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Canada

CANADA'S 7TH NATIONAL COMMUNICATION AND 3RD BIENNIAL REPORT

Canada's Seventh National Communication on Climate Change and Third Biennial Report—Actions to meet commitments under the United Nations Framework Convention on Climate Change

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Minister's Message

As Canada's Environment and Climate Change Minister, I am pleased to submit Canada's *7th National Communication* and *3rd Biennial Report* to the United Nations Framework Convention on Climate Change (UNFCCC).

In the two years since our last Biennial Report to the UNFCCC, Canada has taken significant steps to advance action on climate change and clean growth, both at home and abroad.

In December 2016, the Prime Minister and Provincial and Territorial Premiers adopted Canada's clean growth and climate plan to take ambitious action to fight climate change, build resilience to the changing climate, and drive clean economic growth. A landmark achievement, the Pan-Canadian Framework on Clean Growth and Climate Change is the first climate change plan in Canada's history to include joint and individual commitments by federal, provincial and territorial governments and to have been developed with input from Indigenous Peoples. The Pan-Canadian Framework outlines more than 50 concrete measures to reduce carbon pollution, help the country adapt to the impacts of a changing climate, foster clean technology solutions, and create good jobs that contribute to a stronger economy.

We have covered considerable ground since launching Canada's clean growth and climate plan just over one year ago. Now, we're starting to see results. Our plan includes a pan-Canadian approach to pricing carbon pollution, as well as measures to reduce emissions across all sectors of the economy that put Canada on the path to meet our Paris Agreement target to reduce emissions 30 percent below 2005 levels by 2030. We are determined to meet or exceed that 2030 goal.

Based on our updated greenhouse gas projections included in this report, we have taken great strides towards our target. But of course, much work remains.

We have laid out a comprehensive plan for ourselves, and are now implementing it, along with an ambitious suite of policies, programs, regulations, and funding initiatives. The country has taken steps towards pricing carbon pollution: our approach requires carbon pricing across Canada in 2018. We are also advancing a number of additional measures that will take us the rest of the way to our target, in continued partnership with provinces and territories, and in consultation with stakeholders across sectors.

Despite global action to reduce emissions, adapting to the impacts of climate change will also be critical. In the past year, governments across Canada have taken steps to support communities most affected by impacts of climate change, such as fires, floods and extreme weather. Governments have also invested in climate solutions and clean growth. Their investments will help Canadians save money through the use of smarter energy solutions.

Indigenous Peoples are important environmental leaders in Canada. They are often among the most vulnerable to the effects of a changing climate. The Government of Canada is committed to ensuring that Canada's Indigenous Peoples are real partners in the country's transition to a low-carbon, climate resilient economy. That is why the Government of Canada is working with National Indigenous Organizations to support the implementation of the Pan-Canadian Framework and to advance broader clean growth and climate change priorities.

These and other domestic actions represent Canada's commitment to implementing the Paris Agreement and, much like processes under the UNFCCC, the Pan-Canadian Framework includes accountability and reporting mechanisms that will allow us to revisit our climate change measures and enhance our ambition over time.

The Government of Canada is supporting these domestic actions with historic investments. In June 2017, we launched the Low Carbon Economy Fund to leverage investments in projects that will support clean growth and reduce greenhouse gas emissions from buildings, industries and forestry. The government is also investing billions in green infrastructure and public transit, and through the Canada Infrastructure Bank and green bonds from Export Development Canada, we are using innovative financing mechanisms to support climate investments and help new technologies become mainstream.

At the international level, Canada continues to demonstrate its strong commitment to global leadership on clean growth and climate change. Our country is working closely with its international partners on negotiations to implement the Paris Agreement under the UNFCCC. In advance of the 23rd Conference of the Parties (COP23), together with China and the European Union, Canada co-hosted a Ministerial on Climate Action, bringing together ministers and representatives from more than 30 major economies and other key players on international climate change.

In 2017, Canada also hosted a series of events on key issues under the UNFCCC. These included carbon markets, gender equality, and the engagement of Indigenous Peoples in international climate action. These complementary meetings informed the COP23 negotiations, where Canada was recognized for its leadership in helping to reach agreement on a UNFCCC Gender Action Plan and on the launch of the local communities and Indigenous Peoples' platform to enhance engagement of Indigenous Peoples on international climate action.

Canada remains committed to supporting countries that are most vulnerable to the impacts of climate change. We are delivering on a historic commitment to provide $2.65 billion in climate finance by 2020-21. Canada also recently doubled its funding to the UN Intergovernmental Panel on Climate Change (IPCC), and hosted hundreds of scientists supporting the IPCC at a Montréal conference in fall 2017.

We continue to work through other multilateral fora to advance action on climate change. For example, Canada has acted as a strong advocate for a global hydrofluorocarbon (HFC) phase-down under the Montreal Protocol. Canada also ratified the Kigali Amendment to the Protocol in November 2017, which commits countries to significantly reduce consumption and production of HFCs thereby minimizing their impact on climate change. We played a leadership role in encouraging the support of 21 other Parties to ratify the Kigali Amendment, helping bring it into force on January 1, 2019. Canada is also playing a lead role in Mission Innovation, a global initiative launched in 2015 by countries that have agreed to double national investment in clean energy innovation over five years while encouraging greater levels of private-sector investment in clean energy technologies.

In addition to multilateral work, Canada continues to advance climate action directly with its partners. For example, Canada worked in partnership with the United Kingdom recently to launch the Powering Past Coal Alliance, a global initiative to phase out traditional coal-fired electricity generation. In December 2017, Canada and five provinces joined with Mexico, Chile, Colombia, Costa Rica and two U.S. states to establish the Declaration on Carbon Markets in the Americas, which aims to enhance collaboration on carbon pricing systems and promote carbon markets throughout the Americas.

Canada understands that addressing climate change represents a significant economic opportunity. Those countries that pursue strong climate action will be best placed to compete in the clean growth century. Through reducing emissions and enhancing resilience, we can all work together to avoid the worst impacts of climate change and secure a safer, more prosperous future for our kids and grandkids.

I look forward to continued work with my domestic and international colleagues to make this future a reality.

Sincerely,
Catherine McKenna

CHAPTER 1

Introduction and Executive Summary: 7th National Communication

Canada is pleased to present its *7th National Communication* and *3rd Biennial Report* on Climate Change to meet its reporting requirements under the United Nations Framework Convention on Climate Change (UNFCCC). Canada has prepared these reports in accordance with adopted guidelines and other guidance for National Communications and Biennial Reports.

The following Introduction and Executive Summary provides an overview of *Canada's 7th National Communication* and *3rd Biennial Report* to the UNFCCC.

National Action

Canada has taken significant steps to address climate change since its last report to the UNFCCC. In addition to being one of the first Parties to the UNFCCC to sign and ratify the Paris Agreement, Canada has followed through on its Paris commitments by developing a new national plan to reduce greenhouse gas (GHG) emissions, enhance resilience to the impacts of climate change, and transition to a clean growth economy.

Less than 90 days after Paris Climate Change Conference in December 2015, the Prime Minister of Canada met with all Provincial and Territorial Premiers (collectively referred to as First Ministers) to adopt the Vancouver Declaration on Clean Growth and Climate Change. In the Vancouver Declaration, First Ministers agreed to work together to take ambitious action in support of meeting or exceeding Canada's commitment to reduce GHG emissions by 30 percent below 2005 levels by 2030.

The Declaration also set the path toward the adoption of the Pan-Canadian Framework on Clean Growth and Climate Change on December 9, 2016.[a] A historic achievement, the Pan-Canadian Framework is Canada's first climate change plan to include commitments by federal,

[a] The provinces of Manitoba and Saskatchewan decided not to join the Pan-Canadian Framework at this time.

provincial and territorial governments, and is the country's overarching framework to reduce emissions across all sectors of the economy, stimulate clean economic growth and build resilience to the impacts of climate change.

The Framework is designed to achieve the behavioural and structural changes needed to transition to a low-carbon economy, and was developed collaboratively by Canada's federal, provincial and territorial governments, with input from Indigenous Peoples as well as from businesses, non-governmental organizations, and Canadians across the country.

Working with Indigenous Peoples in Canada

Indigenous Peoples are resilient climate leaders in Canada, despite being among the most vulnerable to climate change. The Government of Canada is committed to ensuring First Nations, Inuit, and the Métis Nation are real partners in Canada's transition to a low-carbon economy. To help do so, the Government of Canada is working in partnership with the Assembly of First Nations, Inuit Tapiriit Kanatami, and the Métis National Council through three senior-level tables. These innovative tables enable ongoing partnership with First Nations, Inuit and the Métis Nation in the implementation of the Pan-Canadian Framework and on broader clean growth and climate change priorities. Supported by Government of Canada Budget 2017 funding, all three tables met for the first time in fall 2017, are planning to meet again in early 2018, and are identifying areas to work together.

The Pan-Canadian Framework builds on the early leadership of provinces and territories and the diverse array of policies and measures already in place across Canada to reduce GHG emissions in all sectors of the economy. The Pan-Canadian Framework includes over fifty concrete measures under four key pillars: carbon-pollution pricing; complementary actions to reduce emissions; adaptation and climate resilience; and clean technology, innovation and jobs.

The plan also includes governance and reporting mechanisms to ensure ongoing collaboration across federal, provincial and territorial governments, to track progress in implementing measures under the Pan-Canadian Framework, and to identify opportunities for further action.

Pricing carbon pollution is central to Canada's plan. The Government of Canada has outlined a benchmark for pricing carbon pollution that will build on existing provincial systems and require that a minimum price of $10 per tonne is in place across Canada in 2018, rising to $50 per tonne by 2022. The Pan-Canadian Framework also includes complementary mitigation measures to achieve emissions reductions in the electricity, transportation, built environment, industry, and forestry, agriculture and waste sectors, both in the near-term and as part of a longer-term strategy.

The Pan-Canadian Framework recognizes the importance of building climate-resilience, and sets out measures to help Canadians understand, plan for, and take action to adapt to the unavoidable impacts of climate change. As Indigenous Peoples and coastal and northern regions are particularly vulnerable to climate impacts, targeted action is being taken to help these communities thrive.

Recognizing the growing global demand for clean technologies, the Pan-Canadian Framework creates the conditions to encourage and enhance the development and adoption of clean technologies. The Framework includes new actions to support early-stage technological innovation, accelerated commercialization and growth, enhanced adoption of clean technology, and improved metrics to measure success.

To support these measures, the Government of Canada has announced significant investments to support national actions to reduce emissions, build resilience and support clean technology and innovation.

International Action

At the international level, Canada is taking strong action to demonstrate its commitment to advancing the international clean growth economy. Under the UNFCCC, Canada is working closely with the international community to implement the Paris Agreement, and at the 23rd Conference of the Parties (COP23) in November 2017 played a leadership role to advance negotiations on the Paris Agreement guidelines.

Leading up to and during COP23, Canada also worked to advance several key initiatives. In September 2017, Canada, in collaboration with China and the European Union, hosted an international ministerial meeting with representatives from 34 countries, including major economies, to support global climate action and the Paris Agreement, providing an opportunity for ministers to advance discussions in support of the Paris Agreement and its goals. Canada will co-host a second meeting in 2018.

Canada has also taken on a leadership role to enhance the engagement of Indigenous People on international climate action. In September 2017, in the lead-up to COP23, the Government of Canada, in full partnership with Indigenous Peoples of Canada, hosted an Informal Dialogue attended by over 60 governments and Indigenous peoples from around the world, which advanced discussions on the local communities and Indigenous Peoples platform under the UNFCCC. Canada was recognized for its leadership in reaching an agreement to launch the operation of the platform. Also in the lead-up to COP23, Canada hosted an international workshop to exchange views on options for the Gender Action Plan under the UNFCCC, and played a leadership role in achieving agreement on the plan at COP23.

Canada is working to support the countries that are most vulnerable to the impacts of climate change and to support clean growth internationally. Canada is delivering its historic climate finance pledge of $2.65 billion to help developing countries transition to low-carbon, climate resilient economies through diverse bilateral and multilateral initiatives.

Canada is also an active participant in a variety of multilateral fora that work to reduce GHG emissions and enhance resilience. Canada was one of the first countries to ratify the Montréal Protocol, and has been a strong supporter of efforts to phase down hydrofluorocarbons (HFCs) under the Kigali Amendment to the Protocol. Following release of draft regulations to phase down HFCs, Canada ratified the Kigali Amendment in November 2017, helping to bring the amendment into force on January 1, 2019.

Canada is playing a leadership role in Mission Innovation—a global initiative of countries working to scale up investment in clean energy innovation—and is a member of the initiatives Steering Committee. At COP23, Canada also announced the formation of a North American Climate Leadership Dialogue with Mexico and the United States Climate Alliance, a bipartisan coalition of 15 United States (U.S.) governors committed to reducing GHGs consistent with the goals of the Paris Agreement.

Canada continues to work with international partners, including through the recent announcement with the United Kingdom of the Powering Past Coal Alliance, a global initiative to phase out traditional coal-fired electricity, as well as ongoing work with Mexico to address methane emissions in the oil and gas sector. In addition, in December 2017 Canada and five provinces joined with Mexico, Chile, Columbia, Costa Rica, and two U.S. states to establish the Declaration on Carbon Markets in the Americas, which aims to enhance collaboration on carbon pricing systems and promote carbon markets throughout the American continents.

National Circumstances

Canada's unique geographic, demographic, and economic circumstances influence its GHG emissions profile. For example, while Canada has a relatively small population, it also has one of the largest landmasses in the world, most of it located in the northern half of the northern hemisphere. These factors contribute to heavier energy and transportation use than in smaller and/or more densely populated countries.

Canada's population remains the smallest among G7 countries but is rapidly growing, mostly through international migration. Currently at 36.7 million inhabitants, it is anticipated that Canada's population could reach between 40.1 and 47.7 million by 2038. Two-thirds of Canada's population and urban centers are located within 100 kilometers of the Canada-U.S. border, leaving large parts of the country sparsely populated. The large distance between metropolitan areas and low population density generates high emissions from the transportation sector making it the second largest contributor of GHG emissions in Canada.

Canada experiences a wide range of climate conditions, with most of the inhabited regions seeing distinct seasons—in particular very warm summers and cold winters. Heating and cooling needs have a great impact on energy use and GHG emissions. Canada's climate has been increasingly warming over the last several years. Northern regions are the most affected, and extreme events such as drought, forests fires, floods and severe thunderstorms are happening more frequently.

Although climate and geography contribute to making Canada a heavy energy user, energy efficiency has improved in recent years. In addition, 80 percent of Canada's total electricity is produced from non-GHG emitting sources, with hydroelectricity comprising most of this production. The share of renewable power from other sources than hydro has been increasing steadily since 1990 while the supply generated from coal has decreased substantially over the same time period.

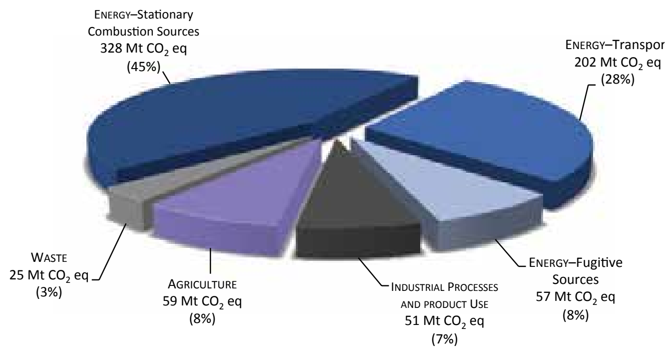
According to the International Monetary Fund, Canada's growth was the fastest among G7 economies in 2016, with an anticipated real GDP growth rate of 3.5 percent in 2017 and 3.6 percent in 2018. While Canada's economy is primarily driven by the service sector, its manufacturing, construction, mining, oil and gas, and forestry sectors still represent about 30 percent of the economy which is unique among industrialized countries. These emissions intensive sectors contribute significantly to Canada's emissions.

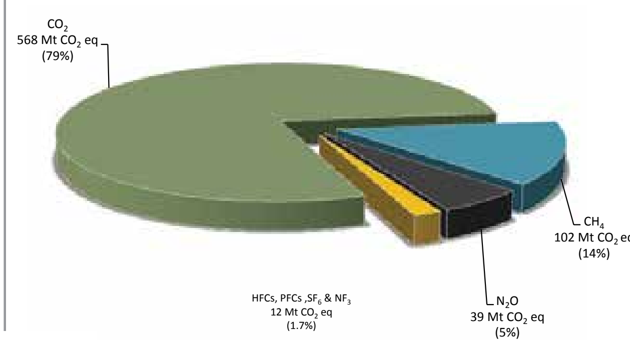
Canada's Greenhouse Gas Inventory

Canada's *National Inventory Report* is prepared and submitted annually to the UNFCCC and includes estimates of CO_2 equivalent (CO_2 eq) in the following six sector categories, as defined by the Intergovernmental Panel on Climate Change: Energy, Industrial Processes and Product Use, Agriculture, Waste, and Land Use, Land-use Change and Forestry (LULUCF).[b] Canada also reports estimates of historical emissions and removals according to the following economic sector categories: electricity, transportation, oil and gas, heavy industry, buildings, agriculture, and waste and others.

In 2015, Canada emitted 722 megatonnes (Mt) of CO_2 eq. The energy sector (consisting of Stationary Combustion Sources, Transport, and Fugitive Sources) continues to account for the majority of Canada's emissions, at 81% or 587 Mt. Other emissions are generated from the Agriculture sector (8%), the Industrial Processes and Product Use sector (7%), and the Waste sector (3%). Alberta continues to have the highest emissions among Canadian provinces, primarily due to expanding oil and gas operations.

[b] The most recent report entitled *National Inventory Report 1990–2015: Greenhouse Gas Sources and Sinks in Canada*, and is available online at: http://unfccc.int/files/national_reports/annex_i_ghg_inventories/national_inventories_submissions/application/zip/can-2017-nir-13apr17.zip.





Total: 722 Mt CO_2 eq

Figure 1: Canada's Emissions Breakdown by IPCC Sector (2015)*

*Note: Totals may not add up due to rounding.

Figure 2: Canada's Total Emissions Breakdown by GHG (2015)*

Similar to other industrialized counties, carbon dioxide from the combustion of fossil fuels is the largest contributor to Canada's GHG emissions and accounted for 79% of Canada's emissions in 2015. Other emissions include methane (14%) largely from fugitive sources in oil and natural gas systems, agriculture and landfills and nitrous oxide (5%) from agricultural soil management and transport. Combined, perfluorocarbons, sulphur hexafluoride, hydrofluorocarbons and nitrogen trifluoride contributed less than 2% of Canada's emissions.

Since 1990, Canada's emissions have overall been increasing gradually, and have increased by 20 Mt since the *6th National Communication* report.

However, Canada's economy has grown more rapidly than GHG emissions and emissions intensity has declined by 33% since 1990 and 16% since 2005.

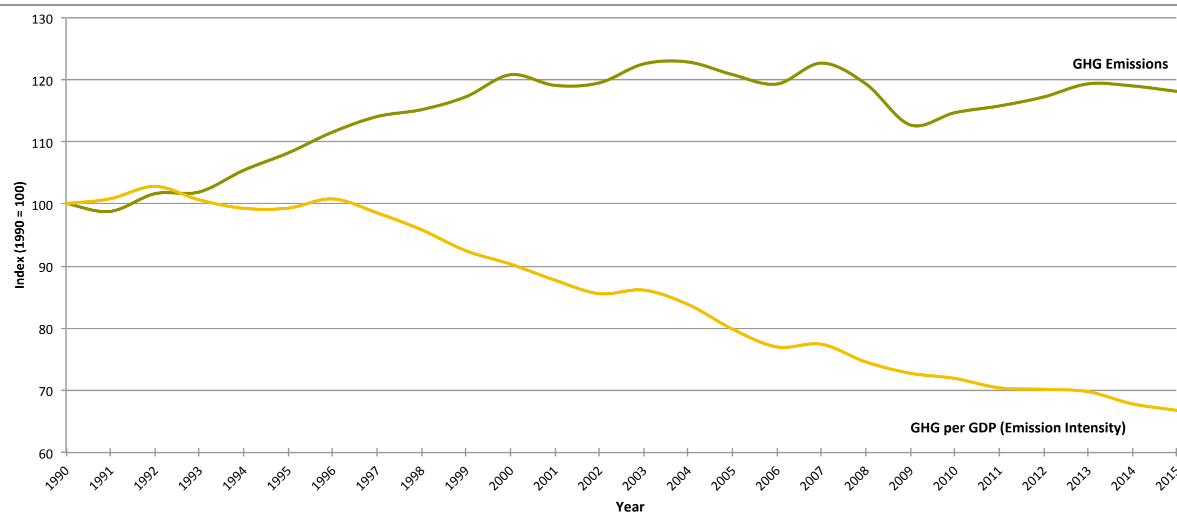


Figure 3: Indexed Trend in GHG Emissions and GHG Emissions Intensity (1990–2015)

The reduction in emissions intensity since 1995 is largely due to fuel switching, increases in efficiency, the modernization of industrial processes, and structural changes in the economy.

As the federal agency responsible for preparing and submitting the national inventory to the UNFCCC, Environment and Climate Change Canada has established and manages all aspects of the arrangements supporting the GHG inventory. The development of Canada's GHG inventory is based on a continuous process of data collection, methodological refinement and review.

Policies and Measures

Institutional Arrangements

Within the Government of Canada, the Minister of Environment is responsible for domestic and international climate change policies. However, as the environment is of shared jurisdiction in Canada and given the cross-cutting nature of climate change, several federal, provincial and territorial ministries work together to address this issue. At the federal level, most climate change regulations are developed under the authorities of the *Canadian Environmental Protection Act, 1999* (CEPA 1999).

The Pan-Canadian Framework on Clean Growth and Climate Change and its supporting governance architecture is now the overarching framework for the coordination and implementation of climate change policy across Canada. Federal, provincial and territorial Ministers are working together through longstanding inter-ministerial fora, such as the Canadian Council of Ministers of Environment or the Energy and Mining Ministers Conference, to implement and report on Pan-Canadian Framework actions.

Policies and Measures to Reduce Emissions

A number of key cross-cutting measures are planned or in place to reduce emissions across Canada. Several provinces already have carbon pricing systems in place: British Columbia has had a carbon tax in place since 2008, Québec and Ontario adopted a cap-and-trade system in 2013 and 2017 respectively, and Alberta extended the scope of its carbon levy in 2017. As a result, over 80 percent of Canada's economy and population are covered by a carbon pricing system in one form or another. Other provinces and territories are considering options to develop systems for carbon pricing. In addition, under the Pan-Canadian Framework the federal government committed to implement a benchmark for pricing carbon pollution. A federal carbon pricing backstop system will be applied in jurisdictions that request it or that do not have a carbon pricing system in place in 2018 that meets the pan-Canadian carbon pricing benchmark. The federal system would take effect January 1, 2019.

Under the Pan-Canadian Framework and through a comprehensive array of existing measures, federal, provincial and territorial governments are working to target emissions across all sectors of the economy. For example:

- In the electricity sector, the federal government is working to phase out traditional coal-fired electricity generation by 2030, and investing in renewable power, Smart Grids, and reducing reliance on diesel in Indigenous, northern and remote communities.
- In the transportation sector, the federal government is regulating emissions standards for light and heavy duty vehicles and investing in infrastructure for zero-emission vehicles. Federal, provincial and territorial governments are also developing a Zero-Emissions Vehicle Strategy for 2018.
- In the building sector, the Pan-Canadian Framework includes measures to improve energy efficiency in buildings and appliances with work underway to adopt more stringent codes for new and existing buildings, including the goal that provinces and territories adopt a "net-zero energy ready" model building code by 2030.
- The federal government is also taking steps to reduce GHG emissions from the industrial sector through adopting regulations to reduce hydrofluorocarbon emissions and methane emissions from the oil and gas

sector, as well as via energy efficiency benchmarking programs such as ENERGY STAR for Industry and ISO 5001.

The Government of Canada is making significant investments to support the measures in the Pan-Canadian Framework. For example, the Low Carbon Economy Fund invests in projects that will generate clean growth and reduce GHG emissions, and the federal government is also providing billions of investments in green infrastructure and public transit investments, which will contribute directly to climate change mitigation and adaptation activities.

Complementary to the Pan-Canadian Framework, Canada released a Strategy on Short-Lived Climate Pollutants which will be instrumental in achieving short-term results on climate change as well as health benefits, especially in the North. In November 2016, Canada also announced its *Mid-Century Long-Term Low-Greenhouse Gas Development Strategy* as required under the Paris Agreement. The Mid-Century Strategy looks beyond 2030 and describes various pathways for innovative and creative solutions for meeting long-term climate change objectives and enabling economic growth.

Projections

For its *7th National Communication* and *3rd Biennial Report*, Canada has presented projections with both a "with measures" scenario and a "with additional measures" scenario.

The "with measures" scenario includes actions taken by governments, consumers and businesses put in place over the last two years, up to September 2017. This scenario does not account for all measures of the Pan-Canadian Framework as a number of them are still under development.

Taking into consideration all climate change policies and measures that have been announced in Canada and for which enough information is available, a "with additional measures scenario" has also been developed. The "with additional measures" scenario accounts for those additional policies and measures that are under development but have not yet been fully implemented, some of which were announced as part of the Pan-Canadian Framework (e.g., pan-Canadian carbon pricing). This scenario is provided for the purposes of presenting progress to Canada's 2030 target and to better demonstrate the expected impact of the Pan-Canadian Framework.

Under this scenario, emissions in 2030 would be 583 Mt, a 232 Mt decline from projections included in the "with measures" scenario in the *2nd Biennial Report*. This decline, equivalent to approximately a third of Canada's emissions in 2015, is widespread across all economic sectors, reflecting the breadth and the depth of the Pan-Canadian Framework.

Figure 4 shows the "with measures" and "with additional measures" projections, as well as the projections presented in Canada's *2nd Biennial Report*. Going forward, it is expected that further progress will take place, especially as current estimates do not include the full reductions from investment in public transit, clean technology and innovation. Potential increases in stored carbon (carbon sequestration) in forests, soils and wetlands will also contribute to reductions which, for a country such as Canada, could also play an important role in achieving the 2030 target.

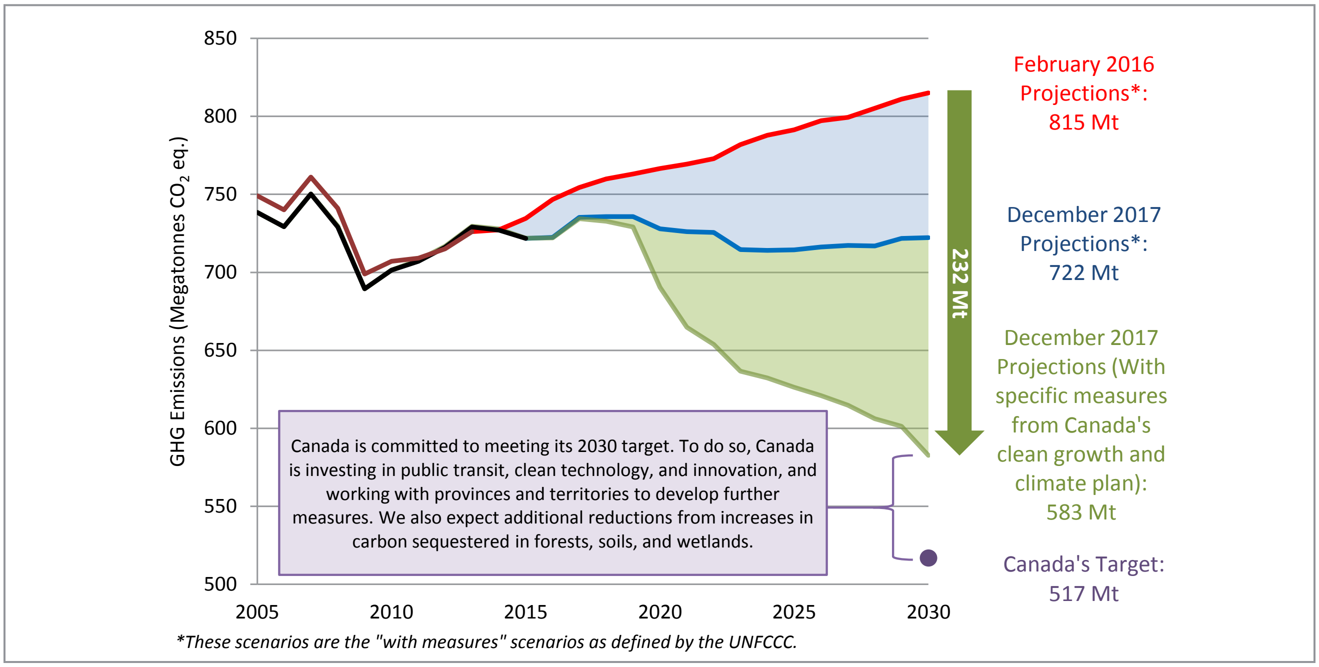


Figure 4: Scenarios of Canadian Emissions to 2020 and 2030 (Mt CO2 eq) (Excluding Land Use, Land-Use Change and Forestry)

Moreover, these projected emission reductions do not account for additional mitigation measures that could be implemented by the provinces and territories between now and 2030. Emissions reductions from additional future actions will be assessed as new measures are implemented.

Environment and Climate Change Canada updates these projections annually, reflecting the latest historical data and up-to-date future economic and energy market assumptions. However, there is significant uncertainty with regards to key drivers of GHG emissions, such as future world oil and gas prices, economic growth and developments in technologies. Projections therefore fluctuate over time as a result of changes in these key drivers assumptions.

Vulnerabilities

Climate change impacts are already being felt in Canada with some of the most vulnerable communities among the most affected. In the Canadian Arctic, average temperature has increased at a rate of nearly three times the global average. Extreme weather events such as those experienced in 2016 with forest fires in Fort McMurray, Alberta, and again in 2017 with forest fires in British Columbia and floods in Ontario and Québec, are also expected to become increasingly frequent.

Northern and Indigenous Peoples and communities are among the most exposed to the impacts of climate change which affects not only infrastructures but also sources of food and water. Federal, provincial and territorial governments have committed to work in partnership with Indigenous communities to address climate change impacts. In the Budget 2017, the Government of Canada provided funding to increase support for First Nations and Inuit communities to undertake climate change and health-adaptation projects that protect public health.

Adapting and building resilience to the impacts of climate change is one of the pillars of the Pan-Canadian Framework on Clean Growth and Climate Change. Building climate resilient infrastructure and developing codes and standards will be instrumental in addressing vulnerabilities and strengthening the resilience of communities and ecosystems. To achieve this, the federal government announced investments of $22 billion in green infrastructure, a portion of which will support adaptation activities. These investments will include $9.2 billion for bilateral agreements with provinces and territories which will include investments in adaptation and climate resilience, and $2 billion for a Disaster Mitigation and Adaptation Fund to support infrastructure required to deal with the effects of a changing climate.

All levels of government in Canada, as well as communities, are increasingly aware of climate change impacts and integrating climate considerations in assessments and decision-support tools. The Government of Canada has published sectoral level and national level assessments and has supported provincial and territorial assessments of climate change impacts and risks, for example in Prince Edward Island which is particularly exposed to flooding and erosion.

The federal government, provinces and territories, municipalities, and several Indigenous communities have been developing plans and strategies to adapt to climate change. The Federal Adaptation Policy Framework and the Pan-Canadian Framework both offer strong guidance and actions for Canada to adapt and strengthen its resilience to climate change. Several provinces and territories have released their own adaptation strategies or action plans since the *6th National Communication* (Yukon, Northwest Territories, Nunavut, British Columbia, Ontario, Québec, Prince Edward Island, and Newfoundland and Labrador) and many others have integrated adaptation planning to better guide government decision-making.

Furthermore, efforts are underway to establish a Canadian Centre for Climate Services as committed to in the Pan-Canadian Framework. This centre will work with provincial and territorial governments, Indigenous Peoples and other partners and provide climate information products, tools and services to support adaptation decision making across the country.

Financial, Technology and Capacity-Building Support

Canada is committed to supporting developing countries to obtain clean and reliable sources of energy and enhance resilience, particularly the poorest and most vulnerable countries, in their fight to adapt to the impacts of climate change.

Recently, Canada significantly increased its financial contribution to support developing countries' transition to low carbon economies. In 2015, Canada pledged $2.65 billion over five years for this initiative and began delivering on this pledge in 2016. Over the last two years, Canada has announced an additional $353 million for assistance to developing countries.

Over 50 developing countries are benefitting directly from recent Canadian climate change support, and a much larger number of countries are also benefitting from contributions made by Canada to other multilateral funds.

Figure 5: Global Map of Countries Directly Receiving Canadian climate finance

Over 2015 and 2016, 54% of Canada's climate finance was allocated to adaptation initiatives, 42% to clean energy and mitigation initiatives, and 4% to cross-cutting initiatives that targeted both mitigation and adaptation.

Canada's climate finance is delivered through various federal departments, sub-national governments, and agencies which work closely together to track Canada's climate finance to present a comprehensive picture of Canada's contribution to the transition to low carbon and climate resilient economies.

The private sector also plays a key role in reaching the investment levels required to shift the world towards a low-carbon and climate resilient path. Canada is actively contributing to global efforts to mobilize private investment, using public climate funding to catalyze private investment for transformational climate change mitigation and adaptation initiatives. This funding helps mobilize private sector investment and expertise, including in clean technology innovation, in developing countries so that they too may seize the economic opportunities of the global shift towards clean growth.

Canada is also actively engaged in a broad range of actions to advance the development and deployment of clean technologies globally. These actions include developing and sharing knowledge and tools to support clean energy software and smart grids.

Research and Systematic Observation

In Canada, climate science research and monitoring approaches involve federal, provincial, municipal, academic and private sector partners.

The federal government is currently developing a federal climate change science plan to support implementation of the Pan-Canadian Framework on Clean Growth and Climate Change and several other research initiatives are already underway within the Government of Canada.

Several research and climate observation programs are being supported by the Canadian Space Agency such as the Polar Space Task Group or the Earth Observation Application Development Program. Three federal Research Granting Agencies are also contributing financial resources to research initiatives related to climate change and atmospheric research led by universities, governments, or partner organizations and through the Network of Centers of Excellence and the Canada Research Chairs program. Two Networks of Centers of Excellence initiatives are directly related to climate research and monitoring: ArcticNet and the Marine Environmental Observation Prediction and Response Network.

With regard to systematic climate monitoring and observation, Canada endorsed the Joint Declaration on Harnessing the Data Revolution for Climate Resilience in December 2016. Canada plays a proactive role in supporting the emerging Open Data for Climate Actions initiative coordinated by the International Open Data Charter.

The Government of Canada is also deploying considerable expertise and resources in monitoring and researching atmospheric, oceans, and land data. As a northern country, Canada is also actively involved in research and observation of sea ice, snow, permafrost and glaciers which will help us understand the impacts of climate change on these fragile ecosystems and the populations living in these regions.

Canada continues to support the involvement of Canadian experts in national and international climate science assessments. Canadian experts are participating in the activities of the Intergovernmental Panel on Climate Change (IPCC), including the preparation of Assessment Reports, and Canada hosted the plenary session of the IPCC in Montréal in September 2017. Canada is also a member of the Arctic Council and participates actively in the scientific assessments undertaken through its working groups.

As mentioned above, a Canadian Centre for Climate Services is currently being established which will improve dissemination of climate data and scenarios from the Government of Canada.

Education, Training, and Public Awareness

Across Canada, all levels of government and numerous non-governmental organizations have undertaken a range of activities to broaden public awareness of climate change and encourage collective action. The 2017 Generation Energy dialogue utilized polls, surveys, and citizen dialogues to engage over 380,000 people in an inclusive discussion on Canada's low-carbon energy future.

Canada also views public engagement as an essential aspect of developing climate change policy, and public input was instrumental in shaping the Pan-Canadian Framework in 2016.

The subject of climate change is integrated into the primary and secondary school curriculum in Canada, and many nongovernmental organizations exist to assist educators to access diverse resources and align teaching activities with the required curriculum. Most Canadian universities offer environmental programs, and several offer courses in climate science and research. Academia and government scientists have also partnered to collaborate on climate change research.

Federal, provincial and territorial governments frequently make use of the web and social media as a platform to deliver relevant information about climate change programs and initiatives. Training programs offered by non-governmental organizations, educational institutions, government agencies and specialist groups also help organizations meet their business or educational objectives and also contribute to Canada's climate change goals. Similarly, numerous organizations in Canada act as climate change resource or information centres for Canadians, governments and businesses. The Canadian Centre for Climate Services will help improve dissemination of climate data and information through an online climate information portal.

Canada also engages in a number of collaborative international initiatives that involve sharing experiences, best-practices and working towards common climate change goals.

CHAPTER 2

Canada's National Circumstances

This chapter outlines national circumstances within Canada that contribute 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.

Canada's unique geographic, demographic, and economic circumstances influence its GHG emissions profile. For instance, Canada has a highly variable climate that contributes to higher energy use for space heating and cooling in the building sector compared to some other industrialized countries. Canada also has a large landmass, 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, as well as faster than average population growth relative to other Organisation for Economic Cooperation and Development (OECD) 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 2014, it is one of the highest per capita emitters due to its size, its climatic conditions, and its energy intensive, resource based economy.[1] Although Canada has the second highest GHG emissions intensity per capita among the G7 countries, since 1990 the level of emissions per unit of real gross domestic product (GDP) has fallen 33% reflecting more efficient industrial processes, a shift to a more service based economy, and lower emitting energy generation through fuel switching.[2]

2.1 Governance Structure

Canada is a geographically large federation composed of a central federal government, 10 provincial governments, and 3 territorial governments. The Canadian Constitution and convention assign different powers to each level of government.

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 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 and Climate Change Canada, Fisheries and Oceans Canada, Natural Resources Canada, Agriculture and Agri-Food Canada, Transport Canada, Health Canada, Parks Canada Agency, the Canadian Environmental Assessment Agency, and Innovation, Science and Economic Development Canada.

In addition, many of the federal Ministers leading these departments have formal mandate letter commitments to work with Environment and Climate Change Canada in addressing climate change. For instance, the Minister of Fisheries, Oceans and the Canadian Coast Guard has been tasked to work with the Minister of Environment and Climate Change Canada and the Minister of Science to examine the implications of climate change on Arctic marine ecosystems. The Minister of Innovation, Science, and Economic Development has also been tasked to work with the Minister of Environment and Change and the Minister of Natural Resources in making strategic investments in a clean technology sector.

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 Indigenous lands (e.g., lands managed by an Indigenous 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 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 related to federal jurisdiction. With respect to climate change, emissions of GHGs are legislated both at the federal and provincial levels.

Given that the environment is an area of shared jurisdiction between the federal and provincial or territorial governments, powers between the federal and provincial/territorial jurisdictions often overlap with regard to particular environmental issues. To that end, several multi-level governance mechanisms ensure close collaboration in policy and regulatory development and implementation, from the Canadian Council of Ministers of the Environment and issue-specific councils and working groups, to equivalency and other types of agreements between federal environmental authorities and their provincial and territorial counterparts.

With the creation of the Pan-Canadian Framework on Clean Growth and Climate Change in December 2016, its supporting governance architecture is now the overarching framework for the coordination and implementation of climate change policy across Canada. Further information on Pan-Canadian Framework institutional arrangements is provided in Chapter 4: Policies and Measures.

First Nations, the Métis Nation, and Inuit are the Indigenous Peoples of Canada, with their own distinct, rights-bearing communities with their own histories. Indigenous Peoples have a special constitutional relationship with the Government of Canada. This relationship, including existing Aboriginal and treaty rights, is recognized and affirmed in section 35 of the *Constitution Act, 1982*. Section 35 contains a full suite of rights, and holds the promise that Indigenous nations will become partners in Confederation on the basis of a fair and just reconciliation between Indigenous Peoples and the Crown.[5] Canada's constitutional and legal order recognizes the reality that Indigenous Peoples' ancestors owned and governed the lands which now constitute Canada prior to the Crown's assertion of sovereignty. All of Canada's relationships with Indigenous Peoples are based on recognition of this fact and supported by the recognition of Indigenous title and rights, as well as the negotiation and implementation of pre-Confederation, historic, and modern treaties. Many modern treaties include environmental provisions.

Indigenous Peoples demonstrate climate change resilience in the face of unique and diverse circumstances that include being among the most vulnerable to climate change. First Nations, Inuit, and Métis continue to be guardians and stewards of the environment. Foundational to Canada's approach to climate change is a commitment to support and partner with Indigenous communities as they take action and exercise their right to self-determination.

As the federal, provincial, and territorial governments take action on climate change, Canada will move forward respecting the rights of Indigenous Peoples, including through robust, meaningful engagement that draws on Traditional Knowledge. A key priority remains strengthening the collaboration between federal, provincial, and territorial governments and Indigenous Peoples on mitigation and adaptation actions, based on recognition of rights, respect, cooperation, and partnership. Indigenous Peoples are important leaders and partners in developing real and meaningful climate action. The Government of Canada is advancing meaningful engagement with First Nations, Inuit, and the Métis Nation on climate action, including through three distinctions-based engagement tables. As such, these tables provide opportunities for ongoing engagement with Indigenous Peoples in the implementation of the Pan-Canadian Framework on Clean Growth and Climate Change and on broader climate change priorities.

2.2 Population Profile

In 2016, Canada's population was 36.3 million.[3] This represents significant growth from 27.7 million in 1990.[4] While the Canadian population remains the smallest among G7 countries, it is the fastest growing with an average annual population growth rate of 1% from 2011 to 2016.[6] Net international migration was responsible for two-thirds of the population increase from 2011 to 2016. It is projected that there will be between 39.4 and 47.8 million people in Canada by 2038 and between 40.0 and 63.5 million by 2063.[7]

Canada's population is not spread evenly across the country. The southern part of Canada is home to a large number of urban centres, leaving the northern regions of the country much less populated. In 2016 it was estimated that two out of three Canadians (66%) lived within 100 kilometers of the southern Canada-United States (US) border, an area that represents 4% of Canada's territory.[8] Moreover, in 2011, it was estimated that 81% of Canada's population lived in urban areas, while 19% lived in rural areas.[9]

Canada has 35 metropolitan areas (where the population is greater than 100,000), many of which have large distances between them (i.e., approximately 450 kilometers between Ottawa and Toronto, Ontario).[10] In 2016, Canada's population density was estimated to be 3.9 people per square kilometre, compared with 35.3 people per square kilometre in the US.[11] Large distances between Canada's metropolitan areas and a low population density contribute to high energy demand (and GHG emissions) related to the transportation of people and goods.

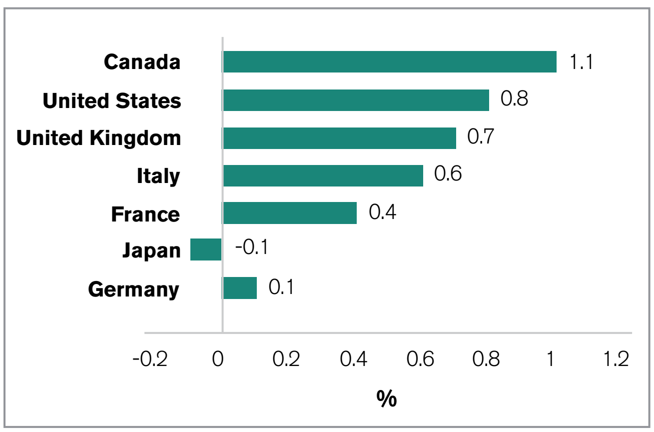


Figure 2.1: Population growth rate (in %) of G7 countries, 2011 to 2016
Source: Chart 1 Average annual population growth rate among G20 and G7 countries, 2011 to 2016. 2017. Statistics Canada.

2.3 Economic Profile

As of 2016, Canada was the world's 10th largest economy with a GDP of CAD$2.1 trillion.[12] On a GDP per capita basis, Canada ranks 17th in the world.[13]

Between 1990 and 2016, Canadian real GDP grew by 80%.[14] At the same time, the population grew by 31%.[15] 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 1.5% in 2016.[16]

Canada's economy is driven by the services sector, comprising 70% of GDP in 2016.[17] 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 2016, the value of total exports of goods and services was $580 billion.[18]

As a resource-rich economy, Canada is also 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. In 2016, Canada's exports of energy, extracted resources, and agricultural commodities were valued at $49 billion.[19] 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 between 2009 and 2016 on an annual basis.[20]

Canada's international trade is highly concentrated on its shared border with the US, with 75% of its exports and 65% of its imports devoted to its southern neighbour in 2016.[21] In recent years however, China has been an increasing source of imports (7% in 2016) and exports (4% in 2016).[22] On May 17th 2017, Canada ratified a free trade agreement with the European Union, its second largest trading partner, which will likely increase the flow of trade between the two regions in the future. Other important trade partners include Japan, Mexico, South Korea and India.[23]

Table 2.1 below describes Canada's employed population by source of employment. Due to the significant size of the service industry, 79% of the working population is employed by the services-producing sectors in 2016.

Table 2.1: Canadian employment by industry (2016)[24]

INDUSTRY	EMPLOYMENT
ALL INDUSTRIES	**18,079.9**
Goods-producing sectors	3,833.0
Agriculture	289.2
Forestry, fishing, mining, quarrying, oil and gas (also referred to as natural resources)	326.8
Utilities	137.2
Construction	1,385.0
Manufacturing	1,694.8
SERVICES-PRODUCING SECTORS	**14,246.9**
Wholesale and retail trade	2,745.9
Transportation and warehousing	907.4
Finance, insurance, real estate, rental and leasing	1,127.0
Professional, scientific and technical services	1,393.7
Business, building and other support services	766.4
Educational services	1,270.0
Health care and social assistance	2,339.3
Information, culture and recreation	782.4
Accommodation and food services	1,212.7
Other services (except public administration)	774.9
Public administration	927.3

*All numbers written in thousands.

Table 2.2 describes the GDP output related to each industry in Canada. The significant contributions to Canada's economy include real estate, manufacturing, mining and oil and gas extraction as well as construction and finance.

Table 2.2: Gross Domestic Product at Basic Prices, by Industry (Annually)[25]

INDUSTRY	2012	2013	2014	2015	2016	2015 TO 2016 (% CHANGE)
ALL INDUSTRIES	**1,560,152**	**1,599,575**	**1,641,305**	**1,656,117**	**1,677,594**	**1.30**
Goods-producing industries	**473,672**	**489,471**	**504,533**	**494,747**	**491,140**	**-0.73**
Agriculture, forestry, fishing and hunting	23,823	28,066	26,437	27, 389	28,713	4.84
Mining, quarrying, and oil and gas extraction	124,136	130,628	139,962	135,107	132,771	-1.73
Utilities	36,850	36,892	36,881	36,711	36,884	0.47
Construction	119,406	124,601	127,463	121,441	117,519	-3.23
Manufacturing	168,638	168,087	173,050	173,342	174,482	0.66
Service-producing industries	**1,087,557**	**1,111,290**	**1,138,046**	**1,162,296**	**1,187,120**	**2.14**
Wholesale trade	88,008	91,725	95,370	96,267	97,638	1.42
Retail trade	81,037	85,555	88,607	90,359	92,730	2.62
Transportation and warehousing	65,623	66,797	69,812	72,532	74,791	3.11
Information and cultural industries	50,547	50,270	50,488	50,521	50,850	0.65
Finance and insurance	102,324	106,072	109,444	114,994	120,038	4.39
Real estate and rental and leasing	194,860	200,269	206,325	213,362	219,794	3.01
Professional, scientific and technical services	83,971	86,242	88,776	90,060	90,984	1.03
Management of companies and enterprises	11,380	12,120	12,173	12,513	12,215	-2.39
Administrative and support, waste management and remediation services	41,301	41,594	42,414	42,318	42,240	-0.18
Educational services	83,538	84,792	85,321	86,768	88,098	1.53
Health care and social assistance	95,134	95,158	96,468	98,198	100,635	2.48
Arts, entertainment and recreation	11,143	11,205	11,266	11,819	12,302	4.08

INDUSTRY	2012	2013	2014	2015	2016	2015 TO 2016 (% CHANGE)
Accommodation and food services	32,056	33,233	34,113	34,606	35,465	2.48
Other services (except public administration)	30,997	31,736	32,523	32,640	32,291	-1.07
Public administration	105,309	104,874	105,565	105,908	107,344	1.36

*All numbers written in millions of chained dollars (2007). **Seasonally Adjusted Annual Rates.

2.4 Geographic Profile

Canada is a country of physical extremes and contrasts, spanning 41 degrees of latitude and 88 degrees of longitude. Its surface area is 9,984,670 km², with land accounting for 9,093,507 km² and fresh water accounting for 891,163 km².[26] The country extends 5,300 kilometers east to west, the distance between Paris and New York, and 4,600 kilometers north to south. It is the second largest country in the world and encompasses six times zones. Canada also has the longest coastline of any country, spanning 243,042 kilometers along the Atlantic, Pacific and Arctic Oceans.[27]

Canada has more lake area than any other country in the world, with lakes that are among some of the largest. The Great Lakes, which straddle the southern Canada-US boundary, contain 18% of the world's fresh lake water.[28] Large rivers also stretch across Canada, with many situated north of 60 degrees latitude. For example, the Mackenzie River is over 4,000 kilometres long and is the country's largest river. Wetlands cover about 14% of the land area of Canada and approximately 60% of Canada's fresh water drains to the north.[29]

The two most extensive types of land cover in Canada are evergreen forest (26%) and low vegetation and barren land (29%).[30] These two types of land cover represent just over half of Canada's land cover. Additional land cover in Canada includes grassland, shrubland, mixed forest, cropland, deciduous forest, water, snow, ice, and urban and built-up land.[31]

Canada is also divided into fifteen terrestrial ecozones, which each represent a large and generalized area of land characterized by interactive and adjusting abiotic and biotic factors. These ecozones range from the Arctic Cordillera Ecozone where the environment is dry and cold and is covered by vast polar ice fields and alpine glaciers; to the Pacific Maritime Ecozone, with ecosystems ranging from humid coastal rainforest to cool boreal and alpine conditions at higher elevations. In contrast, the Boreal Shield Ecozone, the largest of Canada's ecozones, presents an continuous stretch of trees, water bodies, and bedrock and is characterized by long cold winters and short warm summers.

These geographical contrasts present different challenges when assessing climate resilience and mitigating climate change impacts. For instance, coastal erosion, reduction in ice cover, and thawing permafrost increase risks to critical infrastructure, health, and food security in Canada.

2.5 Climate Profile

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 daily temperature of about 8°C which contrasts markedly with the -16°C annual average daily 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.[32]

In most regions in Canada, summer and winter temperatures dictate both heating and cooling needs, which impact energy use. For example, Montréal, Québec, annually experiences on average 271 cooling degree-days (summed daily mean temperature deviations above 18°C) and approximately 4,363 heating degree-days (summed daily mean temperature deviations below 18°C).[33]

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, Resolute, Nunavut sees an average of 161 mm of annual precipitation.[34]

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

Information on vulnerabilities, impacts and adaptation measures is presented in Chapter 6: Vulnerability Assessment, Climate Change Impacts and Adaptation Measures.

2.6 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 80% of its power generation coming from non-GHG emitting sources, ranking 2nd among G7 countries. In terms of renewable energy Canada leads among the G7 with 65% of electricity generated from hydro, wind, solar and other renewable sources.[35]

Energy: Canada's Position in the World

- 2nd in hydroelectricity production
- 2nd in uranium production and exports
- 3rd in oil reserves, 4th in production and 3rd in exports
- 5th in natural gas production and 4th in exports
- 7th in wind energy capacity

Sources: International Energy Agency, Natural Resources Canada, World Nuclear Association.

In 2015, the energy sector accounted for 7.3% of Canada's GDP in current prices (nominal GDP), and directly employed about 280,000 people. Canada is also a major exporter of energy products. In 2015, 78% of Canada's production of crude oil was exported. Canada's energy exports mostly go to the US, with the exception of coal and uranium.[36]

Table 2.3: Canada's Energy Exports (2015)

RESOURCE/ PRODUCT	EXPORTS				IMPORTS
	% of Canadian production	% to U.S.	% of U.S. imports	% of U.S. consumption	% of Canadian consumption
Crude oil	78	99	43	20	33
Refined petroleum products	26	95	29	3	13
Natural gas	51	100	97	10	21
Coal	49	4	10	0.1	19
Uranium	86	33	18	17	–
Electricity	9	100	89	2	2

Source: Energy Markets Fact Book 2016–2017. Natural Resources Canada. 2017. Ottawa.

In 2015, annual capital expenditures by the energy sector totalled $90 billion or 36% of total public and private investments in Canada. This amount has decreased substantially from 2014 by over $27 billion. Investments in Canada's oil sands sector reached $208 billion in 2015, up from $81 billion in 2006. In the electricity sector, capital expenditures have almost quadrupled between 2000 and 2013, from just over $6 billion to over $20 billion.[37]

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.

2.6.1 Energy Reserves, Production, and Trade

Three quarters of Canada's primary energy production in 2014 was in crude oil and natural gas.[38] Western Canada is a producer of crude oil and natural gas, which it exports across Canada and to the US. Eastern Canada imports oil and gas and has some refining facilities.

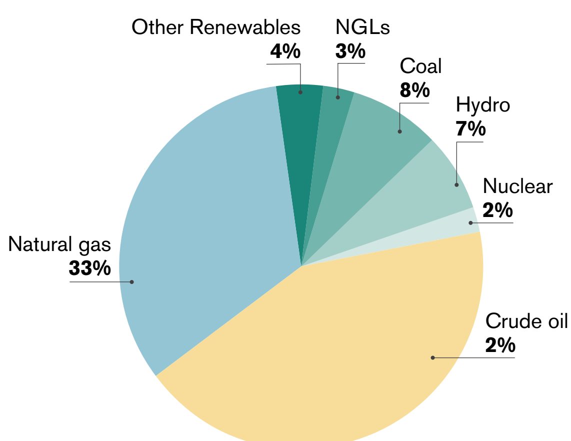


Figure 2.2: Canada's primary energy production, 2014
Source: Energy Markets Fact Book 201-62017. Natural Resources Canada. 2017. Ottawa.

2.6.1.1 Crude Oil

Canada has 10% of the world's established reserves of crude oil, or 170 billion barrels.[39] The oil sands constitute 97% of these reserves.[40] Crude oil production in Canada has grown steadily over the past two decades, up from 1.7 million barrels per day in 1990[41] to 3.9 million barrels per day in 2015.[42] 61% of Canada's current production comes from the oil sands.[43]

In 2015, Canada exported 78% of its annual crude oil production, with 99% of exports going to the US.[44] In 2015, Canadian crude oil represented about 43% of all US crude oil imports and 20% of US refinery crude oil intake, making Canada its leading foreign supplier of crude oil.[45]

2.6.1.2 Natural Gas

Canada is the 5th largest producer and 4th largest exporter of natural gas in the world. 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 2014, Canada has 70 trillion cubic feet of proven natural gas reserves.[46]

In 2015, Canadian natural gas production averaged 15.1 billion cubic feet per day (Bcf/d) of marketable natural gas. Unconventional gas production, including shale and tight gas, now accounts for over 60% of Canadian production. 51% of Canadian production in 2015 was exported to the US, meeting 10% of US natural gas demand. In 2015, Canada imported close to 1.9 Bcf/d of natural gas, mainly from the US. Canada's current production of natural gas is below its mid-2000s peak of 16.6 Bcf/d, reflecting very low natural gas prices, and a reduced US dependence on Canadian natural gas exports.[47]

2.6.1.3 Coal

Canada ranks 15th in the world in proven coal reserves with about 6,600 million tonnes (Mt), and Canada's 2015 coal production was at 62 Mt, down from 67 Mt in 2012.[48] About half of the 2015 production was exported. The majority of exports were destined for Asian markets, with China, Japan, and South Korea receiving 64% of total exports. 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. In 2015, Canada imported about 8 Mt of coal, of which 75% came from the US.[49]

2.6.1.4 Electricity

In 2014, Canada produced 639 terawatt-hours of electricity, generated from a mix of sources. Currently, 80% of Canada's electricity is produced from non-GHG emitting sources, principally hydro (59%) and nuclear (15.9%). Canada is the second largest producer of hydroelectricity in the world. 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 5% of total production.[50] The share of electricity supply generated from coal decreased from almost 17% in 1990 to 9.5% in 2014.[51]

In 2015, Canada exported 68 terawatt-hours of electricity to the US which represents about 9% of the electricity generated in Canada in 2015 and about 2% of total US consumption.[52] In 2015, Canada imported about 9 terawatt-hours of electricity from the US.[53]

2.6.2 Energy Consumption

Canada's economy is becoming increasingly less energy intensive. From 1990 to 2014, Canada's energy intensity per dollar of GDP (in constant 2007 dollars) declined 25.5%.[54] In that time period, Canada's GDP increased by 75.9% (about 2.4% per year) while energy use increased by 31%.[55]

Over the 1990 to 2014 period, energy use on a per capita basis increased by 2%.[56] Canada's per capita consumption of oil products, natural gas, and electricity is higher than in most other industrialized countries, reflecting the energy use of industries such as mining, pulp and paper, and petroleum refining.[57] 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 was 18.1% in 2015, compared to an OECD and world average of 9.6% and 13.4% respectively.[58]

2.7 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 2016, the broader transportation industry contributed 4.5% to Canada's GDP.[59]

Despite improvements in emissions intensity, transportation remains the second largest source of GHG emissions in Canada (see Chapter 3: Canada's Greenhouse Gas Inventory). From 1990 to 2015, Canada saw a 42% growth in transportation emissions that is mainly due to an increase in on-road freight transportation activity, an increase in the overall number of vehicles on the road, and a shift in personal vehicle ownership from cars to light trucks.[60]

2.7.1 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 US. Canada has more than 1.13 million km of 2-lane equivalent roads, roughly 38,000 km of which make up the National Highway System.[61] Canada's road network is shared by different users, including approximately 22 million light passenger vehicles, 1.05 million medium and heavy trucks, 91,000 buses, and 720,000 motorcycles and mopeds.[62] In 2016, more than 24.3 million road motor vehicles were registered in Canada.[63] Between 1990 and 2015, the total number of vehicles in Canada increased by 66%.[64]

On-road freight accounts for 32% of the transportation sector's share of GDP. In 2016, over 55% of Canadian exports to the US were transported by trucks, representing $218 billion of goods, while 72% of imports from the US ($200 billion) were similarly transported.[65] Between 1990 and 2015, GHG emissions from freight trucks increased by 205%.[66]

2.7.2 Aviation

With 36,450 civil aircrafts, Canada has the second largest civil aviation aircraft fleet in the world.[67] Its commercial sector ranges from international scheduled services to small, single aircraft charter companies and business aircraft operators. In 2015, air transportation carried over 75.5 million passengers (up 4.5% from 2014) and 739,000 tonnes of freight.[68] Overall, air transportation represented 13% of the transportation sector's share of GDP in 2016.[69]

2.7.3 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 $6.9 billion in 2016, about 10% of the transportation sector's contribution to Canada's GDP, 91% of which comes from rail freight operations, with the remaining 9% coming from passenger rail services.[70]

2.7.4 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 560 port facilities, about 870 fishing harbours, and 130 recreational harbours.[71] In 2016, marine transportation services handled over $199 billion of Canada's international trade.[72]

Table 2.4: GHG emissions by transportation mode, 1990–2015

SECTOR AND MODE	GHG EMISSIONS (MT CO_2EQ)								CHANGE (%)	
	1990	2005	2010	2011	2012	2013	2014	2015	1990–2015	2005–2015
TRANSPORTATION	122	163	171	171	173	176	173	173	42%	6%
Passenger Transport	78	93	92	90	90	92	89	91	17%	-2%
Cars, trucks and motorcycles	71	85	85	83	83	84	82	83	17%	-2%
Bus, Rail and Domestic Aviation	7	7	7	7	7	8	7	7	0%	0%
Freight Transport	34	64	73	75	77	78	77	76	124%	19%
Heavy duty trucks, Rail	27	56	65	69	71	72	71	71	163%	27%
Domestic Aviation and Marine	6	8	8	7	7	6	6	5	-17%	-38%
Others*	10	7	7	6	6	6	6	6	-40%	-14%

*Others refer to recreational, commercial and residential off-road transporation.

Source: United Nations Framework Convention on Climate Change. 2017. *National Inventory Report 1990–2015: GHG Sources and Sinks in Canada*, Part I, Table 2-12.

2.8 Industry Profile

Canada's industrial sector is very diverse with facilities engaged in mining, manufacturing, construction and forestry. Taken together, these sectors contributed to 29% of Canada's GDP in 2016,[73] with the total value of exports from the top 25 industries representing CAD $517 billion in 2016.[74]

Table 2.5: Emissions by Industry, 1990–2015

INDUSTRY	1990	2005	2010	2011	2012	2013	2014	2015
	MT CO_2 EQUIVALENT							
Heavy Industry	97	86	73	80	79	77	77	75
Mining	7	7	8	8	8	8	8	8
Smelting and refining (non-ferrous metals)	17	14	11	11	10	11	10	10
Pulp and paper	15	9	7	7	7	7	6	6
Iron and steel	16	16	14	17	17	15	16	14
Cement	10	13	10	10	11	10	10	10
Lime and gypsum	3	3	3	3	3	2	3	2
Chemicals and fertilizers	29	23	21	23	24	24	24	25
Coal Production	4	2	3	3	3	3	2	2
Light manufacturing, construction & forest resources	29	24	22	23	22	22	21	21

Source: *National Inventory Report 1990–2015: GHG Sources and Sinks in Canada*. United Nations Framework Convention on Climate Change. 2017.

2.9 Waste

In 2014, Canadians generated 34 million tonnes of municipal solid waste.[75] About 40% of the waste generated originated from residential sources and 60% from non-residential sources.[76] 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.[77] Paper fibres made up the largest portion of all diverted materials at 40% (3.6 million tonnes), followed by organic materials at 30% (2.7 million tonnes).[78]

During the period of 2002 to 2014, the quantity of solid waste diverted through recycling and composting increased by 36%. Despite this increase in waste being diverted from landfills, the overall quantity of municipal solid waste sent for disposal increased by 4% during the 2002 to 2014 period.[79]

The total amount of organic waste diverted to recycling or organics processing facilities doubled between 2002 and 2014.[80] Expenditures on organic processing facilities increased by 8.5% from 2012 to 2014, reaching $92.3 million dollars in 2014.[81]

At many large municipal solid waste landfill facilities, landfill gas is captured to be flared or utilized, or both. Owing to the relatively high concentration of methane in the landfill gas, the gas can be combusted for electricity or heat generation. Between 1997 and 2015, the number of landfill gas capture systems has more than doubled, increasing from 31 to 81 facilities. Total landfill gas capture increased from 21% in 1990 to 38% in 2015.[82]

2.10 Building Stock

2.10.1 Residential

Between 1990 and 2014, the number of households in Canada increased by 41% (4.1 million) and the population grew by 28% (7.9 million).[83] 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 9.5% over the same period as homeowners switched to cleaner energy sources (such as natural gas) and energy efficient technologies.[84]

The main sources of residential energy use include natural gas, electricity, wood, heating oil, and propane. As per Figure 2.3, due to Canada's relatively cold climate, space heating and water heating are the main residential energy uses.

The amount of energy used by the residential sector to heat each square metre of living space decreased significantly between 1990 and 2014, mainly driven by energy efficiency gains. More Canadians shifted from oil to less emissions intensive natural gas as a source of home heating fuel, with natural gas use for space heating increasing by 31% between 1990 and 2014.[85]

The number of major appliances operated in Canada between 1990 and 2014 increased by about 55%. However, the total amount of energy that households used to power major appliances decreased by 26% due to significant energy efficiency improvements.[86] 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 (i.e., EnerGuide) and voluntary standards such as ENERGY STAR that help increase consumer awareness of major appliances' energy use and associated operating costs.

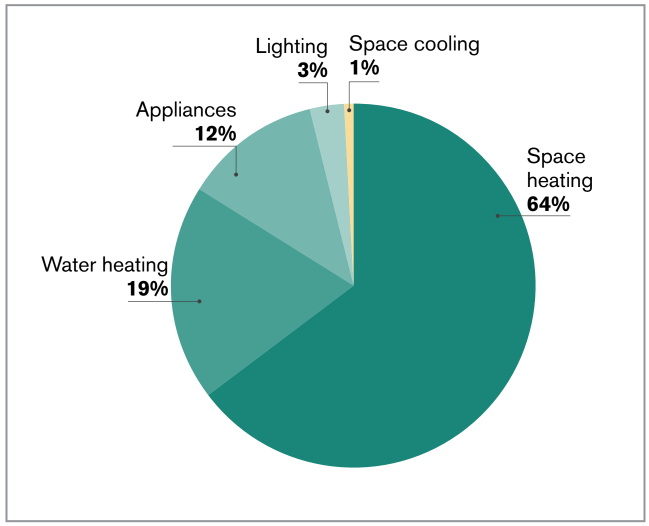


Figure 2.3: Distribution of residential energy use by end-use, 2014
Source: Natural Resources Canada. 2017. Energy Use Data Handbook, 1990–2014, Ottawa (ON).

2.10.2 Commercial/Institutional

In 2014, the commercial/institutional building sector was responsible for 11% of the total energy use in Canada. 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, around 56%, followed by auxiliary equipment at 14%.[87] 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 in terms of energy consumed per unit of floor space by 11% between 1990 and 2014.[88] Over the same period, the total floor space has increased by 48% while total energy consumption rose by 32%.[89] 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.

The estimated participation rate in "green"/energy rating programs—such as LEED (Leadership in Energy and Environmental Design), Green Key Eco-Rating Program, Greenleaf, BOMA BEST (Building Environmental Standards), and ENERGY STAR Portfolio Manager benchmarking tool—is growing. In 2012, about 12% of the commercial and institutional building stock was registered in these programs in Canada.[90]

2.11 Agriculture

In 2016, Canada's primary agriculture sector accounted for 1% of GDP while being at the heart of a broader agriculture and agri-food system which represents 7% of total GDP, employs approximately 2.3 million Canadians (one in eight jobs), and places Canada as the 5th largest exporter of agriculture and agri-food products internationally.[91]

Canada's agriculture and agri-food exports reached $56 billion in 2016, with oilseeds and oilseed products accounting for 25%, followed by grains and grain products at 22%, and live animals, red meat and other animal products at 17%.[92] Crop production and beef farming have long been the backbone of Canada's agriculture industry. In 2016, a third of Canadian farms were engaged in grain and oilseed cropping and one-in-five were raising beef cattle.

Despite having the second highest arable land per capita ratio in the world, only 7% of Canada's land mass is suitable for agricultural production.[93] In 2016, total farm area was 64.8 million hectares (160.1 million acres). Land for crop production has been increasing over time, rising to 37.8 million hectares (93.4 million acres) in 2016 while areas for pasture and other land have been slowly decreasing to reach 27 million hectares (66.7 million acres).[94]

Non-energy GHG emissions directly related to animal and crop production accounted for 59 megatonnes CO_2 eq in 2015. Of this total, livestock emissions from enteric fermentation and manure management, storage and application accounted for 37 megatonnes CO_2 eq while crop production accounted for 22 megatonnes from the application of synthetic nitrogen fertilizer and crop residue decomposition. In addition to non-energy GHG emissions, on-farm fuel use generated 14 megatonnes CO_2 eq in 2015.[95]

In recent decades, Canadian farmers have increasingly substituted conventional tillage with no-till and conservation tillage seeding techniques. No-till practices are currently used on 59% of total land prepared for seeding while conservation tillage is used on 24%.[96] The extensive adoption of such tillage practices, combined with a major reduction in summerfallow and sound crop rotations, has contributed to turn Canadian agricultural soils into a net carbon sink which sequestered 11 megatonnes CO_2 eq in 2015.[97] However since 2006, net removals are slowly levelling off mainly due to soil organic carbon approaching equilibrium levels.

In the beef sector, Canadian farmers have also made significant improvements in feeding and breeding practices. In 2011, Canada produced 32% more beef than in 1981, while using 29% less breeding stock and 24% less land. These gains in productivity have translated into 15% less GHGs being emitted per unit of meat than in 1981.[98] Similar declining emission intensities have also been measured for dairy and swine production.[99]

Overall, total net emissions from agriculture have been slightly declining since 2000 while productivity growth has contributed to higher output levels. More efficient input uses and better management practices have resulted in a decoupling of GHG emissions from output and an improvement of the emission intensity of the Canadian agriculture sector.

2.12 Forest

Canada has 396 million hectares of forest, other wooded land, and other land with tree cover.[100] Forest land accounts for 347 million hectares,[101] 65% of which is considered "managed forest" (forests under direct human influence) for the purposes of the GHG inventory.[102] In 2016, the forest sector contributed $23.1 billion to national nominal GDP (approximately 1.2% of Canada's total GDP) and directly employed an estimated 211,075 Canadians.[103]

Most of Canada's forest land is publicly owned; 90% is under provincial or territorial jurisdiction, 4% is under federal and Indigenous jurisdiction, and the remaining 6% is privately owned.[104] All lands under federal jurisdiction that are harvested for commercial timber must be regenerated naturally, by planting and seeding, or by using a combination of these methods.[105] As of December 2016, Canada had 168 million hectares of forests certified as being sustainably managed under one or more of three globally recognized certification systems.[106]

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 780,000 hectares in 2015) is relatively small compared to the area of natural disturbances caused by fire and insects. Harvest volumes rose through the 1990s and peaked at a record level of 211 million cubic metres in 2004, but subsequently fell to an almost 40-year low of 119 million cubic metres in 2009, as a result of the global recession.[107] Since then, harvest rates have recovered somewhat, to the level of the early 1990s.

Despite Canada's ongoing fire suppression efforts, the annual total area burned by wildfire in the forest has increased in recent years. In 2015, a total of 7,068 forest fires burned about 3.9 million hectares in the total forest (managed and unmanaged forest), which is about 50% above the 10-year average for area burned.[108] Even with an integrated pest management approach, pest infestations including spruce budworm (concentrated in Eastern Canada) and forest tent caterpillar and mountain pine beetle (concentrated in Western Canada) have severely damaged over 17.6 million hectares across Canada in 2015.[109] Insect damage can increase the risk of wildfire, and drought can stress trees, making them more susceptible to attack by insects and disease.[110] It is expected that climate change (changes in temperature, precipitation and season length) will further exacerbate the impacts and increase frequency of natural disturbances.[111]

In previous GHG inventories, Canada's estimates of managed forest emissions and removals displayed large interannual variability due to the impacts of natural disturbances, and this masked the impact of forest management activities. Starting with its *2017 National Inventory Report* on GHGs, Canada implemented an improved approach for estimating and reporting anthropogenic emissions and removals in its managed forests in which emissions and removals in forest stands dominated by natural disturbances are temporarily excluded from reporting (see Chapter 3: Canada's National Greenhouse Gas Inventory).

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CHAPTER 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. 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) their national inventories of anthropogenic emissions by sources and removals by sinks of greenhouse gases (GHGs) not controlled by the Montréal Protocol.[1]

Canada's National Inventory is prepared and submitted annually to the UNFCCC by April 15 of each year, in accordance with revised *Guidelines for the preparation of national communications by Parties included in Annex I to the Convention*, *Part I: UNFCCC reporting guidelines on annual inventories* (UNFCCC Reporting Guidelines), adopted through Decision 24/CP.19 at COP 19 in Warsaw in 2013. The annual inventory submission consists of the National Inventory Report (NIR) and the Common Reporting Format (CRF) tables.

The inventory GHG estimates include carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), perfluorocarbons (PFCs), hydrofluorocarbons (HFCs), sulphur hexafluoride (SF_6), and nitrogen trifluoride (NF_3) in the following five sectors defined by the Intergovernmental Panel on Climate Change (IPCC): Energy, Industrial Processes and Product Use (IPPU), Agriculture, Waste, and Land Use, Land-Use Change and Forestry (LULUCF). The GHG emission and removal estimates contained in Canada's GHG inventory are developed using methodologies consistent with the 2006 IPCC inventory guidelines. In line with the principle of continuous improvement, the underlying data and methodology for estimating emissions are revised over time; hence, total emissions in all years are subject to change as both data and methods are improved.

This chapter summarizes the latest information on Canada's net anthropogenic emissions as reported in the *National Inventory Report 1990–2015: Greenhouse Gas Sources and Sinks in Canada* (Canada's 2017 NIR) and provides a description of the factors underlying the emissions trends. The Executive Summary of Canada's 2017 NIR is available online at: http://www.ec.gc.ca/ges-ghg and the full 2017 submission to the UNFCCC is available at: http://unfccc.int/national_reports/annex_i_ghg_inventories/national_inventories_submissions/items/10116.php.

3.1 Overview a National GHG Emissions

In 2015, the most recent annual dataset in this report, Canada's GHG emissions were 722 megatonnes of carbon dioxide equivalent (Mt CO_2 eq),[2] a net decrease of 16 Mt in total emissions or 2.2% from 2005 emissions (Figure 3-1).[3] Annual emissions fluctuated between 2005 and 2008, dropped in 2009, and gradually increased thereafter.

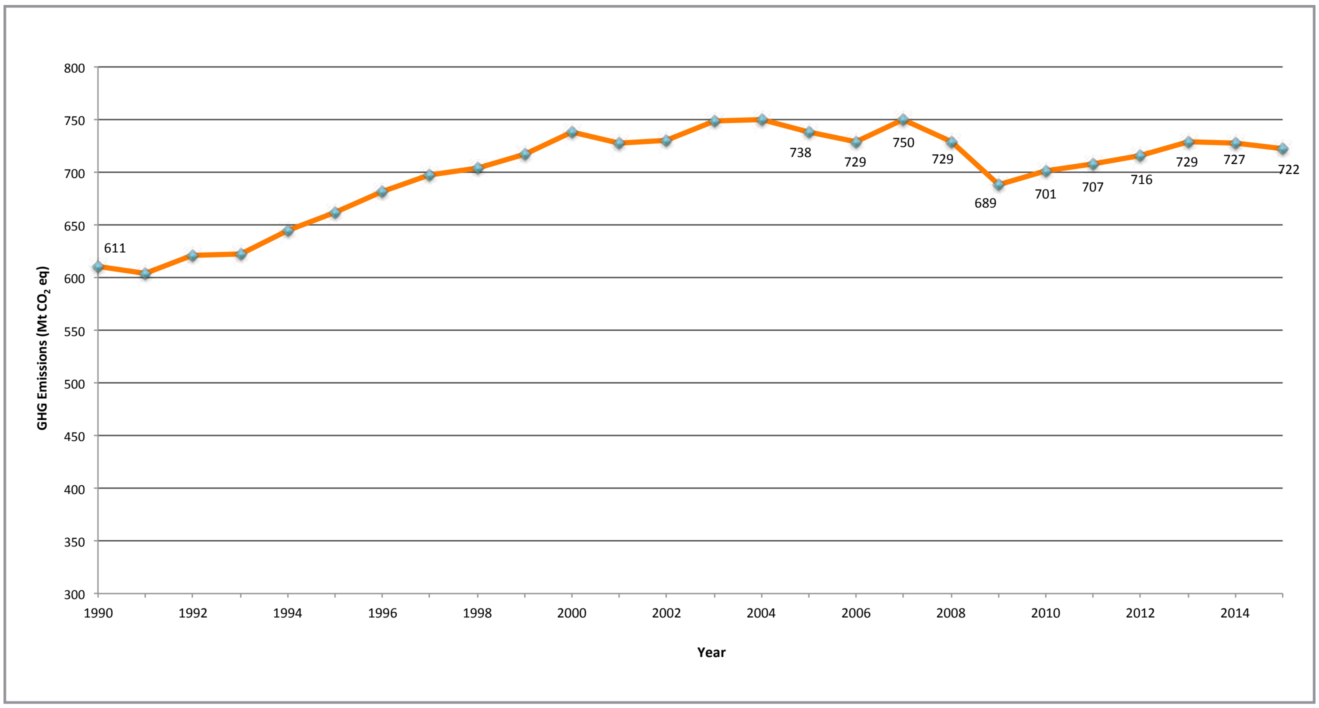
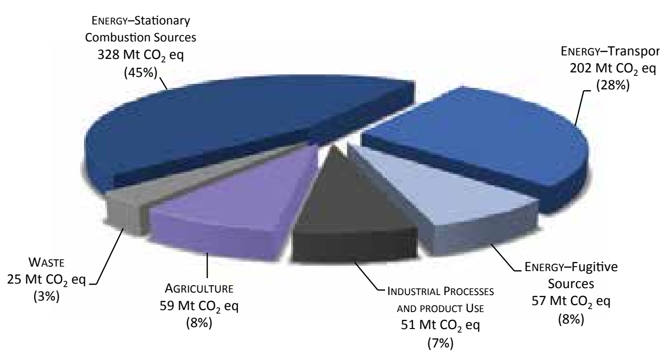
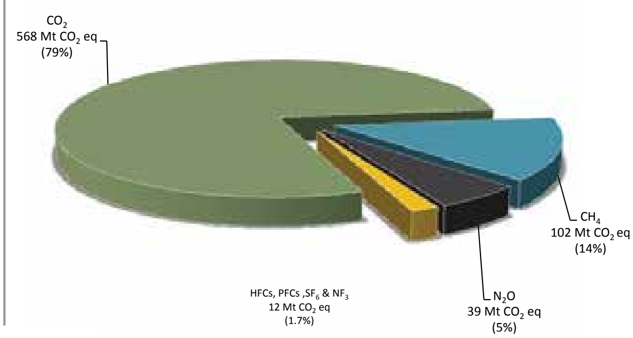


Figure 3-1: Canadian GHG Emissions Trend (2005–2015) and 2030 Target (excluding LULUCF)

In 2015, the Energy Sector (consisting of Stationary Combustion Sources, Transport, and Fugitive Sources) emitted 587 Mt of GHGs, or 81% of Canada's total GHG emissions (Figure 3-2). The remaining emissions were largely generated by the Agriculture (8%) and Industrial Processes and Product Use (7%) Sectors, with minor contributions from the Waste Sector (3%). The LULUCF Sector was a sink in 2015, with net removals of 34 Mt, a 3 Mt reduction from the net removals of 37 Mt in 2005.

Canada's emissions profile is similar to that of most industrialized countries. CO_2 is the largest contributor to Canada's GHG emissions, accounting for 568 Mt or 79% of total emissions in 2015 (Figure 3-3). The majority of the CO_2 emissions in Canada result from the combustion of fossil fuels. CH_4 emissions in 2015 amounted to 102 Mt or 14% of Canada's total. These emissions consist largely of fugitive emissions from oil and natural gas systems, agriculture and landfills. N_2O emissions arise from activities such as agricultural soil management and transport, and accounted for 39 Mt or 5.4% of Canada's emissions in 2015. Emissions of synthetic gases (HFCs, PFCs, SF_6 and NF_3) constituted slightly less than 2%.





Total: 722 Mt CO_2 eq

Figure 3-2: Canada's Emissions Breakdown by IPCC Sector (2015)*

*Note: Totals may not add up due to rounding.

Figure 3-3: Canada's Emissions Breakdown by GHG (2015)*

Over the last decades Canada's economy has grown more rapidly than its GHG emissions. As a result, the emission intensity for the entire economy (GHG per Gross Domestic Product (GDP)) has declined by 16.4% since 2005 (Figure 3-4 and Table 3-1). A divergence of emissions and emissions intensity began in the early 1990s (Figure 3-4) and can be attributed to fuel switching, increases in efficiency, the modernization of industrial processes, and structural changes in the economy. These long-term trends have led to continued reduction in emissions intensity. Section 3.3 provides more information on trends in GHG emissions.

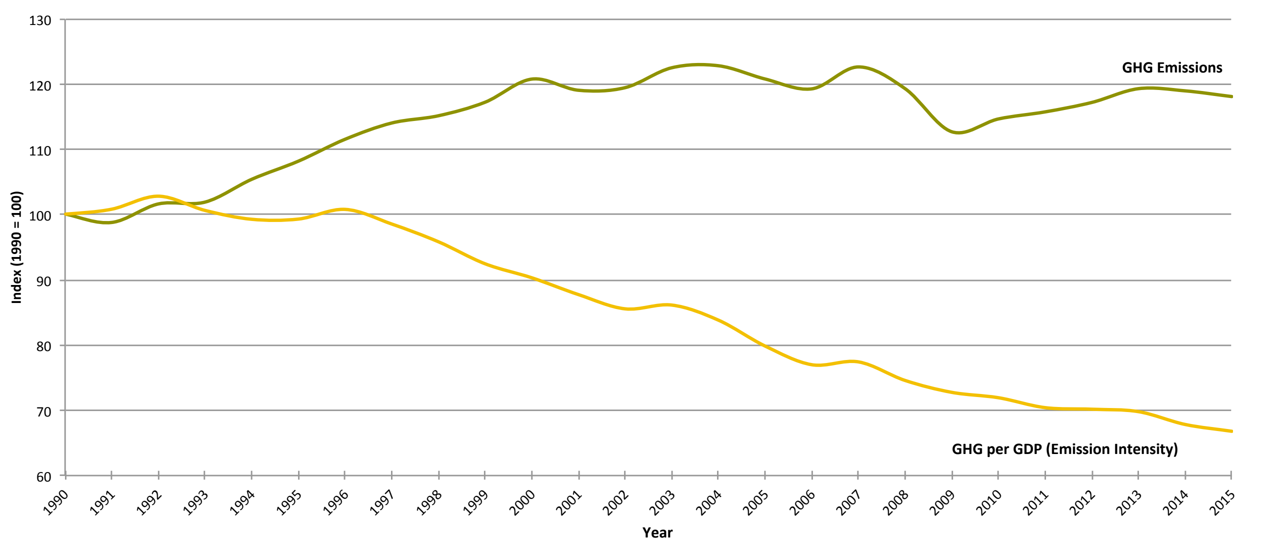


Figure 3-4: Indexed Trend in GHG Emissions and GHG Emissions Intensity (1990–2015)

Table 3-1: Trends in Emissions and Economic Indicators, Selected Years

YEAR	1990	2005	2010	2011	2012	2013	2014	2015
Total GHG (Mt)	611	738	701	707	716	729	727	722
Change since 2005 (%)	NA	NA	-5.1%	-4.2%	-3.0%	-1.2%	-1.5%	-2.2%
GDP (Billion 2007$)	993	1,503	1,584	1,633	1,659	1,698	1,742	1,757
Change since 2005 (%)	NA	NA	5.4%	8.7%	10.4%	13.0%	16.0%	16.9%
GHG Intensity (Mt/$B GDP)	0.62	0.49	0.44	0.43	0.43	0.43	0.42	0.41
Change since 2005 (%)	NA	NA	-9.9%	-11.8%	-12.1%	-12.6%	-15.1%	-16.4%

GDP data source: Statistics Canada (no date(a)) Table 380-0106–Gross domestic product at 2007 prices, expenditure-based, annual (dollars). CANSIM (database).
NA not applicable

Canada represented approximately 1.6% of total global GHG emissions in 2013,[4] although it is one of the highest per capita emitters. Canada's per capita emissions have dropped substantially since 2005, when this indicator was 22.9 t. By 2009, per capita emissions had dropped to 20.5 t and have remained at historic lows ever since, with 2015 seeing the smallest per capita emissions yet at 20.1 t (Figure 3-5).

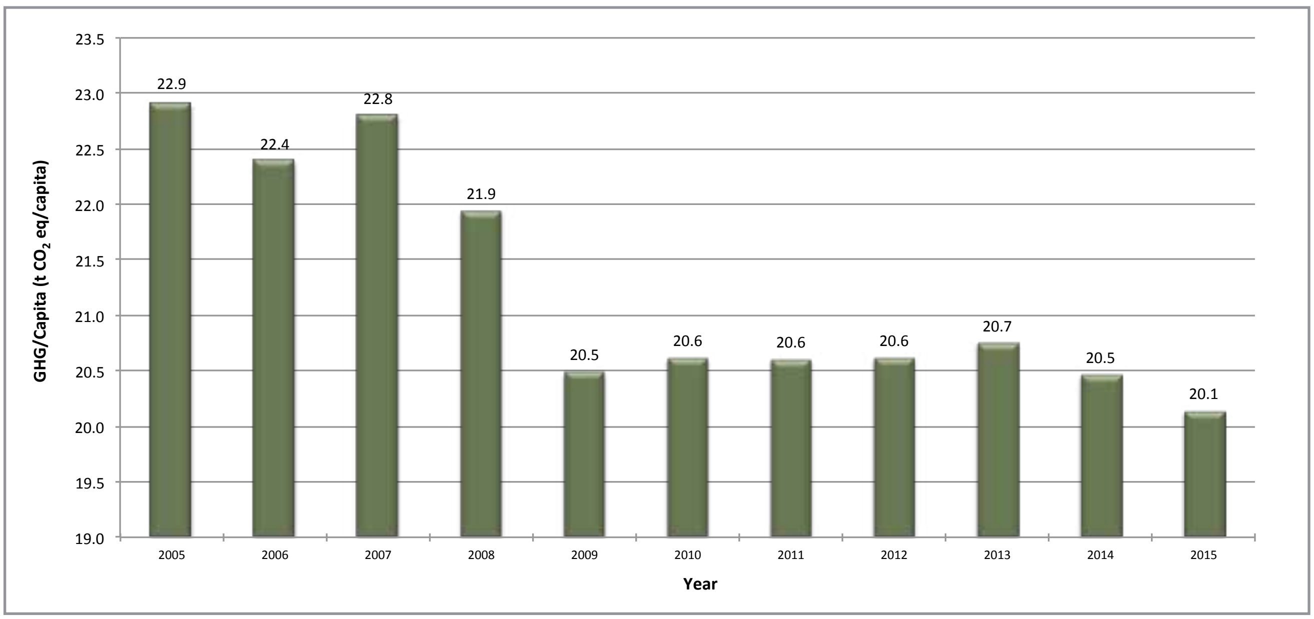


Figure 3-5: Canadian per Capita GHG Emissions (2005–2015)
Population data source: Statistics Canada. No date(b). Table 051-0001: Estimates of Population, by Age Group and Sex for July 1, Canada, Provinces and Territories, Annual (persons unless otherwise noted) CANSIM (database).

3.2 Emissions and Trends by IPCC Sectors

Trends in Emissions

Over the period 2005–2015, total emissions decreased by 16 Mt or 2.2% (Figure 3-6). The Energy Sector dominated the long-term trend, with emission decreases of 11 Mt (3%) in Stationary Combustion Sources and 4 Mt (7%) in Fugitive Sources (Table 3-2). In addition, the IPPU and Waste Sectors each saw decreases of 3 Mt (6% and 10% respectively), while emissions from Agriculture decreased by 2 Mt (3%). Over the same period, emissions from Transport increased by 7 Mt (4%) partially offsetting the decreases from the other sectors (Figure 3-7).

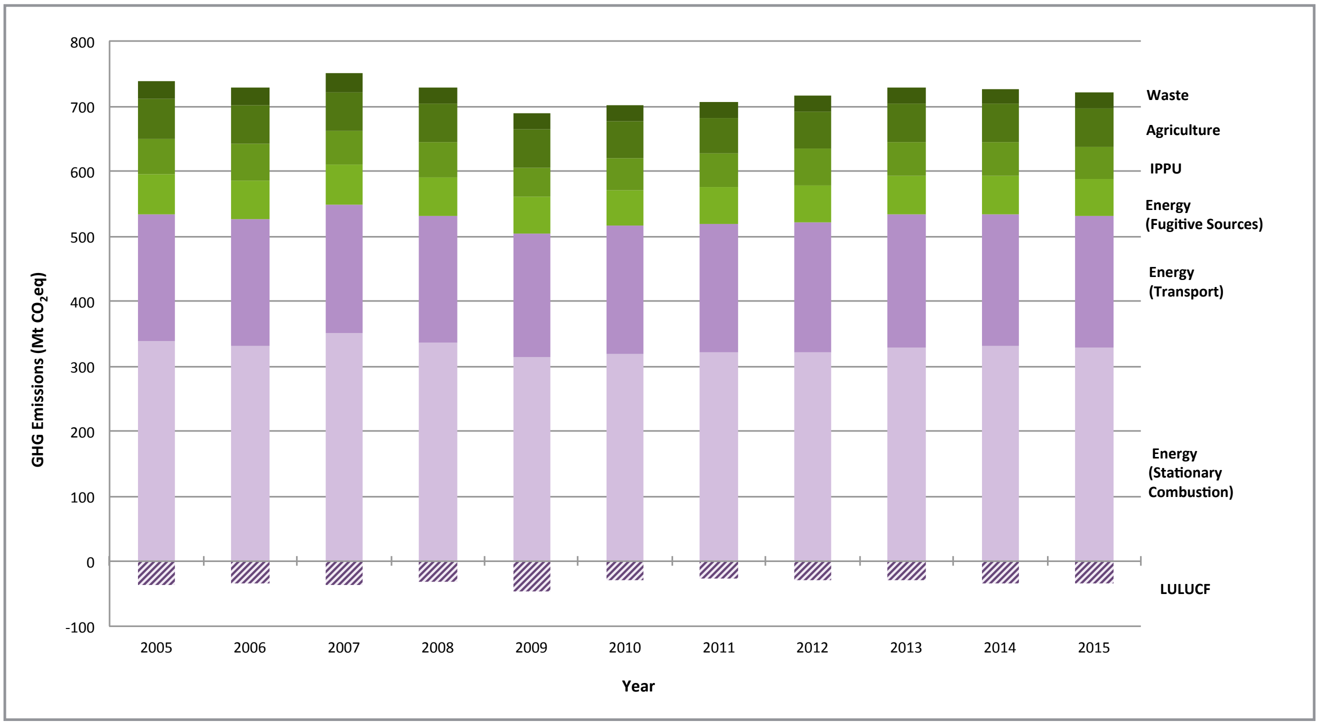


Figure 3-6: Trends in Canadian GHG Emissions by IPCC Sector (2005–2015)

Increases in emissions since 2009 can be attributed to increases in energy consumption and fugitive emissions in oil and gas operations (29 Mt),[5] increases in the number of heavy-duty diesel vehicles in operation (8 Mt), increased consumption of halocarbons (4 Mt), and continuous increases in the application of inorganic nitrogen fertilizers (3 Mt). During the same period, there was a 15 Mt decrease in emissions from electricity generation, which partly offset emission growth.

Chapter 2 of Canada's 2017 NIR provides more information on trends in GHG emissions from both 1990 and 2005 and their drivers.[6] Further breakdowns of emissions by subsector and gas, and a complete time series can be found in Annex 9 of Canada's 2017 NIR.

Table 3-2: Canada's GHG Emissions by IPCC Sector (1990–2015)

GREENHOUSE GAS CATEGORIES	1990	2005	2010	2011	2012	2013	2014	2015
	Mt CO_2 equivalent							
TOTAL[1]	**611**	**738**	**701**	**707**	**716**	**729**	**727**	**722**
Energy	**483**	**595**	**571**	**575**	**578**	**592**	**594**	**587**
a. Stationary Combustion Sources	286	339	318	320	322	329	332	328
Public Electricity and Heat Production	94	122	101	94	91	88	85	84
Petroleum Refining Industries	17	20	19	19	20	19	18	17
Mining and Upstream Oil and Gas Production	41	68	81	82	91	99	102	105
Manufacturing Industries	56	48	41	44	44	45	45	43
Construction	2	1	2	1	1	1	1	1
Commercial and Institutional	26	32	28	30	28	30	32	31
Residential	47	46	43	46	42	44	46	43

GREENHOUSE GAS CATEGORIES	1990	2005	2010	2011	2012	2013	2014	2015
	Mt CO_2 equivalent							
Agriculture/Forestry/Fishing	2	2	3	4	4	4	4	4
b. Transport	148	195	199	200	200	204	202	202
Domestic Aviation	7	8	6	6	7	8	7	7
Road Transportation	92	134	142	143	144	147	144	144
Railways	7	7	7	8	8	7	8	7
Domestic Navigation	5	6	7	6	6	5	5	4
Other Transportation	37	41	38	38	36	37	38	39
c. Fugitive Sources	49	61	54	55	57	59	60	57
Coal Mining	3	1	1	1	1	2	1	1
Oil and Natural Gas	46	59	53	54	56	57	58	56
d. CO_2 Transport and Storage	–	0	0	0	0	0	0	0
Industrial Processes and Product Use	**56**	**54**	**48**	**52**	**56**	**54**	**51**	**51**
a. Mineral Products	8	10	8	8	8	8	8	8
b. Chemical Industry	17	9	5	6	6	6	6	7
c. Metal Production	24	20	16	17	17	15	15	14
d. Production and Consumption of Halocarbons, SF_6 and NF_3	1	5	8	9	9	9	10	11
e. Non-Energy Products from Fuels and Solvent Use	5	9	11	12	15	15	12	11
f. Other Product Manufacture and Use	0	1	0	0	0	0	0	0
Agriculture	**49**	**61**	**56**	**55**	**57**	**60**	**58**	**59**
a. Enteric Fermentation	23	31	26	25	25	25	25	25
b. Manure Management	8	10	8	8	8	8	8	9
c. Agricultural Soils	17	18	20	20	21	23	22	23
d. Field Burning of Agricultural Residues	0	0	0	0	0	0	0	0
e. Liming, Urea Application and Other Carbon-containing Fertilizers	1	1	2	2	2	3	2	3
Waste	**24**	**28**	**25**	**25**	**24**	**24**	**25**	**25**
a. Solid Waste Disposal	22	25	22	22	22	22	22	22
b. Biological Treatment of Solid Waste	1	1	1	1	1	1	1	1
c. Wastewater Treatment and Discharge	1	1	1	1	1	1	1	1
d. Incineration and Open Burning of Waste	1	1	1	1	1	1	1	1
Land Use, Land-use Change and Forestry	**-99**	**-37**	**-28**	**-26**	**-30**	**-29**	**-33**	**-34**
a. Forest Land	-252	-183	-159	-160	-164	-163	-166	-164
b. Cropland	9	-10	-12	-12	-12	-11	-11	-11
c. Grassland	1	1	0	1	2	1	1	1
d. Wetlands	5	3	3	3	3	3	3	3
e. Settlements	4	4	4	4	4	4	4	4
f. Harvested Wood Products	135	149	136	138	137	138	137	135

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

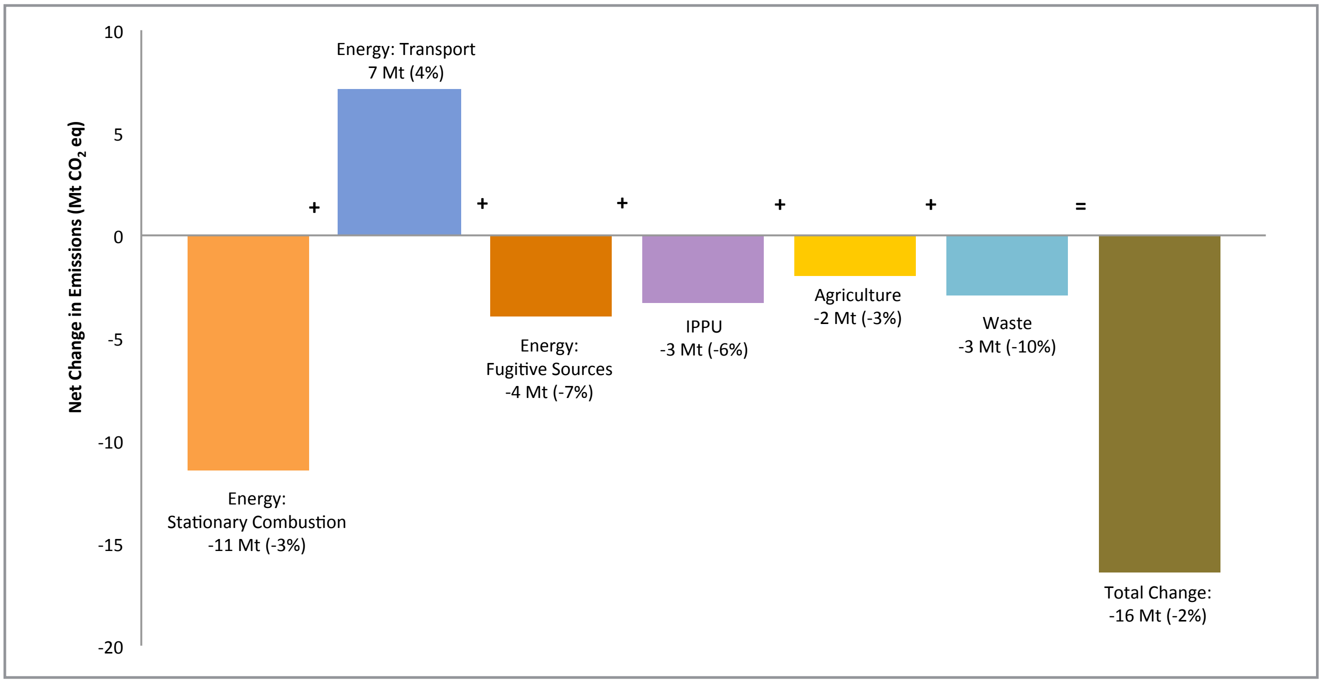


Figure 3-7: Changes in Emission by IPCC Sector (2005–2015)

The following describes the emissions and trends of each IPCC sector in further detail.

