the effectiveness of marine–environmental assessments;
- Lead to more effective observations, understanding, and prediction of the marine system; and
- Improve ocean-observing and forecast products for management and other clients, including in relation to climate change.

This collaboration is based on the implementation and improvement of the Nucleus for European Modelling of the Ocean (NEMO) model. Future versions of Environment Canada's ocean model, for use in both operational environmental prediction and climate modelling, will be based on NEMO. This change will enable Environment Canada to benefit from the international development effort underpinning NEMO, along with the related user support and experiences of a global user community. In addition, moving toward a unified ocean modelling framework within Environment Canada will create synergies across modelling applications. Collaboration with the Canadian university community, under the Network of Centers of Excellence project Marine Environmental Observation Prediction and Response (MEOPAR) will further promote coordinated ocean model development and evaluation using the NEMO model.

8.4.5.2 Global Climate Models

Global climate models are the primary tool for making quantitative projections of future climate change. These models are based on mathematical representations of physical processes that include the three-dimensional atmosphere and ocean, along with sea ice and the land surface (and its vegetation). Global climate models are used in two kinds of simulations: The first is a long "control" run of the model with no change in atmospheric composition or other external forcing. This kind of simulation is used to understand the processes involved in natural climate variability and to estimate the magnitude of this variability for climate change detection studies. The second kind of simulation involves specified changes in forcing such as GHG concentration and aerosol loading. This kind of simulation is used to understand (and attribute) historical climate change, and to make future climate change projections.

The core Canadian global climate modelling effort is housed within Environment Canada, where an increasingly comprehensive progression of global climate models has been developed since the 1970s. Environment Canada plays a central role in collaborative climate research with Canadian university partners and other government departments, notably Fisheries and Oceans Canada, who contribute expertise in ocean carbon cycle modelling. Environment Canada scientists serve on a variety of national and international steering committees and working groups related to climate model development, evaluation, and applications.

Model development at Environment Canada is based on scientific innovations related to fundamental improvements of the Earth System processes through the individual model components (e.g., atmosphere, ocean, land surface, etc.). New model versions with improved atmosphere–ocean–land surface coupling (including sea ice), and which incorporate biogeochemical cycles for carbon and nitrogen, aerosols, and ozone are the basis for generating new historical and future climate scenario runs. Model development combines these Earth system components to regularly update Environment Canada's suite of climate models (e.g., the Canadian Earth System Model, Canadian Global Climate Model, Canadian Regional Climate Model, and the Canadian Seasonal to Inter-annual Prediction System). The end result of the model development stream is the production of a new suite of climate models every 18 months, which are well tested and have known properties. These new versions of the modelling infrastructure are implemented to exploit new supercomputing systems.

Researchers in Environment Canada's model application stream undertake the execution of the suite of climate models to provide information on past, present, and future states of the climate. Environment Canada's participation in international Model Inter-comparison Projects represents its largest application commitment. A large number of Model Inter-comparison Projects involve international efforts to understand physical processes (e.g., convection, clouds, aerosols, and their interactions) and their parameterisation in climate models. Environment Canada's Canadian Earth System Model—Version 2 provided the Canadian contribution to the Coupled Model Inter-comparison Project—Phase 5. The results from these coordinated experiments constituted a significant contribution by Canada to the IPCC 5th Assessment Report.

Output from both the global and regional models is available to the public via Environment Canada's Canadian Center for Climate Modelling and Analysis website. This website allows a user to select specific model variables, from all or part of the model domain, and download it for use in climate change research and impact assessments.

A large portion of climate modelling research is done in collaboration under various national research networks. With funding from NSERC under the Climate Change and Atmospheric Research initiative, a number of networks have recently been established that investigate various aspects of the research necessary to improve both the Canadian regional and global climate models. Additionally, some Canadian universities are also directly involved in climate model development and future projections using these models. For example, the University of Victoria's climate modelling group, within its School of Earth and Ocean Science, has developed the University of Victoria Earth System Climate Model. This Earth System model has been used to analyse various aspects of the climate system including response to future climate forcings. The University of Toronto has a research program on climate models and climate dynamics within its Center for Global Change Science.

8.4.5.3 Regional Climate Modelling and Scenarios

Climate change adaptation planning, impact assessments, and policy development all require access to scientifically-credible, quantitative information

about past and future climate change. Ideally this information should be at the spatial scale required for their particular application. Within Canada, Environment Canada is responsible for the global climate model development, which in turn forms the basis for developing regional scale models and regional scale climate model applications by Environment Canada and regional climate modelling consortia in Canada.

Environment Canada's research in regional downscaling has focused on the development of a new regional climate model, the Canadian Regional Climate Model—Version 4, which makes use of the Global Environmental Multiscale model dynamical core (developed for numerical weather prediction) and the same physics package as the Canadian Earth System Model—Version 2. Environment Canada uses this regional climate model to undertake historical simulations and future projections based on a range of emission scenarios for regional- and local-scale applications (e.g., North American, Arctic, and African domains) at higher spatial resolution (0.44° and 0.22° resolution, approximately 50–25 km scale).

Climate change scenarios are provided by Environment Canada to a broad range of users through the Canadian Climate Change Scenarios Network website. The scenarios are based on climate projections from different climate models (i.e., models from a variety of international modelling centres, in addition to Canadian model results). These projections are transformed into climate change scenarios by superimposing model projections of climate change onto observed historical climate, thereby reducing issues related to local model bias and allowing multiple model results to be compared on the same footing. The system allows users to download data and to produce graphs and maps for their particular region of interest. It is currently being updated to provide output from the latest Coupled Model Inter-comparison Project—Phase 5 model results.

The Ouranos Consortium was created in 2001 as a joint initiative of the Government of Québec, Hydro-Québec, and Environment Canada, and funding from Valorisation-Recherche-Québec. Ouranos fulfils an integrated research mission to develop regional climate projections and scenarios as well as carry out regional and sector-specific impacts and adaptation research. The focus of the Ouranos consortium is on developing and implementing regional climate model projections to identify the potential impacts of climate change in the fields of public safety and infrastructure; energy supply; water resources; health; sectors such as forestry, agriculture, mining, tourism, and transportation operations; and protecting the natural environment.

The Pacific Climate Impacts Consortium was established in 2005 as a regional climate service center on Canada's west coast. Located at the University of Victoria, the Pacific Climate Impacts Consortium carries out research and provides information on the impacts of climate change and variability with a specific focus on Canada's Pacific and Yukon regions. The Consortium's work is centered around three research themes: Climate analysis and monitoring, hydrologic impacts, and regional climate impacts.

8.4.5.4 Seasonal to Inter-Annual Prediction

Coupled global climate models are increasingly being applied to seasonal prediction due to their ability to represent ocean–atmosphere interactions that strongly influence climate variations on seasonal and longer time scales, leading for example to El Niño and La Niña episodes having far-reaching global effects. Intensive work has been conducted over the past several years to adapt Environment Canada's climate models to this application. These efforts led to the implementation in late 2011 of the Canadian Seasonal to Inter-annual Prediction System, which produces Environment Canada's official forecasts of climate anomalies over the coming 1–12 months. The Canadian Seasonal to Inter-annual Prediction System is based on two climate model versions, in order to take advantage of

the generally higher skill of multi-model (compared to single-model) forecasts.

8.4.5.5 Detection and Attribution of Climate Change

The comparison of observed climate change with simulated climate change is central to understanding the causes of climate change, validating climate models, and constraining and improving projections of future climate change. Environment Canada continues research to improve understanding of the causes of trends in a range of variables through climate model applications. Regional detection and attribution analysis using climate models is applied to aid understanding of the causes of climate change over Canada and North America. As the observational record increases, and GHG concentrations continue to increase it will gradually become possible to identify inconsistencies in the rate of warming in climate models and observations, and the analysis of new atmospheric temperature data and climate model output to test the consistency of simulated and observed warming in a range of models.

8.5 Climate Science Assessment

Formal assessments of the state of scientific understanding on environmental issues have become an important mechanism to convey information to decision-makers. Canada recognises the value of such activities and continues to support Canadian involvement in national and international assessments related to climate.

Canada has supported the participation of Canadian experts in the IPCC, including the regular Assessment Reports and the Special Expert Reports. Environment Canada assumed the lead financial responsibility for supporting Canadian science experts in the IPCC 5th Assessment Report, with substantial contributions to Working Group I as Coordinating Lead Authors, Lead Authors, and Review Editors. Canada also supported the participation of experts in the Special Report of Working Groups I and II, "Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation" (SREX[4]).

Canada contributes to the annual State of the Climate Report and Arctic Report Card. These annual reports (led by the U.S. NOAA) incorporate contributions from international researchers to provide updates on the state and recent trends of various indicators and Essential Climate Variables. Data from Canadian observing networks as well as direct involvement of Canadian researchers as report authors form Canada's annual contributions to these international climate science assessments.

The Arctic Council's Arctic Monitoring and Assessment Programme (AMAP) involves Canadian input on various levels. Government of Canada scientists contribute as members, as well as being experts on specific Technical Reports. For example, scientific information and data from Canadian networks and projects formed important contributions to the AMAP report "Snow Water Ice and Permafrost in the Arctic," which was released in 2011–2012.[5]

Statistics Canada, in collaboration with other Government of Canada departments, produces a series of reports using environmental statistics to illustrate topical environmental issues to a general audience. While these reports cover a wide range of topics related to the environment, the series includes climate change indicators: Temperature, precipitation, snow cover, sea ice, and glaciers.

Fisheries and Oceans Canada completed four Large Aquatic Basin climate risk assessments, one for each of Canada's three oceans (Atlantic, Arctic, and Pacific Oceans) and a freshwater assessment that encompasses two of the nation's largest inland watersheds (Lake Winnipeg and the Great Lakes).

In addition to the climate science assessment activities listed in this section, Canada is also involved in

assessments related to climate change adaptation. For example, Natural Resources Canada manages the federal Climate Change Impacts and Adaptation Program, under which a new national-scale assessment of climate change vulnerability, impacts, and adaptation has been launched (for further details, see Chapter 6: Vulnerability Assessment, Climate Change Impacts, and Adaptation Measures).

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9 Education, Training, and Public Awareness

9.1 General Policy Towards Education, Training and Public Awareness

The Government of Canada recognizes that addressing the challenge of climate change will require the collective effort of governments, non-governmental organizations, businesses and individual Canadians. In Canada, all levels of government and numerous non-governmental organizations have undertaken a range of activities to broaden public awareness of climate change. This includes supporting training and education to build broad support for climate change policies and encourage collective action on the part of all Canadians. The education, training and public awareness chapter provides key examples of these initiatives in Canada.

9.2 Primary, Secondary and Post-secondary Education

9.2.1 Primary and Secondary Education

Education in Canada is within provincial jurisdiction and is generally divided into primary education, followed by secondary education and post-secondary education. Policy initiatives in a number of provinces encourage or require the integration of environmental education, including climate change. Climate change is taught across a range of subjects and grades, but is traditionally part of senior science and geography studies. The study of climate change is treated progressively more comprehensively starting from grade 4, with studies in grades 10–12 exploring the more complex nature of climate change including global impacts and anthropogenic drivers.

Many organizations including environmental youth groups, non-governmentalal organizations, and government agencies have developed teachers' guides to assist educators in introducing climate change to their students. Canada has several organizations specifically focused on environmental education. These organizations specialize in providing professional development and training, educational resources, and expertise to support educators both within the formal school system and in other educational facilities. A number of portals exist to help teachers to easily access diverse resources and to allow teachers to align teaching activities with required education curriculum outcomes.

COOL 2.0

The GreenLearning Canada Foundation is one of Canada's leaders in energy and climate change education. The organization provides teachers with education programs and lesson plans that address energy–environment topics in a wide range of subjects. The Foundation's COOL 2.0 site is a hub for education resources on energy, environment and sustainability with lesson plans, videos, research and data, and collaborative projects for a variety of grades and subjects. Teachers can search by keyword, grade level, subject, province, language, and more. The education resources have been contributed by teachers and by GreenLearning and its partners. In the COOL 2.0 teacher space, teachers create and manage learning experiences for students. The web 2.0 platform allows teachers to create assignments, customize resources, and integrate blogs, mapping, online discussions, and media galleries for their classes.

9.2.2 Post-secondary Education

Delivery of post-secondary education in Canada is also the responsibility of the provinces and territories. Environmental programs figure quite heavily in most Canadian universities with most providing a range of courses of study in climate science and research at both the undergraduate and graduate levels. An increasing number of institutions emphasize the social science aspect of environmental studies and many of these programs afford students the opportunity to

study climate change. For example, the University of Ottawa Environmental Sustainability Program aims to provide students with the knowledge and skills needed to analyze the economic, legal, policy and scientific dimensions of environmental problems, and to develop policy options for addressing those problems.

Within Canada, a number of partnerships exist between government scientists and academia in the realm of climate research. These partnerships and network projects build synergy and leverage expertise and resources to increase the efficiency and effectiveness of climate research in Canada and contribute to the training and experience of the next generation of Canadian scientists and researchers.

Additional information on provincial/territorial education initiatives is included below.

9.2.3 Networks of Centres of Excellence

Networks of Centres of Excellence are virtual research networks that combine expertise from academia, industry, government, and not-for-profit organizations. Canada's Networks of Centres of Excellence program has been in place since 1989 and connects multidisciplinary research partnerships with industrial expertise and strategic investment. The networks are led by academia and perform research and development in different fields. This work allows Canadian researchers and students to work with receptor communities to accelerate the creation and application of knowledge. ArcticNet (centered at Laval University) and the Marine Environmental Observation Prediction and Response Network (centered at Dalhousie University) are two Networks of Centres of Excellence which are directly related to climate research in Canada. (Further detail on these networks is presented in Chapter 8: Research and Systematic Observation of Climate Change).

9.2.4 Research Granting Agencies in Canada

In Canada there are three federal granting councils that sponsor academic research and related activities: the Natural Sciences and Engineering Research Council (NSERC), the Canadian Institutes of Health Research, and the Social Sciences and Humanities Research Council.

NSERC is the primary funding source for most engineering and natural science-based projects and; therefore, is the most closely-linked of the three federal granting councils to climate research. Its core role is to support university research and training in the fields of science and engineering. NSERC fulfills its mission by awarding scholarships and research grants through peer-reviewed competition, and by building partnerships among universities, colleges, governments, and the private sector. The Council administers the Climate Change and Atmospheric Research initiative, which supports research at Canadian post-secondary institutions.

The Networks of Centres of Excellence program and Canada Research Chairs program are jointly administered by Canada's three federal granting councils, in partnership with Industry Canada and Health Canada. The Canada Research Chairs program also partners with the Canada Foundation for Innovation to deliver on its mandate (further details on the Canada Research Chairs and Climate Change and Atmospheric Research initiatives are presented in Chapter 8: Research and Systematic Observation of Climate Change).

Canadian government scientists also contribute to academia by holding adjunct professorships at Canadian universities and co-supervising students. The Government of Canada also participates in academic fora, such as the Canadian Resource and Environmental Economics Working Group and the Association des Économistes Québécois, to tap into the knowledge and research capacity that exists in Canadian universities.

Finally, the Government of Canada hires students through co-operative education and other programs. This affords students the opportunity to experience

"hands on" learning about environmental policy and programs. Students may gain experience through co-op programs and placements in both government and private organizations studying climate change, as well as graduate programs with field study components.

9.3 Public Access to Information

9.3.1 Web and Social Media

The web and social media are key channels that the Government of Canada uses to deliver relevant information about climate change and the Government programs and initiatives that help address this important challenge.

The website climatechange.gc.ca provides information on actions that the Government has taken domestically and internationally to address climate change, and up-to-date information on topics such as Canada's sector-by-sector regulatory approach to reducing greenhouse gas (GHG) emissions, climate change impacts and adaptation, international climate change partnerships and negotiations, and Canada's international climate change financing.

Environment Canada's departmental website ec.gc.ca provides detailed information on Environment Canada's climate change science and research, and also features key reports, such as the *National Inventory Report* and *Canada's Emissions Trends*, that provide annual updates on Canada's historical GHG emissions and Canada's progress in reducing GHG emissions.

Ministerial announcements related to the Government's domestic and international action on climate change are also communicated to the public via Environment Canada's website.

Environment Canada actively promotes climate change awareness through its social media channels. Its Twitter, Facebook and Flickr accounts are used to highlight Government of Canada climate change initiatives and to promote national and international events such as Environment Week, Clean Air Day, World Water Day and Earth Hour. Environment Canada's Twitter account is a particularly important channel for communicating to the public as it had close to 80,000 followers as of November 2013.

9.3.2 Conferences and Trade Shows

The Government of Canada participates in a number of national and international conferences and trade shows to share Canada's best practices and gain knowledge of new cutting-edge technology, scientific advancements, and commercial opportunities related to sustainable development and addressing climate change. These events include Americana, Globe, and the Global Methane Expo, all of which focus on finding new and innovative solutions to help build a sustainable future.

9.4 Resource and Information Centres

Numerous organizations in Canada act as climate change resource or information centres for Canadians, governments and businesses. These can include federal government departments (e.g., Environment Canada, Transport Canada, and Health Canada), provincial and municipal governments, utilities (e.g., Ontario Hydro, BC Hydro), and climate focused non-governmental organizations such as Climate Change Central. Further examples are provided in the provincial and territorial activities section of this chapter and in various chapters throughout this report.

An example of a Government of Canada information resource for Canadian consumers and businesses is Natural Resources Canada's (NRCan) Office of Energy Efficiency (OEE), established in 1998. The OEE partners with a variety of stakeholders to promote energy efficiency including provincial and territorial governments, municipal governments, utilities, industries, non-governmental organizations, other countries and international organizations. NRCan's energy efficiency and alternative transportation fuels programs are coordinated through this branch of the department.

The Government's energy efficiency initiatives play an important role in contributing to Canada's climate change objective by reducing energy use and associated GHG emissions.

9.4.1 Providing Energy Efficiency Information

Accessibility of information is an important consideration to enable Canadians to make energy efficient choices. The OEE provides Canadians with a variety of energy efficiency resources including statistics and analysis, reports and other documents, information directories, and tools. Energy management information is accessible from the OEE's website: http://www.nrcan.gc.ca/energy/efficiency

The OEE gathers and publishes a wide range of energy efficiency data such as trends in Canadian energy use and makes this information available to public and private sector organizations and the Canadian public. This raw data forms the basis for energy use, energy efficiency, and GHG calculations for climate change studies and reports, and materials intended for the public.

The OEE maintains online information directories such as the Directory of Energy Efficiency and Alternative Energy Programs in Canada. This directory is an inventory of the energy efficiency and alternative energy programs offered by the Government of Canada, provincial and territorial governments, major Canadian municipalities, and major electric and gas utilities and companies.

Other OEE publications include comprehensive reports and documents which are available online such as the *Fuel Consumption Guide*, which provides information that can be used to compare the fuel consumption of different vehicle models and help Canadians to select the most fuel-efficient vehicle that meets their needs. As well, the EnerGuide Appliance Directory provides energy consumption information for major electrical household appliances, a method of calculating the operating costs of comparable electrical appliances, and tips for saving energy. The EnerGuide Rating System for houses provides customized energy upgrade reports for home owners to guide them to smart home energy renovation actions.

The OEE also offers a wide range of tools to make energy efficiency information more easily accessible. For example, OEE is leading the development of a national building energy benchmarking tool based on the United States Environmental Protection Agency's ENERGY STAR Portfolio Manager. The tool will enable building owners and facility managers to compare their building's energy performance, which is a key first step to understanding and making decisions about how to save energy and reduce a building's carbon footprint.

Energy Efficiency Labelling Programs

The OEE supports two major labelling programs to promote consumer awareness—EnerGuide and ENERGY STAR. EnerGuide is a Government of Canada initiative that rates the energy consumption and efficiency of household appliances, heating, cooling and ventilating equipment, new and existing houses and personal vehicles. EnerGuide labels, which can be affixed to the product alone or be part of its price label, have a standardized design and provide a measurement of energy performance. For new and existing houses, the EnerGuide rating label shows useful information about the home's energy use and provides the name and address of an EnerGuide energy advisor. For vehicles, the current EnerGuide label details a vehicle's city and highway fuel-consumption rating, and the cost of fuelling the vehicle each year.

The international ENERGY STAR symbol takes the EnerGuide concept one step further and identifies specific models that meet or exceed premium levels of energy efficiency. Work to strengthen ENERGY STAR labelling for equipment and appliances has focused on introducing the "Most Efficient" designation to recognize the most efficient products each year in the

Canadian marketplace. Most Efficient ENERGY STAR criteria for nine products were adopted in 2013 and promoted through ENERGY STAR participants.

In the residential sector, the ENERGY STAR for New Homes initiative promotes construction of new homes that are more energy-efficient than those built to minimum building code requirements. The increased efficiency of these homes translates into reduced energy costs for homeowners.

9.5 Training Programs

Climate change training programs in Canada can cover a wide range of activities from improving fleet and building operations, to best practices for businesses (e.g., corporate social reporting, carbon neutral options), to adaptation planning for municipalities. Groups such as non-governmental organizations, educational institutions, government agencies and specialist groups are involved in offering training programs that help meet business and educational objectives and also contribute to Canada's climate change goals.

Information on provincial and territorial training activities is included in the provincial and territorial activities section of this chapter and in other chapters of this report. For example, the Government of Quebec's Climate Change Action Plan includes training activities for healthcare professionals, municipalities, the tourism industry, and community organizations. The Alberta-based Climate Change Central organization provides information and training to help governments and businesses become more sustainable across Canada.

The Government of Canada offers training for Canadian consumers and businesses on the skills they need to improve energy use through NRCan's OEE initiatives.

Since 1997, more than 23,000 representatives of industrial, commercial and institutional organizations from across Canada have enrolled in Dollars to $ense workshops offered by the OEE. These workshops provide energy-saving tips, so that industry and commercial entities can lower operating and production costs, improve economic competitiveness, reduce GHGs, increase operational efficiency, and create a better work environment.

In the residential sector, OEE training efforts focus on the R-2000 standard[1] and the EnerGuide rating service. R-2000, which was developed in partnership with Canada's residential construction industry, promotes the use of cost-effective, energy-efficient building practices and technologies.

In the transportation sector, OEE training initiatives include FleetSmart, Fuel Management 101, SmartDriver, and Auto$mart.

- FleetSmart provides access to training and educational tools and information that help owner-operators, commercial and institutional fleet owners and managers improve the fuel efficiency of their operations.
- Fuel Management 101 workshops give fleet managers practical advice and tools to help them save money on fuel and reduce GHGs.
- The SmartDriver suite of training activities promotes energy efficiency as a cost-effective and responsible way to reduce costs and the environmental impact of fleet operations.
- Auto$mart provides driver educators with information kits to teach students critical defensive driving techniques, and relate road safety to fuel efficiency and the mitigation of climate change and other environmental concerns. In 2012/13, a new Auto$mart curriculum that includes new multimedia components for personal vehicle drivers was completed and launched. The curriculums for highway truck drivers and fleet owners were also updated.

Municipal Training Workshops on Climate Change Action

In Canada, the International Council for Local Environmental Initiatives (ICLEI)—Local Governments for Sustainability, and the Federation of Canadian Municipalities host training workshops on various tools and mechanisms that can help local governments manage their energy use and GHG emissions. Participants learn about creating energy and emissions inventories, choosing appropriate emissions reduction targets, developing local climate change action plans, and monitoring results. The workshops are offered as part of the Partners for Climate Protection program which is a network of Canadian municipal governments that are committed to taking action on climate change. The Partners for Climate Protection program was initiated in 1994 and currently includes over 240 municipalities.

9.6 Public and Non-Governmental Organizations

Non-governmental organizations play a central role in providing information to Canadians, developing public education and awareness campaigns, and encouraging citizen action on climate change. A wide variety of Canadian non-governmental organizations have climate change programs ranging across a spectrum of research and analysis, education and awareness, public advocacy, and online and social media campaigns. The goals of many of these organizations are to inform Canadians about climate change and potential impacts, advance the public policy debate, and encourage collective action on climate change. These efforts have made contributions towards broadening Canadian public awareness of the significance of climate change.

Selection of climate change focused non-governmental organizations in Canada

- **David Suzuki Foundation**
  The David Suzuki Foundation is a national non-profit organization which works with government, business and individuals to conserve the environment by providing science-based research, education and policy work. The organization provides analysis on climate change and provides information and tools to Canadians on how individual Canadians can reduce their personal carbon footprint.
- **International Institute for Sustainable Development**
  The International Institute for Sustainable Development is a Canadian-based, international public policy research institute for sustainable development. The organization conducts policy research, supports information exchange, and contributes analysis and advocacy on climate change. The organization's work also includes analysis on climate change adaptation and risk reduction to help communities and governments in developed and developing countries prepare for and respond to the impacts of climate change.
- **Pembina Institute**
  The Pembina Institute is a national non-profit think tank focused on developing innovative sustainable energy solutions through research, education, consulting and advocacy. The Institute conducts research and provides policy and technical analysis to various levels of government, businesses and other organizations.
- **World Wildlife Fund for Nature**
  The World Wildlife Fund is Canada's largest international conservation organization. The organization conducts research, provides educational programs and materials, and leads Canadian outreach events such as National Sweater Day, which promotes the importance of energy conservation, and Canada's Earth Hour activities to support climate change awareness.

9.7 Provincial and Territorial Activities

Public education and awareness are features of many provincial and territorial climate change strategies. Educational topics range from general information on climate change to specific issues such as adaptation activities. Most jurisdictions' public awareness and education activities include a web-based approach. The Nunavut Climate Change Centre website both disseminates information and invites community members to share Inuit traditional knowledge with respect to climate change. In 2012, Newfoundland and Labrador launched an integrated public awareness campaign with television, print and online components called Turn Back the Tide. The goals of the campaign are to help Canadians understand climate change and how it affects them, and to promote ownership of the issues and inspire citizens to do more. A website is at the heart of the campaign. It is a comprehensive source of information for homeowners, businesses, and communities on ways to reduce GHGs, promote energy efficiency and adapt to climate change. It also features a range of innovative tools, including carbon footprint calculators. Ontario has designed a number of websites ("E-zone", "Obviously.ca" and "Hop To It") which contain many tools to assist the public in understanding environmental matters, including climate change. These websites are specifically designed for students and educators and include interactive tools targeted at children.