Energy—2015 GHG Emissions (587 Mt)

Energy consumption is by far the largest source of GHG emissions in Canada. In line with the *2006 IPCC Guidelines for National Greenhouse Gas Inventories* (IPCC 2006), sources in the Energy Sector are grouped under Stationary Combustion, Transport, Fugitive Sources, and CO_2 Transport and Storage.

Stationary Combustion accounts for the largest portion (56%) of emissions from the Energy Sector. In 2015, emissions totaled 328 Mt, an increase of 15% from the 1990 level of 286 Mt and a decrease of 3.4% from 2005 emissions of 339 Mt (Figure 3-8).

Dominant categories in Stationary Combustion are Mining and Upstream Oil and Gas Production, which contributes 32% of the total Stationary Combustion emissions, and Public Electricity and Heat Production, which contributes 26% in 2015. Manufacturing Industries and Residential each contribute 13% of the total Stationary Combustion emissions, while Commercial and Institutional contributes 9%.

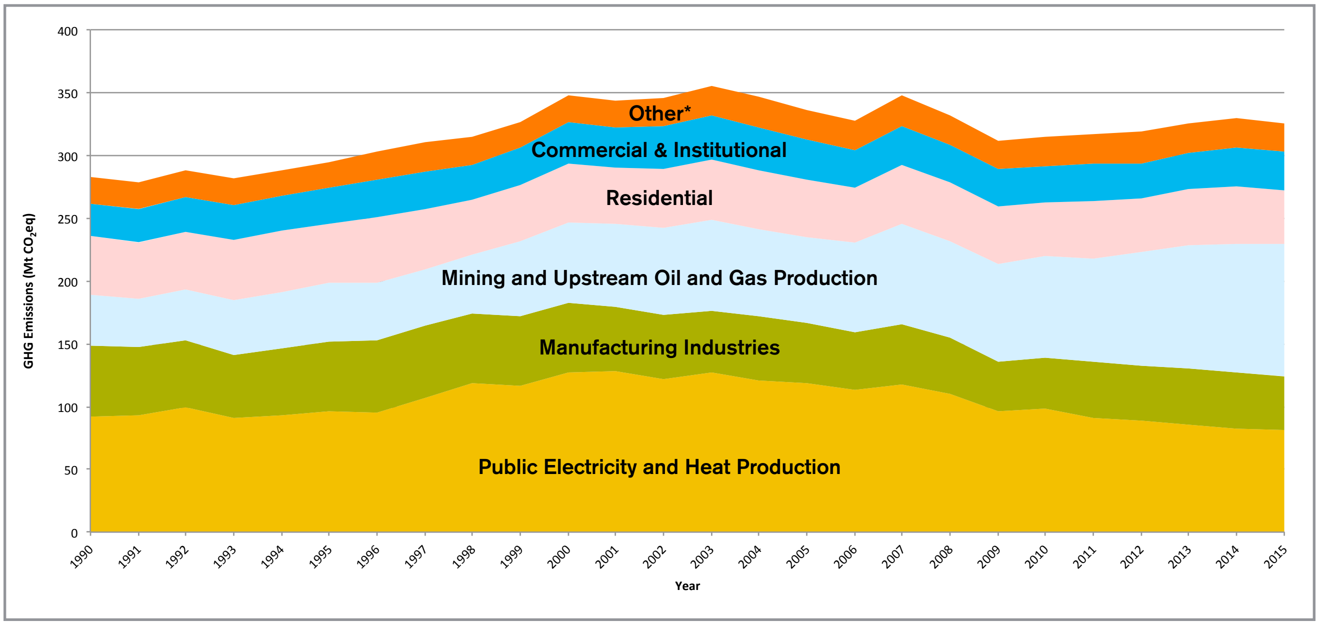


Figure 3-8: Trends in Canadian GHG Emissions from Stationary Combustion Sources (1990–2015)

In 2015, GHG emissions from the IPCC Energy Sector (587 Mt) were 1.4% lower than in 2005 (595 Mt). Within the Energy Sector, the 37 Mt increase in emissions from Mining and Upstream Oil and Gas Production was offset by a 38 Mt decrease in emissions from Public Electricity and Heat Production.

Decreasing energy generation from coal and oil, accompanied by an increase in hydro, nuclear and wind generation, was the largest driver of the 31% decrease in emissions associated with Electricity Production between 2005 and 2015. The permanent closure of all coal generating stations in the province of Ontario by 2014 was the determinant factor.[7] Emission fluctuations over the period reflect variations in the mix of electricity generation sources.[8]

GHG emissions from Manufacturing Industries decreased by 5.0 Mt between 2005 and 2015, consistent with both a 16% decrease in energy use and an observed decline in output[9] in these industries.

Oil production has been driven primarily by a rapid rise in the extraction of bitumen and synthetic crude oil from Canada's oil sands operations, where total output has increased by 140% since 2005. This has contributed to the 37 Mt increase in emissions between 2005 to 2015 from Mining and Upstream Oil and Gas Production. However, from 2010 to 2015 the emission intensity of oil sands operations themselves have dropped by approximately 16% as a result of technological and efficiency improvements, less venting emissions and reductions in the percentage of crude bitumen being upgraded to synthetic crude oil.

Transport is a large and diverse subsector, accounting for 202 Mt of GHG emissions or 34% of Canada's Energy Sector emissions in 2015. Transport includes emissions from fuel combustion in six categories: Road Transportation, Domestic Aviation, Domestic Navigation, Railways, Other Transportation (Off-road), and Pipeline Transport. From 1990 to 2015, Transport emissions rose 36% (54 Mt), accounting for a significant portion of Canada's emissions growth (Figure 3-9).

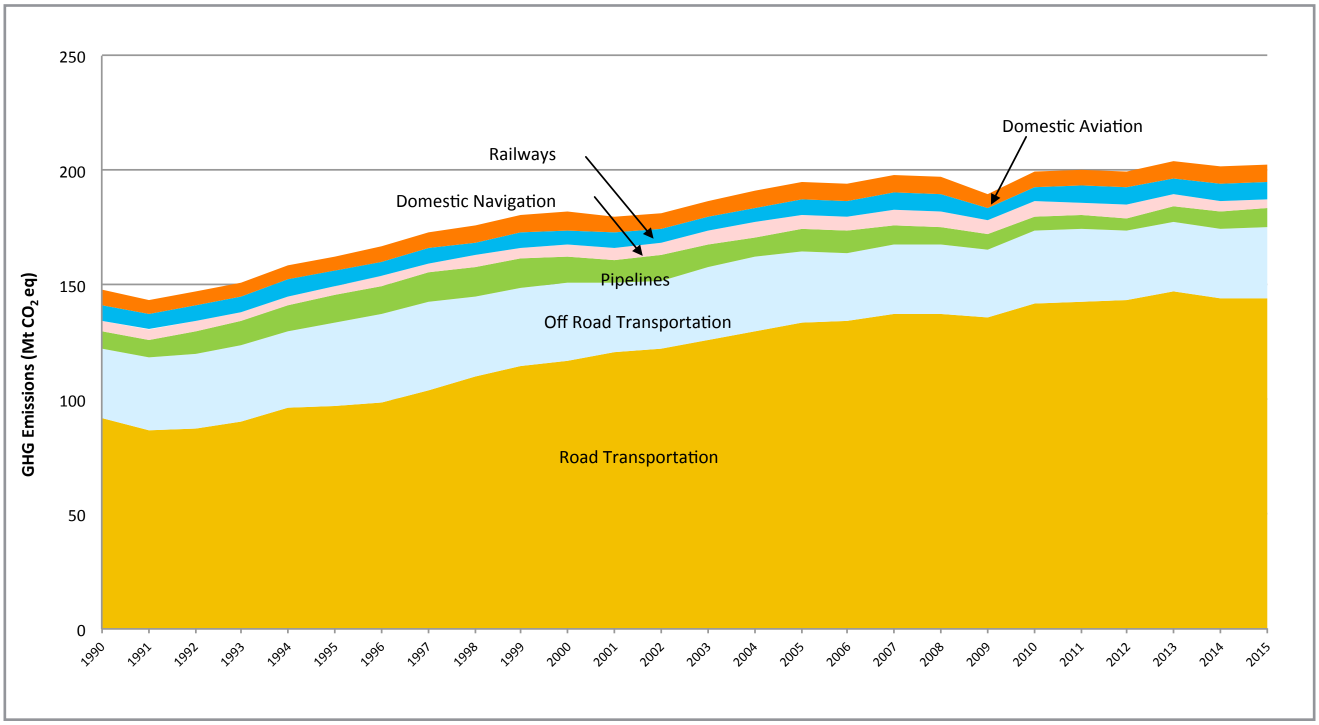


Figure 3-9: Trends in Canadian GHG Emissions from Transport (1990–2015)

The majority of transport emissions in Canada are related to Road Transportation, which includes personal transportation (light-duty vehicles and trucks) and heavy-duty trucks. The growth in road transport emissions is largely due to more driving. Despite a reduction in kilometres driven per vehicle, the total vehicle fleet has increased by 19% since 2005, most notably for trucks (both light and heavy-duty), leading to more kilometres driven overall.

Fugitive emissions are the intentional or unintentional releases of GHGs from the production, processing, transmission, storage and delivery of fossil fuels. Released hydrocarbon gases that are disposed of by combustion (e.g. flaring of natural gases at oil and gas production and processing facilities) are also considered fugitive emissions. Fugitive Sources are broken down into two main categories: Coal Mining and Oil and Natural Gas. Emissions from the Oil and Natural Gas category contributed 98% of the total fugitive emissions in 2015, with Coal Mining accounting for the remaining 2%. Overall, these sources constituted about 10% of Energy Sector emissions in 2015 and alone contributed 7% to the growth in emissions between 1990 and 2015.

Industrial Processes and Product Use—2015 GHG Emissions (51 Mt)

The IPPU Sector covers non-energy GHG emissions that result from manufacturing processes and use of products, such as limestone calcination in cement production and the use of HFCs and PFCs as replacement refrigerants for ozone-depleting substances (ODSs). Emissions from the IPPU Sector contributed 51 Mt (7%) to Canada's 2015 emissions, compared with 56 Mt (9%) in 1990, a decrease of approximately 5 Mt or 9%.

Emissions of most industries decreased in 2008 and 2009 and have remained at similar levels since then. A notable exception includes the 5.9 Mt (116%) increase in emissions from the use of HFCs since 2005 (Table 3-3).

The aluminium industry has decreased its process emissions, largely due to technological improvements introduced to mitigate PFC emissions. The overall decrease in GHG emissions from chemical industries is primarily a result of the closure in 2009 of the sole Canadian adipic acid plant located in Ontario.

Table 3-3: GHG Emissions from IPPU Categories, Selected Years

GHG SOURCE CATEGORY	GHG EMISSIONS (MT CO_2 EQ)								CHANGE (%)	
	1990	2005	2010	2011	2012	2013	2014	2015	1990–2015	2005–2015
Total—Industrial Processes	**56**	**54**	**48**	**52**	**51**	**56**	**53**	**51**	**-8.9%**	**-6.4%**
Mineral Products	8.4	10	7.8	7.9	8.5	7.7	7.8	8.0	-4.7%	-21%
Cement Production	5.8	8	6.0	6.1	6.6	6.0	5.9	6.3	8.8%	-18%
Lime Production	1.8	2	1.4	1.4	1.4	1.4	1.5	1.3	-24%	-22%
Mineral Product Use	0.9	1	0.4	0.5	0.4	0.4	0.4	0.4	-52%	-52%
Chemical Industry	17	9.5	5.5	6.1	6.4	6.4	6.0	6.5	-62%	-31%
Ammonia Production	2.8	3	2.5	2.9	3.0	2.9	2.5	2.9	2.8%	5.3%
Nitric Acid Production	1.0	1.2	1.1	1.1	1.1	1.0	1.0	1.1	14%	-7.7%
Adipic Acid Production	10	3	–	–	–	–	–	–	-100%	-100%
Petrochemical Production & Carbon Black Production	3.3	3.0	1.9	2.1	2.3	2.5	2.4	2.5	-22%	-16%
Metal Production	24	20	16	17	17	15	15	14	-40%	-30%
Iron and Steel Production	10	10	9.2	10	10	8.0	8.9	8.0	-24%	-22%
Aluminium Production	10	9	6.9	6.8	6.5	6.5	5.8	6.0	-42%	-31%
SF_6 Used in Magnesium Smelters and Casters	3.0	1.2	0.2	0.2	0.2	0.2	0.2	0.2	-93%	-82%
Production and Consumption of Halocarbons, SF_6 and NF_3	1.0	5	7.8	8.6	9.1	9.4	10	11	1,029%	116%
Non-Energy Products from Fuels and Solvent Use	5.0	9	11	12	15	15	12	11	115%	22%
Other Product Manufacture and Use	0.4	0.5	0.4	0.4	0.5	0.5	0.4	0.5	29%	-9.3%

Note: Totals may not add up due to rounding.

Agriculture—2015 GHG Emissions (59 Mt)

The Agriculture Sector covers non-energy GHG emissions relating to the production of crops and livestock. Emissions from Agriculture accounted for 59 Mt, or 8% of total GHG emissions for Canada in 2015, down 2 Mt from their peak in 2005, but nonetheless an increase of 10 Mt or 22% since 1990 (Table 3-4).

In 2015, Agriculture accounted for 28% of national CH_4 emissions and 71% of national N_2O emissions.

The main drivers of the emission trend in the Agriculture Sector are the fluctuations in livestock populations and application of inorganic nitrogen fertilizers in the Prairie Provinces. Since 2005, fertilizer use has increased, while livestock populations peaked in 2005 and decreased sharply to 2011. In 2015, emissions from livestock digestion (enteric fermentation) accounted for 42% of total agricultural emissions, and the application of inorganic nitrogen fertilizers accounted for 22% of total agricultural emissions.

Table 3-4: GHG Emissions from Agriculture, Selected Years

GHG SOURCE CATEGORY	GHG EMISSIONS (MT CO_2 EQ)[1]								CHANGE (%)	
	1990	2005	2010	2011	2012	2013	2014	2015	1990–2015	2005–2015
Agriculture	**49**	**61**	**56**	**55**	**57**	**60**	**58**	**59**	**22%**	**-3%**
Enteric Fermentation	23	31	26	25	25	25	25	25	10%	-20%
Manure Management	7.5	9.8	8.5	8.4	8.4	8.4	8.5	8.5	13%	-13%
Agricultural Soils	17	18	20	20	21	23	22	23	36%	24%
Field Burning of Agricultural Residues	0.23	0.05	0.03	0.03	0.04	0.05	0.05	0.05	-76%	19%
Liming, Urea Application and Other Carbon-containing Fertilizers	1.2	1.4	1.8	2.0	2.3	2.7	2.5	2.7	125%	88%

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

Waste—2015 GHG Emissions (25 Mt)

The Waste Sector includes GHG emissions from the treatment and disposal of liquid and solid wastes. Emissions from Waste contributed 25 Mt (3.4%) to Canada's total emissions in 2015 and 28 Mt (3.7%) in 2005 (Table 3-5).

The primary source of emissions in the Waste Sector is Solid Waste Disposal, which includes municipal solid waste (MSW) landfills (19 Mt in 2015) and wood waste landfills (4 Mt in 2015). In 2015, Solid Waste Disposal accounted for 90% of Waste emissions, while Biological Treatment of Solid Waste (composting), Wastewater Treatment and Discharge, and Incineration and Open Burning of Waste contributed 3.8%, 4.3% and 2.2%, respectively.

Methane emissions from publicly and privately owned municipal solid waste landfills (MSW) make up 86% of emissions from Solid Waste Disposal. The remainder originate from on-site industrial landfills of wood residues; such landfills are declining in number as markets for wood residues grow.

Methane emissions from MSW landfills decreased 11% between 2005 and 2015. Of the 30 Mt CO_2 eq of CH_4 generated by MSW landfills in 2015, only 19 Mt (or 62% of generated emissions) were actually emitted to the atmosphere. The other 11 Mt were captured and combusted at 81 landfill gas collection sites. The quantity of captured CH_4 increased from 27% in 2005 to 38% in 2015. Of the total amount of CH_4 collected in 2015, 51% (5.6 Mt) was utilized for various energy purposes and the remainder was flared.

Table 3-5: GHG Emissions from Waste, Selected Years

GHG SOURCE CATEGORY	GHG EMISSIONS (MT CO_2 EQ)								CHANGE (%)	
	1990	2005	2010	2011	2012	2013	2014	2015	1990–2015	2005–2015
Waste Sector	24	28	25	25	24	24	25	25	3.3%	-10%
Solid Waste Disposal	22	25	22	22	22	22	22	22	2.9%	-11%
Biological Treatment of Solid Waste	0.72	0.97	0.96	0.93	0.94	0.94	0.95	0.94	31%	-2.8%
Wastewater Treatment and Discharge	0.87	1.02	1.03	1.04	1.04	1.05	1.06	1.06	22%	4.5%
Incineration and Open Burning of Waste	0.79	0.70	0.66	0.65	0.53	0.55	0.55	0.55	-30%	-21%

Note: Totals may not add up due to rounding.

Land Use, Land-use Change and Forestry—2015 (Net GHG Removals of 34 Mt)

The Land Use, Land-use Change and Forestry (LULUCF) Sector reports anthropogenic GHG fluxes between the atmosphere and Canada's managed lands, including those associated with land-use change and emissions from Harvested Wood Products (HWP), which are closely linked to Forest Land.

In this sector, the net flux is calculated as the sum of CO_2 and non-CO_2 emissions to the atmosphere and CO_2 removals from the atmosphere. In 2015, this net flux amounted to removals of 34 Mt (Figure 3-10), which, if included, would decrease the total Canadian GHG emissions by 4.7%. New this year, the LULUCF estimates now exclude the impact of significant natural disturbances in managed forests (wildfires and insects), revealing more meaningful trends associated with anthropogenic activities. Additional information on the changes made this year can be found in Chapter 6 of Canada's 2017 NIR.

The trend in net removals is mainly driven by a decrease in net CO_2 removals from Forest Land combined with HWP, partially attenuated by an increase in net CO_2 removals in Cropland and reduced emissions from the conversion of forests to other land use.

Net removals from Forest Land decreased from 180 Mt in 2005 to 165 in 2015, fluctuating in recent years between removals of 160 to 170 Mt as forests recover from peak harvest rates and insect disturbance in the mid-2000s. Over this same period emissions from HWP originating from Canada fluctuated between 150 Mt in 2005, to a low of 125 Mt in 2009 (the year of the lowest harvest rates), and have since increased to 135 Mt in 2015. A significant proportion of HWP emissions result from the decay of long-lived wood products reaching the end of their economic life decades after the wood was harvested. HWP emissions like Forest Land emissions and removals are influenced by recent forest management trends, but also by the long-term impact of forest management that occurred in past decades.

Since 2005, net removals from Cropland have increased slightly from 10.3 to 10.9 Mt. However removals actually peaked in 2009 at 11.7 Mt and have since declined as a result of an increase in the conversion of perennial to annual crops on the prairies, the declining effect of conversion to conservation tillage and slower rates of agricultural expansion onto forest land.

The conversion of forests[10] to other land uses is a prevalent, yet declining, practice in Canada and is mainly due to forest conversion to settlements for resource extraction and cropland expansion. Emissions due to forest conversion fell from 16 Mt in 2005 to 14 Mt in 2015.

All emissions and removals in the LULUCF Sector are excluded from the national totals. However, if included, the estimated net removals would decrease Canada's total GHG emissions by about 16%, 5.0% and 4. 6%, in 1990, 2005 and 2015, respectively.

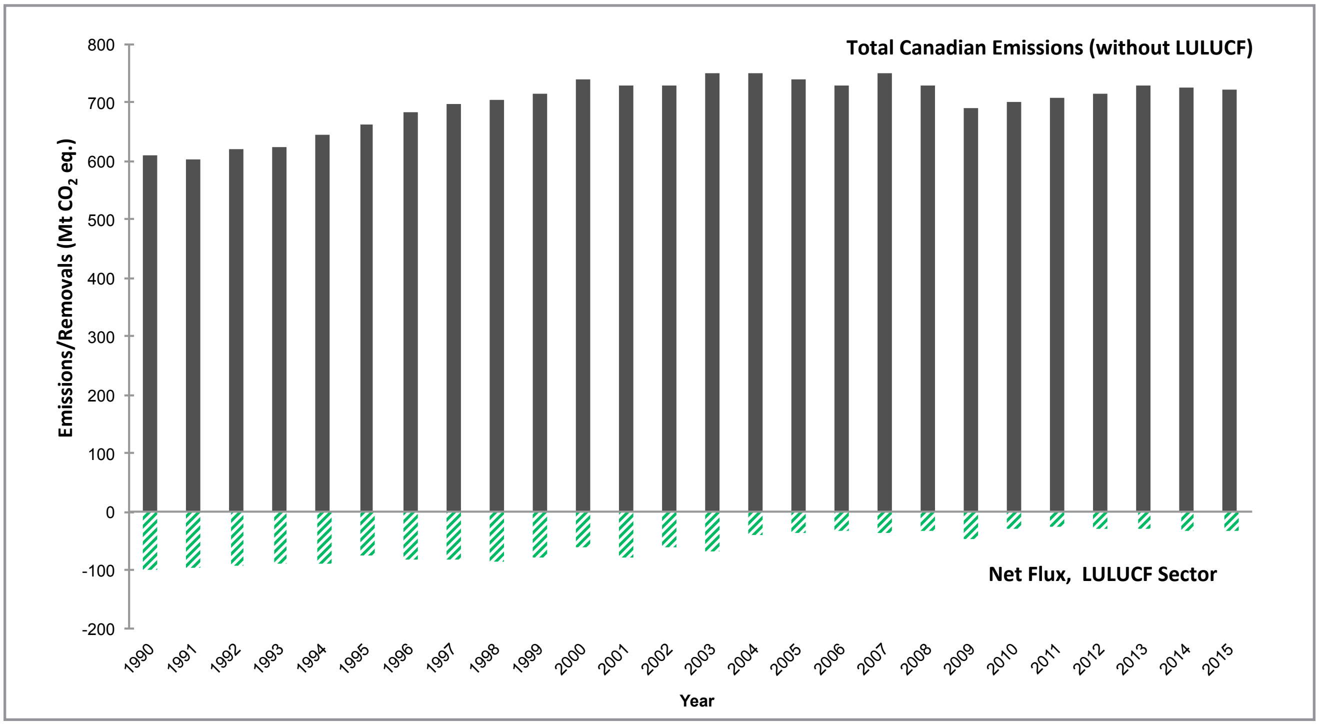


Figure 3-10: Net Flux from LULUCF Relative to Total Canadian Emissions, 1990–2015

3.3 Emissions Trends by Canadian Economic Sectors

For the purposes of analyzing economic trends and policies, it is useful to allocate emissions to the economic sector from which the emissions originate. In general, a comprehensive emission profile for a specific economic sector is developed by reallocating the relevant proportion of emissions from various IPCC subcategories. This reallocation simply re-categorizes emissions under different headings and does not change the overall magnitude of Canadian emissions estimates. The following section reports emissions according to the following Canadian economic sectors: Oil and Gas, Electricity, Transportation, Heavy Industry,[11] Buildings, Agriculture, and Waste and Others.

Examining the historical path of Canadian GHG emissions by economic sectors allows a better understanding of the connection between economic activities and emissions for the purposes of analyzing trends and for policy and public analysis. This approach is also more closely aligned with that taken in the Pan-Canadian Framework on Clean Growth and Climate Change. Within this report, Canada's economic sector categorization is used to present Canada's policies and measures to reduce GHG emissions (see Chapter 4), and Canada's emissions projections are presented using both IPCC and economic sector categories (see Chapter 5). Table A10-3 from Canada's 2017 NIR has been added at the end of this Chapter and illustrates the relationship between IPCC and Canadian economic sectors.

GHG emissions trends in Canada's economic sectors from 2005 to 2015 are consistent with those described for IPCC sectors, with the Oil and Gas and Transportation economic sectors showing emission increases of 20% and 6% respectively over the last decade (Figure 3-11 and Table 3-6). These increases have been more than offset by emission decreases in Electricity (33%), Heavy Industry (13%) and Waste & Others (13%).

Further information on economic sector trends can be found in Chapter 2 of Canada's 2017 NIR. Additional information on the IPCC and economic sector definitions can be found in Part 3 of Canada's 2017 NIR.

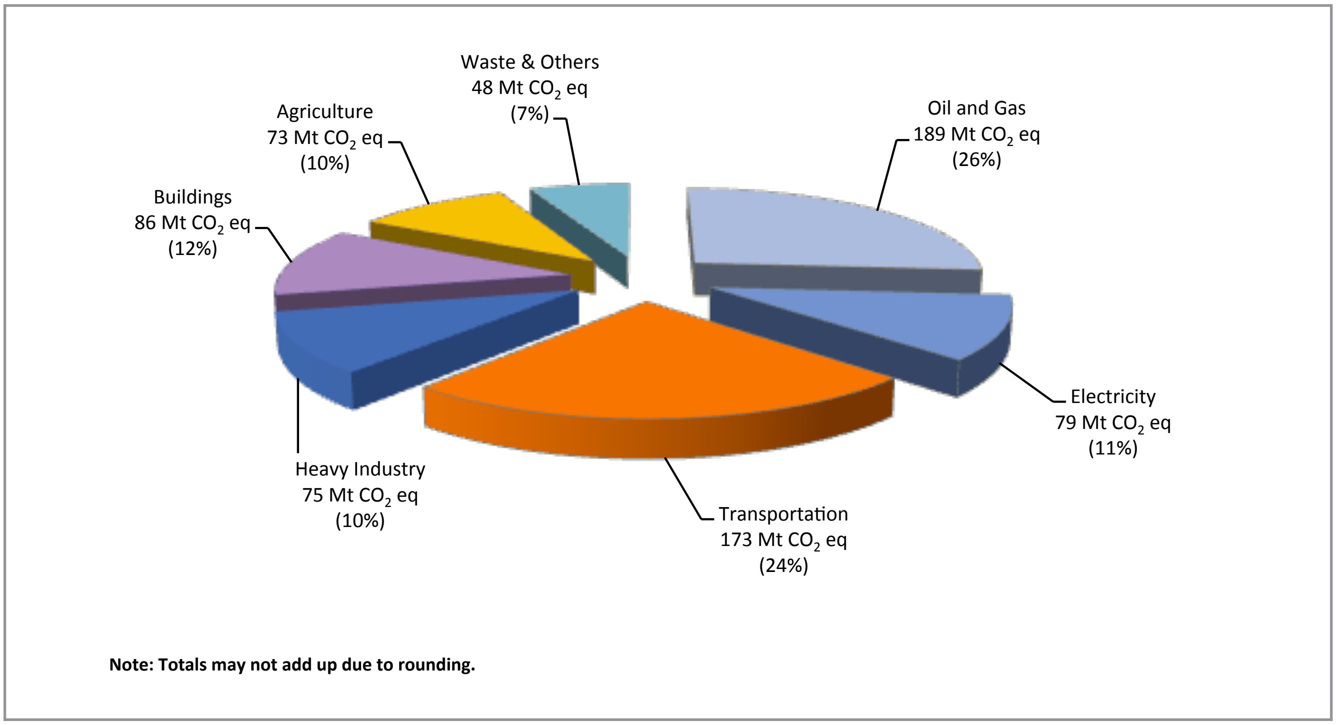


Figure 3-11: Canada's Emissions Breakdown by Economic Sector (2015)

Table 3-6: Canada's GHG Emissions by Economic Sector, Selected Years

	2005	2009	2010	2011	2012	2013	2014	2015
NATIONAL GHG TOTAL	**738**	**689**	**701**	**707**	**716**	**729**	**727**	**722**
Oil and Gas	158	158	160	161	174	185	190	189
Electricity	117	95	96	89	85	82	80	79
Transportation	163	163	171	171	173	176	173	173
Heavy Industry	86	71	73	80	79	77	77	75
Buildings	85	84	81	87	85	85	88	86
Agriculture	74	70	70	70	71	74	72	73
Waste & Other	54	49	50	50	49	49	48	48

Note: Totals may not add up due to rounding.
Estimates presented here are under continual improvement. Historical emissions may be changed in future publications as new data becomes available and methods and models are refined and improved.
*Less than 0.5 Mt CO_2-eq

Oil and Gas

In 2015, the Oil and Gas sector produced the largest share of GHG emissions in Canada (26%). Between 1990 and 2015, emissions from this sector increased by 82 Mt. The majority of this increase (50 Mt) occurred between 1990 and 2005 as the sector expanded and adopted new extraction processes. However, growth in GHG emissions from the oil and gas sector slowed between 2005 and 2015 due to the gradual exhaustion of traditional natural gas and oil resources in Canada.

Transportation

Canada's Transportation sector is the second-largest contributor to Canada's GHG emissions, representing 24% of total emissions in 2015. Between 1990 and 2010 emissions rose by 49 Mt (41%), but since then, emissions from this sector have leveled off. Section 3.3 discusses the main drivers of historical emissions trends associated with passenger and freight transport.

Electricity

In 2015, the Electricity sector (excluding industrial and commercial cogeneration) contributed 11% to total Canadian emissions. Emissions from the Electricity sector increased in parallel with the rising demand for electricity both domestically and to satisfy export to the United States over the earlier years of the reporting period, but have fallen significantly during the latter years. Section 3.3 discusses the main historical drivers of emissions trends associated with electricity generation.

Heavy Industry

The Heavy Industry sector experienced some fluctuation in emissions over the reporting period. Emissions from this sector were responsible for 16% of total Canadian emissions in 1990, falling to 12% in 2005. In more recent years, emissions have fallen further as a result of reduced economic activity and the continued evolution of Canadian production towards other sectors and services, representing a decrease of 11 Mt between 2005 and 2015.

Buildings

GHG emissions from the Buildings sector have increased with population and commercial development but, like all sectors of the economy, decreased in the 2008–2009 recessionary period and have remained relatively steady since then. While residential fuel use has remained relatively steady since 1990, increases in the service industry have resulted in emissions increases from 73 Mt to 86 Mt (17%).

Agriculture and Waste & Other

Emissions from the Agriculture sector continued a slow upward trend throughout the reporting period, rising from 60 Mt in 1990 to 73 Mt in 2015. This increase in emissions is due primarily to increases in livestock and crop production. Emissions from the Waste and Others sector remained relatively stable. Overall emissions decreased over the time series, from a high of 57 Mt in 1990 to 48 Mt in 2015.

3.4 Provincial and Territorial GHG Emissions

Emissions vary significantly by province as a result of population, energy sources and economic structure. All else being equal, economies based on resource extraction will tend to have higher emission levels than service-based economies. Likewise, provinces that rely on fossil fuels for their electricity generation emit relatively more GHGs than those that rely more on hydroelectricity.

Historically Alberta and Ontario have been the highest emitting provinces. Since 2005, emission patterns in these two provinces diverged. Emissions in Alberta increased from 233 Mt in 2005 to 274 Mt in 2015 (18%), primarily as a result of the expansion of oil and gas operations (Figure 3-12 and Table 3-7). In contrast, Ontario's emissions have steadily decreased since 2005 (by 38 Mt or 19%), owing primarily to the closure of coal-fired electricity generation plants.

Electricity production in Québec and British Columbia relies on abundant hydroelectric resources, resulting in more stable emission patterns across the time series. Québec experienced a 9.8% (8.7 Mt) decrease from its 2005 emissions level, while British Columbia had a decline of 4.7% (3.0 Mt).

Emissions in Saskatchewan increased by 7.8% (5.5 Mt) between 2005 and 2015 as a result of activities in the oil and gas industry, potash and uranium mining and transportation. Emissions in Manitoba and Newfoundland and Labrador have also increased since 2005, but to a lesser extent (0.7% and 2% respectively). Provinces which have seen more significant decreases in emissions include New Brunswick (31% reduction, or 6.2 Mt), Nova Scotia (30% reduction, or 7.0 Mt), and Prince Edward (14% reduction, or 0.3 Mt).

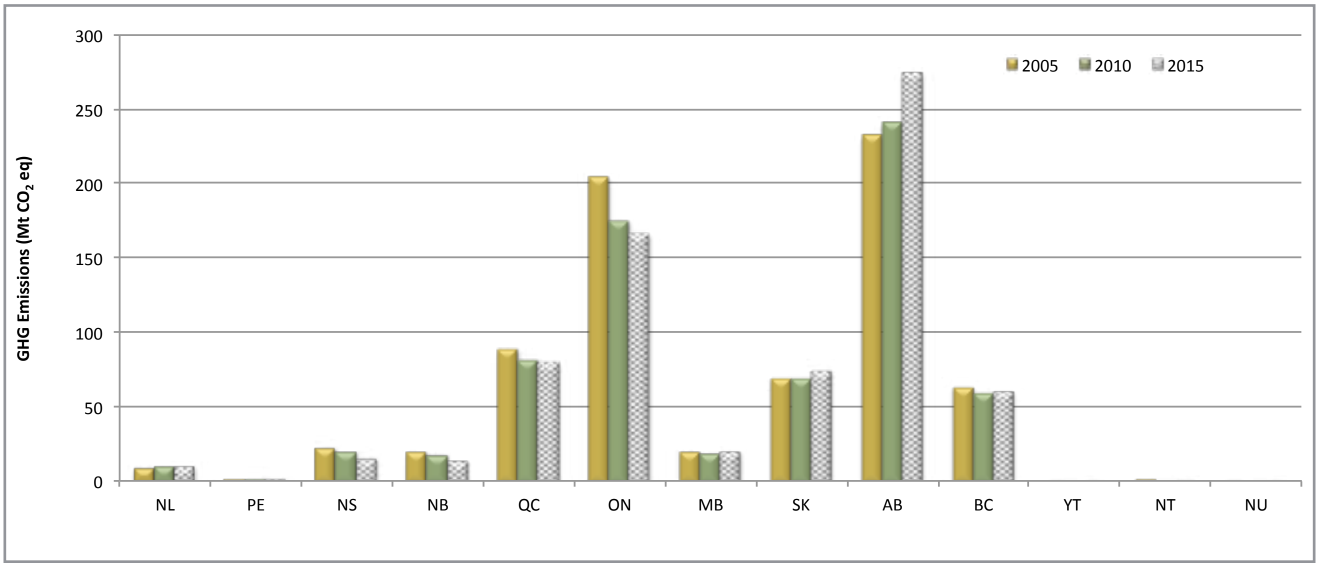


Figure 3-12: Emissions by Province in 2005, 2010 and 2015

Table 3-7: GHG Emissions by Provinces/Territories, Selected Years

	GHG EMISSIONS (MT CO_2 EQ)[1]								CHANGE (%)
YEAR	1990	2005	2010	2011	2012	2013	2014	2015	2005–2015
GHG TOTAL (CANADA)	**611**	**738**	**701**	**707**	**716**	**729**	**727**	**722**	**-2.2%**
NL	9.5	10.1	10.3	10.3	9.9	9.6	10.6	10.3	2.1%
PE	1.9	2.1	2.0	2.2	2.1	1.8	1.8	1.8	-14%
NS	20	23	20	21	19	18	16	16	-30%
NB	16	20	19	19	17	15	14	14	-31%
QC	89	89	82	84	81	82	80	80	-10%
ON	181	204	175	175	171	171	168	166	-19%
MB	19	21	20	19	21	21	21	21	0.7%
SK	45	70	70	69	72	74	75	75	7.8%
AB	175	233	241	246	260	272	276	274	18%
BC	52	64	59	60	61	62	61	61	-4.7%
YT	0.5	0.4	0.4	0.4	0.4	0.4	0.3	0.3	-43%
NT[2]	NA	1.6	1.3	1.4	1.5	1.4	1.3	1.4	-12%
NU[2]	NA	0.5	0.5	0.5	0.6	0.6	0.7	0.6	38%
NT&NU[2]	1.6	NA	NA	NA	NA	NA	NA	NA	–

Note:
[1]Totals may not add up due to rounding.
[2]To account for the creation of Nunavut in 1999, a time series from 1999–2015 is provided for both Nunavut and the Northwest Territories, and the years 1990–1998 are presented as a combined region (see Annex A11 for more information).
NA not applicable

3.5 National Inventory Arrangements

The Pollutant Inventories and Reporting Division within Environment and Climate Change Canada is the single national entity with responsibility for preparing and submitting the National Inventory to the UNFCCC and for managing the supporting processes and procedures.

The institutional arrangements for the preparation of the inventory include: formal agreements supporting data collection and estimate development; a quality management plan, including an improvement plan; the ability to identify key categories and generate quantitative uncertainty analysis; a process for performing recalculations due to improvements; procedures for official approval; and a working archive system to facilitate third-party review.

Submission of detailed information regarding the national inventory arrangements, including details on institutional arrangements for inventory preparation, is also an annual requirement under the UNFCCC reporting guidelines on annual inventories (see Chapter 1, Section 1.2 of Canada's 2017 NIR).

Institutional Arrangements

As the federal agency responsible for preparing and submitting the national inventory to the UNFCCC, Environment and Climate Change Canada has established and manages all aspects of the arrangements supporting the GHG inventory.

Sources and sinks of GHGs originate from a tremendous range of economic sectors and activities. Recognizing the need to draw on the best available technical and scientific expertise and information, Environment and Climate Change Canada has defined roles and responsibilities for the preparation of the inventory, both internally and externally. As such, Environment and Climate Change Canada is involved in many agreements with data providers and expert contributors in a variety of ways, ranging from informal to formal arrangements. These agreements include: partnerships with other government departments, namely Statistics Canada, Natural Resources Canada (NRCan), Agriculture and Agri-Food Canada (AAFC), and Transport Canada; arrangements with industry associations, consultants and universities; and collaborative agreements with provincial and territorial governments on a bilateral basis (Figure 3-13).

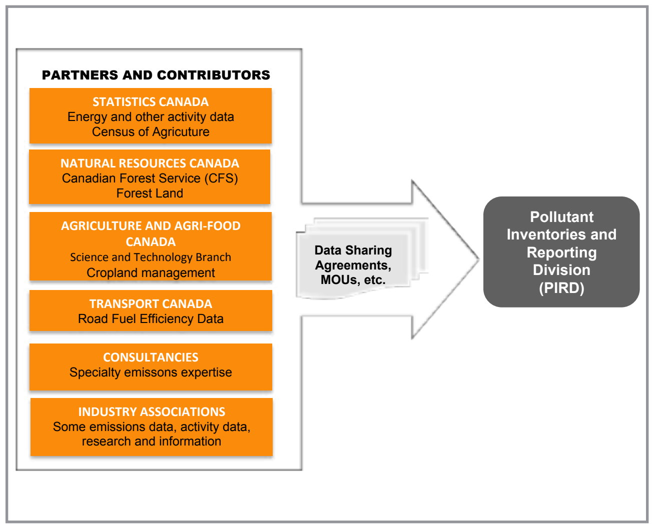


Figure 3-13: Partners and Contributors to National Inventory Arrangements

Process for Inventory Preparation

Canada's inventory is developed, compiled and reported annually by Environment and Climate Change Canada's Pollutant Inventories and Reporting Division, with input from numerous experts and scientists across Canada. Figure 3-14 identifies the various stages of the inventory preparation process.

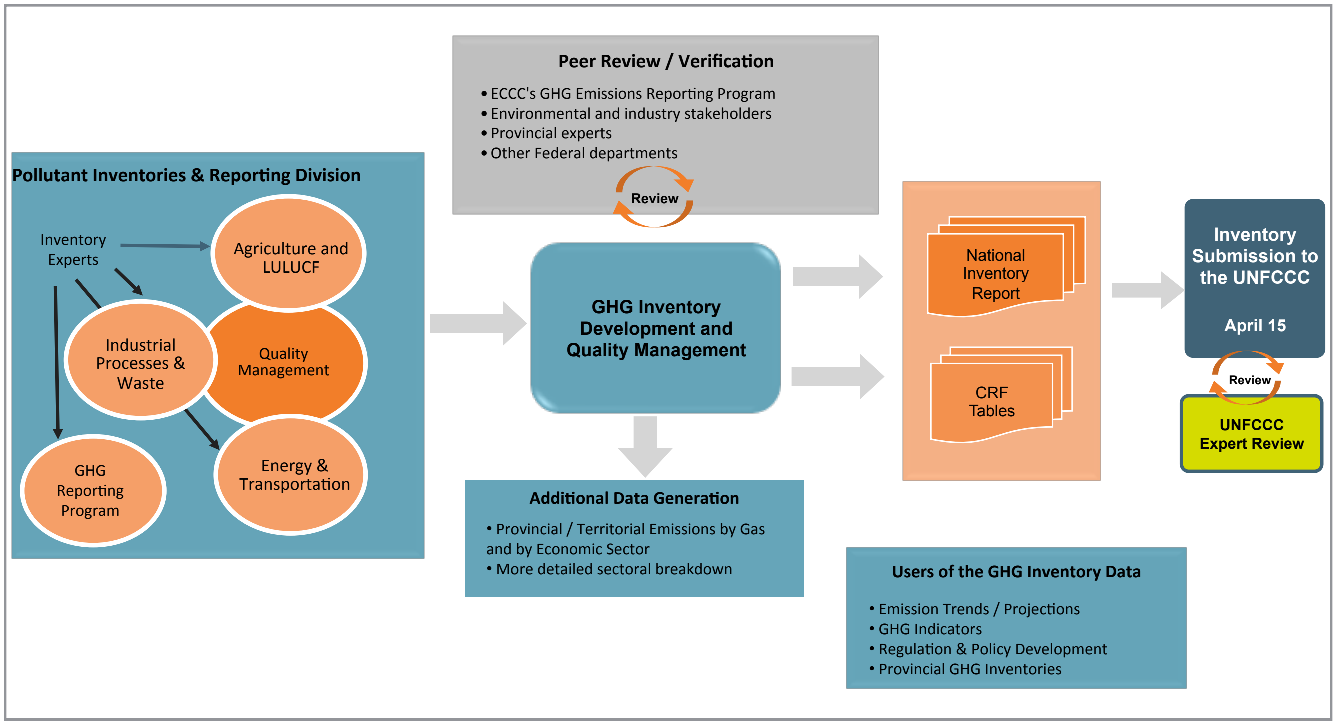


Figure 3-14: Inventory Preparation Process

The inventory builds from 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; the schedule may be adjusted each year based on the results of the lessons-learned review of the previous inventory cycle, Quality assurance, quality control (QA/QC) follow-up, the UNFCCC review report, and collaboration with provincial and territorial governments. Based on these outcomes, methodologies and emission factors are reviewed, developed and/or refined. QA reviews of methodologies and emission factors are typically undertaken for categories for which a change in methodology or emission factor is proposed and for categories that are scheduled for a QA review of methodology or emission factor.

There have been no changes to the National Inventory Arrangements since the previous annual GHG inventory submission.

Quality Assurance, Quality Control and Verification

QA/QC and verification procedures are an integral part of the inventory development and submission processes. These procedures ensure that Canada is able to meet the UNFCCC reporting requirements of transparency, consistency, comparability, completeness and accuracy and, at the same time, continuously improve data and methods to ensure that a credible and defensible inventory is developed.

The development of Canada's GHG inventory is based on a continuous process of data collection, methodological refinement and review. QA/QC procedures take place at all stages of the inventory development cycle.

In order to ensure that an inventory of high quality is produced each and every year, a National Inventory Quality Management System has been developed and implemented for the annual compilation and publication of the national GHG inventory. The Quality Management System is documented in a *Quality Manual*, which includes a QA/QC plan, an Inventory Improvement Plan, processes for creation, documentation and archiving of information, a standardized process for implementing methodological change, identification of key roles and responsibilities, as well as a timeline for completing the various NIR related tasks and activities.

Process for Recalculations of Estimates

It is good practice to continually improve national inventories. Environment and Climate Change Canada consults and works closely with key federal and provincial partners along with industry stakeholders, research centres and consultants on an ongoing 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.

Table A10-3 from Canada's 2017 NIR: Relationship between Canadian Economic Sectors and IPCC Sectors, 2015

ECONOMIC CATEGORY	ECONOMIC CATEGORY TOTAL	National Inventory Category[a]																National Inventory Category									ECONOMIC CATEGORY
		ENERGY								INDUSTRIAL PROCESSES AND PRODUCT USE							AGRICULTURE				WASTE						
		ENERGY: FUEL COMBUSTION				ENERGY: FUGITIVE																					
		Stationary Combustion																									
			Industrial Cogeneration																								
		Stationary	Electricity[c]	Steam for Sale	Transport	Fugitive (Unintentional)	Flaring	Venting	Total	Mineral Products[d]	Chemical Industry[e]	Metal Production[f]	Consumption of Halocarbons, SF_6 and NF_3	Non-Energy Products from Fuels and Solvent Use	Other Product Manufacture and Use	Total	Manure Management	Enteric Fermentation	Agriculture Soils	Total	Solid Waste Disposal	Biological Treatment of Solid Waste	Wastewater Treatment and Discharge	Incineration and Open Burning of Waste	Total	LULUCF[B]	
		Mt CO_2 equivalent																									
National Inventory Total[a,b]	722	305	21.2	1.3	202	21.0	5.1	30.8	587	8.0	6.5	14.2	11.0	10.8	0.5	51.1	8.5	25.0	25.4	59.0	22.1	0.9	1.1	0.6	24.7		National Inventory Total[a,b]
Oil and Gas	**189**	**106.7**	**13.1**	**0.1**	**11.7**	**19.8**	**5.1**	**30.8**	**187.3**					**2.1**		**2.1**											**Oil and Gas**
Upstream Oil and Gas	167	89.9	12.7		11.5	18.7	4.9	29.4	167.2					0.2		0.2											Upstream Oil and Gas
Natural Gas Production and Processing	56	24.8	8.4		0.3	10.1	1.1	10.9	55.6					0.0		0.0											Natural Gas Production and Processing
Conventional Oil Production	31	8.8	0.8		0.1	3.1	2.7	15.2	30.8					0.0		0.0											Conventional Oil Production
Conventional Light Oil Production	14	2.8	0.6		0.1	2.0	2.0	6.8	14.2					0.0		0.0											Conventional Light Oil Production
Conventional Heavy Oil Production	15	5.2			0.0	1.1	0.2	8.4	15.0																		Conventional Heavy Oil Production
Frontier Oil Production	2	0.8	0.3		0.0	0.0	0.5	0.0	1.6																		Frontier Oil Production
Oil Sands (Mining, In-situ, Upgrading)[c]	71	56.3	3.4		3.1	4.4	1.1	2.5	70.8					0.1		0.1											Oil Sands (Mining, In-situ, Upgrading)[c]
Mining and Extraction	18	9.7	0.8		3.1	4.0	0.3		18.0					0.1		0.1											Mining and Extraction
In-situ	34	31.5	1.7			0.3	0.1	0.1	33.7																		In-situ Extraction
Upgrading	19	15.0	0.9			0.1	0.7	2.4	19.1					0.0		0.0											Upgrading
Oil and Natural Gas Transmission	10				8.0	1.2	0.0	0.8	10.0																		Oil and Natural Gas Transmission
Downstream Oil and Gas	22	16.9	0.4	0.1	0.1	1.1	0.2	1.4	20.1					2.0		2.0											Downstream Oil and Gas
Petroleum Refining	21	16.9	0.4	0.1	0.0	0.1	0.2	1.3	19.0					2.0		2.0											Petroleum Refining
Natural Gas Distribution	1				0.1	1.0	0.0	0.1	1.2																		Natural Gas Distribution
Electricity	**79**	**78.1**		**0.5**					**78.6**						**0.2**	**0.2**											**Electricity**
Transportation[g]	**173**				**169.5**				**169.5**				**3.3**	**0.0**	**0.0**	**3.3**											**Transportation[g]**
Passenger Transport	88				86.0				86.0				1.8	0.0	0.0	1.8											Passenger Transport
Cars, Light Trucks and Motorcycles	80				78.8				78.8				1.7	0.0	0.0	1.7											Cars, Light Trucks and Motorcycles
Bus, Rail and Domestic Aviation	7				7.2				7.2				0.1	0.0	0.0	0.1											Bus, Rail and Domestic Aviation
Freight Transport	76				74.1				74.1				1.4	0.0	0.0	1.5											Freight Transport
Heavy Duty Trucks, Rail	70				68.8				68.8				1.4	0.0	0.0	1.4											Heavy Duty Trucks, Rail
Domestic Aviation and Marine	5				5.2				5.2				0.1	0.0		0.1											Domestic Aviation and Marine
Other: Recreational, Commercial and Residential	9				9.5				9.5																		Other: Recreational, Commercial and Residential
Heavy Industry	**75**	**31.3**	**6.7**	**0.6**	**3.3**				**41.9**	**7.9**	**6.5**	**14.2**	**0.6**	**3.5**		**32.7**											**Heavy Industry**
Mining	8	3.6	1.1		2.9				7.6				0.0	0.1		0.1											Mining
Smelting and Refining (Non Ferrous Metals)	10	2.6		0.3	0.1				2.9	0.0		6.2		0.8		7.0											Smelting and Refining (Non Ferrous Metals)
Pulp and Paper	6	4.5	1.3	0.1	0.1				5.9	0.0				0.0		0.0											Pulp and Paper
Iron and Steel	14	5.2	0.0	0.0	0.2				5.4			8.0		0.1		8.1											Iron and Steel
Cement	10	4.1			0.0				4.2	6.3				0.0		6.3											Cement
Lime & Gypsum	2	1.0			0.0				1.0	1.3				0.0		1.4											Lime & Gypsum
Chemicals & Fertilizers	25	10.3	4.2	0.3	0.1				14.9	0.2	6.5		0.6	2.4		9.7											Chemicals & Fertilizers
Buildings	**86**	**72.7**	**0.8**	**0.1**					**73.6**				**6.8**	**4.9**	**0.3**	**12.0**											**Buildings**
Service Industry	41	29.7	0.8	0.1					30.6				5.4	4.9	0.3	10.5											Service Industry
Residential	45	43.0							43.0				1.5			1.5											Residential
Agriculture	**73**	**3.6**			**10.3**				**13.9**					**0.0**		**0.0**	**8.5**	**25.0**	**25.4**	**59.0**							**Agriculture**
On Farm Fuel Use[h]	14	3.6			10.3				13.9					0.0		0.0											On Farm Fuel Use[h]
Crop Production	22																		22.3	22.3							Crop Production
Animal Production	37																8.5	25.0	3.1	36.6							Animal Production
Waste	**25**																				**22.1**	**0.9**	**1.1**	**0.6**	**24.7**		**Waste**
Solid Waste	23																				22.1	0.9			23.1		Solid Waste
Wastewater	1																						1.1		1.1		Waste Water
Waste Incineration	1																							0.6	0.6		Waste Incineration
Coal Production	**2**	**0.5**			**0.5**	**1.1**			**2.1**																		**Coal Production**
Light Manufacturing, Construction & Forest Resources	**21**	**12.6**	**0.5**	**0.0**	**7.0**				**20.2**	**0.2**			**0.4**	**0.2**	**0.0**	**0.7**											**Light Manufacturing, Construction & Forest Resources**
Light Manufacturing	14	11.2	0.5	0.0	1.6				13.4	0.2			0.4	0.2	0.0	0.7											Light Manufacturing
Construction	6	1.3			4.3				5.6					0.0		0.0											Construction
Forest Resources	1	0.1	0.0		1.2				1.3					0.0		0.0											Forest Resources
																										-33.5	

Notes: Totals may not add up due to rounding. Economic category totals rounded to nearest megatonne (Mt). The estimates for the economic categories may not add up to the National Inventory Totals due to rounding and statistical differences in the RESD for the IP category of Other & Undifferentiated Production.
Estimates presented here are under continual improvement. Historical emissions may be change in future publications as new data becomes available and methods and models are refined and improved.

a Categorization of emissions is consistent with the IPCC's sectors following the reporting requirement of the UNFCCC.

b National totals exclude all GHGs from the Land Use, Land Use Change and Forestry Sector.

c Industrial cogeneration includes emissions associated with the simultaneous production of heat and power. At some facilities, a portion of this power is generated by *onsite utility-owned generators*. As such, the cogeneration emissions for these specific facilities are included under the Public Electricity and Heat Generation category in the National Inventory (UNFCCC) format.

d Mineral products includes cement production, lime production and mineral product use.

e Chemical industry includes ammonia production, nitric acid production, petrochemical production, and adipic acid production.
Metal production includes iron and steel production, aluminum production, and SF_6 used in magnesium smelters and casters.

g Emissions from the consumption of propane and natural gas in Transportation are allocated to Cars, Light Trucks and Buses

The number of significant figures presented in this table does not reflect the accuracy of the values. For more information on rounding, please see
0.0 Indicates emissions of less than 0.05 Mt CO_2 eq.

References

[1] Under the United Nations Environment Programme (UNEP), the Montréal Protocol on Substances that Deplete the Ozone Layer is an international agreement designed to reduce the global consumption and production of ozone-depleting substances.

[2] Unless explicitly stated otherwise, all emission estimates given in Mt represent emissions of GHGs in Mt CO_2 eq.

[3] Throughout this Chapter, data are presented as rounded figures. However, all calculations (including percentages) have been performed using unrounded data.

[4] Climate Analysis Indicators Tool (CAIT). (2017). Washington (DC): World Resources Institute. Available online at: http://cait.wri.org/.

[5] Energy consumption and fugitive emissions from oil and gas operations is the sum of emissions from: Petroleum Refining Industries, Mining and Upstream Oil and Gas Production, Pipeline Transport (under *Other Transportation*) and Fugitive Sources (see Table 3-2).

[6] The complete NIR can be accessed here: http://www.ec.gc.ca/ges-ghg/.

[7] Ontario Power Generation News, April 15, 2014; https://www.opg.com/news-and-media/news-releases/Documents/140415TBGSBurnsLastCoal.pdf, (accessed December 2017).

[8] The mix of electricity generation sources is characterized by the amount of fossil fuel vs. hydro, other renewable sources and nuclear sources. In general, only fossil fuel sources generate net GHG emissions.

[9] See, for example, Energy Consumption by the Manufacturing Sector, 2015, Statistics Canada Daily, October 31, 2016; http://www.statcan.gc.ca/daily-quotidien/161031/dq161031d-eng.pdf (accessed January 24, 2017).

[10] Forest conversion emissions are incorporated within sums of emissions of other land-use categories; therefore, the values of 14 and 16 Mt reported here are included in the sums associated with the other land-use category totals.

[11] The Heavy Industry sector represents emissions arising from metal and non-metal mining activities, as well as smelting and refining, pulp and paper, iron and steel, cement, lime and gypsum, and chemicals and fertilizers. This sector was formerly referred to as the Emissions-Intensive, Trade-Exposed sector.

CHAPTER 4

Policies and Measures

4.1 Overall Policy Context

As a decentralized federation, addressing climate change in Canada requires action across federal, provincial and territorial governments. Within the Government of Canada, the Minister of Environment and Climate Change is responsible for domestic and international climate change policies. In recognition of the need for a coordinated national approach, in October 2015, Canada's Prime Minister mandated the Minister of Environment and Climate Change to develop, in partnership with provinces and territories, "a plan to combat climate change and reduce GHG emissions, consistent with [Canada's] international obligations and our commitment to sustainable economic growth."[1]

Arising from this mandate, on December 9, 2016 Canada's federal, provincial and territorial governments took the historic step of adopting the Pan-Canadian Framework on Clean Growth and Climate Change (the Pan-Canadian Framework), a comprehensive plan to reduce emissions across all sectors of the economy, stimulate clean economic growth, and build resilience to the impacts of climate change.

The Pan-Canadian Framework was designed to achieve the behavioral and structural changes needed to facilitate Canada's transition to a low-carbon economy. Actions taken under the Pan-Canadian Framework, supported by significant federal investments announced in the Government of Canada's Budget 2017, will support Canada's efforts to meet its target to reduce GHG emissions by 30 per cent below 2005 levels by 2030, as committed under the Paris Agreement.[2]

The Pan-Canadian Framework will drive both near- and longer-term reductions and has established processes to enhance ambition over time, setting Canada on a pathway consistent with its *Mid-Century Long-Term Low-GHG Development Strategy*. The Pan-Canadian Framework and Mid-Century Strategy are aligned with the Paris Agreement's goal to limit the increase in global average temperature to well below 2°C, and pursue efforts to limit the increase to 1.5°C.

4.1.1 Development of the Pan-Canadian Framework

The Pan-Canadian Framework was developed collaboratively amongst Canada's federal, provincial and territorial governments, with input from Indigenous Peoples as well as from businesses, non-governmental organizations, and Canadians across the country. Development of the Framework began with the Vancouver Declaration issued on March 3, 2016, when Canada's First Ministers agreed to work together on a national plan on climate change and clean growth, building on commitments and actions already taken by provinces and territories.[a] To achieve this objective, the Vancouver Declaration tasked four federal-provincial-territorial working groups to work with Indigenous Peoples; to consult with the public, businesses and civil society; and to present options to act on climate change and enable clean growth.

Following extensive public consultations and analysis undertaken by the working groups, First Ministers reconvened in December 2016 and adopted the Pan-Canadian Framework.[b] The Pan-Canadian Framework builds on existing policies and outlines the additional actions that federal, provincial and territorial governments will take, both individually and collectively, to address climate change. It also describes reporting and oversight provisions to monitor results and ensure transparency. Indigenous Peoples contributed their knowledge and priorities throughout the process to develop the Pan-Canadian Framework through reports, meetings, regional workshops, and national assemblies.

The Assembly of First Nations (AFN), Inuit Tapiriit Kanatami (ITK), and the Métis National Council (MNC), in particular, provided important considerations and recommendations, either directly to working groups or to ministers. This engagement culminated in meetings between the First Ministers and Indigenous leaders before and during the December 2016 First Ministers' Meeting. Moving forward, the Government of Canada and the AFN, ITK, and the MNC are advancing meaningful engagement on implementing the Pan-Canadian Framework and broader clean growth and climate change priorities through three separate engagement tables, as agreed to with the Prime Minister and leaders of the AFN, ITK, and the MNC on December 9, 2016.

Working with Indigenous Peoples in Canada

Indigenous Peoples are resilient climate leaders in Canada, despite being among the most vulnerable to climate change. The Government of Canada is committed to ensuring First Nations, Inuit, and the Métis Nation are real partners in Canada's transition to a low-carbon economy. To help do so, the Government of Canada is working in partnership with the Assembly of First Nations, Inuit Tapiriit Kanatami, and the Métis National Council through three senior-level tables. These innovative tables enable ongoing partnership with First Nations, Inuit and the Métis Nation in the implementation of the Pan-Canadian Framework and on broader clean growth and climate change priorities. Supported by Government of Canada Budget 2017 funding, all three tables met for the first time in fall 2017, are planning to meet again in early 2018, and are identifying areas to work together.

As described below, Pan-Canadian Framework governance and reporting mechanisms are in place to ensure ongoing collaboration across federal, provincial and territorial governments, to track progress in implementing measures, and to identify opportunities for further action. By regularly revisiting progress, the effectiveness of actions will be assessed to encourage continual improvement and to increase ambition over time, in accordance with the Paris Agreement.

4.1.2 Elements of the Pan-Canadian Framework

The Pan-Canadian Framework consists of four main pillars:

1. Pricing carbon pollution;
2. Complementary measures to further reduce emissions across the economy;
3. Measures to adapt to the impacts of climate change and build resilience; and

[a] The Prime Minister of Canada and provincial and territorial Premiers are collectively referred to as First Ministers.

[b] Saskatchewan and Manitoba did not adopt the Pan-Canadian Framework at this time.

4. Actions to accelerate innovation, support clean technology, and create jobs.

Together, these interrelated pillars form a comprehensive plan to address climate change and grow the low-carbon economy.

Carbon pricing is at the heart of the Pan-Canadian Framework. While over 80 per cent of Canadians currently live in a province with economy-wide carbon pricing in place, work is underway to expand this to other provinces and territories. In October 2016, the Government of Canada announced a carbon pricing benchmark, which outlines a set of principles and criteria to ensure that carbon pricing applies across Canada to a broad set of emissions sources with increasing stringency over time. The benchmark explains that provinces and territories can implement the pricing system of their choice (a carbon tax, a carbon levy and performance-based emission system, or a cap and trade system).

In addition, the Government of Canada is also developing a federal backstop carbon pricing system, which will apply in any jurisdiction that requests it or that does not have a carbon pricing system in place in 2018 that meets the benchmark. In 2017, the Government released a technical discussion paper outlining the proposed design of the federal carbon pricing backstop system—composed of a levy and performance-based pricing system. The Government also released additional guidance on the pan-Canadian carbon pollution pricing benchmark as a follow up to the 2016 announcement.

The second pillar of the Pan-Canadian Framework covers complementary mitigation measures that will enable Canada to achieve emissions reductions across all sectors, both in the near-term and as part of a longer-term strategy. The Pan-Canadian Framework approach focuses on the following key areas:

- expanding and linking clean electricity systems across the country;
- improving the energy efficiency of vehicles, buildings and industries;
- putting more zero-emission vehicles on the road; using cleaner fuels to power the economy; and
- reducing emissions and increasing carbon sequestration in the agriculture, forestry and waste sectors.

Under its fourth pillar, the Pan-Canadian Framework also creates the necessary conditions for innovation, accelerating investments in research, development and demonstration (RD&D), and private sector investment in the clean technology sector. Key actions under the Pan-Canadian Framework include: supporting RD&D in emissions reducing technologies; helping companies commercialize and export their products and services; enabling access to capital for clean technology businesses; supporting Indigenous Peoples and northern and remote communities to adapt clean technology to their needs; and aligning investments across all levels of government.

Implementation of the Pan-Canadian Framework is supported by historic investments of over $46 billion by the Government of Canada to meet the 2030 emission reductions target. This funding includes:

- Funding for the Low Carbon Economy Fund, which will support new or expanded actions to reduce emissions by provinces and territories, municipalities, Indigenous governments and organizations, and both not-for-profit and for-profit organizations;
- Investments of $21.9 billion in green infrastructure, which will support projects such as electricity transmission and grids, renewable energy, electric vehicle charging and natural gas and hydrogen refuelling stations, new building codes, and other measures such as increasing the resilience of built and natural infrastructure;
- Investments of $20.1 billion in urban public transit infrastructure; and
- $2.2 billion in clean technology investments including nearly $1.4 billion in financing dedicated to supporting clean technology firms.

In its first year of implementation, federal, provincial and territorial governments have already made good progress in putting the Pan-Canadian Framework into action. Governance, reporting and oversight structures have been established to track progress and ensure success. Funding has been mobilized to support many of the new actions included in the Framework, including significant transfers from federal to provincial and territorial governments. Work is underway to implement carbon pricing systems across Canada, and governments have made significant progress on complementary measures to reduce emissions across the economy.

Action by Provinces and Territories

The Pan-Canadian Framework builds on the considerable leadership and actions taken individually and collectively by Canada's provinces and territories. Over the past several years, provincial and territorial governments have continued to take significant action to address climate change, and several have adopted new or renewed climate change action plans and strategies encompassing a variety of actions and commitments:

- Provincial and territorial Premiers endorsed the Canadian Energy Strategy in July 2015, setting the stage for a cooperative approach toward sustainable energy development. Through the Vancouver Declaration in March 2016, Canada's Prime Minister joined the Premiers in reaffirming the importance of energy to Canada's economy and demonstrated the need for energy policy and climate policy to go hand-in-hand, supporting Canada's transition toward a strong and diversified lower carbon economy.
- British Columbia (B.C.) released a *Climate Leadership Plan* in August 2016, which replaced the previous 2008 Climate Action Plan. The B.C. Plan proposed 21 actions across six sectors: natural gas; transportation; forestry and agriculture; industry and utilities; communities and built environment; and public sector leadership. The new B.C. government appointed in June 2017 is planning additional measures, including setting a new legislated 2030 reduction target.
- The Alberta government presented its *Climate Leadership Plan* in November 2015. The plan details a strategy to reduce GHG emissions and transition towards a lower carbon economy by focusing on four key areas: introducing a new carbon pricing system; beginning a phase out of coal-fired electricity generation and increasing the use of renewable energy options; legislating a limit of 100 Mt on any increase of oil sands emissions; and reducing methane emissions by 45 per cent by 2025.
- In December 2017, Saskatchewan released its climate change plan entitled *Prairie Resilience: A Made-in-Saskatchewan Climate Change Strategy*. The strategy outlines the measures that Saskatchewan will take to reduce GHGs, and highlights adaptation and resilience as an essential part of action on climate change.
- In October 2017, Manitoba released its *Made-in-Manitoba Climate and Green Plan* that includes carbon pricing and specific priorities for addressing climate change, jobs, nature, and water.
- In November 2015, the province of Ontario released its *Climate Change Strategy*. In addition to adopting a cap and trade system, Ontario announced its plans to achieve a capacity of 20,000 megawatts of renewable energy (about half of Ontario's current installed capacity) by 2025. The Strategy provides a high level outline of the steps Ontario will take to reach its GHG emissions reduction target of 37 per cent below 1990 emissions by 2030. Ontario's *Five Year Climate Change Action Plan*, released in June 2016, was adopted to implement the strategy, and establishes the framework necessary to meet targets for 2030 and 2050. It will be assessed and renewed every five years. Key measures from the Action Plan are to promote low-carbon and zero-emission transportation, reduce emissions from fossil fuel in buildings, and make climate change planning mandatory in municipal plans. The Action Plan also lays the foundation for the cap and trade system and proposes measures to support research, innovation, and commercialization of new low-carbon technologies.

- In addition to implementing its *2013–2020 Climate Change Action Plan*, Québec announced its *Energy Policy* in April 2016, which includes five separate targets the province intends to reach by 2030: Improve energy efficiency by 15 per cent, reduce oil consumption by 40 per cent, eliminate thermal coal, increase renewable energy production by 25 per cent, and increase bioenergy production by 50 per cent. The province also intends to go from 47 per cent to 60.9 per cent of renewable energy supplies for its total energy needs. In June 2017, Québec released its first action plan (2017–2020) to implement this policy. It contains 42 measures aimed at accelerating the transition to renewable energies and stimulating the market for electric vehicles.
- New Brunswick released its climate change strategy, *Transitioning to a Low-Carbon Economy*, in December 2016. The plan notes the intention of the government to implement a carbon pricing system, to adopt renewable energies, and to phase out traditional coal-fired electricity. The plan establishes a dedicated climate change fund to advance climate change mitigation and adaptation initiatives using revenues from carbon pricing. Highlights of the plan include a commitment to expand energy efficiency and clean energy programs across all sectors, and to establish performance targets for energy efficiency program-delivery services. The province is also planning for and investing in new technologies that reduce pollution, such as smart grids and renewable electricity, and is committing to increase spending on energy efficiency by 50 per cent in its next capital budget. In addition, New Brunswick commits to making its government operations carbon-neutral by 2030. In addition, in December 2017 New Brunswick tabled a *Climate Change Act* to provide a legal basis for elements of its strategy, including to create legislated GHG emissions reduction targets, provide a legal requirement for a Climate Change Action Plan and annual reporting on climate action and commitments, and other measures.
- In addition to continued work on its *Climate Change Action Plan*, Prince Edward Island released its *2016–17 Energy Strategy* in March 2017. The Strategy identifies actions to undertake in four key sectors: Energy efficiency and Conservation, Power Generation and Management, Biomass and Heating and Transportation. The province intends to take action to develop incentives for buying electric vehicles and will work with regional partners to expand renewable energy exports.

In addition to adopting new and renewed climate change plans, other subnational governments across Canada continue to implement plans already in place, or are developing new or renewed plans:

- Québec continues implementation of the *2013–2020 Climate Change Action Plan* adopted in 2012, and announced in 2015 a new GHG reduction target of 37.5 per cent below 1990 emissions by 2030.
- Yukon is also moving forward with implementation of the *Climate Change Action Plan* adopted in 2009 which sets reduction targets in four economic sectors (electricity, transportation, industrial operations and buildings).
- Nova Scotia, Prince Edward Island, Newfoundland and Labrador and the Northwest Territories are at different stages in developing new or renewed climate change action plans.

4.1.3 Institutional Arrangements

The Pan-Canadian Framework on Clean Growth and Climate Change and its supporting governance architecture is now the overarching framework for the coordination and implementation of climate change policy across Canada.

Environment and Climate Change Canada leads the coordination of Pan-Canadian Framework implementation at the federal level, in close collaboration with several other implicated federal government departments. For example, Natural Resources Canada, Transport Canada, Innovation Science and Economic Development Canada, and

Infrastructure Canada are actively involved in the development and implementation of Canada's climate change policies and measures under the Pan-Canadian Framework. Federal government officials meet regularly through the Pan-Canadian Framework Deputy Minister Oversight Committee to track progress under the Framework, and work closely to implement specific measures. Federal officials regularly brief the Prime Minister on progress under the Pan-Canadian Framework through the Prime Minister's Results Table on Clean Growth and Climate Change.

In addition to coordination at the federal level, implementation of the Pan-Canadian Framework requires close interjurisdictional coordination across federal, provincial, and territorial governments. As described in Chapter 2: National Circumstances, the environment is an area of concurrent jurisdiction in Canada, and aside from a few exceptions, natural resources, including energy, are under provincial jurisdiction. Longstanding mechanisms to support interjurisdictional coordination on environment policies play a key role in the Pan-Canadian Framework.

As the leaders of their respective jurisdictions, Canada's First Ministers provide the most senior level forum to discuss climate change and clean growth policies across Canada.

First Ministers Meetings (FMM), gathering together the Canadian Prime Minister and all provincial and territorial Premiers, are now held regularly to discuss policy issues of importance. In 2016, for the first time, two First Ministers Meetings were held to discuss climate change action exclusively. These discussions led to the Vancouver Declaration on Clean Growth and Climate Change in March 2016 and the adoption of the Pan-Canadian Framework in December 2016.

Beyond First Ministers, federal/provincial/territorial meetings happen throughout the year at all levels, from the working level through to Ministers. Federal, provincial and territorial Ministers with common interests or portfolios are often organized into councils such as the Canadian Council of Ministers of Environment. The Pan-Canadian Framework implicates many portfolios and ministerial mandates. Nine councils and ministerial tables are mandated with overseeing the implementation of the Framework.[c]

The Canadian Council of Ministers of the Environment plays a central role in overseeing the overall implementation of the Pan-Canadian Framework, with responsibility for three of its four pillars (mitigation, adaptation and resilience and carbon pricing (with Finance Ministers)).

In addition to longstanding mechanisms like First Ministers Meetings and the Canadian Council of Ministers of the Environment, specific institutional arrangements have also been established to support the implementation of Pan-Canadian Framework actions, to engage in necessary technical work, and to prepare annual Pan-Canadian Framework progress reports to First Ministers.

An intergovernmental process has been established to prepare annual reports. Federal, provincial, and territorial Ministerial councils and tables are providing First Ministers with Progress Reports on implementation of the Pan-Canadian Framework for actions under their responsibility. A Synthesis Report on Pan-Canadian Framework implementation is also prepared by an intergovernmental committee and provided annually to First Ministers—the First Synthesis Report was released on December 9, 2017.

[c] The councils and ministerial tables overseeing implementation of the Framework are the following: Canadian Council of Ministers of Environment; Canadian Council of Forest Ministers; Energy and Mines Ministers' Conference; Ministers of Finance; Council of Ministers Responsible for Transportation and Highway Safety; Ministers of Innovation and Economic Development; Ministers of Infrastructure; Ministers of Agriculture; and Ministers responsible for Emergency Management.

In addition, government officials from across Canada contribute to Pan-Canadian Framework implementation through coordinating committees, and technical working groups have been established to engage in collaborative technical work to facilitate Pan-Canadian Framework implementation, including on issues such as GHG measurement, inventories and reporting, and carbon offsets and credits.

The arrangements described above represent the current governance and reporting architecture for the Pan-Canadian Framework. These arrangements may be adapted in future years as implementation of the Pan-Canadian Framework continues.

4.1.4 Legislative instruments

Federal action on climate change is enabled by several key legal instruments.[d] *The Canadian Environmental Protection Act*, 1999 (CEPA) is the primary legal instrument allowing 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 GHGs, including setting the quantity or concentration of a GHG that may be released from various types of facilities, or from vehicles, engines, and equipment.

Since submission of the *6th National Communication*, several regulations under the authorities of CEPA have been or are in the process of being developed or amended in order to implement actions announced under the Pan-Canadian Framework. Such regulations include Regulations for Coal-Fired Generation of Electricity, Light and Heavy Duty Vehicles Regulations, Clean Fuel Standard Regulations, Methane Regulations and Regulations for phasing out hydrofluorocarbons (HFCs). New legislation is also being prepared to enable the implementation of a federal 'backstop' carbon pricing system.

In accordance with their unique jurisdictional responsibilities, provinces and territories have adopted legal instruments providing them with authorities necessary to address environmental, climate change, and energy policy. Such examples include Ontario's *Environmental Protection Act* or the *Environment Quality Act* in Québec.

4.2 Monitoring and Evaluation of Progress Towards Canada's Economy-wide Emission Reduction Target

While the Pan-Canadian Framework focuses on Canada's 2030 target of reducing GHG emissions by 30 per cent below 2005 levels, it also includes measures that will reduce emissions in the near term and will bring Canada closer to achieving its Copenhagen target of reducing GHG emissions by 17 per cent below 2005 levels by 2020.[e]

For example, the pan-Canadian carbon price will drive emissions reductions in the pre-2020 period. In addition, several new regulations will soon be finalized, and incoming provincial and territorial policies, plans and measures will decrease Canada's GHG emissions further.

The Pan-Canadian Framework commits to ongoing monitoring and reporting on results in order to ensure that policies are effective, to take stock of progress achieved, and to inform Canada's future national actions in accordance with the Paris Agreement. This includes annual reporting to the Prime Minister of Canada and provincial and territorial Premiers; external assessment and advice by experts; meaningful engagement with Indigenous Peoples, including through distinction-based tables; and reviews of carbon pricing approaches in 2020

[d] Canada's 6th National Communication contains a comprehensive list of the current legal instruments governing environmental issues in different economic sectors, which provide authorities for the federal government to act to reduce GHG emissions. Canada's 6th National Communication can be accessed at the UNFCCC website: https://ec.gc.ca/cc/16153A64-BDA4-4DBB-A514-B159C5149B55/6458_EC_ID1180-MainBook_high_min%20FINAL-s.pdf.

[e] For tabular information on Canada's emission reduction target, please see Section III of the 3rd Biennial Report.

and 2022, including expert assessment of stringency and effectiveness that compares carbon pricing systems across Canada. In addition, the Government of Canada will continue to regularly evaluate regulatory approaches, and track and report on progress.

Annual reports provide an update on Pan-Canadian Framework actions, and allow First Ministers to take necessary decisions and task further work, as appropriate, under the Pan-Canadian Framework. The first of these reports was submitted to First Ministers in December 2017.

Beyond arrangements to oversee the implementation of the Pan-Canadian Framework, progress toward meeting Canada's 2030 GHG reduction target is also monitored through a number of public and corporate reporting tools for government policies and programs.

The *2016–19 Federal Sustainable Development Strategy* (FSDS) was tabled in Parliament in October 2016. The FSDS is the federal government's primary vehicle for sustainable development planning and reporting and demonstrates federal leadership on climate change. The FSDS is now updated periodically within each three-year cycle and tracks Canada's progress towards its GHG reduction target through achievement of short-term milestones.

Canada's *National Inventory Report*, which is submitted annually to the United Nations Framework Convention on Climate Change, provides information on total historical GHG emissions levels and helps track progress on Canada's target from one year to another.

Whether through the *Biennial Report* or through ECCC's *Canada's Reference Case report*,[3] Canada publishes annual detailed GHG emissions projections towards 2030, including future impacts of policies and measures taken by provinces and territories and projections by sector. (See Chapter 5: Projections and the Total Effects of Policies and Measures for further information on Canada's economy-wide GHG projections and an estimate of the total effect of policies and measures.)

Several mechanisms also exist within the federal government for accountability, including the following:

- The Commissioner of the Environment and Sustainable Development reports to the Auditor General and provides objective, independent analysis and recommendations on the federal government's efforts to protect the environment and foster sustainable development. The Commissioner conducts performance audits, and is responsible for assessing whether federal government departments are meeting their sustainable development objectives, including on climate change. Reports and audits are tabled in Parliament and provide observations and recommendations for initiatives that require improvement. In addition to arrangements at the federal level, provinces and territories also have their own respective arrangements to audit the effectiveness of environmental policies and programs.
- The Results and Delivery Charters for Effective Action on Clean Grown and Climate Change, Investing in Canada, and Innovation are reporting tools developed in collaboration with key federal departments that are used for measuring progress against Pan-Canadian Framework outcomes. It will include regular public reporting on progress against key metrics and indicators. Departmental Results Frameworks are another mechanism of the federal government to measure the achievements of departments' results against core responsibilities such as taking action on clean growth and climate change.

4.2.1 Accounting toward Canada's economy-wide emission reduction target

Land-use, land-use change and forestry accounting

A unique challenge in both projecting and accounting for emissions and removals in Canada's managed forest is the fact that natural disturbances result in significant variations in annual forest emission and removal estimates. As well, natural disturbances generally cannot be predicted. Canada's recent Nationally

Determined Contribution, released in May 2017, notes that Canada is examining its approach to accounting in the LULUCF sector towards its 2030 emissions reduction target. It also indicates that Canada will exclude the impacts of natural disturbances and use the IPCC production approach to account for harvested wood products. This approach applies to Canada's 2020 emission reduction target as well.

The historical estimates for LULUCF from 1990–2015 found in Canada's 2017 *National Inventory Report* exclude for the first time the impacts of natural forest disturbances that occurred in the historical period. Work continues to refine LULUCF estimates that focus on anthropogenic emissions and removals as a basis for improved reporting and accounting for LULUCF. As this work is still underway, only historical inventory estimates are provided here.

Contribution of internationally-transferred mitigation outcomes

The federal government, in cooperation with provincial and territorial governments and relevant partners, will continue to explore which types of tools related to the acquisition of internationally transferred mitigation outcomes may be beneficial to Canada and will advance a robust approach to the implementation of Article 6 of the Paris Agreement. A first priority is ensuring any cross-border transfer of mitigation outcomes is based on rigorous accounting rules, informed by experts, which result in real reductions. This clarity is particularly important as Ontario and Quebec's carbon markets are linked with California.

The federal government will work with Ontario, Québec, and other interested provinces and territories, as well as with international partners, to ensure that allowances acquired through international-emissions trading are counted towards Canada's international target.

4.3 Policies and Measures to Reduce Greenhouse Gas Emissions

This section provides a narrative overview of Canada's key policies and measures by economic sector, with an emphasis on those measures that have recently been adopted.[f] Comprehensive tabular information on key policies and measures in place at the federal and provincial/territorial levels, as required by the National Communication guidelines, is provided in the Annex to this chapter, which contains National Communication Table 1: Summary of Policies and Measures by Sector (Biennial Report Table 3). Within this section, the description of policies are organized by economic sector beginning with key federal policies and measures, followed by provincial measures from west to east, and territorial measures. Cross-cutting measures are provided first, followed by economic sectors.

Priority has been given to those policies and measures that have the most significant impact on sectoral GHG emissions. To provide additional context, information is also included on key supporting and enabling measures, such as clean technology policies, investment programs, as well as efforts to green government operations.

Where mitigation estimates were not provided, Canada has indicated the reason why they were not included (see notation legend within the Annex of Chapter 4: Policies and Measures). For example, mitigation estimates were not provided for measures that are still under development, and/or for those measures where it is difficult to estimate the direct mitigation impact, such as for supporting measures. The methodology for estimating expected emissions reductions from individual measures may vary by implementing entity and have been included on an as-provided basis. An estimate of the total mitigation impact of policies and measures—including interactive effects—is provided in Chapter 5: Projections and the Total Impacts of Policies and Measures.

[f] For additional information on the IPCC and economic sector definitions, as well as a detailed cross-walk between IPCC and the economic sector categories, please see Chapter 3: Canada's Greenhouse Gas Inventory.

4.3.1. Cross-cutting policies and measures

Federal, provincial and territorial governments are moving forward with implementation of significant cross-cutting GHG mitigation measures that will reduce emissions across the economy. These measures include, for example, pricing carbon pollution and establishing a clean fuel standard, which will apply to a broad set of economic sectors, as well as funding to improve infrastructure, and clean technology and innovation measures.

4.3.1.1 Carbon Pricing

Federal Carbon Pricing Approach and Backstop System

As described previously, in October 2016, the federal government published a benchmark requiring that carbon pricing applies to a broad set of emission sources throughout Canada, with increasing stringency over time. A federal carbon pricing backstop system will be applied in jurisdictions that request it or that do not have a carbon pricing system in place in 2018 that meets the pan-Canadian carbon pricing benchmark. The federal system would take effect January 1, 2019.

Under this system, provinces and territories will have the flexibility to implement either an explicit price-based system (a carbon tax such as the one in British Columbia, or a hybrid approach composed of a carbon levy and an output-based pricing system, such as in Alberta) or a cap and trade system (such as those in Québec and Ontario).

In addition to the parameters above, the benchmark also stipulates the following:

- Pricing will be based on GHG emissions and applied to a common and broad set of emissions sources to ensure effectiveness and minimize interprovincial competitiveness impacts.
- Stringency of pricing systems will increase over time to contribute to the national target and provide market certainty.
  - For jurisdictions with an explicit price-based system, the carbon price should start at a minimum of $10 per tonne in 2018, and rise by $10 per year to $50 per tonne in 2022.
  - Jurisdictions with cap and trade systems need: (i) a 2030 emissions reduction target equal to or greater than Canada's 30 per cent reduction target; (ii) declining (more stringent) annual caps to at least 2022 that correspond, at a minimum, to the projected emissions reductions resulting from the carbon price that year in price-based systems.
- Revenues from pricing systems are to remain in the jurisdiction of origin and used according to their needs including, for example, to address impacts on vulnerable populations and sectors and to support climate change and clean growth goals.
- The overall approach to carbon pricing will be reviewed by early 2022 to confirm the path forward, including continued increases in stringency.
- Jurisdictions are to provide regular, transparent and verifiable reports on the outcomes and impacts of carbon pricing policies.
- The Government of Canada will work with Canadian territories to address their specific challenges.

Provincial Carbon Pricing Systems

Many provinces are leading the way on carbon pricing and already have systems in place:

- British Columbia's carbon tax, in place since 2008 and currently set at $30/tonne CO_2e, will increase by $5 per tonne per year starting April 1, 2018. The province will take measures to expand carbon pricing to include fugitive emissions and emissions from slash-pile burning.
- Alberta extended the reach of its carbon pricing system to increase coverage across the economy. Starting on January 1, 2017 a carbon levy applies to all fuels that emit GHG emissions when combusted. The levy rate is currently $20/tonne CO_2e and will increase to $30/tonne in 2018. Alberta's current *Specified Gas Emitters Regulation* will be also replaced in 2018 by a Carbon Competitiveness System, which will use an output-based emission allocations approach for emissions-intensive, trade-exposed industries.

- Québec introduced a cap and trade system in 2013. This system has been linked with California's system since 2014. By the end of 2017, Québec and California will have held a total of thirteen joint auctions of GHG emission allowances. Proceeds from the cap and trade auctions are directed to a Green Fund and reinvested in actions to reduce emissions and adapt to climate change impacts.
- Ontario launched its cap and trade program in January 2017 and held its first auction of emission allowances in March 2017. Ontario's cap and trade regulations cover about 82 per cent of emissions (including industry, electricity and fuels, excluding marine and aviation). On September 22, 2017, Ontario, Québec, and California signed an agreement linking the carbon markets of the three jurisdictions. This agreement integrates and harmonizes emissions cap programs, allowing entities to meet their emissions compliance obligations in a more flexible and cost-effective manner while maintaining the environmental integrity of each jurisdiction's progress. Proceeds from Ontario's carbon market are invested into climate actions that help people and businesses reduce GHG emissions and use cleaner technology to power their homes and workplaces.

Work is underway to expand carbon pricing to other provinces and territories:

- Saskatchewan's climate change plan, entitled *Prairie Resilience: A Made-In-Saskatchewan Climate Change Strategy*, does not outline a specific approach to pricing carbon. However, the provincial plan indicates the province will implement sector-specific output-based performance standards on large industrial facilities emitting more than 25,000 tonnes of CO_2 eq per year. Flexible compliance options including emissions intensity reduction investments, purchasing offsets, and 'best performance credits' from facilities that have exceeded their required emissions reductions.
- In 2017, Nova Scotia conducted stakeholder consultations on cap and trade design options. Nova Scotia plans to develop cap and trade program regulations in 2018.
- Manitoba released a *Made-in Manitoba Climate and Green Plan* that includes carbon pricing.
- New Brunswick released an update on its climate change actions and tabled a proposed Climate Change Act in December 2017, which outlined a proposed approach to carbon pricing.
- Prince Edward Island is preparing to launch a carbon pricing mechanism in 2018.
- Newfoundland and Labrador has passed legislation for a performance-based system for large onshore industrial emitters and has put in place reporting requirements.
- Yukon is studying the impacts of carbon pricing on its residents, businesses and industry.
- The Northwest Territories (NWT) is examining an approach to implementing carbon pricing in the NWT in a manner that reflects the unique circumstances in the NWT.
- Nunavut is studying the impacts of carbon pricing on Nunavummiut.

4.3.1.2 Cross-Cutting Regulations

Federal Clean Fuel Standard

In November 2016 the Government of Canada announced that it would consult with provinces and territories, Indigenous Peoples, industries, and non-governmental organizations to develop a Clean Fuel Standard to reduce Canada's GHGs through the increased use of lower carbon fuels and alternative technologies. The objective of the Clean Fuel Standard is to achieve 30 megatonnes of annual reductions in GHG emissions by 2030.

Following this announcement, in February 2017 Canada published a discussion paper to inform development of a Clean Fuel Standard to reduce lifecycle emissions from fuels used in transportation, buildings and industry. A draft regulatory framework was published in December 2017 to inform further consultations ahead of formal publication of proposed regulations in mid-2018. The final regulations will be published in 2019. The coming into force date is still under consideration.

Federal Regulations for the Phase-Down of Hydrofluorocarbons

Canada has long been a proponent of a global phase-down of HFCs, and was a key player in negotiations on the Kigali Amendment to the Montréal Protocol on Substances that Deplete the Ozone Layer, which Canada ratified in November 2017. On October 18, 2017, Canada published regulations to phase down HFCs in accordance with the Kigali Amendment. The regulations will also avoid future emissions of HFCs, thereby minimizing their impact on climate change and contributing to Canada's commitment under the Paris Agreement.

4.3.1.3 Key Investments

Low Carbon Economy Fund

Launched in June 2017, the Government of Canada's Low Carbon Economy Fund (LCEF) is an important part of the Pan-Canadian Framework. Disbursed over five years, the Low Carbon Economy Fund will primarily target energy efficiency measures in residential and commercial buildings, energy efficiency, fuel switching or process changes in the industrial sector, and carbon sequestration and emission reductions in the forestry and agriculture sectors.

Funding has been divided into two envelopes:

- The Low Carbon Economy Leadership Fund will provide $1.4 billion to provinces and territories that have adopted the Framework. The federal government is working with provinces and territories to support priority actions and will put in place funding agreements with eligible jurisdictions so they can undertake action starting in early 2018.
- The remainder of the funding will be available for the Low Carbon Economy Challenge and for implementing the Pan-Canadian Framework. Funded projects under the Challenge will leverage ingenuity across the country to reduce GHGs and generate clean grown in support of the Pan-Canadian Framework. Projects submitted by provinces and territories, municipalities, Indigenous governments and organizations, and both not-for-profit and for-profit organizations will be considered, with a focus on those projects that best reduce GHG emissions and generate clean growth.

Federal Green Infrastructure funding

The Government of Canada committed to provide $21.9 billion in Green Infrastructure funding, which will be a major source of funding for mitigation and adaptation infrastructure.

Disbursed over 11 years, funding will be directed to mitigation initiatives such as upgrading existing infrastructure, including electricity grids, renewables, reducing reliance on diesel in remote and northern communities, public transit, electric and alternative vehicle infrastructure, energy efficient buildings and landfill/solid waste diversion. Adaptation activities could include afforestation, constructed/managed wetlands, dams, dikes, and rain gardens. Discussions are underway with provincial and territorial governments to identify specific projects to be funded.

At least $4.6 billion will be invested in projects that will increase generation of clean energy, increase capacity to manage more renewable energy, improve the energy efficiency of eligible public buildings, and increase access to clean energy transportation.

A new infrastructure Bank will invest $5 billion in green infrastructure projects that have revenue-generating potential and are in the public interest. These could include for example, investments towards green energy transmission or in infrastructure supporting trade and transportation.

In addition to specific investments in green infrastructure, Canada is also investing $20.1 billion over 11 years in urban public transit infrastructure through the Public Transit Infrastructure Fund. These investments will help reduce GHG emissions and improve air quality.

4.3.1.4 Clean Technology and Innovation

As the fourth pillar of the Pan-Canadian Framework, Canada is working to create the conditions to be a leader in the global clean economy. This includes work to build early-stage innovation to create a strong pipeline of ideas in Canada's clean technology ecosystem while positioning Canada's energy, mining, forest and agriculture sectors as leaders in the new resource economy. Several provinces are partnering with the federal government to help clean technology producers access the funding support and capital they need to develop, demonstrate, and show the commercial viability of their new clean technology products. Programs are also being implemented to foster technology adoption through government procurement in order to lay the foundation for a strong domestic clean technology market.

Governments are also working together on a clean technology data strategy, and an international business development strategy for clean technology has been developed to encourage exports and access to global markets. Finally, through the newly established federal Clean Growth Hub, client services will be streamlined for clean technology producers, improving federal program coordination, enabling tracking and reporting on clean technology, and connecting stakeholders to international markets.

Building Early-Stage Innovation

Impact Canada

The Government of Canada allocated $75 million in Budget 2017 to create the clean technology stream of Impact Canada, a new initiative that will help focus and accelerate efforts toward solving Canada's big challenges, such as helping Canada's northern and remote communities reduce their reliance on diesel as a power source. The Impact Canada initiative and initial clean technology challenges are expected to be launched in winter 2018 with additional challenges to follow later in the year.

Clean Growth in Natural Resources Sectors Innovation Program

The Clean Growth in Natural Resource Sectors Innovation Program is a new approach to advancing clean technologies across Canada's energy, mining, and forestry sectors. Leveraging novel cross-sectoral and outcome-oriented mechanisms, the $155 million program will support clean technology RD&D, including up to first commercial installation. This program aims to strengthen federal, provincial and territorial coordination and leveraging of clean technology investments to more effectively help Canada to meet its climate change goals and create economic opportunities, including in international markets. As a result, only projects with provincial and territorial support are eligible for funding.

Energy Innovation Program

The Energy Innovation Program will directly enable implementation of the Pan-Canadian Framework. In the near-term, this program will focus funding on RD&D of clean energy technologies with the potential for replication and adoption prior to 2030. Energy Innovation priorities are: renewable energy, smart grid and storage systems; reducing diesel use by industrial operators in northern and remote communities; methane and volatile organic compound (VOC) emission reduction; reducing GHGs in the building sector; carbon capture, use and storage; and improving industrial efficiency.

Accelerating commercialization and growth

Clean Technology Financing

The Government of Canada announced nearly $1.4 billion in new financing, on a cash basis, to be mobilized through the Business Development Bank of Canada and Export Development Canada to help Canada's clean technology producers grow and expand. Of the $1.4 billion in new financing, $950 million is in growth capital and approximately $450 million is in additional project finance.

The Government of Canada also made available $400 million to Sustainable Development Technology Canada to support projects across Canada to develop and demonstrate new clean technologies that promote sustainable development.

Provinces and Territories are working with the federal government to leverage and maximize the impact of this new funding. For example, the Government of British Columbia and the Government of Canada have established a $40 million partnership between the Innovative Clean Energy Fund and SDTC to support the development of clean energy projects and technologies at the pre-commercialization stage.

Broader innovation support

The Government of Canada announced a suite of innovation initiatives in Budget 2017 to support Canada's innovators. The Innovation Superclusters Initiative, the Strategic Innovation Fund and the Venture Capital Catalyst Initiative will support the growth of innovators in all sectors of the economy, including clean technology. These innovation programs are at various stages of implementation and will continue to be developed and rolled-out in 2018.

Fostering adoption

Innovative Solutions Canada

Budget 2017 established Innovative Solutions Canada, a new innovation procurement program. This new initiative will enhance early stage R&D and later stage prototypes through the development and validation of novel products and services from Canadian innovators and entrepreneurs. The R&D performed by Canadian small businesses may also include clean technology development should departments issue challenges in that area. In return, the Government will have access to the latest, most innovative products and services, and the program will be designed to be scalable, so that other Canadian jurisdictions can take part in the future. To encourage inclusive growth, particular effort will also be made to encourage procurement from companies led by women and other underrepresented groups. The program was launched in the fall of 2017, and the first round of challenges is planned to begin in early 2018.

Strengthening collaboration and metrics for success

Clean Growth Hub

Budget 2017 provided $12 million for Innovation, Science and Economic Development Canada and Natural Resources Canada to establish a Clean Growth Hub to help clean technology proponents navigate federal clean technology programs. The Hub will form a central office with participants from many departments and agencies in order to deliver a public-facing, no-wrong-door approach to streamline client services, improve federal program coordination, enable tracking and reporting on clean technology results across government, and connect stakeholders to international markets. The Clean Growth Hub is being established within Innovation Canada, a coordinating body established to streamline innovative activities across economic sectors.

Clean Technology Data Strategy

Under the Pan-Canadian Framework, federal, provincial, and territorial governments committed to work together to enhance policy and program alignment across jurisdictions and institutions and to establish a clean technology data strategy. The Government of Canada committed $14.5 million to develop this strategy to ensure the alignment and integration of data collection and reporting activities to foster consistent, complementary and comparable information on the Canadian clean technology economy.

4.3.1.5 Government Leadership

Federal, provincial, and territorial governments committed to set ambitious targets for emissions reductions from government operations, cut emissions from government buildings and fleets, and scale up clean procurement. The federal government has committed to reducing its GHG emissions by 40 per cent by 2030, or earlier. Public reporting in July 2017 showed that federal GHG emissions decreased by 19 per cent between

2005–06 and 2014–15. The federal government has also set a goal of using 100 per cent clean power by 2025.

The federal government provides technical support services to federal organizations seeking GHG reductions from their internal building and fleet operations. Support helps federal organizations implement accountability structures, build capacity to integrate energy management into day-to-day operations, develop action plans, establish retrofit financing through energy performance contracting, and sustain long-term progress through continuous learning, monitoring and tracking.

4.3.2 Electricity Sector

With about 80 per cent of electricity coming from non-emitting sources, Canada already has one of the cleanest electricity systems in the world. Canada will continue to reduce GHGs from electricity generation, and under the Pan-Canadian Framework, federal, provincial, and territorial governments agreed to the following actions: increasing the amount of electricity generated from renewable and lower-emitting sources; connecting clean power with places that need it; modernizing electricity systems; and reducing reliance on diesel working with Indigenous Peoples and northern and remote communities.

4.3.2.1 Increasing electricity generated by renewable and lower-emitting sources

The federal, provincial and territorial governments are taking concrete steps to reduce emissions from electricity generation. GHG emissions are being reduced by phasing out coal-fired electricity generation, while new hydro, wind, solar and other renewable capacity is being added to the electricity system.

Reducing CO_2 emissions from coal-fired generation of electricity

With the adoption of the Pan-Canadian Framework, Canada is moving forward to accelerate the phase-out of traditional coal units across the country by 2030.

In early 2018, the Government of Canada will publish draft amendments for coal-fired electricity generation for public comment. The amended regulation will accelerate the phase out of traditional coal electricity by 2030. The amendments will apply to the *Regulations to reduce carbon dioxide emissions from coal-fired electricity*, which took effect in 2015 and required the phase-out of existing coal-fired units without carbon capture and storage once units reach a defined period of operating life. Final amendments are targeted for publication by December 2018.

Building on this domestic action, on November 16, 2017, the governments of Canada and the UK launched Powering Past Coal at the International Climate Change Conference, a global alliance which aims to encourage the phase-out of unabated coal-fired electricity.

Provinces are also taking action on coal-fired electricity. On April 15, 2014, Ontario became the first jurisdiction in North America to fully eliminate coal as a source of electricity generation. This action was the single largest GHG-reduction initiative in North America, eliminating more than 30 Mt of annual GHG emissions and equivalent to taking seven million vehicles off the road. On November 23, 2015, Ontario passed the *Ending Coal for Cleaner Air Act*, permanently banning coal-fired electricity generation in the province.

Under its Climate Leadership Plan released in 2015, Alberta announced it would phase-out emissions from traditional coal-fired electricity by 2030, achieving expected cumulative emission reductions of 67 Mt.

In addition, Nova Scotia has created a regulatory framework to transition from coal to clean electricity generation, and New Brunswick and Saskatchewan will work to eliminate conventional coal-fired electricity generation aligned with federal regulations. Saskatchewan also developed the first commercial-scale carbon capture and storage technology, which can capture 90 per cent of emissions from the Boundary

Dam coal-fired electricity generation power plant. The project has been in operation since 2014.

Federal Limits on Natural Gas-Fired Electricity Emissions

In addition to action to reduce emissions from coal-fired electricity, by 2020 the Government of Canada will implement new performance standards that will impose emissions limits on natural gas-fired electricity generation. Draft federal regulations for natural gas-fired electricity are targeted for publication in early 2018 for public comment, with final regulations targeted for publication by winter 2018/2019.

Emerging Renewable Power Program

Budget 2017 announced investment of up to $200 million to expand the portfolio of commercially-viable renewable energy sources available to provinces. The funding will support renewable power technologies that have been deployed commercially abroad (e.g. offshore wind, geothermal), and have been demonstrated but not deployed at the utility scale in Canada (e.g. tidal). This program can expand the portfolio of commercially-viable, investment-ready, renewable electricity technologies available in Canada, support development of Canadian supply chains, and reduce GHG emissions. The program is scheduled to launch in winter 2018.

Smart Grid Program

This demonstration and deployment program is focused on better utilizing the existing capacity of electricity assets, increasing penetration of renewable energy, and increasing the reliability, resiliency and flexibility of the power system while maintaining cyber security. Budget 2017 announced funding of $100 million over 4 years, and the program is scheduled to launch in winter 2017.

Muskrat Falls Hydroelectric Project

Newfoundland and Labrador continues work towards completion of the Muskrat Falls hydroelectric project. When completed, it is expected that 98 per cent of Newfoundland and Labrador's electricity will come from renewable sources, with surpluses exported to the province of Nova Scotia and other jurisdictions. 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 per cent of the province's current GHG emissions.

Provincial Renewable Electricity Targets

Several provinces have also introduced renewable electricity targets for their electricity supply:

- In 2010, British Columbia introduced the *Clean Energy Act*, which includes the requirement that at least 93 per cent of the electricity in the province come from clean or renewable sources.
- Under its Climate Leadership Plan, Alberta has committed to achieve 30 per cent renewable electricity by 2030, including Micro-Generation Regulations amendments to provide more flexible rules for Albertans generating their own electricity. In 2017, Alberta also proclaimed the *Renewable Electricity Act* and launched the Renewable Electricity Program to increase the share of renewable electricity in its electricity grid.
- In 2015, SaskPower, a crown corporation that is Saskatchewan's main energy supplier, committed to an objective of 50 per cent electricity generation capacity from renewable sources by 2030. Achieving this objective will involve deployment of wind, solar and biomass energy that will reduce Saskatchewan's GHG emissions by about 40 per cent below 2005 levels in Saskatchewan.
- New Brunswick continues to work towards achieving its goal of 40 per cent of electricity supply from renewable sources and 75 per cent non-emitting electricity supply by 2020.
- Nova Scotia is on track to achieve its target of ensuring 40 per cent of electricity is from renewable sources in 2020.

4.3.2.2 Connecting clean power with places that need it

Federal, provincial and territorial governments committed to work together to help build new and enhanced transmission lines between and within provinces and territories. This will improve transmission of clean and renewable electricity to provinces and territories that need it and reduce their reliance on fossil fuels. Provincial and territorial actions are being supported by federal investments.

Provincial and territorial actions in support of this objective include:

- Completion by Prince Edward Island (PEI) of a cable interconnection upgrade within the Northumberland Strait, between the provinces of Prince Edward Island and New Brunswick. Two 180 MW cables will help meet the growing demand for electricity on PEI, deliver reliable, long-term energy to the island, and help balance the intermittent nature of the province's growing wind energy supply. The project was completed in 2017 and cables are in operation.
- In December 2016, Ontario's Independent Electricity System Operator and Québec's Hydro-Québec Energy Marketing signed a multi-year electricity trade agreement for energy, capacity and storage. This agreement will reduce GHG emissions and ensure system reliability and affordability.
- Manitoba Hydro (MH) and Saskatchewan Power Corporation (SPC) signed a Memorandum of Understanding in September 2016 to identify opportunities to increase transmission capacity between the provinces by up to 1,000 MW and to collaborate on generation projects and additional exports and services. MH and SPC have also executed two power purchase agreements in recent years, including a 20-year, 100-MW power sale agreement commencing in June 2020. This sale requires the construction of a new 230 kV transmission interconnection from Manitoba to Saskatchewan and requires 18 per cent of the dependable energy from the 695 MW Keeyask hydroelectric generating station.

4.3.2.3 Modernizing electricity systems

Federal, provincial and territorial governments are also collaborating to support the demonstration and deployment of smart-grid technologies that help electric systems make better use of renewable energy, facilitate the integration of energy storage for renewables, and help expand renewable power capacity. The following examples illustrate measures that are being taken to fulfil this commitment:

- The Government of Canada allocated $100 million to fund next-generation smart grid, storage and clean electricity technology demonstration and deployment projects. The program was launched in fall 2017.
- The Government of Ontario has allocated $4 million through its Green Investment Fund to support micro-grid demonstration projects, and has identified projects to support.
- Prince Edward Island is conducting a study on its electricity grid that aims to maximize the benefits from renewable sources of electricity and the future electrification of the transportation system.

4.3.2.4 Reducing reliance on fossil fuels in Indigenous, northern and remote communities

Under the Pan-Canadian Framework, federal, provincial and territorial governments committed to accelerate and intensify efforts to improve efficiency of diesel generating units, connect communities to the electricity grids, and demonstrate and install new hybrid or renewable energy systems.

This commitment is implemented through programs such as the Clean Energy for Rural and Remote Communities program and the Northern REACHE (Responsible Energy Approach for Community Heat and Electricity) program:

- The Clean Energy for Rural and Remote Communities program will advance sustainable, renewable energy (for heat and power) projects in remote communities to reduce consumption of fossil fuels, through deployment of new renewable energy and energy efficiency technologies, demonstration of innovative clean energy solutions, supporting the development of bioheating projects, and capacity building for local technical expertise.

- The Northern REACHE program provides funding for planning and construction of renewable energy and energy efficiency projects, and related capacity building and planning in the Yukon, Northwest Territories, Nunavut, Nunavik, and Nunatsiavut regions. For example, the governments of Canada and Ontario are collaborating with Wataynikaneyap Power (an electricity transmission company owned by 22 First Nation communities) to connect Pikangikum First Nation to Ontario's power grid and eliminate the community's dependence on diesel fuel.
- As part of funding for rural and northern communities, under Budget 2017 the federal government announced funding for an Arctic Energy Fund which will seek to enhance energy security in communities north of the 60th parallel, including Indigenous communities.
- Ontario also committed in its Climate Change Action Plan to support renewable micro-grid projects to reduce diesel reliance in remote First Nation communities. Ontario is working in collaboration with First Nations to develop a plan for implementing this commitment.

Increasing energy efficiency and the use of renewable energy sources will result in environmental, social, and economic benefits to support healthier, more sustainable Indigenous, northern and remote communities. In addition to reducing GHG emissions, these actions have numerous side-benefits for communities such as improving air quality and energy security and creating the potential for locally owned and operated power generation.

4.3.3 Transportation Sector

The transportation sector is the second largest source of GHG emissions in Canada. The transition towards a low-carbon transportation system is already underway with more zero-emissions vehicles on Canadian roads every year. With currently 80 per cent of its electricity generated from non-emitting sources, Canada has a strong incentive to electrify its transportation system. In particular, under the Pan-Canadian Framework, federal, provincial and territorial governments are working together on the following four priorities: setting emissions standards and improving efficiency; putting more zero-emission vehicles on the road; shifting from higher to lower emitting modes and investing in infrastructure; and, using cleaner fuels.

4.3.3.1 Setting Emissions Standards and Improving Efficiency

Consistent with its role in setting national vehicle emissions standards, under the Pan-Canadian Framework the federal government committed to: continue its work to implement increasingly stringent standards for emissions from light-duty vehicles; work with provinces, territories, and industry to develop new requirements for heavy-duty trucks to install fuel-saving devices; and take a number of actions to improve efficiency and support fuel switching in the rail, aviation, marine, and off-road sectors.

Emission Standards for new Heavy-Duty Vehicles

Canada currently has in place the *Heavy-duty Vehicle and Engine GHG Emission Regulations*. The regulations apply to model years 2014 and beyond to reduce GHG emissions by establishing mandatory GHG emission standards for new on-road heavy-duty vehicles and engines. The regulations are aligned with U.S. national standards given the integrated North American auto market.

In March 2017, Canada published the draft *Regulations Amending the Heavy-duty Vehicle and Engine GHG Emission Regulations and Other Regulations Made Under the Canadian Environmental Protection Act, 1999* which would introduce more stringent GHG emission standards that begin with the 2021 model year for on-road heavy-duty vehicles and engines. Further, the proposed Amendments introduce new GHG emission standards that would apply to trailers hauled by on-road transport tractors for which the manufacture is completed on or after January 1, 2018, starting with model year 2018 trailers. These emission standards for heavy-duty vehicles, engines and trailers would increase in stringency every three model years to the 2027 model year and maintain full stringency thereafter. The final regulations are targeted for publication in 2018.

Emissions Standards for Light-Duty Vehicles

The *Regulations Amending the Passenger Automobile and Light Truck GHG Emission Regulations* (covering model years 2017 and beyond), published in 2014, build on the success of the *Passenger Automobile and Light Truck GHG Emission Regulations* covering model years 2011 through 2016. They have been developed in collaboration with the U.S. to ensure alignment. The amended regulations continue to apply to companies that manufacture or import new light-duty vehicles into Canada for the purpose of sale. Similar to the current regulations which apply to the model years 2011–2016, the amended regulations establish progressively more stringent GHG emission standards to new passenger automobiles and light trucks for model years 2017 and beyond, while providing companies with flexibility to comply in a cost-effective manner.

4.3.3.2 Putting More Zero Emission Vehicles on the Road

Under the Pan-Canadian Framework, federal, provincial, and territorial governments committed to: work with industry and other stakeholders to develop a Canada-wide strategy for zero-emission vehicles (ZEVs) by 2018; and to work together, including with private sector partners, to accelerate demonstration and deployment of infrastructure such as fast chargers for electric vehicles, as well as natural gas and hydrogen refuelling stations.

Canada-Wide Zero-Emission Vehicle Strategy

Consistent with commitments under the Pan-Canadian Framework, in May 2017, the Government of Canada announced plans to develop a national strategy to increase the number of ZEVs on Canadian roads by 2018. As part of the commitments made in the Pan-Canadian Framework, a federal, provincial and territorial Steering Group has been established to oversee the development of the Strategy. The Strategy will complement and build on current ZEV related initiatives taking place across the country.

In addition to a national strategy, provinces are putting in place measures to accelerate the adoption of ZEVs:

Québec Zero-Emission Vehicles Standard

The province of Québec adopted the *Act to increase the number of zero-emission motor vehicles in Québec in order to reduce GHG and other pollutant emissions* on October 26, 2016. Following the adoption of the Act, two draft regulations were published on July 5, 2017. The first details the requirements of the future ZEV standard, while the second determines the number of credits that can be used by individual motor vehicle manufacturers.

These draft regulations were the subject of a 45-day public consultation that ended on August 19, 2017 and the regulations were adopted in September 2017. Manufacturers will have to report their vehicle sales as soon as the regulations come into effect, with mandatory reporting beginning with model year 2018.

This policy is part of a set of initiatives, primarily in conjunction with the Québec 2013–2020 Climate Change Action Plan and 2015–2020 Transportation Electrification Action Plan which sets a target of 100,000 registered plug-in vehicles by 2020. Additional initiatives to meet this target also include fiscal incentives for buyers of electric vehicles and installation of residential charging stations.

Ontario Electric Vehicle Program

Ontario is establishing new initiatives to support the uptake of electric vehicles (EVs), including the EV incentive program, EV Charger Ontario Program, EV charging infrastructure program, EV discovery center, EV overnight charging program, electric/hydrogen vehicle advancement program, and electric school bus pilot program. Ontario has established a sales target of 5 per cent in 2020 for electric and hydrogen passenger vehicles.

The Electric Vehicle Incentive Program allows Ontario consumers and businesses to apply for an incentive towards the purchase or lease of eligible, new plug-in hybrid electric or battery electric vehicles. The value of the incentive is based on the vehicle's battery.

Applicants that received an Electric Vehicle Incentive Program incentive are eligible to apply for up to $1,000 towards the purchase and installation of an eligible Level 2 charging station. The province is also investing up to $20 million to create a network of fast-charging electric vehicle stations in cities, along highways and at workplaces, apartments, condominiums, and public places across Ontario under the Electric Vehicle Chargers Ontario program.

4.3.3.3 Shifting from Higher- to Lower-Emitting Modes and Investing in Infrastructure

Under the Pan-Canadian Framework, federal, provincial, and territorial governments committed to work together to: enhance investments in public-transit upgrades and expansions; invest in building more efficient trade and transportation corridors including investments in transportation hubs and ports; and consider opportunities with the private sector to support charging and refuelling stations for electric or alternative fuel light- and heavy-duty vehicles.

Federal Investments

As described in Section 4.4.1, cross-cutting policies and measures, the Government of Canada is investing approximately $182 million in green infrastructure to support electrification and fuel switching in the light- and heavy-duty vehicle sectors. This includes funding to deploy infrastructure for electric vehicle charging and natural gas and hydrogen refuelling stations; to support technology demonstration projects; and to develop supporting codes and standards. This is in addition to $62.5 million that already had been provided in Budget 2016. By March 2018, deployment projects will result in over 100 new EV fast chargers, seven natural gas and three hydrogen stations built.

B.C. on the move—Transport Infrastructure Investments

In May 2015, the province of British Columbia announced a $2.5 billion, 10-year plan to improve the province's transportation network. The Plan includes transitioning to low carbon fuels, expanding transit, and reducing congestion.

4.3.3.4 Using Cleaner Fuels

As described in the cross-cutting section above, the Government of Canada is working to develop a Clean Fuel Standard. The Standard will be a modern, flexible, performance-based approach that will address a broad suite of fuels in the transportation, industry, and buildings sector.

Several provincial actions are advancing cleaner fuel objectives in this sector:

- British Columbia continues to implement its renewable and low carbon fuel policy, adopted in 2008.
- Ontario is considering design options for a proposed "Modern Renewable Fuel Standard" for gasoline, to reduce GHG emissions from gasoline by 5 per cent by 2020. Ontario is also developing a pilot program to use waste and agricultural methane as a fuel source for the implementation of a Biogas-Based Fueling Initiative.
- New Brunswick is conducting an Energy Efficiency Potential Study on all fuels, for all sectors, including transportation efficiency.
- Under Québec's new 2030 Energy Policy, adopted in 2016, a regulation was announced that would set standards for the inclusion of renewable content (renewable ethanol and diesel) in gasoline and diesel fuel. This regulation is still under development.

4.3.4 Oil and Gas Sector

Canada is a net energy exporter, and is the world's fourth largest exporter of crude oil and fourth largest exporter of natural gas.[4] Legal authorities over the production of oil and gas resources rest primarily with provincial governments. Oil and gas resources are interspersed across Canada's provinces and territories, with the majority of production occurring in Alberta, British Columbia, Saskatchewan, and Newfoundland and Labrador. Canada's oil and gas sector is also highly integrated with its North American partners, in particular the United States.

Federal, provincial, and territorial governments are collaborating to reduce emissions from industrial sectors, including oil and gas. Several cross-cutting federal and provincial policies will contribute to emission reductions within the oil and gas sector, including the federal carbon pricing benchmark and existing provincial pricing systems.

In addition, the following specific initiatives will reduce emissions and encourage innovation in this sector:

Regulations to Address Methane in the Oil and Gas Sector

The oil and gas sector is the largest contributor to methane emissions in Canada. As part of the Pan-Canadian Framework, the Government of Canada reaffirmed its commitment to reduce methane emissions from the oil and gas sector by 40 to 45 per cent from 2012 levels by 2025, building on provincial actions and targets. British Columbia and Alberta have also adopted this methane reduction target within their jurisdictions. In May 2017, Canada published draft federal methane regulations for the oil and gas sector, with an aim to publish final regulations in the first half of 2018.

Programs to reduce emissions

Established in 2016, the Oil and Gas Clean Technology Program has invested in innovative technologies to reduce greenhouse gas emissions and improve environmental performance in the oil and gas sector. These industry-led projects generate direct emission reductions, and are expected to indirectly reduce emissions by reducing technical risk and accelerating market adoption of the funded technologies.

Announced in 2017, the Clean Growth in the Natural Resources Sector Program aims to advance clean technology research and development and demonstration projects in Canada's energy, mining and forestry sectors. This program addresses pressing environmental challenges and economic opportunities facing Canada's natural resource operations in five areas:

- Reducing greenhouse gas and air-polluting emissions;
- Minimizing landscape disturbances and improving waste management;
- The production and use of advanced materials and bioproducts;
- Efficient energy use and productivity; and
- Reducing water use and impacts on aquatic ecosystems.

British Columbia: Electrification of the Oil and Gas Sector

British Columbia is moving ahead with a plan to bring clean grid electricity to natural gas operations in the northeast. B.C. has also recently announced several other policies that will affect emissions in the oil and gas sector, including its Methane Reduction Policy and its Clean Infrastructure Royalty Credit Program.

Alberta: Measures to reduce emissions in the Oil and Gas sector

Alberta is implementing its Climate Leadership Plan, under which it committed to capping oil sands emissions to 100 megatonnes per year and to reducing methane emissions by 45 per cent by 2025. The *Oil Sands Emissions Limit Act*, which received Royal assent in December 2016, sets out the legal framework for implementing a cap on oil sands emissions. In 2018, Alberta plans to develop a policy and/or regulatory system to limit emissions from oil sands activities. The Specified Gas Emitters regulation applied to large industrial emitters including the oil and gas sector, and set emissions intensity targets. This regulation will transition to an output-based allocation system for emissions-intensive trade-exposed industries.

4.3.5 Buildings Sector

Using energy to power, heat and cool buildings, and run appliances accounted for approximately 17 per cent of national GHG emissions in 2015, including indirect emission from electricity generation. The Pan-Canadian Framework outlines an approach to address emissions in the built environment by: making new buildings more energy efficient; retrofitting existing buildings and fuel switching; improving energy efficiency for appliances and equipment; and supporting building codes and energy efficient housing in Indigenous communities. The Government of Canada allocated $182 million in Budget 2017 to support energy efficient buildings, and provinces and territories are also implementing actions to reduce emissions in this sector. The Low Carbon Economy Leadership Fund will also support provinces and territories to undertake energy efficiency retrofits in residential and commercial buildings.

Federal, provincial and territorial Energy Ministers endorsed Canada's Buildings Strategy in August 2017. The strategy provides an implementation plan to make new homes and buildings more efficient, to retrofit existing homes and buildings and to improve the energy efficiency of the appliances and equipment they use.

4.3.5.1 Making new buildings more energy efficient

Federal, provincial and territorial governments are working to develop and adopt increasingly stringent model building codes, starting in 2020, with the goal that provinces and territories adopt a "net-zero energy ready" model building code by 2030. The Government of Canada is providing approximately $95 million to support the development of these more stringent building codes. This includes funding for RD&D projects announced in July 2017 to drive down the — and encourage industry and provincial and territorial uptake—of net-zero energy ready construction, as well as retrofit practices and technologies.

4.3.5.2 Retrofitting existing buildings

Under the Pan-Canadian Framework, federal, provincial and territorial governments also agreed to several measures that will help to improve the energy efficiency of existing buildings. To support this objective, the Government of Canada is providing approximately $73 million to develop new model retrofit codes that set minimum energy performance requirements; develop—and support adoption by provinces and territories of—a model regulatory framework for mandatory recommissioning; and establish a national approach to mandatory energy labelling and information-sharing. The Low Carbon Economy Fund will also support initiatives in the building sector.

4.3.5.3 Improving energy efficiency of appliances and equipment

The Government of Canada has committed to set new standards for heating equipment and other key technologies to achieve the highest level of efficiency that is economically and technically feasible. This commitment is supported by approximately $10 million in ongoing, annual funding to improve energy efficiency regulations and to expand the ENERGY STAR certification program that identifies high-efficiency products for consumers. Taken together, these activities ensure energy efficiency standards are set to the highest level of efficiency that is technically and economically achievable; eliminate the least efficient products from the Canadian market; and helps Canadians instantly identify the best energy performing products, appliances, and equipment on the market.

National market transformation strategies for key equipment technologies were published in August 2017, and federal, provincial and territorial governments are working together to develop equipment roadmaps by fall 2018 to implement these strategies that help accelerate market uptake of clean, energy efficient equipment technologies. Finally, amendments to the federal Energy Efficiency Regulations are underway to introduce new standards for more than 30 product categories.

Provinces and territories are also making significant progress in moving towards greater energy efficiency, including in the building sector:

Efficiency Nova Scotia
Nova Scotia has Canada's first energy efficiency utility, Efficiency Nova Scotia. Since its creation in 2010, this independent organization has achieved annual reductions of 1.2 per cent below the business as usual baseline. It also administers comprehensive energy efficiency programs for low income and First Nations Nova Scotians. These efforts help to reduce GHG emissions while supporting the growth of the low carbon economy. Efficiency Nova Scotia is operated by EfficiencyOne, an independent nonprofit organization.

Energy Efficiency Alberta
Alberta established Energy Efficiency Alberta in 2016, a new government agency dedicated to helping the province save energy and reduce emissions. The agency has a $645-million budget over five years, funded by revenue from Alberta's carbon levy, to raise awareness related to energy use and economic/environmental consequences; promote, develop, and deliver programs; and promote the development of an energy efficiency services industry. In 2017, the agency launched four programs focused on homes, businesses, non-profits, and institutions. The programs used a mix of no-charge installations, rebates, and other incentives to promote the installation of high-efficiency products and appliances and the installation of solar photovoltaic systems. Energy Efficiency Alberta will continue to develop and launch new programs for 2018, focusing on the most effective in helping Alberta meet its energy efficiency goals.

Efficiency Manitoba
In March 2017, the government of Manitoba introduced new legislation that would establish the framework for a new, stand-alone Crown corporation outside of Manitoba Hydro to deliver demand-side management initiatives promoting energy efficiency and conservation that would help Manitoba households and businesses reduce their energy needs and save money. The proposed agency would be known as Efficiency Manitoba and would be managed by a board of directors with support from a stakeholder advisory committee. The agency would deliver a range of efficiency programs beginning with gas and electric energy, with possible long-term expansions into areas such as water and transportation programs. Its mandate would include a focus on reducing the effects of energy use on the environment including reducing greenhouse-gas emissions as part of the province's forthcoming climate and green plan.

Energy savings targets would also be included in the new legislation at 1.5 per cent of annual domestic electricity demand and 0.75 per cent of annual domestic natural gas demand over 15 years. The proposed transition from Manitoba Hydro to Efficiency Manitoba is estimated to take one year.

Transition Énergétique Québec
Québec created the Transition énergétique Québec (TEQ) on April 1, 2017 with a mission to support, stimulate and promote the energy transition, to support innovation and efficiency, and to coordinate the implementation of all the programs and actions necessary to achieve the energy targets defined in the 2030 Energy Policy. In 2018, TEQ will present its 2018–2023 Master Plan, which will guide the actions of the Québec Government and Québec energy distributors in energy innovation, conversion and efficiency.

Atlantic Provinces: Clean Energy Partnership
The Atlantic Provinces announced the Atlantic Clean Energy Partnership in April 2017. The intent of the Atlantic Energy Partnership is to work regionally and with the federal government to identify potential enhancements to electricity generation and transmission infrastructure, the promotion of energy efficiency, and to support the demonstration, deployment, adoption, and export of clean energy technologies.

Arctic Energy Alliance
Northwest Territories committed over $2.7 million in 2017 to the Arctic Energy Alliance (AEA) to provide energy efficiency programs and services to residents, businesses and communities. AEA programs are on track

to be fully subscribed this year. Northwest Territories is also undertaking a program review of AEA to ensure programs and services support targets in the new long-term energy strategy. This energy strategy will ensure significant improvements and funding increases for the AEA.

Yukon Residential and Commercial Energy Incentives programs

The Government of Yukon's new Residential Energy Incentive Program encourages homeowners, homebuilders and general contractors to design, construct, and retrofit homes to a high standard in energy efficiency. Between January and July 2015, the program saw 34 new homes built to EnerGuide 85 or better.

4.3.5.4 Support for energy efficient housing in Indigenous communities

Under the Pan-Canadian Framework, federal, provincial and territorial governments are collaborating with Indigenous Peoples as they move towards more efficient building standards and incorporate energy efficiency into their existing building-renovation programs. In addition, the Government of Canada is planning a joint research project with the National Research Council to define guidelines to support sustainable housing in First Nations communities, and federal, provincial and territorial governments are working together to incorporate principles of Indigenous reconciliation into their programs.

4.3.6 Heavy Industry

The heavy industry economic sector encompasses non-oil and gas mining, smelting and refining, pulp and paper, iron and steel, cement, lime and gypsum, and chemical and fertilizer industries in Canada.[g] Under the Pan-Canadian Framework federal and provincial governments are taking action to reduce emissions within Canadian industry by improving industrial energy efficiency, including by helping industries to reduce energy demand by supporting the adoption of energy management systems. Through investments in technology, federal, provincial and territorial governments will continue to support research and development and to promote deployment of new technologies that help reduce emissions. In addition, as described in the section 4.4.1, Canada has introduced final regulations to address HFC emissions, consistent with the Kigali Amendment to the Montréal Protocol, which Canada ratified in November 2017, helping to bring the agreement force.

The federal government has established cross-cutting programs to improve energy efficiency across several industrial sectors. For example, the Pan-Canadian Framework highlighted ENERGY STAR for Industry, ISO 50001 and Superior Energy Performance as key programs and tools to help businesses track, analyze and improve their energy efficiency. Such energy benchmarking programs increase industrial competitiveness and productivity. They are inexpensive, can be implemented quickly, produce results immediately, generally have payback periods of less than two years, and continually generate savings.

Provinces and territories are also taking action to address emissions in this sector through cross-cutting measures, including Québec and Ontario's cap and trade systems and Alberta's *Specified Gas Emitters Regulation*. Newfoundland and Labrador also passed its *Management of GHG Act* in June 2016 aimed at large GHG emitters. The Act covers approximately 20 per cent of the province's overall emissions, and provides a legislative framework to reduce GHG emissions from large industrial emitters which allows for the use of offsets performance credits or payments into a Greenhouse Gas Reduction Fund.

Newfoundland and Labrador's GHG Reporting Regulations were published on March 7, 2017 and Administrative Penalty regulations on July 28, 2017. Large industrial facilities are required to report

[g] Under Canada's economic sector categorization, this sector was formerly referred to as the Emissions-Intensive, Trade-Exposed sector.

their emissions on an annual basis to the provincial government. First reports were received on June 1, 2017. Moving forward, Newfoundland and Labrador will develop further regulations to support the implementation of the Act.

In addition, a number of other provinces have implemented programs seeking to support emissions-intensive, trade-exposed industries in improving their operations' energy efficiency and adopting more effective energy processes that emit fewer GHGs. This includes Québec's ÉcoPerformance Program and Ontario's Regulatory Changes for Reducing Coal Use in Energy-Intensive Industries.

4.3.7 Waste and Others Sector

The waste sector encompasses solid waste, waste water, and waste incineration. Emissions from the waste sector mainly fall within the responsibilities of municipal governments in Canada, under provincial jurisdiction. Under the Pan-Canadian Framework, federal, provincial and territorial governments will work together to identify opportunities to generate renewable fuel from waste, which can be a key source of cleaner fuels and bioproducts.

As a result of a mix of provincial regulations and incentives, approximately 72 of the 82 largest landfills in Canada have gas collection systems, with collected gas used in a number of ways including for electricity and/or heat generation. In addition to existing regulations in place in several provinces that require the capture of methane at landfill sites, other programs are reducing the creation of methane by increasing organics diversion, including the B.C. Waste to Resource Programme, a planned program which will divert 90 per cent of organic waste from landfill and decrease food waste by 30 per cent; and Prince Edward Island's Biomass-Fired District Heating system—the longest running such system in Canada, operating since the 1980s.

4.3.8 Agriculture Sector

Agriculture is an important sector for the Canadian economy. The majority of emissions in this sector are produced by the biological processes inherent to animal and crop production, with on-farm energy use comprising a smaller portion of sector emissions. Agricultural lands can play an important natural role in absorbing and storing atmospheric carbon. Practices in the agriculture sector are already changing towards less GHG-intensive procedures such as increasing permanent cover crops, conservation tillage, and increased use of bioproducts, precision farming and "smart" fertilizers that release nutrients at the rate the plant needs it.

Under the Pan-Canadian Framework, federal, provincial and territorial governments committed to work together to enhance carbon storage in agricultural lands. Federal, provincial and territorial governments also committed to work together to identify opportunities to produce renewable fuels and bioproducts, and to enhance innovation to advance GHG efficient management practices in forestry and agriculture.

Several key actions are currently advancing these shared objectives. In July 2017, federal, provincial and territorial Ministers of Agriculture reached an agreement on the key elements of a new agricultural policy framework, the *Canadian Agricultural Partnership* (CAP). The new five-year (2018–2023), $3 billion investment will strengthen the agriculture, agri-food and agri-based products sector, ensuring continued innovation, growth and prosperity.

Environmental Sustainability and Climate Change is one of the priorities identified in the CAP. Federal, provincial and territorial governments will collaborate in building capacity to mitigate agricultural GHG emissions, protect the environment and adapt to climate change by enhancing sustainable growth, while increasing production.

Science, Research, and Innovation is another key CAP priority which will be addressed by providing support to industry in adopting practices to improve resiliency and productivity through research and innovation in key areas. In support of this priority, the Government of Canada announced $70 million over six years in its Budget 2017 to further support agricultural discovery science and innovation, with a focus on addressing emerging priorities, such as climate change and soil and water conservation.

In addition, in 2016, the federal government committed $27 million to extend the Agricultural Greenhouse Gases Program, which supports innovative research projects that develop technologies, practices and processes that can be adopted by farmers to mitigate GHG emissions.

Federal, provincial, and territorial governments are also helping expand the production of bioenergy and bioproducts for multiple uses, including helping rural and remote communities reduce reliance on diesel. Governments also continue to promote the use of wood in construction. For example, Alberta, British Columbia, Québec, and New Brunswick recently recommitted to use more low-carbon renewable materials like wood in municipal and government-funded buildings.

4.3.9 Land-Use, Land-Use Change and Forestry

Through the Pan-Canadian Framework, federal, provincial and territorial governments committed to work together to reduce emissions and increase stored carbon in this sector. Examples include land-use and conservation measures to protect and enhance carbon sinks, GHG efficient management practices to reduce emissions, and increased carbon storage through greater use of wood products in construction, including through updated building codes.

4.3.9.1 Increasing the use of wood in building construction

Under the forestry commitments included in the Pan-Canadian Framework, federal, provincial and territorial governments have committed to increasing the use of wood for building construction. Increasing the use of sustainably produced wood in construction contributes to emission reductions as the carbon stored in that wood gets 'locked in' for a long period of time and it displaces emissions from more GHG-intensive building materials, like steel or concrete. Increasing domestic demand for Canadian wood products also supports forest industries across Canada, which have a long history of innovating to develop new products and more efficient and sustainable forest practices. Measures under this Pan-Canadian Framework commitment are listed within the buildings section of Table 1 below.

Federal, provincial and territorial governments have long supported increased wood use for construction which replaces more emission-intensive building products. For example, at the federal level the $39.8 million Green Construction through Wood (GCWood) Program launched in 2017 aims to support projects and activities that increase the use of wood as a greener building material in infrastructure projects (for example, in high-rise buildings, low-rise commercial buildings, and timber bridges).

Provinces, including Alberta, British Columbia, Québec, and New Brunswick, have shown public leadership by recently recommitting to increasing the use of wood and other low-carbon renewable materials in the design and construction of municipal and government-funded buildings. Recent investments include the $11 million Québec Wood Building Demonstration Program and Ontario's Mass Timber Building Project that was also launched in fall 2017 with $4.8 million in funding for 2017–18. Québec's Wood Charter also allocates financial assistance for government-led research, innovation, and training on the use of wood in construction.

In addition to government programs, many jurisdictions also invest in research collaborations on wood building construction and wood product innovation through FPInnovations, a public-private national forest research institute.

4.3.9.2 Advancing the forest bioeconomy and enhancing forest carbon

Federal, provincial and Territorial governments are also implementing the following forestry measures:

- *Forest Bioeconomy Framework*
  In September 2017, the federal, provincial and territorial governments, working together through the Canadian Council of Forests Ministers, launched a Forest Bioeconomy Framework for Canada. This framework will position Canada to become a global leader in the use of forest biomass for advanced bio-products and innovative solutions. The Framework presents an integrated approach to meeting climate change mitigation commitments and advancing innovation in the forest sector for the long term. It affirms federal, provincial and territorial government commitments to work in partnership with forest communities and industry stakeholders, including continually engaging Indigenous peoples.
- *B.C. Forest Carbon Initiative*
  British Columbia's Forest Carbon Initiative will restore up to 300,000 hectares of forests impacted by the mountain pine beetle infestation and wildfires. In February 2017, an investment of $150 million was announced to enhance the carbon storage potential of B.C.'s public forests by increasing the rate of replanting and fibre recovery and by improving forest management practices to capture the carbon benefits of reforestation, while avoiding emissions from burning slash. By 2050, the province has estimated that the ten-year program could to lead to a reduction of annual GHG emissions of up to 11.7 million tonnes.
- *Alberta Forestry and Agriculture Offsets Protocols*
  Alberta is contemplating the possibility of using forestry and agriculture offsets as an option for large industrial emitters to comply with their reduction obligation under the Specified Gas Emitters Regulation or as part of internationally transferrable mitigation options (ITMOs). Alberta is planning to approve agriculture and forestry protocols in 2018.
- *Québec's Wood Innovation Work Plan*
  Québec's Wood Innovation Work Plan unveiled in 2016 supports the transformation and modernization of the forest products industry, with over $86 million in government investments by 2022. Québec also began a Wood Innovation Program in 2015 to encourage applied research, demonstration and implementation of innovative products, processes, and systems in the forest products industry. By July 2017, the Program has already funded 24 forest innovation projects totalling $11.3 million, particularly in the bioenergy and bioproducts sectors.

4.3.10 Strategy on Short-Lived Climate Pollutants

A key element of Canada's approach to climate change includes addressing short-lived climate pollutants (SLCPs) 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 help guide action in reducing these pollutants, a Strategy on Short-Lived Climate Pollutants was developed. The Strategy was published in July 2017. It is complementary to the Pan-Canadian Framework and addresses SLCPs through five pillars for action:

1. Enhancing domestic mitigation efforts;
2. Enhancing science and communications to broaden understanding;
3. Engaging internationally, and building partnerships to reduce SLCPs on a global scale;
4. Coordination of Government of Canada activities; and
5. Collaborating with provincial and territorial governments and other partners.

Implementation of this Strategy will: generate reductions from all key SLCP emissions sources and leverage policy levers across all levels of governments in Canada to better coordinate mitigation efforts. Implementation of this Strategy will be coordinated with, and complementary to, implementation of the Pan-Canadian Framework.

4.4 Modifying Longer-Term Trends in Greenhouse Gas Emissions

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 Pan-Canadian Framework will put Canada on a path towards a low-carbon, clean growth and resilient economy.

Concrete actions such as pricing carbon pollution will send a strong signal that will encourage business and people to pollute less and will stimulate innovation and investments in energy efficiency, clean technologies and non-emitting and renewable electricity generation.

Further actions such as regulations to accelerate the phase out traditional coal-fired electricity generation will implement a permanent shift to lower or non-emitting types of generation and will achieve significant reductions.

These actions are supplemented by investments in clean technology, research, development and demonstration to help Canada meeting its climate change goals and creating economic opportunities. Canada is embracing innovative new tools to support citizen engagement. For example, the recent Generation Energy dialogue utilized polls, surveys, and citizen dialogues to engage over 380,000 people in an inclusive discussion on Canada's low-carbon energy future.

While the Pan-Canadian Framework looks at positioning Canada to achieve or exceed its 2030 GHG emissions reduction target, Canada's Mid-Century Long-Term Low-GHG Development Strategy looks further beyond 2030 to how we can reduce emissions for a cleaner, more sustainable future by 2050. Developed on the basis of a longer horizon, in parallel with the Pan-Canadian Framework, Canada's Mid-Century Long-Term Low-GHG Development Strategy describes possible pathways towards long-term decarbonization, based on modelling of different future scenarios.[5] This includes examining an emissions-abatement pathway that is consistent with net emissions falling by at least 80 per cent in 2050, below 2005 levels.

The Strategy was developed in response to the Paris Agreement's call for Parties to develop long-term, low greenhouse-gas development strategies by 2020, and Canada was one of the first Parties to submit such a report. While Canada's mid-century strategy is not a blueprint for action nor is it policy prescriptive, it is meant to inform the conversation regarding how Canada can continue the transition to a low-carbon economy over the longer term. The strategy complements the Pan-Canadian Framework and was developed concurrently with the Framework.

4.5 Economic and Social Consequences of Measures taken to Address Climate Change

Climate change poses significant risks to communities, health and well-being, the economy, and the natural environment, especially in Canada's northern and coastal regions and for Indigenous Peoples. The changes already being experienced are both dramatic and permanent, with significant social, cultural, ecological, and economic implications. Taking action against current and future climate impacts will help protect Canadians from climate change risks, build resilience, reduce costs, and ensure that society thrives in a changing climate.

Among the array of co-benefits arising from measures to reduce GHG emissions, mitigation policies and measures will reduce air pollution, notably pollution caused by coal-fired electricity generation, thus improving the health of Canadians. Further measures in the Pan-Canadian Framework, such as federal adaptation investments, will also generate multiple benefits for Canadians. For further information on adaptation actions across Canada, please see Chapter 6.

In implementing the Pan-Canadian Framework, key socio-economic aspects and potential impacts are being taken into consideration. Economy-wide measures such as setting a price on carbon pollution can have impacts on economy competitiveness and on most vulnerable groups of society and Indigenous Peoples. Principles adopted in the Pan-Canadian Framework with regards to pricing carbon pollution highlight revenue recycling measures to avoid a disproportionate burden on most vulnerable groups and Indigenous Peoples, and to increase carbon prices in a predictable and gradual way to limit economic impacts.

Another key principle is that carbon pricing policies should minimize competitiveness impacts and carbon leakage, particularly for emissions-intensive, trade-exposed sectors. Federal, provincial and territorial governments are also working together on a study to assess approaches and best practice to address competitiveness of emissions-intensive trade-exposed sectors.

The federal government is working closely with the three territories (Yukon, Northwest Territories and Nunavut) and with Indigenous Peoples to address their particular circumstances such as high costs of living and of energy, challenges with food security and emerging economies.

Chapter 4 Annex:

National Communication Table 1: Summary of Policies and Measures by Sector

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)	Estimate of Mitigation Impact in 2030 (kt CO_2 eq)
CROSS-CUTTING									
Federal Carbon Pricing Approach and Backstop System**	Cross-cutting	CO_2, CH_4, N_2O, HFCs, PFCs, SF_6, NF_3	Reduce GHG emissions, stimulate investments in low-carbon innovation and create a sustainable clean growth economy	Regulatory (economic)	Federal government (Environment and Climate Change Canada, Finance Canada)	Planned	2018	NE[d]	NE[d]
Brief Description	The pan-Canadian approach to pricing carbon pollution, announced in October 2016, establishes a federal benchmark that requires pricing in all jurisdictions in Canada in 2018. It applies to a broad set of emission sources with increasing stringency over time. Provinces and territories have the flexibility to implement their own system: either an explicit price-based program or cap-and-trade. Explicit price-based programs must have a minimum price of CAN\$10/tCO_2e in 2018 that increases annually to CAN\$50/tCO_2e in 2022. Provinces and territories with cap-and-trade must have declining annual caps to at least 2022 that correspond, at a minimum, to projected emissions reductions that would have resulted from the application of the relevant carbon price that year. A federal backstop will apply in provinces and territories that request it or that do not have a carbon pricing system in place in 2018 that meets the federal benchmark. The proposed backstop includes a carbon levy on fossil fuels and an output-based pricing system with emissions trading for industrial facilities emitting over 50 ktCO_2e per year. The Government of Canada has also committed to apply carbon pricing to GHG emissions arising from domestic flights between jurisdictions in Canada.								
Clean Fuel Standard**	Cross cutting	CO_2, CH_4	Reduce GHG emissions from fuels used in transportation, buildings and industry	Regulatory	Federal government	Planned	TBD	NA[b]	30,000 kt
Brief description	In November 2016 the Government of Canada announced that it would consult with provinces and territories, Indigenous Peoples, industries, and non-governmental organizations to develop a Clean Fuel Standard to reduce Canada's GHGs through the increased use of lower carbon fuels and alternative technologies. The objective of the Clean Fuel Standard is to achieve 30 megatonnes of annual reductions in GHG emissions by 2030. A discussion document was published in 2017 and consultations are ongoing. A draft regulatory framework was published in December 2017. Draft regulations are targeted for publication in the Canada Gazette, Part I, for 2018 while final regulations will be published in the Canada Gazette, Part II, in 2019.								
Regulations of Hydrofluorocarbons*	Cross-cutting	HFCs	To reduce emissions of HFCs	Regulatory	Environment and Climate Change Canada	Implemented	2019	1,000 kt	9,000 kt

National Communication Table 1: Summary of Policies and Measures by Sector (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)	Estimate of Mitigation Impact in 2030 (kt CO_2 eq)
Brief Description	In December 2014 the Government of Canada announced its intent to regulate hydrofluorocarbons (HFCs), a category of potent GHGs. In March 2016, Canada and the U.S. reaffirmed their commitment to reduce use and emissions of HFCs using their respective domestic frameworks and propose new actions in 2016. Canada published the regulations in October 2017, which combine a phase-down of production and imports of HFCs with prohibitions on the manufacture and import of products containing HFCs.								
Low Carbon Economy Fund**	Cross-cutting	CO_2	Reduction of GHG emissions in sectors across Canada	Economic	Federal government	Planned	2017	NE[a]	NE[a]
Brief Description	Launched in June 2017, the Government of Canada's Low Carbon Economy Fund (LCEF) is an important part of the Pan-Canadian Framework. Disbursed over five years, the Low Carbon Economy Fund will primarily target energy efficiency measures in residential and commercial buildings, energy efficiency, fuel switching or process changes in the industrial sector, and carbon sequestration and emission reductions in the forestry and agriculture sectors.								
Sustainable Development Technology Canada	Cross-cutting	CO_2, CH_4, N_2O	Support pre-commercial development and demonstration clean technology projects	Economic	Sustainable Development Technology Canada	Implemented	2001	NE[c]	NE[c]
Brief Description	Sustainable Development Technology Canada (SDTC) contributes to the Government of Canada's efforts to boost growth of clean technology in Canada with the aim of fostering the growth of Canadian technologies and companies. The Government has recently made available over $1.3 billion to SDTC, including funding made available in Budget 2017. Since its establishment in 2001, SDTC has allocated $989 million to support 347 projects across Canada, leveraging an additional $2.2 billion in follow-on financing. As of December 31, 2016, SDTC reported that 78 projects were commercialized and these projects generated an estimated 10.1 megatonnes of Co_2e annual emissions reductions, $1.9 billion in annual revenues and 9,400 direct and indirect jobs. SDTC supported projects have also contributed to an estimated $136 million of cost avoided through the benefits of cleaner air, water and soil.								
Investing in Canada Infrastructure Plan**	Cross-cutting	CO_2, CH_4, N_2O	Support GHG mitigation initiatives linked to public infrastructure	Economic	Infrastructure Canada	Planned	2018	NE[a]	NE[a]
Brief Description	The Green Infrastructure-Climate Change Mitigation sub-stream of the Investing in Canada Infrastructure Plan (ICIP) will invest at least $3.8 billion in projects that will increase generation of clean energy, increase capacity to manage more renewable energy, improve the energy efficiency of eligible public buildings, and increase access to clean energy transportation. Provinces are subject to a mandatory 45% minimum investment floor for Climate Change Mitigation projects within the Green Infrastructure stream. ICIP projects above an appropriate threshold will be subject to a Climate Lens, which will require assessment of GHG emissions and/or resilience to climate impacts. Where required, these assessments must be completed as a condition of approval.								
Improving Access to Capital	Cross-cutting	Based on projects supported	Help Canada's clean technology firms grow and expand	Investment	Export Development Canada; Business Development Canada	Planned	2017	NE	NE[c]

National Communication Table 1: Summary of Policies and Measures by Sector (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)	Estimate of Mitigation Impact in 2030 (kt CO_2 eq)
Brief description	The Government of Canada will invest approximately $1.4 billion in new financing to help Canada's clean technology producers grow and expand. Of the $1.4 billion in new financing, $950 million is in growth capital and approximately $450 million is in additional project finance. This new financing will be available through the Business Development Bank of Canada and Export Development Canada.								
Impact Canada Initiative—Clean Technology Stream	Cross-cutting	CO_2, CH_4, N_2O	Unlock breakthrough clean technology solutions to complex and persistent problems	Economic	Natural Resources Canada	Planned	2017	NE[d]	NE[d]
Brief Description	The Clean Technology stream was announced in Budget 2017, for a total of $75M (2017–18 to 2020–21). The program will be co-developed with industry, academia and philanthropic organizations and will launch a series of prizes and challenges to incentivise investment in areas aligned with federal clean technology objectives (e.g., reducing GHG emissions and other environmental impacts, clean energy for remote communities). Different approaches will be used for challenge design, according to technical, market and environmental circumstances.								
Energy Innovation Program	Cross-cutting	CO_2, CH_4, N_2O	Achieve environmental benefits from technology and/or new policies, codes and standards	Economic	Natural Resources Canada	Implemented	2016	282 kt (by 2019)	NE[f]
Brief Description	This initiative provides ongoing funding for core clean energy technology research, development and small-scale demonstration to meet Canada's climate change objectives. In the near-term, the program will focus on technologies with the potential for replication and adoption prior to 2030 in buildings, electricity, transportation and industry. The program indirectly supports emission reductions across all of these sectors, with potential reductions of 10,000–16,000 kt in 2030.								
Carbon Capture and Storage Investment in Canada's Federal Budget 2008	Cross-cutting	CO_2	Support the SaskPower Boundary Dam clean energy technology project	Economic	Government of Canada	Implemented	2014	1,000 kt	1,000 kt
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.								
Greening Government Operations	Cross-cutting (buildings and transportation)	CO_2, CH_4, N_2O	Improve energy efficiency in federal buildings, adopt low carbon vehicles in federal fleets	Fiscal, informational, education	Government of Canada, Natural Resources Canada	Implemented	2017	NE[e]	80 kt

National Communication Table 1: Summary of Policies and Measures by Sector (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)	Estimate of Mitigation Impact in 2030 (kt CO_2 eq)
Brief description	This ongoing program provides enhanced technical support and a Natural Resources Canada one-stop window to Government of Canada organizations seeking ambitious greenhouse gas emission reduction actions from their building and fleet operations. This will support federal organizations to meet Federal commitments to lead by example, including the target of reducing emissions from federal operations by 40% below 2005 levels by 2030 or earlier.								
Clean Growth in Natural Resources Sectors Innovation Program	Cross-cutting	CO_2, CH_4, N_2O	Improve environmental performance of Canada's natural resource sectors	Economic	Natural Resources Canada	Implemented	2017	500 kt	NE[f]
Brief Description	Announced in 2017, the Clean Growth in the Natural Resources Sector Program aims to advance clean technology research and development and demonstration projects in Canada's energy, mining and forestry sectors. This program addresses pressing environmental challenges and economic opportunities facing Canada's natural resource operations in five areas: reducing greenhouse gas and air-polluting emissions; minimizing landscape disturbances and improving waste management; the production and use of advanced materials and bioproducts; efficient energy use and productivity; and reducing water use and impacts on aquatic ecosystems.								
Clean Energy for Rural and Remote Communities**	Cross-cutting	CO_2	Reduce consumption of diesel fossil fuels	Economic	Natural Resources Canada	Planned	2018	NA[e]	138 kt
Brief Description	The program provides funding for renewable energy projects in rural and remote communities to reduce their reliance on diesel and other fossil fuels. Activities include deployment of new renewable energy and energy efficiency technologies, demonstration of innovative clean energy solutions, support for the development of bioheating projects, and capacity building for local technical expertise. This is a Green Infrastructure program under the Investing in Canada Plan.								
Northern REACHE program	Cross-cutting	CO_2	Reduce reliance on diesel in remote Indigenous communities	Investment	Indigenous and Northern Affairs Canada	Implemented	2016	NE[e]	NE[e]
Brief Description	The Government of Canada allocated $53.5 million over ten years and $5.4 million ongoing to continue the Northern Responsible Energy Approach for Community Heat and Electricity Program (Northern REACHE) to reduce reliance on diesel for heat and electricity in rural and remote indigenous communities . As of September 2017 the REACHE program has funded 48 projects to reduce reliance on diesel including: energy efficiency, renewable energy, and capacity building projects.								
Federal Energy Efficient Equipment and Appliances Program *	Cross cutting	CO_2, CH_4, N_2O	Improve standards for equipment and appliances	Regulatory	Natural Resources Canada	Implemented	2016	4,100 kt	10,400 kt
Brief description	This program: sets new standards for heating equipment and other key technologies to the highest level of efficiency that is economically and technically achievable; updates and introduces new energy efficiency standards under Canada's Energy Efficiency Regulations; and updates and introduces new high performance ENERGY STAR specifications.								

National Communication Table 1: Summary of Policies and Measures by Sector (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)	Estimate of Mitigation Impact in 2030 (kt CO_2 eq)
Green Construction through Wood Program**	Cross-cutting	CO_2	To reduce GHG emissions in the buildings sector	Education, economic	Natural Resources Canada	Planned	2018	NE	500–2,000 kt
Brief description	The program supports projects and activities that increase the use of wood as a greener building material in infrastructure projects (for example, in high-rise buildings, low-rise commercial buildings, and timber bridges), helping to create new markets for sustainable Canadian products. Cumulative 1600 – 6400 between 2020 and 2030								
British Columbia Carbon Tax	Cross-cutting	CO_2, CH_4, N_2O, HFCs, PFCs, SF_6	Reduce GHG emissions from fossil fuel use	Economic	British Columbia	Implemented	2008	3,000–9,000 kt	NE[g, h]
Brief Description	This 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 is currently set at $30/tonne CO_2e. British Columbia's carbon tax will increase by $5 per tonne per year starting April 1, 2018 until it reaches $50/tn. B.C. will take measures to expand carbon pricing to include fugitive emissions and emissions from slash pile burning.								
British Columbia Innovative Clean Energy Fund	Cross-cutting	CO_2	Support advancement of clean energy technologies	Economic	British Columbia	Implemented	2008	NE[g]	NE[g]
Brief Description	The Innovative Clean Energy Fund is funded through a levy on energy sales, designed to support the Province's energy, economic, environmental and greenhouse gas reduction priorities, to advance BC's clean energy sector. In April 2016, the Province announced $1.4 million from the Innovative Clean Energy Fund for a suite of programs to help homeowners reduce energy bills and greenhouse gas emissions, and to support training in the construction of high performance, energy efficient homes.								
British Columbia Carbon Neutral Government Program and Carbon Neutral Capital Program	Cross-cutting	CO_2	Achieve carbon neutrality in government operations	Regulatory	British Columbia	Implemented	2007	43 kt	NE[g, h]
Brief Description	The Greenhouse Gas Reduction 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 its fifth year of carbon neutrality in 2015. Since 2010, British Columbia has reduced emissions from the public sector by approximately 1.5% per year.								
British Columbia GHG Emission Control Regulation	Cross-cutting	CO_2, CH_4	Reduce GHG emissions	Regulatory	British Columbia	Implemented	2016	0	NE[g]
Brief Description	The Greenhouse Gas Emission Control Regulation establishes the infrastructure and requirements for issuing emission offset units and funded units. These are the foundational elements that enable compliance with the performance standards listed within a Schedule to the Act. The Regulation also establishes the BC Carbon Registry, which enables the electronic issuance, transfer and retirement of compliance units (emission offset units, funded units and earned credits). BC's GHG Industrial Reporting and Control Act, and associated regulations such as this one, apply carbon pricing requirements to LNG and coal-fired electricity generation (in addition to the provincial carbon tax).								

National Communication Table 1: Summary of Policies and Measures by Sector (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)	Estimate of Mitigation Impact in 2030 (kt CO_2 eq)
British Columbia Promoting Use of Low Carbon and Renewable Materials in Infrastructure	Building sector	CO_2	Reduce the embedded carbon in infrastructure	TBD	British Columbia	Planned	TBD	500 kt	NE[g]
Brief description	BC is developing policies are being developed to increase the use of low carbon and renewable materials in all public sector infrastructure.								
Alberta Carbon Pricing system*	Cross-Cutting	All	Reduce GHG emissions	Regulatory, economic	Alberta	Implemented	2017	NE[g]	NE[g]
Brief Description	Alberta's carbon pricing system has two components: a carbon levy, and a carbon competitiveness system. The carbon levy on heating and transport fuels, starting at $20 per tonne of carbon dioxide equivalent in 2017, will rise to $30 in 2018. Revenue raised through the carbon levy will fund investments in green infrastructure, energy efficiency, renewable energy, bioenergy, and innovation and technology. The Government of Alberta will offer rebates in order to offset the increased costs of the carbon levy for low- and middle-income households. In total, 60% of Alberta households will be eligible for the full rebate and 66% of households will receive either a full or partial rebate. The system also includes the recently announced carbon competitiveness system which will replace the current Specified Gas Emitters Regulation in January 2018. This system will use an output-based emission allocations approach for emissions-intensive, trade-exposed industries. Any facility that emits 100,000 tonnes or more of GHGs will be included in the new GHG management system. Under the output-based allocation system, a facility will receive performance credits if their greenhouse gas emissions are less than the amount freely permitted. If their emissions are above the amount freely permitted, they will be required take several actions to bring the facility into compliance. This new system is expected to cut emissions by 20 million tonnes by 2020, and 50 million tonnes by 2030.								
Alberta Specified Gas Emitters Regulation*	Cross-cutting	All	Reduce the emissions intensity of large emitters	Regulatory, economic	Alberta	Implemented	2007	10,000 kt	NE[i]
Brief Description	Alberta's Specified Gas Emitters Regulation (SGER) requires facilities that emit 100,000 tonnes of CO_2 eq or more annually to reduce their emissions intensity by 20% from a facility-specific baseline based on past emissions and production. 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 $30 per tonne of CO_2 eq to the Climate Change and Emissions Management Fund. As of 2013, the regulation covers 108 facilities from 15 industrial sectors (about half of Alberta's GHG emissions). The regulation will be replaced by the Alberta Carbon Competitiveness Regulation on January 1, 2018.								
Alberta Carbon Capture and Storage Funding Act*	Cross-cutting	CO_2	Enable government support for carbon capture and storage projects	Economic	Alberta	Implemented	2008	2,760 kt	2,760 kt

National Communication Table 1: Summary of Policies and Measures by Sector (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)	Estimate of Mitigation Impact in 2030 (kt CO_2 eq)
Brief Description	This legislation, adopted in 2008, enables Alberta to administer funding to support large-scale carbon capture and storage projects. Two large-scale carbon capture and storage demonstration projects currently under development will capture CO_2 from upgrader facilities: the Quest project and the Alberta Carbon Trunk Line project. Beginning in 2015, the Quest project is expected to capture and store over 1MT CO_2 per year from Shell's Scotford Oil Sands Upgrader. In addition, the ACTL project will collect CO_2 from the North West Redwater Oil Sands Upgrader which will then be sold for injection into mature oil fields, after which it will be permanently stored. This project is expected to capture up to 1.2 MT of CO_2 per year. To date, the Government of Alberta has invested $1.3 billion in CCS technologies. The 2020 estimate of mitigation impact is also included under the Specified Gas Emitters Regulation.								
Saskatchewan SaskPower Demonstration and Implementation of Carbon Capture Technology*	Cross-cutting	CO_2	Reduce GHG emissions from coal energy	Voluntary agreement	Saskatchewan	Implemented	2014	NE[g]	NE[g]
Brief Description	With funding support from the federal government, 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, including the Aquistore project and the Carbon Capture Test Facility. The Weyburn-Midale project is the largest capture and storage demonstration site in the world. Saskatchewan is continuing to fund research related to the Weyburn reservoir through the Saskatchewan CO_2 Oilfield Use for Storage and EOR Research Project. Saskatchewan has implemented the approximately $1.35 billion, 115 megawatt project at Boundary Dam, with a $240 million federal government contribution. The Boundary Dam facility began commercial operation in October 2014 and is expected to capture up to 1MT of CO_2 per year, reducing emissions by 7.2 per cent from 2002 levels. These emission reductions are not listed to avoid double counting since the Boundary Dam emission reductions are listed by the federal government. Saskatchewan has been injecting carbon dioxide into the subsurface since 1984.								
Manitoba Made-in-Manitoba Carbon Pricing	Cross-cutting	CO_2	Reduce GHG emissions across the Manitoba economy	Regulatory	Manitoba	Planned	TBD	NE[d]	NE[d]
Brief Description	Manitoba announced its intention to develop a hybrid pricing system, combining a levy on fuel and an output-based pricing system for emissions-intensive, trade exposed sectors.								
Ontario Low Carbon Natural Gas	Cross-cutting	CO_2	Promote low-carbon energy supply and products	Regulatory	Ontario	Planned	2017	1,000 kt	NE[f]
Brief Description	Ontario will introduce a renewable content requirement for natural gas and provide supports to achieve encourage the use of cleaner, renewable natural gas in industrial, transportation and buildings sectors. The goal is to ensure the lowest possible carbon content to help reduce building and transportation emissions.								

National Communication Table 1: Summary of Policies and Measures by Sector (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)	Estimate of Mitigation Impact in 2030 (kt CO_2 eq)
Ontario Natural Gas Demand Side Management Programs	Cross-cutting	CO_2	Reduce natural gas consumption in the residential, commercial and industrial sectors	Regulatory	Ontario	Implemented	2003	5,706 kt	NE[g,h]
Brief Description	Enbridge Gas Distribution and Union Gas, Ontario's main natural gas utilities, have been delivering natural gas energy efficiency programs to their industrial, commercial, institutional and residential customers for over 20 years under the Demand Side Management Framework which is overseen by the Ontario Energy Board.								
Ontario Industrial Climate Change Action Plan Programs	Cross-cutting	CO_2	Increase the uptake of low-carbon technologies in the industrial emissions sector	Economic	Ontario	Implemented	2015	2,500 kt	NE[f]
Brief Description	Ontario will help Ontario businesses and industries increase their use of low-carbon technologies. Programs and services, such as the Target GHG Program, Green Ontario Fund, and low-carbon technology accelerators, will be designed and delivered by the green bank to help reduce greenhouse gas pollution while also reducing costs.								
Ontario Cap-and-Trade Program*	Cross-cutting	CO_2, CH_4, N_2O, PFCs, HFCs, SF_6 NF_3	Reduce GHG emissions across Ontario's economy	Regulatory, economic	Ontario	Implemented	2017	NE[g]	NE[g]
Brief Description	Ontario's cap and trade program is now in place. It limits greenhouse gas pollution, rewards innovative companies, generates opportunities for investment in Ontario and creates jobs while moving Ontario to a low-carbon economy. Ontario's first quarterly auction was held on March 22, 2017. On September 22, 2017, Ontario, Québec and California signed an agreement to link their carbon markets effective January 1, 2018. Ontario's cap and trade program is designed to support achievement of the province's emission reduction target of 15% below 1990 levels by 2020. The program covers over 80% of Ontario's GHG emissions, including emissions from home heating and transportation fuels. Proceeds raised through the auctioning of emission allowances are used to fund initiatives that reduce or support the reduction of GHG emissions.								
Ontario Provincial Land Use Plans and Legislation	Cross-cutting	All GHGs	Permanently protect prime agricultural land and environmentally sensitive areas	Regulatory	Ontario	Implemented	Various	NE[g]	NE[g]

National Communication Table 1: Summary of Policies and Measures by Sector (continued)

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Brief Description	Originally published in 2006 and updated in 2017, the Growth Plan for the Greater Golden Horseshoe, the Greenbelt Plan, the Oak Ridges Moraine Conservation Plan and the Niagara Escarpment Plan are four provincial land use plans that work together to manage growth, build complete communities, curb sprawl and protect the natural environment. Ontario's Climate Change Action Plans supports actions in land-use planning and the development of low-carbon communities. Ontario's land use plans are enabled by key legislation. The Places to Grow Act (2005) enables the development of regional growth plans that guide government investments and land use planning policies. The Greenbelt Act (2005) allows for the designation of an area of land as the Greenbelt Area—lands protected from development. The Growth Plan for Northern Ontario (2011), established 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's Far North Act (2010) will help ensure sustainable development through the Ontario government and First Nations working together on community-based land use planning.								
***Ontario Planning Act* and the Provincial Policy Statement, 2014**	Cross-cutting	All GHGs	Provide policy direction on matters of provincial interest in land use planning	Regulatory, information	Ontario	Implemented	2014	NE	NE
Brief Description	The Provincial Policy Statement (2014) provides policy direction on matters of provincial interest related to land use planning and development. It plays a key role in Ontario's land use planning system by providing the policy foundation for regulating the development and use of land. The Provincial Policy Statement includes policies to incorporate climate change mitigation and adaptation considerations into land use planning and decision-making, where appropriate.								
Québec Technoclimat Program	Cross-cutting	All GHGs	Develop new innovative technologies or processes in the areas of energy efficiency	Economic	Québec	Implemented	2013	NE[g]	NE[g]
Brief Description	The Technoclimat program promotes the development of new technology or innovative processes in the areas of energy efficiency, emerging energy and GHG emissions reduction by providing financial support to project proponents at various stages of the innovation chain. The main objective of the program is to support R&D, demonstration, measurement, pre-commercialization and dissemination.								
Québec's Cap-and-Trade System for Greenhouse Gas Emission Allowances*	Cross-cutting	All GHGs	Reduce GHG emissions across the economy	Economic, regulatory	Québec	Implemented	2013	NE[g]	NE[g]

National Communication Table 1: Summary of Policies and Measures by Sector (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)	Estimate of Mitigation Impact in 2030 (kt CO_2 eq)
Brief Description	In 2013, the Québec government replaced its carbon levy with a cap and trade system that has been linked with California's system since 2014. During the first two years of the program, industrial emitters and electricity producers were covered. In 2015, the Québec government terminated its carbon levy, when fuel distributers became covered by the cap and trade system. By the end of 2017, Québec and California will have held a total of thirteen joint auctions of GHG emission allowances. Ontario is also committed to join, and by 2018, the three governments are expected to have completed the necessary steps to link their cap and trade systems.								
Québec Heavy Fuel Oil Use Reduction Program	Cross-cutting	CO_2	Reduce GHG emissions	Economic	Québec	Implemented	2008	580 kt	NE[f]
Brief Description	This program, run by the Agence de l'efficacité énergétique du Québec, allows consumers of heavy fuel oil to make the transition to sustainable development and to improve their competitiveness by reducing consumption. Financial assistance is available for the implementation of analyses and energy efficiency measures involving heavy fuel oil and for the conversion to less polluting energy sources, such as natural gas and forest biomass.								
Québec EcoPerformance Program*	Cross-cutting	CO_2, HFC	Reduce GHG emissions	Economic	Québec	Implemented	2013	900.6 kt	NE[f]
Brief Description	This program is centered on three components: the *EcoPerfomance Buildings* program which encourages exoergic residential renovation and heating system conversions intended to reduce the energy use and greenhouse gas emissions of Québec homes; the *EcoPerformance Halocarbons* program to promote substituting refrigerants with substances that have a lower global-warming power; and the *EcoPerformance Industrial* program which seeks to reduce greenhouse gas emissions and energy use in the industrial sector by funding projects or measures connected with energy use and production, as well as with process improvement.								
Québec Regulation Respecting Halocarbons	Cross-cutting	HFC	Reduce halocarbon emissions	Regulatory	Québec	Implemented	2008	NE[g]	NE[g]
Brief Description	The purpose of this regulation is to reduce halocarbon emissions into the atmosphere to ensure that the ozone layer is protected and to minimize the increase in the greenhouse effect connected with the human-source emissions of certain other halocarbons. This regulation is under review.								
New Brunswick's Air Quality Regulations	Cross-cutting	CO_2	To limit GHG emissions from industrial sectors	Regulatory	New Brunswick	Planned	2014	NE[g]	NE[g]
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.								
New Brunswick Energy Efficiency Regulation	Cross-cutting	CO_2	Improve energy efficiency and energy conservation	Regulatory, education	New Brunswick	Implemented	2005	300 kt	NE[f]

National Communication Table 1: Summary of Policies and Measures by Sector (continued)

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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 service 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.								
Nova Scotia Cap and Trade Program	Cross-cutting	All GHGs	Reduce GHG emissions across Nova Scotia's economy	Regulatory	Nova Scotia	Planned	TBD	NE[d]	NE[d]
Brief Description	As part of the Pan-Canadian Framework on Clean Growth and Climate Change, Nova Scotia has committed to implement a cap and trade program.								
Prince Edward Island Energy Strategy	Cross-cutting	CO_2	Reduce energy use, develop renewable energy	Other	Prince Edward Island	Adopted	2016/2017	NE[g]	NE[g]
Brief Description	Prince Edward Island has developed a 10-year energy strategy to reduce energy use, establish cleaner and locally produced energy sources and moderate future energy price increases. The Strategy is guided by three principles: lowering greenhouse gas emissions, cost-effectiveness, and creating local economic opportunities.								
Prince Edward Island Climate Change Action Plan	Cross-cutting	CO_2, CH_4, N^2O	Reduce emissions and increase climate resilience	Other	Prince Edward Island	Planned	TBD	NE[g]	NE[g]
Brief Description	Prince Edward Island is in the process of updating its Climate Change Action Plan, expected in 2018.								
Yukon Government Sector Specific Targets	Cross-cutting	CO_2	Minimize growth in overall Yukon emissions	Regulatory	Yukon	Adopted	2012	NE[e]	NE[e]
Brief Description	The Yukon government has asset a variety of GHG reduction targets in the buildings, transportation, electricity, and industrial sectors. In addition, in 2009 the government pledged to reduce GHG emissions by 20 per cent by 2015 (based on 2010 levels) and to work towards becoming carbon neutral by 2020.								
Nunavut Energy Strategy	Cross-cutting	CO_2	Reduce fossil fuel consumption	Other	Nunavut	Adopted	2006	NE[k]	NE[k]
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.								

National Communication Table 1: Summary of Policies and Measures by Sector (continued)

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ELECTRICITY									
Reduction of CO_2 Emissions from Natural Gas-Fired Electricity**	Electricity	CO_2	Reduce GHG emissions from natural gas-fired electricity	Regulatory	Environment and Climate Change Canada	Planned	2020	NE[d]	NE[d]
Brief description	By 2018 the Government of Canada will finalize new performance standards that will impose emissions limits on natural gas-fired electricity generation. Draft federal regulations for natural gas-fired electricity are targeted for publication in early 2018 for public comment, with final regulations targeted for publication in winter 2018. The regulation will ensure new natural gas-fired electricity generation is efficient and to set limits on the use of coal units converted to run on natural gas								
Reduction of CO_2 Emissions from the Coal-Fired Generation of Electricity Regulations*	Electricity	CO_2	Reduce GHG emissions from coal-fired electricity generation	Regulatory	Environment and Climate Change Canada	Implemented	2015	3,100 kt	5,000 kt
Brief Description	Regulations under the Canadian Environmental Protection Act, 1999 apply a performance standard to new coal-fired electricity generation units and to existing units once they reach a defined period of operating life (generally 50 years). The performance standard of 420 tonnes of CO2 per gigawatt hour came into force July 1, 2015. The regulations are projected to result in a net reduction of approximately 214 Mt CO_2 eq of GHG over the period 2015–2035. The Government of Canada announced its intention to amend these regulations to accelerate action and phase out traditional coal-fired electricity generation by December 31, 2029. In early 2018, the Government of Canada will publish draft amendments for coal-fired electricity generation for public comment, with final amendments targeted for publication by December 2018.								
Strategic Interconnections of Electricity Grids**	Electricity	CO_2	Support large clean electricity generation and transmission projects that significantly reduce GHG emissions	Economic	Infrastructure Canada, Canada Infrastructure Bank, Natural Resources Canada	Planned	2018	NE[i]	12,700 kt
Brief Description	The program provides financial support to large clean electricity generation and transmission projects that can transmit clean electricity from provinces and regions with abundant renewable energy resources to provinces and regions seeking to reduce reliance on fossil fuels for electricity generation. Negotiations on Integrated Bilateral Agreement began in fall 2017; Infrastructure Bank to be operational in 2018.								

National Communication Table 1: Summary of Policies and Measures by Sector (continued)

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Smart Grid program**	Electricity	CO_2	Support the deployment and demonstration of smart grid technologies	Economic	Natural Resources Canada	Planned	2018	NE[d]	900 kt
Brief Description	The program accelerates the transition to a clean growth economy by better utilizing the existing capacity of electricity assets, increasing the penetration of renewable generation, increasing the reliability, resiliency, and flexibility of the power system while maintaining cyber security, and reducing GHG emissions. This is a Green Infrastructure program under the Investing in Canada Plan. The program is expected to generate reductions of 900 kt in 2030—700 kt from deployment and 200 kt from demonstration.								
Emerging Renewable Power**	Electricity	CO_2	Support deployment of emerging renewable power projects	Economic	Natural Resources Canada	Planned	2018	NA[d]	1,000 kt
Brief Description	The program provides funding to support renewable power technologies established abroad but not yet in Canada, such as offshore wind, tidal and geothermal to expand the portfolio of commercially-viable, investment-ready, renewable energy technologies available in Canada, support development of new supply chains, and reduce GHG emissions. This is a Green Infrastructure program under the Investing in Canada Plan. The program is scheduled to launch in winter 2018.								
ecoENERGY for Renewable Power Program	Electricity	CO_2	Reduce GHG emissions by increasing renewable electricity supply in Canada	Economic	Natural Resources Canada	Implemented	2007	6,000 kt	6,000 kt
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.								
Alberta Coal-Fired Electricity Generation phase-out*	Electricity	CO_2	Phase out the use of coal as a source of electricity by 2030	Regulatory	Alberta	Planned	TBD	NE[d]	NE[d]
Brief Description	As part of Alberta's Climate Leadership Plan announced in 2015, pollution from coal-fired sources of electricity will be phased out completely by 2030, which is expected to achieve cumulative emission reductions of 67 Mt. Greater investments in renewable energy projects will be made over time. Retired coal will be replaced with at least two-thirds renewable energy sources resulting in up to 30% of generation from renewable sources by 2030.								
Alberta Renewable Electricity Program*	Electricity	CO_2	Increase renewable energy capacity	Economic	Alberta	Implemented	2017	NE[d]	NE[d]

National Communication Table 1: Summary of Policies and Measures by Sector (continued)

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Brief Description	The Renewable Electricity Program is intended to encourage development of 5,000 megawatts of renewable electricity capacity connected to the Alberta grid system by 2030. The program will be run through a series of competitions to incent the development of renewable electricity generation through the purchase of renewable attributes.								
British Columbia Clean Energy Act: Clean or Renewable Electricity Requirement*	Electricity	CO_2, CH_4	Maintain low carbon electricity supply	Regulatory	British Columbia	Implemented	2010	NE[g]	NE[g]
Brief Description	British Columbia (B.C.) is in the process of creating a roadmap for the future of B.C. energy that will drive innovation, expand energy-efficiency and conservation programs, generate new energy responsibly and sustainably, and create lasting good jobs across the province. British Columbia continued to exceed its target of 93% clean electricity. B.C. amended the Greenhouse Gas Reduction (Clean Energy) Regulation to support the development of additional transmission infrastructure in northeast B.C. to provide clean electricity to meet increasing demand from the upstream natural-gas sector.								
British Columbia Clean Energy Act: Demand Side Management*	Electricity	CO_2	Reduce electricity demand growth	Regulatory	British Columbia	Implemented	2010	75 kt	75 kt
Brief Description	British Columbia (B.C.) amended the Greenhouse Gas Reduction (Clean Energy) Regulation to allow utilities to take demand-side measures to encourage customers to switch from higher-emission fuels to clean electricity. The provincial electricity utility B.C. Hydro is required to meet 66% of its forecasted incremental electricity demand through demand side management. B.C. also amended the Demand-Side Measures Regulation to allow utilities to double energy efficiency programs for natural gas-fired equipment.								
SaskPower Electricity Initiatives	Electricity	CO_2	Reduce GHG emissions from electricity generation and enhance supply of renewables	Voluntary Agreement	Saskatchewan	Implemented	2007	NE[g]	6,000 kt
Brief Description	SaskPower has set a target of 50% generation capacity from renewables by 2030, doubling the percentage of renewables in the supply mix in 15 years. Meeting this target will significantly reduce greenhouse gas emissions—about 40% below 2005 levels in 2030. This will include the addition of 60 megawatts of solar generation by 2021 and up to 1,600 megawatts from wind by 2030. These reductions will also be met through carbon capture and storage (CCS) technology. In the fall of 2014, Boundary Dam Unit 3 became the first power station in the world to successfully use CCS technology. The facility produces 115 megawatts of power and is capable of capturing approximately 1 million tonnes of CO_2 per year.								
Manitoba Emissions Tax on Coal and Petroleum Coke Act*	Electricity	CO_2	Reduce GHG emissions from coal and petroleum coke	Regulatory	Manitoba	Implemented	2013	NE[g]	NE[g]

National Communication Table 1: Summary of Policies and Measures by Sector (continued)

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Brief Description	The Act establishes an emissions tax on the use of petroleum coke in industrial facilities. Funds from Manitoba's emissions tax on coal are redirected to support the transition from coal to biomass. Manitoba plans to phase out its last remaining coal facility in Brandon, Manitoba by 2019. Manitoba's Coal Fired Emergency Operations Regulation, introduced in 2009, restricts Manitoba Hydro's use of coal to generate power in emergency operations.								
Manitoba Coal and Petroleum Coke Heating Ban Regulation	Electricity	CO_2	Reduce GHG emissions from coal and petroleum coke	Regulatory	Manitoba	Implemented	2013	NE[g]	NE[g]
Brief Description	Manitoba banned the use of petroleum coke for space heating in December, 2012.								
Manitoba Biomass Energy Support Program	Electricity	CO_2	Support coal users switch from coal to biomass	Economic	Manitoba	Implemented	2012	NE[g]	NE[g]
Brief Description	This program provides support in the transition to the processing and use of biomass for heating in place of coal. The program will provide financial support for capital and/or infrastructure upgrades that are required to effectively manufacture or consume biomass fuel, including expansion of existing facilities or development of new capacity.								
Ontario Coal Phase-Out*	Electricity	CO_2	Eliminate coal-fired electricity generation and the associated GHG emissions	Regulatory	Ontario	Implemented	2007	30,000 kt	NE[h]
Brief Description	By April 2014, coal-fired electricity was successfully eliminated from all Ontario Power Generation stations—19 generating units in total. More than 90 per cent of the power generated in Ontario now comes from clean energy sources such as water power, nuclear and renewables. Ontario passed the Ending Coal for Cleaner Air Act in 2015 to permanently ban coal-fired electricity generation in the province—a first in North America and a significant step in the fight against climate change. Ontario estimated emissions reductions in the electricity sector include Ontario Coal Phase-Out, Feed-in-Tariff program and other energy efficiency measures in the electricity sector.								
Ontario Feed-In Tariff Program and Large Renewable Procurement*	Electricity	CO_2	Support the development of renewable and clean energy sources	Economic	Ontario	Implemented	2009	30,000 kt	NE[h]
Brief Description	Ontario's Feed-in Tariff was launched in 2009 and allows homeowners, communities, business owners and private developers to generate renewable energy and sell it to the province at a guaranteed price for a fixed contract term. As of March 31, 2017, over 3,500 MW of renewable energy has been brought online under the program. Ontario estimated emissions reductions in the electricity sector include Ontario Coal Phase-Out, Feed-in-Tariff program and other energy efficiency measures in the electricity sector.								

National Communication Table 1: Summary of Policies and Measures by Sector (continued)

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Ontario Supporting Biomass Heat Project	Buildings	CO_2, CH_4, N_2O	Reduce GHG emissions from residential and commercial/ institutional heating	Information	Ontario	Implemented	2014	NE[g]	NE[g]
Brief Description	This project involves multiple ministries working on improving the business and policy environment for biomass heating in Ontario. Activities focus on enabling policy, investment and market development, outreach, and research and innovation. The project is expected to result in increased use of high-efficiency renewable biomass heating in commercial/institutional and residential applications, offsetting fossil fuel use.								
New Brunswick Electricity Act Renewable Portfolio Standard Regulation*	Electricity	CO_2	Achieve 40% of renewable energy for electricity	Regulatory	New Brunswick	Implemented	2014	630	NE[h]
Brief Description	The Electricity from Renewable Resources Regulation requires 40% of electricity supply to be from renewable sources by 2020, consistent with the Energy Blueprint Policy. By 2020, 75 percent of New Brunswick's electricity demand will be met by non-emitting or renewable sources.								
Nova Scotia Electricity Sector Regulations*	Electricity	CO_2, HFCs, CH_4, N_2O, SF_6, PFCs	Reduce GHG emissions from the electricity sector and to increase the share of clean energy in the province's energy use	Regulatory	Nova Scotia	Implemented	2009, 2010, 2013	2,500 kt	NE[h]
Brief Description	Nova Scotia has implemented two separate regulations to address emissions from the electricity sector and enhance the supply of renewables, which are together expected to result in emission reductions of 2,500 kt CO_2 eq in 2020. The Greenhouse Gas Emissions Regulations implement a mandatory declining cap on GHG emissions from electricity generation facilities. From a baseline of 10.2 MT (2007) the decreases are scheduled in progressive steps so the emissions will decline to 7,500 kt or below by 2020 and further to 4,500 kt or below by 2030. Total electricity GHG reduction in Nova Scotia for 2007 to 2030 will be at least 5,500 kt CO_2 eq. The Renewable Electricity 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.								
Nova Scotia Electricity Efficiency Regulations*	Electricity	CO_2	Use energy more efficiently	Regulatory	Nova Scotia	Implemented	2014	1,300 kt	NE[h]

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Brief Description	Nova Scotia created Canada's first energy efficiency utility, Efficiency Nova Scotia. Since its creation, this independent organization has achieved annual reductions of 1.2 per cent below the business as usual baseline. It also administers comprehensive energy efficiency programs for low income and First Nations Nova Scotians. The Electricity Efficiency and Conservation Restructuring Act (2014) requires Nova Scotia Power to purchase efficiency resources whenever they are lower cost than producing power. Efficiency resources are provided by Efficiency Nova Scotia for commercial, industrial, and residential consumers. Targets for electricity efficiency are guided by a periodic Integrated Resource Plan required by the Utility Board. GHG reductions achieved through electricity efficiency are included in the GHG reduction estimates provided for the Nova Scotia Greenhouse Gas Emissions Regulations.								
Newfoundland and Labrador Lower Churchill Project (Muskrat Falls)*	Electricity	CO_2, CH_4, N_2O	Increase the share of clean energy in the province's energy use	Economic	Newfoundland and Labrador	Planned	2019	1,200 kt	NE[g]
Brief Description	Currently under construction, the 824 megawatt Muskrat Falls hydroelectric project will displace oil-fired electricity generation representing over 10% of the province's GHG emissions. The project will also contribute to an estimated GHG reduction of approximately 1 Mt per year in Nova Scotia through a purchase power agreement and other additional exports sales may also result in a further 1 Mt reduction per year. The project is expected to be operational with full power starting in 2020. The second phase of the Lower Churchill Project includes the 2,200 MW Gull Island Project that has received federal and provincial environmental approval. Construction on Gull Island has not started.								
Prince Edward Island Wind Farm Development	Electricity	CO_2	Develop additional renewable electricity supply	Economic	Prince Edward Island	Planned	2017-2019	NE[e]	NE[e]
Brief Description	Prince Edward Island released an Energy Strategy in 2017, with an objective of developing two additional wind farms. Consultation on the first wind farm (30 MW) began in 2017.								
Prince Edward Island- New Brunswick Cable Interconnection Upgrade Project	Electricity	CO_2	Deliver reliable, long-term energy, and balance the growing wind energy supply	Economic	Prince Edward Island, New Brunswick	Implemented	2017	NE[g]	NE[g]
Brief Description	Prince Edward Island (PEI) completed a cable interconnection upgrade within the Northumberland Strait, between the provinces of Prince Edward Island and New Brunswick. Two 180 MW cables will help meet the growing demand for electricity on PEI, deliver reliable, long-term energy for Islanders, and help balance the intermittent nature of growing wind energy supply.								
Prince Edward Island Renewable Energy Act	Electricity	CO_2	Pursue cleaner sources of energy and reduce reliance on imported energy	Regulatory	Prince Edward Island	Implemented	2005	NE[g]	NE[g]
Brief Description	The Renewable Energy Act requires utilities to acquire at least 15% of electrical energy from renewable sources by 2010 (Renewable Portfolio Standard). Currently about 25% of Prince Edward Island's electricity consumption is sourced from on-island wind farms. The Act also established minimum purchase price utilities must pay for power produced by large-scale renewable energy generators and makes it economically feasible for Island homeowners, small businesses or farmers who have an interest in generating their own electricity to install small-scale generating systems through net-metering.								

National Communication Table 1: Summary of Policies and Measures by Sector (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)	Estimate of Mitigation Impact in 2030 (kt CO_2 eq)
Northwest Territories Arctic Energy Alliance	Electricity	CO_2	Educate, raise awareness and help residents adopt energy saving practices	Education	Northwest Territories	Implemented	2007	NE[e]	NE[e]
Brief Description	The Arctic Energy Alliance, a non-profit organization, 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.								
Yukon Independent Power Production Policy	Electricity	CO_2, CH_4, N_2O	Reduce diesel consumption for electricity and heat generation	Information, Economic	Yukon	Adopted	TBD	NE[e]	NE[e]
Brief Description	To assist large scale power producers, the Government of Yukon has adopted the Independent Power Production Policy which aims at enabling independent, non-utility electricity producers to sell electricity to Yukon's two public utilities through renewable energy technologies, such as wind power, micro-hydro, biomass and solar electric (or photovoltaic) systems.								
Yukon Microgeneration Policy	Electricity	CO_2, CH_4, N_2O	Reduce diesel consumption for electricity and heat generation	Information Economic	Yukon	Implemented	2014	41 kt	NE[f]
Brief Description	To assist small scale power producers, the Government of Yukon's Microgeneration Policy enables individuals and businesses to install electrical generating systems and connect them to the grid. The electricity generated is consumed on site and any surplus can be sold into the grid. Since it was announced in October 2013, 12 microgeneration systems have been installed which are expected to generate 41,000 kWh per year.								
Yukon Energy Corporation/ATCO Electric InCharge Program	Electricity	CO_2	Reduce GHG emissions from fossil fuel electricity generation	Voluntary Agreement	Yukon	Implemented	2014	NE[k]	NE[k]
Brief Description	Yukon Energy Corporation and ATCO introduced InCharge in 2014 to promote a culture of electricity conservation in Yukon's residential sector. The initiative consists of three programs; the LED and Automotive Heater Timer Rebate Program, the Low Cost Energy Efficient Products Program and an Engagement, Education and Communication Program. The anticipated annual net savings with transmission and distribution losses is expected to reach 2,644 MWh by 2018.								

National Communication Table 1: Summary of Policies and Measures by Sector (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)	Estimate of Mitigation Impact in 2030 (kt CO_2 eq)
TRANSPORTATION									
National Zero Emission Vehicle Strategy**	Transportation	CO_2, CH_4, N_2O	Reduce GHG emissions from on-road passenger vehicles and support clean transportation innovation	TBD	Government of Canada, provincial and territorial governments, industry	Planned	TBD	NE[d]	NE[d]
Brief Description	The Pan-Canadian Framework indicated a commitment for the federal, provincial and territorial governments to work with industry and other stakeholders to develop a Canada-wide strategy for zero-emission vehicles by 2018. In addition, federal, provincial, and territorial governments will work together, including with private-sector partners, to accelerate demonstration and deployment of infrastructure to support zero-emission vehicles, such as electric-charging stations. The ZEV strategy is under development and is expected to be announced in 2018.								
Light-Duty Vehicle GHG Regulations Phase 1*	Transportation	CO_2, CH_4, N_2O	Reduce GHG emissions from the on-road transportation sector	Regulatory	Environment and Climate Change Canada	Implemented	2011	11,900 kt	23,300 kt
Brief Description	The regulations establish progressively stringent GHG emission standards to new passenger automobiles and light trucks manufactured or imported into Canada for model years 2011-2016.								
Light-Duty Vehicle GHG Regulations Phase 2*	Transportation	CO_2, CH_4, N_2O	Reduce GHG emissions from the on-road transportation sector	Regulatory	Environment and Climate Change Canada	Implemented	2014	2,800 kt	24,300 kt
Brief Description	The regulations establish progressively stringent GHG standards for new vehicles of model years 2017 and beyond.								
Heavy Duty Vehicle GHG Regulations Phase 1*	Transportation	CO_2, CH_4, N_2O	Reduce GHG emissions from the on-road transportation sector	Regulatory	Environment and Climate Change Canada	Implemented	2014	2,600 kt	5,700 kt
Brief Description	These regulations apply increasingly stringent GHG emissions standards to new on-road heavy-duty vehicles and engines of model year 2014 to 2017 imported or manufactured in Canada.								
Heavy Duty Vehicle GHG Regulations Phase 2*	Transportation	CO_2, CH_4, N_2O	Reduce GHG emissions from the on-road transportation sector	Regulatory	Environment and Climate Change Canada	Planned	2018	25 kt	3,000 kt

National Communication Table 1: Summary of Policies and Measures by Sector (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)	Estimate of Mitigation Impact in 2030 (kt CO_2 eq)
Brief Description	These proposed regulations would apply increasingly stringent GHG emissions standards to new on-road heavy-duty vehicles and engines imported or manufactured in Canada starting with model year 2021 and would introduce GHG emissions standards for trailers imported or manufactured in Canada phased—starting with model year 2018. Final regulations are targeted for publication in 2018.								
Federal Renewable Fuels Regulations*	Transportation	CO_2	Regulate renewable content in fuel	Regulatory	Environment and Climate Change Canada	Implemented	2010	4,000 kt	NEf
Brief Description	The regulations require an average 5% renewable fuel content for gasoline, and 2% renewable fuel content in diesel fuel. Provinces such as Alberta, British Columbia and Ontario also have renewable fuel regulations in their respective jurisdictions. For example, these measures include the Alberta Renewable Fuel Standard Regulation, British Columbia Renewable and Low Carbon Fuel Requirements Regulation, Saskatchewan Renewable Diesel Program, Ontario Ethanol in Gasoline Regulation and Ontario renewable fuel requirements for gasoline and diesel. Certain other provinces have established incentive programs for renewable fuels, including the Manitoba Biofuel Production Incentive and the Ontario Ethanol Growth Fund.								
Energy efficiency of replacement tires	Transportation	CO_2	To reduce GHG emissions from transportation fuels	Regulatory	Government of Canada	Planned	2018	NE[d]	NE[d]
Brief Description	Canada is developing a standard for the energy efficiency of replacement tires. In 2017, tire testing was initiated in collaboration with Transport Canada and the United States National Highway Traffic Safety Administration, which will inform the development of the standard. In 2018, the tire efficiency testing results will be released, consultations on the standard development will be initiated, and draft technical standards will be developed.								
Retrofit requirements for existing heavy-duty trucks to install fuel-saving devices	Transportation	CO_2	To reduce GHG emissions from transportation fuels		Government of Canada, provincial and territorial governments,	Planned	2018	NE[d]	NE[d]
Brief Description	Jurisdictions are taking collective action to encouraging greater use of fuel saving devices in heavy-duty trucks.								
Carbon Dioxide Standards for Aviation	Transportation	CO_2	Reduce GHG emissions from new airplanes	Regulatory	Transport Canada	Planned	2018	NE[d]	NE[d]
Brief Description	Canada participated in the development of a new international CO_2 standard for new and in-production airplanes through the Committee on Aviation Environmental Protection at the International Civil Aviation Organization (ICAO). ICAO has adopted the new standard and Canada is working towards adopting the new standard into the Canadian Aviation Regulations in early 2018.								
Canada's Action Plan to Reduce GHG Emissions from Aviation*	Transportation	CO_2, CH_4, N_2O	Reduce GHG emissions from the aviation sector	Voluntary Agreement	Transport Canada	Implemented	2012	NE[k]	NE[k]

National Communication Table 1: Summary of Policies and Measures by Sector (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)	Estimate of Mitigation Impact in 2030 (kt CO_2 eq)
Brief Description	The Action Plan 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 has set an aspirational goal to improve fuel efficiency by an average of 2 percent per year until 2020, measured against a 2005 baseline and also identifies measures that are expected to have the greatest impact in reducing greenhouse gas emissions over time. The Action Plan forms the basis for the Government of Canada's response to the International Civil Aviation Organization's Assembly Resolution A37-19. Canada also benchmarks progress against the Air Transport Action Group's target of 1.5 percent from a 2008 baseline.								
Memorandum of Understanding between Transport Canada and Rail Industry for Reducing Locomotive Emissions*	Transportation	CO_2, CH_4, N_2O	Reduce GHG emissions from railway locomotives operated by Canadian railway companies in Canada	Voluntary Agreement	Transport Canada	Implemented	2011	NE[k]	NE[k]
Brief Description	This Memorandum of Understanding is a Canadian industry-government initiative, originally covering the 2011-2015 time period and extended to the end of 2017. The MOU was signed in April 2013 and includes GHG intensity targets for Class I freight, intercity passenger railways and short line railways and also encourages railways to adopt measures and undertake actions to reduce GHG emission intensity from rail operations. The Government of Canada published the Locomotive Emission Regulations under the Railway Safety Act in the Canada Gazette, Part II on June 28, 2017.								
Shore Power Technology for Ports Program	Transportation	CO_2, CH_4, N_2O	Reduce GHG emissions from docked ships	Economic	Transport Canada	Implemented	2011	7 kt	NE[e]
Brief Description	The Shore Power Technology for Ports Program provides cost-shared funding for the deployment of marine shore power technology at Canadian ports. By providing ship operators with an alternative to running diesel auxiliary engines while docked, shore power technology reduces fuel consumption, fuel costs, and greenhouse gas and air pollutant emissions from vessels. It also supports the competitiveness of Canadian ports.								
ecoTECHNOLOGY for Vehicles Program	Transportation	CO_2, CH_4, N_2O	Support the development of low-emission vehicle regulations, standards, etc.	Research, Information	Transport Canada	Implemented	2011	NE[c]	NE[c]
Brief Description	The ecoTECHNOLOGY for Vehicles program proactively tests, evaluates, and provides expert technical information about the environmental and safety performance of advanced on-road vehicle technologies, including light-duty and heavy-duty vehicles. The program shares technical findings to inform the development of vehicle emission 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 clean vehicle technologies into Canada in a safe and timely manner.								