Tools and resources have been developed for broad public education and for targeted groups such as youth and families. In the Northwest Territories, the Arctic Energy Alliance raises awareness and provides technical energy and climate change advice to residents. The initiative is mainly funded by the territorial government and is operated out of four regional offices as well as a headquarters in Yellowknife. The Arctic Energy Alliance hosts the annual Energy Actions Awards and conducts energy audits to educate residents on how to reduce home energy consumption. In Saskatchewan, broad public awareness initiatives promoting knowledge and understanding of climate change include those supported by the Go Green Fund and the Climate Change Foundation in Saskatchewan. In the Yukon, the Climate Change Secretariat has engaged youth through annual leadership forums on environmental and climate awareness. Through the Family Eco-Challenge, New Brunswick engaged 30 families in a step-by-step program to reduce their environmental footprint, including GHG emissions.

Climate change education for young people is promoted through the formal education system in a number of provinces and territories. The Green Schools Initiative, introduced by the British Columbia Climate Change Secretariat and the Ministry of Education, provides teachers with material and strategies in order to incorporate environmental sustainability in the classroom, as well as games for students. Quebec's 2013–2020 Climate Change Action Plan identifies the assessment of teacher's needs as one of its priorities to ensure teachers have the appropriate tools to communicate the reality of climate change to students. The plan complements the numerous partnerships that the government has developed with civil society organizations to drive climate change-related school activities.

Governments, businesses, and particular industries are also targeted by education and outreach initiatives. For instance, the Government of Quebec's 2013–2020 Climate Change Action Plan aims to increase awareness, mobilization, and training activities for healthcare professionals, municipalities, the tourism industry, and community organizations. A specialized website on the impact of climate change on human health, Mon climat, ma santé, has been developed to disseminate knowledge, skills, and tools to healthcare professionals. Launched in 2000 by the Government of Alberta, the not-for-profit Climate Change Central has since become an independent organization under the brand C3. The organization helps governments and businesses become more sustainable across Canada. In the Yukon, the territorial government has partnered with

Yukon College's Northern Climate ExChange to fund the Climate Change Information and Mainstreaming Program, which provides climate change courses and technical project support to government departments.

Innovative tools have been developed to increase awareness and facilitate climate change education in all types of settings. Apps 4 Climate Action is the result of a contest in 2010 designed by the British Columbia Climate Action Secretariat, GeoBC, and the Ministry of Citizens' Services. These climate action applications (apps) for individuals and businesses are available on the government's main climate change public awareness website: LiveSmart BC.

Provincial and territorial governments also undertake education and awareness in partnership with other organizations. This is the case in Quebec, where partnerships with Climate Reality Canada, *l'EAUdyssée de la Terre* (for the theatre show "Un vent de changement avec Rafale") and Équiterre (Défi Climat), for example, were developed to facilitate the reduction of GHGs. The 2013–2020 Quebec Climate Change Action Plan aims to pursue this type of partnership and create new alliances, especially with regards to climate change adaptation. The Province of New Brunswick has fostered partnerships with municipalities, business and environmental groups, and educational institutions to raise awareness and understanding of climate change issues and reduce GHG emissions. These partnerships have included developing online tools such as Emissions Tracking—Measuring Carbon Footprint and Climate Change Indicators. In British Columbia, the online Climate Action Toolkit, which includes resources for local governments and communities, was developed through a partnership between the provincial government, the Union of British Columbia Municipalities, and the Fraser Basin Council. In Ontario, the Community Adaptation Initiative implemented in 2010 is a partnership between the Government of Ontario, the Clean Air Partnership, and the Ontario Centre for Climate Impact and Adaptation Resources. This two-year initiative provided local communities with technical workshops, citizen forums, videos, best practices, and case studies. These resources continue to be available online.

Intergovernmental collaboration has been another means to support climate change education and awareness in Canada. For instance, NRCan's Regional Adaptation Collaborative (RAC) program in the Atlantic provinces has developed resources and tools to advance education, awareness and action in adapting to the effects of Canada's changing climate. Through the RAC program, Ontario has also strengthened climate change adaptation outreach and training across the province. RAC partners, including government, academia, and non-governmental organizations have developed guidance tools and resources to advance knowledge and action on adaptation at the local community level.

9.8 Participation in International Activities

Canada engages in a number of collaborative international initiatives that involve sharing experiences, best-practices and working towards common climate change goals:

- The Climate and Clean Air Coalition, where Canada is one of the leading countries in a concerted action on short-lived climate pollutants.
- The Major Economies Forum on Energy and Climate, an initiative that brings together the world's 17 largest emitters to advance key issues under consideration in international climate change negotiations and to advance the exploration of initiatives related to clean technologies.
- The Global Methane Initiative, a voluntary initiative that serves as an international framework to promote cost-effective methane recovery and use as a clean energy source. Canada co-hosted the third Global Methane Initiative Partnership Expo, in collaboration with the U.S. Environmental Protection Agency in March 2013.

Canada is equally committed to working with developing countries to help them achieve their GHG emissions reduction goals and adapt to the adverse impacts of climate change. Canada's international support is comprised of a wide range of programs and initiatives that address mitigation, clean energy technology, sustainable forestry and agriculture, and adaptation to climate change by the world's most vulnerable countries and many of these include an element of building capacity through the dissemination of information and knowledge tools. These initiatives include Canada's fast-start climate financing contribution of $1.2 billion, which is described in Chapter 7: Financial Resources and Transfer of Technology.

International Co-operation on Energy Efficiency Initiatives

NRCan's OEE co-operates with several international organizations on energy efficiency and alternative transportation fuels and supports co-operation in these areas with countries and regions such as the United States, China, the European Union, India, Mexico and Russia. Canada benefits from this co-operation by:

- Learning about improved ways of designing and delivering energy efficiency and alternative transportation fuels programs to meet policy objectives
- Working with others on the harmonization of energy efficiency tests and performance standards to reduce barriers to trade in energy-using products
- Sharing Canadian tools and expertise with other international partners to achieve common environmental and energy security goals

Further information on Canada's international activities is included in other chapters of this report.

Reference

1 R-2000 is an official mark of Natural Resources Canada.

Annex 1: Canada's First Biennial Report

Section 1 Introduction

Canada is pleased to present its first Biennial Report (BR), under decision 2/CP.17 of the United Nations Framework Convention on Climate Change (UNFCCC). For 2014, Canada is presenting its BR as an Annex to its 6th National Communication. While the BR and National Communication are complementary documents, Canada has designed them to be self-contained, with each responding to separate reporting requirements mandated by the UNFCCC.

Section 2 Information on Greenhouse Gas Emissions and Trends

In 2011, Canada emitted about 702 megatonnes carbon dioxide equivalent (Mt CO_2 eq) of greenhouse gases (GHG) to the atmosphere, excluding emissions/removals from Land Use, Land-use Change, and Forestry (LULUCF). Since 2005, total Canadian GHG emissions have decreased by 35.7 Mt (4.8%).

The GHG emission and removal estimates contained within Canada's Inventory are developed using methodologies consistent with the guidelines prescribed by the Intergovernmental Panel on Climate Change (IPCC). The inventory estimates include the gases CO_2, methane (CH_4), nitrous oxide (N_2O), sulphur hexafluoride (SF_6), perfluorocarbons (PFCs) and hydrofluorocarbons (HFCs), in the following six IPCC sectors: Energy, Industrial Processes, Solvent and Other Product Use, Agriculture, Waste and LULUCF.

The Common Tabular Format (CTF) Table 1 in Canada's 1st Biennial Report contains the same information as the Common Reporting Format (CRF) Table 10 in Canada's 2013 National Inventory Submission to the UNFCCC.

It should be noted that the LULUCF estimates in CTF Table 1 include the impact of natural disturbances; these figures are not used to evaluate Canada's progress towards its 2020 target. CTF Table 4(a)1 and accompanying text explain how Canada incorporates the LULUCF sector in assessing its progress towards its 2020 emission reduction target.

For a more elaborate analysis of recent historical GHG emission and removal trends, please see Chapter 2 of Canada's 2013 National Inventory Report (NIR) entitled, *National Inventory Report: Greenhouse Gas Sources and Sinks in Canada 1990–2011.*[1]

National Inventory Arrangements

The *Canadian Environmental Protection Act, 1999* (CEPA 1999) provides the legislative authority to designate Environment Canada as the single national entity with responsibility for the preparation and submission of the National Inventory Submission to the UNFCCC and for the establishment of a national system. Canada's national system covers the institutional arrangements for the preparation of the inventory, including:

- the roles and responsibilities of the inventory agency and of the various players involved;
- the processes for inventory preparation, data collection and estimates development;
- quality management of the inventory, and;
- the procedures for official approval of the inventory.

Additional information on Canada's national inventory arrangements can be found in Chapter 1: Introduction of *Canada's 2013 National Inventory Report* and Chapter 3: Canada's Greenhouse Gas Inventory of Canada's 6th National Communication.

Table 1 Emission Trends—Summary

Year: 2011
Submission: 2013
Country: CANADA

GREENHOUSE GAS EMISSIONS	Base year (1990)	1991	1992	1993	1994	1995	1996	1997	1998	1999
Unit	CO_2 eq (Gg)	CO_2 eq (Gg)	CO_2 eq (Gg)	CO_2 eq (Gg)	CO_2 eq (Gg)	CO_2 eq (Gg)	CO_2 (Gg)	CO_2 eq (Gg)	CO_2 eq (Gg)	CO_2 eq (Gg)
CO_2 emissions including net CO_2 from LULUCF	392,295.43	405,859.19	377,419.22	442,735.49	452,068.10	654,303.48	474,644.43	452,490.55	622,818.73	549,056.20
CO_2 emissions excluding net CO_2 from LULUCF	459,313.03	450,393.39	464,651.68	464,063.08	478,748.17	491,116.15	504,425.38	517,254.27	526,370.72	541,572.14
CH_4 emissions including CH_4 from LULUCF	75,331.34	78,883.50	79,133.25	86,094.97	88,400.41	104,802.77	93,631.44	92,511.97	106,878.92	98,033.46
CH_4 emissions excluding CH_4 from LULUCF	72,002.96	73,559.20	77,308.30	79,642.60	82,557.07	85,909.47	89,039.78	90,682.68	92,067.68	91,678.62
N_2O emissions including N_2O from LULUCF	51,126.25	51,063.66	49,590.61	53,431.51	56,547.67	65,475.92	59,149.33	56,205.81	60,199.43	52,734.05
N_2O emissions excluding N_2O from LULUCF	49,065.08	47,783.33	48,467.87	49,433.59	52,924.33	53,749.55	56,300.71	55,072.53	51,002.39	48,786.84
HFCs	767.25	835.33	655.97	NA,NO	NA,NO	479.41	851.53	1,397.69	1,934.68	2,413.69
PFCs	6,538.83	6,949.98	6,556.82	6,450.32	5,965.33	5,489.59	5,622.83	5,512.71	5,601.84	4,645.28
SF_6	3,392.20	3,873.67	2,691.12	2,498.69	2,570.18	2,395.56	1,861.25	1,923.00	2,478.26	2,534.01
Total (including LULUCF)	**529,451.29**	**547,465.33**	**516,046.99**	**591,210.98**	**605,551.68**	**832,946.73**	**635,760.80**	**610,041.74**	**799,911.86**	**709,416.69**
Total (excluding LULUCF)	**591,079.35**	**583,394.90**	**600,331.75**	**602,088.28**	**622,765.08**	**639,139.72**	**658,101.49**	**671,842.89**	**679,455.57**	**691,630.58**

GREENHOUSE GAS SOURCE AND SINK	Base year (1990)	1991	1992	1993	1994	1995	1996	1997	1998	1999
CATEGORIES	CO_2 eq (Gg)	CO_2 eq (Gg)	CO_2 eq (Gg)	CO_2 eqt (Gg)	CO_2 eq (Gg)	CO_2 eq (Gg)	CO_2 eq (Gg)	CO_2 eq (Gg)	CO_2 eq (Gg)	CO_2 eq (Gg)
1. Energy	469,186.20	460,063.71	477,701.94	477,948.42	494,644.59	508,788.47	524,737.56	539,053.97	548,804.37	563,880.54
2. Industrial Processes	55,978.49	57,415.95	55,229.88	55,034.20	56,955.01	57,472.54	59,089.28	58,523.34	55,369.90	52,052.93
3. Solvent and Other Product Use	178.71	169.94	141.76	159.40	175.40	212.58	216.64	230.11	401.45	409.54
4. Agriculture	46,728.50	46,378.90	47,634.68	49,063.17	50,988.99	52,669.69	54,228.77	54,053.38	54,611.44	55,020.12
5. Land Use, Land-Use Change and Forestry[1]	-61,628.06	-35,929.57	-84,284.75	-10,877.30	-17,213.40	193,807.01	-22,340.68	-61,801.15	120,456.29	17,786.11
6. Waste	19,007.45	19,366.39	19,623.49	19,883.09	20,001.09	19,996.44	19,829.24	19,982.10	20,268.41	20,267.45
7. Other	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Total (including LULUCF)[1]	**529,451.29**	**547,465.33**	**516,046.99**	**591,210.98**	**605,551.68**	**832,946.73**	**635,760.80**	**610,041.74**	**799,911.86**	**709,416.69**

Abbreviations: LULUCF = Land Use, Land-use Change and Forestry
Notes 1: Includes net CO_2, CH_4 and N_2O from LULUCF

Table 1 Emission Trends—Summary (continued)

Year: 2011
Submission: 2013
Country: CANADA

GREENHOUSE GAS EMISSIONS	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	Change from base to latest reported year
Unit	CO_2 eq (Gg)	CO_2 eq (Gg)	CO_2 eq (Gg)	CO_2 eq (Gg)	CO_2 eq (Gg)	CO_2 eq(Gg)	CO_2 eq (Gg)	CO_2 eq (Gg)	CO_2 eq (Gg)	CO_2 eq (Gg)	CO_2 eq (Gg)	CO_2 eq (Gg)	(%)
CO2 emissions including net CO2 from LULUCF	510,015.61	505,087.09	647,990.25	618,797.57	675,937.54	632,448.78	633,569.84	635,942.22	558,642.39	522,149.36	638,050.26	624,308.34	59.14
CO2 emissions excluding net CO2 from LULUCF	564,642.46	559,091.55	565,884.09	582,896.04	584,654.92	578,955.01	571,747.40	594,609.51	576,528.04	542,049.92	554,019.16	555,613.97	20.97
CH4 emissions including CH4 from LULUCF	95,527.37	98,266.52	107,128.93	104,648.09	107,554.40	103,757.79	104,764.35	102,796.18	98,308.76	97,147.64	102,222.51	102,018.82	35.43
CH4 emissions excluding CH4 from LULUCF	94,025.84	95,310.44	95,410.53	96,128.71	97,843.22	98,087.81	98,038.65	96,407.19	94,098.57	90,943.19	90,400.78	90,562.54	25.78
N2O emissions including N2O from LULUCF	49,546.19	48,705.06	53,729.79	54,079.64	57,622.28	53,829.90	52,302.00	53,340.78	54,415.48	51,019.46	54,629.21	53,338.12	4.33
N2O emissions excluding N2O from LULUCF	48,613.73	46,870.83	46,450.38	48,791.00	51,592.33	50,308.15	48,124.33	49,373.88	51,802.20	47,165.70	47,287.06	46,221.70	-5.80
HFCs	2,936.12	3,507.83	3,915.58	4,421.71	4,795.35	5,296.47	5,105.86	5,483.71	5,550.65	6,306.34	7,072.55	7,526.83	881.01
PFCs	4,311.08	3,500.42	2,994.81	3,019.03	3,046.98	3,317.26	2,583.90	2,193.70	2,252.32	2,171.97	1,607.49	1,450.89	-77.81
SF6	3,051.86	2,688.58	3,169.42	2,787.46	2,456.88	1,492.14	1,595.90	771.98	683.95	393.06	462.24	415.29	-87.76
Total (including LULUCF)	**665,388.23**	**661,755.50**	**818,928.79**	**787,753.49**	**851,413.42**	**800,142.33**	**799,921.85**	**800,528.58**	**719,853.55**	**679,187.83**	**804,044.25**	**789,058.29**	**49.03**
Total (excluding LULUCF)	**717,581.11**	**710,969.64**	**717,824.81**	**738,043.94**	**744,389.67**	**737,456.83**	**727,196.04**	**748,839.98**	**730,915.73**	**689,030.17**	**700,849.29**	**701,791.22**	**18.73**

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	Change from base to latest reported year
	CO_2 eq (Gg)	CO_2 eq (Gg)	CO_2 eq (Gg)	CO_2 eq (Gg)	CO_2 eq (Gg)	CO_2 eq (Gg)	CO_2 eq (Gg)	CO_2 eq (Gg)	CO_2 eq (Gg)	CO_2 eq (Gg)	CO_2 eq (Gg)	CO_2 eq (Gg)	(%)
1. Energy	589,473.78	585,344.44	591,113.12	606,996.65	603,290.51	597,336.61	586,892.94	609,761.78	592,195.74	560,441.65	570,137.09	571,601.41	21.83
2. Industrial Processes	52,054.26	50,523.86	51,881.16	53,586.49	61,681.05	60,461.41	61,018.70	59,787.20	58,545.80	50,805.78	53,262.13	54,271.29	-3.05
3. Solvent and Other Product Use	449.60	419.52	385.55	445.51	407.41	378.00	329.36	326.32	341.62	260.49	241.97	247.40	38.44
4. Agriculture	55,650.44	54,865.01	54,224.77	56,517.48	58,140.93	58,122.92	57,345.56	57,641.84	58,602.62	56,134.71	55,612.85	53,924.99	15.40
5. Land Use, Land-Use Change and Forestry1	-52,192.87	-49,214.14	101,103.98	49,709.55	107,023.75	62,685.50	72,725.80	51,688.60	-11,062.19	-9,842.34	103,194.97	87,267.07	-241.60
6. Waste	19,953.02	19,816.81	20,220.20	20,497.80	20,869.77	21,157.90	21,609.48	21,322.84	21,229.94	21,387.55	21,595.25	21,746.13	14.41
7. Other	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.00
Total (including LULUCF)1	**665,388.23**	**661,755.50**	**818,928.79**	**787,753.49**	**851,413.42**	**800,142.33**	**799,921.85**	**800,528.58**	**719,853.55**	**679,187.83**	**804,044.25**	**789,058.29**	**49.03**

Abbreviations: LULUCF = Land Use, Land-Use Change and Forestry
Notes 1: Includes net CO_2, CH_4 and N_2O from LULUCF

Section 3 Economy-wide Emission Reduction Target

Under the United Nations Framework Convention on Climate Change (UNFCCC), Canada associated with the Copenhagen Accord in January 2010 and committed to reduce its greenhouse gas (GHG) emissions to 17% below 2005 levels by 2020. In light of strong economic growth, this could be challenging: 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 its environmental objectives.

Table 2(a) Base Year

Base Year	2005
Emission reduction target (% of base year)	17% below 2005
% of 1990	3.6% above 1990 levels, based on the 2013 emission inventory for historical data
Period for reaching target	2020

Canada's GHG projections are derived using a bottom-up macroeconomic model where energy data is allocated to individual subsectors using the North American Industrial Classification system, as shown in Table 2 (b). These subsectors are then aggregated into the Economic Sectors presented in this report. Considering that gross domestic product (GDP) and relative energy prices are a key driver of GHG emissions in most sectors, macroeconomic models are the primary tool for generating emissions projections in Canada. This method of energy and emissions allocation is essential for identifying possible impacts from current and future policies and measures implemented in a particular sector. For example, using an economic sector aggregation for Emission-Intensive and Trade-Exposed (EITE) Industries and the Building Sector allows for policy analysis of all emissions generated from the sector such as stationary combustion and industrial processes.

According to the National Communication reporting guidelines, Parties have the flexibility to present their policies and measures and projections according to sectoral categories that are appropriate to their own national circumstances. Canada has chosen to use economic sectors in our Biennial Report and National Communication as these categories more accurately reflect the drivers of emissions than the Intergovernmental Panel on Climate Change (IPCC) activity based sectoral categories. Paragraph 17 of the National Communication reporting guidelines provide Parties the flexibility to report their sectors using a categorization that they deem appropriate within the policies and measures chapter. Paragraph 34 of the guidelines clarifies that projections should be presented using the same sectoral categorization as the policies and measures chapter.

Table 2(b) Gases and Sectors Covered

Gases Covered	Base Year for Each Gas (year)
CO_2	2005
CH_4	2005
N_2O	2005
HFCs	2005
PFCs	2005
SF_6	2005

Sectors Covered	Oil and Gas	Yes
	Electricity	Yes
	Transportation	Yes
	Emissions-Intensive & Trade-Exposed Industries	Yes
	Buildings	Yes
	Agriculture	Yes
	Waste & Others	Yes
	LULUCF	Yes*

Abbreviation: LULUCF = Land Use, Land-use Change and Forestry
* LULUCF is not included in the base year for setting Canada's quantified economy-wide emission reduction target, but the contribution to the LULUCF Sector will be applied to the target year [see Biennial Report Table 2(d)].

Table 2(c) Description of Quantified Economy-wide Emission Reduction Target: Global Warming Potential (GWP) Values

Gases	GWP Values IPCC Second Assessment Report
CO_2	1
CH_4	21
N_2O	310
HFCs	As per GWPs for the range of HFCs in IPCC's Second Assessment Report
PFCs	As per GWPs for the range of PFCs in IPCC's Second Assessment Report
SF_6	23,900
NF_3	—

Abbreviations: IPCC = Intergovernmental Panel on Climate Change

Canada's 2020 target range was set on the 100 year GWP values in the IPCC Second Assessment Report, 1995, as noted above.

GWP values from the IPCC Fourth Assessment Report will be used starting in the *2015 National Inventory Report*, consistent with the revised UNFCCC Annex I Inventory reporting guidelines adopted at COP 17 (December, 2011).

Table 2(d): the LULUCF Sector

The LULUCF Sector 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*.

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. Under this approach, the contribution of LULUCF in 2020 is estimated to be 28 Mt.

In a spring 2012 submission to the UNFCCC, Canada stated its intent to include the LULUCF sector in its accounting of GHG emissions towards its 2020 target, noting that emissions and related removals resulting from natural disturbances would be excluded from the accounting. It was also indicated that a Reference Level or comparison against a 2005 baseline would be used for accounting.

Canada's submission clarifying its economy-wide emission reduction target under the Copenhagen Accord is at http://unfccc.int/resource/docs/2012/awglca15/eng/misc01a02.pdf

Please see the LULUCF section of Chapter 5: Projections and the Total Effect of Policies and Measures of Canada's 6th National Communication report for details on LULUCF emissions projections and accounting methodology.

Table 2(d) I Description of Quantified Economy-wide Emission Reduction Target; Approach to Counting Emissions and Removals from the LULUCF Sector

Role of LULUCF	LULUCF emissions in base year	Excluded
	LULUCF emissions in 2020	Included • Forest Land Remaining Forest Land • Cropland Remaining Cropland • Forest Land Converted to Other Land Categories • Other Land Categories Converted to Forest Land Excluded • Settlements • Wetlands • Grasslands Land-based approach: No Activity-based approach: No Other: Based on LULUCF Convention reporting categories

Abbreviations LULUCF = Land Use, Land-use Change and Forestry
Description of contribution of LULUCF calculations:
Accounting approaches for all subsectors: Difference between 2005 and 2020 except Forestland remaining Forestland which is measured against a Reference Level consistent with the Reference Level agreed for Canada in the Durban agreement on LULUCF.* Further detail on the LULUCF sector is presented in Table 2(d) II.
* A technical correction to the Reference Level will be used, consistent with the process allowed in the Durban agreement on LULUCF.

Table 2(d) II Projected Emissions (+) or Removals (-) from the LULUCF Sector in 2020

Category (in Mt of GHG emissions/removals)	2020 Projected Emissions/ Removals	2005 Estimate/ Reference Level	Expected Contribution to 2020 Emissions
Forest Land Remaining Forest Land	−133	−107[a]	−26
Cropland Remaining Cropland[b]	−9	−10	1
Forest Land Converted to Other Land Categories[c]	15	18[d]	−3.7
Land Converted to Forest Land	−0.4	−0.9	0.6
Total	−128	−100	−28

Numbers may not add up due to rounding

[a] For Forest Land, Remaining Forest Land, a 2020 reference level is used for determining the contribution.

[b] Cropland remaining Cropland includes residual emissions after 20 years from forest conversion to cropland.

[c] 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.

[d] Differences between these values and those reported in the *National Inventory Report* are due to the reallocation of emissions from conversion of forest to cropland after 20 years or more.

Section 4 Progress in Achievement of Quantified Economy-wide Emission Reduction Targets and Relevant Information

4.A Mitigation actions and their effects–Policies and Measures

Per the United Nations Framework Convention on Climate Change (UNFCCC) guidelines, Biennial Report Table 3 generally focuses on actions implemented since Canada's last National Communication. Priority has been given to those policies and measures that have the most significant impact in affecting Canada's greenhouse gas (GHG) emissions—notably regulations being advanced under Canada's sector-by-sector approach. To provide additional context, information is also included on key supporting and complementary measures such as investments in clean energy technologies and initiatives that may be of interest to international audiences. Given the shared jurisdiction for climate change in Canada, the table also includes information on some of the most important provincial and territorial policies and measures.

Policies and measures in the planning stage are included and these are clearly distinguished from implemented policies and measures throughout. Emissions reductions may not be available for planned measures as final regulations or agreements have not yet been finalized. Similarly, emission reductions may not be available for supporting measures in cases where emission reductions are not the primary objective of the initiative.

The methodology for estimating expected emissions reductions from individual measures may vary by implementing entity and have been included on an as provided basis from the implementing entity. Emissions estimates for individual measures cannot be directly linked to integrated emissions projections in Table 6a of this report given the interactive effects that may occur between different federal and provincial measures.

Rather than the sectoral categories used by the Intergovernmental Panel on Climate Change (IPCC), Canada's policies and measures are organized by the following sectors: Transportation; Oil and Gas, consisting of upstream and downstream sectors; Electricity; Buildings; Emissions-Intensive and Trade-Exposed Industries; Agriculture; Waste and others; and Cross-cutting (please see Chapter 5: Projections and the Total Effect of Policies and Measures of Canada's 6th National Communication for more detail). The sectors appear in order from the largest sources of emissions in Canada to the smallest. Within the sectoral groupings, federal measures appear first, followed by provincial and territorial measures from west to east.