National Communication Table 1: Summary of Policies and Measures by Sector (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)	Estimate of Mitigation Impact in 2030 (kt CO_2 eq)
Truck Reservation System Program	Transportation	CO_2, CH_4, N_2O	Reduce GHG emissions associated with port-related trucking activity	Economic	Transport Canada	Implemented	2013	NE[e]	NE[e]
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 program is currently working with project proponents to gather more complete data on truck movements within port areas to better measure GHG emissions on an ongoing basis. The program will be completed by March 31, 2018.								
Electric Vehicle Charging and Alternative Fuel Refuelling Infrastructure	Transportation	CO_2, CH_4, N_2O	Accelerate demonstration and deployment of charging and refuelling infrastructure, and supporting codes and standards	Economic, regulatory	Natural Resources Canada	Implemented	2016	NE[l]	NE[l]
Brief Description	The program supports the demonstration and deployment of electric vehicle (EV) chargers, and alternative fuel (e.g. natural gas, hydrogen) stations along Canada's highways and freight corridors. In addition, it supports the development and revision of enabling codes and standards for electric and alternative fueled vehicles and refuelling infrastructure. This is a Green Infrastructure initiative under the Investing in Canada Plan. By March 2018, deployment projects will result in over 100 new EV fast chargers, seven natural gas and three hydrogen stations built. The program supports increased uptake of electric vehicle transportation in 2030, and is therefore an enabling measure for the associated emission reductions.								
Energy Efficient Transportation	Transportation	CO_2, CH_4, N_2O	Improve energy efficiency in transportation in Canada	Information, education, regulatory,	Natural Resources Canada	Implemented	2016	1,100 kt	1,900 kt
Brief Description	This program has 4 elements: 1) to provide Canadians a suite of information and awareness tools and materials, including the EnerGuide label for vehicles to help consumers' choose more fuel efficient, less emitting vehicles; 2) to operate Canada's SmartWay Partnership program, which helps Canada's commercial/institutional freight sector benchmark and track their fuel consumption; 3) to develop a tire regulation to introduce a minimum energy efficiency standard for replacement tires for light-duty passenger vehicles, which aligns with a similar regulation being proposed in the U.S.; and 4) to promote freight management best practices and accelerate the adoption of energy management best practices in fleets and supply chains.								
British Columbia Clean Energy Vehicles Program*	Transportation	CO_2, N_2O	Reduce GHGs from transportation	Economic	British Columbia	Implemented	2011	18 kt	20 kt

National Communication Table 1: Summary of Policies and Measures by Sector (continued)

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Brief Description	British Columbia continues to build upon its commitment to support clean energy vehicle uptake and charging infrastructure deployment through incentive programs, an evolving regulatory framework, fleets programs, and outreach and training. The program from December 2011–March 2014 provided incentives for eligible clean energy vehicles and included deployment of charging point infrastructure for these vehicles. A phase 2 of the Clean Energy Vehicles Program began in April 2015 with similar incentives, and the program received further funding in 2016–17 which will be distributed over three years to support continued point-of-sale purchase incentives of up to $5,000 for battery electric vehicles and $6,000 for hydrogen fuel cell electric vehicles. When combined with SCRAP-IT program incentives, total savings could be up to $11,000 for a new electric vehicle.								
British Columbia SCRAP-IT Program	Transportation	CO_2, N_2O	Reduce GHGs from transportation	Economic	British Columbia	Implemented	1996	NE[j]	NE[j]
Brief Description	The SCRAP-IT Program, operational on and off since 1996, offers qualifying vehicle owners incentives to take their older vehicles off the road rather than resell them. Incentives are offered to support the purchase of a low emission vehicle, transit pass, car share, or bicycle. Emissions estimates are captured in the B.C. Clean Energy Vehicles Program.								
British Columbia Transport Infrastructure Investments	Transportation	CO_2, N_2O	Reduce GHGs from transportation	Economic	British Columbia	Implemented	2016	70 kt	70 kt
Brief Description	British Columbia now requires consideration of climate change impacts in transportation infrastructure design plans to improve the province's transportation network and transition to low carbon fuels by increasing the number of B.C. Transit compressed natural gas buses and fuelling stations and investing in dual fuel capable ferries that can run on either liquefied natural gas or ultra-low sulphur diesel.								
British Columbia GHG Reduction Regulation Enabling Utilities to Further Incent Natural Gas Vehicles	Transportation	CO_2, N_2O	Reduce GHGs from transportation	Economic	British Columbia	Implemented	2016	100 kt	100 kt
Brief Description	This amendment to the GHG Reduction Regulation allows utilities to double the total pool of incentives available to convert commercial fleets to 100 per cent renewable natural gas.								
British Columbia Incentives for Natural Gas in Transportation	Transportation	CO_2, N_2O	Reduce GHGs from transportation	Economic	British Columbia	Implemented	2016	40 kt	40 kt
Brief Description	New utility incentives will encourage emission reductions in B.C.'s transportation sector by promoting renewable natural gas for use in commercial fleets, as well as expanding fuelling infrastructure.								

National Communication Table 1: Summary of Policies and Measures by Sector (continued)

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British Columbia Fueling Marine Vessels with Cleaner Burning LNG	Transportation	CO_2, N_2O	Reduce GHGs from marine transportation	Economic	British Columbia	Planned	2016	0[m]	0[m]
Brief Description	Amendments to the Greenhouse Gas Reduction Regulation to allow utilities to provide further incentives for marine bunkering of liquefied natural gas.								
British Columbia Supporting Zero Emission Vehicle Charging Development for in Buildings	Transportation	CO_2, N_2O	Reduce GHGs from transportation	Supporting regulations	British Columbia	Planned	2017	NE[g]	NE[g]
Brief Description	The B.C. government is expanding support for the development of electric vehicle charging stations in buildings across the province by developing regulations to allow local governments to require new buildings to install adequate infrastructure to support electric vehicle charging and developing policies.								
British Columbia Renewable and Low Carbon Fuel Requirements*	Transportation	All GHGs	Reduce GHG from transportation fuels	Regulatory	British Columbia	Implemented	2008	1,200 kt	1,800 kt
Brief Description	British Columbia continues to implement its renewable and low carbon fuel policy. The Regulation requires a minimum renewable fuel content for the fuel supplied in British Columbia (5% for gasoline, 4% for diesel) and requires fuel suppliers to reduce the average carbon intensity of transportation fuels by 10% by 2020.								
Alberta GreenTRIP	Transportation	CO_2	Increase the accessibility and use of public transit in Alberta	Economic	Alberta	Implemented	2010	50 kt	NE[f]
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.								

National Communication Table 1: Summary of Policies and Measures by Sector (continued)

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Ontario Metrolinx: The Big Move: Transforming Transportation in the Greater Toronto and Hamilton Area*	Transportation	CO_2, CH_4, N_2O	Increasing options for transportation, safe and secure mobility, and a smaller carbon footprint and lower GHG emissions	Economic	Ontario	Implemented	2008	3,900 kt	NE[f]
Brief Description	Emission reduction estimate for the Big Move is combined with several initiatives. 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; truck speed limiter regulation; municipal hybrid bus purchase, first generation of Ontario's Green Commercial Vehicle Program; Ontario ethanol regulation; other related transportation initiatives. Initiatives under this plan include: work to accelerate deployment of the Regional Express Rail system, which includes electrification of the existing diesel-operated locomotive fleet to utilize Ontario's low-carbon electricity; a new Green Commercial Vehicle Program to provide incentives to eligible businesses that want to buy low-carbon commercial vehicles and technologies to reduce emissions, including electric and natural gas-powered trucks, aerodynamic devices, anti-idling devices, and electric trailer refrigeration; and a Renewable Fuels Standard to increase the percentage of renewable content required in transportation fuels sold in the province.								
Ontario Electric Vehicle Incentive Program*	Transportation	CO_2, CH_4, N_2O	Accelerate the uptake of electric vehicles in the province	Economic	Ontario	Implemented	2010	50 kt	NE[f]
Brief Description	Ontario's has established or is in the process of establishing new initiatives to support the uptake of electric vehicles, including: electric vehicle (EV) incentive program, EV Charger Ontario Program, EV charging infrastructure program, EV discovery center, EV overnight charging program, electric/hydrogen vehicle advancement program, and electric school bus pilot program. Ontario has established a sales target of 5% in 2020 for electric and hydrogen passenger vehicles.								
Ontario Drive Clean Program	Transportation	CO_2, CH_4, N_2O	Reduce smog-causing pollutants from vehicles	Regulatory	Ontario	Implemented	1999	NE[g]	NE[g]
Brief Description	Ontario's Drive Clean Program is a mandatory vehicle emissions inspection and maintenance program for light-duty and heavy-duty vehicles. Light-duty vehicles registered in the program area are required to be tested biennially, and all heavy-duty vehicles registered in the province must be tested annually unless a biennial testing incentive is earned.								
Québec Assistance Program to Improve Public Transit Services	Transportation	CO_2, CH_4, N_2O	Reduce GHG emissions from the transportation sector	Economic	Québec	Implemented	2013	23 kt	NE[g]
Brief Description	The program will impact GHG emissions associated with passenger transportation through supporting transit authorities to increase public transit services, operations, and capital projects. Investments are made in urban and rural services as well as interregional bus transport.								

National Communication Table 1: Summary of Policies and Measures by Sector (continued)

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Québec Transportation Electrification Initiatives*	Transportation	CO_2, CH_4, N_2O	Reduce GHG emissions in the transportation sector and accelerate the deployment of EVs and associated infrastructure	Economic	Québec	Implemented	2012	30,1 kt	NE[g]
Brief Description	Québec places significant emphasis on electric transportation, including light vehicles and electric public transportation, and promoting the development of the electric industrial sector. Targets for 2020 are to: reach 100,000 electric vehicles and rechargeable hybrids; reduce the number of litres of fuel consumed annually in Québec by 66 million; and have 5,000 jobs in the electric vehicle sector and bring about investments of 500 million dollars. The Drive Green program has two components: the Drive Electric program and the Connected at Work program. The Drive Electric program offers individuals, businesses, not-for-profit organizations and municipalities in Québec a rebate on the purchase or rental of an eligible vehicle. The rebate granted varies from $4,000 to $8,000 for fully electric vehicles and rechargeable hybrids. All those who purchase or rent a fully electric vehicle or a plug-in hybrid electric vehicle (PHEV) can also ask for financial assistance to purchase and install a 240-volt charging station at their home. The Connected at Work program offers businesses, municipalities and organizations a reimbursement on the installation of charging stations in the workplace. The financial assistance offered for a charging station equals the lesser of the following amounts: 50% of the eligible expenses or $5,000. The maximum amount of financial assistance granted to an establishment is set at $2,000 per fiscal year. Hydro-Québec's Electric Circuit is the first public network of charging stations for electric vehicles in Canada, offering 240-volt and 400-volt charging stations. As of June 2017, the network has 875 charging stations in service, including 77 quick-charge stations.								
Québec Eco Trucking Program*	Transportation	CO_2, CH_4, N_2O	Reduce the GHG emissions from the transportation sector	Economic	Québec	Implemented	2013	NE[g]	NE[g]
Brief Description	The Eco-trucking program aims to promote the use of equipment and technology to improve energy efficiency while reducing GHGs in the transportation of goods. This program offers financial support for eligible technology and the completion of projects to reduce GHG emissions.								
Québec Energy Efficiency Program for Marine, Air and Railway Transportation*	Transportation	CO_2, CH_4, N_2O	Reduce GHG emissions in the transportation sector	Economic	Québec	Implemented	2013	NE[g]	NE[g]

National Communication Table 1: Summary of Policies and Measures by Sector (continued)

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Brief Description	This program aims to reduce or avoid GHG emissions by offering financial assistance to improvethe energy efficiency of organizations and companies that use marine, air or railway transportation services, particularly through the use of more efficient transportation materials and equipment. The program consists of two components: Infrastructure and Equipment, and Studies and Pilot Projects. Businesses, municipal organizations and other legally constituted organizations with an establishment in Québec are eligible for the program.								
Québec Program Aiming to Reduce or Avoid GHG emissions through the Intermodal Transportation*	Transportation	CO_2, CH_4, N_2O	Reduce GHG emissions in the transportation sector	Economic	Québec	Implemented	2013	NE[g]	NE[g]
Brief Description	The program aims to reduce or avoid GHG emissions generated by the transportation of goods or people by installing intermodal projects and by promoting marine and railway services. Businesses, municipal organizations and other legally incorporated organizations with an establishment in Québec are eligible for the program. The program has five components—projects with infrastructure expenses, projects with no infrastructure expenses, pilot projects, studies and the promotion of maritime or railway modes of transportation—and the financial contributions vary depending on the component. Assistance can vary from $400 to $750 per tonne of reduced or avoided GHG emissions for components 1 and 2. For component 3, a maximum of $1M can be granted per project, whereas for components 4 and 5, the maximum is $50,000.								
Québec Support for the deployment of electric school buses	Transportation	CO_2, CH_4, N_2O	Reduce GHG emissions from the transportation sector	Economic	Québec	Implemented	2013	NE[e]	NE[e]
Brief Description	A one-time rebate of $105,000 is granted for the purchase of a fully electric school bus. The rebate is issued to (1) school bus providers on contract with school boards and private teaching establishments and (2) school boards and accredited private teaching establishments.								
Québec Zero Emission Vehicle Regulation*	Transportation	CO_2, CH_4, N_2O	Reduce GHG emissions from the transportation sector and accelerate the deployment of electric vehiciles and related infrastrucutre	Regulatory	Québec	Planned	2018	NE[l]	NE[l]
Brief Description	Starting with 2018 models, automakers will be required to meet a zero emisison vehicle (ZEV) sales target set by the government and transposed into credits. Automakers that sell or lease a yearly average of more than 4,500 new vehicles (all light models combined) will be subject to the ZEV standard. The ZEV standard is expected to contribute to the acquisition of approximately 64,000 vehicles by 2020.								

National Communication Table 1: Summary of Policies and Measures by Sector (continued)

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Québec Regulation on the Activation of Speed Limiters with a Maximum of 105 km/h	Transportation	CO_2, CH_4, N_2O	Reduce GHG emissions of heavy vehicles	Regulatory	Québec	Implemented	2009	NE[e]	NE[e]
Brief Description	Since January 1, 2009, serial speed limiters have been activated and regulated in such a way as to prevent vehicles from exceeding 105 km/h. This measure is for heavy vehicle operators from anywhere whose trucks use the Québec roadway network.								
OIL AND GAS									
Regulations to Address Methane in the Oil and Gas Sector*	Oil and Gas	CH_4	Reduce emissions from methane in the oil and gas sectors in Canada	Regulatory	Environment and Climate Change Canada	Implemented	2020	4,000 kt	20,000 kt
Brief Description	As part of the Pan-Canadian Framework, the Government of Canada reaffirmed its commitment to reduce methane emissions from the oil and gas sector by 40 to 45 percent from 2012 levels by 2025, building on provincial actions and targets. To implement this commitment, Canada will introduce federal regulations to reduce venting and fugitive methane emissions from existing and new oil and gas sources. The Government will aim to publish final regulations in early 2018, for implementation in 2020.								
Oil and Gas Clean Technology Program	Oil and Gas	CO_2, CH_4, N_2O	Reduce GHG emissions	Economic	Natural Resources Canada	Implemented	2016	146 kt	NE[f]
Brief Description	The program provides funding for innovative technologies to reduce GHG emissions from the oil and gas sector. In addition to the direct emissions reductions, the program will contribute additional indirect emissions of approximately 1,500–2,500 kt in 2030, by reducing technical risk and accelerating market adoption of the funded technologies.								
British Columbia Flaring and Venting Reduction Guideline	Oil and Gas	CH_4	Reduce flaring and venting in the oil and gas sector	Regulatory	British Columbia	Implemented	2010	125 kt	125 kt
Brief Description	This guideline applies to the flaring, incineration and venting of natural gas at well sites, facilities and pipelines and is expected to reduce 80 million cubic meters of methane flaring annually.								
British Columbia GHG Industrial Reporting and Control Act	Oil and Gas	CO_2, CH_4	Reduce industrial GHG emissions growth	Fiscal	British Columbia	Implemented	2013	180 kt	3,960 kt
Brief Description	British Columbia implemented a liquefied natural gas emissions intensity benchmark under the Greenhouse Gas Industrial Reporting and Control Act. LNG facilities are required to meet the emissions intensity benchmark of 0.16 t CO_2e/t LNG either through adopting more efficient technologies, using clean energy, investing in offsets, or purchasing “funded units” at CA$25/tonne that contribute to clean technologies.								

National Communication Table 1: Summary of Policies and Measures by Sector (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)	Estimate of Mitigation Impact in 2030 (kt CO_2 eq)
British Columbia Clean Infrastructure Royalty Credit Program	Oil and Gas	CH_4, CO_2	Reduce oil and gas GHG emissions	Economic	British Columbia	Implemented	2016	NE[c]	NE[c]
Brief Description	This program adds an additional $20 million program to B.C.'s current successful oil and natural gas royalty programs. The Clean Infrastructure Royalty Credit Program will support the use of clean technologies and result in GHG emissions reductions from BC's oil and natural gas sector and will act to reduce methane emissions in line with Federal reduction commitments.								
British Columbia Electrification of the Natural Gas Sector*	Oil and Gas	CO_2, CH_4, N_2O	Reduce oil and gas GHG emissions	Economic	British Columbia	Planned	2016	1,600 kt	4,000 kt
Brief Description	BC amended the GHG Reduction (Clean Energy) Regulation to support the development of additional transmission infrastructure in northeast B.C. to provide clean electricity to meet increasing demand from the upstream natural gas sector. The regulation enables the electricity utility BC Hydro to provide incentives for electrification to bridge the cost difference between using natural gas and electricity in upstream oil and gas infrastructure.								
British Columbia New Energy Efficiency Standards for Gas Fired Boilers*	Oil and Gas	CO_2, CH_4	Reduce oil and gas GHG emissions	Regulation	British Columbia	Planned	2020	90 kt	300 kt
Brief Description	The new regulations will be implemented by 2020 and will set out energy efficiency standards for large gas-fired package boilers. The regulations are for the industrial sector requiring gas boilers to achieve 85% efficiency by 2016 and 90% by 2021.								
British Columbia Expanded Incentives for Efficient Gas Equipment	Oil and Gas	CO_2, N_2O	Reduce oil and gas GHG emissions	Economic	British Columbia	Planned	2017	80 kt	80 kt
Brief Description	The incentives will allow utilities to expand their incentives by at least 100%, to encourage further adoption of technologies that reduce the emissions from gas fired equipment.								
British Columbia Regulatory Framework for Carbon Capture and Storage	Oil and Gas	CO_2	Reduce oil and gas GHG emissions	Regulation	British Columbia	Planned	2016	NE[g]	NE[g]
Brief Description	The framework will allow carbon capture and storage projects at natural gas extraction and processing facilities to proceed upon the completion of regulatory policy work.								

National Communication Table 1: Summary of Policies and Measures by Sector (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)	Estimate of Mitigation Impact in 2030 (kt CO_2 eq)
British Columbia Methane Reduction Policy	Oil and Gas	CH_4	Reduce oil and gas GHG emissions	Regulation, financial	British Columbia	Planned	2017	100 kt	1,200 kt
Brief Description	The policy targets extraction and processing emissions (referred to as upstream in the natural gas sector), including: legacy phase, targeting a 45% reduction by 2025 in fugitive and vented emissions in infrastructure built before January 1, 2015; transition phase, including incentives through a new offset protocol to encourage further innovative projects and a Clean Infrastructure Royalty Credit Program for all applications built between 2015 and 2018; and future phase, implementing standards to guide developments of projects after the transition phase, where leak detection and repair will be mandatory and protocols developed to align with other jurisdictions.								
Alberta *Oil Sands Emissions Limit Act*	Oil and Gas	CO_2	Cap emissions increase from the Oil Sands sector to 100 Mt	Legislation	Alberta	Adopted	2018	NE[g]	NE[g]
Brief Description	The *Oil Sands Emissions Limit Act* creates the legal framework for setting a legislated maximum emissions limit of 100Mt in any year for oil sands facilities with provisions for cogeneration and new upgrading capacity.								
Alberta reduction of methane emissions	Oil and Gas	CH_4	Reduce methane emissions from oil and gas operations by 45%	Regulatory	Alberta	Planned	TBD	NE[g]	NE[g]
Brief Description	Alberta is targeting a 45% reduction in methane gas emissions from its oil and gas operations by 2025 to be implemented through new oil and gas methane standards.								
Alberta Carbon Capture and Storage Funding Act and Investments*	Oil and Gas	CO_2	Fund carbon capture and storage projects in Alberta	Economic Legislation	Alberta	Implemented	2008	2,760 kt	2,760 kt
Brief Description	This legislation, adopted in 2008, enables Alberta to administer funding to support large-scale carbon capture and storage projects. Two large-scale carbon capture and storage demonstration projects will capture CO_2 from upgrader facilities: the Quest project and the Alberta Carbon Trunk Line project. The Quest project began in 2015 and is designed to capture and store 1.08 Mt CO_2 per year. The Alberta Carbon Trunk Line project is under-development and will collect CO_2 for injection into mature oil fields, after which it will be permanently stored. This project is expected to be operational in 2018 and capture 1.68 Mt of CO_2 per year.								
Alberta Directive 060 Upstream Petroleum Industry Flaring, Incinerating and Venting	Oil and Gas	CH_4, CO_2	To reduce flaring and venting in the oil and gas sector	Regulatory	Alberta	Implemented	1999	4,000 kt	NE[g]

National Communication Table 1: Summary of Policies and Measures by Sector (continued)

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Brief Description	Requirements have been developed in consultation with the Clean Air Strategic Alliance to eliminate or reduce the potential and observed impacts of these activities and to ensure that public safety concerns and environmental impacts are addressed before beginning to flare, incinerate, or vent. Directive 060 requirements are also aligned to ensure compliance with Alberta Environment and Sustainable Resource Development's Alberta Ambient Air Quality Objectives and Guidelines.								
Saskatchewan Directive S-10: Upstream Petroleum Associated Gas Conservation & Directive S-20: Upstream Flaring and Incineration	Oil and gas	CH_4	Reduce flaring and venting in the oil and gas sector	Regulatory	Saskatchewan	Implemented	2012	NE[g]	NE[g]
Brief Description	This directive applies to the flaring, incineration and venting of natural gas at oil well sites and facilities. This regulatory directive is supported by Minister's Order. Start date for new wells and facilities was July 1, 2012 for new wells and facilities and July 1, 2015 for wells and facilities existing prior to 2012. The goal of the directive is to eliminate all routine flaring and venting (>900 m^3/day).								
Manitoba Implementation of World Bank Voluntary Standard for Gas Flaring	Oil and gas	CH_4	Reduce flaring and venting of gas	Voluntary agreement	Manitoba	Implemented	2005	NE[g]	NE[g]
Brief Description	The Voluntary Standard for Global Gas Flaring and Venting Reduction provides guidance on how to achieve reductions in flaring and venting of gas associated with crude oil production worldwide. The parties supporting this Standard voluntarily chose to endorse the principles laid out in the Standard and to work in cooperation with Global Gas Flaring Reduction Partners to seek solutions to overcome barriers that result in gas flaring and venting. In September 2005, Manitoba endorsed the Global Gas Flaring Reduction. The Department of Science, Technology, Energy and Mines will be the province's lead agency for monitoring and reporting on flaring and venting in Manitoba's upstream oil and gas sector.								
Newfoundland and Labrador Implementation of World Bank Voluntary Standard for Gas Flaring	Oil and gas	CH_4	Reduce flaring and venting of gas	Voluntary agreement	Newfoundland and Labrador	Implemented	2007	NE[g]	NE[g]
Brief Description	The Voluntary Standard for Global Gas Flaring and Venting Reduction provides guidance on how to achieve reductions in flaring and venting of gas associated with crude oil production worldwide. The parties supporting this Standard voluntarily chose to endorse the principles laid out in the Standard and to work in cooperation with Global Gas Flaring Reduction Partners to seek solutions to overcome barriers that result in gas flaring and venting. The board sets flaring limits in permit conditions for each facility and reviews and reduces those limits regularly.								

National Communication Table 1: Summary of Policies and Measures by Sector (continued)

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BUILDINGS									
Federal Energy Efficient Buildings Initiatives**	Buildings	CO_2, CH_4, N_2O	Accelerate and enhance the promotion of energy efficiency in the buildings sector	Fiscal, information	Natural Resources Canada	Implemented	2016, 2018	NE[e]	11,200 kt
Brief description	A number of energy efficiency measures have been outlined under Green Infrastructure, as part of the Investing in Canada Plan. These actions include: the development of net-zero energy ready (NZER) model building codes; the development of a new model retrofit code that sets energy performance standards for building retrofits by 2022; a nationally harmonized approach to mandatory energy labelling and disclosure for commercial, institutional and residential buildings, as early as 2019, through the expansion of Natural Resources Canada's existing benchmarking and labelling measures; and driving down the cost of NZER construction and retrofit practices and technologies and encouraging their uptake by industry and PTs through research, development, and demonstration (RD&D). Other actions implemented in 2016 include: enabling and promoting 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; introducing ENERGY STAR Certification for commercial and institutional buildings to recognize top energy performing buildings in Canada; expanding energy benchmarking for commercial and institutional buildings through ENERGY STAR Portfolio Manager; and supporting a new national High-Performance Building Challenge to help bring the Canadian building sector closer to a net-zero energy performance ideal.								
British Columbia Building Green Code*	Buildings	CO_2	Improve energy efficiency in new houses and buildings	Regulatory	British Columbia	Implemented	2008	500 kt	500 kt
Brief Description	Since 2008, British Columbia has been working to improve energy efficiency in the building sector, including for large residential, industrial and commercial buildings, houses and small buildings, as well as in public sector buildings, including a LEED Gold requirement and research on low carbon building material options. In 2017, BC introduced a Step Code: Increased Energy Efficiency Requirements in the BC Building Code, Energy Step Code: Energy Efficiency, and a Net-Zero Energy Ready (NZER) Building Design Incentive.								
British Columbia Technology and Retrofit Incentive Programs	Buildings, industry	CO_2	Reduce GHG emissions in buildings	Economic	British Columbia	Implemented	2015	130 kt	80 kt
Brief Description	A variety of programs provide incentives for energy efficiency measures. The Home Energy Retrofit Offer Program provides incentives for home energy efficiency upgrades. The Oil to Heat Pump Incentive Program provides rebates for homeowners to convert from less efficient oil heating systems to all-electric air source heat pumps. The ISO 50001 incentive is run by the B.C. Government and the federal government and offers up to $80,000 of cost-shared assistance to B.C. industrial companies to implement energy management system projects that help facilities to comply with the standard, which enables companies to systematically reduce energy consumption and emissions.								

National Communication Table 1: Summary of Policies and Measures by Sector (continued)

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British Columbia Climate Action Charter	Buildings	CO_2	Reduce GHG emissions in buildings and transportation	Economic	British Columbia	Implemented	2008	NE	NE
Brief Description	The Charter is an Agreement between provincial and municipal governments to work towards carbon neutral operations and complete, compact, low carbon communities.								
Ontario Green Fund	Buildings	CO_2	Reduce GHG emissions from residential buildings, commercial buildings/ businesses, and from manufacturing	Economic	Ontario	Implemented	2017	NE[g]	NE[g]
Brief Description	The Green Ontario Fund is a not-for-profit provincial agency that invests proceeds from Ontario's carbon market into climate actions that help people and businesses reduce GHG emissions and use cleaner technology to power their homes and workplaces. The agency develops programs and services designed to: reduce GHG emissions from buildings and from the production of goods; increase uptake and overcome market barriers of low-carbon technologies and processes; stimulate economies of scale and private investment; and help households and businesses manage the impact of the cap and trade program, including low-income household.								
Ontario GHG Reductions for Broader Public Sector Buildings	Buildings	CO_2	Reduce GHG emissions from public sector buildings and encourage adoption of energy-efficient technologies	Economic	Ontario	Implemented	2017	113 kt	NE[g]
Brief Description	In 2017, Ontario invested $200 million in funding in 2017–18 for school building upgrades such as high-efficiency lighting, building automation systems, energy-efficient windows, and solar energy and geothermal systems. In total $400–$800 million are intended to be invested in broader public sector buildings out to 2020. Estimate of mitigation impact in 2020 includes supports to hospitals, universities and colleges.								

National Communication Table 1: Summary of Policies and Measures by Sector (continued)

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Ontario Building related initiatives*	Buildings	CO_2, CH_4, N_2O	To plan for growth, and to reduce natural gas consumption throughout Ontario	Regulatory	Ontario	Implemented	2007	1,890 kt	NE[h]
Brief Description	Emission reductions for Ontario's buildings sector are combined, although electricity savings (and associated reductions) are assigned to the Long Term Energy Plan. Combined estimated mitigation impact of 1.89 Mt applies to: Growth Plan for the Greater Golden Horseshoe (2006)—impact on stationary combustion; Building Code changes; Home Energy Savings Program. Ontario's Climate Change Strategy will support net-zero buildings across the Province through, among other initiatives, updates to the Building Code.								
Ontario Building Code*	Buildings	CO_2, CH_4, N_2O	To establish standards and promote improvements in energy efficiency	Regulatory	Ontario	Implemented (ongoing)	2018	NE[d]	NE[d]
Brief Description	Ontario intends to update the Building Code with long-term energy efficiency targets for new net zero carbon emission small buildings that will come into effect by 2030 at the latest, and consult on initial changes that will be effective by 2020. Ontario will consult on how to best achieve these targets through Building Code improvements. The objective is to establish standards, promote improvements in energy efficiency of existing buildings, to plan for growth, and to reduce natural gas consumption throughout Ontario.								
Ontario Energy Efficiency Standards for Products and Appliances	Cross-cutting	CO_2, CH_4, N_2O	Reduce GHG emissions in the buildings sector	Regulatory	Ontario	Implemented	2013, 2014, 2015, 2016	NE[g]	NE[g]
Brief Description	Ontario's regulation O. Reg. 404/12 sets efficiency requirements for over 80 products using electricity, natural gas, and oil in the residential, commercial and industrial sectors. The most recent amendments to the energy efficiency regulation are estimated to reduce GHG emissions in 2030 by 2 Mt CO_2e (this includes1.4 MT CO_2e reduction resulting from natural gas and oil fired products). Ontario is working on its next update to Ontario's energy efficiency regulation that would further reduce GHG emissions in the building sector.								
Ontario Natural Gas Demand Side Management Programs*	Buildings	CO_2	Reduce natural gas consumption in the residential, commercial and industrial sectors	Regulatory	Ontario	Implemented	2003, 2015	5,706 kt	NE[g]

National Communication Table 1: Summary of Policies and Measures by Sector (continued)

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Brief Description	Ontario's main natural gas utilities, have been delivering natural gas energy efficiency programs to their industrial, commercial, institutional and residential customers for over 20 years under the Demand Side Management Framework which is overseen by the Ontario Energy Board. The Demand Side Management Programs have been implemented from 2003 to 2014 with a new plan in operation from 2015 to 2020. The estimated GHG mitigation impact of 5.7 Mt accounts for: GHG savings from historic programs (2003–2014) that are expected to persist in 2020; and GHG savings from planned programs (2015–2020), under the new 2015–2020 Demand Side Management Framework, that are expected to persist in 2020.								
Ontario Social Housing Retrofit and Electricity Efficiency Programs	Buildings	CO_2	Reduce GHG emissions and increase energy efficiency in social housing	Fiscal	Ontario	Ongoing	2016	99 kt **	NE[g]
Brief Description	Ontario is improving energy efficiency in social housing and other multi-tenant residential buildings. Through the Social Housing Apartment Retrofit program, the installation of energy efficient and renewable energy technologies will be a low-cost, high-benefit improvement to the province's social housing. In 2017, Ontario also provided new funding for repairs and retrofits to social housing across the province in order to improve living conditions and reduce GHG emissions. In addition, a separate Social Housing Electricity Efficiency Program targets low-density social housing dwellings that are primarily electrically heated and where tenants pay the utility costs. **Estimate of mitigation impact in 2020 includes supports protecting tenants from the price of carbon and providing incentives for apartment building retrofits.								
Québec Residual Forest Biomass Program	Buildings	CO_2	Reduce GHG emissions from heating buildings	Economic	Québec	Implemented	2013	84 kt	NE[g]
Brief Description	This program aims to reduce GHG emissions and the consumption of fossil fuels by funding specific energy conversion projects to switch from fossil fuels to residual forest biomass.								
Québec Chauffez Vert Program	Buildings	CO_2	Reduce GHG emissions in the building sector	Economic	Québec	Implemented	2013	328.9 kt	NE[g]
Brief Description	Chauffez vert is a program that encourages energy-efficient residential renovations in order to reduce the energy consumption and greenhouse gas (GHG) emissions of homes in Québec, while improving the comfort of their occupants.The financial assistance is granted for the conversion of a primary heating system that uses oil, propane or any other fossil fuel except natural gas, to a primary heating system powered by geothermal, hydro, wind and solar energy.								
Québec Rénovert	Buildings	CO_2	Reduce GHG emissions in the building sector (private homes)	Economic	Québec	Implemented	2016	NE[g]	NE[g]
Brief Description	This program is based on a tax credit and supports eco-friendly renovation work related to heating systems and residential insulation.								

National Communication Table 1: Summary of Policies and Measures by Sector (continued)

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Québec Construction Code*	Buildings	CO_2, CH_4, N_2O	Reduce GHG emissions and energy consumption in the building sector	Regulatory	Québec	Implemented	2012	NE[g]	NE[g]
Brief Description	The Construction Code was amended in August, 2012 in order to introduce new requirements for energy efficiency for residential buildings. The Construction Code will be amended to introduce new requirements for energy efficiency for commercial, institutional, industrial and tall residential buildings. These new measures will improve the energy performance of new buildings by 20% to 25% compared to the previous regulation.								
Québec Novoclimat Programs	Buildings	CO_2, CH_4, N_2O	Reduce GHG emissions and energy consumption in the building sector	Economic	Québec	Implemented	2003	NE[g]	NE[g]
Brief Description	The Novoclimat 2.0 Program House component (implemented in 2013) encourages the construction of new high energy performance houses according to specific construction requirements. Financial assistance of $1,000 is paid exclusively to the first owner of the Novoclimat 2.0 approved house. The Novoclimat 2.0 program applies to small multiple dwelling buildings such as a duplex, triplex and quadruplex as well as multiple-unit complexes of 3 stories or less and 600 m² or less. The first Novoclimat program (implemented in 1999) still applies to properties of more than 600 m² and up to 10 stories for which the main energy source is electricity, natural gas or residual forest biomass.								
Québec Éconologis Program	Buildings	CO_2	Reduce GHG emissions in the building sector	Economic	Québec	Implemented	2013	NE[g]	NE[g]
Brief description	Éconologis is an energy efficiency awareness program intended for modest income households. It consists of a home visit by a service provider to inform and raise awareness of the participating household through personalized suggestions on energy efficiency and improvement of the comfort of their home.								
Québec Programme de Conversion à l'électricité d'Hydro-Québec	Buildings	CO_2	Reduce GHG emissions in the building sector	Économic	Québec	Implemented	2017	NE[g]	NE[g]
Brief description	This program provides financial support to replace equipment that consumes one of the eligible fossil fuels (heavy and light oil and propane) with electrical equipment in commercial, institutional, or industrial buildings. Multi-unit residential buildings are also eligible.								
Nova Scotia Energy Efficiency Measures for Non-Electrically Heated Homes	Buildings	CO_2, CH_4, N_2O	Encourage energy efficiency	Voluntary agreement, economic	Nova Scotia	Implemented	2011	NE[g]	NE[g]

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Brief Description	Homeowners on a low income can qualify for no-charge home efficiency upgrades through Efficiency Nova Scotia's Low Income Homeowner Service. Since 45 per cent of the heat loss in a typical home occurs through the walls, floors and roof, a primary focus is on insulation and draft proofing. For those who qualify for the program, a certified energy advisor will conduct a home-energy assessment and energy efficient upgrades are provided at no cost to the homeowner. Program participants who heat with non-electrical heat sources save, on average, $900 per year.								
New Brunswick Efficiency Measures	Buildings	CO_2	Improve the energy efficiency of buildings	Voluntary agreement	New Brunswick	Implemented	2014	205 kt	NE[g]
Brief Description	These measures are to reduce GHG emissions through fuel switching to renewables and natural gas and improvements in appliance efficiencies.								
Prince Edward Island Residential Rebate Programs	Buildings	CO_2	Support residential energy efficiency	Fiscal	Prince Edward Island	Implemented	2008, 2009	NE[g]	NE[g]
Brief Description	Prince Edward Island (PEI) has implemented several programs to enhance efficiency in the residential and commercial building sector including Heat Pump Rebates, EE Equipment Rebates, HELP Program (Low-income weatherization Building Envelope Upgrades, Home Energy Audit Program and the PEI Multi Unit Residential Buildings grant program (2009).								
Prince Edward Island Building Code Act*	Buildings	CO_2	Reduce energy use and GHG emissions from the building sector	Regulatory	Prince Edward Island	Adopted	2018	NE[g]	NE[g]
Brief Description	In 2017, Prince Edward Island adopted the *National Building Code* (NBC) and the *National Energy Code for Buildings*. The NBC will be a requirement for all commercial buildings in 2018 and residential construction in 2020. Regulations are currently being developed and are anticipated to be in place in early 2018.								
Northwest Territories Building Efficiency Programs	Buildings	CO_2	Support energy and water efficient technologies	Fiscal	Northwest Territories	Implemented	2007	NE[g]	NE[g]
Brief Description	The Northwest Territories has put in place several building efficiency programs including: the Energy Efficiency Incentive Program (2007) that provides rebates for energy efficient appliances, residential retrofits, and new homes ranging from $50 to $4500; the Alternative Technologies Program (2007) to support Aboriginal and community governments, non-for-profit organizations, commercial businesses, and residents to convert to renewable and clean energies; the Capital Asset Retrofit Fund (2008) to improve building efficiency through energy audits, building surveys and energy benchmarking; and the Commercial Energy Conservation and Efficiency Program (2011) that enables eligible small businesses to receive free energy audits and 25% of the cost of retrofit expenses up to a maximum of $10,000.								
Yukon Residential Energy Incentive Program	Buildings	CO_2, CH_4, N_2O	Reduce diesel consumption for electricity and heat generation	Economic	Yukon	Implemented	2015	NE[g]	NE[g]

National Communication Table 1: Summary of Policies and Measures by Sector (continued)

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Brief Description	The Government of Yukon's new Residential Energy Incentive Program encourages homeowners, homebuilders and general contractors to design, construct, and retrofit homes to a high standard in energy efficiency. Between January and July 2015, the program saw 34 new homes built to EnerGuide 85 or better. Estimated annual energy savings are 176,800 kWh with an annual cost savings of $30,600.								
Yukon Commercial Energy Incentive Program	Buildings	CO_2, CH_4, N_2O	Reduce diesel consumption for electricity and heat generation	Economic	Yukon	Implemented	2015	NE[9]	NE[9]
Brief Description	The Government of Yukon's Commercial Energy Incentive Program aims to improve energy use in multi-family dwellings and commercial buildings. Launched May 1, 2015, the program helps building owners retrofit their buildings to improve energy performance and reduce energy consumption, costs and emissions. It also encourages owners to upgrade to energy-efficient and long-lasting LED lighting systems. In its first summer, the program led to upgrades to LED lighting in 10 commercial buildings and should result in future annual energy savings estimated at 1,188,000 kWh and annual cost savings estimated at $142,500.								
HEAVY INDUSTRY									
Energy Efficiency in Industry**	Heavy Industry	CO_2	Improve industrial energy efficiency in Canada	Fiscal, voluntary agreement, information, education	Natural Resources Canada	Adopted	2016	1,100 kt	6,700 kt
Brief description	This program accelerates the adoption of recognized energy management systems, such as ENERGY STAR for Industry, ISO 50001 and Superior Energy Performance to improve industrial energy efficiency.								
British Columbia Cement Low Carbon Fuel Program*	Heavy Industry	CO_2, CH_4, N_2O	Reduce industrial GHG emissions	Economic	British Columbia	Implemented	2016	NE[9]	NE[9]
Brief Description	Over the five year life of the program, British Columbia will offer up to $27 million in conditional incentives to encourage cement producers to use a higher percentage of renewables in their fuel mix, to secure long term renewable fuel supply contracts, and to meet or beat new emissions intensity benchmarks.								
Saskatchewan Management and Reduction of Greenhouse Gases Regulation	Heavy Industry	CO_2	Reduce GHG emissions from large final emitters	Regulatory	Saskatchewan	Planned	TBD	NE[9]	NE[9]
Brief Description	Released in December 2017, Saskatchewan's climate change plan, entitled Prairie Resilience: A Made-In-Saskatchewan Climate Change Strategy, indicates the province will implement sector-specific output-based performance standards on large industrial facilities emitting more than 25,000 tonnes of CO_2 eq. per year. Flexible compliance options including emissions intensity reduction investments, purchasing offsets, and 'best performance credits' from facilities that have exceeded their required emissions reductions.								

National Communication Table 1: Summary of Policies and Measures by Sector (continued)

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Ontario Regulatory Changes for 'Reducing Coal Use in Energy-Intensive Industries'	Heavy Industry	CO_2	Reduce GHG emissions, and coal and petroleum coke use	Regulatory	Ontario	Implemented	2015	NE[d]	NE[d]
Brief Description	Regulatory changes have been developed for major-emitting industrial sectors (including cement, lime and iron and steel manufacturers) that would help facilities use alternative, less carbon-intensive fuels (such as biomass and waste materials) in place of coal and petroleum coke, and stay competitive with other jurisdictions that similarly allow the use of alternative fuel.								
Québec Manufacturing Sector Support Program	Heavy Industry	CO_2	To reduce GHG emissions	Economic	Québec	Implemented	2008	43 kt	NE[g]
Brief Description	This $1-billion program, which was in effect from June 2009 to March 2012, funded environmentally beneficial capital projects carried out by Canadian pulp and paper companies. Although the program was not designed specifically as a climate change mitigation mechanism, by funding projects that resulted in improved energy efficiency and the adoption of new fuels and increased renewable electricity production capacity, it was a catalyst for direct and indirect GHG emissions reductions.								
Newfoundland and Labrador GHG Management Act	Heavy Industry	CO_2, CH_4, N_2O	To reduce GHG emissions	Regulatory	Newfoundland and Labrador	Implemented	2017	NE[g]	NE[g]
Brief Description	The Act targets large industrial emitters in the Province with new emission reporting requirements. Facilities that emit 15,000 tonnes of CO_2 equivalent or more of greenhouse gases in any year must report their emissions to the provincial government in accordance with the methodology provided for in regulations. Reduction targets are being developed to reduce emissions.								
WASTE AND OTHER									
British Columbia Landfill Gas Management Regulation*	Waste and other	CH_4	Increase methane capture rate at landfills	Regulatory	British Columbia	Implemented	2009	811 kt	NE[g]
Brief Description	Under the regulation, regulated landfill sites (landfills that have over 100,000 tonnes of waste in place or receive more than 10,000 tonnes of municipal solid waste in any year after 2008) are required to conduct landfill gas assessments. If the assessment conducted in accordance with the regulation estimates a landfill will generate more than 1000 tonnes of methane in a calendar year, then they must install and operate a landfill gas collection and destruction system. The initial series of landfill gas assessments took place in 2011 with the requirement of a performance standard of 75% capture being in place by 2016. A new series of landfill gas assessments took place in 2016 with the same requirement being required for 2021. Reduction estimates are based on modelling of likely impact of the regulatory approach, allowing for variances in the performance of the technologic solutions applied to meet the standard.								

National Communication Table 1: Summary of Policies and Measures by Sector (continued)

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British Columbia Waste to Resource	Waste and other	CH_4	Decrease waste reaching landfills	Programs	British Columbia	Planned	2017	360 kt	NE[g]
Brief Description	This program will divert 90% of organic waste from landfills and will also decrease food waste by 30%.								
Manitoba Prescribed Landfills Methane Gas Capture Regulation	Waste and other	CH_4	Reduce methane emissions from landfills	Regulatory	Manitoba	Implemented	2009	195 kt	NE[g]
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 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 Waste and Agriculture-Related Actions	Waste and Agriculture	CO_2, CH_4, N_2O, PFCs, HFCs, SF_6, NF_3	Reduce GHG emissions from the waste and agriculture sectors	Regulatory Fiscal	Ontario	Implemented and under development	2008 2017	1,800 kt	NE[g]
Brief Description	Emission reductions for Ontario's waste and agriculture sectors are combined. Combined estimated mitigation impact of more than 1.8 Mt applies to initiatives related primarily to: Landfill Gas Capture and Control Regulations, Waste Free Ontario and other policies and programs in the waste and agricultural sectors. For example in 2008, Ontario introduced regulations requiring all landfills larger than 1.5 million cubic metres to install landfill gas collection and flaring or electricity generating systems. Ontario will also work with stakeholders to develop and implement an Agricultural Soil Health and Conservation Strategy that will maximize long-term carbon storage in soils while protecting their long-term productivity. Ontario plans to implement the Waste-Free Ontario: Building the Circular Economy strategy, which calls for zero waste in the province and zero greenhouse gas pollution from the waste sector. The draft strategy was released in November 2015, and once finalized it will be implemented over five years. The *Waste-Free Ontario Act* will help recover resources and divert more waste from landfills while supporting the province's efforts to tackle climate change.								
Québec Residual Materials Management Policy 2011–2015	Waste and other	CH_4	Reduce emissions from the waste sector	Regulatory, economic	Québec	Implemented	2011	NE[g]	NE[g]
Brief Description	The PQGMR (Québec's policy on residual waste management) is aimed at creating a waste-free society that maximizes value added through sound management of Québec's residual waste, and the policy's underlying objective is to ensure that only residual waste disposed of in Québec is final waste. To help achieve this objective, the policy sets out the implementation of measures for addressing three major residual waste management issues: stop wasting resources; help achieve the objectives of Québec's action plan on climate change and energy strategy; and empower all those concerned by residual waste management. The intermediary quantitative objectives of the first action plan are to, by the end of 2015: reduce the amount of residual waste disposed of to 700 kilograms/resident, which equals a reduction of 110 kilograms/resident compared to 2008; recycle 70% of residual paper, cardboard, plastic, glass and metal; recycle 60% of organic putrescible residual waste; recycle or promote 80% of concrete, brick and asphalt residue; and separate at the source or forward to a sorting centre 70% of the construction, renovation and demolition residue in the construction sector. Among the key PQGMR measures, the Government of Québec announced its intention to ban Québec materials from landfills.								

National Communication Table 1: Summary of Policies and Measures by Sector (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)	Estimate of Mitigation Impact in 2030 (kt CO_2 eq)
Québec Royalties (Regular and Extra) for Residual Material Disposal	Waste and other	CH_4	emissions in the waste sector	Regulatory	Québec	Implemented	2006	NE[g]	NE[g]
Brief Description	Royalties on residual material disposal were implemneted in 2006 and 2010 to reduce the quantities of eliminated residual material and also to increase the lifespan of disposal sites The royalties also fund the preparation, implementation and revision of residual material management plans as well as the measures arising from the Québec Policy on Residual Waste Management (Politique québécoise de gestion des matières résiduelles) and the Biomethanization and compost treatment program for organic material (Programme de traitement des matières organiques par biométhanisation et compostage).								
Québec Biomethanization Program	Waste and other	CH_4, CO_2	Reduce emissions in the waste sector	Economic	Québec	Implemented	2009	100 kt	NE[g]
Brief Description	This program provides financial support to municipalities and the private sector for the development of facilities to process organic materials. The program aims to reduce the amount of organic material for disposal and thus reducing GHG emissions.								
Québec Program to Support Composting in Small Municipalities	Waste and other	CH_4	Reduce emissions in the waste sector	Economic	Québec	Implemented	2014	NE[g]	NE[g]
Brief Description	The Program allows small municipalities and Aboriginal communities to obtain financial support for the implementation of composters, individual or shared, on their territory. The program aims to reduce the amount of organic waste sent to landfill and the associated GHG emissions.								
Québec Regulation Respecting the Landfilling and Incineration of Residual Materials*	Waste and other	CH_4	Réduire les émissions du secteur matières résiduelles	Regulatory	Québec	Implemented	2017	NE[g]	NE[g]
Brief Description	In 2005, the Government of Québec passed a major regulation seeking to minimize the impact of biogases coming from sanitary landfill sites. The Regulation respecting the landfilling and incineration of residual materials requires the largest technical landfill sites (i.e. those that landfill over 50,000 tonnes of residual materials per year) to capture the biogases and ideally make use of them or even eliminate them.								
Nova Scotia Solid Waste Resources Management Regulations*	Waste and other	CH_4	Increase the rate of waste diversion from landfills in Nova Scotia	Regulatory	Nova Scotia	Implemented	1996	NE[g]	NE[g]

National Communication Table 1: Summary of Policies and Measures by Sector (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)	Estimate of Mitigation Impact in 2030 (kt CO_2 eq)
Brief Description	Implemented in 1996, this regulation resulted in Nova Scotia having the highest waste diversion rate in Canada, and includes a ban on organics entering landfills in NS. Currently 55% of Nova Scotia organic waste is diverted from all landfills into aerobic processing, converting the potential methane from these organics to CO_2 emissions (25 times lower global warming potential).								
Prince Edward Island Waste Watch	Waste and other	CH_4	Reduce methane generation from landfill	Program	Prince Edward Island	Adopted	2002	NE[g]	NE[g]
Brief Description	Prince Edward Island is a national leader in sustainable waste management practices through its innovative Waste Watch program. It offers a curbside three source separation system (waste, compost, and recyclables) to all residents. The Waste Watch program was launched province-wide in 2002 by the Island Waste Management Corporation, a provincial crown corporation. The program successfully diverts as much as 65% of waste produced by Islanders from disposal in landfill.								
New Brunswick Landfill Gas Management	Waste and other	CH_4	Increase methane capture rate at landfills	Voluntary agreement	New Brunswick	Adopted	2008	49 kt	NE[g]
Brief Description	Six municipal solid waste landfills have or will install approved landfill gas capture systems. This 2014-2020 voluntary agreement is implemented by New Brunswick and the Landfill Commissions.								
AGRICULTURE									
Growing Forward 2 FPT Cost-Shared Programs	Agriculture	CO_2, CH_4, N_2O	Reduce GHG emissions from the agricultural sector	Economic, education	Federal, Provincial and Territorial Governments	Implemented	2013	NE[g]	NE[g]
Brief Description	Growing Forward 2 (GF2) is a $3 billion investment by federal, provincial and territorial governments over five years (2013–2018) for strategic initiatives in priority areas including to advance environmentally sustainable agriculture in Canada. Many of these initiatives translate into multiple environmental outcomes, including some related to climate change mitigation. Environmental Farm Plan and Environmental Stewardship Incentive Programs support on-farm actions. Examples of supported beneficial management practices with associated climate change mitigation benefits include: improved manure storage, biodigesters, energy use efficiency, cover crops, precision nutrient application, equipment for reduced tillage seeding, and enhanced irrigation efficiency. In July 2017, federal-provincial-territorial Ministers of Agriculture reached agreement on the key elements of the Canadian Agricultural Partnership, a new five-year (2018–2023), $3 billion agricultural policy framework to replace GF2 in 2018.								
Growing Forward 2 Federal-Only Program: AgriInnovation	Agriculture	CO_2, CH_4, N_2O	Support the reduction of GHG emissions from the agricultural sector	Research	Agriculture and Agri-Food Canada	Implemented	2013	NE[g]	NE[g]
Brief Description	The AgriInnovation Program provides $698 million for industry-led research to accelerate the pace of innovation and enhance economic growth, productivity, competitiveness, adaptability and sustainability of the Canadian agriculture sector. Projects funded under the AgriInnovation Program can contribute to decreasing the emission intensity of agricultural production. For example: The Canadian 4R Research Network, a group of nine leading Canadian researchers, is collecting agronomic data to demonstrate the benefits of 4R Nutrient Stewardship, including nitrous oxide emission reductions. The findings are a result of Fertilizer Canada's project "A Canadian Research Network to Improve 4R Nutrient Stewardship for Environmental Health and Crop Production" funded by Agriculture and Agri-Food Canada's AgriInnovation Program with matching funds from Fertilizer Canada.								

National Communication Table 1: Summary of Policies and Measures by Sector (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)	Estimate of Mitigation Impact in 2030 (kt CO_2 eq)
Agricultural Greenhouse Gases Program	Agriculture	CO_2, CH_4, N_2O	Support research on GHG mitigation and make new mitigation technologies available to farmers	Research	Agriculture and Agri-Food Canada	Implemented	2010	NE[g]	NE[g]
Brief Description	The Agricultural Greenhouse Gases Program supports innovative research projects that develop technologies, practices and processes that can be adopted by farmers to mitigate GHG emissions. A first phase of the $27-million federally funded program ran from 2010–2015 and represented Canada's initial contribution to the Global Research Alliance on Agricultural Greenhouse Gases. In March 2016, the Government announced an additional $27 million for a second phase of the program (2016–2021), extending Canada's commitment to support the objectives of the Global Research Alliance on Agricultural Greenhouse Gases.								
British Columbia Nutrient Management Program	Agriculture	CO_2, CH_4, N_2O	Reduce GHG emissions from the agricultural sector	Education, Research, pilot project	British Columbia	Implemented	2013	100 kt	NE[g]
Brief Description	The Nutrient Management Program is being developed to reduce fertilizer use and GHG emissions—accounting for a nearly 100,000 tonne reduction of annual GHG emissions. This program will include: expanding trials to develop and demonstrate nutrient management best practices to the agriculture industry; increasing funding to the sector to implement beneficial management practices that promote better nutrient management and further reductions in GHG emissions; and improving monitoring of nutrient management benefits and developing longer term performance indicators to measure their success.								
Québec Prime Green Program	Agriculture	CO_2, CH_4, N_2O	Reduction of GHG emissions in the agriculture sector	Economic	Québec	Implemented	2014	8.3 kt	NE[g]
Brief Description	Financial assistance dedicated to liquid-management livestock facilities, regardless of the type of animal production for a compliant manure storage facility with no manure treatment (partial or full) system. The assistance provided applies to the purchase and installation of a sealed roof and a system for treating the biogas emitted by stored manure.								
Québec Fertilizer Testing Support Program	Agriculture	CO_2, CH_4, N_2O	Reduction of GHG emissions in the agriculture sector	Economic	Québec	Implemented	2013	NE[g]	NE[g]
Brief Description	This initiative aims to support crop producers in the implementation of crop fertilization trial projects that will adjust fertilizer reference grids in line with today's realities.								

National Communication Table 1: Summary of Policies and Measures by Sector (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)	Estimate of Mitigation Impact in 2030 (kt CO_2 eq)
LULUCF									
Forest Bioeconomy Framework for Canada	LULUCF	CO_2	To reduce GHG emissions and advance innovation in the forest sector	Voluntary agreement	Federal, provincial and territorial governments	Implemented	2017	NE[k]	NE[k]
Brief description	In September 2017, the federal, provincial and territorial governments, working together through the Canadian Council of Forests Ministers, launched a Forest Bioeconomy Framework for Canada. This framework will position Canada to become a global leader in the use of forest biomass for advanced bio-products and innovative solutions. The Framework presents an integrated approach to meeting climate change mitigation commitments and advancing innovation in the forest sector for the long term. It affirms federal, provincial and territorial government commitments to work in partnership with forest communities and industry stakeholders, including continually engaging Indigenous peoples.								
British Columbia Forest Carbon Initiative	LULUCF	CO_2, CH_4, N_2O	Enhance removals through forest carbon	Economic	British Columbia	Implemented	2017	NE[g]	NE[g]
Brief Description	The $150 million program aims to rehabilitate under-productive forests, recover more wood fibre, and avoid emissions from burning slash.								
British Columbia Great Bear Rainforest Forest Management Act	LULUCF	CO_2	Increase carbon stocks through sustainable forest management and conservation	Regulatory	British Columbia	Planned	2017	2,000 kt	NE[g]
Brief Description	The Great Bear Rainforest Forest Management Act supports a strict new ecosystem-based management regime and protects 85 per cent of the 6.4-million-hectare area.								
Alberta Forestry and Agriculture Offset Protocols	LULUCF	CO_2, CH_4, N_2O	Enhance removals and reduce emissions associated with forestry	Economic	Alberta	Under development	2018	NE[g]	NE[g]
Brief Description	Alberta is exploring options for forestry and agriculture offsets as an option for large industrial emitters to comply with their reduction obligation under the Specified Gas Emitters Regulation or as part of internationally transferrable mitigation options (ITMOs). Alberta is planning to approve agriculture and forestry protocols in 2018.								
Saskatchewan SaskPower Shand Greenhouse Seedlings	LULUCF	CO_2	Mitigate GHG emissions from SaskPower's use of fossil fuels to produce electricity	Voluntary agreement	Saskatchewan	Implemented	1992	111 kt	NE[g]

National Communication Table 1: Summary of Policies and Measures by Sector (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)	Estimate of Mitigation Impact in 2030 (kt CO_2 eq)
Brief Description	The SaskPower Shand Greenhouse grows and distributes tree, shrub and native plant seedlings utilizing waste heat from the adjacent coal-fired generating station. Typical annual production is 500, 000 seedlings. Each production cycle is estimated to contribute 3.3 to 5.6 kt of CO_2 eq sequestration per year of growth. It is estimated that 1348 kt CO_2 eq will have been sequestered due to seedling production and associated plantings in the period from 1992 to 2020 and that 2669 kt CO_2 eq will have been sequestered in the period from 1992 to 2030.								
Ontario 50 Million Tree Program	LULUCF	CO_2	Sequester carbon and improve adaptive capacity of the settled landscape	Fiscal	Ontario	Implemented	2007	NE[g]	NE[g]
Brief Description	Ontario will continue to support tree-planting programs, including its commitment to plant 50 million trees across the province by 2025. The number of trees to be planted within the boundaries of urban municipalities will be doubled from one million to two million, with funding for irrigation where appropriate.								
Québec Wood Innovation Workplan	LULUCF	CO_2	Support the transformation and modernization of the forest products industry	Economic	Québec	Implemented	2016	NE[g]	NE[g]
Brief description	Québec's Wood Innovation Work Plan supports the transformation and modernization of the forest products industry, with over $86 million in government investments by 2022. Work plan consists of nearly 40 measures to support the transformation and modernization of the forest products industry. Québec also began a Wood Innovation Program in 2015 to encourage applied research, demonstration and implementation of innovative products, processes and systems in the forest products industry. By July 2017, the Program has already funded 24 forest innovation projects totalling $11.3 million, particularly in the bioenergy and bioproducts sectors.								

*Denotes a policy that was explicitly modeled in the 'with measures' projection in Chapter 5

**Denotes a policy that was explicitly modeled in the 'with additional measures' projection in Chapter 5

[a] While the funds have been allocated, the exact projects that will be funded through this program have not yet been selected. Therefore, at this time it is premature to estimate the mitigation impact.

[b] The policy will come into effect post-2020, therefore it will not have a mitigation impact in 2020.

[c] The measure contributes to the Government of Canada's efforts to boost growth of clean technology in Canada with the aim of fostering the growth of Canadian technologies and companies. Any mitigation impacts cannot be directly attributed to the measure, although the measure may have an indirect impact on GHGs. As such, future GHG reductions estimates associated with the programs are not available.

[d] The details of the policy are still under development. Therefore, at this time it is premature to estimate the mitigation impact.

[e] Impacts in 2020 and/or 2030 are expected to be minimal.

[f] The program is expected to deliver direct reductions in the short term, with indirect, longer term impacts expected.

[g] The department, province or territory did not provide an estimate at the time of submission.

[h] At the time of policy implementation the estimates were conducted based on projections going to 2020; estimates for 2030 were not prepared.

[i] The measure is not expected to be in place in 2020/2030.

[j] Emissions reduction estimates for this measure are aggregated into the estimates for another overarching measure.

[k] The plan is expected to generate indirect, rather than direct, emissions.

[l] The policy/program is an enabling measure that will not directly reduce emissions but will contribute to unlocking larger emissions reductions.

[m] Emission reductions are expected to occur outside the jurisdiction.

NE=Not estimated
NA=Not applicable
TBD=To be determined

References

[1] Minister of Environment and Climate Change Mandate Letter, Office of the Prime Minister, http://pm.gc.ca/eng/minister-environment-and-climate-change-mandate-letter, September, 19, 2017.

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[3] Canada's 2016 Reference Case report can be accessed at Environment and Climate Change Canada's website: https://www.canada.ca/en/environment-climate-change/services/climate-change/publications/2016-greenhouse-gas-emissions-case.html.

[4] Natural Resources Canada.2016. Energy Fact Book 2016-2017 [Report]. Available at: https://www.nrcan.gc.ca/sites/www.nrcan.gc.ca/files/energy/pdf/EnergyFactBook_2016_17_En.pdf.

[5] Canada's Mid-Century Long-Term Low-GHG Development Strategy can be accessed at the UNFCCC website: http://unfccc.int/files/focus/long-term_strategies/application/pdf/can_low-ghg_strategy_red.pdf.

CHAPTER 5

Projections and the Total Effect of Policies and Measures

This chapter provides projections of greenhouse gas (GHG) emissions through 2030, aligned to Canada's historical emissions from 1990 to 2015 as presented in Canada's 2017 *National Inventory Report* (NIR) and in this report in Chapter 3: Canada's Greenhouse Gas Inventory. The projections are presented by gas and by sector as well as selected subsectors. This chapter presents detailed projections according to Canada's economic sector categories, aligned with the presentation of policies and measures in Chapter 4: Policies and Measures. A short presentation of projected emissions by Intergovernmental Panel on Climate Change (IPCC) sector categories is also provided. A description of the relationship between Canada's economic sectors and IPCC sectors can be found in Chapter 3. Canada's GHG inventory is available both online on the Government of Canada website, as well as on the Government of Canada Open Data Portal website.

Under the Paris Agreement, Canada has formally committed to achieving an economy-wide target to reduce GHG emissions by 30% below 2005 levels by 2030, and under the Copenhagen Accord Canada committed to reducing GHG emissions by 17% below 2005 levels by 2020. The Government of Canada, in close collaboration with provinces and territories, has established the Pan-Canadian Framework on Clean Growth and Climate Change (Pan-Canadian Framework). As described in further detail in Chapter 4, this is a federal, provincial and territorial plan to grow the Canadian economy, reduce GHG emissions and help Canadian communities adapt to a changing climate.

Projections presented in this report represent both a "with measures" scenario and a "with additional measures" scenario.[a]

[a] The policies and measures modeled in each of these scenarios are listed in Table 5A.9 in Annex 1 of this chapter, and several 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–as summarized in Table 1, Chapter 4: Policies and Measures of the National Communication–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 different modeling approaches.

The "with measures" scenario, outlined in Section 5.3, includes actions taken by governments, consumers and businesses put in place over the last two years, up to September 2017 (see Section 5.3.2 for more details). This scenario does not account for all measures of the Pan-Canadian Framework as a number of them are still under development.

Taking into consideration all climate change policies and measures that have been announced in Canada and for which enough information is available, a "with additional measures scenario" has also been developed. As described in Section 5.5, the "with additional measures" scenario accounts for those additional policies and measures that are under development but have not yet been fully implemented, some of which were announced as part of the Pan-Canadian Framework (e.g., pan-Canadian carbon pricing). This scenario is provided for the purposes of presenting progress to Canada's 2030 target and to better demonstrate the expected impact of the Pan-Canadian Framework.

Under this scenario, emissions in 2030 would be 583 Mt, a 232 Mt decline from projections included in the "with measures" scenario in the *2nd Biennial Report* (BR2). This decline, equivalent to approximately a third of Canada's emissions in 2015, is widespread across all economic sectors, reflecting the breadth and the depth of the Pan-Canadian Framework.

Figure 5.1 shows the "with measures" and "with additional measures" projections, as well as the projections presented in Canada's BR2. Going forward, it is expected that further progress will take place, especially as current estimates do not include the full reductions from investment in public transit, clean technology and innovation. Potential increases in stored carbon (carbon sequestration) in forests, soils and wetlands will also contribute to reductions which, for a country such as Canada, could also play an important role in achieving the 2030 target.

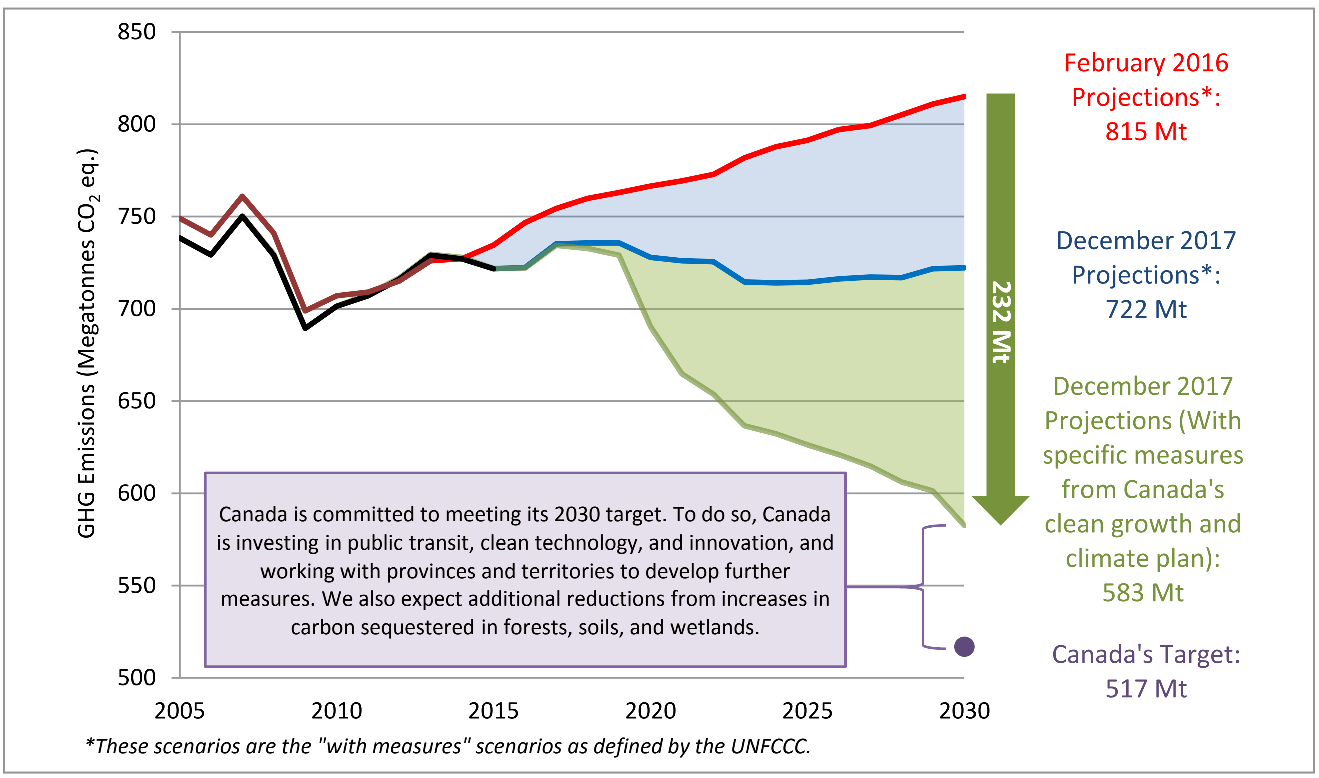

Figure 5.1: Scenarios of Canadian Emissions to 2020 and 2030 (Mt CO_2 eq) (Excluding Land Use, Land-Use Change and Forestry)

Moreover, these projected emission reductions do not account for additional mitigation measures that could be implemented by the provinces and territories between now and 2030. Emissions reductions from additional future actions will be assessed as new measures are implemented.

5.1 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.

In line with United Nations Framework Convention on Climate Change (UNFCCC) reporting guidelines, Canada has chosen to use economic sectors to present policies and measures as well as projections in our *7th National Communication* and *3rd Biennial Report*. Examining the historical path of Canadian GHG emissions by economic sector allows for a better understanding of the connection between economic activities and emissions for the purposes of analyzing trends and for policy analysis. This approach is also more closely aligned with that taken in the Pan-Canadian Framework. This approach to categorisation was used in Canada's previous BR, in Canada's *6th National Communication* and in *Canada's GHG Emissions Reference Case* (December 2016), a publication which provided projections of GHG emissions to the year 2030. It is also presented in Canada's NIR along with GHG emissions categorised under the IPCC reporting requirements by activity sectors.

Figure 5.2 shows the distribution of 2015 emissions on an IPCC activity basis versus an economic sector basis. Some adjustments that are made to the IPCC categories to calculate 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 heavy industry[b] 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 heavy industry and oil and gas sectors). In addition, emissions from landfills are included in the waste and others sector. For a more detailed description of the reconciliation of between economic and IPCC sector categories, please see Chapter 3: Canada's Greenhouse Gas Inventory.

[b] Heavy industry subsectors include mining activities, smelting and refining, and the production and processing of industrial goods such as chemicals, fertilizers, pulp and paper, aluminum, iron and steel and cement.

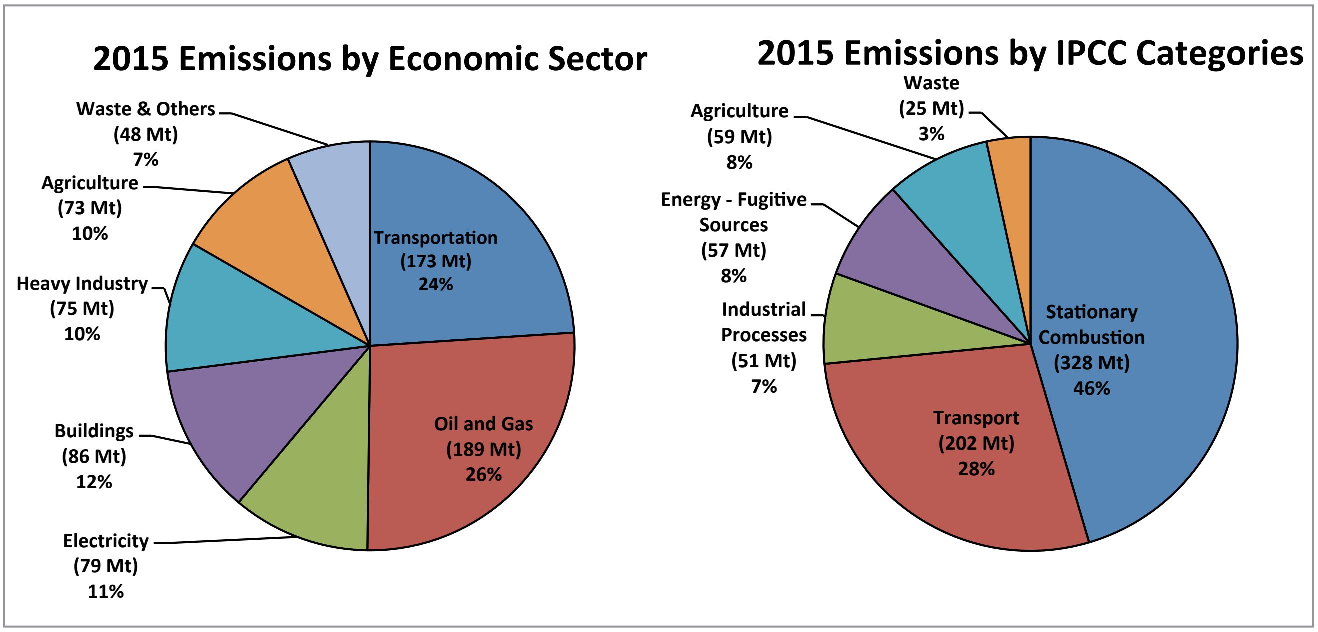

Figure 5.2: Total Canadian 2015 GHG emissions (722 Mt CO_2 eq)–Methods of Categorisation

5.2 Historical Emissions Trends

Although historical emissions have been described in detail in Chapter 3: Canada's GHG Inventory, a brief summary of historical trends by economic sector is provided here.[c] Changes to historical data since Canada's previous National Communication are discussed in Chapter 3: Canada's Greenhouse Gas Inventory.

As shown in Table 5.1, from 1990 to 2005, total emissions grew from 611 Mt to 738 Mt. The majority of this increase occurred in the oil and gas, transportation and electricity[d] sectors. As production increased and Canada's oil sands industry developed, emissions in the oil and gas sector increased 50 Mt. In the transportation sector, population and economic growth were primary drivers of a 41 Mt increase in emissions over this period. The electricity sector contributed to a further 23 Mt of the increase in total emissions as more fossil fueled power generation came online to meet rising demand.

Canadian GHG emissions fell by 16 Mt from 2005 to 2015, driven mostly by reductions in the electricity and heavy industry sectors, while emissions growth came mostly from the oil and gas and transportation 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. 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 link 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

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[c] Canada's NIR 2017 provides historical emissions by IPCC sector and by economic sector.

[d] For purposes of modeling emissions projections, ECCC 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).

emissions generation. In Canada, emissions intensity has declined at an average annual rate of 1.6% between 1990 and 2015, or a cumulative 33.4% over the entire period (Figure 5.3).

Table 5.1: GHG Emissions by Economic Sector (kt CO_2 eq) from 1990 to 2015

SECTOR	HISTORICAL					
	1990	1995	2000	2005	2010	2015
Oil and Gas	108,000	133,000	159,000	158,000	160,000	189,000
Electricity	94,000	98,000	127,000	117,000	96,000	79,000
Transportation	122,000	127,000	147,000	163,000	171,000	173,000
Heavy Industry	97,000	99,000	93,000	86,000	73,000	75,000
Buildings	73,000	79,000	85,000	85,000	81,000	86,000
Agriculture	60,000	70,000	72,000	74,000	70,000	73,000
Waste & Others	57,000	56,000	55,000	54,000	50,000	48,000
Total	**611,000**	**661,000**	**738,000**	**738,000**	**701,000**	**722,000**

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

5.3 Greenhouse Gas Emissions Projections by Economic Sector and Gas under the "With Measures" Scenario

5.3.1 National Emissions Projections

Environment and Climate Change Canada (ECCC) updates Canada's GHG emissions annually, reflecting the latest historical data and up-to-date future economic and energy market assumptions. As such, projections fluctuate over time as a result of changes in these key drivers assumptions.

In this chapter, emissions are projected to 2030 with comparisons made to 2005, Canada's base year for its GHG emissions reduction targets.[e] Projections are based on policies and measures in place as of September 2017 and assume no further government action. Where applicable, historical emissions for 2010 and 2015 (the most recent year for which historical emissions are available) are also shown. Projections are based on the Energy, Environment and Economy Model for Canada (E3MC), which is internationally recognized and incorporates external data from consistent sources (for more information on E3MC, please see Annex 4 of this chapter).

ECCC consults extensively with other government officials, selected experts and provinces and territories on emissions projections. Forecast assumptions such as population growth, industry growth rates, electricity supply plans, and major projects are shared with provinces and territories prior to the development of the projections in order to insure their accuracy. Current modelled provincial policies are clarified and updated based on consultation feedback, and detailed information is obtained on any new provincial/territorial policies so that they can be modelled and incorporated into the forecast. Preliminary projections are prepared midway through their development and shared for consultation to identify any errors or concerns. Adjustments are made as additional information and clarification is being provided about

[e] Under the 2009 Copenhagen Accord, Canada committed to reduce its emissions by 17% below 2005 levels by 2020, or 126 Mt. This target covers all sectors and GHGs.
In May 2015, Canada submitted its Intended Nationally Determined Contribution to the UNFCCC. The submission included an economy-wide target to reduce GHG emissions by 30% below 2005 levels by 2030, or 222 Mt. This submission was updated in 2017 following the release of the Pan-Canadian Framework on Clean Growth and Climate Change, Canada's plan to address climate change and grow the economy. As outlined in the Paris Agreement and accompanying decisions adopted in December 2015, Parties are invited to submit final targets as part of ratifying the new agreement and will be obligated to submit revised nationally determined contributions every five years.

economic assumptions, policies, electricity supply plans, etc. Provincial and territorial details of the final projections are then shared with each jurisdiction prior to publication.

5.3.2 Comparison of Current and Previous "With Measures" Emissions Projections

In 2030, the GHG emissions in the "with measures" scenario in Canada are projected at 722 Mt, 92 Mt below what was presented in Canada's BR2, a decline greater than 2015 emissions from Canada's entire building sector. This reflects the future impacts of a number of federal and provincial policies that were put in place over the last two years, such as:

- Alberta's Carbon levy, 2030 phase-out of coal-fired electricity, and 100 Mt cap on oil sand emissions;
- Domestic reductions from Ontario joining Québec and California in the Western Climate Initiative (WCI) cap-and-trade regime in 2017;
- Québec's regulation for new commercial, institutional and residential high-rise buildings;
- Federal measures to increase efficiency of residential and commercial equipment and appliances;
- Federal regulations to reduce releases of methane in the upstream oil and gas sector;
- Federal regulations phasing-out the use of hydrofluorocarbons;
- Federal GHG emissions standards for heavy-duty vehicles and trailers of model years 2021 to 2027;
- Increasing carbon tax in British Columbia to $50/t by 2022 and onwards; and
- Other provincial and federal policies. (A full list of policies and measures is provided in Annex 1 of this chapter.)

In addition to the new policies, the lower emissions projections for the "with measures" scenario are also driven by a lower GDP growth forecast and lower light oil, oil sands, and natural gas production estimates compared to the BR2. Changes to historical data since Canada's previous National Communication are discussed in Chapter 3: Canada's Greenhouse Gas Inventory.

Table 5.2: Revisions to Canada's "With Measures" GHG Emissions (Mt CO_2 eq) since Canada's 2nd Biennial Report

	2005	2010	2015	2020	2030
2nd Biennial Report	749	707	736	768	815
7th National Communication	738	701	722	728	722
Difference	**-11**	**-6**	**-14**	**-40**	**-92**

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

5.3.3 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 1.6% from 1990 to 2015. Emissions intensity is expected to continue to decrease through 2030 (Figure 5.3).

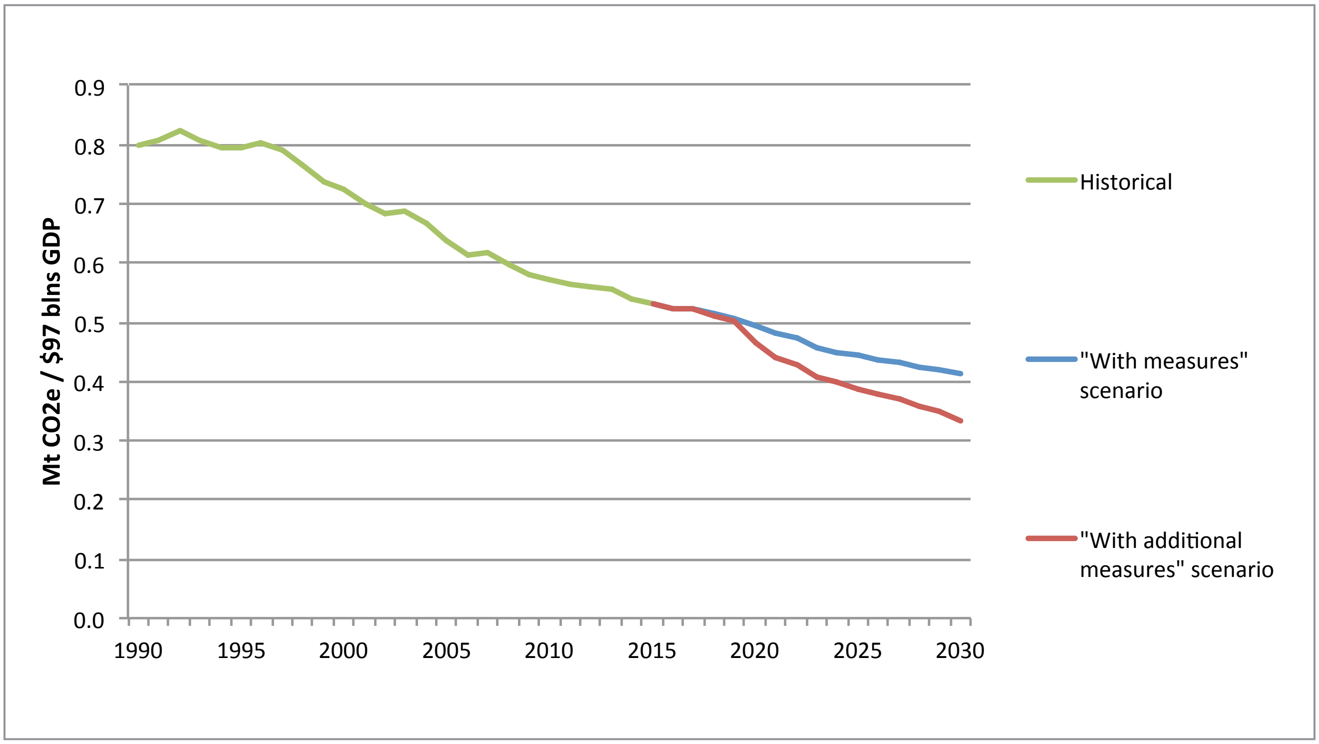

Figure 5.3: Canadian Emissions Intensity (1990 to 2030)

Decomposition of Projected Change in Canada's "With Measures" GHG Emissions Projection

The following explores how different factors contribute to trends in projected emissions through a decomposition analysis of Canada's projected GHG emissions under the "with measures" scenario (Figure 5.4).

- The **Activity Effect** measures the impact of economic growth (estimated to be 53% over the 2005–2030 period). On its own, this growth would have been expected to lead to 327 Mt of additional GHG emissions in 2030 (or 13 Mt per year).
- The **Carbon Intensity Effect** measures changes in the carbon emission coefficient of energy. The shift to cleaner fuels such as the replacement of coal-fired electricity with cleaner sources, as well as measures to reduce fugitive and process emissions, are projected to have a significant impact, reducing emissions by 111 Mt in 2030 (or 4.4 Mt per year).
- The **Energy Efficiency Effect** measures changes in energy efficiency at the subsector level. The projections indicate that the uptake of energy efficient technologies–induced by policies, consumer responses to energy prices, and stock turnover– reduces emissions by 232 Mt in 2030 (or 9.2 Mt per year).

The decomposition shows that over the period 2005–2030, there is a decoupling of economic growth on projected combustion emissions: upward pressure on GHG emission projections arising from GDP growth are slightly more than offset by the switch to cleaner and more efficient energy use.

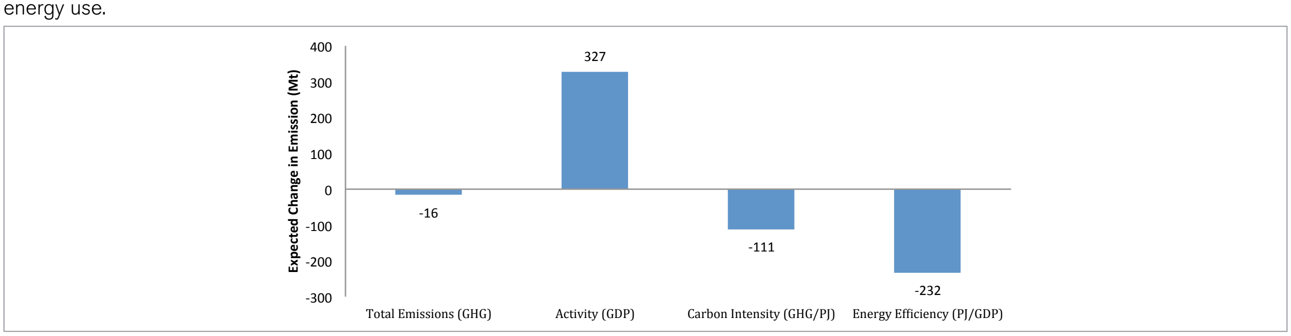

Figure 5.4: Decomposition of Emissions Growth 2005–2030 (excluding Land Use, Land-Use Change and Forestry)

5.3.4 Per Capita Emissions

Canadian per capital GHG emissions have been decreasing significantly since 2005 when they were 22.9 tonnes carbon dioxide equivalent (CO_2 eq) per person. In 2015, emissions per capita were 20.1 tonnes CO_2 eq per person, the lowest level recorded since records began in 1990.

Projections show per capita emissions to continue to decrease through 2030 and are expected to fall to 17.2 tonnes per person in 2030 (Table 5.3). This reflects a projected increase in Canada's population of 17% between 2015 and 2030, while emissions are projected to be at the same level in 2030 as in 2015.

Table 5.3: Canadian GHG Emissions Per Capita

PER CAPITA	2005	2010	2015	2020	2030
Tonnes CO_2 eq	22.9	20.6	20.1	19.2	17.2

5.3.5 Emissions by Gas

Total Canadian GHG emissions over the projection period are presented by gas in Table 5.4 and Table 5.5 in CO_2 eq and in their native gaseous forms respectively. Section 5.3.7 provides additional details by economic sector.

CO_2 emissions decreased by 1% between 2005 and 2015, and are projected to rise by about 3% between 2015 and 2030. On a CO_2 eq basis, CO_2 represented 78% of total Canadian GHG emissions in 2005. By 2030 this share is expected to increase slightly to 81%.

Between 2005 and 2015, CO_2 emissions increased in the agriculture, heavy industry, oil and gas, and transportation sectors. Emissions are projected to continue to increase in these sectors between 2015 and 2030, with the exception of transportation where emissions are projected to decrease. Agriculture CO_2 emissions increase mostly before 2015 and then decline slightly until 2030. In the case of heavy industry, emissions declined by 10% between 2005 and 2015, and are expected to increase between 2020 and 2030.

Total methane (CH_4) emissions have increased in Canada since 1990. Between 1990 and 2005, emissions increased by 21% due to increasing activity in the agriculture and oil and gas sectors. Between 2005 and 2015, this trend reversed, with emissions decreasing by 10%, mostly due to declines in emissions from the agriculture and waste and others sectors. Between 2015 and 2030, CH_4 emissions are projected to continue decreasing, reflecting a projected decrease of 41% in the oil and gas sector. Fugitive CH_4 emissions from conventional oil production are expected to decline as a result of proposed government regulations to reduce emissions in the oil and gas sector. The upstream oil and gas sector remains the largest industrial source of methane in Canada.

Nitrous oxide (N_2O) emissions, which decreased slightly between 1990 and 2005, also declined between 2005 and 2015 and are projected to remain constant between 2015 and 2030. N_2O emissions arise primarily from the agriculture sector.

Hydrofluorocarbons (HFCs) have been increasingly used in the last decade in refrigeration and air conditioning systems as an alternative to ozone damaging hydrochlorofluorocarbons (HCFCs). HCFCs are being phased out under the Montréal Protocol and an amendment to that agreement in 2016 added the phase down of the use and production of HFCs. As a result, emissions of HFCs are projected to peak in 2020 at 14.8 Mt of CO_2 eq before declining to 12.5 Mt of CO_2 eq in 2030.

Perfluorocarbons (PFCs), sulphur-hexafluoride (SF_6), and nitrogen trifluoride (NF_3) 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 *Fourth Assessment Report* of the IPCC and provides emissions totals excluding Land Use, Land-Use Change and Forestry (LULUCF) emissions.

Table 5.4: Total Canadian Emissions Projections by Gas in CO_2 eq, Excluding LULUCF Emissions (Mt CO_2 eq) from 2005 to 2030

	HISTORICAL			PROJECTED		CHANGE 2005 TO 2030
GAS	2005	2010	2015	2020	2030	
CO_2	574	554	568	579	584	11
CH_4	110	100	100	96	86	-24
N_2O	41	37	39	38	39	-2
HFC	5	8	11	15	12	7
PFC	4	2	1	<1	<1	-4
SF_6	1	<1	<1	<1	<1	-1
NF_3	<1	<1	<1	<1	<1	<1
Total	**738**	**701**	**722**	**728**	**722**	**-16**

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

Table 5.5: Total Canadian Emissions Projections by Gas, Excluding LULUCF Emissions (kilotonne (Kt)–natural form) from 1990 to 2030

	HISTORICAL						PROJECTED	
GAS	1990	1995	2000	2005	2010	2015	2020	2030
CO_2	463,000	496,000	570,000	574,000	554,000	568,000	579,000	584,000
CH_4	3,700	4,400	4,700	4,500	4,000	4,100	3,800	3,500
N_2O	140	150	130	140	130	130	130	130
HFC	1	0	2	4	5	8	10	9
PFC	1	1	1	1	<1	<1	<1	<1
SF_6	<1	<1	<1	<1	<1	<1	<1	<1
NF_3	<1	<1	<1	<1	<1	<1	<1	<1

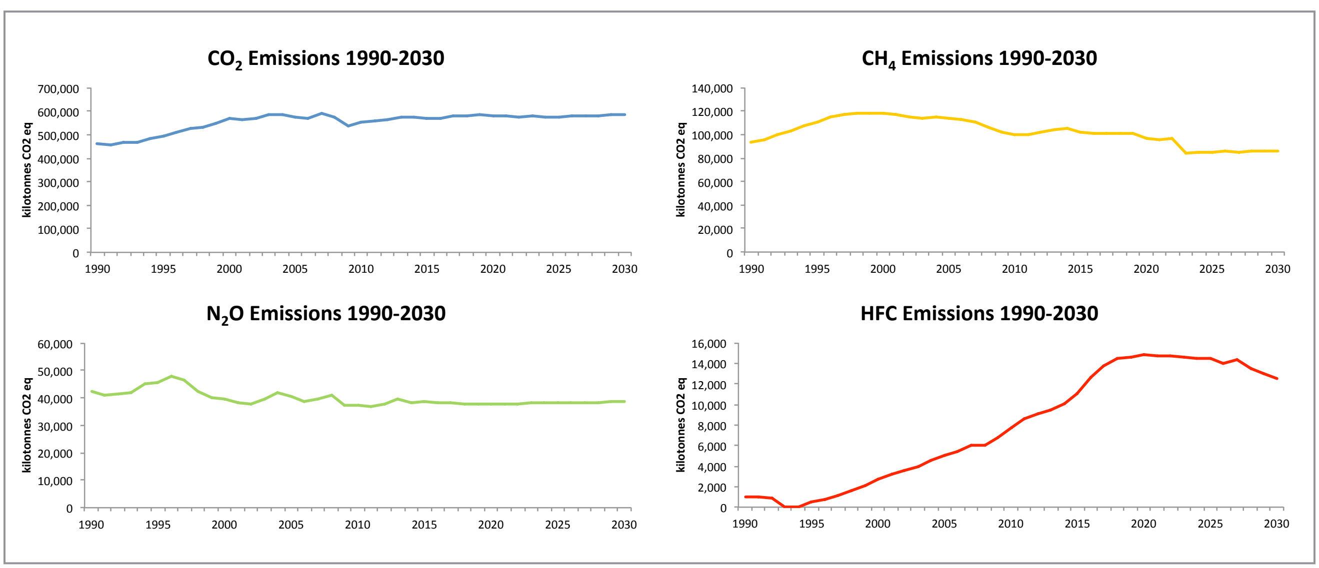

Figure 5.5: Total Canadian Emissions by Gas, 1990–2030: CO_2, CH_4, N_2O, HFC

5.3.6 Emissions Projections by Economic Sector

Table 5.6 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. For example, in the transportation sector, growing economic activity in Canada affects the number of freight trucks on the road, thus emissions from the freight transportation subsector are projected to rise. However, offsetting this trend are the Government of Canada's Light-duty vehicles (LDV) GHG emissions standards for the LDV model years 2011 to 2025 which are causing the average emissions intensity for all on-road passenger 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 5.6: GHG emissions by Economic Sector (Mt CO_2 eq) from 2005 to 2030

SECTOR	HISTORICAL			PROJECTED		CHANGE 2005 TO 2030
	2005	2010	2015	2020	2030	
Oil and Gas	158	160	189	197	215	57
Electricity	117	96	79	71	46	-70
Transportation	163	171	173	168	155	-8
Heavy Industry	86	73	75	83	97	11
Buildings	85	81	86	88	83	-2
Agriculture	74	70	73	71	72	-3
Waste & Others	54	50	48	50	53	-2
Total	**738**	**701**	**722**	**728**	**722**	**-16**

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

Table 5.7 provides a breakdown of projected trends in GHG emissions by IPCC sector.