Table 3 Progress in Achievement of Quantified Economy-wide Emission Reduction Targets: Mitigation Actions and Their Effects

Name of Mitigation Action	Sector(s) Affected	GHG(s) Affected	Objective and/or Activity Affected	Type of Instrument	Implementation Entity	Status of Implementation	Start Date of Implementation	Estimate of Mitigation Impact in 2020 (kt CO_2 eq)
Light-Duty Vehicle GHG Regulations: Phase 1*	Transportation	CO_2, CH_4, N_2O	To reduce GHG emissions from the on-road transportation sector	Regulatory	Environment Canada	Implemented	2011	10,000
Brief Description	The regulations apply increasingly stringent annual GHG emissions emission standards to new passenger automobiles and light trucks manufactured or imported into Canada for the years 2011–2016.							
Light-Duty Vehicle GHG Regulations: Phase 2*	Transportation	CO_2, CH_4, N_2O	To reduce GHG emissions from the on-road transportation sector	Regulatory	Environment Canada	Adopted	2017	3,000
Brief Description	Proposed amendments to the Light-Duty GHG Regulations will involve more stringent standards for model years 2017–2025.							
Heavy Duty Vehicle GHG Regulations*	Transportation	CO_2, CH_4, N_2O	To reduce GHG emissions from the on-road transportation sector	Regulatory	Environment Canada	Implemented	2014	3,000
Brief Description	These regulations will apply increasingly stringent annual GHG emissions standards to new on-road heavy-duty vehicles and engines imported or manufactured in Canada for the years 2014–2018.							
Federal Renewable Fuels Regulations*	Transportation	CO_2	To regulate renewable content in fuel	Regulatory	Environment Canada	Implemented	2010	2,000
Brief Description	Regulations require an average 5% renewable fuel content for gasoline, and 2% renewable fuel content in most diesel fuel.							
Carbon Dioxide Standards for Aviation	Transportation	CO_2	To reduce GHG emissions from new airplanes	Regulatory	Transport Canada	Planned	TBD	NE
Brief Description	Canada is participating in the development of a new international CO_2 standard for new airplanes at the International Civil Aviation Organization. Canada plans to adopt the standard once it has been finalized and approved by the International Civil Aviation Organization.							

Abbreviations: Greenhouse gas (GHG), Kilotonne of carbon dioxide equivalent (kt CO_2 eq), Megatonnes (Mt), Not estimated (NE), To be determined (TBD)

* Asterisk indicates that the policy or measure has been modeled using Environment Canada's energy, environment, and economy model (E3MC) and is reflected in Canada's GHG emissions projection as presented in Table 6a of this report and Chapter 5 of Canada's 6th National Communication. Please note that emissions estimates for individual measures cannot be directly linked to integrated emissions projections in Table 6a of this report, given the interactive effects that may occur between different federal and provincial measures.

Table 3 Progress in Achievement of Quantified Economy-wide Emission Reduction Targets: Mitigation Actions and Their Effects (continued)

Name of Mitigation Action	Sector(s) Affected	GHG(s) Affected	Objective and/or Activity Affected	Type of Instrument	Implementation Entity	Status of Implementation	Start Date of Implementation	Estimate of Mitigation Impact in 2020 (kt CO_2 eq)
Canada's Action Plan to Reduce GHG Emissions from Aviation	Transportation	CO_2, CH_4, N_2O	To reduce GHG emissions from the aviation sector	Voluntary Agreement	Transport Canada	Implemented	2012	NE
Brief Description	A comprehensive voluntary approach that includes all segments of the Canadian aviation sector, from airlines and airports to air traffic navigation and aircraft manufacturers, the Action Plan sets an aspirational goal to improve fuel efficiency from a 2005 baseline by an average annual rate of at least 2% per year until 2020. The Action Plan forms the basis for the Government of Canada's response to the International Civil Aviation Organization's Assembly Resolution A37-19, which encouraged Member States to submit national action plans by June 2012 setting out measures each state is taking or will take to address international aviation emissions.							
Regulatory Cooperation Council Locomotive Emissions Initiative	Transportation	CO_2, CH_4, N_2O	To reduce GHG emissions from locomotives operating in Canada and the U.S.	Voluntary Agreement	Transport Canada	Adopted	TBD	NE
Brief Description	The Emissions Initiative is a joint voluntary approach with the U.S. Environmental Protection Agency on the development of potential strategies to reduce GHG emissions from locomotives. Among other elements, a Canadian industry-government Memorandum of Understanding that includes measures, targets and actions to reduce GHG emission intensity from rail operations was concluded as part of this initiative. The initiative also involves work towards a Canada–U.S. industry-government voluntary action plan to reduce greenhouse gas emissions from locomotives.							
Energy Efficiency Requirements for Marine Vessels	Transportation	CO_2, CH_4, N_2O	To reduce GHG emissions from international shipping	Regulatory	Transport Canada	Implemented	June 2013	366
Brief Description	Canada has enacted national regulations to implement new energy efficiency requirements negotiated under Annex VI of the International Maritime Organization's *Convention for the Prevention of Pollution from Ships*. The regulations require all vessels of 400 gross tonnage and above to have a Ship Energy Efficiency Management Plan on board, stating how each vessel will increase energy efficiency and reduce greenhouse gas emissions. Additionally, under the regulations, new vessels of 400 gross tonnage and above must meet Energy Efficiency Design Index requirements that will increase energy efficiency by 30% by 2025. The Energy Efficiency Design Index requirements do not apply to domestic vessels voyaging only in Canadian waters, as it was found that applying the international standards to these vessels, which are smaller and use shorter routes, would result in increased emissions.							
Energy Efficiency Requirements for Canadian Marine Vessels that Serve Domestic Trade	Transportation	CO_2, CH_4, N_2O	To reduce GHG emissions from domestic shipping	Regulatory	Transport Canada	Planned	TBD	NE
Brief Description	New Canadian ships that serve domestic trade within Canada are currently exempt from the International Maritime Organization's Energy Efficiency Design Index requirements. A technical review found that when the international Energy Efficiency Design Index standard is applied to Canadian ships on domestic service, which are smaller and use shorter routes, the results would reduce the energy efficiency of these ships and increase their CO_2 emissions. The technical review recommended ways to apply the Energy Efficiency Design Index to yield the intended results; Transport Canada plans to implement adjusted domestic Energy Efficiency Design Index standards in the future.							

Name of Mitigation Action	Sector(s) Affected	GHG(s) Affected	Objective and/or Activity Affected	Type of Instrument	Implementation Entity	Status of Implementation	Start Date of Implementation	Estimate of Mitigation Impact in 2020 (kt CO_2 eq)
Shore Power Technology for Ports Program	Transportation	CO_2, CH_4, N_2O	To reduce GHG emissions from docked ships	Economic	Transport Canada	Implemented	2011	7
Brief Description	The Shore Power Technology for Ports Program provides cost-shared funding for the deployment of marine shore power technology at Canadian ports. This technology allows ships to plug into the local electrical grid to power the vessel instead of using their auxiliary diesel engines when docked.							
ecoTECHNOLOGY for Vehicles Program	Transportation	CO_2, CH_4, N_2O	To support the development of low-emission vehicle regulations, standards, codes, protocols, guidelines, and related instruments	Research, Information	Transport Canada	Implemented	2011	NE
Brief Description	The ecoTECHNOLOGY for Vehicles program tests, evaluates, and provides expert technical information on the environmental and safety performance of advanced light-duty vehicle and heavy-duty vehicle technologies. The ecoTECHNOLOGY program shares technical findings to inform the development of vehicle emissions regulations; to guide the proactive development of new or revised safety regulations, standards, codes and guidelines; and to support the development of non-regulatory industry codes and standards to help integrate new vehicle technologies into Canada. The ecoTECHNOLOGY program is not expected to directly result in emission reductions; however, it will inform the development of Canada's light-duty vehicle and heavy-duty vehicle GHG emission regulations and help more low-emission vehicle technologies to enter the Canadian market.							
Truck Reservation System Program	Transportation	CO_2, CH_4, N_2O	To reduce GHG emissions associated with port-related trucking activity at Canada's major container ports	Economic	Transport Canada	Implemented	2013	NE
Brief Description	The Truck Reservation Systems Program provides funding to projects at Canada's major container ports for the deployment of technologies and practices that improve port-trucking efficiency and environmental performance (e.g., reducing truck idling, wait times at port terminals, and congestion on access roads). The Truck Reservation System Program is currently working with project proponents (notably Canadian Port Authorities), to gather more complete data on truck movements within port areas to better measure GHG emissions on an ongoing basis and also in certain regions to set a baseline. Specific GHG emission reduction targets will be set throughout the course of individual projections.							
British Columbia Renewable and Low Carbon Fuel Requirements Regulation*	Transportation		Reduce the carbon intensity and increase the renewable content of fuels sold in B.C.	Regulatory	British Columbia	Implemented	2010	NE
Brief Description	Regulation that targets a 10% decrease in carbon intensity of transport fuels sold in B.C. by 2020, and 5% renewable content in gasoline (4% in diesel).							

Table 3 Progress in Achievement of Quantified Economy-wide Emission Reduction Targets: Mitigation Actions and Their Effects (continued)

Name of Mitigation Action	Sector(s) Affected	GHG(s) Affected	Objective and/or Activity Affected	Type of Instrument	Implementation Entity	Status of Implementation	Start Date of Implementation	Estimate of Mitigation Impact in 2020 (kt CO_2 eq)
British Columbia Clean Energy Vehicles Program	Transportation		To reduce GHGs in transportation	Economic	British Columbia	Implemented	2011	NE
Brief Description	The $14.3 million program provides incentives for eligible clean energy vehicles and includes deployment of charging point infrastructure for these vehicles.							
Alberta Renewable Fuel Standard*	Transportation		To accelerate the use of fuels derived from renewable sources	Regulatory	Alberta	Implemented	2011	1,000
Brief Description	Regulation requires an average of 2% renewable content in diesel fuel and 5% renewable alcohol in gasoline. The renewable fuel content must have at least 25% less GHG emissions than the equivalent petroleum fuel on a life-cycle basis.							
Alberta GreenTRIP	Transportation		To increase the accessibility and use of public transit in Alberta	Economic	Alberta	Implemented	2010	50
Brief Description	This is a $2 billion one-time capital funding program that supports new and expanded public transit in Alberta. To date, 13 projects are receiving funding and only three projects have made estimates for their expected GHG reductions.							
Manitoba Biofuel Production Incentive*	Transportation	CO_2	To provide financial support for ethanol and biodiesel manufacturers in Manitoba in order to reduce transportation emissions	Regulatory	Manitoba	Implemented	2010	NE
Brief description	The Ethanol Fund Grant Regulation started in 2008 and provides a portion of gas tax revenue to be credited to an Ethanol Fund Grant, which provides an eight-year grant to support ethanol manufacturers in Manitoba. The Biodiesel Fund Grant Regulation is a five-year grant program that provides an incentive of 14 cents per litre of biodiesel to support biodiesel production Manitoba. The program started April 1, 2010 and ends March 31, 2015.							
Ontario Ethanol in Gasoline Regulation*	Transportation	CO_2	To reduce GHG emissions from transport sector	Regulatory	Ontario	Implemented	2007	NE
Brief Description	Ontario Regulation 535/05 (Ethanol in Gasoline), requires an annual average of 5% ethanol in gasoline (beginning with calendar year 2007).							
Ontario The Big Move: Transforming Transportation in the Greater Toronto and Hamilton Area*	Transportation		To reduce GHG emissions from the transport sector	Economic	Ontario	Implemented	2008	3,900

Table 3 Progress in Achievement of Quantified Economy-wide Emission Reduction Targets: Mitigation Actions and Their Effects (continued)

Name of Mitigation Action	Sector(s) Affected	GHG(s) Affected	Objective and/or Activity Affected	Type of Instrument	Implementation Entity	Status of Implementation	Start Date of Implementation	Estimate of Mitigation Impact in 2020 (kt CO_2 eq)
Brief Description	This 25-year Regional Transportation Plan aims to improve regional transportation, bolster global competitiveness, protect the environment and enhance quality of life. To date, $16 billion has been committed with projects underway. Ontario's 2013–14 budget allocated $3.4 billion towards public transit infrastructure in the province, a large portion of which was allocated to this plan. Emission reductions for Ontario's transportation sector are combined. Combined estimated mitigation impact of 3.9 Mt applies to initiatives related to: – The Big Move Regional transportation plan and Growth Plan for the Greater Golden Horseshoe – Passenger vehicle efficiency regulations – Freight truck speed limiter regulation – Municipal hybrid bus purchase and Green Commercial Vehicles Program – Ontario ethanol regulation – Other related transportation initiatives							
Quebec Electric Vehicle Action Plan	Transportation		To accelerate the deployment of electric vehicles and related infrastructure	Economic	Quebec	Implemented	2011	NE
Brief Description	The Action Plan aims to have: – 25% of the 2020 sales of new light passenger vehicle be for electric vehicles (plug-in hybrids or all-electric vehicles) – 95% of public transit commuters use vehicles powered by electricity by 2030 – Increase employment in this field from 1,500 to 5,000 by 2020 The Action plan aims to accelerate the deployment of electric vehicles and related infrastructure, such as charging stations, at electrifying Quebec's public transportation system and at supporting Quebec businesses in this field.							
Quebec Public Transit Policy	Transportation		To reduce GHG emissions from the transport sector	Other	Quebec	Planned		NE
Brief Description	Following the success of Quebec's first Public Transit Policy in 2006, which increased ridership by 11% in 2012, a new sustainable mobility policy is being developed and will address land-use planning and transportation, governance and public transit funding, electrification of transportation, regional and rural transportation as well as transit adapted to the needs of persons with disabilities or limited mobility.							
Federal Oil and Gas Sector GHG Regulations	Oil and Gas	TBD	To reduce emissions from the oil and gas sectors in Canada	Regulatory	Environment Canada	Planned	TBD	NE
Brief Description	The Government of Canada is working with provinces to reduce emissions from the oil and gas sectors while ensuring Canadian companies remain competitive.							

Table 3 Progress in Achievement of Quantified Economy-wide Emission Reduction Targets: Mitigation Actions and Their Effects (continued)

Name of Mitigation Action	Sector(s) Affected	GHG(s) Affected	Objective and/or Activity Affected	Type of Instrument	Implementation Entity	Status of Implementation	Start Date of Implementation	Estimate of Mitigation Impact in 2020 (kt CO_2 eq)
British Columbia Flaring and Venting Reduction Guideline	Oil and Gas	CH_4	To reduce flaring and venting in the oil and gas sector; goal is to eliminate all routine flaring by 2016	Regulatory	British Columbia	Implemented	2010	NE
Brief Description	Applies to the flaring, incineration and venting of natural gas at well sites, facilities and pipelines.							
*Alberta Carbon Capture and Storage Funding Act**	Oil and Gas	TBD	To enable government support for carbon capture and storage projects	Economic	Alberta	Implemented	2008	2,800
Brief Description	Enable Alberta to administer funding to support large-scale carbon capture and storage projects.							
Reduction of CO_2 Emissions from Coal-fired Generation of Electricity Regulations*	Electricity	CO_2	To reduce GHG emissions from the coal-fired electricity sector	Regulatory	Environment Canada	Implemented	2015	3,000
Brief Description	Regulations under the *Canadian Environmental Protection Act, 1999* will apply a performance standard to new coal-fired electricity generation units and to old units that have reached the end of their useful life. The performance standard of 420 tonnes CO_2 per gigawatt hour will come into force July 1, 2015. GHG reductions in 2020 are estimated at 3,000 kt CO_2 emissions. The regulations are estimated to result in a net reduction of approximately 214 Mt CO_2 eq GHG over the period 2015–2035.							
ecoENERGY for Renewable Power program*	Electricity	CO_2	To reduce GHG emissions by increasing renewable electricity supply in Canada	Economic	Natural Resources Canada	Implemented	2007	6,240
Brief Description	The program offers an incentive of 1¢ per kilowatt-hour of electricity produced over a period of ten years from a qualifying low-impact renewable energy project built before March 31, 2011.							
British Columbia Clean Energy Act: Clean or renewable electricity requirement	Electricity		To maintain low carbon electricity supply	Regulatory	British Columbia	Implemented	2010	NE
Brief Description	*Clean Energy Act* commits that British Columbia will generate at least 93% of their electricity from clean or renewable sources.							

Table 3 Progress in Achievement of Quantified Economy-wide Emission Reduction Targets: Mitigation Actions and Their Effects (continued)

Name of Mitigation Action	Sector(s) Affected	GHG(s) Affected	Objective and/or Activity Affected	Type of Instrument	Implementation Entity	Status of Implementation	Start Date of Implementation	Estimate of Mitigation Impact in 2020 (kt CO_2 eq)
Manitoba Coal and Petroleum Coke Heating Ban Regulation	Electricity		To reduce GHG emissions from coal and petroleum coke	Regulatory	Manitoba	Implemented	2013	NE
Brief Description	Ban on the use of petroleum coke for space heating effective December 31, 2012. Coal users must submit plans for converting away from coal in June of 2014, plans must be implemented by June 2017. Funds from Manitoba's emissions tax on coal are redirected to support transition from coal to biomass.							
Manitoba *Emissions Tax on Coal Act*	Electricity	CO_2	To reduce GHG emissions from coal in Manitoba	Economic	Manitoba	Implemented	2012	NE
Brief Description	This includes a tax on coal emissions; capital support for coal users to convert to cleaner energy; and support for developing biomass, which is a coal alternative. The *Emissions Tax on Coal Act* came into effect January 2012. The tax is payable by any individual who purchases more than a tonne of coal for use in Manitoba. Different grades of coal are subject to a different tax rate, approximately $10-per-tonne CO_2 eq emissions. The tax will be extended to include petroleum coke.							
Manitoba Coal Fired Emergency Operations Regulation	Electricity	CO_2	To restrict Manitoba Hydro's use of coal	Regulatory	Manitoba	Implemented	2009	NE
Brief Description	This regulation restricts Manitoba Hydro's use of coal to generate power to emergency operations. Manitoba Hydro's last remaining coal-fired facility is located at Brandon Unit # 5 in Brandon, Manitoba.							
Manitoba Geothermal Energy Incentive Program	Electricity	CO_2	To reduce the use of imported natural gas and promote heating and cooling of buildings with renewable geothermal heat pumps	Economic	Manitoba	Implemented	2009	NE
Brief Description	This program offers incentives to residential and commercial building owners for installing geothermal heat-pump systems. Incentives include provincial grants for new houses in natural gas service areas, provincial grants for district geothermal systems, and a Green Energy Equipment Tax Credit.							
Ontario Coal Phase-Out*	Electricity		To reduce GHG emissions from coal-fired electricity generation	Regulatory	Ontario	Implemented	2007	31,600

Table 3 Progress in Achievement of Quantified Economy-wide Emission Reduction Targets: Mitigation Actions and Their Effects (continued)

Name of Mitigation Action	Sector(s) Affected	GHG(s) Affected	Objective and/or Activity Affected	Type of Instrument	Implementation Entity	Status of Implementation	Start Date of Implementation	Estimate of Mitigation Impact in 2020 (kt CO_2 eq)
Brief Description	Ontario mandated the cessation of coal-fired electricity generation by the end of 2014 through a regulatory amendment (O.Reg. 496/07). Ontario has shut down 11 of 19 coal units across five generating stations, with 6 more units to be shut down at the end of 2013, one year ahead of schedule. The Ontario government estimates that this policy will reduce GHG emissions from the electricity sector by up to 30 Mt compared to 2003 levels. Ontario is replacing coal with increased conservation and cleaner energy sources like natural gas, nuclear, solar and wind. Emission reductions for Ontario's electricity sector are combined. The combined estimated mitigation impact of 31.6 Mt applies to initiatives related to Ontario's Long-Term Energy Plan: – coal phase-out – Feed-in-Tariff program – residential, commercial and industrial conservation programs – related electricity policies							
Ontario Feed-in-Tariff*	Electricity		To support the development of renewable and clean energy sources	Economic	Ontario	Implemented	2009	NE
Brief Description	The Feed-in Tariff Program allows individuals and companies to sell renewable energy, like solar, wind, water, biomass, biogas and landfill gas, into the grid at set rates. As of May 2013 about 1,700 projects have been approved, representing over 4,500 megawatts of capacity. This includes over 200 large-scale projects that account for over 4,200 megawatts of capacity. The Feed-in Tariff program was re-launched in December 2012.							
Quebec Energy Strategy	Electricity		To increase renewable electricity generation and energy efficiency	Economic	Quebec	Implemented	2006	NE
Brief Description	The strategy provides for new renewable energy generation (hydroelectricity, wind and bioenergy) by 2015 and an increase in energy efficiency for all types of energy. A new strategy is currently being drafted.							
New Brunswick—*Electricity Act Renewable Portfolio Standard Regulation*	Electricity		To achieve 40% of renewable energy	Regulatory	New Brunswick	Planned	2014	NE
Brief Description	Current Renewable Portfolio Standard is being revised to reflect 40% renewable, consistent with the Energy Blueprint Policy.							
Nova Scotia Greenhouse Gas Emissions Regulations*	Electricity	CO_2, NH_3, N_2O, F_6S, HFCs, PFCs	To reduce GHG emissions from coal energy	Regulatory	Nova Scotia	Implemented	2009	2,500

Table 3 Progress in Achievement of Quantified Economy-wide Emission Reduction Targets: Mitigation Actions and Their Effects (continued)

Name of Mitigation Action	Sector(s) Affected	GHG(s) Affected	Objective and/or Activity Affected	Type of Instrument	Implementation Entity	Status of Implementation	Start Date of Implementation	Estimate of Mitigation Impact in 2020 (kt CO_2 eq)
Brief Description	Nova Scotia has implemented a mandatory declining cap on GHG emissions from Nova Scotia Power Inc., starting at an average of 9.6 Mt over 2010 and 2011 to 7.5 Mt by 2020. In September 2012, the Nova Scotia government and the Canadian federal government published a draft equivalency agreement on coal-fired electricity, which committed Nova Scotia to amend its GHG regulations to require additional reduction requirements for the 2021 to 2030 period. The agreement requires the GHG emissions cap to decline from 7.5 Mt in 2020 to 4.5 Mt in 2030.							
*Efficiency Nova Scotia Corporation Act**	Electricity		To use energy more efficiently	Regulatory	Nova Scotia	Implemented	2009	1,300
Brief Description	The legislation created an independent electricity efficiency administrator called the Efficiency Nova Scotia Corporation. It established a fund that is dedicated to deliver electricity efficiency programs. The Efficiency Nova Scotia Corporation also manages energy efficiency and conservation programs outside of electricity saving measures. Funding comes from a levy on the Nova Scotia electricity rate-payer base and the Province of Nova Scotia.							
Nova Scotia Renewable Electricity Plan*	Electricity		To increase the share of clean energy in the province's energy use	Regulatory	Nova Scotia	Implemented	2010	NE
Brief Description	The Regulations require 25% of electricity supply to be generated from renewable sources by 2015 and 40% by 2020. This will involve the adoption of a diverse mix of energy sources including wind, tidal, solar, hydro and bioenergy.							
Prince Edward Island's Energy Accord	Electricity		To increase Prince Edward Island's reliance on wind power	Voluntary Agreement	Prince Edward Island	Implemented	2011	NE
Brief Description	Prince Edward Island's Energy Accord was released in November 2010 and took effect in March 2011. The Accord is a five-year energy strategy developed by Prince Edward Island in collaboration and partnership with Maritime Electric Company Limited. Its goals are to lower and stabilize electricity rates and increase Prince Edward Island's reliance on locally owned wind power. The Accord contains a number of initiatives including support for an additional 40 megawatts in wind generation. New wind generation is expected to be operational by 2013, at which time 33% of the province's electricity supply would come from wind power.							
Newfoundland and Labrador Green Fund	Electricity	CO_2, CH_3 N_2O	To provide support for climate change initiatives	Fiscal	Newfoundland and Labrador	Implemented	2007	NE
Brief Description	Projects funded through the Green Fund include energy efficiency, small scale wind turbines, biofuels, and waste methane capture.							
Newfoundland and Labrador Muskrat Falls Hydroelectricity project*	Electricity	CO_2, CH_3 N_2O	To increase the share of clean energy in the province's energy use	Economic	Newfoundland and Labrador/ Nalcor Energy in partnership with Emera	Planned	2017	1,200
Brief Description	Once developed, the 824 megawatt Muskrat Falls hydroelectric project will displace oil-fired electricity generation representing over 10% of the province's GHG emissions.							

Table 3 Progress in Achievement of Quantified Economy-wide Emission Reduction Targets: Mitigation Actions and Their Effects (continued)

Name of Mitigation Action	Sector(s) Affected	GHG(s) Affected	Objective and/or Activity Affected	Type of Instrument	Implementation Entity	Status of Implementation	Start Date of Implementation	Estimate of Mitigation Impact in 2020 (kt CO_2 eq)
Northwest Territories Alternative Energy Technologies Program	Electricity		To support conversion to renewable and clean energies	Fiscal	Northwest Territories	Implemented	2007	NE
Brief Description	The program will support Aboriginal and community governments, non-for-profit organizations, commercial businesses, and residents to convert to renewable and clean energies. Technologies eligible for incentives include solar, hot water heating systems, and wind turbines.							
Northwest Territories Energy Efficiency Incentive Program	Electricity		To support upgrades to more energy efficient technologies	Fiscal	Northwest Territories	Implemented	2007	NE
Brief Description	The Energy Efficiency Incentive Program provides rebates for energy efficient appliances, residential retrofits, and new homes ranging from $50 to $4,500.							
Northwest Territories Commercial Energy Conservation and Efficiency Program	Electricity		To support commercial energy and water efficiency	Fiscal	Northwest Territories	Implemented	2011	NE
Brief Description	Eligible small businesses receive free energy audits and 25% of the cost of retrofit expenses up to a maximum of $10,000.							
Northwest Territories Arctic Energy Alliance	Electricity		To educate, raise awareness and help residents of the Northwest Territories adopt energy saving best practices	Education	Northwest Territories	Implemented	2007	NE
Brief Description	Non-profit Arctic Energy Alliance provides free information, advice, incentives and answers to questions from residents of the Northwest Territories on energy efficiency and hosts annual Energy Actions Awards. The Arctic Energy Alliance also conducts energy audits to educate residents on how to reduce home energy consumption.							
British Columbia Building Green Code*	Buildings		To improve energy efficiency in new houses and buildings	Regulatory	British Columbia	Implemented	2008	NE
Brief Description	In September 2008, British Columbia adopted new energy and water efficiency objectives and requirements for all buildings in the British Columbia Building Code. Further efficiency updates to the Code are proposed but not yet adopted.							
LiveSmart BC: Efficiency Incentive Program	Buildings		To support homeowners in improving energy efficiencies of their homes	Economic	British Columbia	Implemented	2008	NE
Brief Description	This program provides incentives for homeowners to improve the energy efficiency of their homes. Since the program was launched in 2008, around $110 million has been invested. This program will end on March 31, 2014.							