Table 5.7: GHG emissions by IPCC Sector (Mt CO_2 eq) from 2005 to 2030

SECTOR	HISTORICAL			PROJECTED		CHANGE 2005 TO 2030
	2005	2010	2015	2020	2030	
Stationary Combustion and Fugitive Sources	400	372	385	388	382	-18
Transport	195	199	202	199	190	-5
Industrial Processes	54	48	51	57	64	10
Agriculture	61	56	59	57	58	-3
Waste	28	25	25	27	28	1
Total	**738**	**701**	**722**	**728**	**722**	**-16**

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

5.3.6.1 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 2015, the oil and gas sector produced the largest share of GHG emissions in Canada (26%). Emissions increased by 50 Mt CO_2 eq 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 increased as a result of growth in production due to higher oil prices and evolving technologies in oil sands operations, from 158 Mt in 2005 to 189 Mt in 2015—a

20% increase. Increased emissions from unconventional oil sands activity have been offset by the gradual depletion of conventional oil and natural gas resources in Canada and limited expansion of the refining sector. Government actions, such as recently published regulations on methane emissions in the upstream oil and gas sector, will also constrain increases in emissions over the projection period.

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

	2005	2010	2015	2020	2030	CHANGE 2005 TO 2030
Natural Gas Production and Processing	57	49	56	50	45	-12
Conventional Oil Production	30	27	31	26	23	-8
Light Oil Production	12	11	14	9	10	-1
Heavy Oil Production	17	14	15	15	11	-6
Frontier Oil Production	2	2	2	2	2	0
Oil Sands[f]	35	53	71	89	115	80
Bitumen In Situ	11	20	34	42	65	54
Bitumen Mining	10	14	18	25	26	17
Bitumen Upgrading	14	19	19	21	23	10
Oil and Natural Gas Transmission	12	7	10	9	9	-3
Petroleum Products	22	22	21	22	22	-1
Natural Gas Distribution	1	1	1	1	1	0
Total	**158**	**160**	**189**	**197**	**215**	**57**

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

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 represents approximately 85% of the oil and gas sector emissions in 2015 and this share is expected to increase to almost 90% by 2030 as oil sands extraction continues to grow.

Table 5.9: Upstream Oil and Natural Gas Production: Emissions and Drivers

	2005	2010	2015	2020	2030
Conventional Oil Production					
Emissions (Mt CO_2 eq)	30	27	31	26	23
Production (1,000 barrels/day)	1,360	1,227	1,264	1,207	1,400
Natural Gas Production and Processing					
Emissions (Mt CO_2 eq)	57	49	56	50	45
Production (1,000 barrels/day)	7,221	6,247	6,320	6,323	6,614
Oil Sands[g]					
Emissions (Mt CO_2 eq)	35	53	71	89	115
Production (1,000 barrels/day)	1,065	1,612	2,526	3,361	4,236

[f] Based on the Alberta Government's announcement, Alberta's 100 Mt cap on oil sands emissions excludes emissions from cogeneration of electricity and new upgrading. When taking these into account, total emissions from oil sands is 99 Mt in 2030 under the "with measures" scenario, below the 100 Mt cap.

[g] Based on the Alberta Government's announcement, Alberta's 100 Mt cap on oil sands emissions excludes emissions from cogeneration of electricity and new upgrading. When taking these into account, total emissions from oil sands is 99 Mt in 2030 under the "with measures" scenario, below the 100 Mt cap.

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 oil sands mining. In the historical period within the oil sands sector, the overall emissions intensity has been decreasing over time, with increasingly energy efficient *in situ* operations and flat energy intensity in oil sands mining operations.

In the forecast, several factors could lead to increasing emissions intensity in the oil sands subsector, such as declining reservoir quality, aging of existing facilities, and shifts from mining operations to more emissions-intensive *in situ* extraction processes. On the other hand, clean technology deployment could lead to significant emissions intensity reductions in the subsector. Considering the uncertainties associated with these counterbalancing trends in oil sands emissions intensities, the projections keep the emissions intensities of new oil sands productions at the level of existing technologies.

Emission projections in the oil and gas sector are driven by the National Energy Board's (NEB) projections of oil and natural gas prices as well as the NEB's corresponding estimates of production.[h] Emissions from upstream oil and gas production are estimated to grow from 158 Mt CO_2 eq in 2015 to 183 Mt CO_2 eq in 2030. This increase is driven by the growth in bitumen production from the oil sands, where emissions are expected to increase from 71 Mt CO_2 eq in 2015 to 115 Mt by 2030.[i] Specifically, emissions from oil sands mining are projected to increase by 8 Mt CO_2 eq and *in situ* production are expected to increase by 31 Mt.

As part of the Pan-Canadian Framework, the Government of Canada reaffirmed its commitment to reduce methane emissions from the oil and gas sector by 40 to 45% from 2012 levels by 2025, building on provincial actions and targets. To achieve this goal, the Canadian government has published regulations which articulate control measures for methane emissions in the oil and gas sector. The regulations are expected to achieve 22 Mt CO_2 eq of reductions in 2030.

Emissions from conventional crude oil production are expected to fall from 31 Mt in 2015 to 23 Mt in 2030. Emissions from natural gas production and processing are also expected to decline from 56 Mt in 2015 to 45 Mt in 2030.

Consistent with the most recent NEB projections, this report does not include the construction of any liquefied natural gas production projects nor emissions from that sector over the projection period.

Transportation and Distribution of Oil and Gas
Emissions from the pipeline transportation of oil and gas and the local distribution of natural gas are expected to remain relatively flat throughout the projection period.

Petroleum Refining and Upgrading
Table 5.10 displays emissions associated with petroleum refining and upgrading from 2005 to 2030. Emissions from traditional petroleum refining are expected to remain relatively unchanged throughout the projection period. Emissions associated with the upgrading of oil sands bitumen are expected to slightly increase from 19 Mt CO_2 eq in 2015 to 23 Mt by 2030, largely driven by additional capacity in Western Canada.[j]

[h] Oil and gas production projections used in preparation of this report are slightly different from the ones published in NEB Energy Future 2017. These projections have been also developed by NEB, but assumption about Canada-wide carbon price of $50 has been removed from the "with measures" scenario, thus leading to slightly higher production numbers than the ones that were published in NEB Energy Futures 2017.

[i] Based on the Alberta Government's announcement, Alberta's 100 Mt cap on oil sands emissions excludes emissions from cogeneration of electricity and new upgrading. When taking these into account, total emissions from oil sands is 99 Mt in 2030 under the "with measures" scenario, below the 100 Mt cap.

[j] The increase in refining sector's emissions between 2015 and 2020 is associated with the new Sturgeon facility in Edmonton, Alberta. This facility is reported under the refining sector as it will be producing refined petroleum products, even though it will be processing bitumen. The facility is expected to be equipped with a carbon capture technology.

Table 5.10: Petroleum Refining and Upgrading Sector Emissions and Drivers

	2005	2010	2015	2020	2030
Traditional Refineries					
Emissions (Mt CO_2 eq)	22	22	21	22	22
Refined Petroleum Processed (1,000 barrels/day)	2,021	1,984	1,861	1,911	1,911
Upgraders					
Emissions (Mt CO_2 eq)	14	19	19	21	23
Refined Petroleum Processed (1,000 barrels/day)	611	849	1,058	1,298	1,415

5.3.6.2 Transportation

In 2015, transportation (including passenger, freight, and residential and commercial off-road emissions) was the largest contributor to Canada's GHG emissions, representing 24% of overall GHGs.

Between 1990 and 2005, emissions in the transportation sector increased 34%, from 122 Mt CO_2 eq in 1990 to 163 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 continued rising, representing 173 Mt in 2015. 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 2015, the sales-weighted on-road fuel efficiency for new gasoline cars improved from 9.2 litres (L) per 100 km to 8.1 L/100 km, while the sales-weighted on-road fuel efficiency for new gasoline light trucks improved from 13.2 L/100 km to 11.1 L/100 km.

Total transportation emissions increased from 163 Mt CO_2 eq in 2005 to 173 Mt by 2015, but are projected to drop to 155 Mt in 2030, a marked decline of emissions in the sector due to the projected increased fuel-efficiency of on-road vehicles. This change from historical trends is being driven by the federal LDV regulations, despite projected increases in population and number of vehicles. Emissions are projected to decrease by 13 Mt between 2020 and 2030 as the stock of existing vehicles is gradually overturned with more efficient gasoline and diesel vehicles as well as the increasing share of zero emission vehicles (ZEV). The federal heavy-duty vehicles (HDV) GHG emissions standards parts 1 and 2 will also contribute to increased fuel-efficiency of on road freight vehicles, though emissions will continue to rise in that sub sector driven by an expanding economy.

In October 2010, the Government of Canada released the Light-duty vehicles (LDV-1) GHG emissions standards, which prescribe progressively more stringent annual emission standards for new vehicles of model years 2011 to 2016. In September 2014, the Government released the Light-duty vehicles 2 (LDV-2) GHG emissions standards for 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. For model years 2017 to 2025, the regulations will reduce GHG emissions by an additional 3 Mt in 2020, increasing to 24 Mt by 2030, as these new efficient vehicles replace the existing stock.

Under both phases of LDV 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. In addition, the LDV regulations are driving the shift away from the use of HFCs in mobile air conditioners, resulting in a significant decrease in emissions of this gas with high global warming potential. See Table 5.24 for trends in HFC emissions.

As depicted in Table 5.11, 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 24 Mt CO_2 eq between 2005 and 2030, while those for ground freight, off-road and other vehicles are projected to grow by 18 Mt over the same time period. 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.

Table 5.11: Transportation: Emissions by Subsector (Mt CO_2 eq) from 2005 to 2030

	2005	2010	2015	2020	2030	CHANGE 2005 TO 2030
Passenger Transport	93	92	91	84	69	-24
Cars, Trucks and Motorcycles	85	85	83	76	61	-25
Bus, Rail and Domestic Aviation	7	7	7	8	8	1
Freight Transport	64	73	76	78	79	15
Heavy Duty Trucks, Rail	56	65	71	72	74	18
Domestic Aviation and Marine	8	8	5	5	5	-3
Other: Recreational, Commercial and Residential	7	7	6	7	8	1
Total	**163**	**171**	**173**	**168**	**155**	**-8**

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

5.3.6.3 Electricity Generation

As about 80% of the utility electricity supply in Canada is generated from non-GHG emitting sources, the electricity sector comprised only 11% of total Canadian GHG emissions in 2015. Since 2005, electricity sector emissions have fallen an average of 4% per year, the fastest of any sector in Canada. The mix of sources of energy used to generate power vary considerably across the country, depending on regional features such as the availability of natural resources such as hydropower, transmission interconnections to other provinces and the United States, and access to natural gas. Several provinces rely almost exclusively on hydropower at present due to abundant hydro resources, while other jurisdictions have highly diversified mixes of power that combine non-emitting power from renewables and nuclear with fossil fuel generation. A few rely primarily on fossil fuels such as refined petroleum products, natural gas, and coal.

Over the 1990 to 2005 period demand for electricity rose considerably, and this increase in demand was 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 and refined petroleum product-fired generation to meet growing demand.

Post-2005, emissions in this sector fell significantly as coal-fired units were closed and more lower and non-emitting sources were brought online to replace coal. Provinces continued to replace some higher-emitting coal and diesel generation with lower-emitting natural gas generation, but also a significant increase in non-hydro renewable generation was observed over the same time period. Wind generation increased from

0.3% of total generation in 2005 to 4.7% by 2015, an average growth rate of over 30% per year, while solar generation has increased nearly 60% per year during the same period. Together, wind, solar, and biomass sources of generation accounted for 5.7% of utility electricity generation in 2015, up from 0.9% in 2005. In particular, Ontario's coal-fired generation phase-out was completed in 2014, with replacement generation coming primarily from non-GHG-emitting sources such as wind, nuclear, solar, and biomass.

Several Canadian provinces have achieved nearly 100% non-emitting grids by 2015, and their electricity supply is expected to remain non-emitting throughout the forecast. Québec, Manitoba and British Columbia generate 97 to 100% of electricity from hydro and other renewables and are expected to continue to develop new renewable resources in the future, maintaining emitting resources only for remote or back-up needs. Prince Edward Island has reduced thermal generation to near zero, with 98% of on-island generation coming from its ample wind resources. The Yukon has also substantially reduced its reliance on diesel and now generates 94% of electricity from renewable sources.

Finally, growing use of on-site cogeneration to meet industrial electricity and steam demands, particularly in the Alberta oil and gas sector, reduced utility demands and further reduced electricity sector emissions. Cogeneration is the simultaneous generation of electricity and heat or steam that can be then used in industrial processes such as *in situ* oil sands extraction. As a result of increasing use of cogeneration, emissions for electricity production are shifted from the utility electricity sector to the oil and gas sector. However, the combined production of power and heat is more efficient than their separate production due to the capturing of waste heat and steam from combustion for useful work that would otherwise need to be produced separately. As a result, the economy-wide impact of shifting from utility natural gas-fired electricity generation (or other fossil fuel sources) to industrial cogeneration using natural gas in general results in a reduction in GHG emissions. In the particular context of Alberta's coal-based electricity grid, these reductions can be substantial.

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 fell by 38 Mt CO_2 eq from 2005 to 2015 and are projected to further decrease 32 Mt by 2030, for a total decrease of 70 Mt over the period while total generation increased. Table 5.12 outlines the decline in projected emissions alongside the expected increase in electricity generation from 2005 through 2030.

Table 5.12: Utility Electricity Sector: Emissions and Drivers

SECTOR	2005	2010	2015	2020	2030
Emissions (Mt CO_2 eq)	117	96	79	71	46
Generation (Terawatt Hours)	551	539	580	588	587

Continued use of on-site industrial cogeneration and an overall decrease in net electricity exports as major exporting provinces use increasingly more electricity domestically are projected to keep utility electricity generation growth low even as electricity demand grows. Furthermore, while population and the economy continue to grow in the forecast, residential and commercial electricity demands remain flat or decline due to improvements in energy efficiency; the majority of increased demand for electricity in the forecast is from industrial and manufacturing sectors. The modest increase in electricity generation expected through 2030 will be supplied by various fuel sources. Although coal usage for electricity generation is declining, the proportion of power generation from fossil fuels is expected to vary by province and territory depending on the availability of electricity from hydro, nuclear power, and non-hydro renewable energy sources such as wind.[k]

The proportion of utility electricity generation coming from renewable sources is projected to increase between 2005 and 2030. Hydropower generation is expected to increase in most Canadian provinces and territories, both through large dam construction and small hydro projects, bringing hydropower from 59% to 63% of utility electricity generated in Canada. Non-hydro renewables such as wind, solar, biomass and waste generation are expected to continue to grow at about 4% per year between 2015 and 2030 and are projected to account for nearly 10% of total generation by 2030. Nuclear power, however, is expected to decline by 23% over the same time frame, as Ontario reduces its nuclear capacity between 2020 and 2030 with the retirement of several ageing units.

Coal generation is expected to fall by 60% between 2015 and 2030 as coal units continue to retire or reduce production in Alberta, Saskatchewan, and Nova Scotia. Natural gas generation is expected to increase to replace coal and nuclear generation, as well as to support increasing use of intermittent sources of generation such as wind.

Federal regulations to reduce CO_2 emissions from coal-fired electricity came into effect on July 1, 2015. 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 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.

The Government of Canada announced its intention to amend these regulations to accelerate action and phase out traditional coal-fired electricity generation by December 31, 2029. Draft amendments are targeted for publication in early January 2018, with final amendments targeted for publication by December 2018. The reductions from this amendment are not included in the Reference Case but are instead reflected in the “with additional measures” scenario, given the timeline of publication for the draft amendments.

In addition, several provinces have introduced significant measures to move away from fossil fuel electricity generation and towards cleaner sources of power that contribute to the decline in emissions in the electricity sector. Nova Scotia aims to decrease emissions in its electricity sector through a declining cap on emissions and a renewable portfolio standard that will require 40% of electricity sales to come from renewable sources by 2020. Alberta will phase out traditional coal-fired generation by the end of 2030, and has introduced complementary plans to achieve 30% renewable capacity over the same time frame. Newfoundland and Labrador is constructing a new large hydro dam and an underwater transmission link between Labrador and Newfoundland Island to replace ageing, high-emitting heavy fuel oil generation on the Island with renewable power.

At a national level, emissions from coal-fired generation are projected to decline by 73 Mt over the 2005 to 2030 time period, and emissions from refined petroleum products such as diesel and fuel oils are expected to fall by 8 Mt. Emissions from natural gas are expected to increase by 11 Mt over the period in this sector, as natural gas replaces coal in some provinces, helps meet growing electricity demand, and supports the integration of higher levels of intermittent renewables.

[k] See Annex Table 5A.7 Electricity Supply and Demand.

Table 5.13: Utility Electricity Sector Emissions by Fuel Type (Mt CO_2 eq) from 2005 to 2030

FUEL	2005	2010	2015	2020	2030	CHANGE 2005 TO 2030
Coal	95	78	61	52	22	-73
Refined Petroleum Products[a]	11	5	5	5	3	-8
Natural Gas	10	14	13	14	21	11
Biomass	<1	<1	<1	<1	<1	0
Total	**117**	**96**	**79**	**71**	**46**	**-70**

Note: Numbers may not sum to the total due to rounding.
[a] These estimates do not include the Government's recent announcement on its intent to amend the existing federal regulations to accelerate action and phase out traditional coal-fired electricity generation by December 31, 2029. The reductions from this amendment are instead reflected in the "with additional measures" scenario.

5.3.6.4 Heavy Industry

The heavy industry 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 heavy industry sector were responsible for 16% of total Canadian emissions in 1990, and fell to 12% in 2005. The decline (11 Mt CO_2 eq) reflects 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 fuels such as biomass and waste in production processes were also responsible for the GHG reductions over time.

Emissions from the heavy industry sector decreased by 11 Mt between 2005 and 2015, but are projected to increase by 22 Mt between 2015 and 2030 due to increased production in some subsectors. Emissions are estimated to have been at their lowest point in 2009 following a decline in pulp and paper, iron and steel, and smelting and refining output, but then recovered somewhat with increased chemical and fertilizer production.

Table 5.14: Heavy Industry: Emissions and Drivers

MT CO_2 EQUIVALENT	2005	2010	2015	2020	2030
Emissions (Mt CO_2 eq)	86	73	75	83	97
Gross Output of Heavy Industry (1997 $billions)	3,251	3,543	4,073	4,582	5,815

On average, emissions generated by heavy industry subsectors are projected to be 4% less than 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, emissions from the iron and steel subsector are projected to rise by 27%. Cement emissions are projected to increase by 27% over the period, while emissions from mining increase by 22%.This reflects expected increases in production while the energy efficiency of the subsectors increase more slowly.

Table 5.15: Heavy Industries' Emissions by Subsector (Mt CO_2 eq) from 2005 to 2030

SECTOR	2005	2010	2015	2020	2030	CHANGE 2005 TO 2030
Mining	7	8	8	9	11	5
Smelting and Refining (Non-ferrous metals)	14	11	10	11	12	-2
Pulp and Paper	9	7	6	6	5	-4
Iron and Steel	16	14	14	15	19	2
Cement	13	10	10	11	14	1
Lime and Gypsum	3	3	2	3	3	0
Chemicals and Fertilizers	23	21	25	28	33	9
Total	**86**	**73**	**75**	**83**	**97**	**11**

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

5.3.6.5 Buildings

Emissions in Canada's commercial and residential buildings increased by 12 Mt CO_2 eq between 1990 and 2005, and then remained relatively stable around the 2005 levels through to 2015. From 1990 to 2015, 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, projected energy efficiency improvements help to keep emissions stable post-2015.

Emissions from commercial and residential buildings are projected to decline by 2% over the 2015 to 2030 time frame (excluding indirect emissions from electricity).

Residential

As shown in Table 5.16, GHG emissions from the residential buildings (e.g., houses, apartments and other dwellings) declined by 1 Mt CO_2 eq between 2005 and 2015, and are projected to decline by a further 3 Mt (or 5%) between 2015 and 2030. This is despite an expected 19% increase (or 2.6 million) of the number of Canadian households (a key driver of residential emissions growth) between 2015 and 2030. This highlights the decreasing emissions intensities in the average dwelling 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 over time.

Table 5.16: Residential Subsector: Emissions and Drivers

	2005	2010	2015	2020	2030
Emissions (Mt CO_2 eq)	46	43	45	44	42
Households (millions)	12.1	13.0	13.9	14.9	16.5
Tonnes per household	3.79	3.32	3.19	2.96	2.55

Commercial

GHG emissions from Canada's commercial buildings increased by 1 Mt between 2005 and 2015, and are expected to be at that level in 2030 (Table 5.17). Emissions in the commercial subsector remained stable between 2005 and 2015 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. Emissions are expected to decline despite an expansion of commercial floor space (the principal driver of emissions from this subsector) as the economy continues to grow. This is a result of continued efficiency improvements and the phase down of and bulk import ban on HFCs used in refrigeration and air conditioning. As HFCs have an average global warming potential that is up to 1900 times more potent than CO_2, decreasing HFC consumption has a significant impact on emissions. Between 2015 and 2030, emissions are projected to stay constant, while floor space increases by 15%.

Table 5.17: Commercial Subsector: Emissions and Drivers

	2005	2010	2015	2020	2030
Emissions (Mt CO_2 eq)	40	38	41	43	41
Floor space (millions m^2)	654	714	749	776	863

5.3.6.6 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 fuel use. Emissions have remained stable over the 2005 to 2015 period at approximately 73 Mt, following an increase of 14 Mt from 1990 to 2005. Since 1990, emissions from the sector have remained stable at about 10% of Canada's total emissions. Emissions and removals (sequestration) of carbon from land management and land-use change associated with agricultural lands would be 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 2015, increases in crop production were offset by decreases in animal production. In the projection, however, emissions from both crop production and livestock are expected to remain stable. Agriculture emissions are projected to be 72 Mt in 2030, 1 Mt less than the 2015 levels.

Table 5.18: Agriculture Sector Emissions by Subsector (Mt CO_2 eq) from 2005 to 2030

SECTOR	2005	2010	2015	2020	2030	CHANGE 2005 TO 2030
On-Farm Fuel Use	14	14	14	14	14	0
Crop Production	16	19	22	21	21	5
Animal Production	45	37	37	36	37	-8
Total	**74**	**70**	**73**	**71**	**72**	**-3**

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

5.3.6.7 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 2005 to 2015, GHG emissions from municipal solid waste landfills declined, with the help of provincial government measures aimed at capturing landfill gas as well as solid waste diversion. Between 2015 and 2030, emissions are expected to grow, driven by projected population growth.

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 the forestry and logging service industry. Emissions from these various subsectors are projected to increase slightly over the 2015 to 2030 timeframe driven by projected growth in these economic activities, but will remain lower than 2005 levels.

Table 5.19: Waste and Others Emissions by Subsector (Mt CO_2 eq) from 2005 to 2030

SECTOR	2005	2010	2015	2020	2030	CHANGE 2005 TO 2030
Waste	28	25	25	27	28	1
Coal Production	2	3	2	2	2	-1
Light Manufacturing, Construction & Forest Resources	24	22	21	22	23	-2
Total	**54**	**50**	**48**	**50**	**53**	**-2**

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

5.3.6.8 Land Use, Land-use Change and Forestry

A unique challenge in both projecting and accounting for emissions and removals in Canada's managed forest is the fact that natural disturbances result in significant variations in annual forest emission and removal estimates. As well, natural disturbances generally cannot be predicted. Canada's Nationally Determined Contribution, released in May 2017, notes that Canada is examining its approach to accounting in the LULUCF sector towards its 2030 emission reduction target. It also indicates that Canada will exclude the impacts of natural disturbances and use the IPCC production approach to account for harvested wood products. This applies to Canada's 2020 emission reduction target as well.

The historical estimates for LULUCF from 1990–2015 found in Canada's 2017 *National Inventory Report* (NIR) exclude for the first time the impacts of significant natural disturbances in the managed forest that occurred in the historical period (see Chapter 6 of the NIR). As noted in the 2017 NIR, work continues to refine LULUCF estimates that focus on anthropogenic emissions and removals as a basis for improved reporting and accounting for LULUCF. As this work is still underway, Canada has not shown LULUCF projections and accounting contributions.

5.3.6.9 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 foreign registered watercraft and aircraft. Emissions declined by 1 Mt between 2005 and 2015, and are expected to increase 14% between 2015 and 2030 as the number of foreign transportation vehicles and number of kilometers traveled increases.

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

SECTOR	2005	2010	2015	2020	2030
Foreign Freight	5	4	2	2	2
Foreign Passenger	8	8	10	11	12

5.3.7 Detailed Emissions Projections by Gas and by Economic Sector

The following tables summarize total GHG projections by sector and by gas under the "with current measures scenario" and illustrate how the projected trends vary by gas and by economic sector.

Table 5.21: CO_2 Emissions Projections by Economic Sector (kt CO_2 eq)

	HISTORICAL						PROJECTED	
SECTOR	**1990**	**1995**	**2000**	**2005**	**2010**	**2015**	**2020**	**2030**
Oil and Gas	70,000	83,000	102,000	109,000	117,000	143,000	157,000	187,000
Electricity	92,000	96,000	125,000	115,000	95,000	78,000	70,000	46,000
Transportation	115,000	119,000	137,000	154,000	163,000	165,000	161,000	151,000
Heavy Industry	79,000	83,000	87,000	80,000	71,000	72,000	80,000	95,000
Buildings	67,000	72,000	77,000	78,000	72,000	74,000	73,000	69,000
Agriculture	12,000	15,000	15,000	14,000	14,000	15,000	15,000	15,000
Waste & Others	29,000	28,000	27,000	24,000	23,000	21,000	22,000	23,000
Total	**463,000**	**496,000**	**570,000**	**574,000**	**554,000**	**568,000**	**579,000**	**584,000**

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

Table 5.22: CH_4 Emissions Projections by Economic Sector (kt CO_2 eq)

	HISTORICAL						PROJECTED	
SECTOR	**1990**	**1995**	**2000**	**2005**	**2010**	**2015**	**2020**	**2030**
Oil and Gas	36,000	49,000	55,000	47,000	42,000	45,000	39,000	27,000
Electricity	0	100	100	100	100	200	100	200
Transportation	600	600	500	400	400	400	400	400
Heavy Industry	200	200	200	100	100	100	100	200
Buildings	4,600	4,500	4,000	3,000	3,200	3,200	3,000	2,800
Agriculture	26,000	31,000	32,000	36,000	30,000	29,000	28,000	29,000
Waste & Others	25,000	25,000	26,000	27,000	25,000	24,000	26,000	27,000
Total	**94,000**	**111,000**	**118,000**	**114,000**	**100,000**	**102,000**	**96,000**	**86,000**

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

Table 5.23: N_2O Emissions Projections by Economic Sector (kt CO_2 eq)

	HISTORICAL						PROJECTED	
SECTOR	**1990**	**1995**	**2000**	**2005**	**2010**	**2015**	**2020**	**2030**
Oil and Gas	500	600	800	800	1,000	1,100	1,300	1,500
Electricity	500	600	700	700	600	500	500	400
Transportation	4,500	5,600	6,500	6,300	4,700	3,600	3,700	3,700
Heavy Industry	12,000	12,100	2,900	4,500	1,800	1,900	1,300	1,600
Buildings	1,100	1,200	1,400	1,200	1,100	1,100	1,100	1,100
Agriculture	22,000	24,000	25,000	25,000	26,000	29,000	28,000	28,000
Waste & Others	1 900	2,000	2,100	2,100	2,100	2,100	2,200	2 ,400
Total	**42,000**	**46,000**	**40,000**	**41,000**	**37,000**	**39,000**	**38,000**	**39,000**

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

Table 5.24: HFC Emissions Projections by Economic Sector (kt CO_2 eq)

	HISTORICAL						PROJECTED	
SECTOR	1990	1995	2000	2005	2010	2015	2020	2030
Oil and Gas	0	0	0	0	0	0	0	0
Electricity	0	0	0	0	0	0	0	0
Transportation	0	100	1,100	1,900	2,600	3,200	2,900	700
Heavy Industry	1,000	0	0	0	500	600	600	400
Buildings	0	300	1,500	2,800	4,400	6,800	10,900	11,100
Agriculture	0	0	0	0	0	0	0	0
Waste & Others	0	0	100	400	300	400	400	300
Total	**1,000**	**500**	**2,800**	**5,100**	**7,800**	**11,000**	**14,800**	**12,500**

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

Table 5.25: PFC Emissions Projections by Economic Sector (kt CO_2 eq)

	HISTORICAL						PROJECTED	
SECTOR	1990	1995	2000	2005	2010	2015	2020	2030
Oil and Gas	0	0	0	0	0	0	0	0
Electricity	0	0	0	0	0	0	0	0
Transportation	0	0	0	0	0	0	0	0
Heavy Industry	0	0	0	0	0	900	300	300
Buildings	0	0	0	0	0	0	0	0
Agriculture	0	0	0	0	0	0	0	0
Waste & Others	7,600	6,300	5,000	3,800	1,900	100	20	20
Total	**7,600**	**6,300**	**5,000**	**3,800**	**1,900**	**1,000**	**300**	**300**

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

Table 5.26: SF_6 Emissions Projections by Economic Sector (kt CO_2 eq)

	HISTORICAL						PROJECTED	
SECTOR	1990	1995	2000	2005	2010	2015	2020	2030
Oil and Gas	0	0	0	0	0	0	0	0
Electricity	200	200	200	200	200	200	100	100
Transportation	0	0	0	0	0	0	0	0
Heavy Industry	3,000	2,100	2,700	1,200	200	200	10	10
Buildings	0	0	0	0	0	0	0	0
Agriculture	0	0	0	0	0	0	0	0
Waste & Others	0	0	0	0	0	0	0	0
Total	**3,200**	**2,300**	**2,900**	**1,400**	**400**	**400**	**100**	**100**

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

[m] While reported at the Provincial/Territorial level in Canada's GHG Emissions Reference Case, 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.

[n] 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. The policies and measures modeled in this section are listed in Table 5A.9 in Annex 1 of this chapter and several are described in more detail in Chapter 4: Policies and Measures.

5.4 Emissions by Province[m]

Emissions vary considerably 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 5.27 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 energy efficiency and renewable electricity programs, carbon taxes or levies (i.e., British Columbia, Alberta, Ontario, and Québec), regulatory measures, and legislated renewable electricity targets.[n]

Table 5.27: Provincial and Territorial GHG Emissions (Mt CO_2 eq) from 2005 to 2030

AREA	2005	2010	2015	2020	2030	CHANGE 2005 TO 2030
Newfoundland	10	10	10	12	10	-1
Prince Edward Island	2	2	2	2	2	0
Nova Scotia	23	20	16	15	13	-11
New Brunswick	20	19	14	14	14	-7
Québec	89	82	80	81	79	-10
Ontario	204	175	166	167	165	-39
Manitoba	21	20	21	21	21	0
Saskatchewan	70	70	75	74	70	0
Alberta	233	241	274	278	287	54
British Columbia	64	59	61	59	58	-6
Territories	3	2	2	4	4	2
Canada	738	701	722	728	722	-16

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

Accounting for Purchasing of International Credits under the WCI Cap-and-Trade Program

The values in Table 5.27 represent domestic emissions. As such, they do not include potential allowances purchased internationally under the Western Climate Initiative (WCI) cap-and-trade program. Ontario and Québec have legislated GHG emissions targets for 2020 and 2030. Both provinces have regulated emissions caps to achieve their 2020 targets, Ontario's target being 15% below 1990 levels and Québec being 20% (representing, as of the 2015 Canadian inventory, 154 Mt and 71 Mt, respectively). In addition, both provinces have 2030 targets, Ontario's being 37% below 1990 levels and Québec's being 37.5% (representing 114 Mt and 56 Mt respectively). The provinces will use a combination of new domestic policies and international allowances acquired from California (also part of the WCI) to meet their legislated targets. The impact of Ontario and Québec's acquisition of international allowances will be additional to reductions shown in Table 5.27, and have been included in the additional measures described in Section 5.5 and in Table 5.28.

5.5 Assessment of Aggregate Effect of Policies and Measures

5.5.1 With Measures and With Additional Measures Scenarios

Under the Paris Agreement, Canada has formally committed to achieving an economy-wide target to reduce GHG emissions by 30% below 2005 levels by 2030, and under the Copenhagen Accord Canada committed to reducing GHG emissions by 17% below 2005 levels by 2020. The federal, provincial and territorial governments established the Pan-Canadian Framework to take action on climate change.

Since the submission of Canada's BR2 a number of policies and measures have been implemented, which have resulted in significantly lower emissions projections under the "with measures" scenario. Whereas in the BR2 emissions were projected to increase to 815 Mt by 2030 (or 9% above 2005 levels), they are now projected to decline to 722 Mt (or 2% below 2005 levels) under this scenario.

Under the Pan-Canadian Framework a large number of policies and measures have been announced, some of which are already reflected in the "with measures" scenario, while some policies are still under development. When taking into consideration all climate change policies and measures that have been announced in Canada and for which enough information is available, Canada's emissions are projected to be 583 Mt in 2030, a 232 Mt decline from projections included in the BR2.

This decline, equivalent to approximately a third of Canada's emissions in 2015, encompasses all economic sectors, consistent with the Pan-Canadian Framework.

Three of the major policies included in the "with additional measures" scenario are described below.

Pricing Carbon Pollution

The Government of Canada has outlined a benchmark for pricing carbon pollution that will build on existing provincial systems and require a minimum price of $10 per tonne is in place across Canada by 2018, rising to $50 per tonne by 2022. Provinces and territories will continue to have the flexibility to implement either an explicit price on carbon (e.g., through a carbon tax) or a cap-and-trade system and will retain all revenue generated by carbon pricing.

A number of provinces have already implemented carbon pricing policies and these are reflected in the "with measures" scenario; over 80% of Canadians currently live in a jurisdiction with a carbon price. Ontario and Québec have joined California in the Western Climate Initiative, and have implemented cap and trade regulations. British Columbia has recently announced an increase in its carbon tax from $30/t to $50/t by 2021 (increasing in $5 increments each year), and Alberta is transitioning from the Specified Gas Emitters Regulation to a carbon levy ($30/t) and output based allocation system.

The additional measures scenario assumes that federal backstop carbon pricing policy is implemented in provinces other than Ontario, Québec, British Columbia and Alberta, and an increase in carbon price to $40/t in 2021 and $50/t by 2022 in Alberta.

Reducing CO_2 emissions from coal-fired generation of electricity

Projections for the "with measures" scenario include the regulation to phase out coal-fired electricity at the end of the economic life of the facilities, with a number of coal-fired facilities continuing to operate in the post-2030 period. With the adoption of the Pan-Canadian Framework, Canada is moving forward to accelerate the phase-out of traditional coal units across the country by 2030.

Clean Fuel Standard

The Clean Fuel Standard will be a modern, flexible, performance-based approach that will encourage the use of a broad range of lower carbon fuels, alternative energy sources and technologies, such as electricity, hydrogen, and renewable fuels, including renewable natural gas. It would address a broad suite of fuels, including gaseous, solid and liquid fuels, and would go beyond transportation fuels to include those used in industry, homes and buildings. The objective of the Clean Fuel Standard is to achieve 30 Mt of annual reductions in GHG emissions by 2030.

Other Complementary Measures Included

Other complementary measures included in the "with additional measures" scenario include actions across all sectors:

- retrofit building codes for existing buildings, net-zero ready building codes for new buildings, as well as more stringent standards for equipment and appliances in the buildings sector;

- measures in the transportation sector targeting off-road vehicles, zero emissions vehicles strategy and further extension of the light duty vehicle standards for the vehicles of the post-2025 model years;
- a policy in the industrial sector to accelerate the adoption of the industrial energy management systems;
- improving electricity transmission system by building strategic interconnections, making investments into emerging renewables and smart grid, and reducing reliance on diesel in northern, remote and indigenous communities;
- and other policies.

A complete list of modeled measures included in the scenario is provided in Annex 1. Also reflected in the “with additional measures” scenario are the purchases of international allowances by Ontario and Québec under the WCI that will allow them to achieve their respective 2030 legislated targets.

The Government of Canada has allocated significant resources under the Pan-Canadian Framework through a number of funds such as the Low Carbon Economy Fund. These resources will be used to fund some of the measures included in the additional measures scenario (e.g., in the building or electricity sectors) and will support the implementation of proposed standards by lowering the costs for consumers and industry.

Figure 5.6 shows the “with measures” and “with additional measures” projections as well as the projections presented in Canada’s BR2.

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.

It is expected that GHG estimates will continue to decline in the near to medium term, especially as current estimates do not include the full reductions from investment in public transit, clean technology and innovation. In addition, possible increases in stored carbon (carbon sequestration) in forests, soils and wetlands will also contribute to reductions, which could also play an important role in achieving Canada’s 2030 target.

Furthermore, these projected emissions reductions do not take into consideration the additional mitigation measures that could be implemented by the provinces and territories between now and 2030. Emissions reductions from additional future actions will be assessed as new measures are implemented.

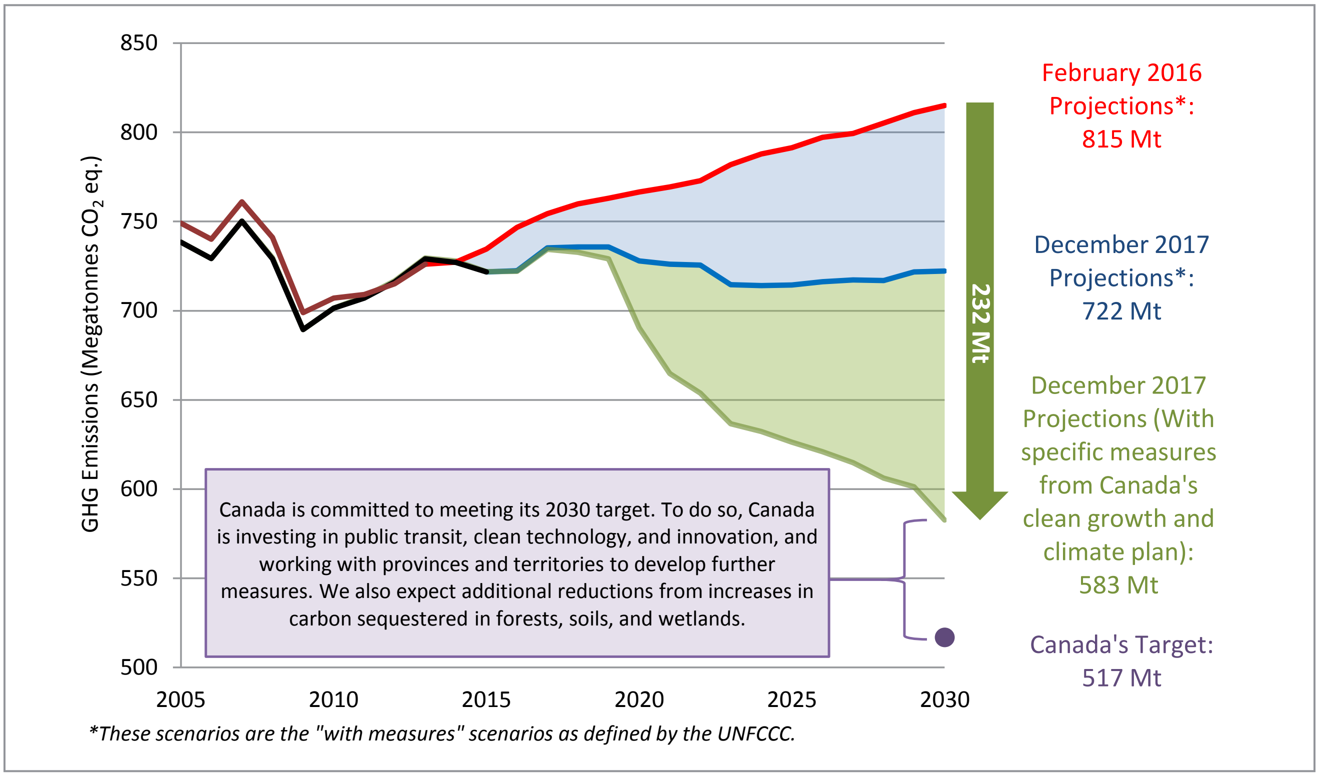

Figure 5.6: Scenarios of Canadian Emissions to 2020 and 2030 (Mt CO_2 eq) (Excluding Land Use, Land-Use Change and Forestry)

Table 5.28 shows the breakdown of emissions by economic sectors for the different scenarios in 2030. Overall, emissions are projected to decrease by 232 Mt compared to the estimates in the BR2 with the biggest reductions happening in the electricity and buildings sectors, followed by oil and gas and transportation sectors.

Table 5.28: Canadian 2030 GHG Emissions Forecast (Mt CO_2 eq) Under Different Scenarios

SECTOR	2ND BIENNIAL REPORT (BR2)	7TH NATIONAL COMMUNICATION (NC7)	7TH NATIONAL COMMUNICATION–ADDITIONAL MEASURES (NC7AM)	DIFFERENCE BETWEEN NC7 AND BR2	DIFFERENCE BETWEEN NC7AM AND BR2
Agriculture	76	72	71	-5	-5
Buildings	109	83	71	-26	-38
Electricity	58	46	21	-12	-37
Heavy Industry	107	97	93	-10	-14
Oil and Gas	242	215	192	-27	-50
Transportation	164	155	143	-9	-21
Waste & Others	59	53	51	-6	-8
Purchases of international allowances under the Western Climate Initiative			-59		-59
Total	**815**	**722**	**583**	**-93**	**-232**

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

5.6. Alternate Emissions Scenarios

5.6.1. Sensitivity Analysis

Projections are updated annually and reflect the latest historical data and up-to-date future economic and energy market assumptions. However, given the uncertainty regarding the key drivers of GHG emissions, the scenario presented in the previous section should be seen as one estimate within a set of possible emissions outcomes in the projection period, as events that will shape future emissions and energy markets cannot be fully anticipated. In addition, future developments in technologies, demographics and resources cannot be foreseen with certainty. The variation in these complex variables implies that modelling results are most appropriately viewed as a range of plausible outcomes.

Uncertainty is addressed via modelling and analysis of alternate cases that focus on variability in two key factors: future economic growth and population projections and the evolution of oil and natural gas prices and production as per the National Energy Board's high and low scenarios. These assumptions are presented in Table 5.29 and Table 5.30, and the overall range of emissions is presented in Figure 5.7.[o]

Table 5.29: Economic Growth and Population from 2015 to 2030

	2015 TO 2030		
	LOW	WITH MEASURES	HIGH
Annual GDP Growth Rate	1.0%	1.7%	2.5%
Annual Population Growth Rate	0.7%	1.0%	1.3%

Table 5.30: Oil and Gas Prices and Production in 2020 and 2030

		2020			2030		
FUEL	UNITS	LOW	WITH MEASURES	HIGH	LOW	WITH MEASURES	HIGH
Crude Oil Price (WTI)	Real 2014 US$/bbl	39	66	81	37	77	116
Heavy Oil (WCS)	Real 2014 US$/bbl	20	43	56	21	56	90
Crude Oil	1000 bbl/day	4,404	4,560	4,907	4,047	5,619	7,567
Natural Gas (Henry Hub)	Real 2014 US$/GJ	2.65	3.13	3.55	2.86	3.77	4.67
Natural Gas	Billion cubic feet	6471	6,789	7084	4828	7101	9570

Table 5.31: Sensitivity of GHG Emissions to Changes in GDP and Prices (excluding LULUCF) in Mt CO_2 eq

SCENARIOS	2020	2030	2030 PROJECTIONS–2005 EMISSIONS
Slow GDP, Low World Oil and Gas Prices	709	651	-87
Fast GDP, High World Oil and Gas Prices	742	793	55
"With Measures" Scenario	728	722	-16
Sensitivity Range	709 to 742	651 to 793	-87 to 55

[o] The High and Low alternate emissions scenarios from Section 5.7 are equivalent to the Fast GDP–High World Oil Prices and Slow GDP–Low World Oil Prices scenarios respectively in Annex 3 of this chapter.

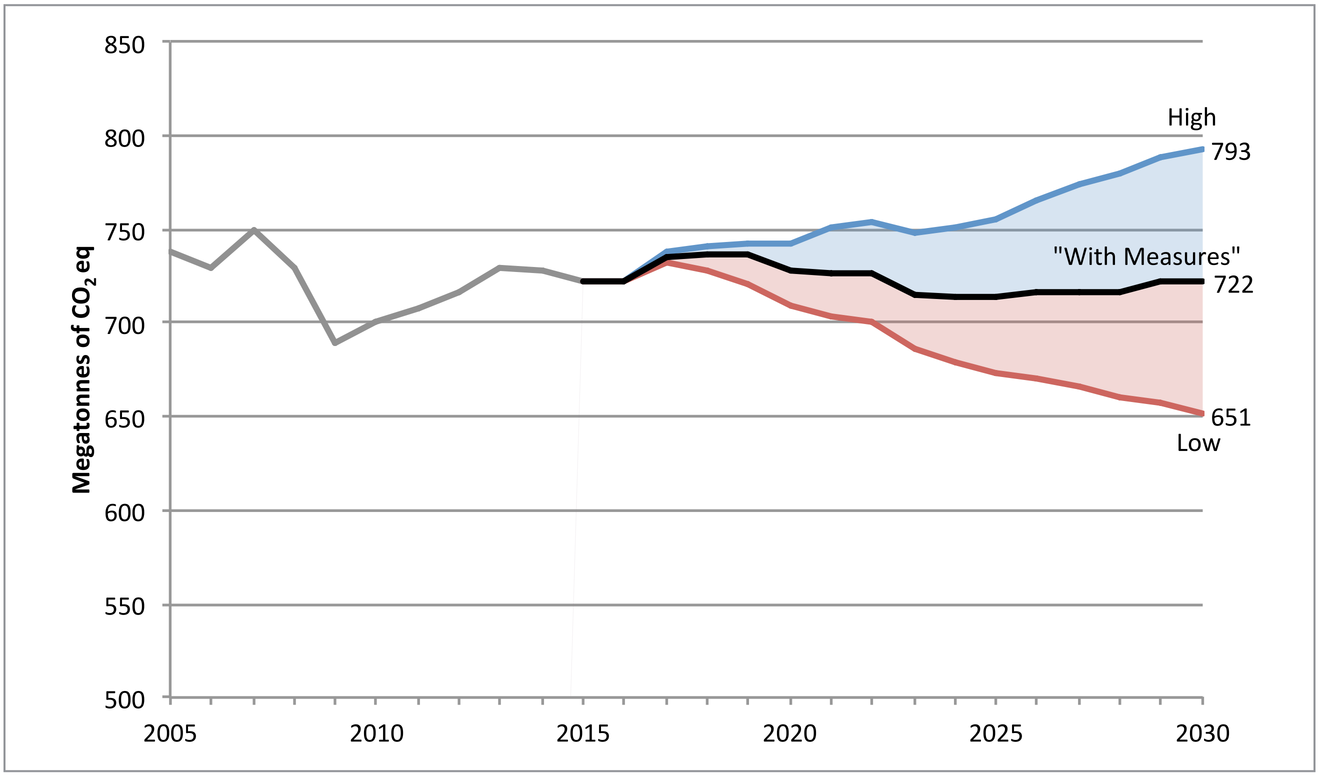

Figure 5.7: Canada's Domestic Emissions Projections (Mt CO_2 eq): low, "with measures" and high scenarios

5.6.2 Main Sources of Uncertainty for Canada's GHG Projections

Canada develops its scenarios of emissions projections using a detailed, proven Energy, Emissions and Economy model. Each year, the model is re-calibrated using the most recent data available (see Annex 4) to provide a robust, well-grounded in empirical evidence forecast. Nevertheless, uncertainty is inherent in the projections of any model that looks decades into the future.

To address this issue, this chapter presents alternative scenarios showing the sensitivity of GHG emission projections to projected energy prices and economic growth. That said, other sources of uncertainty exist, including relating to the decision-making of agents under given assumptions and the pace of clean technology development and adoption. For instance, the observed consumer adoption of emerging technologies may diverge from model predictions due to the influence of behavioral decision-making processes not captured in the model. For example, the diffusion of electric vehicles depends not only on relative vehicle prices, but also consumer awareness of electric vehicles, and the availability of recharging infrastructure both of which will evolve over time and are therefore hard to predict when looking at historical behaviour. This source of projection uncertainty is present across all economic sectors with the rapid emergence of new and cleaner technologies.

Some sources of uncertainty are also specific to sectors, several of which are listed below.

- **Oil and Gas:** As mentioned in the Canada's *National Energy Board 2017 Energy Futures* report, Canadian oil and gas production projections vary significantly depending on wold price assumptions. The global price itself is determined by supply and demand for oil, driven by factors like economic growth, technological developments, and geopolitics and is set in international markets.

- **Electricity:** From the demand side, key factors of uncertainty other than economic and population growth include electricity demand changes arising from the electrification of vehicles or industrial processes. From the supply side, emissions are affected by changes to the supply mix, for example, assumptions for new generating capacity as coal units are being phased out, future costs of renewables, the degree of localized small-scale generation by renewable energy sources, and construction of new transmission linkages.
- **Transportation:** Over the short term, vehicle-kilometers travelled is the key driver of emissions, influenced by assumptions regarding factors such as population, fuel prices and optimization of freight trucks (increased tonnage per km) and freight transportation volume resulting from changes in economic activity. Over the medium to long term, the changing characteristics of the fleet will be important and will be influenced by government policies, different types of vehicles' respective production costs, technological development and consumer choices.
- **Heavy Industry:** Emissions are primarily driven by expected economic growth in each subsector. Future technological developments that would affect the costs of electrification and carbon capture and storage technologies, as well as of other energy efficiency improvements would also have an impact on emissions.
- **Buildings:** Emission projections in this sector will be affected by consumer response to emerging technologies and government policies. Future relative fuel prices and technology costs will also have an impact.
- **Agriculture:** Emissions from agriculture production are affected by production costs such as fertilizer prices, and international prices that affect the crop composition and livestock size.

Annexes

Annex 1: Baseline Data and Assumptions

Key Economic Drivers and Assumptions

Table 5A.1: Summary of Key Price-Related Assumptions Used in Projection Analysis from 1990 to 2030

	HISTORICAL						PROJECTED	
KEY UNDERLYING ASSUMPTIONS	1990	1995	2000	2005	2010	2015	2020	2030
Oil Price ($2015 US/bbl)	$38	$26	$39	$64	$85	$49	$66	$77
Natural Gas Price ($2015 US/mmbtu)	$2.55	$2.34	$5.50	$9.82	$4.63	$2.62	$3.31	$3.98
Consumer Price Index (1992=100)	93	104	114	127	139	151	165	202

Table 5A.2: Summary of Key Economic and Demographic Assumptions Used in Projection Analysis from 1990 to 2030

	HISTORICAL					PROJECTED		
KEY UNDERLYING ASSUMPTIONS	1990–1995	1995–2000	2000–2005	2005–2010	2010–2015	2015–2020	2020–2025	2025–2030
Real GDP Chain-Weighted ($1997)*	1.7%	4.1%	2.6%	1.2%	2.0%	1.7%	1.7%	1.6%
Population*	1.1%	0.9%	1.0%	1.1%	1.1%	1.2%	1.0%	0.9%
Population of driving age (18–75)*	1.4%	1.2%	1.4%	1.4%	1.3%	1.0%	0.9%	0.9%
Labour Force*	0.6%	1.5%	1.8%	1.3%	0.9%	0.9%	0.8%	0.7%

*Average annual growth rate

Baseline Data and Assumptions

Many factors influence the future trends of Canada's GHG emissions. These key factors include economic growth, 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, alternate pathways of key drivers of emissions were modelled to explore 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 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*, 2017 (NIR 2017). Economic projections (including GDP, exchange rates and inflation) to 2021 are calibrated to Finance Canada's March 2017 Budget Fiscal Outlook and economic projections between 2022 and 2030 are based on Finance Canada's long term projections.

Forecasts of oil and natural gas price and production are taken from the National Energy Board's *Canada's Energy Future 2016: Update—Energy Supply and Demand Projections to 2040*—October 2016. The NEB 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 1.6% per year over 2005 through 2015, a period that includes the 2009 global recession. Real GDP growth is expected to average 1.7% per year from 2015 to 2030.

Growth in the labour force and changes in labour productivity influence Canada's real GDP. Labour productivity is expected to increase by an average of 1.1% annually between 2015 and 2020, an improvement over the 0.6% average annual growth during the period between 2005 and 2015. 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 2.3% per year between 2015 and 2020 and 1.7% between 2020 and 2030.

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 1.2% between 2015 and 2020, slowing to 1.0% per year between 2020 and 2030.

Table 5A.3: Macroeconomic Assumptions, 1990–2030 Average Annual Growth Rates

	2005–2015	2015–2020	2020–2030
Gross Domestic Product	1.6%	1.7%	1.7%
Consumer Price Index	1.8%	1.9%	2.0%

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

- **Household formation:** This is the main determinant of energy use in the residential sector. The number of households is expected to increase on average by 1.4% per year between 2015 and 2020 and by an average of 1.0% 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 1.1% per year between 2005 and 2015, and is projected to slow to 0.9% per year between 2015 and 2020 and then further slow to 0.7% 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 share 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 divergence 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 "with measures" scenario is anchored by the world oil price assumptions developed by the NEB. According to the NEB, the world crude oil price for WTI is projected to rise from about 62 Canadian dollars (C$) per barrel of oil (bbl) in 2015 to about C$81/bbl in 2020 and C$89/bbl in 2030. Higher and lower price scenarios are used for the sensitivity analysis in Annex 3 of this Chapter.

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 Canadian NEB expects the bitumen/light-medium differential to average 34% in 2020 and decline slightly to 27% in 2030.

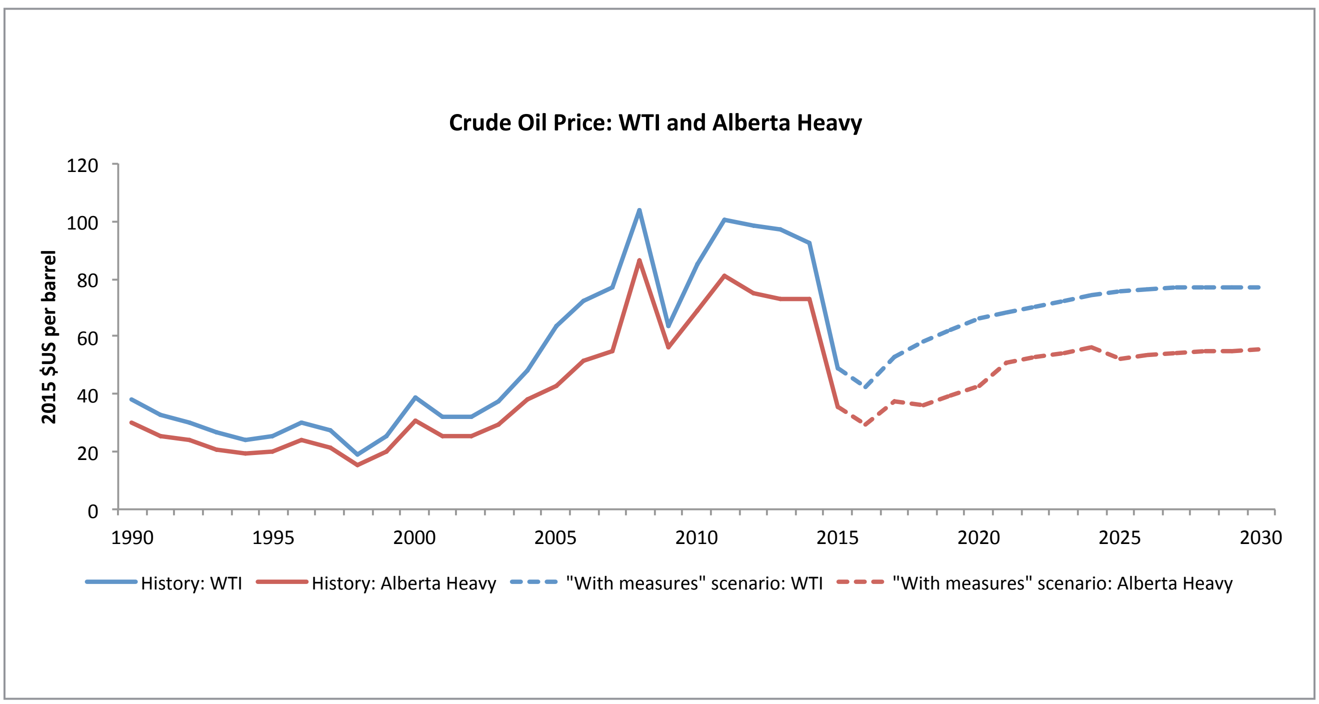

Figure 5A.1: Crude Oil Price: WTI and Alberta Heavy (US$ 2015/bbl)
Source: National Energy Board, *Canada's Energy Future 2017*.

As shown in Figure 5A.2, the Henry Hub price for natural gas in Alberta (the benchmark for Canadian prices) declined in 2015 to about three Canadian dollars per million British thermal units (MMBtu). In the projection, it begins to recover to reach about C$4.14 per MMBtu by 2020 and then C$4.70 per MMBtu by 2030.

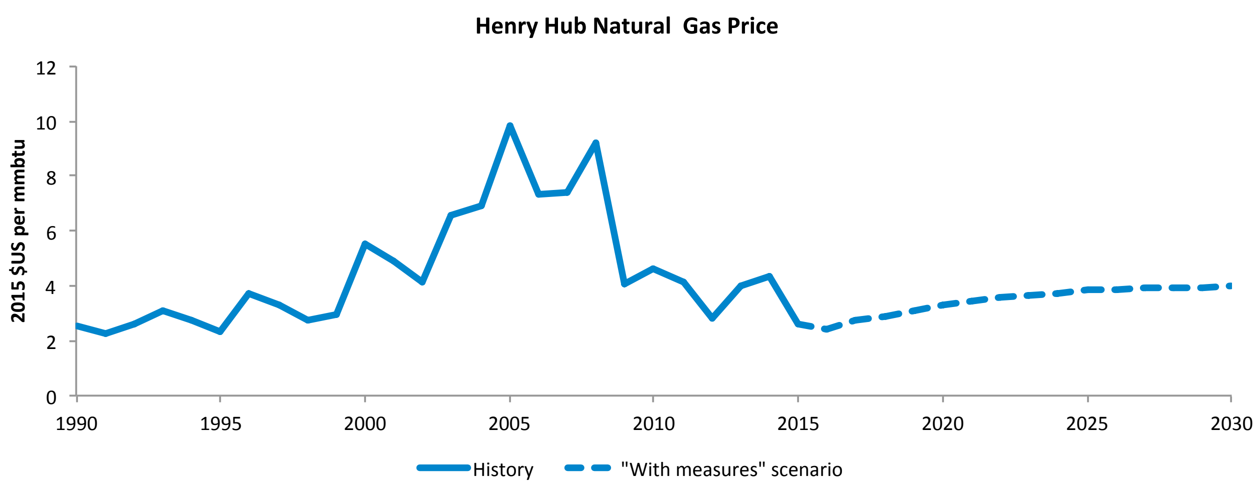

Figure 5A.2: Henry Hub Natural Gas Price ($US 2015/MMbtu)
Source: National Energy Board, *Canada's Energy Future 2017.*

Table 5A.4: Crude Oil Production (thousand barrels per day)

	2005	2010	2015	2020	2030
Crude and Condensates	**1,533**	**1,376**	**1,492**	**1,445**	**1,687**
Conventional Heavy	526	424	430	465	561
Conventional Light	511	512	654	464	640
C5 and Condensates	173	148	228	238	287
Frontier Light (offshore + northern)	323	291	181	278	199
Oil Sands	**1,065**	**1,612**	**2,526**	**3,361**	**4,236**
Oil Sands: Primary	151	194	258	302	379
Oil Sands: In Situ	288	562	1,107	1,426	2,193
Steam-assisted Gravity Drainage	83	318	843	1,100	1,752
Cyclic Steam Stimulation	205	244	263	327	441
Oil Sands Mining	627	857	1,162	1,633	1,663
Total Production (gross)	**2,598**	**2,988**	**4,019**	**4,806**	**5,923**

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

Energy and Electricity Production

NEB projections show that both conventional natural gas and conventional oil production will decrease over time as a result of declining supply, although the projected increase in production from unconventional natural gas resources and 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 2015 to 2030 oil sands *in situ* production will nearly double and oil sands mining production will increase over 40% (see Table 5A.4).

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. Table 5A.5 illustrates historical and projected oil sands disposition. Synthetic crude oil production is projected to slowly increase from about 1.1 million barrels per day (bbl p/d) in 2015 to about 1.3 million bbl p/d by 2020 and then to about 1.4 million bbl p/d by 2030. Non-upgraded bitumen will increase from 1.4 bbl p/d in 2015 to 1.9 million bbl p/d by 2020 and then to 2.7 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.5: Oil Sands Disposition (thousand barrels per day)

	2005	2010	2015	2020	2030
Oil Sands (gross)	**1,066**	**1,613**	**2,527**	**3,363**	**4,238**
Oil Sands (net)	980	1,502	2,412	3,223	4,089
Synthetic Crude Oil	611	849	1,058	1,298	1,415
Non-Upgraded Bitumen	369	653	1,354	1,925	2,674
Own Use	86	111	115	140	148

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

Projections show gross natural gas production will remain steady at about 6.8 trillion cubic feet (TCF) in 2020, as new production and non-conventional sources such as shale gas and coal-bed methane come to market[p] and offset the continued decline in conventional gas production. These new sources of natural gas production increase output to 7.1 TCF by 2030.

Table 5A.6: Natural Gas Production (billion cubic feet)

	2005	2010	2015	2020	2030
Marketable Gas	**6,264**	**5,314**	**5,453**	**5,410**	**5,717**
Natural Gas Production (Gross)	7,753	6,707	6 785	6,789	7,101
Unconventional Gas Production	2,252	2,939	3,828	4,322	5,134
Conventional Gas Production	5,501	3,767	2,958	2,467	1,967
Own Use	-1,489	-1,393	-1,332	-1,379	-1,384

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

The electricity forecast is determined by the interaction between electricity demand from end-use sectors, which changes for each sector depending on fuel and electricity prices, technology choices, efficiency changes, policy impacts, and economic driver growth, and source of electricity supplied, which depends on the historical state of each province and territory's existing supply mix as well as scheduled refurbishments and retirements, planned and modelled additions to capacity, growing industrial generation, interprovincial and international flows. Government actions further constrain supply choices in the forecast, such as the expected retirement of coal units due to the 2012 federal coal-fired electricity regulations, and renewable portfolio standards in provinces such as Nova Scotia and Alberta that mandate the addition of new renewable generation.

Gross electricity demand is projected to grow 11% from 2015 to 2030 as economic growth and fuel-switching outpace electrical efficiency improvements. However,

[p] 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.

utility electricity generation is only expected to increase by 1% over the same period. This is due to two significant supply-side changes in the forecast period. First, net exports of electricity to the U.S. fall by over half from near-historic highs in 2015 to 2030 as major exporting provinces use increasingly more electricity domestically. Second, industrial generation is projected to increase by over 40%, partly offsetting the need for utility generation to meet growing industrial electricity demands. Industrial generation includes both on-site hydropower generation, common in the aluminum industry in Québec, and cogeneration which produces electricity alongside heat and steam used for industrial processes, such as biomass combustion in the pulp and paper sector and own-use gas-fired cogeneration in the oil and gas sector. Emissions associated with industrial generation are allocated to the specific industrial sector, rather than to the electricity sector which captures only utility-generated emissions.

While total utility generation is expected to grow very slowly, the mix changes significantly between 2015 and 2030, with generation from coal, refined petroleum products such as fuel oil and diesel, and nuclear power being replaced by increasing renewables and natural gas generation. While the reduction of nuclear generation in Ontario results in some new, higher-emitting natural gas, Ontario generally replaces nuclear with non-emitting generation or imports, and most of this new natural gas goes to replacing coal in other provinces as it is phased out, reducing the emissions intensity of electricity generation in most provinces in the forecast.

Table 5A.7: Electricity Supply and Demand (Terawatt hours)

	2005	2010	2015	2020	2030
Electricity Required	**604**	**592**	**649**	**668**	**683**
Total Gross Demand	550	538	565	576	625
Purchased from Grid	502	489	504	505	546
Own Use	47	49	61	71	79
Net Exports	24	26	52	60	24
Exports	44	44	61	73	40
Imports	20	19	9	13	15
Losses	31	28	31	32	34
Electricity Produced	**604**	**592**	**649**	**668**	**683**
Utility Generation	551	539	580	588	587
Coal and Petroleum Coke	99	82	68	58	27
Refined Petroleum Products	12	4	4	4	2
Natural Gas	22	30	33	39	55
Nuclear	87	86	96	85	74
Hydro	327	321	346	355	370
Other Renewables	5	16	33	47	58
Industrial Generation	53	53	69	80	97
Refined Petroleum Products	1	<1	1	1	1
Natural Gas	17	21	33	41	54
Hydro	31	27	28	31	34
Other Renewables	4	4	7	8	8

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

Emissions Factors

Table 5A.8 provides a rough estimate of carbon dioxide equivalent emissions emitted per unit of energy consumed by fossil fuel type for combustion and industrial processes. These numbers are estimates based on latest available data based on IPCC methodology. Specific emission factors can vary slightly by year, sector, and province.

Table 5A.8: 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	74.25
Biodiesel	7.31
Biomass	5.47
Coal	90.79
Coke	110.10
Coke Oven Gas	36.25
Diesel	74.23
Ethanol	2.31
Gasoline	68.71
Heavy Fuel Oil	75.22
Jet Fuel	69.38
Kerosene	68.15
Landfill Gases/Waste	35.10
Light Fuel Oil	71.17
LPG	44.60
Lubricants	36.34
Naphtha Specialties	17.77
Natural Gas	46.80
Natural Gas Raw	57.20
Other Non-Energy Products	36.41
Petrochemical Feedstocks	14.22
Petroleum Coke	84.58
Still Gas	51.49

Federal, Provincial and Territorial Measures

Table 5A.9 identifies the major federal, provincial and territorial measures that are included when modeling the “with measures” scenario. This includes federal measures that have been implemented or announced in detail as of September 2017. 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. The Government of Canada involves provinces and territories in extensive consultations to ensure their initiatives are accounted for in analysis and modeling of emissions trends.

The “with measures” scenario does not take into account the impact of broader strategies or future measures within existing plans where significant details are still under development.

Under the Pan-Canadian Framework a number of policies and measures have been announced. As the policy development process is not yet finished, the majority of these policies were not included in the “with measures” scenario, but they were included in a “with additional measures” scenario. They are also included in Table 5A.9.

Note also that the modeled polices and measures in Table 5A.9 will not match the full list of measures included in Chapter 4: Policies and Measures 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.9: GHG Measures Reflected in "With Measures" and "With Additional Measures" Scenarios

<table>
<tr><th>PROVINCIAL/TERRITORIAL MEASURES</th><th>FEDERAL MEASURES</th></tr>
<tr><th colspan="2">"WITH MEASURES" SCENARIO</th></tr>
<tr><td>Adoption of the National Energy Code for Buildings of Canada (2010–2012) by all provinces and territories</td><td rowspan="10">• Reduction of carbon dioxide emissions from coal-fired generation of electricity regulations announced in 2012
• Federal Budget 2016: Supporting Energy Efficiency and Renewable Energy Development. Increase efficiency of residential and commercial devices (including refrigeration, freezers, ranges, dryers) through regulations and ENERGY STAR certification (Amendment 14)
• Equipment Standards (Amendment 13)
• Voluntary emission reductions for planes and trains
• Light-duty vehicles 1 (LDV-1) GHG emissions standards for the light-duty vehicle model years 2011 to 2016
• Light-duty vehicles 2 (LDV-2) GHG emissions standards increases stringency for model years 2017 to 2025
• Heavy-duty vehicles 1 (HDV) GHG emissions standards for heavy-duty vehicle model years 2014 to 2018
• Heavy-duty vehicles 2 (HDV) GHG emissions standards for heavy-duty vehicle model years 2021 to 2027 and trailers
• Regulations Amending the Ozone-depleting Substances and Halocarbon Alternatives Regulations
• Regulations Respecting Reduction in the Release of Methane and Certain Volatile Organic Compounds (Upstream Oil and Gas sector)</td></tr>
<tr><td>Renewable Fuel Content across all provinces and territories (except for Newfoundland and Labrador, Yukon, the Northwest Territories and Nunavut)</td></tr>
<tr><td>Newfoundland
• Muskrat Falls hydro project</td></tr>
<tr><td>Nova Scotia
• Cap on GHG emissions from the electricity sector
• Renewable portfolio standard for electricity generation
• Electricity demand-side management policies
• Solid Waste-Resource Management Regulations</td></tr>
<tr><td>New Brunswick
• Renewable Portfolio Standard</td></tr>
<tr><td>Québec
• Western Climate Initiative cap-and-trade regime
• 5% ethanol objective in gasoline distributors fuel sales
• Drive electric program
• Landfill gas regulation
• Eco-performance program for industry
• Program to support energy efficiency improvements in marine, air and rail transport (PETMAF)
• Program to reduce/avoid GHG emissions by using intermodal transportation (PREGTI)
• Program Écocamionnage</td></tr>
<tr><td>Ontario
• Western Climate Initiative cap-and-trade regime
• Residential electricity peak savings (time-of-use pricing)
• Feed-in tariff program
• Landfill gas regulation (O. Reg. 216/08 and 217/08)
• Strategy for a Waste-free Ontario
• Independent Electricity System Operator contracted electricity supply
• Nuclear refurbishment
• Energy Storage Contract with Québec
• Ontario Natural Gas 2015–2020 Conservation Framework
• Ontario Electricity 2015–2020 Conservation Framework
• Ontario Electric Vehicle Chargers Ontario, Electric Vehicles Incentive Program (EVIP) and Electric and Hydrogen Vehicles Advancement Partnership (EHVAP)</td></tr>
<tr><td>Manitoba
• Emissions tax on coal
• Manitoba Building Code Section 9.36 (for housing)
• Manitoba Composts program</td></tr>
<tr><td>Saskatchewan
• Boundary Dam 3 Carbon Capture Project
• Uniform Building and Accessibility Standards Regulations (2013)</td></tr>
</table>

PROVINCIAL/TERRITORIAL MEASURES	FEDERAL MEASURES
Alberta • Specified Gas Emitters Regulations transitioning to the Emissions Performance Standards in 2018 • Carbon levy • Coal Phase-Out by end of 2030 • 100 Mt cap for oil sands • Renewable Electricity Program • Quest carbon capture and storage project • Carbon Trunk Line Project–CO_2 capture and use for enhanced oil recovery • Energy efficiency requirements for housing and small buildings, section 9.36 of the 2014 Alberta Building Code edition • Municipal Waste Annual Disposal Targets	
British Columbia • Carbon tax increasing to $35 in 2018, $40 in 2019, $45 by 2020 and $50 in 2021 • British Columbia Cement Low Carbon Fuel Program • Renewable and Low Carbon Fuel Requirements Regulation (10% reduction in CI by 2020) • Landfill gas management regulation • British Columbia Clean Energy Act: Clean or renewable electricity requirement–100% of electricity from clean or renewable sources by 2025 • Revisions for energy efficiency of large residential and commercial buildings (Part 3) (reg # 167/2013) • Revisions for energy efficiency of housing and small buildings (Part 9) (reg # 173/2013) • City of Vancouver Building Codes • Clean Energy Vehicles Program (Phase 1, 2, Phase 3 and Beyond) and support for zero emissions vehicle charging stations in buildings • Step Code: Increased Energy Efficiency Requirements in the Building Code • Municipal Waste disposal target and organic waste disposal restriction	
Northwest Territories • Biomass Strategy	
"WITH ADDITIONAL MEASURES" SCENARIO	

<table>
<tr><th>PROVINCIAL/TERRITORIAL MEASURES</th><th>FEDERAL MEASURES</th></tr>
<tr><td>Ontario and Québec
• WCI credits (Assumes Ontario and Québec meet their legislated emissions targets through purchases of WCI allowances.)</td><td rowspan="3">• Federal Backstop Carbon Pricing
• Clean Fuel Standard
• Accelerated Coal Phase Out by 2030
• Accelerating Industrial Energy Efficiency Management
• Low-Carbon Economy Fund
• Performance standards for natural gas electricity generation
• Strategic Interconnections in electricity
• Emerging renewables and smart grids
• Off-diesel energy systems in remote communities
• Net-zero energy ready building codes (for new commercial and residential buildings) by 2030
• Labelling and codes for existing buildings (retrofits)
• More stringent Energy Efficiency Standards for appliances and equipment
• Regulations for off-road industrial, commercial, residential and recreational vehicles
• Post-2025 LDV regulations and ZEV Strategy
• Increased use of wood in buildings construction</td></tr>
<tr><td>Saskatchewan
• SaskPower Renewable Electricity Target</td></tr>
<tr><td>British Columbia
• BC's electrification of natural gas sector
• Increasing the Low Carbon Fuel Standard (15% reduction in carbon intensity by 2030)
• New Energy Efficiency Standards for Gas Fired Boilers</td></tr>
</table>

Canadian provinces and territories have committed to taking action on climate change through various programs and regulations. In the "with measures" scenario, provincial and territorial targets are not modelled. 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.10 lists the emissions reductions targets announced by each province or territory.

Table 5A.10: Announced GHG Reduction Targets of Provincial/Territorial Governments

PROVINCE/TERRITORY	TARGET IN 2020	TARGET IN 2030	TARGET IN 2050
Newfoundland	10% below 1990	35% to 45% below 1990	
Prince Edward Island	10% below 1990	35% to 45% below 1990	75% to 85% below 1990 levels in the long term
Nova Scotia	10% below 1990	35% to 45% below 1990	
New Brunswick	10% below 1990	35% to 45% below 1990	
Québec	20% below 1990	37.5% below 1990	
Ontario	15% below 1990	37% below 1990	80% below 1990
Manitoba	15% below 2005	30% below 2005	50% to 80% below 2005
Saskatchewan	20% below 2006		
Alberta	50 Mt below BAU		200 Mt below BAU
British Columbia	33% below 2007		80% below 2007
Nunavut	No Territorial target announced		
Yukon	Carbon neutral		
Northwest Territories	No Territorial target announced		

Annex 2: Modeling and Methodological

Modeling and Methodological Differences from Canada's 2nd Biennial Report

- A new methodology to model solid waste disposal emissions was developed to better capture the effects of population growth, waste diversion, and landfill gas capture on projected emissions.
- Improvements to the alignment between different measures of GDP increased the growth rates of sectors driven by regional GDP, such as freight transportation.
- Electricity transmission and distribution line losses were revised to reflect real historical transmission and distribution losses by province and territory rather than utilizing a Canadian average.
- A new module was developed to simulate the emissions from the production of liquid biofuels—ethanol and biodiesel—used primarily for transportation.
- The historical calibration procedure was changed for the buildings sector so that historical process efficiency improvements were captured in the process efficiency variable rather than non-price factors. The overall efficiency trends in the U.S. National Energy Modeling System (NEMS) were also applied to building sector device efficiencies.
- In the previous forecast, all HFCs were driven at the same growth rate; now, transportation-related HFC emissions are split out and grown at a separate growth rate. This new, lower growth rate captures the shift away from using HFCs in automobile air conditioning, which helps manufacturers comply with the LDV regulations. As a result, transportation HFCs are lower and buildings HFCs are higher; although the HFC regulation reduces HFC emissions in all scenarios.
- The current forecast includes new assumptions related to ZEV sales up to 2030 in all provinces and territories based on regional preferences and existing incentives. The modeling approach has also been improved, and now captures with more precision the expected uptake in ZEV sales in all provinces and territories.
- In the previous forecast, LDV regulations were modelled as an efficiency standard for gasoline and diesel vehicles only. For 2017, the impact of increased ZEV uptake has been incorporated and this change increases GHG emissions in the current forecast. The phase-out of HFCs in passenger vehicle air conditioners was also incorporated as a compliance mechanism for LDV2. Vehicle manufacturers get credits that can be applied to meeting the LDV2 efficiency standard. This was modelled as a small decrease in gasoline and diesel vehicle efficiencies. There is no net change in GHG emissions as a result of this change, though HFC emissions are down and combustion emissions are higher.
- Fuel demands associated with industrial and commercial cogeneration in the history were split between electricity production and steam/heat production rather than assigned to only electricity generation, allowing for more accurate representation of the relative efficiency of cogeneration in the model.
- Previous modelling of growth of industrial generation in the forecast was limited to particular sectors and generation technologies. A more holistic approach now adds industrial generation proportionate to growth in energy demands and relative to the utility price of electricity in all sectors with self-generation in the historical data.
- The Western Climate Initiative (WCI) has been remodeled. Until now, the cap-and-trade was modeled as a carbon tax in line with the expectations of the price of allowances. This year, the WCI has been remodeled as a proper cap-and-trade system with all the available compliance mechanisms, including offsets, and all participating jurisdictions, including not only Québec and Ontario but also California. This allows us to more properly capture the dynamics of the cap-and-trade, including the reductions occurring from the system and the trading of allowances. As well, the price assumptions of the cap-and-trade

allowances have been revised in line with the latest expectations based on analysis by California Carbon. These improvements are all driving further reductions compared to the previous forecast.

- The modeling of the building codes has been improved and now better reflects the stringency of the different building codes implemented by the provinces. The model was improved to facilitate the addition of geothermal heat pumps and solar photovoltaics.
- Historical building-related device efficiencies were revised and updated, subject to availability.
- Natural gas pipeline drivers were changed to specifically reflect the best-correlated driver for each province and territory.

Annex 3: Alternate Emissions Scenarios

Given the uncertainty regarding the key drivers of GHG emissions, the emissions projections for the "with measures" scenario presented in Figure 5.1 should be seen as one estimate within 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 impact on macroeconomic growth and energy consumption.

In Table 5A.11, 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.

Table 5A.11: Sensitivity Analysis

SCENARIO	GHG EMISSIONS IN 2030	DIFFERENCE BETWEEN 2005 AND 2030
Fast GDP—High World Oil Prices	793	44
High World Oil Prices	777	28
Fast GDP	746	-2
With Measures	722	-27
Slow GDP	691	-58
Low World Oil Prices	685	-64
Slow GDP—Low World Oil Prices	651	-98
Range	651 to 793	-98 to 44

In our scenario with slow GDP, slow population growth and low world oil prices, GHG emissions could be as low as 651 Mt CO_2 eq by 2030 on the low end and 793 Mt CO_2 eq on the high end. This represents a range of 142 Mt CO_2 eq.

The oil and gas price and production assumptions come from the NEB's 2017 high and low scenarios. The fast and slow GDP assumptions were derived from the 2017 *Annual Energy Outlook* by the U.S. Energy Information Agency. As for the population growth assumptions, they were derived by applying the relative differences between Statistics Canada's 2013 high, M1 and low scenarios to the population growth from our "with measures" scenario.

Figure 5A.3 illustrates how differing price and GDP growth assumptions in various combinations might impact Canadian GHG emissions through 2030.

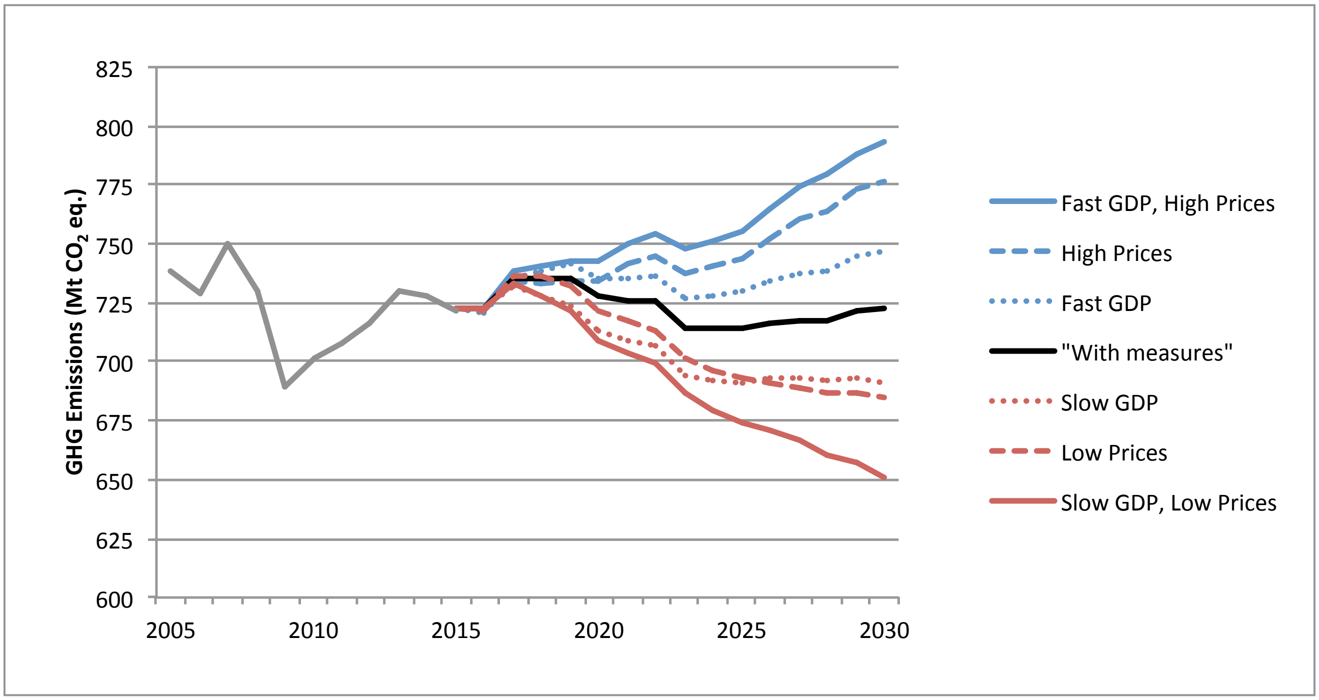

Figure 5A.3: Projected GHG Emissions under Full Range of Alternative Economic Assumptions (excluding LULUCF)

In all of these scenarios, 2015 is the last year of historical data. In 2017, the different scenarios already start to diverge. By 2020, there is already a 33 Mt CO_2 eq range in emissions which stretches out to 142 Mt CO_2 eq in 2030. In 2023, there is a noticeable drop in emissions in all seven of the scenarios, due to the federal methane regulation.

Note that the high and fast scenarios cross around 2020 and the slow and low scenarios cross around 2025. For the low and slow scenarios, this crossing can be explained by the lag between the effect of slow GDP growth on heavy industry and the effect of low world oil price on oil and gas. Since growth of our heavy industry sector is closely tied to that of GDP, the slow GDP growth scenario has much lower emissions in the heavy industry sector compared to the "with measures" scenario. When world oil prices are low, Canada's oil and gas production suffers, but its heavy industry sector grows a bit due to lower fuel costs. The opposite is true for the fast growth and high price scenarios.

Table 5A.12 contains a sectoral breakdown of the 2030 emissions levels in the various alternate emission scenarios.

Table 5A.12: Projected Difference in GHG Emissions Between the "With Measures" Scenario and the Alternate Emission Scenarios by Sector (excluding LULUCF) in Mt CO_2 eq in 2030

SECTOR	FAST GDP–HIGH WORLD OIL PRICE	HIGH WORLD OIL PRICES	FAST GDP	SLOW GDP	LOW WORLD OIL PRICES	SLOW GDP–LOW WORLD OIL PRICES
Oil and Gas	60	60	0	0	-49	-49
Electricity and Steam	7	5	3	-4	-2	-6
Transportation	4	0	8	-8	1	-7
Heavy Industry	-2	-11	10	-16	9	-9
Buildings	1	0	1	-1	1	0
Agriculture	0	0	0	0	0	0
Waste and Others	1	0	2	-2	2	-1
Grand Total	**71**	**55**	**24**	**-31**	**-37**	**-72**

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

The range of oil and gas emissions between scenarios is 109 Mt of CO_2 eq. This represents about 75% of the total range of emissions in the alternate emissions scenarios, reflecting the sector's overall contribution to Canadian emissions and its sensitivity to the highly uncertain driver of world oil and gas prices.

Annex 4: Methodology for Development of Emissions Scenarios

The scenarios developed to support 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. With the exception of the "with additional measures" scenario, the projections also assume no further government actions to address GHG emissions beyond those already in place as of September 2017.

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 (E3MC).

Up-to-date Data and Key Assumptions

Each year, ECCC 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. Historical emissions are aligned to the latest NIR. For these projections, the most recent historical data available were for 2015.

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:

- NEB views on energy prices and large-scale energy projects.
- Economic projections (including GDP, exchange rates and inflation) to 2021 are calibrated to Finance Canada's March 2017 Budget Fiscal Outlook. Economic projections between 2022 and 2030 are based on Finance Canada's long term projections.
- Statistics Canada's population growth projections.[q]

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.

Energy, Emissions and Economy Model for Canada

The projections presented in this chapter were generated from ECCC'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, multisector 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,

[q] Population forecasts are based on Statistics Canada projections, the M1 median growth scenario released in May 2015, and based on the 2011 census. These projections have been updated and adjusted based on provincial consultations.

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_4 and N_2O) by sector and by province.

Figure 5A.4 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.

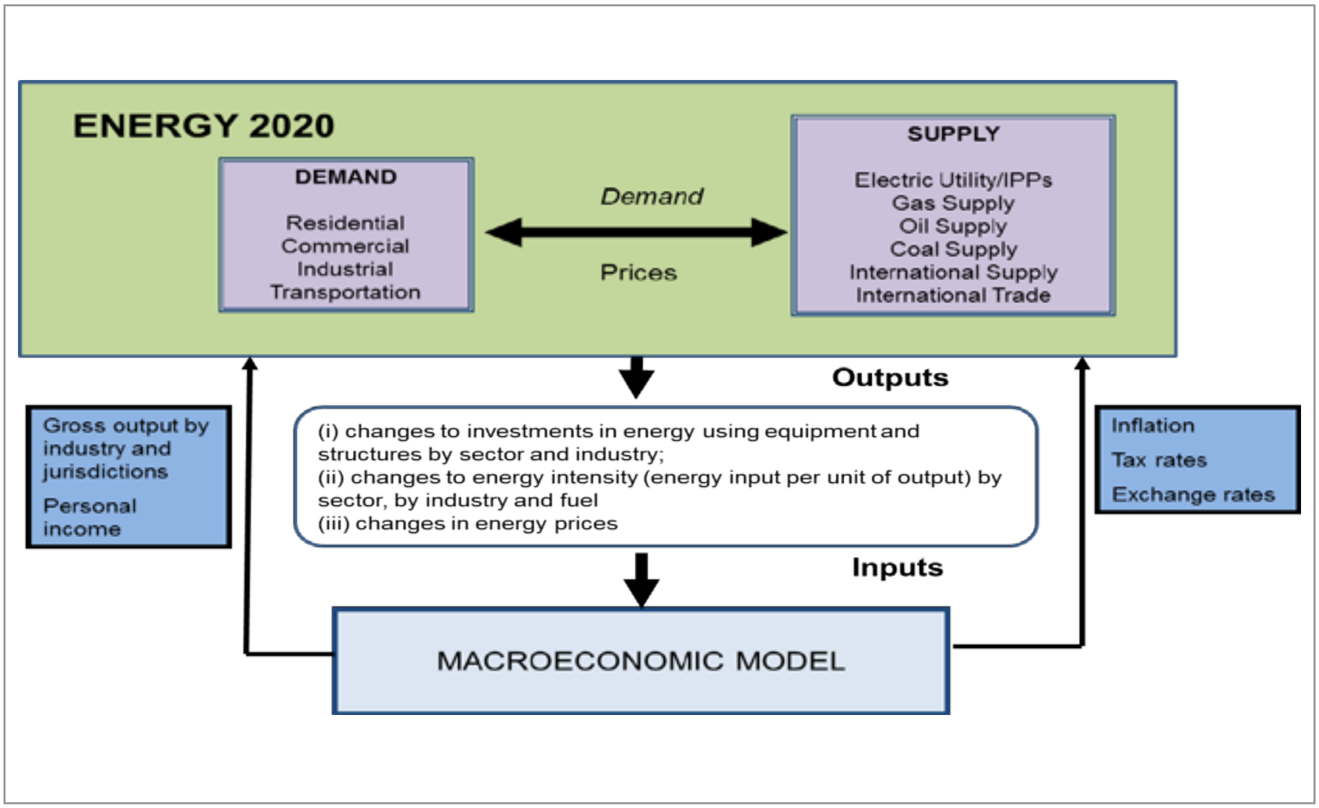

Figure 5A.4: Energy, Emissions and Economy Model for Canada

To develop this projection of energy use and related emissions, it was necessary to provide a view of the Canadian economy to 2030. 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 "with measures" scenario: 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 "with measures" scenario. 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.[r] 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

[r] 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.

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 and Endogenous Technological Change

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 ECCC, does not generate changes in nominal interest rates and exchange rates, as would occur under a monetary policy response to a major economic event.

Annex 5: Further Sources

Canada produces three products that report on GHG 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 GHG inventory covering anthropogenic emissions by sources and removals by sinks. The Report is prepared with input from numerous experts and scientists across Canada.

2. *Facility GHG Emissions Reporting*

The GHG Emissions Reporting Program (GHGRP) is Canada's legislated, publicly accessible inventory of facility-reported GHG (GHG) data and information. Unlike the NIR, which compiles GHG data at a national level and is developed from national and provincial statistics, the GHG Reporting Program applies only to the largest GHG emitters in Canada (industrial and other types of facilities). Through the GHG Reporting Program, all facilities that emit the equivalent of 50 kt CO_2 eq or more of GHGs per year are required to submit a report to ECCC.

3. *Canada's GHG Emissions Reference Case*

Canada's GHG Emissions Reference Case is a projection of GHG emissions to the year 2030, 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.

The NEB's *Canada's Energy Future* forms the basis for the oil and gas sector modeling. This report 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 NEB provides data on energy prices, factors affecting prices and the deliverability of natural gas. Data and projections from the NEB are incorporated into the exogenous oil and gas module in E3MC.

CHAPTER 6

Vulnerability Assessment, Climate Change Impacts and Adaptation Measures

The impacts of climate change are being felt across Canada. Ongoing climate change poses significant risks to communities, public safety, health and well-being, the economy, and the natural environment. Mobilizing action on adaptation helps protect Canadians from climate change risks, build resilience, and ensure that society thrives in a changing climate.

Climate resilience is the ability to survive and prosper in the face of the new climate reality. Adaptation is key to achieving climate resilience, and is about making informed, forward looking decisions in response to climate change, in order to moderate harm or take advantage of new opportunities. Implementing effective adaptation measures saves lives, minimizes damage, and lowers costs over the long term for individuals, businesses, organizations, and governments.

Adapting to climate change impacts is a shared responsibility. Governments, communities, the private sector, academia, the non-profit sector, professional organizations, and individuals all have important roles to play in building resilience to climate change. In Canada, there is growing awareness of the impacts of climate change and the value of adaptation, and there are examples of initiatives being advanced across the country.

This chapter provides an overview of progress on adaptation in Canada since *Canada's 6th National Communication* (2014). It includes a brief overview of climate change impacts in Canada and outlines key programs, policies, strategies, and frameworks related to adaptation implemented domestically and internationally by federal, provincial, territorial, municipal, and Indigenous governments and Indigenous Peoples.

Key Developments since 2014

As described elsewhere in this report, Canada's First Ministers adopted the Vancouver Declaration on Clean Growth and Climate Change on March 3, 2016. Under the Vancouver Declaration, First Ministers committed to build on the momentum of the Paris Agreement by developing a concrete plan to achieve Canada's international commitments through a Pan-Canadian Framework on Clean Growth and Climate Change.

The Government of Canada became a signatory to the Paris Agreement on October 5, 2016, and committed to continuing to enhance its domestic adaptation activities and supporting international adaptation actions for developing countries.

The Pan-Canadian Framework on Clean Growth and Climate Change was adopted on December 9, 2016 by federal, provincial, and territorial governments.[a] The Pan-Canadian Framework sets out a collaborative plan for building resilience to climate change, encouraging clean economic growth, and reducing GHG emissions.

In 2016, the Government of Canada announced funding over five years (2016–2021) for seven federal departments and agencies to implement federal adaptation programming, and to integrate climate resilience into building design guides and codes.

Building on 2016 adaptation investments, in 2017 the Government of Canada announced funding over five years (2017–2022) for a suite of adaptation and climate resilience programs to protect communities and all Canadians from the risks associated with climate change. The Government of Canada also announced green infrastructure funding, a significant portion of which will help communities prepare for challenges that result from climate change. This includes significant investments in a Disaster Mitigation and Adaptation Fund to support large-scale national, provincial and municipal infrastructure projects that are resilient to the effects of a changing climate.

Provinces and territories have recognized the need to adapt either through stand-alone plans or strategies or as part of broader climate change plans or strategies and have made investments to support adaptation initiatives.

At the local level, cities and communities are actively planning for climate risks including, for example, through the development of adaptation strategies that inform city planning and infrastructure decisions and encourage action by homeowners and businesses.

Indigenous Peoples are also taking adaptation action, in the form of, for example, the development of community plans and hazard maps, and specific actions to maintain cultural practices and engage youth.

In the private sector, some companies are integrating climate considerations into their investment, planning, and operational decisions in order to improve their long-term resilience and competitiveness. Professional associations (e.g., engineers, planners, accountants, insurers, foresters) are working to inform and equip their members to be able to address a changing climate within their professional practice.

Banks are also beginning to engage in climate change risk reporting. Toronto-Dominion Bank and Royal Bank of Canada are among 14 of the world's leading banks to work with the United Nations Environment Programme Financial Initiative to develop better climate-risk assessments for financial institutions.

[a] Manitoba and Saskatchewan did not join the Pan-Canadian Framework at this time.

6.1 Climate Modelling, Projections, and Scenarios

Temperatures in Canada have been increasing at roughly double the average global rate, with average temperatures in Canada having already increased by 1.7°C since 1948.[1,2] Warming has been observed consistently across most of Canada, and across all seasons, but with stronger trends in the north and west, and in winter and spring.[3] Annual average precipitation has also changed in Canada with most of the country (particularly the North) having experienced an increase in precipitation since the mid-20th century. The strong regional and seasonal variability in precipitation is illustrated in Figure 6-1.