Name of Mitigation Action	Sector(s) Affected	GHG(s) Affected	Objective and/or Activity Affected	Type of Instrument	Implementation Entity	Status of Implementation	Start Date of Implementation	Estimate of Mitigation Impact in 2020 (kt CO_2 eq)
Ontario Building Code*	Buildings		To reduce GHG emissions in the buildings sector	Regulatory	Ontario	Implemented	2012	2,900
Brief Description	The Building Code is phasing in higher energy efficiency requirements for new buildings over time, which plays a significant role in limiting greenhouse gas emissions while allowing businesses and residents the flexibility to move forward in a cost-efficient manner. Emission reductions for Ontario's buildings sector are combined. Combined estimated mitigation impact of 2.9 Mt applies to initiatives related to: – The Growth Plan for the Greater Golden Horseshoe – Natural gas demand side management programs – Building Code changes – Other related buildings and cross-cutting initiatives							
Northwest Territories Capital Asset Retrofit Fund	Buildings		To increase building energy system efficiencies in schools and other territorial buildings. Targets benchmarking of healthcare facilities and/or government buildings across the Northwest Territories	Other	Northwest Territories	Implemented	2008	NE
Brief Description	Through energy audits, building surveys and energy benchmarking, buildings are identified and retrofitted to improve their energy efficiency. The program tracks actual financial savings from retrofits and reinvests them into the Capital Asset Retrofit Fund.							
Northwest Territories Initiatives for New Buildings	Buildings		To reduce energy consumption and ensure quality control for buildings in the north	Other	Northwest Territories	Implemented		NE
Brief Description	Initiatives include the development and use of *A Good Building Practice for Northern Facilities* guidebook. The Government of the Northwest Territories Public Works and Services conducts design reviews and engages in energy modelling workshops, public awareness activities related to energy use and conservation and information sharing with other groups and Territories.							
Northwest Territories Housing Corporation Energy Initiatives	Buildings		To achieve higher high energy efficiency and meet Natural Resources Canada's minimum standard	Other	Northwest Territories	Implemented		NE
Brief Description	Three key initiatives include: 1) A draft Retrofit Strategy; 2) The Northern Sustainable Housing Project for the design of a highly efficient building with reduced operating costs and greenhouse gas emissions and; 3) Promoting energy efficiency through the Homeownership Program "Solutions To Educate People".							

Table 3 Progress in Achievement of Quantified Economy-wide Emission Reduction Targets: Mitigation Actions and Their Effects (continued)

Name of Mitigation Action	Sector(s) Affected	GHG(s) Affected	Objective and/or Activity Affected	Type of Instrument	Implementation Entity	Status of Implementation	Start Date of Implementation	Estimate of Mitigation Impact in 2020 (kt CO_2 eq)
Yukon Government Green Building Standards	Buildings		To increase energy efficiency of new buildings within the City of Whitehorse	Regulatory	Yukon	Implemented		NE
Brief Description	Increased minimum insulation values, requirements for a Blower door test on all new construction, and requirements for heat-recovery ventilators.							
Emission-Intensive and Trade-Exposed Sector Regulations	Emissions-Intensive and Trade-Exposed	CO_2 and TBD	To reduce GHG emissions from major-emitting industrial sectors	Regulatory	Environment Canada	Planned	TBD	NE
Brief Description	Sector-specific regulatory approaches are being developed for major-emitting industrial sectors under Canada's sector-by-sector regulatory approach to reducing greenhouse gas emissions. These approaches are currently under development.							
Pulp and Paper Green Transformation Program*	Emissions-Intensive and Trade-Exposed	CO_2, CH_4, N_2O	To improve the environmental performance of Canada's pulp and paper industry in the areas of renewable energy production and energy efficiency	Fiscal	Natural Resources Canada	Implemented	2009	1,360
Brief Description	Operating from June 2009 to March 2012, the $1-billion Pulp and Paper Green Transformation Program provided funding to Canadian pulp and paper companies for capital projects with environmental benefits. Though not specifically designed as a climate change mitigation mechanism, through projects that improved energy efficiency, enabled fuel switching and added capacity to generate renewable electricity, the Pulp and Paper Green Transformation Program generated both direct and indirect GHG emission reductions.							
Saskatchewan Management and Reduction of Greenhouse Gases Regulation	Emissions-Intensive and Trade-Exposed		To reduce GHG emissions from large final emitters	Regulatory	Saskatchewan	Planned	2013	NE
Brief Description	The regulation requires large final emitter facilities that emit over 50,000 tonnes CO_2 to reduce their emissions by 20% by 2020 from a 2006 baseline. Compliance options include payments into a non-profit technology fund only accessible to regulated emitters for low carbon investments. Monies not used can be held in the technology fund for 5 years and then transfers into the Climate Change Foundation which is accessible for climate change related research and development or education, and is available to anyone in the province upon approval of an application.							
Ontario Greenbelt Plan	Agriculture		To permanently protect prime agricultural land and environmentally sensitive areas	Regulatory	Ontario	Implemented	2005	NE

Table 3 Progress in Achievement of Quantified Economy-wide Emission Reduction Targets: Mitigation Actions and Their Effects (continued)

Name of Mitigation Action	Sector(s) Affected	GHG(s) Affected	Objective and/or Activity Affected	Type of Instrument	Implementation Entity	Status of Implementation	Start Date of Implementation	Estimate of Mitigation Impact in 2020 (kt CO_2 eq)
Brief Description	The Greenbelt Plan identifies 1.8 million acres of land where future urbanization should not occur by providing permanent protection for prime agricultural land and environmentally sensitive areas.							
The Ontario Biogas Systems Financial Assistance Program	Agriculture		To support the reduction of GHG emissions from farms	Fiscal	Ontario	Implemented	2008	NE
Brief Description	The program, completed in 2010, successfully led to more than 11 megawatts installed electrical capacity, enough power for 10,000 homes. It supported GHG emission reductions by direct avoidance of emissions from manure storage and offsetting emissions by replacing fossil fuel generated electricity or natural gas.							
The Ontario Ethanol Growth Fund	Agriculture		To support the production of ethanol fuel	Fiscal	Ontario	Implemented	2005	NE
Brief Description	The Fund has helped create an industry with domestic production that is currently at 885 million litres per year, projected to grow to over 1 billion litres per year. Ontario has seven ethanol facilities in place.							
British Columbia Landfill Gas Management Regulation*	Waste	CH_4	To increase methane capture rate at landfills	Regulatory	British Columbia	Implemented	2009	NE
Brief Description	Requires larger municipal solid waste landfills (>1,000 tonnes methane/year) to install approved landfill gas capture systems with a capture rate target of 75%. Regulations will take effect in 2016.							
Manitoba Prescribed Landfills Methane Gas Capture Regulation	Waste	CH_4	To reduce methane emissions from landfills	Regulatory	Manitoba	Implemented	2009	195
Brief description	Regulation 180/2009 pertaining to Manitoba's *Climate Change Emissions and Reduction Act*, in combination with s.15 of the Act, requires Manitoba's three largest landfills—the Eastview Landfill in Brandon, the Brady Landfill south of Winnipeg, and the BFI Canada Prairie Green Landfill—to capture or flare excess methane. The Regulation is expected to result in emissions reductions of 195 kt GHG per year.							
Ontario Landfill Gas Collection*	Waste	CH_4	To reduce GHG emissions from the waste sector	Regulatory	Ontario	Implemented	2008	2,000

Name of Mitigation Action	Sector(s) Affected	GHG(s) Affected	Objective and/or Activity Affected	Type of Instrument	Implementation Entity	Status of Implementation	Start Date of Implementation	Estimate of Mitigation Impact in 2020 (kt CO_2 eq)
Brief Description	In 2008, Ontario introduced regulations requiring all landfills larger than 1.5 million cubic metres to install landfill gas collection and flaring systems. Currently, most of the largest landfills are now collecting landfill gas in Ontario. Emission reductions for Ontario's agriculture and waste sectors are combined. Combined estimated mitigation impact of 2 Mt applies to initiatives related to: – Biogas Financial Assistance Program – Landfill gas capture regulation – Other policies and programs in the waste and agricultural sectors.							
ecoENERGY Efficiency*	Cross-cutting	CO_2, CH_4, N_2O	To improve energy efficiency in Canada	Information, regulatory, and education	Natural Resources Canada	Implemented	2011	6,500
Brief Description	The ecoENERGY Efficiency program: – supports the development and implementation of energy codes, benchmarking tools, training and information materials to improve the energy efficiency of commercial and institutional buildings in Canada; – enables and promotes the construction and retrofit of energy efficient low-rise residential housing through the EnerGuide Rating System, the R-2000 Standard, and ENERGY STAR for New Homes initiatives; – introduces or raises energy efficiency standards for a range of products, and promotes energy-efficient products through the ENERGY STAR initiative; – aids the adoption and implementation of an energy management standard in Canada, accelerates energy-savings investments in industrial facilities and supports the exchange of best-practices information within Canada's industrial sector; and, – provides Canadians with decision-making tools for buying more fuel efficient vehicles including introducing improved vehicle fuel consumption labels. It also provides Canadians and Canada's commercial/institutional fleet sector with information to operate their vehicles to reduce fuel consumption by exposing drivers to fuel-efficient driving techniques. Note: The estimated mitigation impact of 6,500 kt in 2020 only includes energy efficiency impacts associated with policies and measures that occurred since Canada's 5th National Communication and associated in-depth review in 2011. This figure does not include the estimated mitigation impact of 44,750 kt in 2020 resulting from energy efficiency standards published prior to 2011.							
ecoENERGY Innovation Initiative	Cross-cutting	CO_2	To support renewable and clean energy technologies	Fiscal	Natural Resources Canada	Implemented	2011	NE
Brief Description	The Government of Canada has invested $268 million over five years (2011–2016) in renewable energy and clean energy technologies. The objective is to support energy technology innovation to produce and use energy more cleanly and efficiently. The initiative primarily involves research projects; only minor direct GHG emissions reductions are expected.							
ecoENERGY Technology Initiative	Cross-cutting	CO_2	To increase clean energy supply, reduce energy waste, and reduce pollution from conventional energy	Fiscal	Natural Resources Canada	Implemented	2007	200

Table 3 Progress in Achievement of Quantified Economy-wide Emission Reduction Targets: Mitigation Actions and Their Effects (continued)

Name of Mitigation Action	Sector(s) Affected	GHG(s) Affected	Objective and/or Activity Affected	Type of Instrument	Implementation Entity	Status of Implementation	Start Date of Implementation	Estimate of Mitigation Impact in 2020 (kt CO_2 eq)
Brief Description	$230 million investment in science and technology to accelerate the development and market readiness of technology solutions in clean energy. The ecoENERGY Technology Initiative also contributed $7.2 million to the International Energy Agency Greenhouse Gas Research and Development Programme Weyburn-Midale CO_2 Monitoring and Verification Project which studied CO_2 geological storage in depleted oilfields. It was conducted in conjunction with two commercial CO_2-enhanced oil recovery operations near Weyburn, Saskatchewan. Other carbon capture and storage funding through the ecoENERGY Technology Initiative includes Enhance Energy's Alberta Carbon Trunk Line (1.8 Mt CO_2 per year beginning in 2015) and Husky's Lloydminster pilot project (0.1 Mt CO_2 per year since 2011). The latter is expected to result in emissions reductions of up to 200 kt CO_2 per year.							
Carbon capture and storage investment in Canada's Federal Budget 2008*	Cross-cutting	CO_2	To support the SaskPower Boundary Dam clean energy technology project	Fiscal	Government of Canada	Implemented	2014	1,000
Brief Description	As part of Budget 2008, a one-time allocation of $240 million was given towards the SaskPower Boundary Dam carbon capture and storage project which will capture and store up to 1,000 kt CO_2 per year from 2014 onwards for the life of the plant.							
Clean Energy Fund	Cross-cutting	CO_2	To support clean energy technology research, demonstration and development	Fiscal	Natural Resources Canada	Implemented	2009	2,800
Brief Description	The Government of Canada has allocated $317.6 million over five years (2009/10–2013/14) for the demonstration of promising technologies, including large-scale carbon capture and storage projects, and renewable energy and clean energy systems demonstration and research and development projects. The Fund is expected to result in emissions reductions of up to 2,800 kt CO_2 eq per year from 2015 to 2025, and possibly beyond.							
Sustainable Development Technology Canada—Sustainable Development Tech Fund	Cross-cutting	CO_2, CH_4, N_2O	Support for renewable and clean energy technologies as part of a broader mandate to support the development, demonstration and commercialization of clean technologies	Economic	Sustainable Development Technology Canada (Environnent Canada and Natural Resources Canada)	Implemented	2001	NE
Brief Description	The Government of Canada has allocated a total of $915 million to Sustainable Development Technology Canada's Sustainable Development Tech Fund, including an injection of $325 million in Budget 2013. To date, the Sustainable Development Tech Fund has allocated $592 million to support 245 projects across Canada, leveraging an additional $1.5 billion mostly from industry. GHG emissions reductions (as well as other positive environmental outcomes) are an indirect and long-term objective. It is estimated that Sustainable Development Technology Canada's efforts will have resulted in a total cumulative global GHG reduction of 135.8 Mt CO_2 eq by 2020. As of 2012, completed projects are estimated to have yielded a total of 2.1 Mt CO_2 eq.							

Table 3 Progress in Achievement of Quantified Economy-wide Emission Reduction Targets: Mitigation Actions and Their Effects (continued)

Name of Mitigation Action	Sector(s) Affected	GHG(s) Affected	Objective and/or Activity Affected	Type of Instrument	Implementation Entity	Status of Implementation	Start Date of Implementation	Estimate of Mitigation Impact in 2020 (kt CO_2 eq)
ecoENERGY for Aboriginal and Northern Communities	Cross-cutting	CO_2	Reduced GHG emissions in Aboriginal and northern communities	Fiscal	Aboriginal Affairs and Northern Development Canada	Implemented	2011	70
Brief Description	The ecoENERGY for Aboriginal and Northern Communities Program is investing $20 million over five years to support Aboriginal and northern communities, including off-grid communities, to reduce GHG emissions through the integration of proven renewable energy technologies such as residual heat recovery, biomass, geothermal, wind, solar and small hydro. The program provides funding support for the design and construction of renewable energy projects integrated with community buildings, and for the feasibility stages of larger renewable energy projects, thereby displacing natural gas, coal and diesel generation of electricity and heat. The objective of the ecoENERGY for Aboriginal and Northern Communities Program (2011–2016) is to reduce or displace natural gas, coal and diesel generation of electricity thereby reducing greenhouse gas emissions by a projected 1.5 Mt over a 20-year project lifecycle for all projects funded by March 31, 2016. Note: The program funds larger renewable energy projects at the feasibility stages. As a result, it is possible that not all of the funded projects will reach the implementation phase and realize greenhouse gas emission reductions. In some cases, greenhouse gas reductions may be not be realized until after 2020.							
British Columbia Carbon Tax*	Cross-cutting	CO_2, CH_4, N_2O, HFCs, PFCs, SF_6	To introduce a cost for GHG emissions from fossil fuels	Economic	British Columbia	Implemented	2008	3,000
Brief Description	This revenue-neutral tax applies to virtually all fossil fuels, including: gasoline, diesel, natural gas, coal, propane, and home heating fuel. The carbon tax started at a rate based on $10 per tonne of associated carbon or carbon-equivalent emissions, and will rise by $5 each year over the next four years, reaching $30 per tonne in 2012 where it will remain. The revenue generated by this tax is returned to individuals and businesses through reductions to other taxes and other tax credits.							
Carbon Neutral Government of British Columbia	Cross-cutting		To achieve carbon neutrality in government operations	Regulatory	British Columbia	Implemented	2007	NE
Brief Description	The *Greenhouse Gas Reductions Targets Act* required the provincial government, including provincial ministries and agencies, schools, colleges, universities, health authorities and Crown corporations, to become carbon neutral by 2010 and to make public a report every year detailing actions taken towards carbon neutrality. The province has since announced that it achieved carbon neutrality in 2010, 2011 and 2012. Emissions reductions offset market development, outreach, and demonstration.							
Alberta Industrial Regulations*	Cross-cutting		To limit emissions intensity from the industrial sector	Regulatory	Alberta	Implemented	2007	10,000

Table 3 Progress in Achievement of Quantified Economy-wide Emission Reduction Targets: Mitigation Actions and Their Effects (continued)

Name of Mitigation Action	Sector(s) Affected	GHG(s) Affected	Objective and/or Activity Affected	Type of Instrument	Implementation Entity	Status of Implementation	Start Date of Implementation	Estimate of Mitigation Impact in 2020 (kt CO_2 eq)
Brief Description	Industrial facilities that emit more than 100,000 tonnes CO_2 eq are required to reduce their emissions intensity by 12% using a baseline based on past emissions. Regulated facilities have four compliance options: improve the GHG intensity of their operations; buy emissions performance credits from other regulated facilities that achieve reductions beyond their requirement; buy Alberta-based offsets; or pay $15 per tonne CO_2 eq to the Climate Change and Emissions Management Fund. As of 2013, the regulation covers 106 facilities from 15 industrial sectors (about half of Alberta's GHG emissions).							
Alberta Climate Change Emissions Management Fund	Cross-cutting		To promote investments in green projects and technologies	Economic	Alberta	Implemented	2008	700
Brief Description	The Climate Change and Emissions Management Fund invests in projects and technology to reduce GHG emissions in Alberta, including renewable forms of energy and cleaner energy development. Funds come from companies who have chosen to pay for their excess emissions, one of the four compliance options under Alberta's Industrial Regulations. Since 2007, around $400 million has been paid into the clean technology fund, and 182 million has been invested in 48 clean energy projects.							
SaskPower demonstration carbon capture and storage projects*	Cross-cutting		To support the development of carbon capture and storage technology	Fiscal	Saskatchewan	Implemented		NE
Brief Description	Saskatchewan has invested upwards of $17 million in capture and storage projects and projects that reduce flaring. Together with industry and government partners, it has several capture and storage projects underway. The Weyburn-Midale project is the largest capture and storage demonstration site in the world. Saskatchewan is also implementing the approximately $1 billion, 115 megawatt project at Boundary Dam, with a $240 million federal government contribution. Once operational in 2014, the Boundary Dam Project is expected to capture up to 1 Mt CO_2 per year, thereby reducing emissions by 7.2% from 2002 levels.							
Saskatchewan Go Green Fund in Environment	Cross-cutting		To reduce GHG emissions through green initiatives	Fiscal	Saskatchewan	Implemented		NE
Brief Description	Launched as part of the Go Green Plan, this fund invests in projects which reduce or avoid GHG emissions, among other environmental priorities such as water conservation. The 2011 Saskatchewan budget included $17 million in funding to the Go Green Fund and green initiatives funding for Energy and Resources. Previously funded initiatives include the High Wind and Storage Project, which aims to develop wind energy and energy storage technology, and AQUISTORE, which will develop technologies for carbon dioxide storage in saline aquifers.							
Manitoba Biomass Energy Support Program	Cross-cutting	CO_2	To reduce GHG emissions from coal to promote biomass energy	Economic	Manitoba	Implemented	2012	NE

Table 3 Progress in Achievement of Quantified Economy-wide Emission Reduction Targets: Mitigation Actions and Their Effects (continued)

Name of Mitigation Action	Sector(s) Affected	GHG(s) Affected	Objective and/or Activity Affected	Type of Instrument	Implementation Entity	Status of Implementation	Start Date of Implementation	Estimate of Mitigation Impact in 2020 (kt CO_2 eq)
Brief description	This program provides up to $400,000 in grants to encourage coal users to switch to biomass energy products and support the expansion and growth of the biomass energy production industry. It consists of two components: 1) a consumer support component that provides grants of up to $12,000 to coal users to help offset the price differential between coal and biomass products; and 2) a capital component that provides grants of up to $50,000 to help biomass users and processors develop high-quality, renewable biomass products for use in combustion heating systems.							
Ontario *Places to Grow Act*	Cross-cutting		To reduce GHG emissions from land use and transportation	Regulatory	Ontario	Implemented	2005	NE
Brief Description	The Growth Plan for the Greater Golden Horseshoe 2006, is designed to support greater density and transit alternatives. These help limit growing traffic congestion and urban sprawl. The Growth Plan for Northern Ontario, 2011, under the *Places to Grow Act*, 2005, includes policies to incorporate climate change mitigation and adaptation considerations into planning and decision making where appropriate.							
Ontario Provincial Policy Statement	Cross-cutting		To provide policy direction in matters of provincial interest in land use planning and development	Information	Ontario	Implemented	2005	NE
Brief Description	The Provincial Policy Statement guides municipalities in making land use planning decisions that influence transportation, energy demand, and encourages the development of compact communities and the reduction of emissions.							
Ontario Next Generation Jobs Fund	Cross-cutting		To support the development of green technologies	Fiscal	Ontario	Implemented	2007	NE
Brief Description	This fund supports projects related to the development of clean cars, clean fuels, and clean products and technology in Ontario. Projects must demonstrate environmental and economic benefits, including job creation and GHG emissions reduction.							
Ontario Innovation Demonstration Fund	Cross-cutting		To support the development of green technologies	Fiscal	Ontario	Implemented	2006	NE
Brief Description	The Innovation Demonstration Fund supports pilot demonstrations in emerging technologies with a preference towards environmental, alternative energy, bio-products, hydrogen and other green sectors. The Innovation Demonstration Fund helps companies mitigate technological risk and addresses the financing gap that exists between research and development and commercialization.							
Ontario 50 Million Tree Program	Cross cutting		To sequester carbon and improve adaptive capacity of the settled landscape	Fiscal	Ontario	Implemented	2007	NE
Brief Description	This 18 year program, to invest $79 million in the planting of 50 million trees on the settled landscape of southern Ontario that will sequester 6.6 Mt CO_2 by 2050 and help restore forest cover on this highly fragmented landscape.							

Table 3 Progress in Achievement of Quantified Economy-wide Emission Reduction Targets: Mitigation Actions and Their Effects (continued)

Name of Mitigation Action	Sector(s) Affected	GHG(s) Affected	Objective and/or Activity Affected	Type of Instrument	Implementation Entity	Status of Implementation	Start Date of Implementation	Estimate of Mitigation Impact in 2020 (kt CO_2 eq)
Quebec 2013–2020 Climate Change Action Plan and Adaptation Strategy	Cross-cutting		To reduce GHG emissions by 25% compared to 1990 levels in 2020	Regulatory	Quebec	Implemented	2013	NE
Brief Description	The 2013–2020 Climate Change Action Plan has an estimated $3 billion budget over 8 years to finance 30 priorities in the following areas: transport, industry, buildings, land-use planning, research and development, government procurement, energy efficiency, bio-energy, agriculture and waste management. At the heart of the action plan is Québec's cap-and-trade system which allows for the funding of most of its GHG reduction measures through the government sale of emission allowances. This plan takes over from the 2006–2012 action plan.							
Quebec Duty on Non-Renewable Fossil Fuels Payable to the Green Fund*	Cross-cutting	TBD	To reduce emissions from gasoline and other fossil fuels	Regulatory	Quebec	Implemented	2007	NE
Brief Description	A levy that applies to distributors of gasoline and fossil fuel used for energy efficiency purposes. It is calculated based on GHG by type of energy and generates revenues of $200 million a year that are directed to the provincial Green Fund to reduce GHG emissions and improve public transport.							
Quebec's Cap-and-Trade System*	Cross-cutting		Cap-and-trade system	Economic and Regulatory	Quebec	Implemented	2012	NE
Brief Description	One of the key elements of Quebec's approach to climate change is a cap-and-trade system which became effective in January 2012, with a first compliance period starting January 2013. Covered entities primarily include electricity production and distribution and large industrial facilities. In 2015, the system will expand to cover the distribution of fuel used in the transportation, building, and small- and medium-sized business sectors. Quebec and California will formally link their emissions trading schemes in 2014. Quebec anticipates its auction of GHG emission allowances for the fall of 2013 and the first Quebec–California joint auction at the beginning of 2014.							
Development strategy for Quebec's environmental and green technology industry	Cross-cutting		To support research and development as well as businesses in the field of green technology	Information, Research	Quebec	Implemented	2008	NE
Brief Description	In relation to climate change, new energies, energy efficiency, and carbon capture and sequestration among other areas, the strategy aims to: – support industrial research; – help disseminate information on university research projects in green technology; – support technology refinement and demonstration projects; and, – improve environmental certification mechanisms and the implementation of measures to facilitate the execution of demonstration projects.							