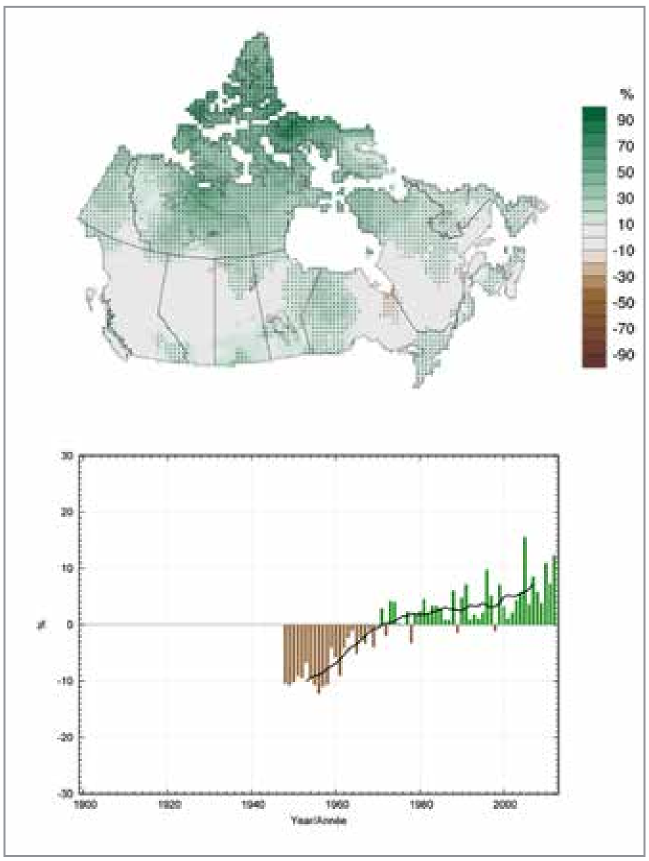

Figure 6-1: Annual total precipitation 1948–2012
The upper panel shows linear trends in annual total precipitation (expressed as per cent change relative to the local 1961–1990 climatology) for the period 1948–2012 for all of Canada. Grid squares with trends statistically significant at the 5% level are marked with a dot. Note that the distribution of observing stations over northern Canada is sparse. The bottom panel shows the time series and the 11-year moving average for Canada (Vincent et al., 2015[4]).

Future climate projections for Canada, fully consistent with those used in the IPCC Fifth Assessment Report (AR5), are developed by Environment and Climate Change Canada's Climate Research Division and made available to Canadians through the Climate Data and Scenarios website.

Continued amplification of warming at high latitudes compared to the global average is projected under all scenarios of future climate change; therefore, Canada's temperature will continue to warm at a faster rate than the world as a whole. Within Canada, climate change is not projected to be uniform, with both seasonal and geographic differences in rates of projected warming. The strongest warming is projected for winter and for northerly latitudes, a robust result consistent across all scenarios.

See Figure 6-2 for climate projections under a scenario based on a mid-range global GHG emissions scenario (e.g., Representative Concentration Pathway (RCP) 4.5).

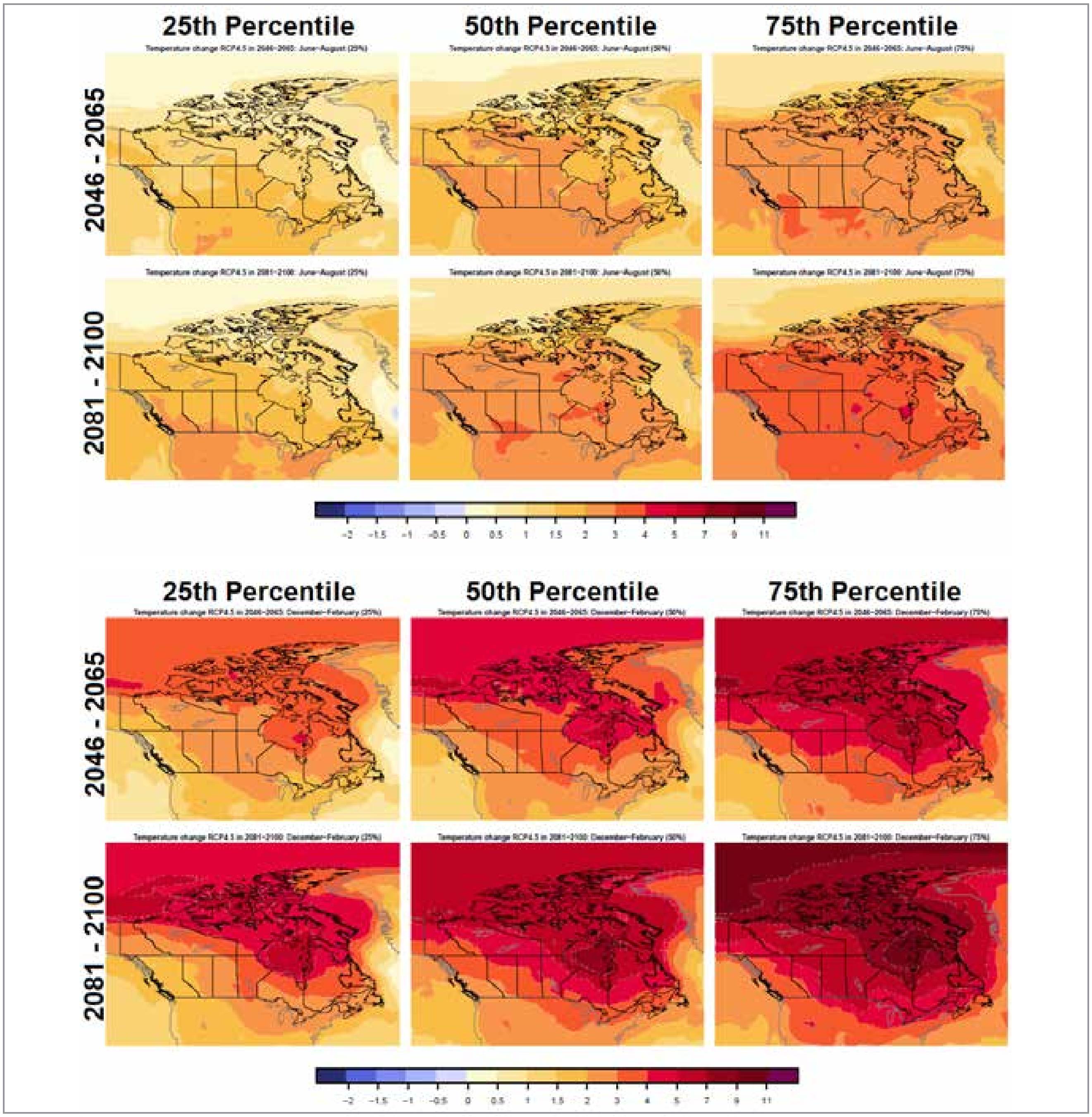

Figure 6-2: Temperature Change Projected by the CMIP5 Multi-Model Ensemble for the RCP4.5 Scenario; Summer and Winter

Maps of temperature change projected by the Coupled Model Intercomparison Project (CMIP5) multi-model ensemble for the RCP4.5 scenario, for summer (top frame, averaged over June–August) and winter (bottom frame, averaged over December-February). Change is computed relative to the 1986–2005 baseline period.[5] As in the IPCC Atlas (Annex 1, IPCC, 2013),[6] the top row shows results for the period 2046–2065, and the bottom row for 2081–2100. For each row the left panel shows the 25th percentile, the middle panel the 50th percentile (median), and the right panel the 75th percentile. The color scale indicates temperature change in °C with positive change (warming) indicated by yellow through red colors and cooling by blue colors, consistent with the color scale used in the IPCC AR5 Annex I.

Figure 6-3 below provides a projection of changes in summer and winter precipitation for Canada under a mid-range GHG emissions scenario (RCP4.5). Relative precipitation increases (% changes) are larger in the north and in winter versus summer.

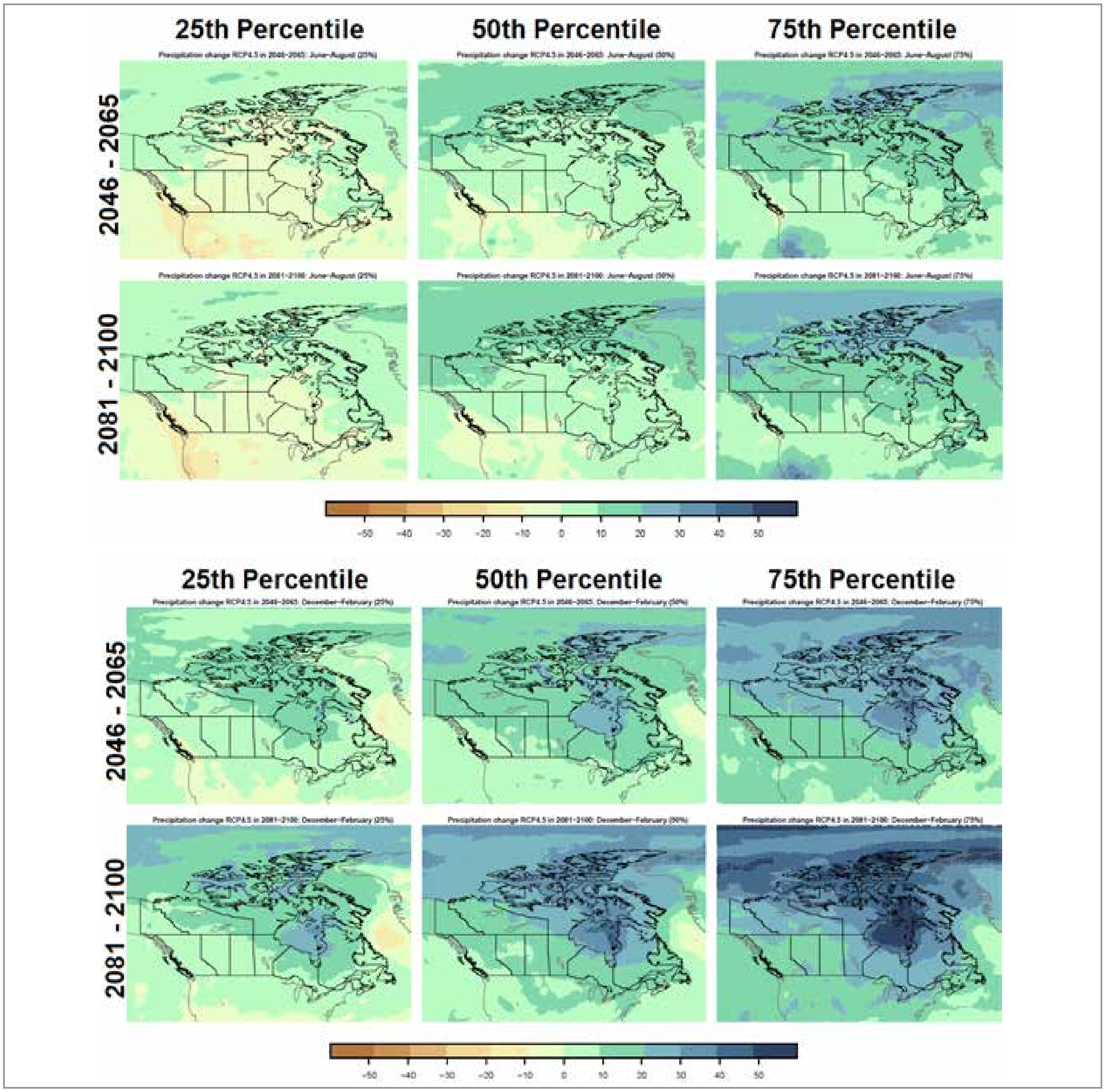

Figure 6-3: Precipitation Change Projected by the CMIP5 Multi-Model Ensemble for the RCP4.5 Scenario; Summer and Winter

Maps of precipitation change projected by the CMIP5 multi-model ensemble for the RCP4.5 scenario, for summer (top frame, averaged over June–August) and winter (top frame, averaged over December-February). Change is computed relative to the 1986–2005 baseline period.[7] As in the IPCC Atlas (Annex 1, IPCC, 2013),[8] the top row shows results for the period 2046–2065 and the bottom row for 2081–2100. For each row the left panel shows the 25th percentile, the middle panel the 50th percentile (median), and the right panel the 75th percentile. The colour scale indicates precipitation change in % with positive change (increased precipitation) indicated by green colours and decrease by yellow to brown colours, consistent with the colour scale used in the IPCC AR5 Annex I.

Overall, Canada can expect to continue to experience warmer temperatures and more rainfall across the country as a whole, although regional and seasonal variability will continue. Associated with these trends in average temperature and precipitation are projected increases in daily hot extremes and heavy rainfall events, and declines in snow and ice cover (see section 6.2.2.2 on Canada's North).[9] Sea level along many of Canada's coastlines will continue to rise, and this rise will be greatest in areas where the land is currently eroding, such as most of the Maritime Provinces. Warmer waters and ocean acidification are expected to become increasingly evident in most Canadian ocean waters over the next century.[10]

The impacts being observed are the result of historical emissions. Even with a successful transition to a carbon-neutral society, the impacts of changing temperature, precipitation, and the occurrence and severity of extreme events will continue to touch all regions, sectors, communities, and ecosystems for decades to come.

6.2 Assessment of Risk and Vulnerability to Climate Change Impacts

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.

Since Canada's *6th National Communication*, more Canadian governments and communities 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. While there has been no systematic attempt to conduct risk or vulnerability assessments across Canada, a number of individual initiatives employing a wide range of methodologies have been undertaken.

The consequences of climate change are evident across Canada, and include impacts to natural and built environments, as well as to the safety, health, socio-economic, and cultural well-being of Canadians. These impacts have high human and financial costs, and are already causing rapid and irreversible change in Canada's northern and coastal regions. These threats are often more acute for some Indigenous Peoples, who live closer to the land, with a strong socio-economic and spiritual connection to it. These changes have been well documented in several assessment reports (for example, *Canada in a Changing Climate: Sector Perspectives on Impacts and Adaptation, Canada's Marine Coasts in a Changing Climate, Climate Risks & Adaptation Practices for the Canadian Transportation Sector 2016)*.

This section outlines assessments conducted by federal, provincial, territorial, and municipal governments, and Indigenous Peoples and provides a brief summary of some impacts of concern identified by assessments, focusing on extreme events, northern and coastal regions, Indigenous Peoples, food and water security, health and well-being, and economic prosperity.

6.2.1 Assessments of Risk and Vulnerability to Climate Change

Assessments have been performed by the Government of Canada as a tool to further highlight the importance of understanding and addressing climate change impacts. These assessments are scientific reports that assess, critically analyze, and synthesize the growing knowledge base on the issue. Working with subject matter experts in government, universities, and non-government organizations, federal departments produce science assessments that are current, relevant, and accessible sources of information to help inform planning of policies, programs, and actions.

Fisheries and Oceans Canada completed four Large Aquatic Basin Risk Assessments covering the Pacific, Arctic, Atlantic Oceans and Canada's inland waters represented by the Lake Winnipeg and Great Lakes' drainage systems. Each large basin assessment included an analysis of climate trends and projections for the aquatic environment in order to help managers make strategic, climate-sensitive decisions about aquatic resource management activities and coastal infrastructure which are at risk to a changing climate.

Natural Resources Canada published a national-scale scientific assessment on the impacts of climate change in Canada in 2014, titled Canada in a Changing Climate: Sector Perspectives on Impacts and Adaptation. This report was an update to the 2008 report, titled *From Impacts to Adaptation: Canada in a Changing Climate*. The updated report took a sector-based approach, and focused on natural resources (e.g., forestry, mining, and energy), food production, industry, biodiversity and protected areas, human health, and water and transportation infrastructure. This assessment illustrated how Canada's climate is changing and will continue to change, and how adaptation has been accepted as a necessary response to climate change, complementing global measures to reduce GHG emissions.

Natural Resources Canada also published a sectoral assessment focused on marine coasts in 2016, titled *Canada's Marine Coasts in a Changing Climate*. This assessment emphasized the impacts of climate change on Canada's coasts, and presented both the challenges and potential opportunities for coastal communities, ecosystems, and the economy as a result of these changes. The assessment highlighted a variety of adaptation measures that are being adopted in different coastal regions, such as presenting enhanced use of natural infrastructure as an alternative to hard coastal protection measures to reduce climate risks, and emphasized the importance of adaptation in ensuring the sustainability and continued prosperity of Canada and its coastal regions.

Transport Canada released a national-level assessment of climate risks and adaptation practices for the Canadian transportation sector in 2017, titled *Climate Risks & Adaptation Practices for the Canadian Transportation Sector 2016*. The report represents the state of knowledge on climate risks to the sector and identifies existing or potential adaptation measures to mitigate risks. The report is structured regionally, with a synthesis chapter that brings together knowledge relevant to each main mode of transportation (e.g., rail, marine, aviation, road), as well as a chapter specifically dedicated to urban transportation. The information will help decision-makers across the sector better understand potential climate risks and the actions that can be taken to mitigate them.

The Government of Canada also supports sectors, provinces, territories, and communities in conducting their own assessments. For example, through the AgriRisk Initiatives program, Agriculture and Agri-Food Canada is supporting the agriculture sector in developing regional climate vulnerability and opportunity assessments to evaluate potential climate change impacts on local agricultural production.

Together with the governments of the Northwest Territories and of Nunavut, the Government of Canada assessed infrastructure engineering vulnerabilities of three northern airports (Churchill Airport, Inuvik Airport and Cambridge Bay Airport), using the Public Infrastructure Engineering Vulnerability Committee (PIEVC) Protocol. The knowledge gained through these assessments is intended to inform asset management plans, investment plans, and other decision-making relevant to these assets.

The Government of Yukon is developing better methodologies for assessing the financial impacts of permafrost thaw, and experimenting with new approaches to building and maintaining infrastructure on permafrost-affected terrain. The territory has also performed risk and/or vulnerability assessments, disaster resiliency planning, and is actively monitoring permafrost temperatures and identifying intervention opportunities to mitigate impacts with the help of the Yukon Permafrost Knowledge Network.

Assessments are often the first stage of municipal adaptation planning processes. For example, the municipality of Wawa, Ontario brought together varied stakeholders from across the community to come together and identify local climate change impacts. Using this information they then worked through a process of vulnerability and risk assessment and they will use the results to protect Wawa's community by integrating the identified climate risks into their broader *Emergency Preparedness Plan*.

Similarly, Calgary and Edmonton, Alberta, worked with the Prairie Climate Centre to create a series of publications for the public and government officials that explore how to build cities that are resilient to the impacts of climate change, drawing on lived experience and best practices. The reports touch on climate change and its local impacts on a number of sectors, including economics and finance, agriculture and food security, urban ecosystems, transportation, water supply, and electricity.

While important, assessments of adaptation planning in Indigenous and northern communities have occurred on a predominantly ad-hoc basis. Despite this the Government of Canada, as well as provincial, territorial and municipal governments, contribute to increasing northern and Indigenous Peoples' resilience to climate change by supporting them in the identification of high risk areas for climate change impacts. Indigenous and Northern Affairs Canada has provided financial support to communities to engage in a variety of planning activities including: gathering traditional knowledge, participating in regional planning activities, producing Indigenous-specific tools and guides and conducting vulnerability assessments and adaptation plans.

6.2.2 Climate Change Impacts

Assessments present the latest knowledge on climate change impacts and adaptation, and act as accessible sources of information to help inform planning of policies, programs, and actions.

6.2.2.1 Extreme Weather Events

Extreme weather events are a key concern for Canada and there is growing confidence that some types of extreme events will increase in frequency and/or intensity as the climate continues to warm.[11] Changes in temperature and precipitation patterns have made the wildfire season longer, while drought- and pest-stressed forests and rangelands are increasing the severity of wildland fires.[12] Sea level rise is increasing the extent of storm surge flooding.[13]

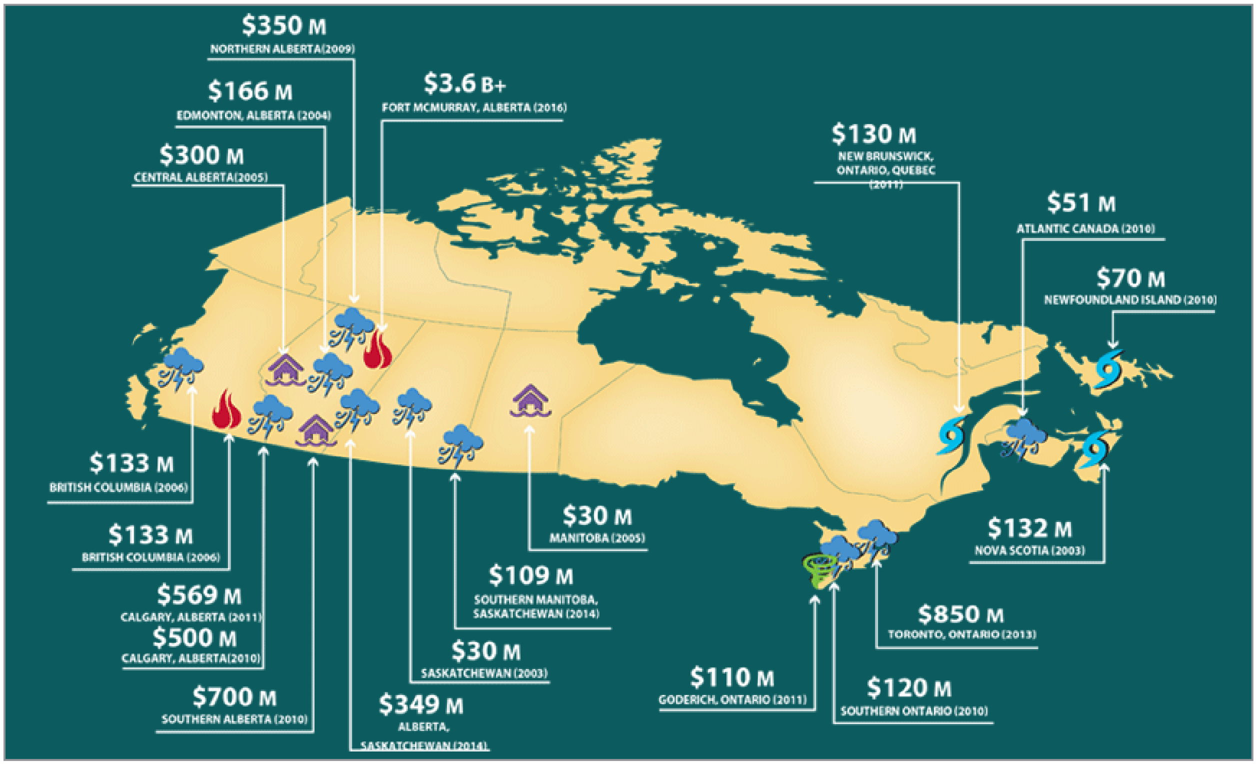

Figure 6-4: Insured Losses from Extreme Weather Events in Canada
Examples of insured losses from extreme weather events in Canada (Sources: Updated from Kovacs and Thistlethwaite, 2014[14])

Recent examples demonstrate the potentially devastating effects of these events and the vulnerability of communities to an increasing risk of climate-related extreme events. The 2016 Fort McMurray wildfire displaced 90,000 people, destroyed approximately 2,400 homes and other buildings, and caused disruptions in local economic activities. With insured losses in excess of $3.5 billion, this fire was the costliest insurable loss in Canada's history. In early May 2017, a strong and prolonged precipitation event caused historic floods in eastern Ontario and western Québec. The flooding caused thousands of people to evacuate their homes, and even more were affected by the flooding.[15] The response to the flooding required over 2,000 Canadian Armed Forces personnel to be deployed to assist in relief efforts.[16]

6.2.2.2 Canada's North

While Canada's temperature increases are outpacing the global average, temperatures are rising even faster in Canada's Arctic and northern areas. The rapid warming of Canada's North is leading to significant reductions in the extent of sea ice, accelerated permafrost thaw and loss of glaciers, and other ecosystem impacts.

The volume and coverage of sea ice have decreased significantly since observations began in 1979. A nearly-ice free summer is considered a strong possibility for the Arctic Ocean by the middle of the century although summer sea ice may persist longer in the Canadian Arctic Archipelago region, which will have wide ranging implications in Canada's North, as well as globally.[17] Northern Arctic ice shelves have undergone significant changes in the last 100 years, eroding from one large ice shelf that spanned the entire northwest coast of Ellesmere Island into three smaller ice shelves. Since 2005, the total remaining area of ice shelves has decreased by more than 50%.[18] Sea ice provides critical transportation in parts of the North, and its rapid loss is having a profound impact on communities that rely on ice to access hunting grounds and traditional sites, as well as on seasonal ice roads that provide access to food and supplies from the south. As Simeonie Amagoalik, an Elder from Nunavut, recalls: "I used to go egg hunting but now it is too dangerous to travel by ice so I cannot go to the places that I used to go to. I think it is mainly the ice on the sea that has affected me the most."[19]

The loss of sea ice also alters animal ranges (e.g., seals, walruses, salmon, whales) and opens new pathways for disease (e.g., a seal-killing virus previously seen only in the Atlantic Ocean was found in a population of Pacific sea otters in Alaska). These impacts are especially felt by Indigenous Peoples that depend on these animals for sustenance and cultural survival. While reduced ice cover is increasing marine access to the North for resource development, shipping, and tourism, these activities bring with them new risks of accidents and spills, which put people and ecosystems at risk and place additional stress on limited search and rescue and disaster response capacity.

Warmer temperatures, along with other factors such as fire, increased rainfall, and erosion, are causing permafrost to degrade. The loss of permafrost is causing irreversible changes to the landscape, including slumping, erosion, ground instability, and forest mortality. Habitat is changing and, for some species, being lost altogether. Since permafrost impacts how far water can penetrate into the ground, permafrost degradation leads to changes in drainage patterns, expansion or drainage of ponds, lakes, and wetlands, changes in water quality, and shifts in the timing of peak and minimum flows in rivers and streams. For example, in the summer of 2015, a large permafrost thaw slump caused rapid drainage of a tundra lake near the Mackenzie Delta in the Northwest Territories. This event was driven, in part, by rising temperatures and increased rainfall. More information pertaining to permafrost impacts can be found in Chapter 8: Research and Systematic Observation of Climate Change.

Northern infrastructure, including roads, buildings, communications towers, energy systems and facilities, community landfills, sewage lagoons, and large-scale waste containment sites (including berms around tailings ponds), often depend on stable permafrost. Degradation causes costly damage and unsafe or unstable conditions.

Remote communities, Indigenous Peoples, and isolated economic sites often depend on a network of winter roads for critical shipments of medical supplies, food, fuel, and equipment. Climate change continues to affect the length of time that winter roads can be operational and whether they are viable at all, making these communities and sites more reliant on other transportation routes or modes. This significantly increases the cost of living and doing business in the North, affecting the ability to attract investment, the prosperity of local businesses, and the strength, health, and well-being of remote communities and Indigenous Peoples.

6.2.2.3 Canada's Coasts

Canada has the longest coastline in the world, and many coastal areas are of great economic, social, historical, and environmental significance. Through changes in relative sea level, rising water temperatures, increased ocean acidity, and loss of sea ice and permafrost, climate change is posing considerable challenges for Canada's coastal areas.

Coastlines projected to experience the greatest relative sea level rise are the Atlantic Provinces, the Gulf of St. Lawrence, the Beaufort Sea, Haida Gwaii, parts of Vancouver Island, and other parts of the British Columbia coast.[20] Relative sea level rise will negatively impact some coastal ecosystems (including dunes, wetlands, tidal flats, and shallow coastal waters) and the services they provide. When combined with high winds, storms, and high tides, sea level rise causes storm surges to reach higher elevations, affecting both natural shorelines and human built coastal infrastructure.

Sea ice acts as natural protection against waves and storm surges. The loss of sea ice further increases storm surge risks and coastal erosion in the Beaufort Sea and Atlantic region. Along the northern coast, the additional challenges posed by the loss of permafrost are contributing to unprecedented rates of erosion.[21]

Coastal communities are experiencing challenges that include: unstable shorelines; flooding damage to property and agricultural lands; permanent loss of archaeological sites and cultural heritage landmarks; contamination of water supplies; increasing costs for protection, maintenance, and insurance; disrupted transportation and trade routes and infrastructure (e.g., small craft harbours); and impacts on human health (e.g., water-borne diseases). Increases in water temperatures and ocean acidity also impact fisheries, traditional foods, iconic species (e.g., salmon), and food and water safety (e.g., harmful algal blooms).[22]

In some cases, ensuring the continued safety of coastal communities will require considerable effort and resources, and in others it will be necessary to relocate. Given the strong ties to land and place, relocation is likely to have social, cultural, and mental health impacts.

6.2.2.4 Indigenous Peoples and Communities

Indigenous Peoples have a strong cultural connection to the land, water, and air. While this increases their exposure and sensitivity to climate change impacts, it is also a source of strength, understanding, and resilience.[23]

Indigenous Peoples are among the most vulnerable to climate change and experience unique challenges. A range of factors, largely related to historical legacies, contribute to this vulnerability.[24,25,26] Unprecedented changes to the environment and ecosystems challenge traditional ways of knowing and Indigenous Peoples' ability to maintain practices, languages, and culture. Indigenous Peoples also face challenges of access to climate change adaptation resources, programs, and tools.

Although Indigenous Peoples are among the most vulnerable to a changing climate due to their close relationship with the environment and its resources, they are not passive recipients of climate change impacts. Rather, they are active drivers of change who contribute vital knowledge, experience, and leadership to adaptation efforts across Canada. In the face of the challenges presented by climate change, Indigenous Peoples are changing the way they live and interact with the environment and each other, and are taking tangible steps to become agents of change.

Building resilience for Indigenous Peoples is fundamentally about food, water, and energy independence, where communities are self-sufficient in all means needed for survival and cultural expression.[27,28] Indigenous Peoples and their knowledge-holders have a long history of, and deep understanding about, adapting to changes in climate and the land.

6.2.2.5 Food and Water Security

Climate change is impacting agricultural productivity and access to traditional food sources. Risks are directly related to increased incidence of drought, floods, storms, and heat waves, as well as changes to plant lifecycles and productivity, shifting plant and animal ranges, the spread of invasive species, and the emergence and spread of pests and disease. Higher temperatures and potentially longer growing seasons present opportunities for agricultural production in certain areas.

In the North and for Indigenous Peoples, changes in seasonal weather and climate conditions impact the transportation of food and other supplies and have made some traditional travel and hunting routes unsafe, thereby deepening existing food security challenges. For example, climate change is affecting the timing of freeze- and break-up on rivers used for transportation and gathering food through hunting, trapping, and fishing. Reduced access to country foods is increasing reliance on expensive store-bought foods with negative effects on health (e.g., diabetes, obesity) and cultural identity. Costs for transporting food and other supplies have also increased, especially in areas that are increasingly dependent on shipments by air.

Water flows, availability, and quality are also changing due to temperature increases and precipitation changes. Rising temperatures are leading to a rapid loss of glaciers, impacting water flow and temperature in glacial-fed streams and rivers. More information pertaining to climate change impacts on glaciers can be found in Chapter 8: Research and Systemic Observations of Climate Change.

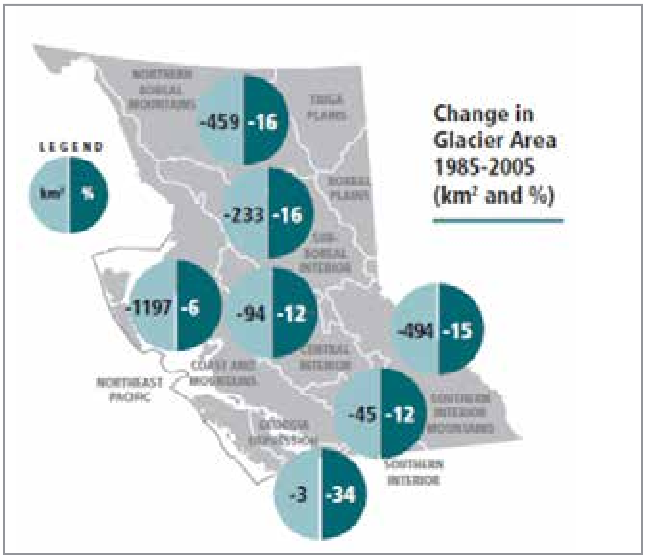

Figure 6-5: Change in Glacier Area 1985–2005 (km and %)
From 1985 to 2005 the glacier coverage in British Columbia decreased by 2,525 km^2 (Bolch et al, 2010).[29]

Water availability, in terms of both the amount of water and the times of minimum and peak flows, is also impacted by changes in spring precipitation and reduced snow accumulation. These changes in the timing and amount of water have consequences for agriculture, industrial activities, power generation, and ecological function.

Higher water temperatures (and less available oxygen) and higher acidity in the water threaten marine life and habitats, impacting commercial, recreational and subsistence fisheries and aquaculture activities. Shorter seasons of ice cover, higher water temperatures, and changing precipitation patterns can affect lake water levels, impacting shipping, tourism, and water quality. For example, observed water levels in the Great Lakes basin have been highly variable, making it difficult to predict the direction of long-term change. However, warming temperatures and changing precipitation patterns are expected to contribute to altered (increased or decreased) water levels, with implications for shipping capacity in the Great Lakes-St. Lawrence Seaway system.[30]

6.2.2.6 Health and Well-Being

Climate change impacts affect the health and well-being of Canadians in many ways, both directly and indirectly. More frequent and severe extreme weather events increase the risk of physical injury, illness, and death. Health systems are challenged and health care facilities can be impacted, with consequences for patient care, safety, and health care costs. In addition, the impact of natural disasters and changing landscapes, the loss of property and cultural heritage sites, and the inability to attend work or school have a negative impact on public health, including mental health, and can diminish individual and community resilience. This can have a significant impact on people, their families, communities, the economy, and the functioning of society as a whole.

Heat waves can cause heat-related illness and death, as well as exacerbate existing conditions, such as respiratory and cardiovascular diseases. Higher temperatures also contribute to increased air pollution and production of pollens, worsening allergies and asthma and exacerbating some existing health conditions. Smoke from wildland fires also impacts air quality. Increased contamination of drinking and recreational water by run-off from heavy rainfall can cause illness and disease outbreaks (e.g., acute gastrointestinal illness, E-coli).[31]

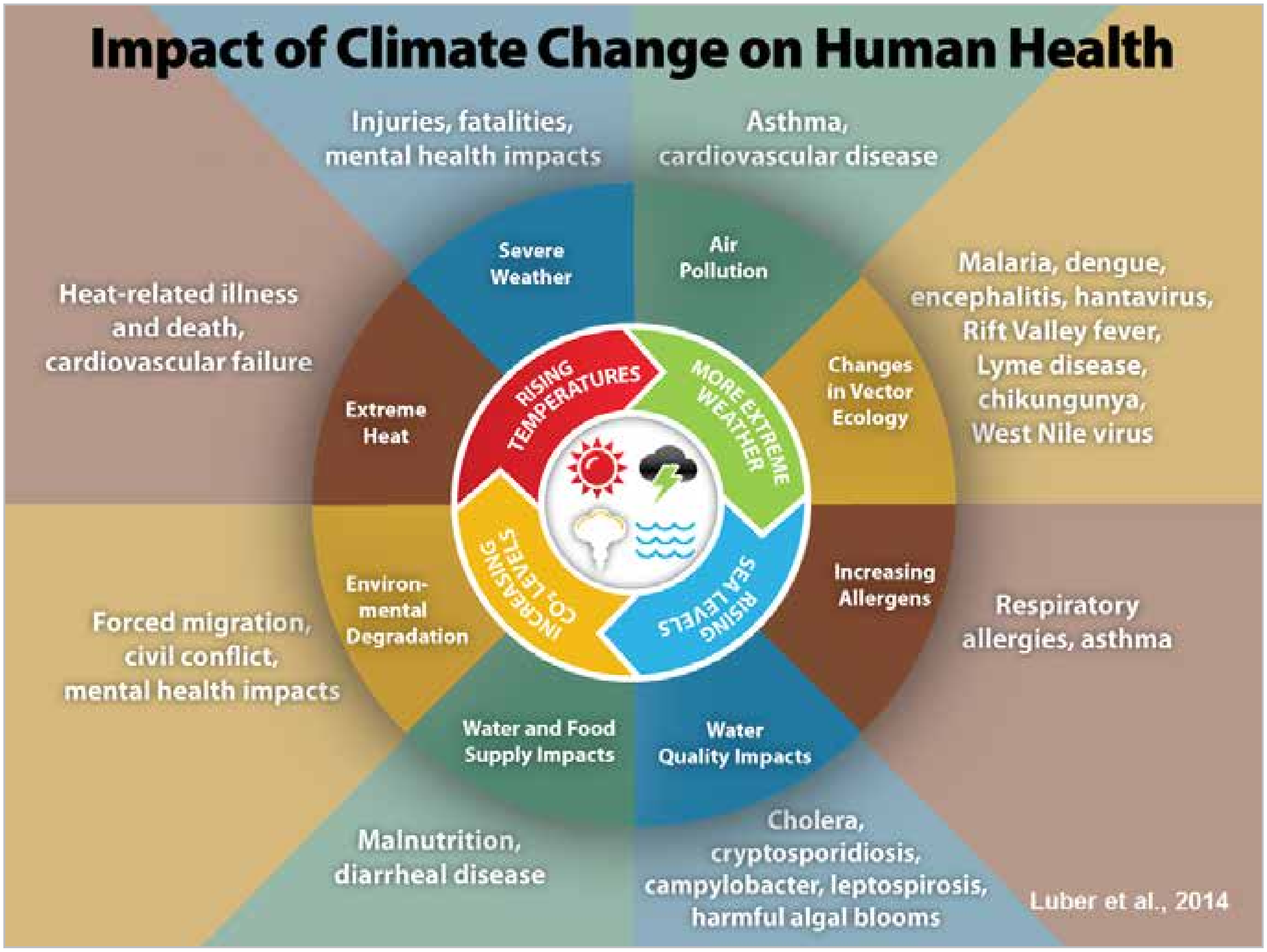

Figure 6-6: Climate Change Effects on Health and Well-Being
Overview of the ways in which climate change affects health and well-being.[32]

Climate change is also likely increasing the prevalence and spread of certain zoonotic, foodborne, or waterborne diseases. For example, Canada is already seeing increased prevalence and geographic range of vector-borne diseases, such as Lyme disease and West Nile virus, as higher temperatures and changes in precipitation can make the environment more hospitable for insects, such as ticks and mosquitoes. In addition, there may be an emergence or re-emergence of diseases that are currently considered to be rare or exotic to Canada (e.g., malaria, chikungunya, Zika virus).

More broadly, climate change affects the various social determinants of health (e.g., food security, availability of potable water, housing, working conditions, income) and reduces resilience. Household food insecurity has been associated with a range of poor physical and mental health outcomes, including multiple chronic conditions and depression.

6.2.2.7 Economic Prosperity

Canadian industries are affected by climate change in various ways. Impacts associated with climate change and extreme weather (for example, the loss of permafrost, coastal erosion, and changing precipitation patterns) are already affecting transportation systems, services and operations across all modes, in all regions of Canada. Associated disruptions in the movement of freight and people, represents risks to the economy and Canadians.

Disruptions in productivity, critical trade infrastructure, electricity generation, and supply chains have broad consequences for many economic sectors, services to consumers, and businesses. Climate change impacts in Canada and around the world affect global food and water security issues, commodity prices, trade, supply chains, conflict, and displaced people, which will have consequences for Canadian immigration, defense, and private sector prosperity. Tourism and recreation activities that rely on weather conditions are particularly sensitive to climate change.[33]

Canada's resource economy is vulnerable to the impacts of climate change. The forestry and agriculture sectors have been affected by increased incidence of drought, floods, storms, heat waves, wildfires, and pests and diseases (e.g., mountain pine beetle and spruce budworm), which has consequences for productivity, the quality of the harvest, and work opportunities.[34] Mining, oil and gas production, hydroelectric power generation, transportation, and agriculture are all affected by variable water levels. Increased temperatures, changing precipitation patterns, and increased frequency and intensity of extreme weather events are creating risks and operational challenges for agriculture and aquaculture production, though rising temperatures could also increase growing days and present opportunities for new crops or species in some regions.

Some of the most vulnerable components of Canada's transportation system are integral to the resource industry in the North. Climate change impacts, such as permafrost degradation, can cause infrastructure damage and deterioration, disruptions to transport operations, and unsafe conditions for the resource sector and for other local economies.

6.3 Climate Information and Services

Climate information can inform decision-making in key sectors such as health (e.g., air and water quality, heat, infectious diseases such as Lyme), agriculture (e.g., food production and security), infrastructure (buildings, roads, bridges and water assets), and natural resource management (e.g., energy, forestry, fisheries, and mining). It is also a foundation for developing appropriate adaptation and risk management strategies. Climate services include climate data, predictions, information, and tools to support adaptation decision-making. Climate services in Canada are a responsibility shared by federal, provincial, and territorial governments.

6.3.1 Federal Climate Information and Services

The Government of Canada undertakes science and monitoring activities related to past, present, and future states of the climate system and how it functions, as well as on the changing composition of the atmosphere and related impacts. These activities include foundational climate and climate change science as well as climate information and services provided by federal departments to inform effective adaptation planning and decision-making. Climate change science includes research related to the impacts of climate change on biodiversity and ecosystem services, as well as options and opportunities for using ecosystems to support climate change adaptation and mitigation. More information pertaining to climate modelling, projections, and scenarios can be found in Chapter 8: Research and Systematic Observation of Climate Change.

Environment and Climate Change Canada currently provides some climate information products and services including seasonal outlooks (e.g., bulletins and consultation process), historical climate data sets, trends analysis, and climate change scenarios. Environment and Climate Change Canada also provides some tailored climate information products and services. For example, the department provides long-term historical climate data sets for internal and external clients and users through its engineering climate services. This includes information about historical snow and ice conditions, which is incorporated into the development of rooftop snow load requirements for the National Building Code of Canada; wind pressure analysis that informs the telecommunications and renewable energy industries (e.g., siting communications towers and wind farms); and analysis on the intensity, duration, and frequency of extreme rainfall to support storm and waste water management.

Agriculture and Agri-Food Canada also provides a variety of climate data products, information, and services specifically for Canada's agriculture and agri-food sector. The Department translates highly technical research, applied research and resultant products for a broader agriculture and agri-food audience to use when making climate change adaptation decisions. Agriculture and Agri-Food Canada's National Agroclimate, Geomatics and Earth Observation Service is an authoritative source for a wide variety of agroclimate data, indices, information, tools, and models for use by the agricultural sector, such as monitoring and assessing climate-related risks to agricultural production, analyzing changing land suitability and forecasting crop production (see Drought Watch for current product offerings).

Through its Aquatic Climate Change Adaptation Program, Fisheries and Oceans Canada is monitoring and studying the effects that changing ocean conditions is having on Canada's fisheries, aquatic ecosystems, and coastlines. The department is also looking at the impacts of sea level rise and more frequent storms and storm surges on coasts and ocean infrastructure, such as wharfs and dams.

The Government of Canada created Polar Knowledge Canada through the *Canadian High Arctic Research Act*, which came to force on June 1, 2015. Polar Knowledge Canada reports to the Minister of Crown-Indigenous Relations and Northern Affairs and is led by a Board of Directors and a President. Polar Knowledge Canada is responsible for advancing knowledge of the Canadian Arctic and strengthening Canadian leadership in polar science and technology. Polar Knowledge Canada's pan-northern Science and Technology program priorities for 2014–2019 include: alternative and renewable energy; baseline information to prepare for northern sustainability; predicting the impacts of changing ice, permafrost, and snow on shipping; infrastructure and communities; and catalyzing improved design, construction, and maintenance of northern built infrastructure.

Efforts are underway to improve climate information products and services provided by Environment and Climate Change Canada and other federal departments, including investments in 2017 to support the establishment of a new Canadian Centre for Climate Services. The Canadian Centre for Climate Services will deliver trusted climate information, data, and tools that will support adaptation decision-making. Training, support, and user-driven products will ensure tools are used while partnerships with other organizations will shape and deliver services across the country.

Additionally, Indigenous and Northern Affairs Canada launched an Indigenous Community-Based Climate Monitoring program that will support Indigenous communities in developing climate impact monitoring projects and initiatives using both Indigenous Knowledge and western science while collaborating with researchers. The program will assist with the development of community-led initiatives and help build collaborative partnerships between communities, researchers and existing monitoring networks at regional, national and international levels when appropriate. It will help communities document their Indigenous Knowledge and integrate current technologies in monitoring community relevant indicators of climate change, and contribute to advancing climate research. The information resulting from projects and connections to research and monitoring networks will help communities access more comprehensive climate information and help communities take concrete actions to manage climate change risks associated with activities on the land.

6.3.2 Provincial and Territorial Climate Information and Services

Provinces and territories, private consultants, and research institutions provide climate information products and services. These are usually regionally, locally and/or sector specific. This section focuses on jurisdictions that provide climate information and services, such as data, information, and tools, to support climate change adaptation decision-making.

6.3.2.1 British Columbia

The Government of British Columbia's ministries and partners continue to operate and improve hydrological monitoring (climate, snow, surface water, and groundwater) in order to provide better data to support decision-making for drought, flood, infrastructure planning, environmental flow needs, and ecological modelling.

Additionally, the Pacific Climate Impacts Consortium, a regional climate service centre established in 2005, supports climate change adaptation in Canada's Pacific and Yukon regions by carrying out research and providing information and projections of future climate change impacts and conditions.

6.3.2.2 Manitoba

Manitoba's Prairie Climate Centre, a collaboration of the University of Winnipeg and the International Institute for Sustainable Development, enables governments, businesses, and community members across the Prairies to reduce their vulnerability to climate variability and change by providing access to an innovative, stakeholder-driven hub for data, guidance, research, knowledge exchange, training and capacity building. The Prairie Climate Centre has developed a Prairie Climate Atlas to provide information about how Canadian Prairie Provinces may change in the coming decades. The Prairie Climate Atlas is an interactive website that includes climate data, geo-visualizations, and multimedia tools to communicate climate change impacts to the general public and provide decision-makers and regional leaders with information to inform adaptation and mitigation decision-making.

6.3.2.3 Ontario

The Government of Ontario is working to establish a new independent climate change organization, which will serve as a one-window source for climate data and services in the province. This new organization will work with municipalities, Indigenous Peoples, and leaders to help both public and private sectors make informed and evidence-based decisions regarding adapting to climate change and increasing resilience. By offering a range of climate services, the organization will provide access to expertise to understand how climate change may affect different activities or lines of business, and help plan for and manage risks in areas such as agriculture, infrastructure, and public health.

In addition, the Ontario Centre for Climate Impacts and Adaptation Resources, operating out of Laurentian University, is a resource hub for researchers and stakeholders searching for information on climate change impacts and adaptation.

6.3.2.4 Québec

To better inform decision-making at all levels, the Government of Québec has a strong partnership with the Ouranos consortium, which it jointly created with Hydro-Québec, Environment and Climate Change Canada, and Valorisation-Recherche-Québec in 2001 to provide specialized information on regional climate science and adaptation. Ouranos is a network of approximately 450 researchers, experts, practitioners, and policy-makers from a variety of climatology-related disciplines that has implemented over 100 projects in collaboration with government, academia, and industry. Ouranos brings together researchers, practitioners, and policy-makers to promote and support adaptation, develops climate scenarios and services, and produces regional climate simulations. Ouranos also develops and implements climate projections to identify the potential impacts of climate change and inform adaptation decision-making across sectors.

6.3.2.5 Newfoundland and Labrador

In 2015, Newfoundland and Labrador undertook a detailed assessment of 19 rainfall monitoring locations to ensure that extreme precipitation events could be reviewed in the context of projected climate change conditions. At the same time, the province established 113 coastal erosion monitoring sites to inform planning and development decisions given the risk of more rapid coastal erosion in a province where 90% of the population lives along the coast. These products, which are available at a publicly available Climate Information Portal, have facilitated improvements in related adaptation tools and resources, such as flood risk mapping, and complement other data, such as coastal erosion monitoring, to provide stakeholders with a range of planning information to inform decision-making processes.

6.3.2.6 Yukon

The Government of Yukon has prioritized improving baseline climate science to support data-driven, targeted adaptation investments and actions. The territory has improved the accessibility of its flood risk data through a flood risk mapping project that uses light detection and ranging remote sensing and historic water-level data to identify flood risks for Yukon communities.

6.4 Domestic Adaptation Policies, Plans, and Programs

Governments across Canada are developing adaptation policies and plans to build Canada's resilience to climate change; working to ensure that Canadians understand how they may be affected by climate change; and helping Canadians make the best decisions to protect their homes, businesses, health, and communities.

Recognizing that adaptation is a long-term challenge, adaptation and climate resilience is one of the four pillars of the Pan-Canadian Framework on Clean Growth and Climate Change.

Under this pillar, federal, provincial and territorial governments made commitments to address the significant risks that climate change impacts pose to communities, the health and well-being of Canadians, the economy, and the natural environment—in particular in Canada's northern and coastal regions, and for Indigenous Peoples. It represents the first time that federal, provincial, and territorial governments have identified priority areas for collaboration to build resilience to a changing climate across the country. These priorities include:

- Ensuring Canadians have information and expertise to consider climate change in their planning and decision-making;
- Building climate resilience through infrastructure;
- Working to protect the health and well-being of Canadians;
- Supporting particularly vulnerable regions and Indigenous Peoples in addressing climate impacts; and,
- Reducing the risks to communities from climate-related hazards and disasters.

For each priority area, federal, provincial, and territorial governments identified new actions that would advance efforts towards a more resilient Canada. These actions range from measures to improve access to climate science and information that supports adaptation decision-making, to investments in built and natural infrastructure to increase climate resilience in communities, to efforts that help better understand and take action to address climate-related health risks such as extreme heat and infectious diseases. These actions are further outlined in the following section.

6.4.1 Federal Adaptation Policies, Plans and Programs

The federal government has a long history of working on adaptation. Research on the impacts of climate change has been underway for decades, and permanently funded federal adaptation work began in 1998. Since then, federal efforts have expanded from research and assessment to policy development and investments to enable action at the local level, with a key principle of current federal action being collaboration with provincial, territorial, and municipal governments, and Indigenous Peoples.

Through the Pan-Canadian Framework on Clean Growth and Climate Change, the federal government has committed to working with provinces and territories to complement and support their climate change actions. The federal government has further committed to working with provinces and territories, municipalities, and Indigenous Peoples to bring together partners to share and leverage knowledge, capacity, and resources.

Significant investments have been made in climate change adaptation since 2014. In 2016, the Government of Canada strengthened its approach to domestic climate change adaptation by funding seven federal departments and agencies for a suite of adaptation programs. These programs include those related to science, health, northern and Indigenous Peoples, and key economic sectors ($129.5 million), Canada's National Research Council to develop climate-resilient building design guides and codes ($40 million), and the Federation of Canadian Municipalities' Municipalities for Climate Innovation Program ($75 million), which helps municipalities prepare for, and adapt to, climate change, and to reduce GHG emissions.[35]

Building on 2016 adaptation and climate resilience investments, the Government of Canada announced further funding over five years in 2017 for a suite of federal adaptation programs related to information and capacity, climate-resilient infrastructure, human health and well-being, vulnerable regions, and climate-related hazards and disaster risks ($260 million). Climate change adaptation initiatives funded by the Government of Canada under Budget 2017 include:[36]

- Environment and Climate Change Canada's Canadian Centre for Climate Services.
- Natural Resources Canada's efforts to build regional adaptation capacity and expertise.
- Health Canada, the Public Health Agency of Canada, and the Canadian Institutes of Health Research work to respond to the broad range of health risks caused by climate change.
- Health Canada's implementation of a climate change and health adaptation program for First Nations and Inuit communities.
- Indigenous and Northern Affairs Canada's integration of Indigenous Knowledge to build a better understanding of climate change and to guide adaptation measures; enhance Indigenous community resilience through infrastructure planning and emergency management in those communities where flooding risks are increasing; and enhance resilience in northern communities by improving the design and construction of northern infrastructure.
- Fisheries and Oceans Canada's Aquatic Climate Change Adaptation Services Program.
- Transport Canada's Northern Transportation Adaptation Initiative.
- Transport Canada's risk assessments on federal transportation infrastructure assets.

Investments announced in 2017 also included further detail on green infrastructure investments ($21.9 billion) intended to boost economic growth and build resilient communities. These investments will include funding for bilateral agreements with provinces and territories ($9.2 billion), a portion of which will be invested in adaptation and climate resilience, and funding for a Disaster Mitigation and Adaptation Fund ($2 billion) to support infrastructure required to deal with the effects of a changing climate, the most significant commitment to invest in adaptation by the federal government to date. In addition, $5 billion will be made available through the Canada Infrastructure Bank for green infrastructure projects.

Investments in climate change adaptation made in 2017 were guided by the adaptation and climate resilience pillar of the Pan-Canadian Framework on Clean Growth and Climate Change (2016).

Specific examples of federal adaptation programming include Canada's Adaptation Platform, chaired by Natural Resources Canada, which brings together key groups from governments, industry, professional and Indigenous organizations to collaborate on adaptation priorities. The overarching goal of the Adaptation Platform is to create an enabling environment for adaptation, where decision-makers in regions and key industries are equipped with the tools and information they need to adapt to a changing climate.

The Standards Council of Canada's new program, Standards to Support Resilience in Infrastructure, supports the development of standardization guidance on weather data, climate information and climate change projections, in support of the Government of Canada's objective to adapt infrastructure to climate change impacts. This initiative also supports an update of a broad range of existing standards to ensure infrastructure across Canada is climate-ready, and invests in new standards that support northern infrastructure through the Northern Infrastructure Standardization Initiative.

Agriculture and Agri-Food Canada supports and leads research and collects agro-climate, soil, drought, and crop information to inform adaptation decision-making in Canada's agriculture sector. These efforts contribute to the development of decision-support tools and practices for farmers to adapt to climate change, including through the optimization of land use and production, pest and disease surveillance, variety selection, and breeding for new climatic conditions. The department also undertakes research on current and future weather trends, as well as efforts to improve regional weather forecasting and crop forecasting to help assess potential impacts on crop yields and changes to disease pressures from climate change.

Indigenous and Northern Affairs Canada is working collaboratively with territorial and northern governments and Indigenous Peoples to develop a *Northern Adaptation Strategy*. The purpose of the *Northern Adaptation Strategy* is to strengthen northern capacity for climate change adaptation and to establish partnerships and collaboration mechanisms to guide investments (from all partners including federal, territorial and provincial governments) across the territorial north as well as Inuit Nunangat.

The Government of Canada also collaborates with provinces and territories to implement adaptation actions. For example, the Canadian Parks Council, which is the federal, provincial, and territorial coordination body for parks and protected areas, re-established the Canadian Parks Council Climate Change Working Group in 2017. Parks Canada and the Northwest Territories co-chair the working group, which intends to: build on its previous work by promoting the concept of parks and protected areas as natural climate change solutions through new approaches, tools, and communication opportunities; provide a forum for cross-jurisdictional sharing tools, information and best practices for mainstreaming climate change decision-making into park and protected area management planning and operations, considering both mitigation and adaptation; identify key common issues, challenges, and opportunities for federal, provincial, and territorial coordination and collaboration on climate change and parks and protected areas dialogues and initiatives, such as the Pan-Canadian Framework on Clean Growth and Climate Change.

6.4.2 Provincial and Territorial Adaptation Policies, Plans and Programs

The Pan-Canadian Framework on Clean Growth and Climate Change recognizes the varying scope and scale of adaptation efforts across the country and that provinces and territories have been early leaders in this context. Provinces and territories have undertaken a variety of adaptation activities, including: implementing adaptation strategies; funding for research, pilot projects, and regional risk and vulnerability assessments to support adaptation planning and decision making; action to strengthen land-use planning processes, infrastructure investments, and building codes through the inclusion of climate change considerations; efforts to increase awareness about impacts and adaptation options for communities; and the development of tools to help integrate adaptation into all levels of decision-making.

6.4.2.1 Yukon

The Government of Yukon has undertaken adaptation actions to enhance the resilience of Yukon communities both directly and through partnerships with the federal government and non-government organizations. The territory has committed to enhancing the knowledge and capacity of communities and local decision-makers to respond to challenges to the territory's landscapes, natural resources, and traditional ways of life resulting from climate change. The territory is exploring opportunities to better understand the relationship between climate change and food security in Yukon, integrate Indigenous Knowledge into the understanding of climate change impacts, and target investments towards evidence-based adaptation actions.

Yukon released a *Climate Change Action Plan Progress Report* (2015), which reviewed the progress made since the implementation of its *Climate Change Action Plan* (2009). The report included the addition of four new actions to support climate change goals, including the addition of a specific adaptation goal.[37] The territory also released a Climate Change Indicators and Key Findings report in 2016 to provide an objective and accessible overview of the current state of Yukon's climate system, which will be regularly updated.

6.4.2.2 Northwest Territories

The Government of the Northwest Territories is developing a comprehensive Climate Change Strategic Framework, which will include both climate change adaptation and climate change mitigation. The framework will have three main themes: (1) reducing the territory's reliance on fossil fuels and the production of GHG emissions; (2) increasing knowledge of how a warming climate is impacting the territory's biophysical environment, economy, and peoples' health and safety; and (3) increasing the territory's resilience to climate change impacts and identifying ways to adapt to unavoidable impacts. The territorial government also supported building climate change adaptation capacity within communities by integrating climate change adaptation curriculum into their School of Community Government.

6.4.2.3 Nunavut

The Government of Nunavut has been developing programs, policies, and partnerships that assist Nunavummiut (the people of Nunavut) with increasing adaptive capacity and addressing the impacts of climate change that are being experienced in the North. The Government of Nunavut acknowledges that support for adaptation initiatives in the near-term will result in long-term benefits for all communities, such as decreased costs to infrastructure, increased safety and security, economic prosperity, and more sustainable communities. The Government of Nunavut is therefore committed to working nationally to address climate change impacts and supports the undertaking of a coordinated, strategic, Canadian approach that will lead to improved resiliency of the territory's communities.

Climate change impacts and adaptation initiatives in Nunavut are supported through both standard scientific methods and Inuit Qaujimajatuqangit, the system of Inuit Indigenous Knowledge and societal values. Inuit Qaujimajatuqangit is based upon a long and close relationship with the land that provides detailed insight into climate change in Canada's north. The Government of Nunavut places great weight and importance on Inuit Qaujimajatuqangit in its planning, program, and policy development on climate change.

The Government of Nunavut's Climate Change Secretariat has initiated a number of projects to support adaptation in Nunavut over the years. These include the Nunavut Climate Change Centre (NC³) website that provides Nunavummiut with current information on climate change, the Nunavut Permafrost Databank that improves access to open-source permafrost data from across the North, outreach initiatives like the Tukisigiaqta web-based risk tool that informs Nunavummiut about climate change risks in the home and on the land, and creating and delivering the Climate Change Adaptation Training Course for Nunavut Decision-Makers that instructs community and government staff on climate change impacts and adaptation and builds on both scientific and Inuit Qaujimajatuqangit.

6.4.2.4 British Columbia

Adaptation action in British Columbia is guided by the *Preparing for Climate Change: British Columbia's Climate Adaptation Strategy* (2010), a plan to increase knowledge about climate change and its impacts on key economic sectors, and government programs and services, and produce tools to help governments, businesses, and communities find out how climate change will affect them, and what they can do now to prepare.

In 2017, the Office of the Auditor General of British Columbia conducted a performance audit examining the provincial government's action to adapt to a changing climate, including the 2010 Adaptation Strategy, initiatives to assess risks and vulnerabilities and monitoring and reporting on performance and achievements. The audit also examined the efforts of specific ministries to adapt, including Environment; Forests, Lands and Natural Resource Operations; Agriculture; Transportation and Infrastructure/ Emergency Management BC; and, Ministry of Municipal Affairs and Housing.

6.4.2.5 Alberta

Alberta's approach to adaptation includes research on current or potential climate change impacts in specific sectors and developing capacity to better use science and Indigenous Knowledge to understand the implications of climate change and innovative adaptive measures.

Alberta is also beginning to reinvest carbon emissions revenues to understand and implement innovative adaptive measures.

The Alberta Government currently allocates $15 million annually for the Alberta FireSmart program. FireSmart uses preventable measures to reduce wildfire threat to Albertans and their communities while balancing the benefits of wildfire on the landscape. For example, the FireSmart Forest Resource Improvement Association of Alberta program focuses on improving the protection of forest communities, resources, and values through operational and planning activities designed to prevent wildfire occurrence and to reduce fire hazard throughout Alberta.

The Government of Alberta is developing policy to enable and encourage water reuse and stormwater use, in an effort to mitigate flood and drought cycles in Alberta, and to offset fresh water withdrawals. The Government of Alberta has also made changes to the *Forest and Prairie Protection Act* and associated regulations to improve public safety as they relate to preventing human-caused wildfires and protecting Albertans, their communities, natural resources, and infrastructure from wildfire damage.

Alberta has worked with the universities of Alberta and British Columbia on projects such as "AdapTree": Assessing the Adaptive Portfolio of Reforestation Stocks for Future Climates. Through this project Alberta has gained additional knowledge on the ecological genetics of white spruce and lodgepole pine to support decision-making for climate change adaptation. Alberta is currently supporting new genomics research projects at the University of Alberta which are partly designed to address climate change adaptation in three specific pine and spruce tree breeding regions.

6.4.2.6 Saskatchewan

Saskatchewan is enhancing its Wildfire Management program to mitigate wildfire risks by improving wildfire response capacity, strengthening collaboration with international, national, and provincial jurisdictions, increasing government, community, and industry mitigation efforts, and adopting proactive wildfire legislation. The Government of Saskatchewan is also developing a drought strategy and a new water allocation policy and legislation that will provide flexibility to manage water shortages, and an irrigation strategy that will focus on long-term capacity building in the irrigation sector.

In partnership with the Crop Development Centre at the University of Saskatchewan, the province supports public sector plant breeding and several plant breeders who focus on developing crop varieties that can better withstand changing climatic conditions. In addition to the improvement of existing crop varieties, the province supports the development of new crops that will be suited to future climatic conditions in Saskatchewan. Saskatchewan also works with the federal government to support a strong suite of business risk management programs for the agriculture sector, including crops insurance that assist growers in managing risks associated with crop yield declines that can be the result of extreme climatic events. Further, the province has implemented an assisted migration project and associated scientific trial as part of its ongoing forest renewal activities to identify seed sources that are best adapted to projected climatic conditions. Lastly, Saskatchewan has increased monitoring of recreational water quality in the province and has an on-going surveillance for West Nile and Lyme disease.

The Government of Saskatchewan has also identified multiple areas for action. For instance, Saskatchewan is using technology in winter road maintenance to provide early warning of weather events and gather better road information and data, thereby improving response times and ensuring the plows are properly equipped for extreme weather events. Saskatchewan is also addressing increased severity and frequency of localized flooding from rainstorms and other extreme precipitation events through flood mapping and related infrastructure planning initiatives with municipal governments.

6.4.2.7 Manitoba

Manitoba has developed a Made in *Manitoba Climate and Green Plan* that includes carbon pricing and specific priorities for addressing climate change, jobs, nature, and water.

Manitoba has taken significant measures to reduce the impacts of flooding within the Red and Assiniboine River basins, as well as strategies to conserve polar bears, caribou, and moose populations, and address invasive species in Manitoba. Actions include enhancing infrastructure resiliency, provincial strategies on surface water management and drought preparedness, further initiatives in land use and watershed planning and working with municipalities and Indigenous Peoples across the province.

Manitoba is also working with partners to implement a province-wide program based on the Alternative Land Use Services model to help reduce flooding and improve water quality and nutrient management. It will also develop a framework to reconcile the needs of industry and rural and northern communities while continuing to enhance the network of protected areas in Manitoba. Collectively these measures support enhanced landscape resiliency to flood, drought, and other risks posed by a changing climate, thereby helping to ensure communities and economic sectors are better prepared and less vulnerable to these changes.

6.4.2.8 Ontario

Ontario announced its next steps to help ensure communities, the private sector, governments, and individual Ontarians have the information they need to identify climate change risks and vulnerabilities and to take action to prepare for these risks. Ontario will: launch a new organization for climate change data and services; undertake a province-wide risk assessment; raise public awareness of climate change impacts; and develop a new governance framework to help ensure that adaptation is considered in program and policy decisions across all departments.

Ontario's next steps build on actions Ontario is already taking to prepare for the effects of climate change, including in the areas of public health, natural environment and agriculture, the built environment, and Indigenous Peoples. These current and ongoing actions are outlined in Ontario's first adaptation strategy and plan *Climate Ready: Ontario's Adaptation Strategy and Action Plan (2011–2014)*.

On-going or already completed actions include the Ontario Climate Change and Health Toolkit released in 2016 to help raise community awareness of the health impacts of climate change, identify local vulnerabilities, and support a more resilient health system that can manage emerging health risks.

In 2014, Ontario updated its *Provincial Policy Statement* to require municipalities to consider the impacts of climate change in planning for resilient communities, including planning for new or expanded infrastructure, and to strengthen protection for natural features and areas including key hydrological features such as wetlands. In 2017, Ontario updated its four provincial land use plans to include revised requirements such as stormwater management planning and Low Impact Development and green infrastructure, as well as strengthened protection for natural areas and key hydrological areas and features.

6.4.2.9 Québec

Québec adopted its *Government Strategy for Climate Change Adaptation* and *2013–2020 Climate Change Action Plan* in 2012. The strategy and the plan bring together stakeholders and key players in implementing actions from the Québec government, municipalities, civil society, and research organizations. Through commitment and action, the strategy aims to reduce the impacts of climate change, to strengthen the resilience of Québec society and to seize new opportunities provided by climate change. The Plan is financed through the revenues of Québec's carbon market, which are entirely dedicated to addressing climate change. As such, in addition to investments in GHG reduction initiatives, more than $200 million is dedicated to a wide range of concrete actions that will strengthen Québec's collective capacity to adapt.

Examples of these initiatives include the Québec government's financing of a systematic evaluation of short-, medium-, and long-term vulnerabilities related to coastal erosion for municipalities along the estuary and Gulf of St. Lawrence. This work, in close collaboration with municipalities, will also focus on identifying priority areas for intervention and developing decision-making tools for choosing adaptation solutions. The Québec government also supports community initiatives to reduce urban heat island effect in urbanized areas of the province. Projects include planting trees and vegetation, and greening roofs, parking lots, and other surfaces that absorb and retain heat.

To ensure consistency and more efficient government action, Québec included adaptation and climate resilience in many of its government documents, such as the *Sustainable Development Strategy 2015–2020* and the *Québec Policy 2014–2024 on Civil Security*. In 2017, the government of Québec committed to amending the *Environment Quality Act* to modernize the environmental authorization scheme and other legislative provisions (e.g., Green Fund), to ensure that climate changes impacts, as well as greenhouse gas emissions, are better taken into account in the environmental evaluation and authorization of projects.

6.4.2.10 New Brunswick

New Brunswick released *Transitioning to a Low-Carbon Economy—New Brunswick's Climate Change Action Plan* in December of 2016. The Plan includes a comprehensive list of adaptation actions grouped into six themes: (1) understand climate change impacts; (2) build climate resilient infrastructure; (3) support community adaptation planning; (4) adapt natural resources and agriculture; (5) reduce climate related hazards; and (6) reduce climate change impacts on public health.

Adaptation actions that ensure the well-being and resilience of citizens, ecosystems, communities, and natural resources, as well as enhancing the Province's economic competitiveness are a priority in New Brunswick. Examples of adaptation efforts include vulnerability assessments that address flooding, erosion, and sea level rise, the adoption of adaptation plans in several municipalities, incorporating future climate conditions into infrastructure design, vegetation management to reduce potential power outages following storms, incorporating updated sea level rise and storm surge projections into land use planning and to inform infrastructure placement, and modelling tree species distribution under future climate conditions to help inform forest management decisions. An increasing availability of adaptation tools, guidance, improved projections, and science has also contributed to the attainment of these initiatives.

Communities and municipalities continue to be a strong focus of New Brunswick's adaptation efforts. The New Brunswick Climate Change Secretariat is focusing on facilitating adaptation efforts with municipalities, putting strong emphasis on conducting vulnerability assessment and adaptation planning across sectors, and disseminating climate change knowledge to inform decision makers and the general public. This reflects the Government of New Brunswick's resolve to deal with issues that are emerging and will be exacerbated by future climate conditions.

6.4.2.11 Nova Scotia

Nova Scotia is focusing its efforts on building the provincial government's capacity to mainstream climate adaptation into all department planning policies and operations, so that it becomes a normal, automatic part of how government does business. This is done through the delivery of an integrated program that strengthens the socio-cultural competencies of the public service to effectively communicate climate concerns, lead complex adaptation initiatives, work across department silos, and build strong public-private partnerships. Participating departments are undertaking the program and associated capacity building programs by creating teams that will design adaptation projects that move research into action. Qualitative and quantitative metrics are used to measure progress on the implementation and impact of the projects and mainstreaming strategies, as well as the ability of the program to enhance the government's capacity to anticipate, prepare for, and respond to projected and unforeseen climate risks.

Departmental adaptation projects underway in 2016–2017 include risk-proofing the Nova Scotia grape and wine industry, integrating climate risks into protected area management, re-aligning dykes and restoring salt marshes for flood risk reduction, and developing new climate smart standards for dyke construction and repair.

6.4.2.12 Prince Edward Island

Prince Edward Island is developing a climate change action plan that will include key climate change mitigation actions and key adaptation actions that will seek to minimize the impacts of climate change on Prince Edward Island. This climate change action plan will replace Prince Edward Island's previous climate change strategy, *Prince Edward Island and Climate Change: A Strategy for Reducing the Impacts of Global Warming* (2008).

Through its partnership in the Atlantic Climate Adaptation Solutions Association and with funding from Natural Resources Canada, Prince Edward Island co-led two regional projects, the development of a decision support tool for small coastal communities and an economic analysis of adaptation options for coastal infrastructure and property. Both projects included extensive stakeholder involvement across federal, provincial, and municipal governments. Future adaptation efforts on Prince Edward Island will continue to focus on assessments of coastal risk to infrastructure, buildings, and property and Prince Edward Island will expand this focus to include the dissemination of existing products that will assist provincial and local decision-makers as they seek to minimize climate change impacts.

6.4.2.13 Newfoundland and Labrador

The Government of Newfoundland and Labrador released *Charting Our Course: Climate Change Action Plan* in 2011, a five-year strategy that contained 18 commitments aimed at improving the province's resilience to the impacts of climate change. The action plan ended in 2016, and all 18 of the commitments were implemented. The commitments focus broadly on improving the understanding of climate change impacts in Newfoundland and Labrador and mechanisms to integrate that understanding into decision-making by individuals, businesses, communities, and governments. The Government of Newfoundland and Labrador is now in the process of developing a new five-year climate change action plan, to be released in 2017–2018, which will include adaptation as a key pillar.

Newfoundland and Labrador has collaborated with various stakeholders to develop provincial adaptation programs and actions, as well as build knowledge capacity and expertise. For example, capacity building and education is facilitated and maintained through workshops in cooperation with partners such as Engineers Canada to raise awareness of climate change impacts on infrastructure and available datasets among local private sector and provincial and municipal government decision-makers, engineers, and planners.

To increase collaboration on adaptation, the Government of Newfoundland and Labrador established an Adaptation Network that includes representatives from government departments, industry, and Memorial University. The network identifies research needs and shares best practices for integrating climate change adaptation into planning and decision-making. The work of the Adaptation Network has resulted in the impacts of climate change being more thoroughly integrated in the government's decision-making processes for environmental assessments and the granting of crown land.

6.4.3 Municipal Adaptation Policies, Plans and Programs

Canadian municipalities have been consistently taking action to build local capacity to identify the impacts from a changing climate, assess their local vulnerabilities and risks, develop and implement plans to address these risks, and ultimately to implement actions and monitor their results. Municipalities have responded to climate change impacts in Canada with stand-alone adaptation strategies, innovative communications strategies, practical projects to better manage stormwater absorption, and programs that provide emergency shelter during extreme weather events. Some specific examples of municipal leadership on climate change adaptation and resilience are presented below.

6.4.3.1 Municipal Adaptation Policies and Plans

In 2016, Durham Region, Ontario completed its *Community Climate Adaptation Plan*. The plan is a response to the risks posed by climate change to the municipality's infrastructure, health, welfare, and economy. It includes 18 proposed programs to improve Durham's resilience to climate change impacts, such as flooding and extreme heat. Durham's proposed programs are anticipated to begin implementation in 2018.

The City of Surrey, British Columbia began its adaptation efforts in late 2010 through the development of the *Climate Change Adaptation Strategy*. Since then it has taken many steps to become more prepared and resilient. Most recently, the City is exploring the timing and extent of changing flood hazards and using this to inform a *Coastal Flood Adaptation Strategy*. Through this effort the City has been engaging residents and stakeholders in public meetings to determine the best solutions for adaptation to sea level rise and flood risk within Surrey.

In some cases municipal regions have developed climate change adaptation plans that include a number of different municipalities. For example, the agglomeration of Montréal, Québec released its first climate change adaptation plan in 2015. The Plan is divided into two volumes. The first volume presents a diagnosis of the adaptation challenges faced by the agglomeration of Montréal, and presents a vulnerability analysis of six climactic hazards: increased temperature, heavy rainfalls, heat waves, destructive storms, droughts, and floods. The second volume is dedicated to adaptation measures that need to be consolidated or developed in the agglomeration of Montréal in order to reduce the risks of climate change.

Municipalities have also released plans to address specific challenges. For example, the City of Vancouver, British Columbia introduced a *Sewer Separation Strategy* (2016) to separate stormwater from wastewater to prevent flooding and eliminate combined sewer overflow during heavy rain events. Additionally, the City of Vancouver developed the *Greenest City 2020 Action Plan* (2011), which outlined ten goal areas and 15 measurable targets to guide Vancouver toward becoming the greenest city in the world by 2020. The strategy was updated in 2015, *Greenest City 2020 Action Plan Part Two: 2015–2020*, to include 50 new actions, which included adaptation commitments and the development of an Integrated Rainwater Management Plan (2016), which recognizes the importance of considering climate change impacts in the management of stormwater. Similarly, the City of Toronto, Ontario introduced the *Toronto Hot Weather Response Plan* (2016), which is a protocol for hot weather response that includes both proactive and reactive actions.

6.4.3.2 Municipal Adaptation Initiatives

As part of the Town of Oakville, Ontario's ongoing implementation activities, the municipality spreads the word about emergency preparedness and the importance of local action to the public using communications and gamification. For example, in 2017 the Town of Oakville's outreach work involved public talks, adaptation games, and the Prepare 2 Be Prepared Challenge, all centered on the Keep Calm and Adapt: Emergency and Extreme Weather Preparedness Event. This type of creative and "out-of-the-box" engagement is reaching new audiences and is helping to ensure that residents know what they can do to prepare for more extreme weather and a changing climate.

Non-Governmental Organizations Supporting Municipal Adaptation Action

Municipal adaptation action in Canada is supported by all levels of governments, as well as the Federation of Canadian Municipalities and ICLEI Canada.

The **Federation of Canadian Municipalities** supports municipalities on climate change through policy and capacity building programming. The Municipalities for Climate Innovation Program further raises awareness about climate change, offers technical assistance, direct grants for municipalities and mobilizes knowledge on climate mitigation, adaptation, and infrastructure asset management. This program will generate new knowledge on transitioning to low carbon communities along with ways to integrate climate change into asset management through peer learning programs like the Climate and Asset Management Network and Transition 2050. In parallel, the Federation of Canadian Municipalities delivers the Partners for Climate Protection program in partnership with ICLEI Canada as a resource for municipalities.

ICLEI Canada works with local governments on sustainability issues, including supporting communities in preparing for climate change. ICLEI's *Building Adaptive and Resilient Communities* program is a framework guiding municipalities through a comprehensive planning methodology that includes research and climate impact assessment frameworks, plan development, action-setting processes, implementation planning, and monitoring and review strategies. It is supported through a variety of resources and tools to build municipal capacity to respond to climate change. The BARC method has been applied by municipalities across the country, including in British Columbia, Alberta, Ontario, New Brunswick, Nova Scotia, and Nunavut.

The City of Windsor, Ontario is enhancing public awareness of the steps individual home owners can take to minimize the risk of basement flooding by making a city-owned 1920s home flood resilient and installing a number of stormwater management practices on site. The City of Windsor will document the improvements through a series of YouTube videos as part of a larger basement flooding education campaign. Each measure will be permanently displayed on site, outlining their purpose, how they function, and any required maintenance, and the home will be available for public open houses.

Similarly, Calgary, Alberta initiated a low impact development project in the redevelopment of the Currie Barracks Brownfield in order to ensure that the rate of the runoff leaving the site would not exceed the capacity of the downstream stormwater system. The project was pursued in order to deal with extreme rain events which have caused Calgary hundreds of millions of dollars in damages since 2005. In particular, abandoned fields were converted into rain gardens, and vegetated swales and gravel infiltration trenches were incorporated at strategic locations as part of the green space in the new urban fabric.

Vancouver launched a unique program in 2016 that provides extreme weather shelter spaces to those who are homeless or at risk of homelessness when a community issues an extreme weather alert. The Extreme Weather Response program is an initiative that "funds community based services to provide temporary emergency shelter spaces during periods of extreme winter weather which threaten the health and safety of homeless individuals". Emergency shelter, safe refuge, and hospitality are provided by community members, congregations from faith groups, and advocates. The expected outcomes of the Extreme Weather Response program are decreased health and safety risks to homeless people during periods of extreme winter weather and a reduction of street homelessness during extreme winter weather.

6.4.4 Indigenous Adaptation Policies, Plans and Programs

Indigenous Peoples are active drivers and agents of change who contribute vital knowledge, experience, and leadership to adaptation efforts across Canada. Indigenous Peoples have responded to climate change impacts in Canada in a number of ways, such as developing and implementing climate change adaptation plans in their communities, adjusting subsistence activities in response to environmental changes, launching a multi-media website to share Indigenous Knowledge of the impacts of climate change, and developing Indigenous guardians programs.

Indigenous Peoples are Active Drivers and Agents of Change

"All across Canada…there are…ground-breaking First Nations' initiatives addressing food security, sustainable land-use management, the preservation of oral histories about the land, and the charting of territories. Clearly, First Nations have been, and, will continue to be, diligent in the face of this ongoing threat to our social, cultural, environmental, and economic well-being." (Assembly of First Nations, 4, 2016)

"We are among the first to put a human face on the unprecedented climate changes happening in the Arctic. We have been active partners in efforts to understand and develop policies and actions to adapt to the changes we are experiencing and to increase the awareness of other Canadians and people around the world of climate impacts." (Inuit Tapiriit Kanatami, 31, 2016)

"The Métis people have historically and in contemporary times excelled as entrepreneurs, as environmental stewards and conservationists, as negotiators and middlemen across cultures, landscapes and economies, adapting to the changing landscape and times with a keen enthusiasm and sweat on the brow." (Métis National Council, 2, 2016)

"Indigenous peoples have known for thousands of years how to care for our planet. The rest of us have a lot to learn. And no time to waste." (Prime Minister Justin Trudeau, COP21, 2015)

The Government of Canada has committed to a renewed, nation-to-nation, government-to-government, and Inuit-to-Crown relationships with First Nations, the Métis Nation, and Inuit. Sustained and meaningful collaboration between the federal government and Indigenous Peoples must recognize the rights and interests of Indigenous Peoples as set out in Canada's Constitution. This approach must also advance the implementation of the United Nations Declaration on the Rights of Indigenous Peoples, of which the Government of Canada is a full supporter, without qualification, and which includes the principle of free, prior, and informed consent. Collaboration must also recognize the treaty rights of Indigenous Peoples to make laws and manage resources on their Settlement

Lands where comprehensive land claim agreements have been signed. This engagement should be community led, regionally facilitated, and nationally coordinated.

The Government of Canada upholds its commitment to respect the rights of Indigenous Peoples, undertake robust, meaningful engagement, and respectfully receive and consider Indigenous Knowledge while implementing the Pan-Canadian Framework on Clean Growth and Climate Change.

The Government of Canada as well as provincial, territorial and municipal governments, non-governmental organizations, Indigenous organizations and universities support adaptation efforts for Indigenous Peoples. Indigenous communities have used the results of vulnerability assessments to inform the prioritization of adaptation measures and plan future infrastructure investments and emergency preparedness measures with climate change in mind. They have developed culturally appropriate tools for their communities and have integrated their planning into regional adaptation planning initiatives. The following are examples of a number of projects funded through these initiatives. The Nunavik project Life on Permafrost: Community Planning Empowerment, funded by Indigenous and Northern Affairs Canada, focused on communities becoming better informed technically and more knowledgeable about local and regional permafrost and climate conditions. This way, leaders and members of the Nunavik communities were in a better position to address the challenges arising from environmental changes, including permafrost issues related to buildings and road infrastructure, and to make well supported, science-based recommendations and decisions relative to their development. In addition, the education component of this project was implemented in collaboration with the Kativik School Board and the local schools, enabling it to have an impact on youth through the practice of hands-on scientific activities of actual significance for them and their community.

Indigenous Knowledge systems are cumulative, dynamic, and adaptive knowledge systems that are intertwined with personal, community, and national/cultural knowledge. Indigenous Knowledge is heterogeneous, and varies between Indigenous Peoples and groups.

Indigenous Knowledge systems are broader than what is commonly referred to as Traditional Knowledge. However, it is important to note that Indigenous Knowledge systems are a "way of being" that is broader than just specific ecological knowledge. Further, it is important to recognize that "Traditional" does not mean narrow, static, or historic. Indigenous Knowledge continues to be applicable to policy and can support a more comprehensive understanding of climate change's social, economic, and environmental impacts.

Inuit Qaujimajatuqangit is the system of Inuit Indigenous knowledge and societal values. It includes "all aspects of traditional Inuit culture including values, world-view, language, social organization, knowledge, life skills, perceptions and expectations" and provides detailed insight into climate change in Inuit Nunangat.

Another successful community project took place in Georgina Island First Nation. This community received funding from Indigenous and Northern Affairs Canada from 2012–2015. Over the course of the three years, the community completed a vulnerability assessment, developed adaptation recommendations, released the *Georgina Island First Nation Climate Change Adaptation Plan*, and conducted a review of the Band's policies to integrate climate change considerations. This stepwise approach, engaging with the community to identify priorities and addressing these through planning exercises was successful because it built on the community's internal capacity to develop and manage the project in a way that was meaningful to the community as a whole. All members of the community were engaged throughout the process and became more involved in the project as it progressed. The community now has better and more detailed information regarding the likely risks posed by climate change and is better prepared to respond to those threats by planning proactive adaptation measures.

The First Nations of Québec and Labrador Sustainable Development Institute is developing a guide to support First Nations who want to create their own climate change adaptation plan, and has collaborated with seven

First Nations (Akwesasne, Odanak, Opitciwan, Pessamit, Pikogan, Uashat mak Mani-Utenam and Wôlinak) to support them in the development of their first climate change adaptation plans. The First Nations of Québec and Labrador Sustainable Development Institute also supported Uashat mak Mani-Utenam in implementing their first climate change adaptation plan, starting in 2014. Implementation included creating working committees for each of the challenges specified in the plan, networking with local and regional environmental organizations, and conducting outreach activities in schools.[38]

IsumaTV is a Canadian collaborative multimedia platform for Indigenous filmmakers and media organizations to share their work with a broader audience. IsumaTV hosts over 6,000 videos in over 80 languages, representing cultures and media organizations across Canada and the world. IsumaTV has also developed an IsumaTV Mediaplayer to ensure remote communities, as well as anyone with access to the internet, a computer, or a mobile device, can participate. IsumaTV uses its platform to provide a comprehensive overview of human rights challenges Indigenous peoples face globally, and a number of their featured products provide information on climate change and Inuit Qaujimajatuqangit, and how climate change is impacting the lives of Inuit living in Northern Canada. IsumaTV enables Indigenous Peoples to share their experiences and perspectives on a range of topics (e.g., human rights, resource development, climate change), in their own language, with a global audience.

Indigenous guardians programs in the Northwest Territories provide significant social, economic, and environmental benefits by using Indigenous Knowledge to help preserve Indigenous culture and land. The Ni Hat'ni Dene program in Lutsel K'e, modelled after the Haida Gwaii Watchmen program, partners youth with older community members to maintain the integrity of cultural sites, provide tours of the area, monitor and record activity on and changes to the land and water, and transmit cultural and scientific knowledge to youth. The Deh Co K'ehondi program in the Dehco First Nations uses the Dene language and culture to rebuild relationships with the land. These programs are only two of the approximately 30 Indigenous guardians programs across Canada. Community level Indigenous guardians programs are part of broader efforts to create a National Indigenous Guardians Network in Canada. The Government of Canada provided funding to support the development of the national network and prepare Indigenous Peoples to launch their own Indigenous Guardian programs ($25 million over five years in Budget 2017).

The Métis have made significant efforts to build relationships at the local and regional level, including by entering into relationships with municipalities and developing urban governance authorities and regional governance authorities to support future relationship building. Some Métis authorities have also been party to provincial agreements on the environment or resource management, creating an opportunity to focus on climate change.

6.5 International Adaptation Policies and Strategies

At the international level, the United Nations Framework Convention on Climate Change and other fora (e.g., the World Health Organization, North American Climate Change and Human Health Working Group, the United Nations Convention to Combat Desertification, and the United Nations Office for Disaster Risk Reduction) offer the opportunity for Canada to strengthen and disseminate research and science; share best practices and lessons learned about climate change and climate change adaptation; and assist developing countries in increasing their resilience.

The Government of Canada committed to strong action to address climate change through the ratification of the Paris Agreement on October 5, 2016. Canada declared it would continue to support a prominent international focus on adaptation actions. In Paris, Canada offered support to vulnerable countries faced with the challenge of adapting to the impacts of climate change by contributing $30 million to the Least Developed Countries Fund. Canada also pledged $2.65 billion over five years (2015–2020) to help developing countries tackle climate change, including $10 million to improve early warning systems for hazards like tropical cyclones, floods, heat waves and forest fires in developing countries.

The Paris Agreement recognizes the need to strengthen knowledge, technologies, practices and efforts of local communities and Indigenous Peoples related to addressing and responding to climate change, and establishes a platform under the United Nations Framework Convention on Climate Change for the exchange of experiences and sharing of best practices on mitigation and adaptation in a holistic and integrated manner. Through the Pan-Canadian Framework on Clean Growth and Climate Change, the federal government committed to continue to engage and support Indigenous Peoples' action on international climate change issues, including by advancing the implementation of this platform. In 2017, Canada, including the Government of Canada working in partnership with First Nations, Inuit, and the Métis Nation, took a leadership role in working with the international community—including by convening informal discussions and in the formal negotiations at the 23rd Conference of the Parties to the United Nations Framework Convention on Climate Change—towards launching the meaningful operationalization of the platform.

Canada also rejoined the United Nations Convention to Combat Desertification (UNCCD) in March, 2017. The UNCCD works to improve the living conditions for people in drylands (both domestically and internationally), maintain and restore land and soil productivity, and mitigate the effects of drought. Through the UNCCD, Canada is exploring options to engage internationally and provide scientific and technical expertise on topics related to sustainable land management, drought monitoring, land restoration, and landscape resilience.

Canada collaborates with the United States of America and Mexico on the conservation, protection, and enhancement of the North American environment through the Commission for Environmental Cooperation. Canada assumed chairmanship of the Commission for Environmental Cooperation in 2016. Canada's chairmanship enables Canada to take proactive action on climate change priorities, which include advancing efforts on the commitments made at the North American Leaders' Summit in 2016.

The Government of Canada supported the Arctic Council's development of an *Arctic Resilience Action Framework* (2017), and will continue to support its implementation. The *Arctic Resilience Action Framework* provides a framework of common priorities and targets that promote improved collaboration and effectiveness among the Arctic Council and Arctic Council partners as they strive to enhance Arctic resilience. The *Arctic Resilience Action Framework* will be the first comprehensive regional adaptation and resilience framework for the Arctic.

In 2010, Canada and other Parties to the *Convention on Biological Diversity* (CBD) adopted the global *Strategic Plan for Biodiversity 2011–2020*. The Strategic Plan is comprised of a shared vision, a mission, strategic goals and 20 targets, collectively known as the Aichi Targets. These international Targets acknowledge the linkages between biodiversity and climate change mitigation and adaptation.

Provinces and territories also work with the international community to share best practices, and support adaptation efforts in developing countries. For example, following the Paris Agreement, the Québec government announced a set of cooperative measures totaling $25.5 million to fight climate change to help the most vulnerable developing countries face the impacts of climate change, especially in Francophone countries. It since gave $6 million to the Global Environment Facility's Least Developed Countries Fund, and launched calls for projects centered on climate cooperation and youth initiatives.

The governments of Québec, British Columbia, Alberta, and Prince Edward Island also joined the international RegionsAdapt initiative that supports and reports efforts on adaptation at the state and regional level. Québec and British Columbia are also members of the International Alliance to Combat Ocean Acidification, a worldwide network of governments and organizations that addresses the impact of acidification on the health of oceans.

British Columbia also participates in the Pacific Coast Collaborative, a forum for cooperative action, leadership, and information sharing between California, Oregon, Washington, and British Columbia on the issues facing Pacific North America, such as climate change.

The Northwest Territories has also collaborated with the United States on climate projections and landscape conservation cooperatives. In conjunction with the University of Alaska, Fairbanks, the Northwest Territories has developed easy to use climate change projections to support communities in adapting to climate change. Additionally, through the Northwest Boreal Landscape Conservation cooperative, the Northwest Territories has coordinated with Alaska, northern British Columbia, and Yukon to share climate change information and resilience best practices.

6.6 Oversight and Reporting

Measuring progress on adaptation is challenging, as the various approaches, goals, timelines, and scales of adaptation actions make it difficult to develop single, uniform, meaningful metrics to measure progress. Coordinated reporting on progress on adaptation across the federal government is carried out through a *Horizontal Management Framework* and the *Results and Delivery Charter on Clean Growth and Climate Change* (the Charter) on an ongoing basis. The Charter was developed in collaboration with federal counterparts to serve as the key monitoring and reporting platform for measuring progress against the Pan-Canadian Framework on Clean Growth and Climate Change outcomes. Regular public reporting of progress using the indicators described in the Charter ensures that the Government of Canada remains accountable to Canadians. The *Horizontal Management Framework for Clean Growth and Climate Change* demonstrates the linkages between the authorities being sought for climate change adaptation programs and activities by federal partners to adaptation and resilience in the Charter.

As discussed in Chapter 4: Policies and Measures, First Ministers from federal, provincial, and territorial governments receive annual reports on the Pan-Canadian Framework on Clean Growth and Climate Change through a federal, provincial and territorial process established for this purpose. This reporting provides relevant and timely information on the effectiveness of policy development towards implementing the Pan-Canadian Framework and ensuring Canadians are resilient and can adapt to the impacts of climate change.

Respect and recognition of the distinct cultures of First Nations, Inuit, and Métis people in Canada is central to Canada's approach to climate change policy. Three separate senior-level tables are being established to implement the Pan-Canadian Framework on Clean Growth and Climate Change. The tables will support First Nations, Métis, and Inuit clean growth and climate change priorities, including adaptation and resilience building actions. These efforts support Canada's broader commitment to reconciliation with Indigenous Peoples. The Government of Canada, through Indigenous and Northern Affairs Canada, has committed to providing funding support for Indigenous engagement in domestic climate policy, which will include supporting the implementation of the three tables.

The Government of Canada also reports through the 2016–2019 *Federal Sustainable Development Strategy*, which is the Government's primary vehicle for sustainable development reporting to both Parliament and Canadians. The *Federal Sustainable Development Strategy* demonstrates federal leadership towards implementing the environmentally-related global United Nations' Sustainable Development Goals. The *Federal Sustainable Development Strategy* will report on several goals, including those that support adaptation and climate resilience, such as Effective Action on Climate Change and Modern and Resilient Infrastructure.

As a Party to the United Nations Convention on Biological Diversity (CBD), Canada has also developed national biodiversity goals and targets. Target 5 of Canada's 2020 Biodiversity Goals and Targets relates to climate change adaptation: "By 2020, the ability of Canadian ecological systems to adapt to climate change is better understood, and priority adaptation measures are underway." The targets, announced in 2015, were developed collaboratively by federal, provincial and territorial governments, with input from Indigenous organizations and others, and are intended to encourage and promote collective action. National progress toward the targets will be reported in December 2018, in *Canada's 6th National Report* to the CBD.

The Government of Canada, led by Environment and Climate Change Canada, launched an external Expert Panel on Climate Change Adaptation and Resilience Results in 2017 to provide advice on measuring progress on adaptation and climate resilience under the Pan-Canadian Framework on Clean Growth and Climate Change, in an effort to overcome the challenges associated with identifying successful adaptation actions. The advice of the Expert Panel on Climate Change Adaptation and Resilience Results will support the federal government and others in better communicating results to Canadians, and demonstrating progress in enhancing Canada's resilience to climate change.

Provinces, territories, and municipal organizations (e.g., ICLEI Canada, the Federation of Canadian Municipalities) will be engaged in the work of the Expert Panel on Climate Change Adaptation and Resilience Results; however, they are also leading their own efforts to develop and examine monitoring and evaluation strategies for climate change adaptation. For example, the Government of Alberta is launching a process to identify climate specific indicators and metrics relevant to Alberta's social, economic, and environmental systems and assess the potential impacts of climate change and climate change policy inaction in the province.

ICLEI Canada, with funding from Natural Resources Canada's Enhancing Competitiveness in a Changing Climate program, led a project to examine how available metrics from varying sectors and orders of government can contribute to measuring the effectiveness and progress of implementing climate change adaptation actions.[39] ICLEI Canada examined indicators currently used to measure sustainability through a case study series, and evaluated the potential application of sustainability indicators to measuring progress on climate change adaptation.

More specifically, ICLEI Canada and the Clean Air Partnership conducted a series of sector-focused case studies and catalogued existing sustainability indicators that are currently being used to measure and/or monitor the effectiveness of policies or actions in coastal management, flood management, health and infrastructure, and examined the pertinence of such indicators in measuring climate change adaptation.

6.7 Conclusion

The wide range of impacts being experienced across Canada will be exacerbated as the climate continues to change. Taking action now to adapt to current and future climate impacts will help protect Canadians from climate change risks, reduce costs, and ensure that society continues towards a more resilient future.

Adaptation requires a sustained, ambitious, and collaborative approach across regions, orders of government, and sectors. The Pan-Canadian Framework on Clean Growth and Climate Change marked a significant effort by federal, provincial, and territorial governments to collaborate on adaptation efforts, and all levels of government will continue to work together to implement the framework.

Federal, provincial, territorial, and municipal governments have developed independent 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, sharing of adaptation experiences, and support for local adaptation projects. Indigenous Peoples have also developed adaptation strategies and policies, and have worked with federal, provincial, territorial, and municipal governments, universities, non-governmental and Indigenous organizations to enhance their resilience to climate change.