Table 3 Progress in Achievement of Quantified Economy-wide Emission Reduction Targets: Mitigation Actions and Their Effects (continued)

Name of Mitigation Action	Sector(s) Affected	GHG(s) Affected	Objective and/or Activity Affected	Type of Instrument	Implementation Entity	Status of Implementation	Start Date of Implementation	Estimate of Mitigation Impact in 2020 (kt CO_2 eq)
New Brunswick Energy Blue Print	Cross-cutting		To improve energy security, affordability and reliability, environmental responsibility, effective regulation	Other	New Brunswick	Implemented	2011	1,300
Brief Description	The policy is a three year plan, with a ten year view and includes five key energy objectives. 13 of the 20 actions relate directly or indirectly to reducing GHG emissions.							
New Brunswick Energy Efficiency Regulation	Cross-cutting		To improve energy efficiency and energy conservation	Regulatory, Education	New Brunswick	Implemented	2005	300
Brief Description	Efficiency New Brunswick is a Crown Corporation Agency established in 2005. Its mandate is to provide advice and solutions to help residents use energy more efficiently, make better energy choices, manage energy expenses and lessen the impact of energy use on the environment, More specifically, the agency's mandate is to: – Promote energy efficiency measures in the residential, community and business sectors; – Develop and deliver programs and initiatives in relation to energy efficiency; – Promote the development of an energy efficiency services industry; – Act as a central resource for the promotion of energy efficiency; and, – Raise awareness of how energy efficiency measures can lead to a more reliable energy supply for New Brunswick.							
New Brunswick's Air Quality Regulations	Cross-cutting		To limit GHG emissions from industrial sectors	Regulatory	New Brunswick	Planned	2014	NE
Brief Description	This sets the context for all industrial sectors operating in the province and includes a strong industrial approvals program which generally incorporates facility level emission caps, as well as monitoring and reporting programs.							
Yukon Government Carbon-Neutrality	Cross-cutting		To achieve carbon neutrality	Regulatory	Yukon	Adopted	2009	NE
Brief Description	The Government of Yukon's 2009 Climate Change Action Plan commits the Yukon Government to cap GHG emissions from its internal operations in 2010, reduce them by 20% by 2015 and become carbon neutral by 2020. It also committed the government to report on these emissions through the Climate Registry and to develop a carbon offset policy for internal operations.							

Table 3 Progress in Achievement of Quantified Economy-wide Emission Reduction Targets: Mitigation Actions and Their Effects (continued)

Name of Mitigation Action	Sector(s) Affected	GHG(s) Affected	Objective and/or Activity Affected	Type of Instrument	Implementation Entity	Status of Implementation	Start Date of Implementation	Estimate of Mitigation Impact in 2020 (kt CO_2 eq)
Yukon Government Sector Specific Targets	Cross-cutting		To minimize growth in overall Yukon emissions	Regulatory	Yukon	Adopted	2012	NE
Brief Description	Building Sector – By 2016, increase the average energy efficiency of new buildings constructed outside of Whitehorse by 25% compared to 2011 standards – By 2020, reduce the emissions intensity of existing buildings across Yukon by 5% – By 2020, meet 20% of government buildings' space heating needs with clean energy sources Transportation Sector – By 2015, reduce emissions from Yukon government light fleet operations by 5% – By 2015, reduce emissions in the transportation sector by 10% Electricity Sector – By 2020, reduce the emission intensity of on-grid diesel power generation by 20% – By 2016, reduce on-grid electrical usage by 5 gigwatts per hour through demand-side management programs Industrial Sector – By 2016, reduce the electrical energy intensity of industrial operations present in 2011 by 15% – By 2014, establish reporting protocols for stationary facilities emitting over 2.5 kt GHG per year							
Nunavut's Energy Strategy	Cross-cutting		To reduce fossil fuel consumption	Other	Nunavut	Adopted	2006	NE
Brief Description	As part of the Energy Strategy, the Nunavut Government stated a goal to reduce the Territory's dependency on imported fuel through conservation and development of renewable energy sources.							

4.B Reporting on Progress

Total Canadian GHG emissions were 737,000 kt CO_2 eq in the base year (2005). By 2011, the latest year of reporting, GHG emissions were 702,000 kt without accounting for a reduction of almost 9,000 kt CO_2 eq from the Land Use, Land-use Change and Forestry (LULUCF) sector. Contributions from the LULUCF sector are quantified for 2010 and 2011 but applied only to the 2020 CO_2 eq emissions total.

Further detail on reductions measures can be found in Chapter 4: Policies and Measures of the 6th National Communication Report as well as the relevant tables within this Biennial Report.

Table 4: Reporting on Progress

Year	Total Emissions Excluding LULUCF (kt CO_2 eq)	Contribution from LULUCF (kt CO_2 eq)	Quantity of Units from Market Based Mechanisms Under the Convention (number of units and kt CO_2 eq)	Quantity of Units from Other Market Based Mechanisms (number of units and kt CO_2 eq)
2005	737,000	NA		
2010	701,000	−2,000		
2011	702,000	−9,000		

NA = Not applicable, numbers rounded to the nearest Mt, 2012 historical estimates are not yet available.

4.C Estimates of Emission Reductions and Removals and the Use of Units from the Markets-Based Mechanisms and Land Use, Land-use Change and Forestry Activities

Overview

The accounting contribution by the LULUCF Sector amounts to credits of 2,400 and 9,100 kt for 2010 and 2011, respectively.[2] The difference in the net LULUCF contribution between 2010 and 2011 is largely due to the changing contribution from Forest Land Remaining Forest Land. The net GHG flux from LULUCF subcategories included in the accounting amounted to emissions of 72,000 and 57,000 kt CO_2 eq for the 2010 and 2011 inventory years, respectively.

Canada's general approach to including LULUCF in accounting

Canada's approach to LULUCF accounting incorporates the Convention categories Forest Land and Cropland, including all land conversion to these categories since 1970, and the conversion of Forest Land to Wetlands and Settlements. The LULUCF subcategories that are reported in Canada's 2013 *National GHG Inventory* submission (NIR 2013) but excluded from the accounting are: Other Land converted to Wetlands (Other Land converted to Flooded Lands), Grassland conversion to Settlements (non-forest land conversion to Settlements in the Canadian North) and Settlements remaining Settlements (urban forests). The notation "NI" in Table 4(a)I of Canada's 1st Biennial Report indicates that a LULUCF category, although reported in the national inventory, is "not included" in the accounting. The exclusion of these categories results in minor differences from the National Inventory estimates.

All of Canada's managed land is Forest Land, Cropland, Grassland, Wetlands or Settlements. The category "Other Land" entirely consists in unmanaged land; thus, its inclusion in the accounting would not be appropriate (notation key "NA" for "not applicable").

The notation "IE" in the last row indicates that estimates of delayed emissions from the pool of wood products from domestic harvest have been "included elsewhere", specifically in the category Forest Land remaining Forest Land (FLFL). Additional explanations on the FLFL and Harvested Wood Products (HWP) categories are provided in the sections concerning "Forest Land Remaining Forest Land" and "Harvested Wood Products."

For all categories except FLFL, the accounting contribution is calculated by subtracting the 2005 (base-year) estimates from the 2010 and 2011 estimates. For FLFL, reference level (RL) accounting is used: the accounting contribution is calculated by subtracting the RL value for any given year from the corresponding inventory FLFL estimate reported. The 2010 and 2011 values for "Base year/period or reference level value" of Table 4(a)I—74,000 and 66,000 kt CO_2 eq respectively—were generated automatically by adding the FLFL RL value to the base year emissions of all other categories. Because Canada uses different accounting rules for different categories, the significance of these numbers is unclear.

Canada's target is formulated for the year 2020 as opposed to a time period; for this reason, a cumulative contribution from LULUCF is "not applicable".

Accounting Framework in Table 4(a)I

Forest Land Remaining Forest Land

The accounting "contribution from LULUCF for reported year" of Table 4(a)I is derived using a RL approach. The contribution is calculated by comparing the RL value for that year to the actual emissions and removals that occurred in that year. The resulting accounting contribution for 2010 is 1,200 kt CO_2 eq (an accounting debit) and, for 2011, −4,800 kt CO_2 eq (an accounting credit).

To derive the RL values Canada has followed the same methodology as that used for the RL for Forest Management (FM) it submitted in 2011, which was subsequently assessed and included in the Annex to Decision 2/CMP.7.[3] Canada's RL was based on a projection for each year from 2010 to 2020, with the RL calculated as the average value for the period 2013–2020. HWPs were included, with the pool starting in 1990, and emissions estimated for historical years and projected based on assumptions about future harvest levels and the use of harvested wood products. In keeping with the focus on anthropogenic emissions and removals, Canada's RL also excluded the impact of natural disturbances, apart from a low, constant background level of fire emissions expected to occur each year.

The RL approach is an internationally accepted, scientifically credible method of accounting for managed forests. Canada will continue to use the RL approach and the assumptions about future harvest levels and the use of harvested wood products integral to the approach, although it is no longer a party to the Kyoto Protocol. The derivation of Canada's RL times series, and the specific values for 2010 and 2011 shown in "Contribution from LULUCF for reported year" of Table 4(a)I, is described below, and reflects the following changes:

a. Canada is now accounting for managed forests using the UNFCCC category of FLFL rather than the activity of FM.
b. Canada's Copenhagen target of reducing emissions 17% below 2005 levels is in relation to 2020, not a commitment period of 2013–2020, as under the Kyoto Protocol. Consequently, the contribution from managed forests in 2020 will be accounted for on the basis of the 2020 value from the RL time series, not the average of values for each year in the 2013–2020 period.
c. Canada has applied a technical correction process to its RL time series for 2010 to 2020 in order to ensure the integrity of the accounting approach, and as a result of revisions and recalculations in its FLFL estimates. The technical correction aims for consistency with good practice as defined by the Intergovernmental Panel on Climate Change (IPCC), although the relevant guidance was not adopted yet at the time of writing this report.

Category definition

Canada has derived the values indicated in Table 4(a) I using the UNFCCC category FLFL. This category includes all land that was converted to forest more than 20 years ago.

The net GHG emissions and removals from FLFL are estimated at 68,000 kt CO_2 eq in 2010 and 54,000 kt CO_2 eq in 2011. These values are derived using the same data and methodologies used to produce FLFL estimates for NIR 2013. While the historical FLFL values in column "Net GHG emissions/removal from LULUCF categories" are identical to estimates in Table 7.5, Chapter 7 of NIR 2013, they are not the same as numbers reported in the Common Reporting Format (CRF) tables because of the treatment of HWPs. In the CRF tables, HWP carbon is assumed to be instantaneously oxidized at the time of harvest. In Table 7.5 the estimates assume a pool of HWP carbon that starts in 1990 from domestically harvested wood and include emissions of carbon from the pool over time.

Reference level

In column "base year/period or reference level value" of Table 4(a)I, the 2010 value of the RL time series is estimated at 67,000 kt CO_2 eq, and for 2011, at 59,000 kt CO_2 eq. These RL values are derived using the same data and methodologies used to produce FLFL estimates for NIR 2013,[4] and differ from the RL values Canada submitted in 2011. This is because the historical data used in developing FLFL inventory estimates and constructing the time series for the RL have been revised and updated since 2011.

The updates and recalculations to the historical data and the methodological improvements are explained in detail in Chapter 7: Land Use, Land-use Change, and Forestry of NIR 2013, including:

a. *Harvest and natural disturbance data updates*: Data for 2010 and 2011 are now available and revisions to official harvest data from 1990 onward were incorporated in NIR 2013. The largest recalculation in NIR 2013 FLFL estimates was for the 2010 inventory year, where official data replaced preliminary harvest estimates. Updated wildfire data that utilized more detailed mapping of areas affected by fires for 2009 and 2010 caused upward recalculations for these years.
b. *Forest conversion updates:* Updated estimates for conversion of forests to other uses were obtained based on digital remote sensing analysis. Forest conversion rates and corresponding emissions decreased for the 1990–1999 time period, while both increased in the 2000–2009 time period. This affects the total land area captured within the FLFL category.
c. *Error corrections:* Errors identified in the implementation of various methodological changes introduced in past NIRs were corrected, namely those related to harvest activities. The error correction with the largest influence on total recalculations was related to a reduced Ontario harvest discount factor, which affected all years prior to 2008.

Implementing these methodological changes and corrections in the calculation of the RL time series is required to maintain the comparability of the FLFL estimates and the RL values, and therefore, the integrity of the accounting approach.[5] Incorporating these changes required a technical correction to the RL time series that Canada submitted in 2011. The technical correction reflects the following:

- Re-estimation of the projected RL time series for 2010–2020 as a result of the above-mentioned updates to the historic data (1990–2009) and methodological changes.
- No changes to the harvest and management assumptions for the 2010–2020 period from the original RL, apart from the correction of an error in treatment of slash burning emissions in one province in 2020.[6]
- No change to the assumption of no natural disturbances used in deriving the RL in the projection period, apart from a low, constant background level of fire emissions (equal to 95,000 hectares).[7] However, as actual disturbance data is now available for 2010 and 2011, the impacts of disturbance in these two years (approximately 2.3 million hectares burned by wildfire) is now included in the RL. In this way, the impact of these natural disturbances is excluded from accounting because the impact is included both in the RL values for 2010 and 2011 and in the FLFL values for those years, and so cancels out in the accounting.

The technical correction is equal to the difference between Canada's original RL (from 2011) and the updated and recalculated RL reflecting the above data updates, methodological improvements and switch to focussing on FLFL. For 2010, the technical correction is estimated at 163.7 megatonnes (Mt) CO_2 eq; for 2011, the correction is 164.4 Mt CO_2 eq. The size of the correction is largely attributable to the inclusion of emissions from natural disturbances—the known emissions for 2010 and 2011 are considerably higher than the low background level of disturbance assumed in the RL (see below). The technical correction is not a result of any changes in policy assumptions for the 2010–2020 period (e.g. harvest rates) from the original RL assumptions.

Breakdown of the technical correction (Mt CO_2 eq)

	2010	2011
Methodological changes	−5.9	−6.9
Data updates	2.9	3.1
Inclusion of actual natural disturbances	166.7	168.2
Technical correction	163.7	164.4

The technical correction is the value that must be added to the original value from the RL time series that Canada submitted in 2011, in order to reflect methodological changes, data updates and actual natural disturbance impacts rather than only a low background level of fire. Positive values indicate the correction reduces the RL sink while negative values indicate the correction increases the RL sink.

Exclusion of natural disturbance impacts

Natural disturbance (fire, insect infestation) impacts are excluded from the accounting for 2010 and 2011, as explained above. The approach Canada has used to calculate a "background level" of natural disturbance is explained in Canada's 2011 RL submission. Detailed, spatially-referenced information on the year, location, and type of natural disturbances excluded from the accounting is available upon request. The modelling approach Canada uses to estimate emissions and subsequent removals associated with natural disturbances is described in Chapter 7, Section 7.3.1 of NIR 2013. Canada's National Forest Carbon Monitoring, Accounting and Reporting System, the same system used to provide FLFL estimates for NIR, is used to estimate the emissions and will be used to identify any subsequent removals from the lands affected by natural disturbances, as well as to monitor lands affected by natural disturbances for salvage logging or subsequent land use change in order to account for any associated emissions.

The excluded natural disturbance impacts are "beyond control" and "not materially influenced" by Canada, as these natural disturbances occur each year in spite of significant and costly efforts to manage disturbance. Canada engages in on-going efforts to prevent, manage and control natural disturbances to the extent practicable. For fires, efforts occur through the Provincial and Territorial Forest Fire Management Agencies, the Canadian Interagency Forest Fire Centre (www.ciffc.ca), and the use of fire information tools. A Canadian Wildland Fire Strategy (see http://www.nrcan.gc.ca/forests/fire/13157) helps guide fire management agencies and research to better mitigate forest fires in Canada. For insects, Canada uses risk analysis and an integrated pest management approach under a National Forest Pest Strategy which provides a venue for sharing knowledge and expertise on pest status, methods, and best practices (see http://www.nrcan.gc.ca/forests/insects-diseases/13361). Canada also engages in efforts to rehabilitate land that has been subject to natural disturbance, where practicable: these efforts are governed by forest regeneration policies that exist in each province and territory.

Cap

Canada does not apply a cap in accounting for FLFL.

Land Converted to Forest Land

The accounting contribution in 2010 is 180 kt CO_2 eq and, in 2011, is 230 kt CO_2 eq (both accounting debits). The contribution is derived using a net-net approach that compares the estimated emissions in the year of interest to the emissions in Canada's base year (2005).

Canada is using the UNFCCC inventory category of Land Converted to Forest Land (LFL), noting that net removals from LFL that are more than 20 years old are captured under FLFL. In any given year, LFL always consists of forest that existed for less than 20 years; as such, it differs from the activity of Afforestation under the Kyoto Protocol, which includes all Forest Land created since 1990.

Historical estimates for LFL and their associated removals are the same as those reported in the CRF table of the NIR 2013. For 2010, reported LFL net removals are estimated at 740 kt CO_2 eq; for 2011, 700 kt CO_2 eq.

The base year (2005) value for LFL is the same as that reported in Canada's NIR 2013.

Cropland

The accounting contribution of the Cropland category for 2010 is −3,500 kt CO_2 eq and, for 2011, −3,900 kt CO_2 eq (both accounting credits). The contribution is calculated by subtracting the net 2005 GHG flux from the values for 2010 and 2011.

The category definitions and the methodologies used to derive the estimates for 2005, 2010 and 2011 are described in NIR 2013. The estimates in the 2nd and 3rd columns of Table 4(a)I are identical to those in the Common Reporting Format tables in NIR 2013 for the corresponding categories and years.

Forest Land converted to Other Land categories

The categories "Wetlands" and "Settlements" of Table 4(a)I include only emissions from the conversion of Forest Land. Forest conversion to Wetlands contributes credits of 490 and 650 kt CO_2 eq in 2010 and 2011 respectively. Meanwhile, Forest conversion to Settlements results in a debit of 150 and a small credit of 12 kt CO_2 eq for 2010 and 2011, respectively. These contributions are derived by subtracting the emissions in Canada's base year (2005) from the estimated emissions in the year of interest.

The category definitions and the methodologies used to derive the estimates for 2005, 2010 and 2011 are described in NIR 2013 (Table 7.1 and Section 7.8). The estimates in "Net GHG emissions/removals from LULUCF categories" and "Base year/period or reference level value" columns of Table 4(a)I are identical to those in the Common Reporting Format tables in NIR 2013 for the corresponding categories and years. As in NIR 2013, all carbon stored in forest products produced in the course of forest conversion is deemed an immediate emission.

Harvested Wood Products

There are significant temporal inaccuracies resulting from a default assumption that all carbon transferred out of forests in wood commodities is emitted immediately. To improve the temporal accuracy of estimates, Canada has developed a country specific model, the Carbon Budget Model Framework for Harvest Wood Products (CBM-FHWP) to monitor and quantify the fate of carbon from domestic harvest, according to the general framework of the production approach (IPCC 2006). For the purpose of this report, in Table 4(a)I the delayed emissions from the Harvested Wood Product pool are included in the FLFL category for the 2010 and 2011 inventory year estimates and the corresponding FLFL reference level values.

In general, the incorporation of the long term carbon storage in HWP changes the temporal pattern of emissions as carbon storage in the HWP pool delays emissions. A comparison of the estimates of net flux from FLFL using both the default instantaneous oxidation approach (IPCC 2003) and the incorporation of HWP using the CBM-FHWP is presented in Table 7-5 of the NIR 2013. More information on Canada's application of the production approach using the CBM-FHWP is provided in section 7.3.1.1 and A3.4.7 of NIR 2013.

Table 4(a) I Progress in Achieving the Quantified Economy-wide Emission Reduction Targets—Further information on mitigation actions relevant to the contribution of the Land Use, Land-use Change and Forestry Sector in 2010

	Net GHG Emissions/ Removals from LULUCF Categories (kt CO_2 eq)	Base Year/Period or Reference Level Value (kt CO_2 eq)	Contribution from LULUCF for Reported Year (kt CO_2 eq)	Cumulative Contribution from LULUCF (kt CO_2 eq)	Accounting Approach
Total LULUCF	**71,788**	**74,189**	**−2,401**	**NA**	
A. Forest land	67,300	65,874	1,426		
Forest land remaining forest land	68,044	66,802	1,242		2010–RL2010
Land converted to forest land	−744	−928	184		2010–2005 BY
Other (please specify)					
B. Cropland	−7,584	−4,100	−3,484		2010–2005 BY
Cropland remaining cropland	−12,879	−10,127	−2,752		
Land converted to cropland	5,296	6,027	−732		
Other (please specify)					
C. Grassland	NI	NI	NI		NI
Grassland remaining grassland					
Land converted to grassland					
Other (please specify)					
D. Wetlands	2,559	3,053	−494		2010–2005 BY
Wetlands remaining wetlands	1,978	2,164	−185		
Land converted to wetlands	580	889	−308		
Other (please specify)					
E. Settlements	9,514	9,363	151		
Settlements remaining settlements	NI	NI	NI		NI
Land converted to settlements	9,514	9,363	151		2010–2005 BY
Other (please specify)					
F. Other land	NA	NA	NA		NA
Other land remaining other land					
Land converted to other land	NA	NA	NA		NA
Other					
G. Other (please specify)					
Harvested wood products	IE	IE	IE		

Abbreviations: LULUCF = Land Use, Land-use Change and Forestry, RL = Reference level, BY = Base year, IE = Included elsewhere, NA = Not applicable, NI = Not included

Table 4(a) I Progress in Achieving the Quantified Economy-wide Emission Reduction Targets—Further information on mitigation actions relevant to the contribution of the Land Use, Land-use Change and Forestry Sector in 2011

	Net GHG Emissions/ Removals from LULUCF Categories (kt CO_2 eq)	Base Year/Period or Reference Level Value (kt CO_2 eq)	Contribution from LULUCF for Reported Year (kt CO_2 eq)	Cumulative Contribution from LULUCF (kt CO_2 eq)	Accounting Approach
Total LULUCF	**57,077**	**66,173**	**−9,096**	**NA**	
A. Forest land	53,296	57,858	−4,562		
Forest land remaining forest land	53,994	58,786	−4,792		2011–RL_{2011}
Land converted to forest land	−697	−928	230		2011–2005 BY
Other (please specify)					
B. Cropland	−7,974	−4,100	−3,873		2011–2005 BY
Cropland remaining cropland	−13,240	−10,127	−3,113		
Land converted to cropland	5,267	6,027	−761		
Other (please specify)					
C. Grassland	NI	NI	NI		NI
Grassland remaining grassland					
Land converted to grassland					
Other (please specify)					
D. Wetlands	2,403	3,053	−649		2011–2005 BY
Wetlands remaining wetlands	1,935	2,164	−229		
Land converted to wetlands	468	889	−420		
Other (please specify)					
E. Settlements	9,351	9,363	−12		
Settlements remaining settlements	NI	NI	NI		NI
Land converted to settlements	9,351	9,363	−12		2011–2005 BY
Other (please specify)					
F. Other land	NA	NA	NA		NA
Other land remaining other land					
Land converted to other land	NA	NA	NA		NA
Other					
G. Other (please specify)	IE	IE	IE		
Harvested wood products	IE	IE	IE		

Abbreviations: LULUCF = Land Use, Land-use Change and Forestry, RL = Reference level, BY = Base year, IE = Included elsewhere, NA = Not applicable, NI = Not included

Section 5 Projections

Between 2005 and 2011, real gross domestic product (GDP) grew at an annual average rate of 1.4%, significantly less than the historical and projected trends due to the economic downturn of 2008. This historical data is available from Statistics Canada's *National Income and Expenditure Accounts*[8] (and CANSIM table 380-0002).[9] Stronger growth trends are assumed after 2011. Between 2011 and 2020, real GDP is expected to increase by 2.1% on average each year. The economic projections to the year 2018 are based on private sector projections from Finance Canada's Private Sector Survey, June 2013.

The outer years are based on Finance Canada's longer-term fiscal projections included in their Labour Productivity Growth is based on Human Resources and Skills Development Canada's employment projections.

The outer years (2018–2030) are based on the Department of Finance's longer-term fiscal projections included in their *Economic and Fiscal Implications of an Aging Population* report.[10] Forecasts of major energy supply projects and prices forecasts are taken from the National Energy Board's preliminary 2013 projections.

Population growth in Canada is assumed to slow from its historical trajectory out to 2030.[11] The Canadian labour force follows an assumed path of diminishing growth, slowing from 17% overall growth in the last decade (2000–2010), to 9% between 2010 and 2020, and to 5% between 2020 and 2030. According to Statistics Canada[12] and Finance Canada,[13] the decline in the labour participation rate is mostly attributable to the growing number of retirees (the "Baby Boomer" generation), increasing life expectancy, and a decline in fertility rates below the replacement level of 2.1 children per woman. Population growth rate assumptions use data provided by Statistics Canada.

Oil and natural gas price and production forecasts were provided by the National Energy Board (preliminary projections 2013).

For further detail on Macroeconomic assumptions, please see Chapter 5, Annex I: Baseline Data and Assumptions, in Canada's 6th National Communication.

Table 5 Summary of Key Variables and Assumptions Used in the Projections Analysis

Key Underlying Assumptions	Historical						Projected			
	1990	1995	2000	2005	2010	2011	2015	2020	2025	2030
Oil Price (C$2010/bbl)	$38.63	$25.75	$39.04	$64.38	$81.87	$97.73	$97.86	$105.42	$108.09	$110.82
Natural Gas Price (C$2010/GJ)	$2.71	$2.49	$5.85	$10.45	$4.77	$4.28	$4.46	$5.29	$5.90	$6.34
Real GDP Chain-Weighted ($1997)*	0.2%	2.8%	5.2%	2.9%	3.2%	2.5%	2.6%	1.6%	1.5%	1.7%
Real GDP Per Capita ($1997)*	−1.3%	1.8%	4.3%	2.0%	2.0%	1.3%	1.5%	0.6%	0.6%	0.9%
Consumer Price Index (1992=100)*	4.8%	2.2%	2.7%	2.2%	1.8%	2.9%	2.0%	2.2%	2.0%	2.1%
Population*	1.5%	1.0%	0.9%	1.0%	1.2%	1.2%	1.1%	1.0%	0.9%	0.8%
Population of Driving Age (18–75)*	1.5%	1.2%	1.2%	1.2%	1.4%	1.3%	1.1%	0.7%	0.6%	0.6%
Labour Force*	1.3%	0.8%	1.7%	0.8%	1.1%	0.9%	1.0%	0.7%	0.5%	0.5%

* Annual growth rate
Abbreviations: C$ = Canadian dollars, bbl = Barrels, GJ = Gigajoule, GDP = Gross domestic product

Table 6(a) Information on Updated Greenhouse Gas Projections Under a 'With Measures' Scenario

Sector	Historical							Projected	
	Base year	1990 (kt CO_2 eq)	1995 (kt CO_2 eq)	2000 (kt CO_2 eq)	2005 (kt CO_2 eq)	2010 (kt CO_2 eq)	2011 (kt CO_2 eq)	2020 (kt CO_2 eq)	2030 (kt CO_2 eq)
Oil and Gas	2005	101,000	124,000	150,000	162,000	164,000	163,000	200,000	241,000
Electricity	2005	94,000	98,000	129,000	121,000	99,000	90,000	82,000	59,000
Transportation	2005	128,000	137,000	155,000	168,000	167,000	170,000	176,000	179,000
Emissions-Intensive & Trade-Exposed Industries	2005	93,000	94,000	85,000	87,000	75,000	78,000	90,000	101,000
Buildings	2005	70,000	76,000	82,000	84,000	79,000	84,000	95,000	110,000
Agriculture	2005	54,000	61,000	66,000	68,000	69,000	68,000	69,000	70,000
Waste & Others	2005	50,000	49,000	51,000	49,000	48,000	49,000	50,000	55,000
LULUCF Emissions[a]		-158,000	130,000	-120,000	-7,000	72,000	57,000	-128,000	-142,000
Gas									
CO_2 emissions including net CO_2 from LULUCF	2005	296,000	590,000	443,000	563,000	607,000	594,000	484,000	512,000
CO_2 emissions excluding net CO_2 from LULUCF	2005	459,000	491,000	565,000	579,000	554,000	555,000	614,000	656,000
CH_4 emissions including CH_4 from LULUCF	2005	75,000	105,000	96,000	104,000	102,000	102,000	87,000	88,000
CH_4 emissions excluding CH_4 from LULUCF	2005	72,000	86,000	94,000	98,000	90,000	91,000	85,000	86,000
N_2O emissions including N_2O from LULUCF	2005	51,000	66,000	50,000	54,000	54,000	53,000	50,000	52,000
N_2O emissions excluding N_2O from LULUCF	2005	49,000	54,000	49,000	50,000	47,000	46,000	49,000	51,000
HFCs	2005	800	500	3,000	5,000	7,000	8,000	13,000	19,000
PFCs	2005	7,000	6,000	4,000	3,000	2,000	2,000	2,000	2,000
SF_6	2005	3,000	2,000	3,000	2,000	400	400	300	400
Totals									

[a] While the historical Forest Land remaining Forest Land (FLFL) values are consistent with information reported in Canada's National Inventory Report (NIR) 2013, they are not the same as numbers reported in the Common Reporting Format (CRF) tables of NIR2013 because of the treatment of harvested wood products (HWPs). In the CRF tables, HWP carbon is assumed to be instantaneously oxidized at the time of harvest. In contrast, all estimates shown in this Table assume a pool of HWP starting in 1990 from domestically harvested wood and include emissions of carbon from the pool over time. The historical FLFL numbers here correspond to numbers shown in Table 7.5 of NIR 2013. Values for 2012 onward use provincial/territorial projections for harvest and assume no natural disturbance impacts except a low background level of fire emissions.

Table 6(a) Information on Updated Greenhouse Gas Projections Under a 'With Measures' Scenario (continued)

Sector	Historical							Projected	
	Base year	1990 (kt CO_2 eq)	1995 (kt CO_2 eq)	2000 (kt CO_2 eq)	2005 (kt CO_2 eq)	2010 (kt CO_2 eq)	2011 (kt CO_2 eq)	2020 (kt CO_2 eq)	2030 (kt CO_2 eq)
Total with LULUCF		433,000	769,000	598,000	730,000	773,000	759,000	635,000	673,000
Total without LULUCF		591,000	639,000	718,000	737,000	701,000	702,000	762,000	815,000
LULUCF Contribution								−28,000	NE
Total with LULUCF Contribution		591,000	639,000	718,000	737,000	701,000	702,000	734,000	NE

Abbreviations: kt CO_2 eq = Kilotonne of carbon dioxide equivalent, LULUCF = Land Use, Land-use Change and Forestry, NE = Not estimated; Totals may not add up due to rounding.

Table 6(a) Notes:

Canadian emission projections point to significant progress that has already been achieved through actions taken by consumers, businesses and governments. 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 (the "without measures" scenario). The projections indicate that further efforts will be required in order to meet the Copenhagen target. Further actions by federal, provincial and territorial governments, as well as actions by individual Canadians and businesses, 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 as well as businesses and individuals to lower their respective emissions.

Due to limitations with the Common Tabular Format (CTF) software, there are some inconstancies in Table 6(a) and 6(b) between the information presented in this report and in the CTF. The information presented here is considered to be an accurate representation of data.

Table 6(b) Information on Updated Greenhouse Gas Projections Under a 'Without Measures' Scenario

	Historical							Projected	
	Base Year	1990 (kt CO_2 eq)	1995 (kt CO_2 eq)	2000 (kt CO_2 eq)	2005 (kt CO_2 eq)	2010 (kt CO_2 eq)	2011 (kt CO_2 eq)	2020 (kt CO_2 eq)	2030 (kt CO_2 eq)
Gas									
CO_2 emissions including net CO_2 from LULUCF	2005	NE	NE	NE	NE	NE	NE	NE	NE
CO_2 emissions excluding net CO_2 from LULUCF	2005	459,000	491,000	565,000	579,000	584,000	577,000	702,000	NE
CH_4 emissions including CH_4 from LULUCF	2005	NE	NE	NE	NE	NE	NE	NE	NE
CH_4 emissions excluding CH_4 from LULUCF	2005	72,000	86,000	94,000	98,000	93,000	93,000	95,000	NE
N_2O emissions including N_2O from LULUCF	2005	NE	NE	NE	NE	NE	NE	NE	NE
N_2O emissions excluding N_2O from LULUCF	2005	49,000	53,700	49,000	50,000	49,000	47,000	50,000	NE
HFCs	2005	800	500	3,000	5,000	7,000	8,000	13,000	NE
PFCs	2005	7,000	5,500	4,000	3,000	2,000	2,000	2,000	NE
SF_6	2005	3,000	2,000	3,000	2,000	500	500	400	NE
Totals									
Total with LULUCF		NE	NE	NE	NE	NE	NE	NE	NE
Total without LULUCF		591,000	639,000	718,000	737,000	735,000	727,000	862,000	NE

Abbreviations: kt CO_2 eq = Kilotonne of carbon dioxide equivalent, LULUCF = Land Use, Land-use Change and Forestry, NE = Not estimated; Totals may not add up due to rounding.

Table 6 (b) Notes:

Progress in reducing GHG emissions is measured against a "without measures" 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 is 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 electric generation sector energy use resulting from non-policy driven factors, including nuclear refurbishment or historical weather-related fluctuations in hydroelectric dam capacities are included in the "without measures" scenario. Oil sands emissions are derived using 2005 emissions intensities. Agriculture emissions from livestock and crop production are maintained at reference scenario levels throughout the entire projection period.

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

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 emissions in 2020 are expected to be 734 Mt (with the contribution from LULUCF). This means that, taken together, actions by consumers, businesses, and federal, provincial and territorial governments have decreased emissions substantially from the "without measures" scenario.

For further information on the "without measures" scenario, including methodologies, please see the "Assessment of Aggregate Effect of Policies and Measures" Section 5.6 of Chapter 5 of Canada's 6th National Communication Report.

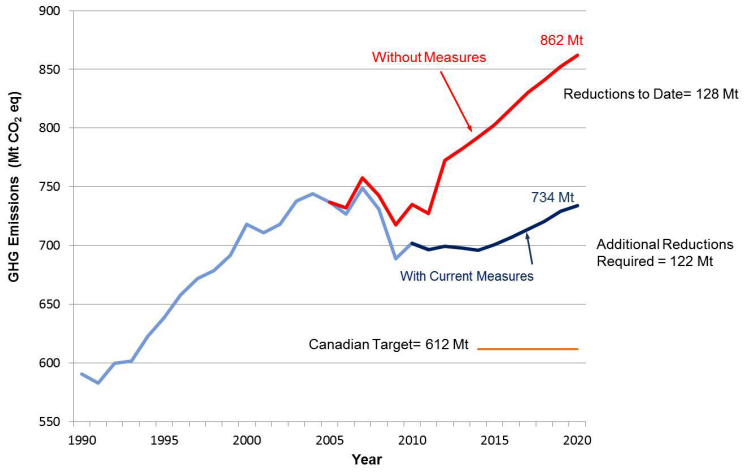

Figure 5.1 Scenarios of Canadian emissions to 2020 (Mt CO_2 eq)

Section 6 Provisions of Financial, Technological and Capacity Building Support to Developing Country Parties

6.A Finance

Developed country parties are required to report on the financial resources they have provided over the last two years in Tables 7, 7.A, and 7.B. These tables provide accurate and transparent information on the type of climate support provided by Canada to developing countries and multilateral agencies. In order to give a full account of Canada's contributions to international climate finance since our last National Communication and the fast-start financing period, Canada is providing information for the past four fiscal years, 2009/10, 2010/11, 2011/12, 2012/13.

Table 7 gives a summary of Canada's climate finance support. Table 7.A provides information on Canada's contributions through multilateral channels and Table 7.B outlines information on Canada's support to bilateral programs.

Funds in the following tables are reported in Canadian dollars in millions. Currency exchange rates are based on data from the Organization for Economic Co-operation Development (OECD), Development Assistance Committee (DAC).

For more information on Canada's financial support to climate change action, please consult Canada's 6th National Communications to the United Nations Framework Convention Climate (UNFCCC) and Canada's May 2013 Fast-Start Financing Submission to the UNFCCC.

You can also consult Canada's Climate Finance website at: http://www.climatechange.gc.ca/finance/default.aspx?lang=en-CA

Effectively Addressing Developing Countries Needs
Through its climate finance, Canada provided extensive support to efforts that effectively address climate

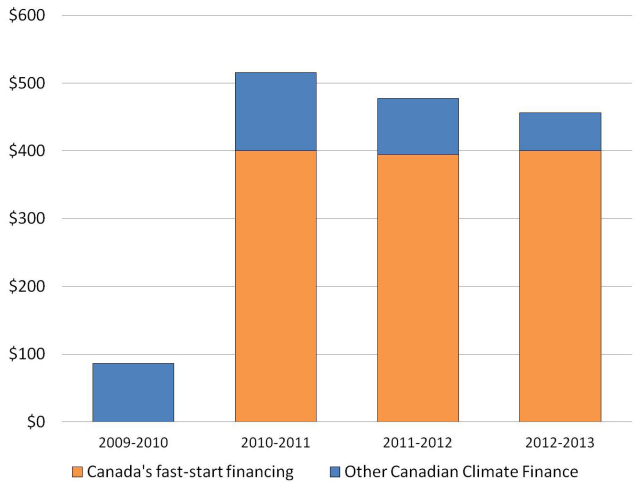

Figure 7.1 Canadian Climate Finance Programming for Fiscal Years 2009–2010 to 2012–2013 (Not including contributions to the Global Environment Facility)

change in developing countries, delivered through a wide range of multilateral, bilateral and partnership channels. Canada responded to priorities identified by bilateral partners in the context of ongoing and longstanding development partnerships that include addressing climate change issues as part of development objectives set by our partners.

Over the last four fiscal years (2009–2010 to 2012–2013), Canada provided over $1.54 billion[14] to support climate change projects through a variety of channels and programs (see figure 6.1). This amount includes $1.2 billion in fast-start financing delivered over the last three fiscal years (2010–2011 to 2012–2013), as well as $350 million[15] of international assistance projects with a direct or significant focus on climate change. Canada also provided over $204 million to support the Global Environment Facility (GEF) in the last four years, of which approximately a quarter came from Canada's fast-start financing. Detailed information on Canada's support to the GEF can be found in table 7A of this Biennial Report.

New and additional resources

Canada's provision and mobilization of financial support is in line with its obligation under the UNFCCC to provide new and additional resources as part of its overall support to help developing countries implement actions to address climate change.

Canada's fast-start financing effort is the prime example of Canadian support that is fully new and additional. Canada provided $1.2 billion in support to projects that were above and beyond what was planned prior to the Copenhagen Accord.

Over the past four years, Canada also responded to priorities identified by bilateral partners in the context of ongoing and longstanding development partnerships that include addressing climate change issues as part of objectives set by its partners. For this support, it is not possible to determine a simple definition under which this programming is new and additional or not, nor is it necessary to do so given the importance of seeking to mainstream climate change results in country-driven programming.

Mobilising Investments

The majority of financing for climate change will come from private sector sources, scaled up climate-focused investment will be a key part of scaled up action on climate change. There are a number of potential barriers to facilitating sufficient private investment, and therefore Canada is actively contributing to international efforts to better understand opportunities for mobilizing private investment.

A large portion of Canada's climate financing over the reporting period was provided to multilateral organizations such as the International Finance Corporation, the Inter- American Development Bank and the Asian Development Bank for the establishment of Canadian facilities targeting the mobilization of climate friendly private-sector investment in developing countries. The first two facilities, at the international Finance Corporation and Inter-American Development Bank, are fully operational and are showing results on the ground.

Projects supported by these Canadian facilities are expected to generate significant environmental benefits and contributed to leveraging investment from the public and private sectors. As of September 2013, out of the $684 million provided to multilateral financial institutions through our fast-start financing, direct project investments using approximately $110 million of the Canadian funding provided has been approved, helping to mobilize over $1.050 billion of public and private sector investment and contributing to achieving annual GHG emission reductions of over 675 kilotonnes carbon dioxide equivalent (Kt CO_2 eq). These facilities achieve an incremental benefit by providing support to projects with measurable, positive climate impacts that require some financing on concessional terms to be viable.

Table 7 Provision of Public Financial Support–Summary Information in 2009–10

2009–10										
Allocation Channels	Domestic Currency (CAD Millions)					USD* (Millions)				
	Core/ General	Climate Specific				Core/ General	Climate Specific			
		Mitigation	Adaptation	Cross-Cutting	Other		Mitigation	Adaptation	Cross-Cutting	Other
Multilateral climate change fund	33.94	0	5.50	0	0	38.73	0	6.28	0	0
Multilateral financial intuitions	0	0	15.00	0	0	0	0	17.12	0	0
Specialized United Nations bodies	0	0	38.50	0	0	0	0	43.93	0	0
Total contributions through bilateral, regional and other channels	0	12.43	15.17	1.41	0	0	14.18	17.31	1.61	0
Total	**33.94**	**12.43**	**74.17**	**1.41**	**0**	**38.73**	**14.18**	**84.64**	**1.61**	**0**

Abbreviations: CAD = Canadian dollars, USD = United States dollars
* Based on OECD/DAC Exchange Rates for fiscal year (FY) 2009/10: 1.141

Table 7 Provision of Public Financial Support–Summary Information in 2010–11

2010–11										
Allocation Channels	Domestic Currency (CAD millions)					USD (millions)*				
	Core/ General	Climate Specific				Core/ General	Climate Specific			
		Mitigation	Adaptation	Cross-Cutting	Other		Mitigation	Adaptation	Cross-Cutting	Other
Multilateral climate change fund	58.58	0	20.00	1.00	0	60.35	0	20.60	1.03	0
Multilateral financial institutions	0	44.50	34.00	291.55	0	0	45.84	35.03	300.35	0
Specialized United Nations bodies	0	0	55.55	0	0	0	0	57.23	0	0
Total contributions through bilateral, regional and other channels	0	1.23	53.76	6.20	0	0	1.27	55.38	6.39	0
Total	**58.58**	**45.73**	**163.31**	**298.75**	**0**	**60.35**	**47.11**	**168.24**	**307.77**	**0**

* Based on OECD/DAC Exchange Rates for FY 2010/11: 1.0302

Table 7 Provision of Public Financial Support–Summary Information in 2011–12

2011–12										
	Domestic Currency (CAD millions)					USD (millions)*				
		Climate Specific					Climate Specific			
Allocation Channels	Core/ General	Mitigation	Adaptation	Cross-Cutting	Other	Core/ General	Mitigation	Adaptation	Cross-Cutting	Other
Multilateral climate change fund	54.75	0.60	0	0.65	0	54.15	0.59	0	0.64	0
Multilateral financial institutions	0	100.00	10.00	225.00	0	0	98.91	9.89	222.55	0
Specialized United Nations bodies	0	0	41.35	0	0	0	0	40.90	0	0
Total contributions through bilateral, regional and other channels	0	2.39	67.90	2.86	0	0	2.37	67.15	2.83	0
Total	**54.75**	**102.99**	**119.25**	**228.51**	**0**	**54.15**	**101.87**	**117.94**	**226.02**	**0**

* Based on OECD/DAC Exchange Rates for FY 2011/12: 0.9891

Table 7 Provision of Public Financial Support–Summary Information in 2012–13

2012–13										
	Domestic Currency (CAD millions)					USD (millions)*				
		Climate Specific					Climate Specific			
Allocation Channels	Core/ General	Mitigation	Adaptation	Cross-Cutting	Other	Core/ General	Mitigation	Adaptation	Cross-Cutting	Other
Multilateral climate change fund	57.29	0	0.99	2.30	0	56.67	0	0.97	2.28	0
Multilateral financial institutions	0	100	0	197.17	0	0	98.91	0	195.02	0
Specialized United Nations bodies	0	15.50	29.14	2.50	0	0	15.36	28.28	2.47	0
Total contributions through bilateral, regional and other channels	0	9.16	81.43	5.02	0	0	9.07	80.50	4.97	0
Total	**57.29**	**124.66**	**111.56**	**206.99**	**0**	**56.67**	**123.34**	**110.34**	**204.74**	**0**

* Based on OECD/DAC Exchange Rates for FY 2012/13: 0.9891

New and additional: Canada's fast-start financing effort is the prime example of Canadian support that is fully new and additional. Canada provided $1.2 billion in support to projects that were above and beyond what was planned prior to the Copenhagen Accord.

Over the past four years, Canada also responded to priorities identified by bilateral partners in the context of ongoing and longstanding development partnerships that include addressing climate change issues as part of objectives set by its partners. For this support, it is not possible to determine a simple definition under which this programming is new and additional or not, nor is it necessary to do so given the importance of seeking to mainstream climate change results in country-driven programming.

Table 7(a) Provision of Public Financial Support–Contribution through Multilateral Channels 2009-10

2009–2010									
	Total Amount (millions)								
	Core/ General		Climate Specific						
Multilateral Organization	CAD	USD	CAD	USD	Status	Funding Source[a]	Financial Instrument	Type of Support	Sector
Multilateral Climate Change Fund									
Global Environment Facility†	33.94	38.73	0	0	Provided	ODA	Grant	Cross-cutting	Cross-cutting
Consultative Group on International Agricultural Research—Research Program on Climate Change, Agriculture and Food Security†	0	0	5.50	6.28	Provided	ODA	Grant	Adaptation	Agriculture
Subtotal	**33.94**	**38.73**	**5.50**	**6.28**					
Multilateral financial institutions, including regional development banks[b]									
Strategic Climate Fund—Pilot Program for Climate Resilience†	0	0	15.00	17.12	Provided	ODA	Grant	Adaptation	Cross-cutting
Specialized United Nations bodies									
World Food Programme—Food for Asset Building—Ethiopia*	0	0	3.00	3.42	Provided	ODA	Grant	Adaptation	Agriculture
World Food Programme—Productive Safety Net Programme—Ethiopia*	0	0	35.50	40.51	Provided	ODA	Grant	Adaptation	Agriculture
Subtotal	**0**	**0**	**38.50**	**43.93**					
Total	**33.94**	**38.73**	**59.00**	**67.33**					

† Contribution targeting the Rio Conventions as a 'principal objective'
* Contribution targeting the Rio Conventions as a 'significant objective'
Abbreviations: ODA = Official development assistance, OOF = Other official flows; USD= United States dollars; CAD = Canadian dollars

[a] Refers to "type of funding" in Canada. For more information on Canada's International Assistance, please consult the Government of Canada's Statistical Report on International Assistance: http://www.acdi-cida.gc.ca/acdi-cida/acdi-cida.nsf/eng/JUD-4128122-G4W

[b] While it is expected that contributions made to multilateral banks will mostly flow to mitigation projects, Canadian support to the International Finance Corporation, the Inter-American Development Bank, and the Asia Development Bank have been reported as supporting "cross-cutting" activities because both adaptation and mitigation projects can receive funding from these facilities. Please refer to Canada's 6th National Communications to the UNFCCC for a more detailed estimation of the expected sectorial breakdown of these contributions and Canadian climate finance overall. More information can also be found on www.climatechange.gc.ca, which should be consulted for the latest information.

Table 7(a) Provision of Public Financial Support–Contribution through Multilateral Channels 2010-11

2010–2011									
Multilateral Organization	Total Amount (millions)				Status	Funding Source	Financial Instrument	Type of Support	Sector
	Core/ General		Climate Specific						
	CAD	USD	CAD	USD					
Multilateral Climate Change Fund									
Global Environment Facility†	58.58	60.35	0	0	Provided	ODA	Grant	Cross-cutting	Cross-cutting
Least Developed Countries Fund†	0	0	20.00	20.60	Provided	ODA	Grant	Adaptation	Agriculture
UNFCCC Trust Fund for Participation†	0	0	1.00	1.03	Provided	ODA	Grant	Cross-cutting	Cross-cutting
Subtotal	**58.58**	**60.35**	**21.00**	**21.63**					
Multilateral financial institutions, including regional development banks[a]									
BioCarbon Fund†	0	0	4.50	4.64	Provided	ODA	Grant	Mitigation	Agriculture
Forest Carbon Partnership Facility—Readiness Fund†	0	0	40.00	41.21	Provided	ODA	Grant	Mitigation	Forests
International Finance Corporation—Canada Climate Change Program†	0	0	271.00	279.18	Provided	ODA	Concessional	Cross-cutting	Energy
International Finance Corporation—Canada Climate Change Program†	0	0	5.83	6.01	Provided	ODA	Grant	Cross-cutting	Energy
International Finance Corporation—Catalyst Fund†	0	0	14.72	15.17	Provided	OOF	Concessional	Cross-cutting	Energy
World Bank—Productive Safety Net Programme—Ethiopia*	0	0	34.00	35.03	Provided	ODA	Grant	Adaptation	Agriculture
Subtotal	0	0	**370.05**	**381.24**					
Specialized United Nations bodies									
World Food Programme—MERET—Ethiopia†	0	0	15.00	15.45	Provided	ODA	Grant	Adaptation	Cross-cutting
World Food Programme—Productive Safety Net Programme—Ethiopia*	0	0	40.55	41.77	Provided	ODA	Grant	Adaptation	Agriculture
Subtotal	**0**	**0**	**55.55**	**57.22**					
Total	**58.58**	**60.35**	**446.6**	**460.09**					

† Contribution targeting the Rio Conventions as a 'principal objective'
* Contribution targeting the Rio Conventions as a 'significant objective'

Table 7(a) Provision of Public Financial Support–Contribution through Multilateral Channels 2011–12

2011–2012									
Multilateral Organization	Total Amount (millions)				Status	Funding Source	Financial Instrument	Type of Support	Sector
	Core/ General		Climate Specific						
	CAD	USD	CAD	USD					
Multilateral Climate Change Fund									
Global Environment Facility†	54.75	54.15	0	0	Provided	ODA	Grant	Cross-cutting	Cross-cutting
Global Alliance for Clean Cookstoves†	0	0	0.60	0.59	Provided	ODA	Grant	Mitigation	Cross-cutting
UNFCCC Trust Fund for Supplementary Activities†	0	0	0.65	0.64	Provided	ODA	Grant	Cross-cutting	Cross-cutting
Subtotal	**54.75**	**54.15**	**1.25**	**1.23**					
Multilateral financial institutions, including regional development banks									
Caribbean Development Bank—Disaster Risk Management†	0	0	10.00	9.89	Provided	ODA	Grant	Adaptation	Cross-cutting
Clean Investment Fund—Clean Technology Fund†	0	0	100.00	98.91	Provided	ODA	Concessional	Mitigation	Energy
Congo Basin Forest Fund†	0	0	20.00	19.78	Provided	ODA	Grant	Cross-cutting	Forestry
Forest Carbon Partnership Facility—Carbon Fund†	0	0	5.00	4.95	Provided	ODA	Grant	Cross-cutting	Forestry
Inter-American Development Bank—Canadian Climate Fund for the Private Sector in the Americas†	0	0	200.00	197.82	Provided	ODA	Concessional	Cross-cutting	Cross-cutting
Subtotal	**0**	**0**	**335.00**	**331.35**					
Specialized United Nations bodies									
International Fund for Agricultural Development†	0	0	19.85	19.63	Provided	ODA	Grant	Adaptation	Agriculture
World Food Programme—Cambodia*	0	0	4.00	3.96	Provided	ODA	Grant	Adaptation	Agriculture
World Food Programme—Productive Safety Net Programme—Ethiopia*	0	0	17.50	17.31	Provided	ODA	Grant	Adaptation	Agriculture
Subtotal	**0**	**0**	**41.35**	**40.09**					
Total	**54.75**	**54.15**	**377.60**	**373.48**					

† Contribution targeting the Rio Conventions as a 'principal objective'
* Contribution targeting the Rio Conventions as a 'significant objective'

Table 7(a) Provision of Public Financial Support–Contribution through Multilateral Channels 2012–13