Since Canada's *6th National Communication* federal, provincial, territorial, and municipal governments universities, non-governmental and Indigenous organizations and Indigenous Peoples have made significant progress in implementing adaptation measures. These measures include improvements to climate science, impacts and adaptation research and science assessments (including regional and sectoral assessments), community monitoring programs, and capacity-building and awareness raising efforts (particularly at the municipal level and for Indigenous Peoples).

Building from existing efforts and past successes, Canada will continue to play an important leadership role on climate change adaptation through measures such as strategic investments for building resilience in priority areas and facilitating collaboration.

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CHAPTER 7

Financial, Technology, and Capacity Building Support

Climate change is one of the greatest challenges facing humanity with implications for health, agriculture, economy, trade, and infrastructure globally. Developing countries, particularly the poorest and most vulnerable, are the hardest hit by climate change and have a limited capacity to prevent and cope with its consequences. Canada is committed to acting in accordance with science, promoting de-carbonization, supporting climate change efforts in developing countries, empowering women and girls and enabling future prosperity through a sustainable national and global economy.

One of the core aims of the Paris Agreement is to make all financial flows consistent with a pathway towards low-emission, climate-resilient development. This goal requires all actors—public and private—to transition to green and sustainable investments and accelerate clean growth. Canada is supporting this transition by: delivering $2.65 billion (B) over five years in climate finance to developing countries, scaling up to $800 million (M) per year by 2020; integrating climate change into our development assistance; using public finance to address market failures, helping to attract and mobilize climate investments from the private sector; and deploying innovative climate resources, such as providing climate investment through Export Development Canada.

Over 2015 and 2016 Canada delivered $625M in public finance alone from various channels to a wide range of mitigation and adaptation initiatives. These initiatives are helping developing countries make the transition towards low-carbon and climate resilient economies by providing support to manage risks and build resilience to the impacts of climate change, deploy clean energy technology, and support climate-smart agriculture in line with low carbon and climate resilient pathways. This support includes:

- $242M as part of Canada's $2.65B commitment to significantly scale up climate financing for developing countries by 2020;
- $104M of international assistance projects with a climate change component as part of Canada's efforts to integrate climate change considerations into its development funding;

- $6M from Québec to the Least Developed Countries Fund, making Québec the first subnational government to support the fund; and
- $273M from Export Development Canada, Canada's export credit agency, to mobilize private sector finance in sectors such as clean energy.

A breakdown of Canada's public climate finance delivered over 2015 and 2016 is shown in Figure 7.1.

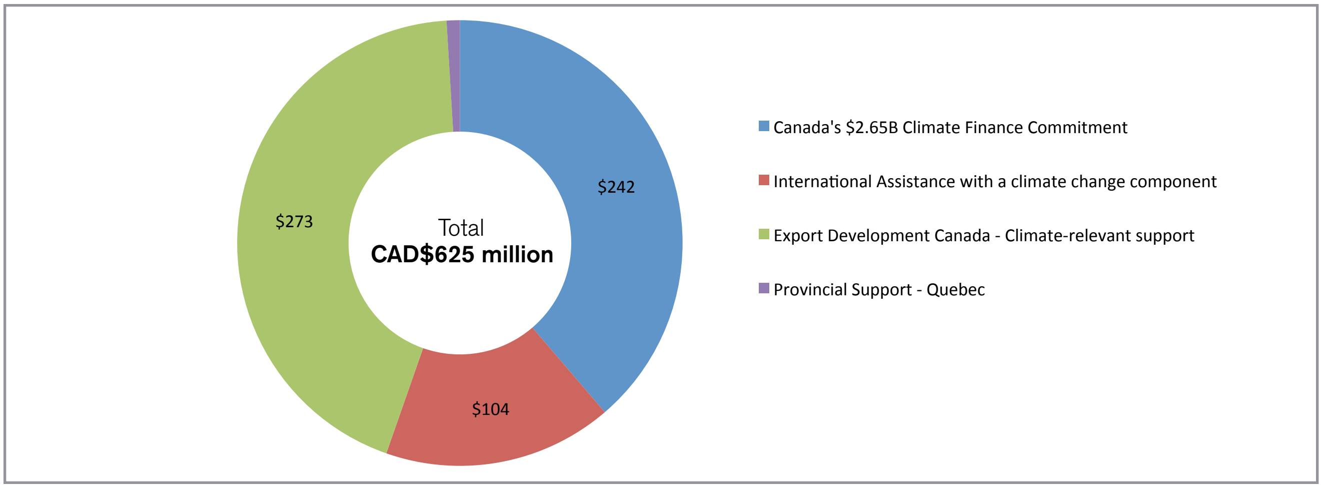

Figure 7.1: Canada's Public Climate Finance Delivered over 2015 and 2016 (CAD$ millions)

Canada and other developed country partners are committed to continue to collectively mobilize climate finance from a wide variety of sources, to address the needs of developing countries. In 2016, Canada and other donor partners delivered a collective *Roadmap to US $100 billion* to demonstrate how we are meeting the US $100B goal, highlighted at the 22nd Conference of the Parties (COP22) to the United Nations Framework Convention on Climate Change (UNFCCC). The Roadmap provides clarity on the range of actions donors are taking to get there, including leveraging private sector finance, significantly scaling up finance for adaptation, and enhancing access to finance.

Clean, innovative technologies and capacity building for climate change are key to addressing climate change and to growing a global low-carbon economy. Canada is actively engaged in a broad range of actions to advance the development and deployment of clean technologies and supporting a range of actions to support capacity building for climate change in developing countries.

7.1 Delivering on Canada's Climate Finance Commitments

In November 2015, Canada made a historic pledge of $2.65B over five years to 2020 to support developing countries transition to low-carbon economies that are both greener and more climate-resilient. This financial contribution is a substantial increase from Canada's past levels of climate funding, scaling up to $800M per year by 2020.

Canada works multilaterally, as well as bilaterally with key partner countries, to reduce greenhouse gas (GHG) emissions and increase adaptive capacity to the impacts of climate change. In addition to specific climate focused efforts, Canada is integrating climate change considerations across its development assistance.

Canada's climate finance will closely align with its overall development priorities with a focus on the empowerment of women and girls and gender equality, outlined in Canada's new Feminist International Assistance Policy.

7.1.1 Delivering Canada's $2.65 Billion Climate Finance Pledge

In 2016, Canada began delivering its $2.65B pledge, providing $242M through multilateral and bilateral channels to initiatives that help developing countries transition to low-carbon economies and manage risks and build resilience to the impacts of climate change.

This includes support to the organizations and financial mechanism of the UNFCCC. These organizations play an important role in global action on climate change by facilitating the delivery of climate finance and are part of Canada's efforts to successfully implement the Paris Agreement. As part of its commitment, in 2016, Canada provided:[a]

- **$168M to the Green Climate Fund (GCF).** The GCF is the largest dedicated international climate fund, helping developing countries to reduce their GHG emissions and adapt to the impacts of climate change. The GCF has approved US $2.7B for 54 climate change projects around the world. These investments are expected to mobilize an additional US $6.5B in public and private finance, and are expected to avoid 1 billion metric tonnes of CO_2 equivalent, equal to taking over 214 million cars off the road. GCF funding will also support 159 million people in increasing their resilience to climate change.[b] This contribution is part of Canada's $300M pledge to the GCF. An example of a GCF-financed project in 2016 is the GCF's Pacific Islands Renewable Energy Investment Program in seven small island developing states (SIDS)—the Cook Islands, Tonga, Republic of Marshall Islands, Federated States of Micronesia, Papua New Guinea, Nauru and Samoa. This program will support the development of battery storage and wind, solar and hydro renewable energy in these fossil fuel dependent SIDS. The project is expected to result in the reduction of 120,000 tonnes of carbon dioxide equivalent per year, while dramatically increasing the penetration of renewables in these markets.
- **$18.45M to the Global Environmental Facility (GEF).** Canada supported climate change activities through its regular contributions to the GEF. Under Canada's $2.65B commitment, $18.45M per year of Canada's total contribution of $233.09M to the GEF 6th replenishment (2014–2018) supports the GEF's climate change efforts. Since its establishment in 1992, GEF-funded projects have achieved concrete climate change impacts, including removing nearly 2.7 billion tonnes of GHGs through GEF projects. An example of a GEF project supported during this replenishment is the GEF project Facilitation of the Achievement of Sustainable National Energy Targets of Tuvalu in Tuvalu. This project aims to support the Government of Tuvalu's updated target of reducing emissions of greenhouse gases from the electricity generation sector by 100% by 2025. Tuvalu's goal of 100% renewable energy-powered electricity will be generated with a mix of the following methods: solar PV installations, wind energy farms, battery storage and back-up bio-diesel generators. The project is expected to result in the reduction of 273,000 tonnes of carbon dioxide equivalent per year.

Canada's $2.65B commitment also includes bilateral support for the implementation of developing countries' Nationally Determined Contributions and National Adaptation Plans, and to contribute to their transition to clean and climate resilient economies.

- For example, through a project with Cowater International Inc. Canada is supporting low-carbon economic growth in Jordan. A rapidly expanding population, industrial pollution and climate change

[a] Canada also contributed $500K to the UNFCCC Trust Fund for Supplementary Activities. This fund supports capacity building activities to assist developing countries in undertaking mitigation, adaptation and climate reporting actions. This contribution is in addition to Canada's regular core contributions to the UNFCCC budget, which supports UNFCCC activities. Canada' support to the UNFCCC budget is not counted as part of Canada's climate finance.

[b] Up to date as of 31 October 2017.

exposure have taken a toll on Jordan's environment. In line with Jordan's National Green Growth Plan, this project will help introduce energy efficient solutions in Jordan by: launching an awareness campaign targeting 25,000 people to raise awareness of renewable energy and energy efficiency (RE&EE) solutions; strengthening women's organizations and community-based organizations in the management of RE&EE initiatives; and, help to procure and install 22,800 RE&EE units, including solar panels. Overall the project is expected to improve the livelihoods of 150,000 people in poor communities, particularly for women and youth.

ROLLING OUT CANADA'S $2.65B COMMITMENT

Since announcing Canada's climate finance pledge in November 2015, Canada has been rolling forward at a fast pace implementing its $2.65B commitment. In 2015 Canada announced $275M to specific initiatives.[c] Over 2016 and 2017, Canada has announced an additional $335M, including:

- $200M to the Asian Development Bank to catalyze private investments in climate change in low and lower-middle income countries and small island developing states in Asia and the Pacific;
- $122M for bilateral adaptation and mitigation projects in Burkina Faso, Haiti, Morocco Vietnam, Senegal, South Africa, and Latin America and the Caribbean;
- $5M for the UNFCCC Capacity Building Initiative for Transparency;
- $3M to World Bank Transformative Carbon Asset Facility to support emission reductions;
- $2.5M to the Clean Technology Centre and Network to improve access to clean technologies; and
- $2M to the National Adaptation Plans Global Network for climate-capacity building.

Canada has also provided more details on several previous announcements, including:

- $10M for climate and disaster resilience in Myanmar as part of Canada's $50M G7 Initiative on Climate Risk Insurance, announced at 21st Conference of the Parties to the UNFCCC. This initiative will improve the capacity of the Government of Myanmar, private sector and communities to better prepare and respond to extreme weather events;
- $14M to support nationally determined contribution (NDC) implementation in Mexico and Chile as part of Canada's $35M short-lived climate pollutant (SLCP) reduction support announced at COP21.

For the most up-to-date information on recent project announcements please visit: https://climate-change.canada.ca/finance/Default.aspx

7.1.2 Integrating Climate Considerations into Development Assistance

It is widely understood that climate change is both a contributing factor and an exacerbating factor for other development challenges, such as health, security, economic growth, and gender equality. To reflect this reality, Canada's climate finance flows are consistent with Agenda 2030 for Sustainable Development and, in particular, Sustainable Development Goal (SDG) 13, which sets out targets for climate action, including: implementing UNFCCC commitments; enhancing adaptation and climate resilience; and promoting effective climate planning with a focus on women, youth and local and marginalized communities. Over 2015 and 2016 Canada delivered $104M of international assistance projects with a climate change component as part of Canada's efforts to integrate climate change considerations into its development funding.

Empowering Women and Girls

Women and girls are at particular risk when it comes to climate threats, and their participation is crucial in planning and implementing adaptation strategies to deal with those threats. For example, when communities organize themselves to adapt to climate change, women often do not participate in the decision making and do not get equal access to technologies. Having women and girls as leaders and full participants leads to more effective adaptation plans and projects that benefit all

[c] Found in *Canada's 2nd Biennial Report,* page 23.

members of the community. When women have better access to climate-resilient resources and technologies, they are able to devote more time to the activities—such as education, paid work, political and public participation, and leisure activities—that enhance the quality of life for entire communities.

The Paris Agreement emphasizes the importance of gender equality in climate change action. Advancing the health and rights of, and protecting and empowering, women and girls is thus an overarching objective of Canada's approach to climate change. Canada's pledge and its development assistance both have a particular focus on empowering women and girls.

Canada adopted a Feminist International Assistance Policy in June 2017, a central theme of which is to promote gender equality and help empower all women and girls. Environment and climate action are one of six action areas highlighted in the new policy, recognizing that women and girls are disproportionately at risk from the effects of climate change and need better support to mitigate and adapt to changes that threaten their health and economic well-being. Canada's climate finance will also have a focus on the empowerment of women and girls and gender equality.

- For example, over 2015 and 2016 Canada provided $324,000 to the Caribbean Disaster Risk Management Program which aims to improve resilience in the Caribbean extreme weather events, such as hurricanes and floods, and reduce their impact on communities. Greater resiliency is achieved when all people and sectors are involved in disaster risk prevention. To ensure this, the Caribbean Disaster Risk Management Program gives special attention to gender equality, to ensure equal access to resources and opportunities for both men and women in building their resilience and adaptive capacity.

More information on Canada's bilateral support provided over 2015 and 2016 can be found in Table 8 below.

7.1.3 Action by Canadian Sub-National Governments

Canada recognizes the essential role sub-national governments are playing in responding to climate change. Sub-national governments are also playing an increasingly important role in sustained and scaled-up climate finance flows. Most notably, at the 2015 Paris Climate Conference, Québec announced its support of $25.5M to support actions to fight against climate change in francophone countries that are the most vulnerable to climate change.

Québec delivered $6M of this support in 2016 to the GEF's Least Developed Countries Fund, making Québec the first sub-national government to support the Fund. The remainder of Québec's support to be delivered includes: $18M for technology transfer and capacity building initiatives in francophone countries. A first call for projects has been launched earlier this year. Fourteen projects from Québec non-governmental organizations, businesses and research institutions have been selected for funding and will be implemented in 12 countries. A second call for projects is planned within the next few months. An additional $1.5M is aimed at strengthening the capacities of francophone countries to negotiate in French within the UNFCCC process and implementing international climate commitments, and strengthening the climate change actions of Francophone youth aged 18 to 35.

Québec's climate finance support is funded by Québec's Green Fund through the *2013–2020 Action Plan on Climate Change*.[d] The majority of the Green Fund's revenue comes from Québec's linked carbon market with California, a tool used by Québec to help achieve its ambitious targets for reducing GHG emissions and increase its resiliency to climate change impacts.

[d] For more information, please visit: http://www.mddelcc.gouv.qc.ca/changementsclimatiques/plan-action-fonds-vert-en.asp.

Canadian municipalities are also taking actions to combat climate change notably through their engagement and financing of the Federation of Canadian Municipalities. For example, Canada is providing $5M over five years starting in 2017 to the *Building Inclusive Green Municipalities* initiative. This initiative is being implemented by the Federation of Canadian Municipalities and will provide support to South African municipal governments to realized mitigation and adaptation activities such as analyzing local mitigation potentials in key emission reduction sectors and securing the built environment against hazards emerging from climate change impact.

7.1.4 Sectorial Distribution of Public Support

Canada's climate finance is focused on supporting developing countries in obtaining clean and reliable sources of energy and enhance resilience, particularly the poorest and most vulnerable countries, in their fight to adapt to the impacts of climate change.

Over 2015 and 2016, 54% of Canada's public climate finance was allocated to adaptation initiatives, 42% to clean energy and mitigation initiatives, and 4% to cross-cutting initiatives that targeted both mitigation and adaptation.[e] Canada's public finance delivered during this period consisted of 100% grant financing. The sectorial distribution of Canada's climate finance support over the reporting period is shown in Figure 7.2.

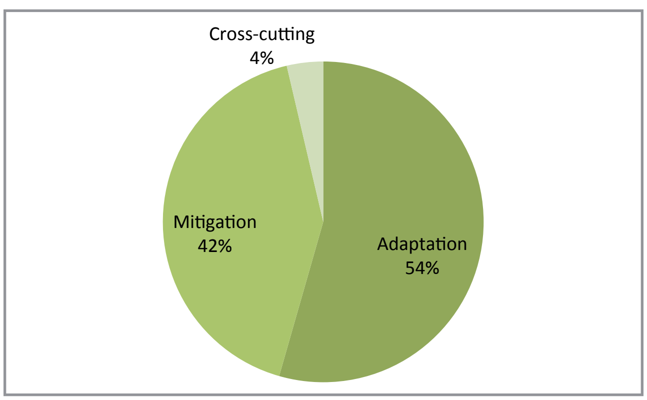

Figure 7.2: Canadian Climate Finance by Sector

Adaptation by the Poorest and Most Vulnerable

Canada is delivering on its promise to increase support for vulnerable countries to adapt to climate change, with new projects launched this year, working through multilateral channels as well as in partnership with organizations that make a difference at the community level. Adaptation initiatives supported by Canada during this reporting period aim to increase resilience in vital sectors through climate–smart agriculture, risk reduction insurance, meteorological services and climate science and research.

- For example, Canada is providing $10M over five years (2016–2021) to support the improvement of early warning systems in some of the most vulnerable communities. Canada's contribution will be delivered through the World Meteorological Organization to the Climate Risk Early Warning System (CREWS) project to help developing countries, particularly the small island developing states and least developed countries. These systems have been proven to reduce loss of life and economic hardship caused by meteorological hazards such as tropical cyclones, floods, severe storms, forest fires, and heat waves.
- Canada also provided $3M in 2016 to AgroLAC 2025, a fund managed by the Inter-American Development Bank to support climate-smart agriculture in Latin America and the Caribbean. It is projected that in the absence of climate-smart agriculture and risk management, climate change could cost the region up to 137 percent of current GDP by the end of the century. Therefore, this fund aims to sustainably increase agricultural productivity in support of food security while adapting and building resilience to climate change in Latin America and the Caribbean. Canada's support will help to increase access for agricultural sector players to regional and global food markets; increase sustainable and resilient productivity of targeted farmers; and, improve sustainable natural resource management by targeted governments and farmers.

[e] Excludes support from EDC. Projects marked as 2. Mitigation and 2. Adaptation, such as the GCF, are accounted for 50% Adaptation and 50% Mitigation in this figure.

Clean Energy

Canada's mitigation support is consistent with the needs identified in developing partners Nationally Determined Contributions (NDCs). This support focuses on deploying clean and renewable energy to shift countries away from reliance on fossil fuels for energy. In addition, Canada's mitigation finance also supports sustainable forest and agricultural management, to reduce GHG emissions from these sectors.

- For example, Canada provided $973,000 in 2016 through the United Nations Foundation to help tackle Haiti's deforestation and air pollution challenges. Most Haitians use charcoal and wood as their source of energy for cooking which contributes to the country's extreme deforestation. Household fuel consumption in Haiti emits black carbon, contributing to indoor and outdoor air pollution and global warming. In fact, it is estimated that 9,500 Haitians die each year due to hazardous air pollutants. Haiti has set a target of reducing its GHG emissions by 31% by 2030. Canada is committed to helping Haiti to address climate change and reduce harmful emissions by supporting the development of a Clean Energy Action Plan in Haiti. This plan will help build a national household energy strategy focused on reducing the use of wood and charcoal. By 2018, Canada will deliver a total of $1.25M to support this initiative.

7.1.5 Geographic Distribution of Public Support

Over 50 developing countries are benefitting directly from Canadian climate change support provided over 2015 and 2016. A much larger number of countries are also benefitting from contributions made by Canada to multilateral funds such as the GCF and GEF. The geographic distribution of countries directly benefitting from Canada's climate finance support over the reporting period is shown in Figure 7.3.

Figure 7.3: Global Map of countries directly receiving Canadian climate finance

7.2 Scaling Up Climate Finance

The level of investment needed to address climate change will not be met by public finance alone. The private sector plays a key role in reaching the investment levels required to shift the world towards a low-carbon and climate resilient path. Canada is actively contributing to global efforts to mobilize private investment, using public climate funding to catalyze private investment for transformational climate change mitigation and adaptation initiatives. This funding helps mobilize private-sector investment and expertise, including in clean-technology innovation, in developing countries so that they too may seize the economic opportunities of the global shift towards clean growth.

7.2.1 Partnering with Multilateral Development Banks and Other Development Partners

In scaling up climate financing, Canada works collaboratively with a number of multilateral organizations to provide innovative financing aimed at removing investment risks to the private sector. Risks preventing investment can include high upfront costs or barriers such as lack of awareness of financial benefits of climate investments.

Canada established Canadian facilities at multilateral development banks (MDBs) designed to catalyze private sector investments. Using concessional financing, these facilities enable private investments, for example in clean energy and climate resilience that would not otherwise happen due to market barriers to investment.

Mobilizing Private Climate Finance for Solar Energy in Sri Lanka

In 2016, through the International Finance Corporation—Canada Climate Change Program, Canada invested US $7.5M to support the installation of rooftop solar photovoltaic (PV) panels and the implementation of green building measures on a chain of 18 supermarkets in Sri Lanka. This is the first solar PV and green buildings project in the retail sector. Canada's loan provided the long-term financing needed for this type of investment to be successful, mobilizing over $12M from other public and private sources. The panels will meet 30 to 50 percent of the supermarkets' energy consumption, avoiding an estimated 2,300 tonnes of GHG emissions per year.[f] The project is also demonstrating the financial success of rooftop solar PV for commercial initiatives in Sri Lanka, helping to encourage similar investments in the future.

To date, these facilities have invested US $453M of Canadian funding to projects, alongside US $2.56B in co-financing from MDBs and from other public sources. It is estimated that this financing has collectively mobilised a total of US $1.7B in private climate investment, approximately US $234M of which can be directly attributed to Canada's financial support.

[f] Ex-ante estimated GHG emission reductions. Actual reductions may not match estimates.

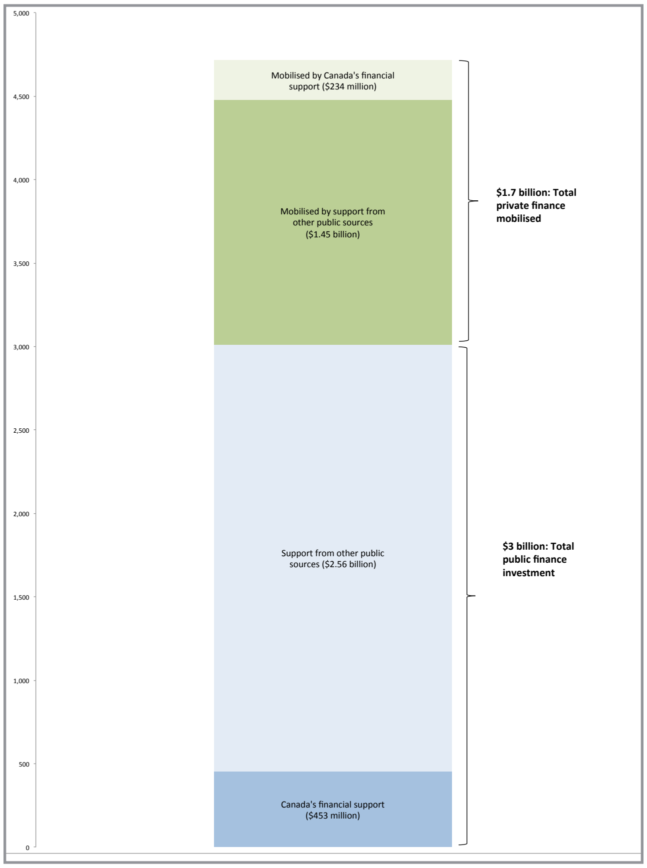

Figure 7.4: Private Climate Finance Mobilized through Canadian Climate Change Facilities at MDBs ($ USD)

In May 2017, Canada announced a reinvestment of $200M in funding to the Canadian Climate Fund for the Private Sector in Asia at the Asian Development Bank (CFPS). This fund aims to catalyze private investment in climate change action in developing Asian and Pacific countries, including small-island developing states that are among the most impacted by climate change. Canada's investment will help to reduce emissions, support a range of adaptation efforts, create jobs and advance low-carbon, women-focused projects to support development in the region. As of December 2016, Canada's investment in the CFPS has resulted in an expected 1.8 million tonnes of carbon reductions per year. These emission reductions are due to the 674 megawatts of anticipated or installed renewable energy capacity, leading to 3.3 terawatt-hours of renewable energy generation per year.

Further, the Canadian Climate Fund for the Private Sector in the Americas (C2F)—a fund established by Canada in 2012 at the Inter-American Development Bank—abated 138,570 tonnes of CO_2 in 2016 alone, and 260,340 tonnes of CO_2 cumulatively. This was due to 200,547 megawatt hours of renewable electricity being produced in 2016 alone, and 362,383 megawatt hours being produced cumulatively in the project to date. The C2F provided support for Divisa Solar, the first utility scale solar photovoltaic project in Panama, operational since August 2015. The project transmits the power it generates to the national electricity grid, directly competing with fossil fuel generators and testing the long-term competitiveness of solar power in the region. In 2016, Divisa Solar generated 13,857 megawatt hours of energy, abated 9,284 tonnes of carbon dioxide equivalent, and mobilized US $5.92M from the private sector. Divisa Solar was also the first project under the C2F to include a gender-targeted internship program for women in science, technology, engineering and mathematics.

MDBs are an important component in reaching the US $100B goal and the transition toward low-carbon sustainable development. Canada continues to provide core contributions to MDBs, which supports their funding of climate activities. Over 2015 and 2016, Canada provided an estimated $184M in core contributions to MDBs that supported climate activities.[g] This support is provided in addition to what Canada reports as climate finance, which does not include any core contributions.

7.2.2 Action by Export Development Canada

Export credit agencies contribute to the global goal to address climate change by spurring investment in

g Calculated based on OECD stats on MDB imputed climate shares in 2015. 2016 shares are assumed constant from 2015 levels, in the absence of 2016 data at the time of this report.

climate activities around the world. As a self-financing crown corporation, Export Development Canada (EDC) contributes to the Government of Canada's priority to support a global transition to a low carbon economy in line with the objectives of the Paris Agreement.

EDC actively supports clean-technology, implementing a 'cleantech strategy' to help enhance clean technology deployment abroad. EDC has put in place specific guidelines for higher-risk, earlier-stage clean-tech transactions and, provides distinctive financing and insurance in areas such as water treatment, energy efficient lighting, waste-to-energy sectors, alternative energy transportation, renewable energy generation, smart-grid infrastructure, and energy efficiency. Further, EDC contributed to global efforts to address climate change by providing $273M in 2016 to climate finance activities in developing countries.[h]

The adoption of the Paris Agreement was a commitment to action by all and continues to send a clear and strong signal to markets. For instance, green bonds are another growing financing vehicle used to drive private climate finance. EDC issued its first green bond in 2014, valued at $300M reflecting EDC's commitment to support businesses that are active in protecting the environment and mitigating climate change. In alignment with trends towards low carbon and climate resilient technologies, EDC issued its second green bond in December 2015 valued at US $300M. In May 2017, EDC issued their third Green Bond valued at US $500M, their largest Green Bond to date, reflecting the increase demand for sustainable finance products with predictable, strong financial returns.

In 2017, Canada announced the launch of a new Development Finance Institution (DFI). The new institute will enable partnerships with small and medium enterprises from the private sector. It will mobilize its resources and expertise to promote inclusive green economic growth, while promoting the involvement of women and young entrepreneurs in achieving sustainable development objectives. The institute has an initial capitalization of $300 million over five years and will be housed at EDC. Canada's new DFI will become operational by early 2018.

7.3 Effectively Addressing the Needs of Developing Countries

Canada is committed to help developing countries address the challenges of climate change and make the transition to sustainable, low-carbon economies. Canada is providing $2.65B to developing countries and international assistance projects with climate benefits to support development based on climate resilience and access to clean energy technologies. Through Canada's climate finance we are supporting initiatives that strengthen developing country capacities in line with country-driven priorities and needs to seize clean growth opportunities and address climate change.

- For example, through recent support, Canada supported the Canada-Honduras Value-Added Agroforestry Project, which is promoting sustainable agricultural practices in Honduras. Central America is one of the regions most affected by climate change. Climate impacts could cause significant damage to Honduras's coffee production, a market important to the Honduran economy. By implementing agroforestry systems which are diversified and taking measures to improve soil stability, crops will be more resistant to extreme climatic conditions, such as drought. Focusing on vulnerable regions and low-income farmers, this project is expected to directly improve the standard of living of 9,000 beneficiaries, 4,000 of which are women.

7.4 National Approach to Tracking

Canada's climate finance is delivered through various federal departments, sub-national governments, and agencies, including Global Affairs Canada, Environment

[h] Eligible transactions and projects are identified by using the International Finance Corporation (IFC) "Special Climate" category within the IFC-Definitions and Metrics for Climate-Related Activities.

and Climate Change Canada and the International Development and Research Centre. These departments work closely together to track Canada's climate finance to present a comprehensive picture of Canada's contribution to the transition to low carbon and climate resilient economies.

The most up-to-date information on climate finance support from Canada is found on the climate finance website.[i] This interactive website provides detailed project level information, including results achieved. Users can search for projects on this site by country, region, priority sector, year of contribution, and key word.

Canada provides transparent information on climate financing to showcase successful contributions, strengthen accountability and results, and maximize demonstration effects. Granular reporting is an important part of this, which is why Canada reports at the project level for all of its climate finance. Canada is committed to continue to improve the overall transparency and tracking of its climate finance. Canada is working with other donors and international organizations, such as the OECD, to improve the measurement and reporting of climate finance. Since the *2nd Biennial Report* Canada has implemented changes to its accounting approach which are better aligning Canada's accounting to that of its donor partners. These changes include transitioning from reporting by fiscal year to calendar year and applying a 30% co-efficient to all projects where climate change is a component and not the principal purpose of the initiative. This harmonization is helping to facilitate collective reporting exercises and is increasing the comparability of climate finance data across donors.

More information on the methodologies used for reporting Canada's climate finance can be found in Annex 4 at the end of this chapter.

7.5 Technology and Capacity Building

7.5.1 Technology

Clean, innovative technologies are key to addressing climate change and to growing a global low-carbon economy. Access to clean technologies helps developing countries reduce GHG emissions and better adapt to the effects of climate change they are already facing. Canada is actively engaged in a broad range of actions to advance the development and deployment of clean technologies globally. These actions include developing and sharing knowledge and tools to support forest greenhouse gas mitigation, forest management adaptation goals, clean energy software, smart grids, reducing black carbon and methane emissions, and financing for climate change adaptation and mitigation. Examples of these actions that occurred between 2015–2016 are outlined below and in Table 10. Featured success stories are included in Table 9.

Mitigation and Adaptation

Throughout 2015 and 2016, Canada supported the United Nations Climate Technology Centre and Network (CTCN) as a member of the Advisory Board (AB) and through the outreach work of its National Designated Entity (NDE) to the CTCN. The CTCN provides climate advice and expertise to enable the transfer of technologies to developing and emerging countries at their request. Canada's NDE worked with private sector partners and members of the CTCN to provide seven webinars on topics ranging from implementing energy efficiency to risk mapping for climate change.

Canada has also actively raised awareness of the Private Financing Advisory Network (PFAN), under the United Nations Industrial Development Organization (UNIDO), and has promoted PFAN's core work of mobilizing private sector resources in international climate finance. The International Development

[i] For more information, please visit: https://climate-change.canada.ca/finance/.

Research Centre (IDRC) of Canada worked with PFAN in assessing barriers to private investment in adaptation, developing a portfolio of adaptation initiatives that are investment-ready, and testing a new model for bridging investors with SMEs focused on adaptation called the Investor Forum. The 2nd Investor Forum was held in February 2017. This forum identifies viable investment opportunities, develops project pipelines, and connects companies with investors and financiers. Projects from Ethiopia, Uganda, and Kenya were successful in raising finance through the Investor Forum.

IDRC is working with Sistema B, an institution that promotes B Corporations in Latin America (companies that foster environmental sustainability or create public goods by leveraging the power of the private sector), to develop an action-research program and taskforce of sustainable enterprises and academics in Latin America. The goal is to co-develop knowledge on climate change and sustainable venturing, a movement that aims to harness the innovative power of entrepreneurship as a transformative mechanism to achieve the dual goals of development and environmental sustainability. This partnership evaluates the direct impacts of B Corporations on climate change adaptation and mitigation, and assesses the potential of market innovators to motivate larger companies to act for climate resilience. It aims to develop strategies, policy instruments and knowledge on effective climate change adaptation and mitigation.

Clean Energy

Promoting clean energy is a pillar of Canada's strategy to mitigate climate change. An example of promoting clean energy is the RETScreen Clean Energy Management Software (RETScreen). Developed by Natural Resources Canada, RETScreen is the world's foremost clean energy decision making software which has helped to significantly reduce costs associated with identifying and assessing potential energy projects. The latest generation of the software was released globally in 2016 and is available in 36 languages.

Canada hosted events to support smart grids and distributed energy technologies through the International Smart Grid Action Network (ISGAN), the implementing agreement under the International Energy Agency, and an initiative under the Clean Energy Ministerial. In 2016, Canada hosted the 7th international Conference on Integration of Renewable and Distributed Energy Resources to share knowledge among North American, European and Asian practitioners and researchers.

Several Latin American countries, including Mexico and Colombia, have benefited from Canadian collaboration on the development of Nationally Appropriate Mitigation Action (NAMA) plans for oil and natural gas industry reductions of black carbon, methane and volatile organic compound (VOC) emissions from flaring, venting and fugitive equipment leaks, as well as reduced GHG and pollutant emissions through improved energy efficiency. Both Mexico and Colombia are now using their NAMA project outcomes on their NDCs submitted in 2015 and ratified in 2016.

Forestry and Land-Use Management

Canada has provided knowledge, mentoring and guidance on forest GHG emissions mitigation and forest management adaptation through the provision of the Carbon Budget Model of the Canadian Forest Sector (CBM-CFS3) to Mexico (2003–present), Korea (2013–present), Poland (2012–present), Italy (2009–present), and USA (2008–present). The CBM-CFS3 is a framework that supports the analysis of past and projected GHG emissions and removals in the forest sector.

The Global Fire Early Warning System is operated by Canada and is a project of the Global Observation of Forest Cover and Landcover Dynamics Fire Implementation Team. As part of this system, Canada has developed and installed new regional and national Fire Danger Rating Systems and provided training to Indonesia, Malaysia, Mexico, Armenia and Georgia.

Canada has also collaborated with Chile on science and technology exchanges and workshops for capacity building to further develop and apply the Canadian Forest Fire Weather Index System as the foundation for a fire early warning system in Chile and a mitigation tool for wildlife disaster.

7.5.2 Capacity Building

Implementation of the Paris Agreement requires action in all parts of the world. Therefore, the Agreement commits to enhance capacity building to ensure all countries, at various stages of development and with different levels of capabilities, have the necessary skills and knowledge to contribute to global efforts to reduce emissions and adapt to climate change. Canada is committed to a range of actions to support capacity building for climate change in developing countries. This includes building capacity through the dissemination of training on software and tools developed by Canada, the provision of support to help partners effectively use these tools, research and development collaboration, building capacity on adaptation to climate change, as well as provision of support for the use of tools to inform mitigation actions across the forest sector. This section highlights initiatives that Canada carried out since its BR2 and covers the period between 2015 and 2016. Additional information is provided in Table 11.

Mitigation and Adaptation

In 2013, Canada's International Development Research Centre (IDRC) launched the Integrated Climate Change Modeling and Policy Linkages for Adaptive Planning project—a multi-year capacity building initiative targeted at helping research teams to deliver policy-relevant and demand-driven assessments that are informed by climate and hydrological modeling. Completed in November 2015, this project assisted countries in Africa, Asia, Latin America and the Caribbean.

IDRC also supports the Frankfurt School of Management and the Thailand Development Research Institute to train future leaders in the science, policy and private sectors who are active in climate adaptation finance by discussing current challenges and opportunities in adaptation and adaptation finance. The project, launched in February of 2016, is developing a typology for adaption projects, outlining criteria for attracting and securing investments, investigating the mitigation of financial and business risks associated with adaptation projects, and determining how public policy can enable larger financial flows into adaptation.

Since September of 2015 IDRC has been collaborating with Business for Social Responsibility to identify barriers and opportunities in climate change adaptation for sustainable enterprises in Africa and Asia. Together, these organizations have developed innovative strategies and policy instruments, and published new knowledge.

The South Asian Water Leadership Program on Climate Change, funded by the IDRC from 2016–2020, aims to increase the number of women occupying leadership roles in the climate change field and the water sector in particular. With IDRC support, the program will be awarding fellowships to 36 women enrolled in graduate level integrated water resources management programs in Bangladesh, India, Nepal, and Sri Lanka, and providing these women with opportunities to access decision-making environments through internships.

Canada's IDRC also approved funding in 2016 for the Build Leadership for Latin American and Caribbean Cities in a Changing Climate program, from 2017–2021, which aims to develop multiple technical capacities among young leaders, in particular women. It consists of a Postgraduate Diploma focuses on providing young leaders with practical knowledge of climate risk and urban management accompanied by participatory planning and negotiation skills to enable them to advise local public and private stakeholders for the effective development of climate resilient transformative policies in medium-sized cities.

Clean Energy

The RETScreen Clean Energy Management Software is the world's leading clean energy decision-making software. The software has helped significantly reduce the costs associated with identifying and assessing potential clean energy projects as well as with ongoing performance analysis. In 2015 and 2016, Canada provided RETScreen expertise and tools to the Clean Energy Ministerial's Clean Energy Solutions Center (CESC), and created a series of free publicly accessible webinars with CESC. The majority of participants in the webinars were from developing countries.

Canada also participates in the Heavy Oil Working Group (HOWG), which is part of the Energy and Climate Partnership of the Americas. It serves as a forum for heavy oil producers/consumers in the Americas, including exchange of information on best practices and technological innovation in the area of reducing methane emissions. In 2015, Canada led the 4th HOWG meeting, held on the margins of the Heavy Oil Latin America Conference & Exhibition, in Bogotá, Colombia.

Canada also shared its knowledge and experiences with carbon capture, utilization and storage (CCUS) technology in a presentation at the Latin American and Caribbean Carbon Forum in Panama City in 2016. The presentation focussed on the CCUS business cases of successful Canadian projects.

As part of trilateral Canada-U.S.-Mexico collaboration on clean energy, Canada hosted the third trilateral multi-stakeholder CCUS workshop in October 2016, which included a delegation of 10 from Mexico. The event featured site visits to Canada's CCUS projects in Saskatchewan, and an additional program in Alberta for the Mexican delegation to tour a CCUS project and meet with Government of Alberta officials. This workshop facilitated the sharing of first-of-a-kind Canadian knowledge and experiences in support of Mexico's future CCUS projects.

Multilaterally, Canada is a member of the Carbon Sequestration Leadership Forum (CSLF) which is a Ministerial-level international initiative, composed of 25 countries and the European Commission, that seeks to advance CCUS globally through collaborative efforts. Canada is a member of the CSLF Capacity Building Governing Council which approved five projects to support CCUS capacity building in Brazil, South Africa, Mexico and China in 2015–16.

Canada is playing a leadership role in Mission Innovation (MI) and the Clean Energy Ministerial (CEM). MI is a global initiative of countries working to scale up investment in clean energy innovation. Canada is taking action to double its public investments in clean energy research and development over five years while encouraging collaboration among partner nations, sharing information, and coordinating with businesses and investors. Canada is a member of the MI Steering Committee.

The CEM is a global initiative to advance the development and deployment of clean energy technologies, including through various technical initiatives. Canada participates in a number of clean energy initiatives under CEM, which enable policy/best practice collaboration amongst member countries in a number of key areas related to energy demand, energy supply, energy systems and integration, and crosscutting policy support. For example, as a member of the Clean Energy Solutions Centre, Natural Resources Canada provides technical expertise through the Centre's "Ask an Expert" service on its world-leading RETScreen Clean Energy Management Software, bringing clean energy solutions to decision makers globally. Canada is a member of the CEM Steering Committee.

Forestry and Land Use Management

The Carbon Budget Model of the Canadian Forest Sector (CBM-CFS3) provides ongoing support to scientists in South Korea, Poland, Italy, Mexico and the United States. Canada collaborated with South Korea on scientific and technical cooperation, hosting a visiting scientist, preparing a national-scale application and testing the CBM in South Korea. The CBM-CFS3 has also been used in the trilateral Canada-U.S.-Mexico context, through a joint project on Integrated Modeling and Assessment of Climate Change Mitigation Options in the North American Forest Sector. This project involves collaboration on the analyses of mitigation scenarios for two regions in Mexico and two regions in the U.S. (2016).

The International Model Forest Network (IMFN) provides capacity building through research extension, the development of policy options, and communications activities to increase awareness of the need to adapt to the impacts of climate change. Canada contributed to the IMFN by producing communications products and delivering presentations at the World Forestry Congress in 2015.

Canada also co-sponsored a series of workshops through Model Forests on building sustainability in landscape management, landscape restoration, and governance in restoring degraded landscapes. These workshops were held in Latin America and the Caribbean in 2013, 2014 and 2015. At each workshop, over 40 participants from 13 Latin American and Caribbean countries advanced the understanding of Climate Change/REDD+ agencies, activities and processes among Model Forest experts.

Canada is the co-chair of the Global Partnership on Forest and Landscape Restoration (GPFLR)—a proactive global network of governments, organizations, research institutes, and communities who aim to restore the world's degraded forests and their surrounding landscapes. As co-chair and an active partner and member of the e-secretariat, Canada continued to help organize multiple and varied learning opportunities related to Forest and Landscape Restoration around the world and online in 2015 and 2016.

Annexes

Annex 1: Financial Tables (2015 and 2016)

Table 6: Summary of Public Financial Support (2015 and 2016)

2015										
	DOMESTIC CURRENCY					USD				
		Climate Specific					Climate Specific			
ALLOCATION CHANNELS	Core/General	Mitigation	Adaptation	Cross-Cutting	Other	Core/General	Mitigation	Adaptation	Cross-Cutting	Other
Total contributions through multilateral channels:	**139,191,509**	**15,000**	**500,000**	**3,250,000**		**108,827,384**	**11,728**	**390,930**	**2,541,047**	
Multilateral climate change funds	38,325,000			250,000		29,964,815			195,465	
Other multilateral climate change funds										
Multilateral Financial Institutions, including regional development banks	95,571,679					74,723,749				
Specialized United Nations bodies	5,294,830	15,000	500,000	3,000,000		4,138,820	11,728	390,930	2,345,582	
Total contributions through bilateral, regional and other channels		**1,962,715**	**45,761,317**	**1,655,707**			**1,534,568**	**35,778,979**	**1,294,532**	
Total	**139,191,509**	**1,977,715**	**46,261,317**	**4,905,707**		**108,827,384**	**1,546,296**	**36,169,909**	**3,835,579**	

2016										
	DOMESTIC CURRENCY					USD				
		Climate Specific					Climate Specific			
ALLOCATION CHANNELS	Core/General	Mitigation	Adaptation	Cross-Cutting	Other	Core/General	Mitigation	Adaptation	Cross-Cutting	Other
Total contributions through multilateral channels:	**132,525,006**	**15,000**	**16,712,000**	**172,400,000**		**99,988,687**	**11,317**	**12,609,023**	**130,073,939**	
Multilateral climate change funds	38,325,000		6,000,000	168,000,000		28,915,799		4,526,935	126,754,186	
Other multilateral climate change funds										
Multilateral Financial Institutions, including regional development banks	88,905,176					67,077,996				
Specialized United Nations bodies	**5,294,830**	**15,000**	**10,712,000**	**4,400,000**		**3,994,892**	**11,317**	**8,082,088**	**3,319,753**	
Total	**132,525,006**	**13,013,151**	**60,349,803**	**177,644,776**	**0**	**99,988,687**	**9,818,282**	**45,533,274**	**134,031,066**	

2015: Information covers calendar year January 2015 to December 2015. Exchange rates based on OECD/DAC Rates for 2015: 0.7818608.
2016: Information covers calendar year January 2016 to December 2016. Exchange rates based on OECD/DAC Rates for 2016: 0.7544892.

Table 7: Finance delivered through Multilateral Channels (2015 and 2016)

2015									
	TOTAL AMOUNT				STATUS	FUNDING SOURCE	FINANCIAL INSTRUMENT	TYPE OF SUPPORT	SECTOR
	Core/General		Climate-specific						
DONOR FUNDING	CAD	USD	CAD	USD	Committed, Disbursed	ODA OOF Other	Grant Concessional Non-concessional Loan Equity Other	Mitigation Adaptation Cross-cutting Other	Energy Transport Industry Agriculture Forestry Cross-cutting Other Not applicable
Multilateral Climate Change Funds									
1. Global Environment Facility	38,325,000	29,964,815			Disbursed	ODA	Grant	Mitigation	Cross-cutting
2. Least Developed Countries Fund									
3. Special Climate Change Fund									
4. Adaptation Fund									
5. Green Climate Fund									
6. UNFCCC Trust Fund for Supplementary Activities			250,000	195,465	Disbursed	ODA	Grant	Cross-cutting	Cross-cutting
7. Other multilateral climate change funds									
Subtotal	**38,325,000**	**29,964,815**	**250,000**	**195,465**					
Multilateral financial institutions, including regional development banks									
1. World Bank									
2. International Finance Corporation									
3. African Development Bank	6,902,585	5,396,861			Disbursed	ODA	Grant	Cross-cutting	Cross-cutting
4. Asian Development Bank	7,153,519	5,593,056			Disbursed	ODA	Grant	Cross-cutting	Cross-cutting
5. European Bank for Reconstruction and Development									
6. Inter-American Development Bank	2,019,583	1,579,032			Disbursed	ODA	Grant	Cross-cutting	Cross-cutting
7. Other									
8. International Development Association	79,495,992	62,154,800			Disbursed	ODA	Grant	Cross-cutting	Cross-cutting
Subtotal	**95,571,679**	**74,723,749**							
Specialized United Nations Bodies									
1. United Nations Development Programme (specific programmes)									

Table 7: Finance delivered through Multilateral Channels (2015 and 2016) (continued)

2015									
	TOTAL AMOUNT				STATUS	FUNDING SOURCE	FINANCIAL INSTRUMENT	TYPE OF SUPPORT	SECTOR
	Core/General		Climate-specific						
DONOR FUNDING	CAD	USD	CAD	USD	Committed, Disbursed	ODA OOF Other	Grant Concessional Non-concessional Loan Equity Other	Mitigation Adaptation Cross-cutting Other	Energy Transport Industry Agriculture Forestry Cross-cutting Other Not applicable
2. United Nations Environment Programme (specific programmes)									
3. Other									
The Partnership for Clean Fuels and Vehicles (PCFV): Systems Approach to Clean Fuels and Vehicle Regulations*			15,000	11,728	Disbursed	ODA	Grant	Mitigation	Transport
Multilateral Fund for the Montreal Protocol+	5,294,830	4,138,820			Disbursed	ODA	Grant	Mitigation	Environmental management
Contribution to the Global Framework for Climate Serviced (GFCS)+			200,000	156,372	Disbursed	ODA	Grant	Adaptation	Cross-cutting
Support to the International Organisation of the Francophonie (OIF)+			300,000	234,558	Disbursed	ODA	Grant	Adaptation	Cross-cutting
Consultative Group on International Agricultural Research (CGIAR)*			3,000,000	2,345,582	Disbursed	ODA	Grant	Cross-cutting	Agriculture
Subtotal	**5,294,830**	**4,138,820**	**3,515,000**	**2,748,240**					
Total	**139,191,509**	**108,827,384**	**3,765,000**	**2,943,705**					

Table 7: Finance delivered through Multilateral Channels (2015 and 2016) (continued)

2016									
	TOTAL AMOUNT				STATUS	FUNDING SOURCE	FINANCIAL INSTRUMENT	TYPE OF SUPPORT	SECTOR
	Core/General		Climate-specific						
DONOR FUNDING	CAD	USD	CAD	USD	Committed, Disbursed	ODA OOF Other	Grant Concessional Non-concessional Loan Equity Other	Mitigation Adaptation Cross-cutting Other	Energy Transport Industry Agriculture Forestry Cross-cutting Other Not applicable
Multilateral Climate Change Funds									
1. Global Environment Facility	38,325,000	28,915,799			Disbursed	ODA	Grant		
2. Least Developed Countries Fund			6,000,000	4,526,935	Disbursed	ODA	Grant	Adaptation	Cross-cutting
3. Special Climate Change Fund									
4. Adaptation Fund									
5. Green Climate Fund			168,000,000	126,754,186	Disbursed	ODA	Grant	Cross-cutting	Cross-cutting
6. UNFCCC Trust Fund for Supplementary Activities									
7. Other multilateral climate change funds									
Subtotal	**38,325,000**	**28,915,799**	**174,000,000**	**131,281,121**					
Multilateral financial institutions, including regional development banks									
1. World Bank									
2. International Finance Corporation									
3. African Development Bank									
4. Asian Development Bank	7,153,519	5,397,253			Disbursed	ODA	Grant	Cross-cutting	Cross-cutting
5. European Bank for Reconstruction and Development									
6. Inter-American Development Bank	2,237,757	1,688,364			Disbursed	ODA	Grant	Cross-cutting	Cross-cutting
7. Other									
8. International Development Association	79,513,900	59,992,379			Disbursed	ODA	Grant	Cross-cutting	Cross-cutting
Subtotal	**88,905,176**	**67,077,995**	0	0					
Specialized United Nations Bodies									
1. United Nations Development Programme (specific programmes)									
2. United Nations Environment Programme (specific programmes)									
3. Other									

Table 7: Finance delivered through Multilateral Channels (2015 and 2016) (continued)

2016									
	TOTAL AMOUNT				STATUS	FUNDING SOURCE	FINANCIAL INSTRUMENT	TYPE OF SUPPORT	SECTOR
	Core/General		Climate-specific						
DONOR FUNDING	CAD	USD	CAD	USD	Committed, Disbursed	ODA OOF Other	Grant Concessional Non-concessional Loan Equity Other	Mitigation Adaptation Cross-cutting Other	Energy Transport Industry Agriculture Forestry Cross-cutting Other Not applicable
United Nations Development Programme—Support for COP22			1,400,000	1,056,285	Disbursed	ODA	Grant	Cross-cutting	Cross-cutting
International Fund for Agricultural Development: Climate Change Adaptation+			10,000,000	7,544,892	Disbursed	ODA	Grant	Adaptation	Agriculture
The Partnership for Clean Fuels and Vehicles (PCFV): Systems Approach to Clean Fuels and Vehicle Regulations*			15,000	11,317	Disbursed	ODA	Grant	Mitigation	Transport
World Meteorological Organisation—Climate Risk Early Warning Systems (CREWS)+			462,000	348,574	Disbursed	ODA	Grant	Adaptation	Disaster prevention and preparedness
Multilateral Fund for the Montreal Protocol+	5,294,830	3,994,892			Disbursed	ODA	Grant	Mitigation	Environmental management
Contribution to the Global Framework for Climate Serviced (GFCS)+			200,000	150,898	Disbursed	ODA	Grant	Adaptation	Cross-cutting
Support to the International Organisation of the Francophonie (OIF)+			50,000	37,724	Disbursed	ODA	Grant	Adaptation	Cross-cutting
Consultative Group on International Agricultural Research (CGIAR)*			3,000,000	2,263,468	Disbursed	ODA	Grant	Cross-cutting	Agriculture
Subtotal	**5,294,830**	**3,994,892**	**15,127,000**	**11,413,158**					
Total	**132,525,006**	**99,988,686**	**189,127,000**	**142,694,279**					

2015: Information covers calendar year January 2015 to December 2015. Exchange rates based on OECD/DAC Rates for 2015: 0.7818608.
2016: Information covers calendar year January 2016 to December 2016. Exchange rates based on OECD/DAC Rates for 2016: 0.7544892.
Amounts are rounded to the available level of confidence.
(+) Contribution targeting the Rio Conventions as a 'principal objective.'
(*) Contribution targeting the Rio Conventions as a 'significant objective.'
The Green Climate Fund is aiming for a 50:50 balance between mitigation and adaptation over time, on a grant-equivalent basis.
Core contributions to multilateral organizations are calculated based on OECD stats on MDB imputed climate shares in 2015. 2016 shares are assumed constant from 2015 levels in the absence of 2016 at the time of this report. CAD $18.45M per year of Canada's contribution to the Global Environment Facility (GEF) 6th replenishment represents an increase of annual payments to support the GEF's climate change efforts.
Canada's contribution to the Least Developed Countries Fund reported in 2016 was provided by the province of Québec.
For further information please refer to Canada's *7th National Communication* and Canada's *3rd Biennial Report*.

Table 8: Finance delivered through Bilateral, Regional, and Other Channels (2015 and 2016)

2015								
RECIPIENT COUNTRY/ REGION/ PROJECT/ PROGRAMME	TOTAL AMOUNT CLIMATE-SPECIFIC		STATUS	FUNDING SOURCE	FINANCIAL INSTRUMENT	TYPE OF SUPPORT	SECTOR	ADDITIONAL INFORMATION
	CAD	USD						
Afghanistan, Bangladesh, Egypt, India, Kenya, Kyrgyzstan, Madagascar, Mali, Mozambique, Pakistan, Tajikistan, Tanzania, Uganda/Partnership for Advancing Human Development in Africa and Asia*	5,823,101	4,552,854	Disbursed	ODA	Grant	Adaptation	Health	Support to development goals across Africa and Asia, including women and children's health in Central Asia, education in East Africa, and civil society initiatives such as gender equality, innovation, and climate change adaptation.
Africa/African Water Facility—Advisory Services*	13,968	10,921	Disbursed	ODA	Grant	Mitigation	Energy	Aims to enhance the equitable and sustainable development and management of African water resources for socio-economic development, the environment and resilience to water-related disasters and climate change.
Africa/African Water Facility Cooperation*	540,000	422,205	Disbursed	ODA	Grant	Mitigation	Energy	Aims to enhance the equitable and sustainable development and management of African water resources, infrastructure and data management systems for poverty alleviation, socio-economic development, the environment and resilience to water-related disasters and climate change.
Asia/Global Challenge and Grow Asia*	600,000	469,116	Disbursed	ODA	Grant	Cross-cutting	Agriculture	Support to address challenges and risks to smallholder farmer food systems, including climate change, in order to increase sustainability.
Bangladesh, Honduras, Mali, Mozambique, Tanzania/World Renew Food & Economic Security*	330,106	258,097	Disbursed	ODA	Grant	Adaptation	Agriculture	Aims to address rural poverty issues caused mainly by erratic weather, declining soil infertility, lack of agricultural inputs and land tenure, through strategies including food security, economic growth and community governance capacity.
Bolivia/Agro-Industrial Production and Exports*	524,596	410,161	Disbursed	ODA	Grant	Adaptation	Agriculture	Strengthening of climate-resilient agriculture in Bolivia through crop production to withstand climate fluctuation and instability, and through new investments in irrigation to combat periodic drought conditions.
Bolivia, Ethiopia, Ghana, Mali/Linking Initiatives, Stakeholders and Knowledge for Livelihood Security*	672,402	525,725	Disbursed	ODA	Grant	Adaptation	Agriculture	Aims to improve livelihood security and resilience in environmentally sustainable ways, in order to increase available food, improve management practices, and diversify sources of income.

Table 8: Finance delivered through Bilateral, Regional, and Other Channels (2015 and 2016) (continued)

2015								
RECIPIENT COUNTRY/ REGION/ PROJECT/ PROGRAMME	TOTAL AMOUNT CLIMATE-SPECIFIC		STATUS	FUNDING SOURCE	FINANCIAL INSTRUMENT	TYPE OF SUPPORT	SECTOR	ADDITIONAL INFORMATION
	CAD	USD						
Burkina-Faso, Benin, Ethiopia, Guatemala, Nicaragua/Seeds Survival Program*	1,099,094	859,338	Disbursed	ODA	Grant	Adaptation	Agriculture	Aims to increase food security and agricultural training among small-scale farmers who are experiencing food security challenges for various reasons, including climate change.
Burkina-Faso, Bolivia, Peru/Food Security Innovation and Mobilization*	1,035,707	809,779	Disbursed	ODA	Grant	Cross-cutting	Agriculture	Increase food security and promote sustainable livelihoods in rural semi-arid areas in Burkina Faso, Bolivia and Peru, through the transfer of technology and practical leadership training.
Burkina-Faso, Ghana, Malawi, Uganda, Zambia/Building Innovative and Adaptive Capacity*	451,249	352,814	Disbursed	ODA	Grant	Adaptation	Agriculture	Provide support to increase the capacity of public service institutions and small and growing businesses to innovate, adapt to changing circumstances, and incorporate gender equality and environmental sustainability.
Cambodia, Indonesia, Philippines, Thailand, Vietnam/Integrated Disaster Risk Management*	592,500	463,253	Disbursed	ODA	Grant	Adaptation	Disaster preparedness and prevention	Aims to reduce the impact of disasters on vulnerable populations and increase resilience by providing support to governments and civil society to manage and reduce disaster risk, for instance through the development of disaster risk financing.
Caribbean/Caribbean Disaster Risk Management Program*	216,546	169,309	Disbursed	ODA	Grant	Adaptation	Disaster prevention and preparedness	Aims to increase the capacity of regional organizations, national governments and local communities in the Caribbean to respond to and manage natural disasters through institutional support and gender-equal programming, disaster risk management and community resilience strategies.
Cuba/Integrated Coastal Zone Management*	4,336	3,390	Disbursed	ODA	Grant	Adaptation	Disaster preparedness prevention/ coastal protection	Protection of vulnerable people, and inclusion of all residents in governance and management strategies, in the coastal zone of south-east Cuba, to address poverty eradication and environmental protection and sustainability.
Democratic Republic of Congo, Haiti, Senegal/Knowledge of the People of the Earth*	571,519	446,848	Disbursed	ODA	Grant	Adaptation	Agriculture	Increase food security and promote sustainable livelihoods to increase climate resilience.
Ethiopia/Food Sufficiency for Farmers*	955,104	746,759	Disbursed	ODA	Grant	Adaptation	Agriculture	Improve resilience of communities to climate risks by improving food capacity through increased incomes or greater ability to grow food.

Table 8: Finance delivered through Bilateral, Regional, and Other Channels (2015 and 2016) (continued)

2015								
RECIPIENT COUNTRY/ REGION/ PROJECT/ PROGRAMME	TOTAL AMOUNT CLIMATE-SPECIFIC		STATUS	FUNDING SOURCE	FINANCIAL INSTRUMENT	TYPE OF SUPPORT	SECTOR	ADDITIONAL INFORMATION
	CAD	USD						
Ethiopia/Sustainable Land Management Program*	1,602,608	1,253,016	Disbursed	ODA	Grant	Adaptation	Agriculture	Support smallholder farmers through sustainable watershed and land management measures to address low agriculture yields exacerbated by the impacts of climate change.
Ethiopia, Kenya, Tanzania/Agriculture in East Africa*	783,451	612,550	Disbursed	ODA	Grant	Adaptation	Agriculture	Support to farmers to address issues such as soil fertility and climate change to increase food security and support conservation agriculture.
Ghana/Farmers' Economic Advancement Through Seedlings*	560,416	438,167	Disbursed	ODA	Grant	Adaptation	Agriculture	Support to enhance the productivity of small farmers in tree crops, including through increased environmentally sustainable farming in Ghana's tree crop industry.
Ghana/Food Security Through Cooperatives in Northern Ghana*	917,900	717,670	Disbursed	ODA	Grant	Adaptation	Agriculture	Support for sustainable, gender equitable food security though cooperatives and introducing climate resilience strategies such as increasing access to drought-resistant seed varieties.
Ghana/Resilient & Sustainable Livelihoods Transformation in Northern Ghana*	1,488,135	1,163,514	Disbursed	ODA	Grant	Adaptation	Agriculture	Offers solutions that address the root causes behind lack of access to sufficient, nutritious food and the vulnerability to food shortages such as technical in climate change adaptation and disaster risk management practices.
Ghana/Water, Sanitation and Hygiene in Disaster-prone Communities in Northern Ghana*	3,475,500	2,717,357	Disbursed	ODA	Grant	Adaptation	Disaster preparedness and prevention	Aims to increase access to disaster-resilient water, sanitation and hygiene services, and to strengthen disaster preparedness, for 200,000 people in 265 at-risk communities in Northern Ghana.
Ghana, Mali, Sierra Leone, Senegal/ System Approach to Improve and Sustaining Food*	543,716	425,110	Disbursed	ODA	Grant	Adaptation	Agriculture	Aims to increase food security and promote sustainable livelihoods of people living in poor rural communities across multiple African countries, through the adoption of agricultural practices.
Guatemala/Purchase for Progress and Scaling Up Nutrition in Guatemala*	495,465	387,384	Disbursed	ODA	Grant	Mitigation	Agriculture	Support to increase food security and improve incomes through access to technical assistance, best practices and management enhancement, to adapt to extreme weather brought on by climate change.
Guatemala, Honduras/Promoting Sustainable Economic Growth in Coffee-growing Regions*	211,706	165,525	Disbursed	ODA	Grant	Adaptation	Agriculture	Supports increasing farm productivity and promoting sustainable, participatory and gender equal agricultural practices in Guatemala and Honduras.

Table 8: Finance delivered through Bilateral, Regional, and Other Channels (2015 and 2016) (continued)

2015								
RECIPIENT COUNTRY/ REGION/ PROJECT/ PROGRAMME	TOTAL AMOUNT CLIMATE-SPECIFIC		STATUS	FUNDING SOURCE	FINANCIAL INSTRUMENT	TYPE OF SUPPORT	SECTOR	ADDITIONAL INFORMATION
	CAD	USD						
Honduras/Agricultural Value Chain Initiative*	7,705	6,024	Disbursed	ODA	Grant	Mitigation	Agriculture	Support to small-scale coffee and cacao farmers through improvements in crop productivity, quality and diversity, and environmentally friendly farming practices to improve land management, planting and agroforestry practice.
Honduras/Increasing Income for Honduras Forestry*	147,286	115,157	Disbursed	ODA	Grant	Mitigation	Forestry	Aims to strengthen the Honduran forestry sector, including through establishing sustainable forestry practices, through the transfer of Canadian forestry knowledge and expertise.
Honduras/Promoting Food Security (PROSADE)*	266,215	208,143	Disbursed	ODA	Grant	Adaptation	Agriculture and water	Enhance food security through improved agricultural productivity, diversity and the promotion of sustainable natural resource management practices, as well as through an environmental fund and a self-sustaining credit facility to acquire agricultural technologies.
Honduras/Special Program for Food Security*	450,000	351,837	Disbursed	ODA	Grant	Adaptation	Agriculture	Implementation of climate-smart agricultural practices such as protection from soil erosion, no-till and multiple cropping practices and the adoption of environmentally friendly technologies.
Honduras/Sustainable Coffee Production*	164,100	128,303	Disbursed	ODA	Grant	Mitigation	Agriculture	Support for environmentally sustainable coffee production to improve and implement sustainable practices, such as shade-grown coffee, for small-scale farmers.
Honduras/UWI Enhancing Knowledge and Application of Comprehensive Disaster Management+	384,005	300,238	Disbursed	ODA	Grant	Adaptation	Disaster prevention and preparedness	Support to inform policies on climate change and sustainable development at national and the global level, to reduce the impact of natural and technological hazards and the effect of climate change in the region.
Honduras, El Salvador/Improved Economic Livelihoods*	67,915	53,100	Disbursed	ODA	Grant	Adaptation	Agriculture	Promotes the use of sustainable agriculture in rural communities through inputs, market assistance, agricultural knowledge, and leadership training in Honduras and El Salvador, which encourages ecologically sustainable and diverse food production.
Kenya/Equitable Prosperity Through Private Sector Development*	280,967	219,677	Disbursed	ODA	Grant	Adaptation	SME Development	Aims to create sustainable economic growth by supporting the development of competitive small- and medium-sized enterprises (SMEs), applying environmentally sustainable and green business in the agriculture and construction sectors.

Table 8: Finance delivered through Bilateral, Regional, and Other Channels (2015 and 2016) (continued)

2015								
RECIPIENT COUNTRY/ REGION/ PROJECT/ PROGRAMME	TOTAL AMOUNT CLIMATE-SPECIFIC		STATUS	FUNDING SOURCE	FINANCIAL INSTRUMENT	TYPE OF SUPPORT	SECTOR	ADDITIONAL INFORMATION
	CAD	USD						
Kenya/Innovations—Sustainable School Feeding*	2,100,000	1,641,908	Disbursed	ODA	Grant	Adaptation	Agriculture	Aims to improve the health, nutrition and education of schoolchildren in drought-prone areas of Kenya.
Latin America and the Caribbean/ Disaster Risk Management—Health Sector*	4,761	3,722	Disbursed	ODA	Grant	Adaptation	Disaster preparedness and prevention	Aims to increase the capacity of regional organizations, national governments and local communities in the Caribbean to respond to and manage natural disasters.
Latin America and the Caribbean/ Sustainable Energy Access for Latin American and Caribbean Region*	525,191	410,626	Disbursed	ODA	Grant	Mitigation	Energy	Support for improved access to sustainable and affordable energy needed to promote economic growth in the region, by improving capacities for energy planning and regulation across countries in the region.
Latin American and the Caribbean/ Disaster Risk—Community Resilience*	48,542	37,953	Disbursed	ODA	Grant	Adaptation	Disaster preparedness and prevention	Aims to increase the capacity of regional organizations, national governments and local communities in the Caribbean to respond to and manage natural disasters.
Malawi/Farmer-to-Farmer Agroecology*	277,727	217,144	Disbursed	ODA	Grant	Adaptation	Agriculture	Support to organic smallholder farms through farmer-to-farmer teaching methods, the development of farmer associations and a pilot youth-led small business initiative to train households on sustainable agro ecological methods.
Mali/Rehabilitation of Agricultural Irrigation Infrastructures in the Zone of the Office du Niger (PAON)*	23,581	18,437	Disbursed	ODA	Grant	Adaptation	Agriculture	Helping to develop and rehabilitate agricultural irrigation infrastructure and hydro-agricultural development to increase agricultural production in Mali.
Mali/Strengthening Irrigated Agriculture in Mali (REAGIR)*	819,963	641,097	Disbursed	ODA	Grant	Adaptation	Agriculture	Support to sustainably develop irrigated agriculture to increase food security through the construction and rehabilitation of productive infrastructure, such as irrigated fields and micro dams.
Multiple Countries/Canadian International Food Security Research Fund*	4,488,311	3,509,234	Disbursed	ODA	Grant	Adaptation	Agriculture	Promotion of productive, sustainable and gender-sensitive agricultural techniques to build food security and climate change resilience for women subsistence farmers.
Multiple Countries/IDRC—Adaptation+	9,200,000	7,193,119	Disbursed	ODA	Grant	Adaptation	Cross-cutting	International Development and Research Centre support for adaptation action.
Multiple Countries/IDRC—Adaptation*	240,000	187,647	Disbursed	ODA	Grant	Adaptation	Cross-cutting	International Development and Research Centre support for adaptation action.
Multiple Countries/IDRC—Cross-cutting+	20,000	15,637	Disbursed	ODA	Grant	Cross-cutting	Cross-cutting	International Development and Research Centre support for climate change action.

Table 8: Finance delivered through Bilateral, Regional, and Other Channels (2015 and 2016) (continued)

2015								
RECIPIENT COUNTRY/ REGION/ PROJECT/ PROGRAMME	TOTAL AMOUNT CLIMATE-SPECIFIC		STATUS	FUNDING SOURCE	FINANCIAL INSTRUMENT	TYPE OF SUPPORT	SECTOR	ADDITIONAL INFORMATION
	CAD	USD						
Multiple Countries/IDRC—Mitigation*	69,000	53,948	Disbursed	ODA	Grant	Mitigation	Cross-cutting	International Development and Research Centre support for mitigation action.
Multiple Countries/Market-led Improved Livelihoods*	428,399	334,949	Disbursed	ODA	Grant	Adaptation	Agriculture	Improving market-led agricultural production and market processing knowledge through small scale irrigation activities, drought resistant crops and other agricultural capacity building methods.
Nicaragua/Purchase for Progress Food Security Program*	600,000	469,116	Disbursed	ODA	Grant	Adaptation	Agriculture	Aims to increase food security, increased farming productivity, and gender equality in Nicaraguan small-scale farming exposed to extreme weather brought on by climate change.
Nicaragua/Support to the Productive Rural Development Sector Program (PRORURAL)*	20,008	15,644	Disbursed	ODA	Grant	Adaptation	Agriculture	Aims to strengthen the Nicaraguan agriculture sector and promote sustainable use and management of the forestry sector, strengthening economic growth, food security, and quality and diversity of food production.
Nicaragua/Young Agricultural Producers*	658,159	514,589	Disbursed	ODA	Grant	Adaptation	Agriculture	Aims to improve agricultural production, increasing food security while providing equal rural opportunities for women and men.
Peru/Agricultural Training Program and Support of Youth Entrepreneurship in Peru*	264,442	206,757	Disbursed	ODA	Grant	Adaptation	Agriculture	Aims to improve and strengthen sustainable agriculture practices and to develop adaptation measures including efficient water management, water conservation, crop diversification, green infrastructure for water conservation, and improved climate-resilient pasture management.
Philippines/Haiyan Reconstruction Assistance: Restoring, Empowering and Protecting (REAP) Livelihoods Post Haiyan*	897,905	702,037	Disbursed	ODA	Grant	Adaptation	Reconstruction relief and rehabilitation	Support for reconstruction and the restoration of lost assets and livelihoods after Typhoon Haiyan, including increased participation of women and men in affected regions, and improved access to business development services.
Caribbean/Promotion of Regional Opportunities for Produce through Enterprises and Linkages (PROPEL)*	472,404	369,354	Disbursed	ODA	Grant	Adaptation	Small and medium-sized enterprises (SME) development	Support to enhance the quantity and quality of agricultural crops in the region through technical training to farmers.
South Sudan/Fortifying Equality & Economic Diversity*	2,944,028	2,301,820	Disbursed	ODA	Grant	Adaptation	Agriculture	Support train smallholder farmers to protect natural resources and become more food secure in seven South Sudanese states.

Table 8: Finance delivered through Bilateral, Regional, and Other Channels (2015 and 2016) (continued)

2016								
	TOTAL AMOUNT		STATUS	FUNDING SOURCE	FINANCIAL INSTRUMENT	TYPE OF SUPPORT	SECTOR	
	Climate-specific							
RECIPIENT COUNTRY/ REGION/PROJECT/ PROGRAMME	CAD	USD	Committed, Disbursed	ODA OOF Other	Grant Concessional Non-concessional Loan Equity Other	Mitigation Adaptation Cross-cutting Other	Energy Transport Industry Agriculture Forestry Cross-cutting Other Not applicable	ADDITIONAL INFORMATION
Africa/Africa Enterprise Challenge Fund (AGRA)*	450,000	339,520	Disbursed	ODA	Grant	Cross-cutting	Agriculture	Supports new businesses, including clean energy and adaptation, to create jobs, boost agricultural productivity and increase access to food.
Africa/African Water Facility—Advisory Services*	12,859	9,702	Disbursed	ODA	Grant	Mitigation	Energy	Aims to enhance the equitable and sustainable development and management of African water resources for socio-economic development, the environment and resilience to water-related disasters and climate change.
Bangladesh, Honduras, Mali, Mozambique, Tanzania/World Renew Food & Economic Security*	355,809	268,454	Disbursed	ODA	Grant	Adaptation	Agriculture	Aims to address rural poverty issues caused mainly by erratic weather, declining soil infertility, lack of agricultural inputs and land tenure, through strategies including food security, economic growth and community governance capacity.
Bolivia/Agro-Industrial Production and Exports*	566,537	427,446	Disbursed	ODA	Grant	Adaptation	Agriculture	Strengthening of climate-resilient agriculture in Bolivia through crop production to withstand climate fluctuation and instability, and through new investments in irrigation to combat periodic drought conditions.
Bolivia, Ethiopia, Ghana, Mali/Linking Initiatives, Stakeholders and Knowledge for Livelihood Security*	91,320	68,900	Disbursed	ODA	Grant	Adaptation	Agriculture	Aims to improve livelihood security and resilience in environmentally sustainable ways, in order to increase available food, improve management practices, and diversify sources of income.
Burkina-Faso, Benin, Ethiopia, Guatemala, Nicaragua/Seeds Survival Program*	933,629	704,413	Disbursed	ODA	Grant	Adaptation	Agriculture	Aims to increase food security and agricultural training among small-scale farmers who are experiencing food security challenges for various reasons, including climate change.
Burkina-Faso, Bolivia, Peru/ Food Security Innovation and Mobilization*	1,177,141	888,140	Disbursed	ODA	Grant	Cross-cutting	Agriculture	Increase food security and promote sustainable livelihoods in rural semi-arid areas in Burkina Faso, Bolivia and Peru, through the transfer of technology and practical leadership training.

Table 8: Finance delivered through Bilateral, Regional, and Other Channels (2015 and 2016) (continued)

2016								
RECIPIENT COUNTRY/ REGION/PROJECT/ PROGRAMME	TOTAL AMOUNT Climate-specific		STATUS	FUNDING SOURCE	FINANCIAL INSTRUMENT	TYPE OF SUPPORT	SECTOR	ADDITIONAL INFORMATION
	CAD	USD	Committed, Disbursed	ODA OOF Other	Grant Concessional Non-concessional Loan Equity Other	Mitigation Adaptation Cross-cutting Other	Energy Transport Industry Agriculture Forestry Cross-cutting Other Not applicable	
Burkina-Faso, Ghana, Malawi, Uganda, Zambia/Building Innovative and Adaptive Capacity*	271,710	205,002	Disbursed	ODA	Grant	Adaptation	Agriculture	Provide support to increase the capacity of public service institutions and small and growing businesses to innovate, adapt to changing circumstances, and incorporate gender equality and environmental sustainability.
Cambodia, Indonesia, Philippines, Thailand, Vietnam/Integrated Disaster Risk Management*	796,500	600,951	Disbursed	ODA	Grant	Adaptation	Disaster preparedness and prevention	Aims to reduce the impact of disasters on vulnerable populations and increase resilience by providing support to governments and civil society to manage and reduce disaster risk, for instance through the development of disaster risk financing.
Caribbean/Caribbean Disaster Risk Management Program*	106,866	80,629	Disbursed	ODA	Grant	Adaptation	Disaster prevention and preparedness	Aims to increase the capacity of regional organizations, national governments and local communities in the Caribbean to respond to and manage natural disasters through institutional support and gender-equal programming, disaster risk management and community resilience strategies.
Caribbean/Health Sector Resilience to Disasters*	259,500	195,790	Disbursed	ODA	Grant	Adaptation	Disaster preparedness and prevention	Aims to increase health care and health sector capacity in the Caribbean to improve resilience and respond to and manage natural disasters through increased safety and environmental standards and performance.
Caribbean/Promotion of Regional Opportunities for Produce through Enterprises and Linkages (PROPEL)*	1,270,213	958,362	Disbursed	ODA	Grant	Adaptation	Small and medium-sized enterprises (SME) development	Support to enhance the quantity and quality of agricultural crops in the region through technical training to farmers.
Caribbean/Support to Energy in the Caribbean+	850,000	641,316	Disbursed	ODA	Grant	Mitigation	Energy policy/technical assistance	Support to increase energy efficiency measures and address barriers to private sector investments in renewable energy in the region.

Table 8: Finance delivered through Bilateral, Regional, and Other Channels (2015 and 2016) (continued)

2016								
RECIPIENT COUNTRY/ REGION/PROJECT/ PROGRAMME	TOTAL AMOUNT Climate-specific		STATUS	FUNDING SOURCE	FINANCIAL INSTRUMENT	TYPE OF SUPPORT	SECTOR	ADDITIONAL INFORMATION
	CAD	USD	Committed, Disbursed	ODA OOF Other	Grant Concessional Non-concessional Loan Equity Other	Mitigation Adaptation Cross-cutting Other	Energy Transport Industry Agriculture Forestry Cross-cutting Other Not applicable	
Colombia/Building Sustainable Extractive Sector Governance*	375,047	282,969	Disbursed	ODA	Grant	Mitigation	Policy	Supports strengthening the capacities of the government entities to enable the Colombian extractive sector to contribute to more environmentally sustainable economic growth through strengthened policy, regulatory and implementation frameworks and better public sector and community engagement.
Democratic Republic of Congo, Haiti, Senegal/ Knowledge of the People of the Earth*	1,102,840	832,081	Disbursed	ODA	Grant	Adaptation	Agriculture	Increase food security and promote sustainable livelihoods to increase climate resilience.
Ethiopia/Agricultural Growth Program*	1,200,000	905,387	Disbursed	ODA	Grant	Adaptation	Agriculture	Aims to increase agricultural productivity and public agricultural services, including through the promotion of climate-smart agriculture.
Ethiopia/Food Sufficiency for Farmers*	507,810	383,137	Disbursed	ODA	Grant	Adaptation	Agriculture	Improve resilience of communities to climate risks by improving food capacity through increased incomes or greater ability to grow food.
Ethiopia/Integrated Approach to Maternal, Newborn and Child Health in Rural Ethiopia*	2,315,298	1,746,867	Disbursed	ODA	Grant	Adaptation	Water and sanitation	Addressing malnutrition by increasing access to quality nutrition, water, and sanitation services, for the most vulnerable populations affected by climate change in Ethiopia.
Ethiopia/Productive Safety Net Program*	6,000,000	4,526,935	Disbursed	ODA	Grant	Mitigation	Agriculture	Aims to enhance household and community resilience to shocks, such as droughts, and improve household food security, nutrition and economic well-being for up to 10 million people in Ethiopia's most vulnerable communities through improved watershed management.
Ethiopia, Kenya, Tanzania/ Agriculture in East Africa*	771,776	582,297	Disbursed	ODA	Grant	Adaptation	Agriculture	Support to farmers to address issues such as soil fertility and climate change to increase food security and support conservation agriculture.

Table 8: Finance delivered through Bilateral, Regional, and Other Channels (2015 and 2016) (continued)

2016								
	TOTAL AMOUNT		STATUS	FUNDING SOURCE	FINANCIAL INSTRUMENT	TYPE OF SUPPORT	SECTOR	
	Climate-specific							
RECIPIENT COUNTRY/ REGION/PROJECT/ PROGRAMME	CAD	USD	Committed, Disbursed	ODA OOF Other	Grant Concessional Non-concessional Loan Equity Other	Mitigation Adaptation Cross-cutting Other	Energy Transport Industry Agriculture Forestry Cross-cutting Other Not applicable	ADDITIONAL INFORMATION
Ghana/Farmers' Economic Advancement Through Seedlings*	453,937	342,490	Disbursed	ODA	Grant	Adaptation	Agriculture	Support to enhance the productivity of small farmers in tree crops, including through increased environmentally sustainable farming in Ghana's tree crop industry.
Ghana/Food Security Through Cooperatives in Northern Ghana*	464,864	350,735	Disbursed	ODA	Grant	Adaptation	Agriculture	Support for sustainable, gender equitable food security though cooperatives and introducing climate resilience strategies such as increasing access to drought-resistant seed varieties.
Ghana/Modernizing Agricultural Production*	7,538	5,687	Disbursed	ODA	Grant	Mitigation	Agriculture	Training and teaching of climate-smart agricultural practices to contribute to emissions reductions in agriculture, including research to apply to future training methods.
Ghana/Resilient & Sustainable Livelihoods Transformation in Northern Ghana*	1,313,149	990,757	Disbursed	ODA	Grant	Adaptation	Agriculture	Offers solutions that address the root causes behind lack of access to sufficient, nutritious food and the vulnerability to food shortages such as technical in climate change adaptation and disaster risk management practices.
Ghana, Mali, Sierra Leone, Senegal/System Approach to Improve and Sustaining Food*	434,525	327,844	Disbursed	ODA	Grant	Adaptation	Agriculture	Aims to increase food security and promote sustainable livelihoods of people living in poor rural communities across multiple African countries, through the adoption of agricultural practices.
Guatemala/Purchase for Progress and Scaling Up Nutrition in Guatemala*	871,842	657,796	Disbursed	ODA	Grant	Mitigation	Agriculture	Support to increase food security and improve incomes through access to technical assistance, best practices and management enhancement, to adapt to extreme weather brought on by climate change.
Guatemala, Honduras/ Promoting Sustainable Economic Growth in Coffee-growing Regions*	322,858	243,593	Disbursed	ODA	Grant	Adaptation	Agriculture	Supports increasing farm productivity and promoting sustainable, participatory and gender equal agricultural practices in Guatemala and Honduras.

Table 8: Finance delivered through Bilateral, Regional, and Other Channels (2015 and 2016) (continued)

2016								
	TOTAL AMOUNT		STATUS	FUNDING SOURCE	FINANCIAL INSTRUMENT	TYPE OF SUPPORT	SECTOR	
	Climate-specific							
RECIPIENT COUNTRY/ REGION/PROJECT/ PROGRAMME	CAD	USD	Committed, Disbursed	ODA OOF Other	Grant Concessional Non-concessional Loan Equity Other	Mitigation Adaptation Cross-cutting Other	Energy Transport Industry Agriculture Forestry Cross-cutting Other Not applicable	ADDITIONAL INFORMATION
Haiti/Clean Energy Plan+	973,280	734,329	Disbursed	ODA	Grant	Mitigation	Energy	Support to build a national household energy strategy to replace the use of wood and charcoal and tackle Haiti's deforestation and air pollution challenges.
Haiti/Support to School feeding Program in Haiti*	3,000,000	2,263,468	Disbursed	ODA	Grant	Cross-cutting	Agriculture	Improved school meals in Haiti, including through increasing the use of environmentally friendly cooking methods, such as clean stoves.
Honduras/Canada-Honduras Value Added Agroforestry Project*	176,439	133,122	Disbursed	ODA	Grant	Cross-cutting	Forestry	Implementation of agroforestry practices to mitigate carbon emissions through carbon sequestration and diverse planting for soil preservation, as well as promoting varieties of climate-resilient crops to withstand climate change impacts and yield more products available to markets.
Honduras/EcoMicro Green Finance+	950,000	716,765	Disbursed	ODA	Grant	Mitigation	Energy	Facilitates access to renewable, low-cost energy and adaptation technologies through green financing products.
Honduras/Promoting Food Security (PROSADE)*	2,057	1,552	Disbursed	ODA	Grant	Adaptation	Agriculture and water	Enhance food security through improved agricultural productivity, diversity and the promotion of sustainable natural resource management practices, as well as through an environmental fund and a self-sustaining credit facility to acquire agricultural technologies.
Honduras/Sustainable Coffee Production*	30,093	22,705	Disbursed	ODA	Grant	Mitigation	Agriculture	Support for environmentally sustainable coffee production to improve and implement sustainable practices, such as shade-grown coffee, for small-scale farmers.
Honduras/UWI Enhancing Knowledge and Application of Comprehensive Disaster Management+	266,157	200,812	Disbursed	ODA	Grant	Adaptation	Disaster prevention and preparedness	Support to inform policies on climate change and sustainable development at national and the global level, to reduce the impact of natural and technological hazards and the effect of climate change in the region.

Table 8: Finance delivered through Bilateral, Regional, and Other Channels (2015 and 2016) (continued)

2016								
RECIPIENT COUNTRY/ REGION/PROJECT/ PROGRAMME	TOTAL AMOUNT		STATUS	FUNDING SOURCE	FINANCIAL INSTRUMENT	TYPE OF SUPPORT	SECTOR	ADDITIONAL INFORMATION
	Climate-specific							
	CAD	USD	Committed, Disbursed	ODA OOF Other	Grant Concessional Non-concessional Loan Equity Other	Mitigation Adaptation Cross-cutting Other	Energy Transport Industry Agriculture Forestry Cross-cutting Other Not applicable	
Honduras, El Salvador/ Improved Economic Livelihoods*	14,288	10,780	Disbursed	ODA	Grant	Adaptation	Agriculture	Promotes the use of sustainable agriculture in rural communities through inputs, market assistance, agricultural knowledge, and leadership training in Honduras and El Salvador, which encourages ecologically sustainable and diverse food production.
IDRC—Adaptation*	228,000	172,024	Disbursed	ODA	Grant	Adaptation	Cross-cutting	International Development and Research Centre support for adaptation action.
Indonesia/Restoring Coastal Livelihoods in South Sulawesi*	103,582	78,152	Disbursed	ODA	Grant	Adaptation	Forestry	Enhance the livelihood security and well-being of vulnerable coastal communities in South Sulawesi through improved income security, access to coastal resources for vulnerable populations, and engagement with vulnerable communities in governmental planning.
Jordan/Sustainable Development in Jordan*	674,458	508,871	Disbursed	ODA	Grant	Mitigation	Energy	Introducing cost-saving renewable energy-efficient solutions for poor households, supporting low-carbon development in Jordan.
Jordan/Sustainable Economic Development through Renewable Energy+	1,735,368	1,309,316	Disbursed	ODA	Grant	Mitigation	Energy	Aims to improve livelihoods through the introduction of renewable energy and energy efficiency solutions at the household level.
Kenya/Construction of Sand Dam*	1,500	1,132	Disbursed	ODA	Grant	Adaptation	Water resources conservation (including data collection)	Government of Manitoba support for a Sand Dam address persistent drought in Kenya.
Kenya/Education for Employment Program*	402,454	303,647	Disbursed	ODA	Grant	Cross-cutting	Employment	Supports Kenyans living in poor and drought-prone areas take advantage of employment opportunities in the agriculture sector.
Kenya/Equitable Prosperity Through Private Sector Development*	804,033	606,634	Disbursed	ODA	Grant	Adaptation	SME Development	Aims to create sustainable economic growth by supporting the development of competitive small- and medium-sized enterprises (SMEs), applying environmentally sustainable and green business in the agriculture and construction sectors.

Table 8: Finance delivered through Bilateral, Regional, and Other Channels (2015 and 2016) (continued)

2016								
RECIPIENT COUNTRY/ REGION/PROJECT/ PROGRAMME	TOTAL AMOUNT Climate-specific		STATUS	FUNDING SOURCE	FINANCIAL INSTRUMENT	TYPE OF SUPPORT	SECTOR	ADDITIONAL INFORMATION
	CAD	USD	Committed, Disbursed	ODA OOF Other	Grant Concessional Non-concessional Loan Equity Other	Mitigation Adaptation Cross-cutting Other	Energy Transport Industry Agriculture Forestry Cross-cutting Other Not applicable	
Latin America and the Caribbean/Climate Smart Agriculture in Latin America and the Caribbean+	3,000,000	2,263,468	Disbursed	ODA	Grant	Adaptation	Agriculture	Support to sustainably increase agricultural productivity in support of food security while adapting and building resilience to climate change in Central America.
Latin America and the Caribbean/Sustainable Energy Access for Latin American and Caribbean Region*	512,667	386,802	Disbursed	ODA	Grant	Mitigation	Energy	Support for improved access to sustainable and affordable energy needed to promote economic growth in the region, by improving capacities for energy planning and regulation across countries in the region.
Malawi/Farmer-to-Farmer Agroecology*	68,926	52,004	Disbursed	ODA	Grant	Adaptation	Agriculture	Support to organic smallholder farms through farmer-to-farmer teaching methods, the development of farmer associations and a pilot youth-led small business initiative to train households on sustainable agro ecological methods.
Mali/Rehabilitation of Agricultural Irrigation Infrastructures in the Zone of the Office du Niger (PAON)*	80,892	61,032	Disbursed	ODA	Grant	Adaptation	Agriculture	Helping to develop and rehabilitate agricultural irrigation infrastructure and hydro-agricultural development to increase agricultural production in Mali.
Mali/Strengthening Irrigated Agriculture in Mali (REAGIR)*	4,527,578	3,416,009	Disbursed	ODA	Grant	Adaptation	Agriculture	Support to sustainably develop irrigated agriculture to increase food security through the construction and rehabilitation of productive infrastructure, such as irrigated fields and micro dams.
Multiple Countries/Canadian International Food Security Research Fund*	4,848,774	3,658,347	Disbursed	ODA	Grant	Adaptation	Agriculture	Promotion of productive, sustainable and gender-sensitive agricultural techniques to build food security and climate change resilience for women subsistence farmers.
Multiple Countries/Climate Change Support for Francophone Countries+	38,742	29,230	Disbursed	ODA	Grant	Cross-cutting	Environmental policy and administrative management	Government of Québec support to developing francophone countries address climate change.

Table 8: Finance delivered through Bilateral, Regional, and Other Channels (2015 and 2016) (continued)

2016								
RECIPIENT COUNTRY/ REGION/PROJECT/ PROGRAMME	TOTAL AMOUNT Climate-specific		STATUS	FUNDING SOURCE	FINANCIAL INSTRUMENT	TYPE OF SUPPORT	SECTOR	ADDITIONAL INFORMATION
	CAD	USD	Committed, Disbursed	ODA OOF Other	Grant Concessional Non-concessional Loan Equity Other	Mitigation Adaptation Cross-cutting Other	Energy Transport Industry Agriculture Forestry Cross-cutting Other Not applicable	
Multiple Countries/IDRC—Adaptation+	2,311,380	1,743,911	Disbursed	ODA	Grant	Adaptation	Cross-cutting	International Development and Research Centre support for adaptation action.
Multiple Countries/Market-led Improved Livelihoods*	413,491	311,975	Disbursed	ODA	Grant	Adaptation	Agriculture	Improving market-led agricultural production and market processing knowledge through small scale irrigation activities, drought resistant crops and other agricultural capacity building methods.
Multiple Countries/ Partnership for Advancing Human Development in Africa and Asia*	4,402,120	3,321,352	Disbursed	ODA	Grant	Adaptation	Health	Support to various human development goals across Africa and Asia, including women and children's health in Central Asia, education in East Africa, and civil society initiatives such as gender equality, innovation, and climate change adaptation.
Nicaragua/Purchase for Progress Food Security Program*	900,000	679,040	Disbursed	ODA	Grant	Adaptation	Agriculture	Aims to increase food security, increased farming productivity, and gender equality in Nicaraguan small-scale farming exposed to extreme weather brought on by climate change.
Nicaragua/Young Agricultural Producers*	330,339	249,238	Disbursed	ODA	Grant	Adaptation	Agriculture	Aims to improve agricultural production, increasing food security while providing equal rural opportunities for women and men.
Peru/Agricultural Training Program and Support of Youth Entrepreneurship in Peru*	1,016,128	766,658	Disbursed	ODA	Grant	Adaptation	Agriculture	Aims to improve and strengthen sustainable agriculture practices and to develop adaptation measures including efficient water management, water conservation, crop diversification, green infrastructure for water conservation, and improved climate-resilient pasture management.
Philippines/El Nino Emergency WASH Response*	7,500	5,659	Disbursed	ODA	Grant	Adaptation	Food security	Government of Manitoba support for to address the impact of El Niño, including drought.

Table 8: Finance delivered through Bilateral, Regional, and Other Channels (2015 and 2016) (continued)

2016								
	TOTAL AMOUNT		STATUS	FUNDING SOURCE	FINANCIAL INSTRUMENT	TYPE OF SUPPORT	SECTOR	
	Climate-specific							
RECIPIENT COUNTRY/ REGION/PROJECT/ PROGRAMME	CAD	USD	Committed, Disbursed	ODA OOF Other	Grant Concessional Non-concessional Loan Equity Other	Mitigation Adaptation Cross-cutting Other	Energy Transport Industry Agriculture Forestry Cross-cutting Other Not applicable	ADDITIONAL INFORMATION
Philippines/Haiyan Reconstruction Assistance: Restoring, Empowering and Protecting (REAP) Livelihoods Post Haiyan*	1,723,218	1,300,149	Disbursed	ODA	Grant	Adaptation	Reconstruction relief and rehabilitation	Support for reconstruction and the restoration of lost assets and livelihoods after Typhoon Haiyan, including increased participation of women and men in affected regions, and improved access to business development services.
South Sudan/Fortifying Equality & Economic Diversity*	1,520,804	1,147,430	Disbursed	ODA	Grant	Adaptation	Agriculture	Support train smallholder farmers to protect natural resources and become more food secure in seven South Sudanese states.
Southeast Asia/ Strengthening Community Resilience to Natural Disasters*	345,047	260,334	Disbursed	ODA	Grant	Adaptation	Disaster preparedness and prevention	Help communities establish effective risk reduction plans and policies to reduce people's vulnerability to natural disasters, by working to ensure that disaster risk reduction policy and law considers vulnerable communities, gender equality, and the environment.
Tanzania/Rubana River and Wetland Integrated Riverbank Land Rehabilitation and Food Security*	2,850	2,150	Disbursed	ODA	Grant	Adaptation	Reconstruction relief and rehabilitation	Government of Manitoba support for food security and agroforestry initiatives, including address deforestation and droughts and flooding caused by climate change.
Uganda/BioChar in Uganda+	5,000	3,772	Disbursed	ODA	Grant	Mitigation	Energy	Government of Manitoba support for food security by supporting the use of biochar as an agriculture tool.
West Bank Gaza/Building the Resilience of Farmers and Herders*	1,080,000	814,848	Disbursed	ODA	Grant	Adaptation	Disaster preparedness and prevention	Provide emergency agricultural based livelihood support to herding households affected by climate shocks as well as strengthening evidence based food security coordination.
West Bank Gaza/Support for Farmers in Vulnerable Communities*	2,100,000	1,584,427	Disbursed	ODA	Grant	Adaptation	Food security	Support for farmers who live in the most vulnerable communities in the eastern slopes and the Jordan Valley in the West Bank strengthen food security, including through adaptation measures.