2012–2013									
Multilateral Organization	Total Amount (millions)				Status	Funding Source	Financial Instrument	Type of Support	Sector
	Core/ General		Climate Specific						
	CAD	USD	CAD	USD					
Multilateral Climate Change Fund									
Global Environment Facility†	57.29	56.67	0	0	Provided	ODA	Grant	Cross-cutting	Cross-cutting
Global Alliance for Clean Cookstoves†	0	0	1.30	1.29	Provided	ODA	Grant	Cross-cutting	Cross-cutting
International Center for Tropical Agriculture—Adaptation Research Fellowship†	0	0	0.50	0.49	Provided	ODA	Grant	Adaptation	Agriculture
International Network for Bamboo and Rattan—Climate Resilience in Ethiopia†	0	0	0.49	0.48	Provided	ODA	Grant	Adaptation	Cross-cutting
UNFCCC Trust Fund for Supplementary Activities†	0	0	1.00	0.99	Provided	ODA	Grant	Cross-cutting	Cross-cutting
Subtotal	**57.29**	**56.67**	**3.29**	**3.25**					
Multilateral financial institutions, including regional development banks									
International Finance Corporation—Catalyst Fund†	0	0	60.28	59.62	Provided	OOF	Concessional	Cross-cutting	Energy
Asian Development Bank—Canadian Climate Fund for the Private Sector in Asia†	0	0	82.39	81.49	Provided	ODA	Concessional	Cross-cutting	Energy
Inter-American Development Bank—Canadian Climate Fund for the Private Sector in the Americas†	0	0	50.00	49.46	Provided	ODA	Concessional	Cross-cutting	Energy
Caribbean Development Bank—Disaster Risk Management†	0	0	4.50	4.45	Provided	ODA	Grant	Adaptation	Cross-cutting
Clean Investment Fund—Clean Technology Fund†	0	0	100.00	98.91	Provided	ODA	Concessional	Mitigation	Energy
Subtotal	**0**	**0**	**297.17**	**293.93**					
Specialized United Nations Bodies									
United Nations Development Programme—Canadian Climate Adaptation Facility†	0	0	16.50	16.32	Provided	ODA	Grant	Adaptation	Cross-cutting
United Nations Development Programme—Mexico†	0	0	2.50	2.47	Provided	ODA	Grant	Cross-cutting	Cross-cutting
United Nations Environment Programme—Climate and Clean Air Coalition†	0	0	13.00	12.89	Provided	ODA	Grant	Mitigation	Cross-cutting
United Nations Environment Programme—Climate Technology Center and Network†	0	0	2.50	2.47	Provided	ODA	Grant	Mitigation	Cross-cutting
World Meteorological Organization—Haiti Weather Services and Global Framework for Climate Services†	0	0	12.64	12.50	Provided	ODA	Grant	Adaptation	Cross-cutting
Subtotal	**0**	**0**	**47.14**	**46.65**					
Total	**57.29**	**56.67**	**347.60**	**343.82**					

† Contribution targeting the Rio Conventions as a 'principal objective'
* Contribution targeting the Rio Conventions as a 'significant objective'

Table 7(b) Provision of Public Financial Support: Contribution through Bilateral, Regional and Other Channels, 2009–10

2009–2010								
Recipient Country/Region	Total Amount (in millions)		Status	Funding Source	Financial Instrument	Type of Support	Sector	Additional Information
	Climate Specific							
	CAD	USD						
Africa*	1.41	1.61	Provided	ODA	Grant	Cross-cutting	Forests	Support for the African Model Forest Initiative through the International Model Forest Network.
Africa†	0.01	0.01	Provided	ODA	Grant	Adaptation	Cross-cutting	Support for climate change adaptation and capacity building in Western Africa.
Africa, Asia, Latin America and the Caribbean, and the Middle East*	0.18	0.21	Provided	ODA	Grant	Adaptation	Agriculture	Support to the Canadian International Food Security Research Fund.
Africa, Asia†	7.75	8.84	Provided	ODA	Grant	Adaptation	Cross-cutting	Support to the International Development Research Centre for adaptation and climate resilience research.
Asia#	11.80	13.46	Provided	OOF	Grant	Mitigation	Energy	Support for clean energy and mitigation projects through the Asia Pacific Partnership.
Bolivia*	0.25	0.29	Provided	ODA	Grant	Adaptation	Water and sanitation	Support to the University du Québec à Montréal for building capacities in community-based eco-development and environmental health in connection with water and sanitation.
Caribbean countries*	1.28	1.46	Provided	ODA	Grant	Adaptation	Cross-cutting	Supporting the implementation of the CARICOM's disaster risk management framework, including the improvement of the capacities of national governments and local communities to respond to and manage natural disasters.
Costa Rica, Dominican Republic, Honduras*	0.15	0.17	Provided	ODA	Grant	Adaptation	Cross-cutting	Support to the Canadian Urban Institute's International Urban Partnerships Program for advancing sustainable economic growth and development in urban regions, consistent with the countries' national development agendas.
Haiti*	2.03	2.32	Provided	ODA	Grant	Adaptation	Cross-cutting	Supporting the rehabilitation of the Artibonite River watershed in the border zone between Haiti and the Dominican Republic.
Honduras*	0.17	0.19	Provided	ODA	Grant	Adaptation	Agriculture	Enhancing food security through improved agricultural productivity, diversity and the promotion of sustainable natural resource management practices.

Table 7(b) Provision of Public Financial Support: Contribution through Bilateral, Regional and Other Channels, 2009–10 (continued)

2009–2010								
Recipient Country/Region	Total Amount (in millions)		Status	Funding Source	Financial Instrument	Type of Support	Sector	Additional Information
	Climate Specific							
	CAD	USD						
Indonesia*	0.50	0.57	Provided	ODA	Grant	Adaptation	Coastal zone management	Enhancing the livelihood security and well-being of vulnerable coastal communities on the west coast of South Sulawesi.
Jamaica, Ethiopia, Philippines*	0.23	0.26	Provided	ODA	Grant	Adaptation	Cross-cutting	Advancing sustainable economic growth and development in urban regions, consistent with the countries' national development agendas.
Latin America*	0.50	0.57	Provided	ODA	Grant	Mitigation	Cross-cutting	Support to the Latin American Energy Organization.
Nigeria†	1.52	1.73	Provided	ODA	Grant	Adaptation	Cross-cutting	Supporting effective climate change governance.
Peru*	0.10	0.11	Provided	ODA	Grant	Adaptation	Cross-cutting	Supporting the development of sustainable management policies and programs.
Philippines†	1.00	1.14	Provided	ODA	Grant	Adaptation	Cross-cutting	Support the improvement of enabling policies and strategic environment for disaster risk reduction.
Senegal, South Africa, Tanzania*	0.13	0.15	Provided	ODA	Grant	Mitigation	Transport	Increasing the capacity of local authorities and their stakeholders to develop integrated long-term sustainability plans.

† Contribution targeting the Rio Conventions as a 'principal objective'
* Contribution targeting the Rio Conventions as a 'significant objective'
# Other climate finance excluding official development assistance
ODA = Official development assistance, OOF = Other official flows; USD = United States dollars; CAD = Canadian dollars

Table 7(b) Provision of Public Financial Support: Contribution through Bilateral, Regional and Other Channels, 2010–11

2010–2011								
Recipient Country/Region	Total Amount (in millions) Climate Specific CAD	Total Amount (in millions) Climate Specific USD	Status	Funding Source	Financial Instrument	Type of Support	Sector	Additional Information
Africa*	1.75	1.80	Provided	ODA	Grant	Cross-cutting	Forests	Support for the African Model Forest Initiative through the International Model Forest Network.
Africa†	1.25	1.21	Provided	ODA	Grant	Adaptation	Cross-cutting	African Adaptation Research Centers Program support (launch costs, communications, research information services to partners, institutional risk assessments, economic analysis training, adaptation finance consultancy).
Africa*	0.06	0.06	Provided	ODA	Grant	Adaptation	Cross-cutting	Support for climate change adaptation and capacity building in Western Africa.
Africa, Asia†	8.28	8.53	Provided	ODA	Grant	Adaptation	Cross-cutting	Support to the International Development Research Centre for adaptation and climate resilience research.
Africa, Asia, Latin America and the Caribbean, and the Middle East*	7.04	7.25	Provided	ODA	Grant	Adaptation	Cross-cutting	Support to the Canadian International Food Security Research Fund.
Asia#	1.20	1.24	Provided	OOF	Grant	Mitigation	Energy	Support for clean energy and mitigation projects through the Asia Pacific Partnership.
Benin†	0.78	0.80	Provided	ODA	Grant	Adaptation	Cross-cutting	Support to the "Initiatives pour un Développement Intégré Durable » for strengthening economic skills and climate change adaptive capacity.
Benin, Bolivia, Burkina Faso, Ethiopia, Honduras, Mali, Nepal, Senegal, East Timor*	1.53	1.58	Provided	ODA	Grant	Adaptation	Agriculture	Support for the Unitarian Service Committee—Seeds of Survival 2010–2015 program.
Bolivia*	0.13	0.13	Provided	ODA	Grant	Adaptation	Water and sanitation	Building capacities in community-based eco-development and environmental health in connection with water and sanitation.
Burkina-Faso†	1.28	1.32	Provided	ODA	Grant	Adaptation	Irrigation	Support to the "Institut International d'Ingénierie de l'Eau et de l'Environnement» for irrigation and climate information.

Table 7(b) Provision of Public Financial Support: Contribution through Bilateral, Regional and Other Channels, 2010–11 (continued)

2010–2011								
Recipient Country/Region	Total Amount (in millions) Climate Specific CAD	Total Amount (in millions) Climate Specific USD	Status	Funding Source	Financial Instrument	Type of Support	Sector	Additional Information
Caribbean countries*	1.60	1.65	Provided	ODA	Grant	Adaptation	Cross-cutting	Supporting the implementation of the CARICOM's disaster risk management framework, including the improvement of the capacities of national governments and local communities to respond to and manage natural disasters.
Congo Basin Region*	0.29	0.30	Provided	ODA	Grant	Adaptation	Cross-cutting	Supporting a fair and sustainable management of natural resources in Congo Basin countries.
Costa Rica, Dominican Republic, Honduras*	0.04	0.04	Provided	ODA	Grant	Adaptation	Cross-cutting	Helping communities restore degraded forests and addressing livelihood issues of local landowners in areas with high levels of rural poverty.
Cuba*	0.10	0.10	Provided	ODA	Grant	Adaptation	Coastal zone management	Enhancing municipal environmental management practices and the quality of life of the communities in coastal zones.
Egypt†	1.16	1.20	Provided	ODA	Grant	Adaptation	Cross-cutting	Support to the University of Alexandria for the establishment of the Alexandria Research Centre for Adaptation to Climate Change.
Ethiopia†	7.35	7.57	Provided	ODA	Grant	Adaptation	Sanitation	Support to the World Health Organization to reduce population health vulnerability and increase resilience to vector-borne tropical diseases.
Ethiopia, Kenya, Sudan, Tanzania†	1.34	1.38	Provided	ODA	Grant	Adaptation	Agriculture and Water	Support to the Sokoine University of Agriculture, Tanzania, for enhancing climate change adaptation in agriculture and water resources (irrigation) in the Greater Horn of Africa.
Ethiopia, Jamaica, Philippines*	0.68	0.70	Provided	ODA	Grant	Adaptation	Cross-cutting	Support to the Sokoine University of Agriculture, Tanzania, for enhancing climate change adaptation in agriculture and water resources (irrigation) in the Greater Horn of Africa.

Table 7(b) Provision of Public Financial Support: Contribution through Bilateral, Regional and Other Channels, 2010–11 (continued)

2010–2011								
Recipient Country/Region	Total Amount (in millions) Climate Specific CAD	USD	Status	Funding Source	Financial Instrument	Type of Support	Sector	Additional Information
Ghana†	1.40	1.44	Provided	ODA	Grant	Adaptation	Cross-cutting	Support to the Regional Institute for Population Studies of the University of Ghana for Climate change adaptation research and capacity development.
Haiti*	1.90	1.96	Provided	ODA	Grant	Adaptation	Cross-cutting	Supporting the rehabilitation of the Artibonite River watershed in the border zone between Haiti and the Dominican Republic.
Haiti†	4.90	5.05	Provided	ODA	Grant	Adaptation	Cross-cutting	Support to Oxfam-Québec, UNDP, and the Center for International Studies and Cooperation for improving local response to climate change impacts, and reducing vulnerability to natural disasters.
Honduras*	5.93	6.11	Provided	ODA	Grant	Adaptation	Agriculture	Enhancing food security through improved agricultural productivity, diversity and the promotion of sustainable natural resource management practices.
Indonesia*	0.99	1.02	Provided	ODA	Grant	Adaptation	Coastal zone management	Enhancing the livelihood security and well-being of vulnerable coastal communities on the west coast of South Sulawesi.
Kenya†	1.12	1.15	Provided	ODA	Grant	Adaptation	Agriculture	Support to the Kenya Agricultural Research Institute for enhancing climate change adaptation research capacity in the agriculture sector.
Lesotho, Malawi, Swaziland†	1.50	1.55	Provided	ODA	Grant	Adaptation	Agriculture	Support to the Food, Agriculture and Natural Resources Policy Analysis Network, South Africa, for linking climate change adaptation to sustainable agriculture in southern Africa.
Latin America*	0.03	0.03	Provided	ODA	Grant	Mitigation	Cross-cutting	Support to the Latin American Energy Organization.
Mali*	0.50	0.52	Provided	ODA	Grant	Adaptation	Agriculture	Supporting the development and rehabilitation of the agricultural irrigation infrastructure.

Table 7(b) Provision of Public Financial Support: Contribution through Bilateral, Regional and Other Channels, 2010–11 (continued)

2010–2011								
Recipient Country/Region	Total Amount (in millions) Climate Specific CAD	Total Amount (in millions) Climate Specific USD	Status	Funding Source	Financial Instrument	Type of Support	Sector	Additional Information
Nigeria†	1.17	1.21	Provided	ODA	Grant	Adaptation	Cross-cutting	Supporting effective climate change governance.
Peru*	0.04	0.04	Provided	ODA	Grant	Adaptation	Cross-cutting	Supporting the development of sustainable management policies and programs.
Philippines*	1.40	1.44	Provided	ODA	Grant	Adaptation	Cross-cutting	Improving the investment climate for sustainable economic growth.
Vietnam†	4.45	4.58	Provided	ODA	Grant	Cross-cutting	Cross-cutting	Supporting the implementation of the National Target Program on climate change.

† Contribution targeting the Rio Conventions as a 'principal objective'
* Contribution targeting the Rio Conventions as a 'significant objective'
# Other climate finance excluding official development assistance

Table 7(b) Provision of Public Financial Support: Contribution through Bilateral, Regional and Other Channels, 2011–12

2011–2012								
Recipient Country/Region	Total Amount (in millions) Climate Specific CAD	Total Amount (in millions) Climate Specific USD	Status	Funding Source	Financial Instrument	Type of Support	Sector	Additional Information
Africa*	2.72	2.69	Provided	ODA	Grant	Cross-cutting	Forests	Support for the African Model Forest Initiative through the International Model Forest Network.
Africa, Asia†	16.1	15.92	Provided	ODA	Grant	Adaptation	Cross-cutting	Support to the International Development Research Centre for adaptation and climate resilience research.
Africa, Asia, Latin America and the Caribbean, and the Middle East *	12.23	12.10	Provided	ODA	Grant	Adaptation	Agriculture	Support for the Canadian International Food Security Research Fund.
Argentina†	1.26	1.25	Provided	ODA	Grant	Adaptation	Water	Support to the Fondacion Bariloche for adaptation to water stress research in the Comahue Region.
Barbados, Guyana, Grenada, Jamaica, Trinidad and Tobago†	1.50	1.48	Provided	ODA	Grant	Adaptation	Water	Support to the University of the West Indies, Barbados, for sustainable water management under climate change in small island states of the Caribbean.

Table 7(b) Provision of Public Financial Support: Contribution through Bilateral, Regional and Other Channels, 2011–12 (continued)

2011–2012								
Recipient Country/Region	Total Amount (in millions) Climate Specific CAD	Total Amount (in millions) Climate Specific USD	Status	Funding Source	Financial Instrument	Type of Support	Sector	Additional Information
Benin, Bolivia, Burkina Faso, Ethiopia, Honduras, Mali, Nepal, Senegal, East Timor*	2.09	2.07	Provided	ODA	Grant	Adaptation	Agriculture	Support for the Unitarian Service Committee—Seeds of Survival 2010–2015 program.
Bolivia*	0.43	0.43	Provided	ODA	Grant	Adaptation	Water and sanitation	Support to the Université du Québec à Montréal for building capacities in community-based eco-development and environmental health in connection with water and sanitation.
Bolivia†	1.08	1.07	Provided	ODA	Grant	Adaptation	Water	Support to Agua Sustentable for strengthening local capacity for adaptation to climate change in the Bolivian Altiplano.
Cambodia†	1.50	1.48	Provided	ODA	Grant	Adaptation	Water	Support to the Cambodia Development Resource Institute for improving water governance and climate change adaptation.
Cambodia, Ghana, Kenya, Mozambique, Zimbabwe*	1.38	1.36	Provided	ODA	Grant	Adaptation	Cross-cutting	Support to the Canadian Hunger Foundation for providing improved food and economic security for communities who are among the poorest and most vulnerable people in their societies.
Caribbean countries*	2.04	2.02	Provided	ODA	Grant	Adaptation	Cross-cutting	Supporting the implementation of the CARICOM's disaster risk management framework, including the improvement of the capacities of national governments and local communities to respond to and manage natural disasters.
Chile†	1.30	1.29	Provided	ODA	Grant	Adaptation	Water	Support to the Centro de Cabio Global, Pontificia Universidad Catolica de Chile,for vulnerability and adaptation to climate variability and change research in the Maipo Basin.

Table 7(b) Provision of Public Financial Support: Contribution through Bilateral, Regional and Other Channels, 2011–12 (continued)

2011–2012								
Recipient Country/Region	Total Amount (in millions) Climate Specific CAD	Total Amount (in millions) Climate Specific USD	Status	Funding Source	Financial Instrument	Type of Support	Sector	Additional Information
Chile, Colombia, Dominican Republic, Mexico†	0.45	0.45	Provided	ODA	Grant	Mitigation	Waste and Landfill	Support to the Center for Clean Air Policy for supporting the development of policy frameworks and projects for waste management, including a series of measures for the whole waste stream that will reduce emissions of short-lived climate pollutants such as black carbon and methane.
China†	1.50	1.48	Provided	ODA	Grant	Adaptation	Water	Support to the Chinese Center for Agricultural Policy of the Chinese Academy of Sciences for water resources and adaptation to climate change research in North China Plains and Poyang Lake Region.
China, Nepal, Pakistan†	1.53	1.51	Provided	ODA	Grant	Adaptation	Water	Support to the Kunming Institute of Botany of the Chinese Academy of Sciences, China, for building effective water governance in the Asian Highlands.
Colombia, Mexico†	1.10	1.09	Provided	ODA	Grant	Mitigation	Energy	Support to the Petroleum Technology Alliance Canada for providing technical advice to countries to help them establish implementable mitigation actions in the Oil and Gas sector, including actions that will significantly reduce emissions of short-lived climate pollutants, notably black carbon and methane.
Congo Basin Region*	0.50	0.49	Provided	ODA	Grant	Adaptation	Cross-cutting	The project supports the implementation of the Central Africa Forests Commission (COMIFAC) Action plan, including supporting a fair and sustainable management of natural resources in Congo Basin countries.

Table 7(b) Provision of Public Financial Support: Contribution through Bilateral, Regional and Other Channels, 2011–12 (continued)

2011–2012								
Recipient Country/Region	Total Amount (in millions)		Status	Funding Source	Financial Instrument	Type of Support	Sector	Additional Information
	Climate Specific							
	CAD	USD						
Congo Basin Region†	0.14	0.14	Provided	ODA	Grant	Cross-cutting	Forests	Support for the Congo Basin Forest Partnership.
Costa Rica, Dominican Republic, Honduras*	0.05	0.05	Provided	ODA	Grant	Adaptation	Cross-cutting	Helping communities restore degraded forests and addressing livelihood issues of local landowners in areas with high levels of rural poverty.
Costa Rica, Guatemala, Nicaragua†	1.48	1.46	Provided	ODA	Grant	Adaptation	Water	Support to the Centro Agronómico Tropical de Investigación y Enseñanza, Costa Rica, for research on the adaption of community-based water supply to a changing climate.
Costa Rica, Mexico, Peru†	0.50	0.49	Provided	ODA	Grant	Mitigation	Housing	Support to the Energy Efficiency Exporters Alliance for providing technical advice to countries to help them establish mitigation actions in the Housing sector.
Cuba*	0.07	0.07	Provided	ODA	Grant	Adaptation	Coastal zone management	Enhancing municipal environmental management practices and the quality of life of the communities in coastal zones.
Dominican Republic, Guatemala†	1.49	1.47	Provided	ODA	Grant	Adaptation	Water	Support to the Centro del Agua del Trópico Húmedo para América Latina y el Caribe, Panamá, for water security and climate change research in Central America and the Caribbean.
Ethiopia*	1.50	1.48	Provided	ODA	Grant	Adaptation	Agriculture	Increasing agricultural productivity for smallholder farmers.
Ethiopia, Jamaica, Philippines*	1.44	1.42	Provided	ODA	Grant	Adaptation	Cross-cutting	Support to the Canadian Urban Institute's International Urban Partnerships Program for advancing sustainable economic growth and development in urban regions, consistent with the countries' national development agendas.

Table 7(b) Provision of Public Financial Support: Contribution through Bilateral, Regional and Other Channels, 2011–12 (continued)

2011–2012								
Recipient Country/Region	Total Amount (in millions) Climate Specific CAD	Total Amount (in millions) Climate Specific USD	Status	Funding Source	Financial Instrument	Type of Support	Sector	Additional Information
Haiti†	2.93	2.90	Provided	ODA	Grant	Adaptation	Cross-cutting	Support for climate change adaptation and local risk management.
Haiti*	0.19	0.19	Provided	ODA	Grant	Adaptation	Cross-cutting	Supporting the rehabilitation of the Artibonite River watershed in the border zone between Haiti and the Dominican Republic.
Honduras†	0.15	0.15	Provided	ODA	Grant	Adaptation	Water	Support to Engineers Canada for building capacity to assess infrastructure vulnerability.
Honduras*	4.70	4.65	Provided	ODA	Grant	Adaptation	Agriculture	Enhancing food security through improved agricultural productivity, diversity and the promotion of sustainable natural resource management practices.
India†	1.50	1.48	Provided	ODA	Grant	Adaptation	Water	Support to the Ashoka Trust for Research in Ecology and the Environment for research on adaption to climate change in urbanizing watersheds.
Indonesia*	1.30	1.29	Provided	ODA	Grant	Adaptation	Coastal zone management	Enhancing the livelihood security and well-being of vulnerable coastal communities on the west coast of South Sulawesi.
Latin America and the Caribbean*	0.21	0.21	Provided	ODA	Grant	Adaptation	Cross-cutting	Improving capacities for energy planning and regulation across countries in the region.
Mali*	0.04	0.04	Provided	ODA	Grant	Adaptation	Agriculture	Support to the Office du Niger for supporting the development and rehabilitation of the agricultural irrigation infrastructure.
Mexico†	0.34	0.34	Provided	ODA	Grant	Mitigation	Cross-cutting	Support for clean energy and mitigation projects through the Commission for Environmental Cooperation.

Table 7(b) Provision of Public Financial Support: Contribution through Bilateral, Regional and Other Channels, 2011–12 (continued)

2011–2012								
Recipient Country/Region	Total Amount (in millions) Climate Specific CAD	Total Amount (in millions) Climate Specific USD	Status	Funding Source	Financial Instrument	Type of Support	Sector	Additional Information
Nicaragua*	1.10	1.09	Provided	ODA	Grant	Adaptation	Cross-cutting	Support to CUSO International and International Coach Federation for supporting sustainable economic growth in rural areas and increase access to safe, nutritious food for poor communities.
Nigeria†	0.61	0.60	Provided	ODA	Grant	Adaptation	Cross-cutting	Supporting effective climate change governance.
Philippines*	0.70	0.69	Provided	ODA	Grant	Adaptation	Cross-cutting	Improving the investment climate for sustainable economic growth.
Thailand†	1.23	1.22	Provided	ODA	Grant	Adaptation	Water	Support to the Faculty of Social Science, Chiang Mai University, for inland aquaculture and adaptation to climate change research in northern Thailand.
Thailand†	1.43	1.41	Provided	ODA	Grant	Adaptation	Water	Support to the Thailand Development Research Institute for improving flood management planning.

† Contribution targeting the Rio Conventions as a 'principal objective'
* Contribution targeting the Rio Conventions as a 'significant objective'

Table 7(b) Provision of Public Financial Support: Contribution through Bilateral, Regional and Other Channels, 2012–13

2012–2013								
Recipient Country/Region	Total Amount (in millions) Climate Specific CAD	Total Amount (in millions) Climate Specific USD	Status	Funding Source	Financial Instrument	Type of Support	Sector	Additional Information
Africa*	3.16	3.13	Provided	ODA	Grant	Cross-cutting	Forests	Support for the African Model Forest Initiative through the International Model Forest Network.
Africa, Asia†	0.15	0.15	Provided	ODA	Grant	Adaptation	Cross-cutting	Support to the World Resources Institute for capacity building in tracking climate finance.
Africa, Asia†	16.05	15.88	Provided	ODA	Grant	Adaptation	Cross-cutting	Support to the International Development Research Centre for adaptation and climate resilience research.

Table 7(b) Provision of Public Financial Support: Contribution through Bilateral, Regional and Other Channels, 2012–13 (continued)

2012–2013								
Recipient Country/Region	Total Amount (in millions)		Status	Funding Source	Financial Instrument	Type of Support	Sector	Additional Information
	Climate Specific							
	CAD	USD						
Africa, Asia, Latin America and the Caribbean, and the Middle East*	10.08	9.97	Provided	ODA	Grant	Cross-cutting	Forests	Support to the Canadian International Food Security Research Fund.
Benin, Bolivia, Burkina Faso, Ethiopia, Honduras, Mali, Nepal, Senegal, East Timor *	2.21	2.19	Provided	ODA	Grant	Adaptation	Agriculture	Support for the Unitarian Service Committee—Seeds of Survival 2010–2015 program.
Bolivia*	0.71	0.70	Provided	ODA	Grant	Adaptation	Water and sanitation	Support to the Université du Québec à Montréal for building capacities in community-based eco-development and environmental health in connection with water and sanitation.
Bolivia, Ethiopia, Ghana, Mali*	1.11	1.10	Provided	ODA	Grant	Adaptation	Cross-cutting	Support to CARE Canada for improving livelihood security and resilience.
Burkina Faso†	2.50	2.47	Provided	ODA	Grant	Adaptation	Agriculture	Improving food security through the sustainable development of agriculture. Support provided to the "union des producteurs agricoles" through the Canada Fund for African Climate Resilience.
Cambodia, Ghana, Kenya, Mozambique, Zimbabwe*	0.73	0.72	Provided	ODA	Grant	Adaptation	Cross-cutting	Support provided to the Canadian Hunger Foundation for providing improved food and economic security for communities who are among the poorest and most vulnerable people in their societies.
Cambodia, Indonesia, Laos, Philippines, Thailand, Vietnam*	2.61	2.58	Provided	ODA	Grant	Adaptation	Cross-cutting	Support to the Asian Development Bank to reduce the impact of disasters on vulnerable populations by providing support to governments and civil society to manage and reduce disaster risk.

Table 7(b) Provision of Public Financial Support: Contribution through Bilateral, Regional and Other Channels, 2012–13 (continued)

2012–2013								
Recipient Country/Region	Total Amount (in millions)		Status	Funding Source	Financial Instrument	Type of Support	Sector	Additional Information
	Climate Specific							
	CAD	USD						
Cameroon†	2.72	2.69	Provided	ODA	Grant	Adaptation	Agriculture	Increasing access to sufficient, nutritious and safe food, and the economic well-being of producers in model forests, and improving climate resilience capacities. Support provided to CUSO International through the Canada Fund for African Climate Resilience.
Caribbean countries*	2.10	2.08	Provided	ODA	Grant	Adaptation	Cross-cutting	Supporting the implementation of the CARICOM's disaster risk management framework, including the improvement of the capacities of national governments and local communities to respond to and manage natural disasters.
Chile†	0.33	0.33	Provided	ODA	Grant	Mitigation	Agriculture	Support to the Instituto de Investigaciones Agropecuarias for the development of a Nationally Appropriate Mitigation Action proposal based on atmospheric carbon capture by soils, and support for research on climate change adaptation.
Chile, Kenya, Mexico	3.30	3.26	Provided	ODA	Grant	Adaptation	Cross-cutting	Building the capacity of protected-area agencies to enhance the resilience to climate change of ecosystems and local communities that depended on them.
Chile, Colombia, Mexico, Dominican Republic†	2.70	2.67	Provided	ODA	Grant	Mitigation	Waste and landfill	Support to the Center for Clean Air Policy for supporting the development of policy frameworks and projects for waste management, including a series of measures for the whole waste stream that will reduce emissions of short-lived climate pollutants such as black carbon and methane.

Table 7(b) Provision of Public Financial Support: Contribution through Bilateral, Regional and Other Channels, 2012–13 (continued)

2012–2013								
Recipient Country/Region	Total Amount (in millions)		Status	Funding Source	Financial Instrument	Type of Support	Sector	Additional Information
	Climate Specific							
	CAD	USD						
Colombia†	0.32	0.32	Provided	ODA	Grant	Mitigation	Risk management	Support to the Corporación Autónoma Regional del Alto Magdalena for the implementation of an environmental education program for risk management to support climate change adaptation.
Colombia, Mexico†	1.90	1.88	Provided	ODA	Grant	Mitigation	Energy	Support to the Petroleum Technology Alliance Canada for providing technical advice to countries to help them establish implementable mitigation actions in the Oil and Gas sector, including actions that will significantly reduce emissions of short-lived climate pollutants, notably black carbon and methane.
Congo Basin Countries*	0.50	0.49	Provided	ODA	Grant	Adaptation	Cross-cutting	The project supports the implementation of the Central Africa Forests Commission (COMIFAC) Action plan, including supporting a fair and sustainable management of natural resources in Congo Basin countries.
Congo Basin Countries†	0.78	0.77	Provided	ODA	Grant	Mitigation	Capacity building	Support to the International Institute for Sustainable Development for capacity building in 10 countries located in the Congo Basin Region to help identify and develop Nationally Appropriate Mitigation Actions.
Congo Basin Region†	1.86	1.84	Provided	ODA	Grant	Cross-cutting	Forests	Support to the Congo Basin Forest Partnership.
Costa Rica, Mexico Peru†	3.00	2.97	Provided	ODA	Grant	Mitigation	Housing	Support to the Energy Efficiency Exporters Alliance for providing technical advice to countries to help them establish mitigation actions in the housing sector.

Table 7(b) Provision of Public Financial Support: Contribution through Bilateral, Regional and Other Channels, 2012–13 (continued)

2012–2013								
Recipient Country/Region	Total Amount (in millions)		Status	Funding Source	Financial Instrument	Type of Support	Sector	Additional Information
	Climate Specific							
	CAD	USD						
Cuba*	0.64	0.63	Provided	ODA	Grant	Adaptation	Cross-cutting	Enhancing municipal environmental management practices and the quality of life of the communities in coastal zones and strengthening local capacities to implement industrial agricultural techniques that reduce the need for imported energy and resources.
Democratic Republic of Congo†	1.75	1.73	Provided	ODA	Grant	Adaptation	Agriculture	Reducing poverty and increasing food self-sufficiency. Support provided to the University of Guelph through the Canada Fund for African Climate Resilience.
Ethiopia†	1.81	1.79	Provided	ODA	Grant	Adaptation	Agriculture	Increasing economic, social and ecological resilience of smallholder Ethiopian farmers to climate change. Support provided to the Canadian Co-operative Association through the Canada Fund for African Climate Resilience.
Ethiopia†	1.87	1.85	Provided	ODA	Grant	Adaptation	Agriculture	Increasing the food security of Ethiopian households. Support provided to the Canadian hunger foundation through the Canada Fund for African Climate Resilience.
Ethiopia*	5.34	5.28	Provided	ODA	Grant	Adaptation	Agriculture	Increasing agricultural productivity for smallholder farmers and supporting market-led approach to development for increased food consumption and higher incomes.
Ethiopia, Jamaica, Philippines*	0.87	0.86	Provided	ODA	Grant	Adaptation	Agriculture	Support to the Canadian Urban Institute's International Urban Partnerships Program for advancing sustainable economic growth and development in urban regions, consistent with the countries' national development agendas.

Table 7(b) Provision of Public Financial Support: Contribution through Bilateral, Regional and Other Channels, 2012–13 (continued)

2012–2013								
Recipient Country/Region	Total Amount (in millions)		Status	Funding Source	Financial Instrument	Type of Support	Sector	Additional Information
	Climate Specific							
	CAD	USD						
Ghana*	1.00	0.99	Provided	ODA	Grant	Adaptation	Agriculture	Supporting climate resilient agriculture capacity building for smallholder farmers.
Ghana†	2.08	2.06	Provided	ODA	Grant	Adaptation	Agriculture	Implementing measures to ensure sustainable access to food and livelihoods. Support provided to Feed the Children through the Canada Fund for African Climate Resilience.
Ghana†	2.10	2.08	Provided	ODA	Grant	Adaptation	Agriculture	Increasing resilience of the vulnerable households to climate change. Support provided to the Canadian Hunger Foundation through the Canada Fund for African Climate Resilience.
Guatemala†	0.66	0.65	Provided	ODA	Grant	Adaptation	Forest	Support to the International Union for Conservation of Nature for reducing socio-environmental vulnerability to climate change.
Haiti†	0.50	0.49	Provided	ODA	Grant	Adaptation	Cross-cutting	Support for climate change adaptation and local risk management.
Haiti*	0.48	0.47	Provided	ODA	Grant	Adaptation	Cross-cutting	Supporting the rehabilitation of the Artibonite River watershed in the border zone between Haiti and the Dominican Republic.
Honduras*	2.87	2.84	Provided	ODA	Grant	Adaptation	Agriculture	Enhancing food security through improved agricultural productivity, diversity and the promotion of sustainable natural resource management practices.
Honduras†	0.60	0.59	Provided	ODA	Grant	Adaptation	Cross-cutting	Support to Engineers Canada for building capacity to assess infrastructure vulnerability.
Indonesia*	1.33	1.32	Provided	ODA	Grant	Adaptation	Coastal zone management	Enhancing the livelihood security and well-being of vulnerable coastal communities on the west coast of South Sulawesi.

Table 7(b) Provision of Public Financial Support: Contribution through Bilateral, Regional and Other Channels, 2012–13 (continued)

2012–2013								
Recipient Country/Region	Total Amount (in millions)		Status	Funding Source	Financial Instrument	Type of Support	Sector	Additional Information
	Climate Specific							
	CAD	USD						
Latin America and the Caribbean*	0.17	0.17	Provided	ODA	Grant	Adaptation	Cross-cutting	Improving capacities for energy planning and regulation across countries in the region.
Mexico†	0.13	0.13	Provided	ODA	Grant	Mitigation	Cross-cutting	Support to Eco Perth for technical support for GHG emission inventory.
Nicaragua*	2.05	2.03	Provided	ODA	Grant	Adaptation	Cross-cutting	Supporting sustainable economic growth in rural areas and increase access to safe, nutritious food for poor communities.
Peru†	0.30	0.30	Provided	ODA	Grant	Adaptation	Capacity building	Support to the United Nations Development Programme for climate change adaptation integration in the poorest communities.
Rwanda†	2.24	2.22	Provided	ODA	Grant	Adaptation	Agriculture	Increasing access to sufficient, nutritious and safe food among those most vulnerable to climate change. Support provided to the Adventist Development and Relief Agency through the Canada Fund for African Climate Resilience.
Senegal†	3.02	2.99	Provided	ODA	Grant	Adaptation	Agriculture	Reducing poverty by improving the ability to adapt to climate change. Support provided to the "Cégep de la Gaspésie et des Îles" through the Canada Fund for African Climate Resilience.
Tanzania†	3.11	3.08	Provided	ODA	Grant	Adaptation	Agriculture	Improving market-led agricultural production and market and processing knowledge. Support provided to World Vision Canada through the Canada Fund for African Climate Resilience.

† Contribution targeting the Rio Conventions as a 'principal objective'
* Contribution targeting the Rio Conventions as a 'significant objective'

7.B Technology Development and Transfer

Canada is committed to a broad range of actions to advance the development and deployment of clean technologies globally. Additional details are included in Canada's 6th National Communication, and some examples are highlighted below. A portion of Canada's fast-start climate change financing has also focused on the development and deployment of clean energy technologies. Additional details of projects and activities funded under Canada's fast-start financing can be found in Chapter 7: Financial Resources and Transfer of Technology of Canada's 6th National Communication, and in Biennial Report Table 7B.

- Canada's RETScreen Clean Energy Project Analysis Software is the world's foremost clean energy decision-making software. It has helped significantly to reduce costs associated with identifying and assessing potential energy projects. It is estimated that RETScreen has helped spur the installation of at least 24 gigawatts of installed clean energy capacity worldwide with a value of approximately $41 billion.
- The Generation IV International Forum (GIF) is an international treaty-supported research and development (R&D) collaboration that is working to develop and promote advanced generation (Generation IV) nuclear-based clean energy systems. Canada provides funding of approximately $4 million annually to support its contributions to GIF collaborative R&D, as well as in-kind support from Canadian national labs and participating university partners.
- Canada supports the United Nations Framework Convention on Climate Change's (UNFCCC) Climate Technology Centre and Network (CTCN). The CTCN will provide tailored advice and technical assistance to developing countries to support the implementation of technology actions for mitigation or adaptation objectives. With a seat on the CTCN advisory board, Canada is actively participating in the development of this key institution.
- Canada led the development of the Global Early Warning System for Wildland Fire under the Global Observation of Forest Cover and Landcover Dynamics (GOFC-GOLD) Fire Implementation Team. This system contributes to the Global Multi-Hazard Early Warning System evolving under the auspices of the United Nations International Strategy for Disaster Reduction. Canada is collaborating with the European Commission's Joint Research Centre to enhance the current system. Regional early warning products using more detailed local data are also in development.
- The Canadian Forest Service undertakes a broad range of cooperation with international partners to advance GHG mitigation and forest management adaptation goals, including activities such as software training and scientific and technical mentoring and guidance in a range of countries.

Table 8 Provision of Technology Development and Transfer Support

Recipient Country and/ or Region	Targeted Area	Measures and Activities Related to Technology Transfer	Sector	Source of the Funding for Technology Transfer	Activities Undertaken By	Status	Additional Information
Global	Mitigation	Development and dissemination of the RETScreen Clean Energy Project Analysis Software.	Energy	Public & private	Public	Implemented	Canada has developed RETScreen, the world's foremost clean energy decision-making software. Additional details are contained in Chapter 7 of Canada's 6th National Communication and at the RETScreen website: www.retscreen.net
China, Euratom (the European Atomic Energy Community), France, Japan, Russia, South Korea, South Africa, Switzerland, and the U.S.	Adaptation	Canada supports international collaboration through the Generation IV-International Forum (GIF). Measures and activities include: workshops, reports, publications, and ongoing collaborative R&D projects.	Energy	Public	Public	Planned	Sharing of knowledge, resources and infrastructure through the GIF, has enabled GIF participants to reduce individual costs and financial risks while enhancing their mutual R&D capabilities.
Global	Mitigation & adaptation	As a member of the Advisory Board (AB) of the Climate Technology Centre and Network (CTCN), Canada supported the operationalization and work of the Centre in 2013.	Other	Public	Public	Implemented	With other AB members, Canada actively engaged in the elaboration of the CTCN's administrative procedures, project prioritization and network membership. These will ensure that the CTCN will strengthen capacity for climate technology transfer; foster collaboration and access to information to accelerate climate technology transfer; and, manage requests from developing countries and deliver responses.

Table 8 Provision of Technology Development and Transfer Support (continued)

Recipient Country and/ or Region	Targeted Area	Measures and Activities Related to Technology Transfer	Sector	Source of the Funding for Technology Transfer	Activities Undertaken By	Status	Additional Information
China, Mexico, Poland, Korea, Australia, Italy, Russia	Mitigation & adaptation	Forest GHG emissions mitigation and forest management. Adaptation: software training and scientific and technical mentoring and guidance.	Other	Public	Public & private	Implemented & Planned	This program will target forest GHG emissions mitigation and forest management adaptation. The Canadian Forest Service undertakes a broad range of cooperation with international partners to advance GHG mitigation and forest management adaptation goals. Additional details are contained in Chapter 7 of Canada's 6th National Communication.
United Nations International Strategy for Disaster Reduction (global), southeast Asia and Southern Africa Regions	Mitigation & adaptation	Canada led the development of the Global Early Warning System for Wildland Fire under the Global Observation of Forest Cover and Landcover Dynamics (GOFC-GOLD) Fire Implementation Team. Current activities include information sessions and a website.	Other	Public	Public	Implemented & planned	Additional details are contained in Chapter 7 of Canada's 6th National Communication.

Capacity Building

Canada undertakes a range of actions to support capacity building for climate change in developing countries. Capacity building needs are also addressed through many of Canada's activities focused on technology development. This includes building capacity through the dissemination of software and tools developed by Canada, the provision of support to help partners effectively use those tools, and research and development collaboration. Additional details are included in Canada's 6th National Communication, and some examples are highlighted below. A portion of Canada's fast-start climate change financing has also focused on developing institutional and technical capacity in developing countries. Additional details of projects and activities funded under Canada's fast-start financing can be found in Chapter 7: Financial Resources and Transfer of Technology of Canada's 6th National Communication, and in Biennial Report Table 7B.

- Canada's RETScreen Clean Energy Project Analysis Software is the world's foremost clean energy decision-making software. It has helped significantly reduce costs associated with identifying and assessing potential energy projects. It is estimated that RETScreen has helped spur the installation of at least 24 gigawatts of installed clean energy capacity worldwide with a value of approximately $41 billion.
- Canada has also developed forest carbon accounting software called the Carbon Budget Model of the Canadian Forest Sector (CBM-CFS3). This forest carbon accounting software, developed by the Canadian Forest Service, helps forest managers meet criteria and indicator reporting requirements for sustainable forest management and forest certification, and understand how their actions affect the net carbon balance of their forest estate.
- Natural Resources Canada has supported Engineers Canada to lead the development of a standardized methodology tool to assess the engineering vulnerability of infrastructure in a changing climate in Canada. After testing in Canada, it was introduced at a regional workshop in Brazil in 2010. Since then, it has been successfully applied in two infrastructure risk assessments, in Costa Rica and Honduras.
- The International Model Forest Network (IMFN) is a global learning network of 60 member Model Forests around the world, which together cover more than 100 million hectares. Canada has hosted the IMFN Secretariat since its inception in 1995, and works with international partners to advance the sustainable management of forest-based landscapes through the Model Forest approach.
- Canada led the development of the Global Early Warning System for Wildland Fire under the Global Observation of Forest Cover and Landcover Dynamics (GOFC-GOLD) Fire Implementation Team. This system contributes to the Global Multi-Hazard Early Warning System evolving under the auspices of the United Nations International Strategy for Disaster Reduction. Canada is collaborating with the European Commission's Joint Research Centre to enhance the current system. Regional early warning products using more detailed local data are also in development.
- The Generation IV International Forum (GIF) is an international treaty-supported R&D collaboration that is working to develop and promote advanced generation (Generation IV) nuclear-based clean energy systems. Canada's participation in collaborative R&D through the GIF facilitates the development of leading edge technology and knowledge through sharing of confidential and protected data, resources and infrastructure, shared training of highly qualified people, and through the undertaking of collaborative research.
- The Clean Energy Ministerial (CEM) is a high-level process focused on clean technology to address climate change. Canada works through the CEM with 22 other governments, including major emerging economies, with the goal of facilitating the transition to a global clean energy economy. Canada is an active participant in four of the CEM's technical initiatives: the Carbon Capture, Use and Storage Action Group; the International Smart Grids Action Network; the Global Superior Energy Performance Partnership;

and the Super-Efficient Equipment and Appliance Deployment Initiative.

- The International Partnership on Energy Efficiency Cooperation (IPEEC) also facilitates capacity building in the area of energy efficiency, promoting information exchange on best practices. Canada participates in both the Executive and Policy Committees of IPEEC. Canada is the current IPEEC Policy Committee Chair.
- Canada supports the UNFCCC's CTCN, which will play a key role in supporting capacity building in developing countries. Canada made a $2.5 million fast-start financing contribution to support CTCN, which will provide tailored advice and technical assistance to developing countries to support the implementation of technology actions for mitigation or adaptation objectives. Canada's contribution will support start-up costs of the Centre as well as specific capacity-building activities. Canada also sits on the advisory board of the CTCN.

Table 9 Provision of Capacity-building Support

Recipient Country/Region	Targeted Area	Program or Project Title	Description of Program or Project
Global	Multiple areas	RETScreen Clean Energy Project Analysis Software	World's leading clean energy decision-making software and has helped significantly reduce costs associated with identifying and assessing potential clean energy projects. Provided to users free-of-charge and in multiple languages, and includes comprehensive training materials. More information available at www.retscreen.net
China	Multiple areas	Carbon Budget Model of the Canadian Forest Sector (CBM-CFS3) Technology Transfer	CBM-CFS3 Training Workshop and project planning, scientific and technical guidance.
Mexico	Multiple areas	Carbon Budget Model of the Canadian Forest Sector (CBM-CFS3) Technology Transfer	Potential CBM-CFS3 Training Workshop. Guidance with estimation of Land Use, Land-use Change and Forestry (LULUCF) GHG emissions and removals, development of measuring reporting and verification system and related reducing emissions from deforestation and forest degradation (REDD+) activities.
Poland	Multiple areas	Carbon Budget Model of the Canadian Forest Sector (CBM-CFS3) Technology Transfer	Planning CBM-CFS3 Workshop and project meetings. Scientific and technical guidance.
Republic of Korea	Multiple areas	Carbon Budget Model of the Canadian Forest Sector (CBM-CFS3) Technology Transfer	Scientific and technical guidance.
China, Euratom (the European Atomic Energy Community), France, Japan, Russia, South Korea, South Africa, Switzerland, and the United States	Adaptation & Technology development and transfer	Generation IV International Forum	The Generation IV International Forum is a treaty-supported international collaboration that includes several developing and developed countries The Forum supports the establishment and sharing of existing and new knowledge and infrastructure needed for the development of advanced nuclear-based clean energy systems with enhanced safety, improved sustainability, improved economics and enhanced proliferation resistance and physical protection.

Table 9 Provision of Capacity-building Support (continued)

Recipient Country/Region	Targeted Area	Program or Project Title	Description of Program or Project
Latin America, South-East Asia, Central and North Africa	Multiple areas	International Model Forest Network	The International Model Forest Network (IMFN) is a global learning network whose members work toward a common goal: the sustainable management of forest-based landscapes through the Model Forest approach. The IMFN is comprised of 60 Model Forests around the world, which together cover more than 100 million hectares. Canada has hosted the IMFN Secretariat since its inception in 1995. During the reporting period, Canada provided targeted support for climate change initiatives in Model Forests which focused on: 1) Forest management through reforestation and applied research on climate change impacts on forests; 2) Capacity building through research extension and, communications activities to increase awareness of the need to adapt to the impacts of climate change; and, 3) The development and ground-truthing of policy options based on research conducted in Model Forests.
Association of Southeast Asia Nations, Southern Africa Development Community	Multiple areas	GOFC-GOLD Global Early Warning System for Wildland Fire	Global and regional systems developed collaboratively with various government agencies; ongoing consultation and advice.
International Partnership for Energy Efficiency Cooperation Members: G8 countries, the European Commission, Australia, Brazil, China, India, Mexico and South Korea	Multiple areas	International Partnership for Energy Efficiency Cooperation	The International Partnership for Energy Efficiency Cooperation aims to promote information exchange on best practices and facilitate initiatives to improve energy efficiency. Canada transfers its policy, program and technology-related best practices via Committee discussions and through its participation in two task groups—the Super-efficient Equipment and Appliance Deployment Initiative and the Global Superior Energy Performance initiative. Canada's specific expertise related to minimum energy performance standards, energy labelling and industrial capacity building have been shared.
Various	Technology development and transfer	Carbon Capture Use and Storage Action Group—Clean Energy Ministerial	The Carbon Capture Use and Storage Action Group aims to create greater political momentum to advance the level of carbon capture and storage deployment required to meet the global GHG mitigation challenge.
Non-Annex I members of the Global Superior Energy Performance Initiative	Technology development and transfer	Global Superior Energy Performance Initiative	Canada actively participates on Global Superior Energy Performance Initiative Energy Management Working Group, which aims to pursue continuous improvements in energy performance, primarily through sharing information, the development of tools, reporting mechanisms, common accreditation systems, resources and credentialing processes. To date, Canada's participation in the Initiative has been in-kind, including the implementation of three ISO 50001 Energy Management Systems Standard pilot projects, as well as commitments to share expertise and information.

Table 9 Provision of Capacity-building Support (continued)

Recipient Country/Region	Targeted Area	Program or Project Title	Description of Program or Project
When operational, developing countries will be the recipient of the Climate Technology Centre and Network's assistance.	Multiple areas	Canada's support for the Climate Technology Centre and Network. As a member of the Advisory Board of the Climate Technology Centre and Network, Canada supported the operationalization and work of the Centre in 2013.	Canada has also made a $2.5 million fast-start financing contribution to support the United Nations Framework Convention on Climate Change's Climate Technology Centre and Network. The Network will provide tailored advice and technical assistance to developing countries to support the implementation of technology actions for mitigation or adaptation objectives. Canada also sits on the Advisory Board of the Climate Technology Centre and Network, thereby supporting the operationalization and work of the Centre.

References

1 *Canada's National Inventory Report: Greenhouse Gas Sources and Sinks in Canada 1990–2011* is available online at: http://www.ec.gc.ca/ges-ghg

2 In this explanatory text, estimates referring to Table 4(a)I are expressed in kt CO_2 eq, and rounded to two significant figures.

3 Canada's 2011 Submission of its Forest Management Reference Level can be accessed on the UNFCCC website portal: http://unfccc.int/files/meetings/ad_hoc_working_groups/kp/application/pdf/canada_frml_en.pdf

4 See Section 7.3 of Canada's 2013 National Inventory Report. Like the historical FLFL estimates shown in Table 7.5 of the National Inventory Report, the RL assumes a pool of HWP carbon starts in 1990 from domestically harvested wood and includes emissions of carbon from the pool over time.

5 Canada's shift to the use of FLFL as the basis for accounting is treated as a methodological change.

6 The RL included in 2/CMP.7 mistakenly excluded the emissions associated with slash burning in British Columbia in 2020, although slash burning emissions were included for the province in every other year, and were included for other provinces for all years including 2020. This error has been corrected in the updated RL.

7 This low, constant level of natural disturbance is based on the assumption that 95,000 hectares of managed forest will burn each year, based on data from the past 51 years (1959–2009), which shows that at least this amount burned during 90% of the years. Using this approach, Canada has ensured that the RL has been derived without the expectation of net debits or credits.

8 Statistics Canada [internet database]. 2002–2008. National income and expenditure accounts, quarterly estimates. Available online at: http://www5.statcan.gc.ca/bsolc/olc-cel/olc-cel?catno=13-001-X&CHROPG=1&lang=eng

9 Statistics Canada [internet database]. 2012. CANSIM Table 380-0002 Gross domestic product (GDP), expenditure-based, quarterly. http://www5.statcan.gc.ca/cansim/a26?lang=eng&retrLang=eng&id=3800002&paSer=&pattern=&stByVal=1&p1=1&p2=49&tabMode=dataTable&csid=

10 Finance Canada, 2012. Economic and fiscal implications of Canada's aging population. Ottawa (ON): Department of Finance Canada. http://www.fin.gc.ca/pub/eficap-rebvpc/index-eng.asp

11 Statistics Canada [internet database]. 2010. Population projections for Canada, provinces and territories. catalogue no. 91-520-XWE. Available online at: http://www5.statcan.gc.ca/bsolc/olc-cel/olc-cel?catno=91-520-XWE&lang=eng

12 Statistics Canada, Canadian Economic Observer, Vol. 24, no. 6 (11-010-x, free) June 2011. Available online at: http://www.statcan.gc.ca/daily-quotidien/110817/dq110817b-eng.htm

13 Finance Canada, 2012. Economic and fiscal implications of Canada's aging population. Ottawa (ON): Department of Finance Canada. http://www.fin.gc.ca/pub/eficap-rebvpc/index-eng.asp

14 All figures are in Canadian dollars unless otherwise stated.

15 Including over $112 million of contributions made to projects with a primary focus on climate change (i.e. marked as targeting the Conventions as a 'principal objective' under the OECD/DAC Rio markers), and over $236 million to projects with a significant climate change component (i.e., marked as targeting the Conventions as a 'significant objective' under the OECD/DAC Rio markers). Canada has not included every contribution reported as targeting the Conventions as a 'significant objective' under the OECD/DAC Rio markers to ensure this report focusses on the most relevant contributions to climate action. For example, core contributions made to multilateral organizations are not reported on in this report.