Documentation Box

1: Core/general In tracking core contributions to multilateral organizations, Canada uses the climate related-imputed multilateral contributions calculated annually by the OECD Development Assistance Committee (DAC). Canada draws on this imputed multilateral contribution (outflow) data from the OECD, to report on the climate-related share of its core contributions to multilateral institutions.
2: Climate specific Climate finance contributions are clearly identified as being entirely dedicated to climate or significantly dedicated to climate, using the OECD-DAC Creditor Reporting System (CRS). Through the CRS, activities are marked as either principal or significant. Activities marked with a principal climate change objective are counted in their totality. Recognizing, a number of international assistance projects have strong climate change co-benefits Canada counts 30% of the funding to projects with a significant climate change marker.
3: Status Canada reports climate finance at the disbursement level. Disbursements record the transfer of financial resources and are defined as the releasement of funds to a recipient or implementing partner; by extension, the amount spent.
4: Funding Source Projects with climate change activities supported through Canada's Official Development Assistance (ODA) and other official flows (OOF) are part of Canada's climate finance. Canadian ODA is defined in the Official Development Assistance Accountability Act. This definition is compatible with the international definition created by the DAC of the OECD. When support does not qualify as ODA, it is classified as OOF.
5: Financial Instrument Canada uses a blend of financial instruments to deliver its climate finance, including: grant, concessional loans, equity, among others in line with UNFCCC commitments. All instruments are accounted for at face value.
6: Type of Support Canada defines a climate project as a project with one of the following objectives or co-benefits: mitigation , adaptation, and cross-cutting. Canada's definition of these sectors is based on the ones of the OECD-DAC. When funded activities support both adaptation and mitigation, support is identified as "cross-cutting" programming.
7: Sector Sectors are determined at a project level for bilateral contributions using OECD-DAC definitions.
New and Additional: Canada's $2.65B climate finance commitment is a substantial increase from Canada's past levels of climate funding, scaling up to $800M per year by 2020. Through this commitment, Canada is supporting climate projects that are above and beyond what was planned prior to the Convention and Copenhagen Accord. Looking forward, a key goal of the Paris Agreement is to ensure financial flows are consistent with low GHG emission and climate resilient development. While finance to developing countries to enhance their climate action will continue to play an important role, success in achieving this goal will also depend on strategically using all available public resources and smart climate policies to mobilize private finance as well as aligning these investments with the goals set out in the Paris Agreement and the 2030 Sustainable Development Agenda.

Annex 2

Technology and Capacity Building Tables

Table 9: Description of selected projects or programmes that promoted practicable steps to facilitate and/or finance the transfer of, or access to, environmentally sound technologies.

Project/programme title: Climate Technology Centre and Network (CTCN)—Training Webinars

Purpose: The Centre promotes the accelerated transfer of environmentally sound technologies for low carbon and climate resilient development at the request of developing countries

Recipient country	Sector	Total funding	Years in operation
International	Adaptation/Mitigation	In-kind	3

Description: Canadian members have provided 7 webinars on issues from implementing energy efficiency to risk mapping for climate change through the CTCN in 2015–2016. Webinar participants were predominantly professionals from developing countries.

CTCN webinars conducted by Canadian firms included:

1. Risk Mapping for Climate Change Adaptation–Using Open GIS Data and Tools in Order to Build Resilience (November 30, 2016, Design+Environment)
2. Mitigation technologies to protect small farm holders and food producers–From West Africa to North America (June 29, 2016, Ecoaction Innovative Solutions Inc.)
3. Solar-powered, low-complexity, robust solutions for decentralized wastewater treatment (August 31, 2016, Island Water Technologies Inc.)
4. Structuring Utility Demand-Side Management Programs (April 27, 2016, Econoler)
5. Energy Efficiency Policies, Regulations, and Programs (March 16, 2016, Econoler)
6. Sector-Based Energy Efficiency (March 9, 2016, Econoler)
7. RETScreen: a Tool for Greenhouse Gas Mitigation (November 4, 2015, RETScreen International, Natural Resources Canada)

Indicate factors which led to project's success: The Canadian government has dedicated resources to supporting the office of the National Designated Entity (NDE) which has allowed the NDE to engage with potential CTCN members and encourage their participation. CTCN membership is free and provides exposure for companies seeking opportunities in developing and emerging markets.

Technology transferred: Various categories (see above)

Impact on greenhouse gas emissions/sinks (optional): Mitigation focused webinars provide information to enable decisions and actions that reduce GHGs.

Project/programme title: RETScreen Clean Energy Management Software

Purpose: RETScreen is a Clean Energy Management Software system for energy efficiency, renewable energy and cogeneration project feasibility analysis as well as ongoing energy performance analysis. RETScreen's overall mission is to empower cleaner energy decisions worldwide.

Recipient country	Sector	Total funding	Years in operation
Global	Clean energy	$1.5M/annum	19

Description: The RETScreen Clean Energy Management Software is the world's leading clean energy decision-making software and has helped significantly reduce costs associated with identifying and assessing potential clean energy projects as well as with ongoing energy performance analysis. Provided free-of-charge and in 36 languages, RETScreen is used by more than 525,000 people across the globe.

Key RETScreen training and webinars from 2015–2016:

- Webinar with CTCN (Climate Technology Centre & Network) on RETScreen as a Tool for Greenhouse Gas Mitigation (2015);
- On-going series of webinars with the Clean Energy Solutions Center (CESC) in 2015 and 2016 with participants predominantly from developing countries;
- Multi-day webinar based training (English & French) on RETScreen to ECREEE (West African Clean Energy Agency) (2015); and
- Multi-day in-person RETScreen Expert training to OLADE (Latin American Clean Energy Agency) and sponsoring of 1-year subscriptions to RETScreen Expert Professional mode for all participants (2016).

Indicate factors which led to project's success: Factors that have led to RETScreen's success include that the full software is provided to users completely free-of-charge; the availability of the software in 36 languages covering two-thirds of the world's population; the availability of comprehensive and integrated training material; an internet-based business model resulting in extremely low maintenance, replication and distribution costs; and consistent and stable funding by Natural Resources Canada.

Technology transferred: The technology transferred is the RETScreen Clean Energy Management Software including comprehensive training material.

Impact on greenhouse gas emissions/sinks (optional): By virtue of enabling viable clean energy projects, RETScreen indirectly contributes to a substantial reduction in greenhouse gas emissions, conservatively estimated at 20 million tonnes per annum.

Table 9: Description of selected projects or programmes that promoted practicable steps to facilitate and/or finance the transfer of, or access to, environmentally sound technologies (continued)

Project/programme title: Private Financing Advisory Network (PFAN)

Purpose: The goal of this project to establish whether and under what conditions private sector financing for adaptation related projects (adapting to life in a changing climate by adjusting to actual or expected future climate) can be secured in the same way as mitigation related projects (reducing climate change by reducing the flow of heat-trapping GHGs into the atmosphere) using sub-Saharan Africa as the geographical area of focus.

Recipient country	Sector	Total funding	Years in operation
International	Adaptation	$850,000	3

Description: PFAN screens business plans, selects the most economically viable and environmentally beneficial projects, and provides extensive coaching and guidance before projects are presented to investors at Clean Energy Financing Forums hosted across Asia, Latin America and Africa. In 2015, Canada played a constructive role in efforts to raise awareness of PFAN's success and increase its role in mobilizing private sector resources in the context of international climate finance.

The International Development Research Centre (IDRC) is working with PFAN in assessing barriers to private investment in adaptation, developing a portfolio of feasible and bankable adaptation initiatives that are investment-ready, and testing a new model for bridging investors with SMEs focused on adaptation. The PFAN-IDRC collaboration is unique and has centred thus far on the innovative Investor Forum. This Forum aims to address the important investment gap between investors and project developers and entrepreneurs by identifying viable investment opportunities and developing project pipelines, linking entrepreneurs, start-up companies and existing companies with investors and financiers, and taking the form of a business plan competition in a Dragon's Den/ Shark Tank style selection process. Projects that were successful in raising finance to further their development include:

- African Bamboo (Ethiopia) that has secured funding of over USD 1.5 million to support initial scale-up. This company currently produces floor boards from bamboo; with a vision to become the largest bamboo flooring manufacturer in Africa. In addition to mitigation benefits, sustainable management of bamboo also offers a number of adaptation benefits such as livelihood support to local communities, income generating opportunities, and soil and water conservation.
- Classic Foods (Kenya) pioneered the collection and processing of milk from small scale farmers by providing refrigeration for bulk milk. The new initiative is aimed at assisting farmers to implement sustainable farming practices that enhance soil productivity and move up the economic ladder to improved farm economics.

Indicate factors which led to project's success: Strong focus on capacity building (e.g. targeted to project developers for developing bankable adaptation projects that could attract private investment), awareness raising on adaptation to climate change and protection of supply chain, etc.

Technology transferred: Adaptation-related

Impact on greenhouse gas emissions/sinks (optional):

Project/programme title: Forest Carbon Research, Reporting and Policy Advice

Purpose: Technology transfer and support for the Carbon Budget Model of the Canadian Forest Sector (CBM-CFS3)

Recipient country	Sector	Total funding	Years in operation
Mexico and USA	Forest	$300,000	2

Description: CBM-CFS3 technology transfer and support under the Commission for Environmental Cooperation tri-national project on "Integrated Modeling and Assessment of Climate Change Mitigation Options in the North American Forest Sector" for policy development in support of forest GHG emissions reduction.

Indicate factors which led to project's success: This project expanded upon the successful results obtained during the previous project in which the project team developed the capacity to inform estimates of forest GHG balances. In this project, carbon budget models were applied to estimate projections of future GHG balance and climate change mitigation options in the forest sector in six regions of interest in North America. Results from all three countries were recently presented at the 2017 Joint North American Carbon Program (NACP) & AmeriFlux Principal Investigators (PI) Meeting.

Technology transferred: The assessment of mitigation options requires a systems approach that includes the assessment of changes in GHG emissions in forests, the harvested wood product sector and the changes in emissions associated with product substitution. This project developed methods to integrate US and Mexican data into Canadian carbon models to support comprehensive analyses of mitigation options in all three countries.

Impact on greenhouse gas emissions/sinks (optional): Results showed significant potential for climate change mitigation in 2030 and 2050. Several forest sector activities, which varied by region, were found to be effective: reaching a net-zero deforestation rate, lengthening harvest rotations, using waste wood for bioenergy to substitute for fossil fuels, and increasing harvest to produce long-lived wood products and substitute more energy-intensive materials.

Table 10: Provision of support for technology development and transfer

RECIPIENT COUNTRY AND/ OR REGION	TARGETED AREA	MEASURES AND ACTIVITIES RELATED TO TECHNOLOGY TRANSFER	SECTOR	SOURCE OF FUNDING	ACTIVITIES UNDERTAKEN BY	STATUS	ADDITIONAL INFORMATION
Global	Mitigation	Development and dissemination of the RETScreen Clean Energy Management Software	Energy	Public & private	Public	Implemented	Canada has developed RETScreen, the world's foremost clean energy decision-making software. The next generation of the software, a significant advance from the previous version, was released in September 2016 in 36 languages. Additional details are contained in Chapter 7 of Canada's National Communication and at the RETScreen website: https://climate-change.canada.ca/finance/Default.aspx
Global	Mitigation + Adaptation	In support of Smart Grids and distributed energy technologies International Smart Grid Action Network (ISGAN) (Implementing Agreement under the International Energy Agency and Initiative under the Clean Energy Ministerial)	Energy	Public	Public	Implemented	CanmetENERGY scientist share knowledge in various international activities including: In 2014, Canada hosted a workshop in Montréal on innovation aimed at improving the way ISGAN experts and partners communicate complex technical information to key decision-makers. Details available on ISGAN website: www.iea-isgan.org Canada hosted the 7th international Conference on Integration of Renewable and Distributed Energy Resources in Niagara Falls, October 24–28, 2016. The growth of decentralized generation, liberalized markets, modern power electronics, and the introduction of advanced integrated circuit technologies are leading to a dramatic change in the management and operation of electricity grids worldwide. The 7th International Conference on the Integration of Renewable and Distributed Energy Resources aims at knowledge-sharing among North American, European, and Asian practitioners and researchers in the fields of renewable energy (RE) and distributed energy resources (DER).
Mexico	Mitigation	Canada-US-Mexico Trilateral Workshop on methane reductions	Energy	Public	Public	Implemented	As part of the trilateral commitment made by North American leaders to reduce methane emissions in the oil and gas sectors form 40% to 45% by 2025, a first workshop, held in Mexico City in December 2016, brought together government officials, NGOs, researchers, and industry representatives to collaboratively identify shared methane emission reduction challenges as well as cost-effective and actionable opportunities for abatement.

Table 10: Provision of support for technology development and transfer (continued)

RECIPIENT COUNTRY AND/ OR REGION	TARGETED AREA	MEASURES AND ACTIVITIES RELATED TO TECHNOLOGY TRANSFER	SECTOR	SOURCE OF FUNDING	ACTIVITIES UNDERTAKEN BY	STATUS	ADDITIONAL INFORMATION
Mexico, Korea, Poland, Italy, USA	Mitigation and adaptation	Forest GHG emissions mitigation and forest management adaptation: scientific and technical mentoring and guidance, including provision of Carbon Budget Model of the Canadian Forest Sector (CBM-CFS3) to various countries	Other	Public and Private	Public and Private	Implemented and planned	This program targets forest GHG emissions mitigation and forest management adaptation. The Canadian Forest Service (CFS) of Natural Resources Canada (Natural Resources Canada) undertakes a broad range of activities with international partners to advance GHG mitigation and forest management adaptation goals. The main funding sources for planned activities are in the host countries. Activities for the USA and Mexico were partially funded through the commission for Environmental Cooperation.
United Nations International Strategy for Disaster Reduction, Southeast Asia, Mexico, Chile	Mitigation and adaptation	Canada operates the Global Fire Early Warning System, a project of the Global Observation of Forest Cover and Landcover Dynamics (GOFC-GOLD) Fire Implementation Team	Other	Public	Public	Implemented and planned	Regional and national systems developed or in development collaboratively with various government agencies; ongoing consultation and advice. Current activities include information sessions and website recently updated with new data sources and enhanced products. • New regional and national Fire Danger Rating Systems (FDRS) developed and installed in South Caucasus region (Armenia, Georgia); 2 training workshops provided through Organization for Security and Cooperation in Europe • Installation of Mexico FDRS software in CONAFOR Fire-HQ, and system training provided in Canada and Mexico; through Canada-Mexico CMP • FDRS training and consultation planned for Costa Rica (late 2017)
Chile	Mitigation	Forest management and applied research on climate change impacts on forests, including through development of landscape level fire management capacities and technologies	Other	Public	Public	Implemented and planned	Collaboration between Canada and Chile has included capacity building through science and technology exchanges and workshops to further develop and apply the Canadian Forest Fire Weather Index (FWI) System as the foundation for a fire early warning system in Chile and a mitigation tool for wildfire disaster. • Chile's three Model Forests are representative of three unique forest types and are being used as landscape level demonstration sites to build capacity, calibrate models and pilot landscape fire management plans for eventual use at a national scale. • Data sharing in the form of key information concerning weather and vegetation has been initiated to advance the adaptation of the Canadian FWI system at a pilot scale in Chile.

Table 10: Provision of support for technology development and transfer (continued)

RECIPIENT COUNTRY AND/ OR REGION	TARGETED AREA	MEASURES AND ACTIVITIES RELATED TO TECHNOLOGY TRANSFER	SECTOR	SOURCE OF FUNDING	ACTIVITIES UNDERTAKEN BY	STATUS	ADDITIONAL INFORMATION
Global	Mitigation and adaptation	Canada supported the work of the Climate Technology Centre and Network (CTCN) as a member of the Advisory Board (AB) and through work of its National Designated Entity (NDE) to the CTCN	Other	Public	Public and Private	Implemented	In 2015, Canada continued to actively engage in the AB of the CTCN and nominated its NDE, located within Natural Resources Canada. From 2015–2016 Canada's NDE worked with private sector partners to deliver 7 training webinars via the CTCN on topics ranging from implementing energy efficiency, to risk mapping for climate change. Participants were predominantly from developing countries.
Global	Mitigation	Private Financing Advisory Network (PFAN)	Other	Public & private	Public & private	Implemented and planned	In 2015, Canada played a constructive role in efforts to raise awareness of PFAN's success and increase its role in mobilizing private sector resources in the context of international climate finance. The International Development Research Centre (IDRC) is working with PFAN in assessing barriers to private investment in adaptation, developing a portfolio of feasible and bankable adaptation initiatives that are investment-ready, and testing a new model for bridging investors with SMEs focused on adaptation. The PFAN-IDRC collaboration is unique and has centred thus far on the innovative Investor Forum. This Forum aims at addressing the important investment gap that exists between investors and project developers/entrepreneurs by identifying viable investment opportunities and developing project pipelines, linking entrepreneurs, start-up companies and existing companies with investors and financiers, and taking the form of a business plan competition in a Dragon's Den/Shark Tank style selection process. Projects that were successful in raising finance to further their development include: • African Bamboo (Ethiopia) that has secured funding of over USD 1.5 million to support initial scale-up; • Eastern Rice (Uganda) that secured funding of 1.5 billion Ugandan Shillings for an out-grower scheme; and • Classic Foods (Kenya) that raised funding for project development and risk capital.

Table 10: Provision of support for technology development and transfer (continued)

RECIPIENT COUNTRY AND/ OR REGION	TARGETED AREA	MEASURES AND ACTIVITIES RELATED TO TECHNOLOGY TRANSFER	SECTOR	SOURCE OF FUNDING	ACTIVITIES UNDERTAKEN BY	STATUS	ADDITIONAL INFORMATION
Latin America and the Caribbean	Adaptation Mitigation	Climate Change Risks and Opportunities for B Corporations (B Corps) in Latin America. Assessing the Climate Change Risks and Opportunities for the Private Sector in Latin America	Other	Public & private	Private	Implemented	IDRC is currently working with Sistema B (an institution that promotes B Corporations in Latin America) to evaluate the direct impacts of B Corps on climate change adaptation and mitigation, assessing the potential of these market innovators to motivate larger companies to act for climate resilience, and exploring ways to successfully partner to accelerate the adoption and scaling of potentially game-changing innovations. This project, launched in May of 2016, aims to develop an action-research program and taskforce of sustainable enterprises and academics in Latin America for the co-development of knowledge at the intersection of climate change and sustainable venturing. At the end of the project, we would have developed strategies, policy instruments, and knowledge for effective climate change mitigation and adaptation.
Global	Adaptation	Mobilizing Private Sector Investment in Adaptation to Climate Change	Other	Public & private	Private	Implemented	This activity is led by Business for Social Responsibility (BSR) http://www.bsr.org IDRC's work with BSR, launched in October of 2015, aims to identify the barriers and opportunities in climate change adaptation for sustainable enterprises; develop and publish new knowledge based on rigorous and novel methodologies; and co-develop innovative strategies and policy instruments.

[a] To be reported to the extent possible.

[b] The table should include measures and activities implemented or planned since the previous national communication or biennial report.

[c] Parties may report sectoral disaggregation, as appropriate.

[d] Additional information may include, for example, information on funding for technology development and transfer provided, a short description of the measure or activity and information on cofinancing arrangements.

Table 11: Provision of capacity building support[a]

RECIPIENT COUNTRY/ REGION	TARGETED AREA	PROGRAMME OR PROJECT TITLE	DESCRIPTION OF PROGRAMME OR PROJECT [b,c]
Global	Multiple areas	Clean Energy Ministerial (CEM)—Clean Energy Solutions Centre (CESC)	Canada provided RETScreen experts and tools to the CESC, including creating a series of free publicly accessible webinars with the CESC (developing country participants were the primary audience): https://www.youtube.com/user/cleanenergypolicy/search?query=retscreen
Global	Multiple areas	RETScreen Clean Energy Management Software	World's leading clean energy decision-making software which has helped significantly reduce costs associated with identifying and assessing potential clean energy projects as well as with ongoing energy performance analysis. Provided to users free-of-charge and in 36 languages, and includes comprehensive integrated training materials. More information available at www.retscreen.net In the 2015–2016 period Natural Resources Canada led various RETScreen training modules: • RETScreen as a Tool for Greenhouse Gas Mitigation—webinar with CTCN (Climate Technology Centre & Network): https://www.ctc-n.org/calendar/webinars/retscreen-tool-greenhouse-gas-mitigation (2015) • A series of webinars with the Clean Energy Solutions Center (participants primarily from developing countries): https://www.youtube.com/user/cleanenergypolicy/search?query=retscreen (2015) • Multi-day webinar based training (English & French) on RETScreen to ECREEE (West African Clean Energy Agency) (2015) • Multi-day in-person RETScreen Expert training for OLADE (Latin American Clean Energy Agency) + sponsoring of 1-year subscriptions to RETScreen Expert Professional mode for all participants (2016) • A series of webinars with the Clean Energy Solutions Center (participants primarily from developing countries): https://www.youtube.com/user/cleanenergypolicy/search?query=retscreen (2016)
Global	Mitigation	Participation in Carbon Sequestration Leadership Forum Capacity Building Governing Council	Canada is a member of the Carbon Sequestration Leadership Forum (CSLF) which is a Ministerial-level international initiative, composed of 25 countries and the European Commission, that seek to advance carbon capture, utilization and storage (CCUS) globally through collaborative efforts. Within the CSLF, Canada is a member of the CSLF Capacity Building Governing Council which approved 5 projects to support CCUS capacity building in Brazil, South Africa, Mexico and China in 2015–16.
Latin America	Mitigation	4th Meeting of the Heavy Oil Working Group (HOWG)	The Heavy Oil Working Group (HOWG) is part of the Energy and Climate Partnership of the Americas (ECPA) and serves as a forum for heavy oil producers/consumers in the Americas, including exchange of information on best practices and technological innovation in the area of methane emissions reduction and volatile organic compound (VOC) and solvent management. The 4th HOWG meeting was led by Canada and held on the margins of the Heavy Oil Latin America (HOLA) Conference & Exhibition, in Bogotá, Colombia on September 22, 2015.
Latin America	Mitigation	Latin American and Caribbean Carbon Forum	Natural Resources Canada presented on Canadian experiences with carbon capture, utilization and storage (CCUS) technology at the Latin American and Caribbean Carbon Forum in Panama City, on September 30, 2016. The focus of the presentation was on the CCUS business cases of successful Canadian projects. The Executive Secretary of the Latin American Energy Organization (OLADE) sent a thank you letter to Natural Resources Canada for providing important technical information in this area.

Table 11: Provision of capacity building support[a] (continued)

RECIPIENT COUNTRY/ REGION	TARGETED AREA	PROGRAMME OR PROJECT TITLE	DESCRIPTION OF PROGRAMME OR PROJECT [b,c]
Mexico	Mitigation	Knowledge sharing on carbon capture, utilization, and storage technology (CCUS)	Carbon capture, utilization and storage (CCUS) is a key area for North American trilateral collaboration. Canada hosted the 3rd in a series of trilateral multi-stakeholder CCUS workshops in Regina from October 25–27, 2016 with 47 workshop participants including a delegation of 10 from Mexico. The event also featured site visits to Canada's CCUS projects in Saskatchewan with an Alberta side visit on October 24 for the Mexican delegation to tour a CCUS project and meet with Government of Alberta officials. This workshop, in addition to the previous one hosted in Mexico City in April 2016, have facilitated the sharing of first-of-a-kind Canadian knowledge and experiences in support of Mexico's future CCUS projects. Mexican attendance was funded by the World Bank.
Mexico	Mitigation	Carbon Budget Model of the Canadian Forest Sector (CBM-Canadian Forest Service) technology transfer	Part of the Commission for Environmental Cooperation tri-national project on "Integrated Modeling and Assessment of Climate Change Mitigation Options in the North American Forest Sector". Involves collaboration on the analyses of mitigation scenarios for two regions in Mexico (Quintana Roo and Durango) and two regions in the USA (Wisconsin and South Carolina) (2015/2016).
Republic of Korea	Multiple areas	Carbon Budget Model technology transfer	Scientific and technical cooperation, hosting of visiting scientist, preparation of national-scale application and testing of spatially-explicit CBM in South Korea using the moja.global/Flint platform.
Latin America, South-East Asia, Central and North Africa, Mediterranean, and the Caribbean	Multiple Areas	The International Model Forest Network (IMFN) 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.)	During the reporting period, Canada provided targeted support for climate change initiatives in Model Forests which focused on: • Globally (throughout the reporting period), produced legacy project videos, Impacts Notes, e-news, twitter feed, and presentations, as well as assistance in, delivery of papers and oral presentations at the World Forestry Congress 2015 on the contribution Model Forests are making to climate change adaptation. • Within Latin America and the Caribbean (13 countries)—Natural Resources Canada co-sponsored a series of regional workshops entitled "Building Sustainability for Landscape Management: Experiences of Model Forests in times of Climate Change" (2013/14); "Landscape Restoration and Experiences of Model Forests" (2015); and "Governance in Restoring Degraded Landscapes" (2017) where, during each workshop, over 40 participants from 13 countries from the Latin American and Caribbean region contributed to strengthening the partnerships between Climate Change/REDD+ agencies and Model Forest experts, while also advancing the understanding of REDD+ activities and processes within the region and amongst Model Forests. • Natural Resources Canada-Canadian Forest Service facilitated a workshop and presented at the 5th Mediterranean Forest Week in Morocco (2017) "Towards an enhanced regional cooperation to restore Mediterranean landscapes: improving resilience for the benefit of people and environment". This capacity building aims to facilitate the mitigation and adaptation of Mediterranean forest landscapes to climate change, as well as the achievement of non-carbon benefits in order to support the implementation of Intended Nationally Determined Contributions (INDCs) as part of Article 5 of the Paris Agreement.
Global	Multiple areas	The Global Partnership on Forest and Landscape Restoration (GPFLR)	Canada (Natural Resources Canada-Canadian Forest SErvice) is the Co-chair of the GPFLR—a proactive global network that unites governments, organizations, academic/research institutes, communities and individuals under a common goal: to restore the world's lost and degraded forests and their surrounding landscapes. As an active partner, Co-chair and member of the e-secretariat, Canada helps organize multiple and varied courses and learning opportunities related to Forest and Landscape Restoration all over the world and online.

Table 11: Provision of capacity building support[a] (continued)

RECIPIENT COUNTRY/ REGION	TARGETED AREA	PROGRAMME OR PROJECT TITLE	DESCRIPTION OF PROGRAMME OR PROJECT [b,c]
Africa, Asia, Latin America and the Caribbean	Adaptation	Integrated Climate Change Modelling and Policy Linkages for Adaptive Planning (funded by IDRC)	Multi-year capacity building initiative launched in October 2014, targeted at helping IDRC-funded research teams to deliver policy-relevant and demand-driven assessments that are informed by climate and hydrological modelling.
Global	Adaptation	Adaptation Finance: Linking Research, Policy and Business (funded by IDRC)	IDRC supports the Frankfurt School of Management and Thailand Development Research Institute to train next generation of leaders from the scientific community, policy and private sector who are active in a climate adaptation finance related field and to bring those groups together to discuss and analyse current challenges and opportunities in adaptation and adaptation finance from policy, private sector and research angle. The project, launched in April of 2016, will also help sharpen the definition of adaptation from the perspective of the private sector. The project is developing a typology for adaptation projects, outlining criteria that must be met in order to attract and secure investment, and investigating the financial and business risks associated with adaptation projects, including how such risks can be mitigated and how financial institutions and public policy can enable larger financial flows into adaptation.
Asia	Adaptation	South Asian Water (SAWA) Leadership Program on Climate Change (funded by IDRC)	The goal of the SAWA leadership program is to increase the number of women occupying leadership roles in the climate change field and the water sector in particular. With IDRC support, the program will be awarding fellowships to 36 women enrolled in master's-level integrated water resources management programs in Bangladesh, India, Nepal, and Sri Lanka, and providing these women with opportunities to access decision-making environments through internships. The program will generate greater participation by women professionals in policy and decision-making processes by encouraging them to occupy leadership roles in water planning and management and by encouraging them to develop climate-resilient policies to address water insecurity resulting from climate change in their own local contexts. More details available at: http://www.saciwaters.org/sawafellowships/index.html
Africa	Adaptation	Climate Leadership Program: Building Africa's Resilience through Research, Policy and Practice (funded by IDRC)	This program, proposed in 2016 and approved to run from 2017–2020, is one among three leadership programs to be implemented by IDRC's climate change program in Africa, Asia, Latin America and the Caribbean. It seeks to address climate change capacity gaps by developing leadership capacity of African scientists, policy advisers and practitioners for advancement in current climate knowledge, long-term adaptation, decision-making and climate action thus improving the effectiveness of science-policy-practice interface for positive impact in society.
Latin America and the Caribbean	Adaptation	Building leadership for LAC cities in a changing climate (funded by IDRC)	This 4-year leadership program aims to develop multiple technical capacities among young leaders, in particular women. It is one of the three leadership programs implemented by IDRC's climate change program in Latin America, the Caribbean, Africa and Asia. This program consists of a Postgraduate Diploma that combines a theoretical training module with practical exercises to consolidate the acquired knowledge in the field. It focuses on providing young leaders with practical knowledge of climate risk and urban management accompanied by participatory planning and negotiation skills to enable them to advise local public and private stakeholders for the effective development of climate resilient transformative policies in medium-sized cities.

[a] To be reported to the extent possible.

[b] Each Party included in Annex II to the Convention shall provide information, to the extent possible, on how it has provided capacity building support that responds to existing and emerging capacity building needs identified by Parties not included in Annex I to the Convention in the areas of mitigation, adaptation and technology development and transfer.

[c] Additional information may be provided on, for example, the measure or activity and cofinancing arrangements.

Annex 3

Methodological Approach for Measuring Canada's Climate Finance

This annex provides background information on the underlying assumptions and methodologies used to produce information on finance for Canada's *7th National Communication* and *3rd Biennial Report*. Additional definitions are provided in the documentation box as part of the reporting guidelines and the Common Tabular Format.

Definitions

- **Repayable Contributions:** Canada tracks flows that have been returned to Canada from past repayable contributions. These flows are tracked in the year they are received.
- **Year of Measurement:** In the past, Canada reported its climate finance to the UNFCCC by fiscal year (April–March). To facilitate collective reporting exercises, Canada is aligning its year of measurement to that of other donors, transitioning to reporting climate finance by calendar year. Changing to calendar year reporting will increase the comparability of climate finance data across donors.
- **Reporting Currency/Exchange Rates:** Data is reported in Canadian dollars and United States dollars based on OECD Development Assistance Committee (DAC) exchange rates for each relevant year.
- **Avoiding Double Counting of Financial Contributions:** In line with best international practice, Canada tracks climate finance at the project level. This level of granularity allows for a comprehensive picture of Canada's climate finance and avoids double counting of public flows.
- **Support through Export Development Canada:** Eligible transactions and projects are identified by EDC using the International Finance Corporation (IFC) "Special Climate" category within the IFC-Definitions and Metrics for Climate-Related Activities.[j] The transaction or project must take place in non-Annex I countries.

Tracking Climate Finance

Canada has monitoring and evaluation systems in place to effectively manage its climate finance. These systems allow for the collection and tracking of detailed project-by-project information based on the parameters defined in the Annex and the Common Tabular Format Documentation Box, and additional indicators to measure results. These reporting parameters and indicators enable the tracking of provision and evaluation of the effectiveness and impacts of Canada's climate finance.

Reporting parameters include: expected results, results achieved, estimated and actual GHG reduction or avoidance, number of people benefitting from adaptation projects.

By tracking both the expected and achieved results at the project level, we can evaluate the success of a project. The success of a project is measured by its achievement of planned outcomes and impacts. Furthermore, by tracking the specific activities of a project we are able to assess what activities are the most effective at achieving desired outcomes.

Canada works with partners that that have clear accountability frameworks. These partners measure and evaluate project results and report back to Canada on outcomes and indicators.

Measuring Mobilized Private Finance

Donor countries are working together to define quantification methodologies and improve the measurement and reporting of publicly mobilized private finance. These processes are paving the way for improved data, enhanced transparency and better harmonization:

[j] For more information, please visit: IFC-Definitions and Metrics for Climate-Related Activities.

- The OECD hosted Research Collaborative on Tracking Private Climate Finance is exploring options for the development of improved methodologies for measuring private flows mobilized by developed countries' public interventions.
- The Technical Working Group (TWG), established in 2015, developed a common and robust methodology[k] for measuring mobilized private climate finance towards the US $100B goal, building upon the work conducted under RC.
- Collective reporting exercises test methodologies. Canada participated in the report *Climate Finance 2013–2014 and the US $100 billion goal* (OECD 2015) which used the methodology developed by the TWG. This report found that developed countries jointly mobilized US $12.8B in 2013 and US $16.7B in 2014 from private sources.
- The OECD DAC has been working to measure private investment mobilized by official development finance interventions, including climate-related ones.

In accounting for mobilized private climate finance, Canada assesses the amount of private finance mobilized on an activity-by-activity basis and to report on private finance associated with activities where there is a clear causal link between a public intervention and private finance and where the activity would not have moved forward, in the absence of Canada's intervention.

Double counting is avoided across private finance estimated through the use of volume based pro-rata attribution of private co-finance among public actors involved based on respective contributions.

Taking into consideration the consensus on the four-stage framework, the TWG common methodology, and Canada's experience in tracking and reporting climate finance, Canada calculates its pro-rata share of mobilized private climate finance by:

1. Identifying Canada's public climate finance interventions—climate benefits as a motivating factor—designed to reduce GHG emissions or support adaptation.
2. Identifying the private finance contribution.
3. Taking into consideration the mobilization effect of other public co-financing to the project, and ensure that Canada is only attributing private finance pro-rated to its funding contribution.
4. Identifying Canada's pro-rated share of mobilized private finance.

[k] For more information on the TWG methodology please visit: http://www.oecd.org/env/cc/OECD-CPI-Climate-Finance-Report.pdf, Annex F.

CHAPTER 8

Research and Systematic Observation of Climate Change

Climate system observations and research are critical for understanding how the climate system works, how natural forces and human activities may cause the climate to change, and how these changes can affect ecosystems, socio-economic systems and human health. In Canada, climate system observation and research activities are undertaken jointly through core government programs, academic institutions, and collaborative research networks.

This chapter provides an overview of climate change research and scientific observation activities in Canada, with an emphasis on the developments which have taken place since the 2014 publication of Canada's *6th National Communication on Climate Change*. Recognizing the importance of sustained research and monitoring programs and the Government of Canada's role in providing the essential infrastructure for these programs, the perspective presented is largely from the federal government. However, given the collaborative nature of climate research and monitoring in Canada, as well as the range of climate related scientific services provided, highlights of provincial, academic and consortium based programs and research networks are also provided.

Research related to climate change impacts and adaptation is captured in Chapter 6: Vulnerability Assessment, Climate Change Impacts and Adaptation Measures, of this report.

8.1 Policy Context

8.1.1 Overview

In Canada, climate science research and monitoring approaches involve federal, provincial, municipal, academic, and private sector partners. The federal government provides most of the essential infrastructure for climate system research and long-term systematic observations programs. This work is complemented primarily by research and observation activities undertaken by the Canadian academic community, whose focus is 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 federal programs then play a major role in the provision of scientific findings and services to inform decision-making on climate change mitigation and adaptation domestically, as well as internationally.

Recognizing that meeting the Paris Agreement objectives requires coordinated efforts, First Ministers adopted the first ever federal-provincial-territorial climate change plan on December 9, 2016—the Pan-Canadian Framework on Clean Growth and Climate Change.

A federal climate change science plan to support implementation of the Pan-Canadian Framework on Clean Growth and Climate Change is under development, which will help to link the policy direction to delivery of programs. Understanding that the Pan-Canadian Framework will set the policy direction and will continue to influence research and systematic observations efforts well into the future, the following sections highlight some of the existing organizational mechanisms for climate research and systematic observations within Canada.

8.1.2 Research and Systematic Observation efforts 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. Federal government climate scientists, leveraging the collaborative research of national and international partners, generate and disseminate new knowledge and data to understand climate system behaviour, the human influence on climate, and future climate change. Funding for this work is embedded within annual departmental budget allocations, and priorities for climate research and monitoring in Canada are determined largely by consultative processes between federal government departments and academia, with some input from industry and other stakeholder groups. In addition to federal departments' core programs, some of which are currently under transformation such as the Meteorological Service of Canada's (MSC) monitoring networks, the Government of Canada funds targeted initiatives to enhance climate related research and monitoring. Programs that contribute to this work include:

- The renewal of the core monitoring infrastructure of MSC's Surface Weather and Climate Networks and Marine Networks.
- Environment and Climate Change Canada's Climate Change Prediction and Scenarios program.
- Fisheries and Oceans Canada's Aquatic Climate Change Adaptation Services Program.
- The Sustainable Science and Technology Advancement initiative of Agriculture and Agri-Food Canada's *Growing Forward 2* policy framework.

The Clean Air Agenda (2007–2021), which includes programs across 11 Government of Canada departments and aims to address the challenges of climate change and air pollution, has, to date, provided the foundation for effective policies, programs and services through sound scientific monitoring and research activities.

The following sections provide additional details on specific Government of Canada initiatives.

8.1.2.1 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.

Over the next three years, the program will support, in partnership with federal departments, five new initiatives focused on key policy areas of terrestrial monitoring activities supporting climate change impacts and ecosystem resilience. These include: two initiatives led by Natural Resources Canada to address Canada's climate change information needs and development of data analytic capabilities; two initiatives led by Environment and Climate Change Canada to monitor ecosystem variables and assimilation of space and surface-based data sources for a national Canadian Land Data Assimilation system; and one initiative led by Agriculture and Agri-Food Canada to estimate crop productivity. Supported initiatives will use data from Canadian space-based assets for Earth observation, including RADARSAT-2, RCM and other space missions of interest to Canadian government departments, such as the European Space Agency Sentinels and optical high resolution missions offered by the Canadian industry.

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 development of Innovative Earth Observation Solutions for Disaster Management in a Canadian Context using RADARSAT-2 satellite data in complementarity with other satellite and in situ observations.

Sun-Earth System Sciences Program

The Sun-Earth System Sciences Program supports university research teams from across Canada, often in collaboration with government researchers, in analyzing data from instruments aboard Canadian and international satellites. These research grants support validation of data products and retrieval algorithms, advance scientific knowledge and understanding of physical and chemical processes of the Earth System, and develop or improve analytical and computational models. Fourteen current projects in atmospheric science focus on topics such as ozone recovery, greenhouse gases, air quality and climate change, with special attention to the Arctic. One example of Canadian Space Agency supported academia-government collaboration is the development and testing of the carbon assimilation system using space-based observations of atmospheric carbon dioxide, carbon monoxide and methane. There are currently six research grants related to the remote sensing of soil moisture and soil freeze/thaw state.

Polar Space Task Group (World Meteorological Organisation)

The Canadian Space Agency continues to play a key role in supporting the Polar Space Task Group's efforts to collect and compile coherent and extensive satellite radar data over Polar Regions to support the scientific community to better understand the current and potential impacts of climate change. Canadian Earth Observations satellites have been used for monitoring sea ice and ice sheet conditions over polar regions for the past 20 years.

8.1.3 Research Granting Agencies and Funded Initiatives in Canada

Canada has three major research funding agencies, known collectively as the tri-councils: the Natural Sciences and Engineering Research Council of Canada (NSERC), the Social Sciences and Humanities Research Council of Canada (SSHRC) and the Canadian Institutes of Health Research (CIHR). Of the three, NSERC is the most closely linked to climate science research programs. NSERC is concerned with administering funds for university research and training in the fields of science and engineering. It also fosters innovation by encouraging Canadian companies to participate and invest in postsecondary research projects.

NSERC reports to Parliament through the Minister of Innovation, Science and Economic Development. It is governed by a President and a Council of distinguished members selected from the private and public sectors. The Council is advised by various standing committees that are guided by a peer review process. 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 the Natural Sciences and Engineering Research Council.

On February 27, 2015, Canada's three major research funding agencies announced a new harmonized "Open Access Policy on Publications" that requires research publications supported by public funds to be made openly available for the benefit of the community at large. This approach is aligned with Canada's commitments to the Open Government Partnership, as outlined in the Third Biennial Plan to the Open Government Partnership 2016 -18. The Plan can be found at http://open.canada.ca/en/content/third-biennial-plan-open-government-partnership. More information on Canada's commitments to Open Data is covered in section 8.3.1.

8.1.3.1 Climate Change and Atmospheric Research Grants

Under the Natural Sciences and Engineering Research Council's Climate Change and Atmospheric Research (CCAR) initiative, seven research teams were awarded grants totalling more than $32 million over 5 years to support climate change and atmospheric research at Canadian post-secondary institutions (2012–13 to 2017–18). The teams, comprised of university researchers, government researchers and partner organisations carried out 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.

The Climate Change and Atmospheric Research initiative has addressed many aspects of climate and atmospheric science. Highlights of the projects include:

- Explanations of atmospheric conditions that caused the 2013 floods in Calgary, Alberta.

- Shaping research agendas on wildfires in the northern boreal and taiga forest.
- Improved understanding of how aerosols affect climate and air quality in Canadian regions.
- Better understanding of the hydrologic response to climate change.
- Advancements on hydrological, ecological, and atmospheric model development.
- Improved climate predictions in Arctic regions.
- Enhancements to Environment and Climate Change Canada's earth system based model components for aerosols, land-surface and hydrology, and the cryosphere.

8.1.3.2 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. The program supports large-scale academically-led research networks, delivering multidisciplinary research partnerships with industrial expertise and strategic investment through the involvement of academic, industry, government and non-for-profit partners. The Networks of Centers of Excellence initiative is supported by the three major Canadian federal granting councils: the CIHR, the NSERC and the SSHRC, as well as by two government departments: Health Canada and Innovation, Science and Economic Development 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 three phases of ArcticNet took place from 2003–2014, and were discussed in the *5th* and *6th National Communication* reports. Since 2014, the fourth phase of ArcticNet was launched, which focuses on four main themes: marine ecosystems; terrestrial ecosystems' Inuit health, education and adaptation; northern policy development; and knowledge transfer. This integrated research approach brings together scientists and managers in the natural, human health and social sciences with their partners from Inuit organizations, northern communities, federal and provincial agencies and the private sector to study the impacts of climate change in the coastal Canadian arctic. To date, there are over 145 ArcticNet researchers from 30 Canadian universities while 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 seeks to observe, predict and respond to changing marine hazards arising from climate change, chemical/biological change, geophysical events and direct human impacts. Primary activities include support for interdisciplinary research, providing training to bolster the Canadian workforce, and mobilizing scientific knowledge, technology and people through cross sector engagement. Cycle I (2012–2017) projects, focused on developing disaster and risk reduction tools and identifying adaptation measures for Canada to better manage ocean influences on coastal environments. This has been 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. Cycle I funding was described in the *6th National Communication* report. In 2017, $28.5 million in renewed federal funding was secured, allowing MEOPAR to continue the research that was started in Cycle I.

8.1.3.3 Canada Research Chairs

The Canada Research Chairs 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 the tri-councils—the NSERC, the SSHRC and the CIHR and managed by a steering committee that reports to the Minister of Innovation, Science and Economic Development Canada. The program offers eligible Canadian degree-granting institutions the opportunity to nominate outstanding researchers for senior professorships, and offers exceptional emerging researchers support to kick-start their careers in faculty positions at Canadian universities. The Program spans a wide range of research areas and as of April 2017, there were seven Canada Research Chairs contributing directly to climate research in Canada; two at the University of Manitoba (global warming and sea ice; chemical cryospheric processes) and one each at the Université du Québec à Montréal (regional climate processes), the University of Toronto (environmental impacts of nitrogen), Dalhousie University (atmospheric composition observation), McGill University (atmosphere and climate dynamics) and the Université de Montréal (arctic and sub-arctic: carbon, water and energy exchange).

8.1.3.4 Canada First Excellence Research Fund

Launched in 2014, the Canada First Excellence Research Fund invests approximately $200 million per year to support Canada's postsecondary institutions in their efforts to become global research leaders. One project directly supports academic research related to the climate system. Global Water Futures is a university led research network awarded with $77.8 million which aims to place Canada as a global leader in water science for cold regions and address strategic needs of the Canadian economy to adapt to change and risks in uncertain water futures. Specific projects focusing on climate change science include, Climate-Related Precipitation Extremes, The Changing Arctic Network and "Improving snowfall and snowpack measurement, modelling and prediction across Canada for hydrometeorological applications."

8.1.4 Other Initiatives

Atmosphere-Related Research in Canadian Universities

Established in 2016–17, the Atmosphere-Related Research in Canadian Universities (ARRCU) Working Group is a group of Canadian university faculty who undertake research in weather, climate, and air quality under the general framework of atmosphere-related research. Atmospheric-related research considers the whole atmosphere, from the surface to space, and its interaction with land-surface, hydrologic, ocean, cryospheric, and space systems. Work in this area connects atmospheric and related sciences to many other areas of environmental and social science.

The ARRCU has initiated a strategic planning process in Canadian atmospheric-related research across the university, government, and industrial sectors. The group seeks to help configure academic atmospheric-related research to most benefit Canada in a time of rapid environmental and socio-economic change. Efforts are aimed at benefitting atmospheric related research activities within and outside the wide range of University departments and disciplines where such research takes place.

8.2 Systematic Observation

8.2.1 Overview

Systematic climate observations are essential for understanding the mean states of various climate components over time and the natural variability around these means, for detecting changes in these means and extremes, and for attributing these changes to specific causes. Observations can also help to clarify the processes by which components of the climate system interact and the sensitivity of these processes to natural and anthropogenic influences. Accurate observations can also provide an objective basis for verifying reported emissions. Climate modellers incorporate observations into climate system models through mathematical equations, allowing for the prediction of changes and the long-term projections of future climates.

Data management is an important aspect of any systematic observations endeavor. 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 organizations, agreements, and commitments, climate data is collected, quality controlled, and disseminated according to international standards.

In 2013, Canada and the other G8 members adopted the Open Data Charter, committing to a set of open data principles: open data by default; quality and quantity; usable by all; releasing data for improved governance; and releasing data for innovation. As part of Canada's commitments under the G8 Open Data Charter, federal government departments and agencies must release their data holdings proactively by default, subject to privacy, security and/or confidentiality restrictions. In order to deliver on this commitment the Government of Canada is taking steps to make all outbound data for public consumption, including scientific data related to peer-reviewed publications, discoverable through the Open Government Portal at http://open.canada.ca.

Recognizing the complexity and horizontality of many national policy priorities including climate change, Canada has developed the Federal Geospatial Platform (FGP), an innovative Canadian initiative designed to bring together economic, social, and environmental data from multiple departments and agencies and make it publically available to support climate resilience. Over seven hundred data layers are now available and the number is constantly growing. From Open Maps (powered by the FGP), users can view climate change scenarios interactively, and overlay them with other map layers (e.g. communities, energy infrastructure, wildfires) to get a sense of how climate may change in relation to their livelihood. Visit http://open.canada.ca/en/open-maps for more information. In December 2016 following the Paris Agreement, Canada endorsed a Joint Declaration on Harnessing the Data Revolution for Climate Resilience, and was committed to sharing tools and best practices from Open Maps. Canada also plays a proactive role in supporting the emerging Open Data for Climate Actions initiative coordinated by the International Open Data Charter.

Canada is a significant contributor to the Global Climate Observing System (GCOS), an internationally coordinated network of observing systems and a programme of activities that support and improve the network. GCOS was established in 1992 as an outcome of the Second World Climate Conference. Canada also makes significant contributions to the related 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 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.

8.2.2 Monitoring Networks

8.2.2.1 Atmosphere

Surface Weather and Climate

Environment and Climate Change 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. While network spatial densities and station distributions are relatively stable, lower densities are found in the sparsely populated northern regions. To address these spatial gaps, Environment and Climate Change Canada continues to make 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 through a network of networks approach. This Canadian collaborative monitoring initiative is aimed at addressing 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.

As of 2017, the Surface Weather Network includes approximately 570 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 46 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 World Meteorological Organization guidelines. In addition to these networks, the Environment and Climate Change Canada drifter buoy network provides marine observations from most of the data sparse areas in the Arctic, north Atlantic, and north Pacific oceans. Environment and Climate Change Canada also contributes to the Global Drifter Program by upgrading approximately 30 drifter buoys with barometers every year.

Within this broader atmospheric monitoring program, Environment and Climate Change Canada operates two surface networks specific to climate change—the Canadian Reference Climate Stations Network and the daily Climatological Network. As of 2017, 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 thirty 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 and Climate Change Canada has been converting about 10% of these stations per year to a standardized auto-station configuration. About 250 of the Canadian Reference Climate Station's network stations are Environment and Climate Change Canada operated automatic weather stations. The remaining Reference Climate Stations continue to be a mix of aviation weather monitoring stations operated by Nav Canada and the Department of National Defence and a small number of daily temperature and precipitation stations operated by the volunteer based Co-operative Climate Network. Renewal investments have allowed Environment and Climate Change Canada to install and upgrade to automatic weather stations to reduce third party dependency for climate observations.

Environment and Climate Change 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 400 sites where observations of temperature (minimum and maximum), precipitation (rainfall or snowfall), and snow depth are recorded once or twice daily. Data entry systems (one internet based and one telecommunications based) allow observers to submit their observations in near real-time. Ongoing modernization processes provide more timely access and better quality of daily climate data from these stations.

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 by the Canadian Aircraft Meteorological Data Relay (AMDAR) program which, from 14 aircraft of a commercial airline fleet, generates approximately 300 wind and temperature soundings per week from 18 Canadian airports. 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 and Climate Change Canada operates the long term observations network for near real-time atmospheric measurements of CO_2 and other greenhouse gases (GHGs) (CH_4, N_2O, and SF_6), with a subset of these stations also providing additional CO_2 and CH_4 stable carbon isotope measurements. These long term monitoring stations are located across Canada to provide regional scale information on GHG emissions from local and regional natural (forests, wetlands) and anthropogenic (coal, oil and gas, agriculture, waste) sources. As of April 2017, there were 16 long-term and 6 shorter-term project measurement sites located in coastal, interior, and Arctic regions in Canada. A major focus of the GHG measurement program since the *6th National Communication* has been to enhance the regional coverage in Canada's North. This includes the addition of a fourth monitoring site in Canada's Arctic. Environment and Climate Change Canada's Global Atmosphere Watch Observatory at Alert is one of three World Meteorological Organization Global GHG inter-comparison sites. The Alert Observatory celebrated its 30th anniversary in 2015.

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. Detailed measurements of aerosol chemistry and microphysics are conducted at 6 sites in Canada to monitor short and longer term changes in concentrations of the atmospheric aerosol. Baseline locations represent the high Arctic with the Alert and Resolute Bay Nunavut (NU) stations. The three decades long measurements at Alert provides valuable information for understanding linkages to the changes in emissions and atmospheric transport when compared with observations conducted at other southern stations. Aerosol measurements at different stations vary. The Alert, NU and Whistler, British Columbia stations have more comprehensive instrumentation for aerosol measurements (i.e. particle number and size distributions, light scattering and absorption, refractory and equivalent black carbon mass concentrations, near real-time submicron particle chemistry, filters for submicron particle inorganics, carbonaceous mass and stable carbon isotope). In addition, routine chemical composition measurements of aerosols are conducted at 18 sites of the Canadian Air and Precipitation Monitoring Network.

Stratospheric ozone measurements support Canada's international obligations as a party to the Montréal Protocol on Substances that Deplete the Ozone Layer, and also party to the Vienna Convention for the Protection of the Ozone Layer. More specifically, total ozone column measurements are being taken to study the temporal and vertical ozone trends; and monitor the recovery of the ozone layer and polar ozone depletion events, such as those that occur naturally over the Antarctic during spring time. In addition, the total ozone and spectral ultraviolet irradiation measurements by the Brewer network are used by modellers to generate ultraviolet index forecasts, which are then validated by Brewer ultraviolet measurements. Surface ozone measurements are also made at 17 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.

Environment and Climate Change 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 eight Brewer stations. Six of the eight ozonesonde stations are co-located with the Brewer stations.

Environment and Climate Change Canada operates the AEROCAN (AEROsol CANada) network, a sun photometer and sky-scanning radiometer network of 19 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. AEROCAN provides data that can be used for aerosol optical depth trend analysis, optical properties characterization, and validation of satellite retrievals, potentially helping to reduce uncertainty of the aerosol radiative forcings.

Data management among Environment and Climate Change Canada's atmospheric composition measurement networks adheres to principles set out by the World Meteorological Organization (WMO) Global Atmosphere Watch Program. Ozone, GHG, and aerosols data are reported to the relevant the WMO World Data Centers. Ground level ozone data and aerosol composition data collected by the Canadian Air and Precipitation Monitoring Network will be reported through the Government of Canada Open Data Portal. The World Ozone and Ultraviolet Radiation Data Center is operated by Environment and Climate Change Canada and located in the city of Toronto. GHG and aerosols data are archived in the Canadian National Atmospheric Chemistry Database and Analysis System. Ultimately data will be made publically available through the Government of Canada Open Data Portal, pending resolution of third party licensing issues. Canada's participation in these national and international data archives ensures open access to the first-order data collected under the various monitoring programs.

8.2.2.2 Oceans

Fisheries and Oceans Canada (DFO) is responsible for the collection, management and interpretation 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. Collaborations are established with universities, other government departments (primarily Environment and Climate Change Canada) both national and international, and agencies to include oceanographic activities for which the responsibility falls outside Fisheries and Oceans Canada.

DFO's strategic outcomes include: Economically Prosperous Maritime Sectors and Fisheries; Sustainable Aquatic Ecosystems; and Safe and Secure Waters. DFO conducts research and long-term monitoring of key ocean parameters (e.g. salinity, temperature, dissolved oxygen, total carbon dioxide), and manages the resulting data to ensure integrity and accessibility. In turn, the generation of new knowledge allows the Department to provide advice, products and services that support ecosystem management decisions, adaptation to climatic change and its consideration for food security, emergency preparedness, search and rescue, the mitigation of oil spills, and at-sea operations such as fisheries and offshore energy exploration. Ocean monitoring is a crucial requirement for achieving the goals of these strategic outcomes.

Pacific and Atlantic Ocean Monitoring

The Atlantic Zone Monitoring Program (AZMP) includes a network of six stations sampled bi-weekly, 17 seasonal cross-shelf sections sampled one to three times annually, and fisheries resource surveys that collect data temperature, salinity, oxygen, nutrients, carbonate system, and zooplankton. The Atlantic Zone Off-shelf Monitoring Program (AZOMP) includes a section across the Labrador Sea 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 AZMP Halifax section to provide annual downstream sampling of these same variables. Similarly, a transect from Vancouver Island to Ocean Station Papa (Line P) is surveyed three times per year for temperature, salinity, oxygen, carbon system variables, chlorophyll, nutrients, and zooplankton. This is a cornerstone of long-term observations of the effects of climate variability and change on ocean ecosystems in Canadian Pacific waters. The Line P program celebrated its 60th anniversary in 2016.

Line P sampling is also coordinated with other collaborative groups including local, national and international academia incorporating metagenomics, biogeochemistry, plankton ecology, physical and chemical oceanography into Line P data and publications. The west coast of Vancouver Island is surveyed twice a year (late spring and late summer) and there are surveys of the Salish Sea three times per year (spring, summer, and fall). Carbon system variables are being sampled in coastal British Columbia in collaboration with the academic led MEOPAR (Marine Environmental Observation Prediction and Response) network. Other academic and non-profit initiatives (e.g. Hakai Institute and Oceans Networks Canada) are providing valuable data in physical, biological and chemical oceanography.

Satellite data images are captured by Fisheries and Oceans Canada at a receiving station at the Bedford Institute of Oceanography. Sea-surface temperatures images are derived from Advanced Very High Resolution Radiometer (AVHRR) on the U.S. NOAA series of polar orbiting weather satellites and from the Moderate Resolution Imaging Spectroradiometer (MODIS). Chlorophyll concentration images are produced from the Sea-viewing Wide Field-of-view Sensor (SeaWiFS), the Visible Infrared Imaging Radiometer Suite (VIIRS), the MEdium Resolution Imaging Spectrometer (MERIS) and MODIS. Primary Production images are derived from the semi-monthly composites of chlorophyll concentration and temperature. On-line archives of imagery are publicly available.

Canada also contributes to the international Argo program, which now has over 3,800 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 ocean circulation models, creation of 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 variability. Canada's contribution to the Argo program to date has included deployment of over 446 ocean floats in the northwest Atlantic and northeast Pacific and Southern Oceans.

The Arctic

Arctic Ocean observing programs include year-round monitoring of oceanographic conditions via subsurface moorings that record sea-ice thickness and drift, ocean currents, temperature and salinity. These moorings are located to measure through-flow in key straits of the Canadian Arctic Archipelago; oceanographic conditions over the Canadian Beaufort Shelf and within the Beaufort Gyre Region and an Arctic Ice Mooring north of the Chukchi Sea. The Joint Ocean Ice Studies (JOIS) program is an international collaboration to monitor sea-ice, oceanographic and ecosystem conditions in the Beaufort Gyre Region of the Canada Basin in the Arctic Ocean via an annual month-long, scientific expedition aboard the Canadian icebreaker Canadian Coast Guard Ship Louis S. St-Laurent. JOIS is a collaboration between the U.S. and Canada that has provided oceanographic surveys of the central Beaufort Gyre annually since 2003 and is supported by a team of scientists from across Canada, the U.S. and Japan. A recent Arctic Science Fund will support research that bridges the gap between physical and geochemical drivers and biological components.

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. This network is maintained by the Canadian Hydrographic Service (part of DFO).

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. The Marine Environmental Data Service (MEDS) manages and archives ocean data collected by Fisheries and Oceans Canada, or acquired through national and international programs in ocean areas adjacent to Canada. MEDS 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 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. As a designated Responsible National Oceanographic Data Centre, Fisheries and Oceans Canada partners with the Atlantic Oceanographic and Meteorological Laboratory in the U.S. to provide long term archive facilities for the Global Drifter Center data. Observed Essential Climate Variables are surface temperature and salinity, air pressure and pressure tendency, and surface currents.

8.2.2.3 Cryosphere

Sea Ice

Environment and Climate Change Canada's Canadian Ice Service observes sea ice conditions on a daily and weekly basis in the ice-encumbered waters within and adjacent to Canada's exclusive economic zone, including the Great Lakes. The RADARSAT-2 satellite is the primary observing platform, with over 10,000 Synthetic Aperture Radar images manually analysed annually. Radar data are complemented by visual and infrared satellite images and ship and aircraft reports. Aircraft reconnaissance is also conducted in active marine areas.

In addition to improving the safety of navigation, the sea ice information gathered through these observations and analyses provide invaluable data for climate studies. Environment and Climate Change Canada produces data on sea ice distribution on a weekly basis, which are used for ice climate purposes. These data have been digitised back to 1968, and are available freely on the Canadian Ice Service website. The weekly data follows international standards 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 and Climate Change Canada produced 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 ice data for 1980–2010. The Canadian Ice Chart Digital Archive and graphing tools available on the Canadian Ice Service website at https://www.ec.gc.ca/glaces-ice can be used to analyse sea ice variability, trends, and current departure from normal.

Environment and Climate Change Canada also produces daily charts of the iceberg limit along the East Coast of Canada. The limit of all known icebergs is monitored weekly, weather permitting. Icebergs within the limit are surveyed less often, using aerial reconnaissance in conjunction with the International Ice Patrol. Satellite imagery is used for areas free of sea ice north of approximately 55°N. 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 and Climate Change Canada's Canadian Ice Service.

Using an ice tracking algorithm for deriving ice motion from sequential RADARSAT-2 images, a series of studies examining ice fluxes through the Canadian Arctic Archipelago have been undertaken within Environment and Climate Change Canada. Environment and Climate Change Canada's ice data is also 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 experimentally 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 and Climate Change Canada's Canadian Ice Service sea and lake ice data, ice concentrations derived from satellite passive microwave observations and scatterometer satellite observations, and ice/water retrieval from visible/infrared satellite observations.

Lake and River Ice

Dates of freeze-up and break-up of ice cover on lakes and rivers are useful indicators of climate change, being well correlated with air temperature during the transition seasons, and are important ecological indicators. 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. As of 2017, ice thickness measurements continue to be recorded at 11 stations across northern Canada. The Canadian Ice Service monitors over 130 lakes in Canada and the US for ice concentration based on visual interpretation of Synthetic Aperture Radar and optical satellites. A volunteer "Icewatch" program, a partnership between several academic and non-government organizations, provides lake and river ice reports for about 85 locations across Canada.

Snow on Ground

Canada's national snow on ground in situ measurement program involves a composite of inputs including automatic and manual stations that are part of Environment and Climate Change Canada's Reference Climate Stations and Surface Weather Network (described in section 8.3.2.1). In addition, volunteer climate observing networks, municipalities, and other government departments (e.g. Department of National Defence) continue to own and operate a significant portion of the Canadian Reference Climate Stations. Reports from contracted aviation service providers also contribute data to the program. Efforts continue to improve measurement of snow depth and derivation of snowfall from auto-stations, and Canada has had a leadership role in the World Meteorological Organization Solid Precipitation Intercomparison Experiment (SPICE). Environment and Climate Change 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 and Climate Change 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. Efforts are currently underway to extend the snow water equivalent map products to other regions in Canada based on current satellite capabilities. Environment and Climate Change 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 continues to produce daily snow cover derived from the U.S. NOAA's Advanced Very High Resolution Radiometer observations.

Permafrost

Permafrost is an important priority for Canada with one third of the permafrost regions of the northern hemisphere lying within Canada and the permafrost zone covering about half of the Canadian landmass. Measurements for two key indicators, permafrost thermal state and active layer thickness, are acquired through in situ observations. At most thermal monitoring sites, ground temperatures are measured to depths of 20 m. At active layer monitoring sites, regular measurements are made of the thickness of the soil layer above the permafrost that freezes and thaws annually.

Natural Resources Canada continues to maintain, in collaboration with partners, a network of reference sites that was largely enhanced between 2004 and 2011 through various initiatives, including the federal government's International Polar Year Program as described in the *5th* and *6th National Communications*. The network consists of over 150 thermal/and or active layer monitoring sites with observation periods ranging from less than 10 years to more than 30 years.

The current network covers the major ecoclimatic zones with transects in western, central and eastern portions of Canada's northern territories, as well as an elevational transect in the Yukon. Through recent research projects, additional instrumented sites have been established for example in the Slave region of the Northwest Territories, and the Inuvik-Tuktoyaktuk highway corridor.

The Canadian monitoring sites contribute to the Global Terrestrial Network for Permafrost (GTN-P) 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 GTN-P and provides Canadian representation on the executive. The GTN-P includes two components, the Thermal State of Permafrost (TSP) and the Circumpolar Active Layer Monitoring Program (CALM). The GTN-P website, originally established and maintained by Natural Resources Canada, was transferred to European partners in 2013. Summary data for Canadian thermal monitoring sites has been submitted to the GTN-P and will be made available through the website http://gtnp.arcticportal.org. Active layer data are submitted annually to CALM and posted on the website hosted by George Washington University which will also be accessible through the GTN-P web site.

Glaciers

In Canada, some 200,000 km^2 of glacier cover is found throughout the Western Cordillera region and in the Arctic Islands. Glaciers in both regions have recently experienced accelerated retreat and thinning having significant impacts on freshwater inputs to stream flow and sea-level rise. Monitoring rates of change of glaciers in both regions thus remains a major priority for the Government of Canada.

Natural Resources Canada is the lead federal department responsible for measuring and reporting on the state of health of Canada's glaciers. 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 (WGMS). Digital data are accessible through the WGMS at http://wgms.ch/ and its mirror site at the U.S. National Snow and Ice Data Center, https://nsidc.org/.

Of Canada's 15 reference observing sites, record length requirements dictate that 7 of these provide Essential Climate Variables (e.g. mass balance) 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 initiated in 2010 continues 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.

In the Canadian Arctic, Earth Observation strategies have been integrated into the in-situ mass balance monitoring program to improve the spatial and temporal resolution of glacier mass balance from this region. For example, results from the CryoSat-2 radar altimeter provide preliminary assessments of select glaciers, allowing routine assessment of glacier change beyond the traditional long-term in-situ network. Data telemetry capabilities allow near-real time (1–2 days) retrieval of glacier mass balance measurements, reporting, and analysis. Both strategies complement the existing in-situ measurement program to provide timely access to data essential for characterising climate system dynamics and global glacier change analysis.

8.2.2.4 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 and Climate Change Canada is responsible for the collection, interpretation, and dissemination of standardized water level and river discharge data and information in Canada. The data are collected under a national program jointly administered and paid for under federal–provincial and federal–territorial cost-sharing agreements. It operates a fully-digital network of over 2,100 hydrometric stations, with over 1,800 stations transmitting data in near real-time. The data are made available online in an archive database, and where possible, in near-real time, as well as being published annually in the national HYDAT archive database. Station metadata are stored in the national HYDEX database. Similar to the ground-based national meteorological networks, the hydrometric program is well established, with defined standards and operating procedures and is certified as ISO-9001. In support of the Global Terrestrial Network for Rivers, Canada provides data from discharge stations located at or near the mouth of large rivers. In support of the World Meteorological Organization (WMO)'s Arctic Hydrological Observing System (Arctic-HYCOS), Canada provides data on discharge and water levels for a selection of stations on rivers that flow to the Arctic Ocean and are representative of all Arctic hydrological regimes.

Most of the hydrometric stations are located in the southern half of the country where the density of the population and economic activities are greatest. As a result, the adequacy of the hydrometric network to describe hydrologic characteristics, both spatially and temporally, decreases significantly in the north. A subset of stations is included in the Reference Hydrometric Basin Network (RHBN), representing locations with little or no upstream regulation (i.e. natural conditions).

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.

Forests

Natural Resources Canada's National Forest Inventory provides ongoing monitoring of Canada's forests. The National Forest Inventory (NFI) is a collaborative effort of federal, provincial, and territorial governments from across Canada. The NFI is currently monitoring a network of 13,158 remote sensing survey plots across Canada on a ten year re-measurement cycle (2008–2017). A 20 km by 20 km sampling grid is used in southern Canada with less intensive sampling in northern Canada. Detailed ground measurements are taken at a subset of the NFI 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 NFI provides national and regional scale estimates of above-ground forest biomass and biomass estimation models. Updated biomass estimation models were embedded in an updated version of the Carbon Budget Model of the Canadian Forest Sector (CBM-CFS3) which was released in January of 2015. The CBM-CFS3 and NFI biomass calculation tools are available through the National Forest Information System at http://nfis.org/.

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 national mapping and monitoring of forest disturbances (cover losses) and post-disturbance forest recovery. Disturbances have a high impact on the carbon balance of Canada's forests. Tree cores collected at NFI plots are also being used to investigate forest growth responses to changing climate.

Agricultural Soils and Vegetation and Agroclimate

Agriculture and Agri-Food Canada has active research and operational activities internally, and in partnership with others, across the spectrum of soil, water, climate and biodiversity systems. Much of the output from these activities is available online on departmental websites and on Government of Canada open data sites, such as http://www.agr.gc.ca/eng/science-and-innovation/.

Since 2011, Agriculture and Agri-Food Canada has produced weekly maps of soil moisture condition and anomalies over North America, which are used as input to other monitoring systems for flood forecasting and climate-related production risk assessment.

Agriculture and Agri-Food Canada and Environment and Climate Change 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 calibrate and validate surface and rooting zone moisture conditions. The network was initially installed in 2011 and 2012. Routine public data dissemination began in 2013 and is ongoing. These data are important to Environment and Climate Change Canada's land surface assimilation modelling and the U.S. National Aeronautics and Space Administration's (NASA) calibration and validation of satellite moisture assessment systems.

Agriculture and Agri-Food Canada continues annual monitoring of agricultural land use and cover on a national scale since 2011, through the Agriculture and Agri-Food Canada Annual Space-Based Crop Inventory. This product maps the crop types of every field in Canada, along with other non-agricultural land cover found within the agricultural extent of Canada. Agriculture and Agri-Food Canada is also developing land use change information from this land use inventory. Agriculture and Agri-Food Canada is working with Environment and Climate Change Canada and Natural Resources Canada to develop a terrestrial monitoring framework for Canada.

The Canadian Ag-Land Monitoring System (CALMS) has been providing weekly Normalized Difference Vegetation Index (NDVI) composites and their anomalies (i.e. differences from normal conditions) across Canada's agricultural extent in near real time since 2009 and weekly data is available from 2000–2016. This system is based on the use of daily satellite observations acquired at a 230 m spatial resolution.

Agriculture and Agri-Food Canada has developed a monthly crop production forecasting system using real time weather and satellite vegetation condition data. Monthly forecasts are produced for major crops in Canada during the growing season. The data sets and models have been adopted for estimating yield production by Statistics Canada, replacing traditional telephone surveys for the late growing stage assessment. This program was an experimental research and development program until 2015, and is now operational.

Agriculture and Agri-Food Canada is the lead for drought monitoring and reporting for the Government of Canada. Agriculture and Agri-Food Canada has developed new tools and indices to enhance its monitoring of drought conditions on Canada's agricultural landscapes. The Drought Watch website at www.agr.gc.ca/drought has been updated with a new section dedicated to the Canadian Drought Monitor. This section features a geospatial application, a timeline tool and embedded maps.

Progress has also been made on the development of a Canadian version of important drought indices (the Vegetative Drought Response Index or VegDRI) initially developed by the United States. Adoption of VegDRI by Canada is improving the homogeneity of integrated North America drought assessments.

The Agroclimate Impact Reporter (AIR) was launched in 2013 to automate reporting of agroclimate impacts, including the capture of crowd-sourced observations. The network of volunteer reporters continues to expand nationally. AIR is currently used to validate extent, location, and severity of the impacts of drought and other extreme weather and climate conditions and events on agriculture.

Agriculture and Agri-Food Canada has contributed to the enhancement of weather and climate monitoring networks in the Prairies and Atlantic Canada and, with Environment and Climate Change Canada and the private sector, and has helped establish the Community Cooperative Rain, Hail, and Snow (CoCoRaHS) project in Canada to increase community participation in monitoring. The CoCoRaHS network, started in 2011, is now national.

Agriculture and Agri-Food Canada, through the Canadian Soil Information Service (CanSIS), continues to work closely with provincial governments, other federal departments, and academia to ensure Canadians have access to the best available soil data. This data provides a baseline for Canada's agricultural soils, which can be combined with modelling techniques to understand the potential impact a changing climate may have on agricultural soils.

As a member of the Global Soil Partnership, Agriculture and Agri-Food Canada, is working with partners to develop a National Soil Organic Carbon Map. The National Soil Organic Carbon Map will contribute to the Global Soil Organic Carbon Map. A precise and reliable global view on soil organic carbon (SOC) is needed under different UN conventions, such as the UN Convention on Climate Change and Desertification. The first version of this map was released in December 2017.

Agriculture and Agri-Food Canada's near real-time crop assessment activities feed into monthly assessments of global crop production through the GEO Global Agricultural Monitoring (GEOGLAM) initiative, a contributor to the G20 Action Plan on Food Price Volatility, which can be found at http://www.amis-outlook.org/amis-monitoring/crop-monitor/overview/en/. The global assessments also support early warning for food scarcity in food insecure nations.

8.2.3 Space-based Observations

8.2.3.1 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 information on the depletion/recovery of the ozone layer.

RADARSAT

RADARSAT-1, operating from 1995 until March 2013, provided 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.

8.2.3.2 Canadian Instruments aboard International Satellites and Missions

CLOUDSAT

CLOUDSAT, launched in 2006, is a National Aeronautics and Space Administration (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 17-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, nitrogen dioxide and aerosol concentrations 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.

Surface Water and Ocean Topography

Surface Water and Ocean Topography is a joint mission of NASA and the Centre National d'Études 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.

8.2.3.3 Canadian Involvement in International Missions

In addition to the Canadian initiatives listed sections 8.2.3.1 and 8.2.3.2, 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 Earth Observation 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.

Specific international missions in which Canadian researchers are involved, and which inform climate research in Canada, include the following:

- The ESA's Earth Cloud Aerosol and Radiation Explorer (EarthCARE) satellite mission, which aims to advance our understanding of the role that clouds and aerosols play in reflecting incident solar radiation back out to space and trapping infrared radiation emitted from Earth's surface.
- The Japanese Aerospace Exploration Agency's Greenhouse gases Observing Satellite (GOSAT-2) mission, which aims to gather observations of greenhouse gases with higher levels of accuracy via even higher-performance onboard observation sensors than its predecessor, the IBUKI mission. NASA's Orbiting Carbon Observatory (OCO-2) mission, which aims to collect the first space-based measurements of atmospheric carbon dioxide with the precision, resolution and coverage needed to characterize its sources and sinks and quantify their variability over the seasonal cycle.
- NASA's Soil Moisture Active Passive (SMAP) mission, which aims to provide information on the soil moisture content and freeze/thaw state of the earth's land surface required to understand and characterize the flows of water, heat energy and carbon between the surface and atmosphere and improve the predictive capability of weather and climate models. A SMAP Validation Experiment was carried out in southern Manitoba in June–July 2016 to support the ongoing verification and improvement of SMAP derived products.
- ESA's Soil Moisture Ocean Salinity (SMOS) mission, which aims to make global measurements of soil moisture, an important variable in the water cycle. Canadian scientists also use these measurements to perform research on the freeze/thaw state of soils.

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.

8.3 Research

8.3.1 Overview

Numerous scientific disciplines from a range of government and academic institutions are involved in research on the climate system and climate change in Canada. The key federal departments involved in such research are Environment and Climate Change Canada, Fisheries and Oceans Canada, Natural Resources Canada, and Agriculture and Agri-Food Canada. Environment and Climate Change Canada provides the foundational scientific understanding of the climate system by generating and disseminating new knowledge and data to understand climate system behaviour, the human influence on climate, and future climate change. Other federal departments carry 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 our understanding of past and potential future climate change impacts on the Canadian environment, economy, and society.

8.3.2 International Cooperation & Collaboration

International coordination of climate research and assessment of climate change science is achieved through the closely interconnected programs of the World Meteorological Organization, the Intergovernmental Panel on Climate Change and the World Climate Research Programme (WCRP). The WCRP was established jointly by the World Meteorological Organization, the International Council for Science and the Intergovernmental Oceanographic Commission of the United Nations Educational, Scientific and Cultural Organization (UNESCO). In 2016, Environment and Climate Change Canada became the lead for the Canadian Coordinating Committee to the World Climate Research Programme, facilitating coordination and communication with respect to the WCRP in Canada. Further, the Canadian Coordinating Committee has connected with the nascent Atmospheric-Related Research in Canadian Universities initiative (described in section 8.2.4) to further enhance communication, and coordinated engagement in atmospheric science, including for the WCRP. Canada makes significant contributions and benefits strongly from the leadership, participation and collaboration opportunities presented by these programs.

8.3.3 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.

8.3.3.1 Atmosphere

Climate Data Analysis and Research

Environment and Climate Change 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. These data products are used in climate trend and variability analyses and climate impact studies. This includes the development of statistical downscaling techniques and climate change detection and attribution research, particularly for climate extremes (e.g. temperature and precipitation).

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 model simulations 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.

Climate data homogenization and analysis 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) dating back to the early 1900s. These data are also included in the collaborative production of North American gridded datasets for global and regional climate model validation. Since 2010, these time series have been updated and improved, using new and improved methods for data validation, correction and fusion. Since 2014, several new datasets have become available including the Canadian Blended Precipitation datasets (from blending satellite and in-situ precipitation data sources) and marine wind/wave datasets. The latter include the Environment Canada Davis Strait Baffin Bay (DSBB) Wind and Wave Reanalysis, Meteorological Service of Canada (MSC) North Atlantic Hindcast (MSC50), and MSC Beaufort Wind and Wave Reanalysis. Environment and Climate Change Canada's methods and computer programs for homogenisation of climate data and calculation of extremes are freely available (provided via World Climate Research Program's 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 and Climate Change 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.

8.3.3.2 Oceans

Marine Ecosystems

The oceanography and climate science research program of Fisheries and Oceans Canada encompasses analysis, process, and modelling research into the oceans and their 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 2011, Fisheries and Oceans Canada initiated the Aquatic Climate Change Adaptation Services Program (ACCASP) to focus on issues such as ocean acidification and hypoxia, and on regional climate change trends, risks, impacts and adaptation. The ACCASP provides a comprehensive assessment of the potential impact of ocean climate on marine ecosystem components, from lower trophic levels to top predators, including marine mammals, in Atlantic, Arctic and Pacific Ocean basins adjacent to Canada, as well as the Great Lakes and Lake Winnipeg. The program also funds research to increase understanding of the vulnerability of marine organisms to climate change variables, including ocean acidification.

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. Climate changes may also affect stock productivity and sustainable harvest rates. Fishing could also exacerbate the impacts of climate change 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.

Climate change trends and variability were analyzed for Canada's aquatic environments as part of the Aquatic Climate Change Adaptation Services Program (ACCASP). This information formed the basis of climate change risk assessments carried out in 2013 in four Large Aquatic Basins, 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).

8.3.3.3 Cryosphere

Environment and Climate Change 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, led by the University of Waterloo, 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 (GCW) 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 (http://globalcryospherewatch.org/) and is planned to be operational by 2020. 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 and nominating cryosphere monitoring sites for inclusion as stations in the GCW CryoNet surface-based observational network. In 2013, Environment Canada hosted a workshop in support of a proposed Snow Watch Group initiative under the Global Cryosphere Watch Program. A follow-up Snow Watch Workshop took place in June 2016 and was co-chaired by Environment and Climate Change Canada. The workshop report identifies several recommendations for continued efforts to improve the sharing and archiving of global snow data sets and development of GCW snow products.

Environment and Climate Change 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 30+ years through the permafrost monitoring network is used to characterize recent trends and variability in permafrost conditions across the Canadian Arctic.

During the International Polar Year (IPY, 2007–09), a baseline of the thermal state of permafrost was established for northern Canada. A comparison of data collected about 5 years after IPY, in 2012–14, to the IPY baseline was used to assess recent changes in permafrost for a range of ecoregions from the boreal forest to the tundra and polar desert.

The continued data collection since the 6th National Communication, has allowed the extension of time series beyond 30 years for some sites. The analysis of these data shows that permafrost continues to warm across the Canadian permafrost region. The continued data collection from the monitoring network is facilitating a better understanding of permafrost-climate linkages and assessments of the response of permafrost to a changing climate as well as providing critical data to validate models for predicting future changes.

Glaciers

Natural Resources Canada conducts research on Canada's glaciers through collaboration with partners and researchers from other Canadian and international government departments and universities. This includes formal collaborative networks such as the Changing Cold Regions Network (under the NSERC Climate Change and Atmospheric Research initiative) and within elements of the new "Global Water Futures" program led by the University of Saskatchewan—recently funded, in-part by a grant from the Canada First Research Excellence Fund. 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 Organization. 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 signs of acceleration.

Research activities also address temporal context through the documentation of Neo-glacial and post-Neoglacial 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). A landmark international study led by the World Glacier Monitoring Service (WGMS) with co-author contributions from participating nations' WGMS National Correspondents concludes that rate of early 21st century mass loss are without precedence on a global scale, at least for the time period observed (since c. 1850) and probably also for recorded history.

Mass balance measurements and glacier research in the Canadian High Arctic began in 1959. Recent trends towards extremely negative mass balance of glaciers and ice caps in this region has motivated research efforts towards quantifying the contributions from glaciers in the Canadian Arctic to global sea-level rise, and the associated impacts on the freshwater budget for the Arctic and sub-Arctic basins. Computer modeling and remote sensing techniques are being used to investigate the relative contributions of ice-berg calving versus surface melt on total mass loss from glaciers and ice caps in the Canadian Arctic. Results from this work provide insight into the processes controlling current change which will help to predict the response of glaciers and ice caps across this region to future climate scenarios.

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. Reanalysis of the long-term balance time series for reference glaciers in the Western/northern Cordillera and the Arctic regions is currently being facilitated through collaborations with the World Glacier Monitoring Service and participating international space agencies.

Paleoclimate

The majority of paleoclimate research conducted in Canada is undertaken by researchers based at academic institutions. Faculties at a number of Canadian universities have established research programs and laboratories that use a variety of paleoclimate archives to develop records of past climate and environmental change in Canada. There are a number of laboratories that collect and analyze information in sediment records to study climate history, glacier history and ecological changes, including Paleoecological Environmental Assessment and Research Laboratory, Queen's; University of Ottawa, Laboratory for Paleoclimatology and Climatology; Paleoecology Laboratory at the University of Toronto; and the University of Northern British Columbia. Ice cores from a number of Canadian sites are stored in the Canadian Ice Core Archive housed at the University of Alberta. Several Canadian universities have laboratories where scientists use tree-ring records to reconstruct past climate, glacier history and other aspects of environmental history. Examples include the University of Victoria Tree-Ring Laboratory and the Paleoecology Lab at Brock University. Funding for these laboratories and research programs is primarily through NSERC and other sources and some of these data are available through the NOAA/NCEI Paleoclimatology Search Engine at https://www.ncdc.noaa.gov/paleo-search/.

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, interannual variability, and climate change.

Canadian Wildland Fire Information System

The Canadian Wildland Fire Information System provides daily fire weather and fire behaviour maps year-round and hot spot maps throughout the forest fire season, generally between April 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 quantifying and communicating 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 based on effects of vegetation type (fuel) and topography.

Fire Weather Index values are calculated using standard daily noon observations of temperature, relative humidity, wind speed, and 24-hour precipitation at local noon from approximately 2,000 weather stations. Forecasts are created for the next two weeks using numerical weather prediction output, and predictions of seasonal fire weather severity are made using Environment and Climate Change Canada's seasonal forecasts of temperature and precipitation anomalies. Other information that is collected and maintained includes data on fire locations; from both satellite imagery derived hotspots that provide estimated fire perimeters, and official fire location data provided from federal (Parks Canada), provincial and territorial wildland fire management agencies. The wealth of data on fire weather, fire behaviour, and fire locations provides an important source of information for monitoring the nation's current forest fire activity, for examining seasonal change in wildland fire occurrence, and for research into past and present fire events.

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 and Climate Change Canada, university research groups, the Canadian Carbon Program, and others.

8.3.4 Greenhouse Gas Sources and Sinks

8.3.4.1 Agricultural Ecosystems

Since the *6th 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.
- Developing tools and best practices to maintain productivity, sustainability and resilience of agro-ecosystems.
- 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.
- 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. 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 40 member-countries, devoted to collaboration in agricultural research on GHG mitigation and beneficial management practices for farmers in Canada and around the world.

The Agricultural Greenhouse Gases Program represents Canada's initial contribution to the Global Research Alliance on Agricultural Greenhouse Gases and provides Canadian farmers with technologies to manage their land and livestock in a way that will mitigate GHG emissions. This federally funded program supported $27 million in research projects from 2010–2015 towards the program objective of to enhance the understanding and accessibility of agricultural technologies; Beneficial Management Practices (agricultural practices aimed at reducing the environmental impact and increasing the resiliency of farming activities on the landscape); and processes that can be adopted by farmers to mitigate GHG emissions. An additional $27 million has been approved for projects from 2016–2021.

8.3.4.2 Forest Ecosystems

Canada's National Forest Carbon Monitoring Accounting and Reporting System continues to build 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 reporting guidelines. With the Carbon Budget Model of the Canadian Forest Sector as its core model, the System continues to provide 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, continues to use 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.

8.3.4.3 Ocean systems

Fisheries and Oceans Canada's research programs focus on understanding the processes that control the variability of the carbon system and the flows within it. These flows include the flux of carbon into and out of ocean systems, and significant focus is on assessing the potential and verifiability of mitigation of climate change by ocean processes. The key scientific considerations being addressed are whether the oceans will continue to sequester CO_2 at the same rate, the pathways to ocean acidification including local nearshore anthropogenic sources, and the effects acidification has on ocean life. Making progress in this area requires an integrated approach of observations, experiments, and model development from local to global scales.

Fisheries and Oceans Canada, Pacific Region, is a partner with the Province of British Columbia, and several U.S. State agencies (AK, WA, OR, CA) in a Pacific Coast Collaborative Ocean Acidification and Hypoxia Task Force that is developing an oceanographic data inventory and monitoring gap analysis.

8.3.4.4 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 additional constraints to nationally reported GHG emissions. These observations-based estimates allow for the tracking of seasonal and annual variability in 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. The first approach is to develop a Carbon Assimilation System, working closely with researchers at the University of Toronto and with funding support from the Canadian Space Agency. The system involves coupled meteorological and greenhouse gas data assimilation and modelling within an ensemble Kalman Filter framework. This novel approach should permit more realistic flux estimates, along with the associated uncertainties. While the main focus is on global scale CO_2 and CH_4 simulation, regional model development work is also underway. The regional model will support the second approach which focuses on resolving the influence of the greenhouse gas fluxes from the regions surrounding the in situ measurement sites. In this second approach, particle dispersion models are used to map in greater detail the area of influence or footprint surrounding each measurement site.

8.3.5 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, for example the CCAR networks projects described in section 8.1.3.1.

8.3.5.1 Land and Cryosphere

Much of the research with respect to cryospheric processes within the climate system has been led by Environment and Climate Change 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 and Climate Change 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 and Climate Change Canada includes enhancing the representation of snow, soil, and vegetation in Environment and Climate Change Canada's climate models. Recent developments include new physical and biogeochemical parameterizations for peatland and permafrost landscapes and a Canadian Small Lake Model to characterize sub-grid lake processes including ice cover.

Environment and Climate Change 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. Some of these projects have contributed to advancing cryosphere and land surface modelling—namely the Canadian Sea Ice and Snow Evolution Network, the Canadian Network for Regional Climate and Weather Processes and the Changing Cold Regions Network, which are captured in section 8.1.3.1 (NSERC CCAR projects).

8.3.5.2 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 the CCAR initiative (covered in section 8.2.3.1). Fisheries and Oceans Canada scientists have also conducted research funded by the Aquatic Climate Change Adaptation Services program to address knowledge gaps in ocean climate processes; this research has ranged from physical climate to marine ecosystem and fisheries studies as well as the development of adaptation tools.

8.3.5.3 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 and Climate Change Canada's Water and Climate Impact Research Centre continues to guide 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.

Climate change impact studies are being conducted in the Great Lakes by Environment and Climate Change Canada, 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.

The studies under the International Joint Commission Upper Great Lakes Study led to the development, by Environment and Climate Change Canada, of 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. Data from the most recent future climate scenarios (CMIP5) have been used to simulate future hydrometeorological variable such as streamflow, soil moisture, and snow water equivalent as well as future lake levels.

In the Arctic, Environment and Climate Change 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.

8.3.5.4 Atmospheric Physics and Chemistry

Environment and Climate Change Canada carries out research in atmospheric physics and chemistry with the goal of improving the understanding of these processes and better representing them in models used to predict weather, climate and air quality. 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 and Climate Change 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. Two key projects are the "Network on Climate and Aerosols: Addressing Key Uncertainties in Remote Canadian Environments" which 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.

Parameterisations for chemistry, aerosols, and clouds are continually being developed and tested by Environment and Climate Change Canada. A particular priority is improving the simulation of the effects of short-lived climate pollutants on climate and future air quality. Work is underway to interactively simulate methane sources and tropospheric chemistry processes in Environment and Climate Change Canada's Canadian Earth System Model. 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.

8.3.6 Climate Modelling and Applications

Environment and Climate Change Canada develops and applies the Canadian Earth System Model to predict and project climate on timescales of seasons to a century. Other climate modelling research, including development and application of regional models, in Canada is undertaken in 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.

8.3.6.1 Ocean Modelling

Fisheries and Oceans Canada, Environment and Climate Change 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.
- 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. The NEMO ocean model is now also used in Environment and Climate Change Canada's earth system climate model. This change will enable Environment and Climate Change 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 and Climate Change 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.

8.3.6.2 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 to simulate climate change in response to 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 and Climate Change Canada, where an increasingly comprehensive progression of global climate models has been developed since the 1970s. Environment and Climate Change 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 and Climate Change 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 and Climate Change 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.). Model development combines these Earth system components to regularly update Environment and Climate Change Canada's suite of climate models (the Canadian Earth System Model, Canadian Global Climate Model, Canadian Regional Climate Model, and the Canadian Seasonal to Interannual Prediction System). Current attention is focused on finalizing a version of the Canadian Earth System Model for participation in the Sixth Coupled Model Intercomparison Project, which will inform the *Sixth Assessment Report of the Intergovernmental Panel on Climate Change*. This model includes the NEMO ocean model and improvements to atmospheric physics, among other innovations. At the same time, longer term development work is focused on the inclusion of methane sources and tropospheric and stratospheric chemistry in the Canadian Earth System Model, and the move to a shared common dynamical with weather prediction in Environment and Climate Change Canada, to support improved efficiency on new supercomputing resources, and support a move to higher resolution.

Researchers in Environment and Climate Change 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 and Climate Change 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.

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 are carrying out research which supports the improvement of 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.

8.3.6.3 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 and Climate Change Canada develops and applies the Canadian Regional Climate Model (CanRCM), and has collaborated on the development and application of another regional climate model together with the regional climate modelling consortium Ouranos and the Université du Québec à Montréal (UQAM). In the last five years this model has been further developed at UQAM, and has been used to downscale scenarios of future climate change over North America and other regions at 0.44 and 0.22 degrees, as well as having been used for higher resolution simulations over smaller regions by UQAM, other universities in Canada and the regional climate consortium Ouranos.

Environment and Climate Change 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).

8.3.6.4 Seasonal to Interannual Prediction

Coupled global climate models are 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 to adapt Environment and Climate Change Canada's climate models to this application, leading to the implementation in late 2011 of the Canadian Seasonal to Interannual Prediction System, which produces Environment and Climate Change Canada's official forecasts of climate anomalies over the coming 1–12 months. Since 2014, Environment and Climate Change Canada research has focused on developing new Canadian Seasonal to Interannual Prediction System (CanSIPS) data products for dissemination including large scale circulation indices, and snow, soil moisture and sea ice variables. CanSIPS also contributes to a World Meteorological Organisation lead prediction centre. In addition Environment and Climate Change Canada contributes decadal climate predictions made using the same system to a public multi-model forecast exchange, which will transition to a World Meteorological Organisation lead centre. Recent research has demonstrated that the system has significant skill in seasonal predictions of snow cover and sea ice, and work is underway to produce and disseminate predictions of these variables operationally.

8.3.6.5 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 and Climate Change 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 may increasingly become possible to identify inconsistencies in the rate of warming in climate models and observations, and work on observational constraints on projections of climate change may help to reduce uncertainties.

8.4 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 the involvement of Canadian experts in national and international assessments related to climate.

Canada supported the participation of Canadian experts in the Intergovernmental Panel on Climate Change (IPCC) *Fifth Assessment Report*, which concluded in 2014, and is supporting Canadian experts during the IPCC's *Sixth Assessment Report* cycle (2015–2022). This includes participation in both the comprehensive Assessment Reports and Special Reports. Environment and Climate Change Canada has the lead financial responsibility for supporting ECCC and non-federal government Canadian science experts to the IPCC. For the sixth assessment cycle, Canada has committed to supporting two lead authors for the *Special Report on Global Warming of 1.5°C*, five lead authors and one review editor to the *Special Report on Oceans and Cryosphere in a Changing Climate*, two lead authors and one review editor to the *Special Report on Climate Change and Land* and 7 lead authors for the *2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories*. Canada will support Canadians who are selected to participate as authors or review editors for the Working Group Reports of the Sixth Assessment. In addition, Canada's annual contributions to the IPCC Trust Fund help support the participation of developing country experts in IPCC assessment processes (Canada is a top 10 contributor).

Canada also supports the Canadian member of the IPCC Working Group I Bureau and the Canadian member of the Task Force on National Greenhouse Gas Inventories representing Region IV. Further to these contributions, Canada hosted the plenary session of the IPCC in September 2017 in Montréal and will host an IPCC sponsored Cities and Climate Change Science Conference in 2018.

Canada is a member of the Arctic Council and participates actively in scientific assessments undertaken through programmes of Arctic Council Working Groups. The Arctic Council's Arctic Monitoring and Assessment Programme (AMAP) undertakes regular scientific assessments on topics related to Arctic pollution and climate change. Canadian input occurs on various levels. Government of Canada scientists contribute as members of AMAP expert groups (e.g. expert groups on short-lived climate pollutants), Canadian experts contribute as authors to specific Technical Reports, and scientific information and data from Canadian networks and projects with an Arctic focus provide important contributions to AMAP reports. Canada contributed to the recent AMAP assessments of short-lived climate pollutants (SLCPs) and *The Arctic: Methane as an Arctic Climate Forcer (2015)* and *Black Carbon and Ozone as Arctic Climate Forcers (2015)*. Canada also contributed to recent climate-focused AMAP reports on freshwater (*The Arctic Freshwater System in a Changing Climate (2016)*, *on the cryosphere (Snow, Water, Ice and Permafrost in the Arctic (SWIPA) Update Report (2017)*, and on adaptation (*Adaptation Actions in a Changing Arctic (AACA) (2017)*).

Canada also has a national-scale assessment process focused on impacts and adaptation (for further details, see Chapter 6: Vulnerability Assessment, Climate Change Impacts, and Adaptation Measures). Two recently completed assessments were: *Canada in a Changing Climate: Sector Perspectives on Impacts and Adaptation (2014)* and *Canada's Marine Coasts in a Changing Climate (2016)*. Both of these reports included chapters providing an assessment of historical and future changes in climate and sea level for Canada. The next comprehensive national-scale assessment of climate change impacts and the current state of adaptation in Canada is planned to be completed in 2021 with work already launched on reports that will be delivered early in the assessment cycle. A stand-alone report on Canada's Changing Climate will form a contribution to the 2021 National Assessment, with planned completion in 2018. This report will provide the climate science foundation for other products of the National Assessment and for action by decision-makers, and will be a key awareness building tool. *Canada's Changing Climate Report (CCCR)* will include essential information on climate science and will provide an assessment of observed and future changes in key climate indicators, covering the Canadian land mass and Canada's oceans. While this is a federal-government led initiative, non-government experts will also be engaged.

In 2015, Natural Resources Canada's Canadian Forest Service completed a Boreal Syntheses to provide a comprehensive review of the state of science on the Canadian boreal zone and its ecosystems, with particular emphasis on ecosystem health and sustainability. This information will help increase understanding of natural processes and how these processes are affected by anthropogenic factors and climate change. Eleven papers in total were produced, with the first set reviewing the state of science with respect to boreal ecosystems as they currently exist and the impacts of resource development. The impact of climate change on the future state of these ecosystems is the subject of a second set of papers in the syntheses.

Additionally, Fisheries and Oceans Canada initiated a new national process for State of the Ocean reporting in 2016 which will include key variables for future climate change assessments. This process will operate on a 4-year cycle which will be comprised of three regional reports (Pacific, Atlantic, Arctic) and a national report.

In addition to the comprehensive science assessment activities reported on above, Canada contributes to international and national state-of-the environment reporting to track progress on key environmental sustainability issues including climate change.

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 assessments of current trends for key climate-related indicators.

Environment and Climate Change Canada, in collaboration with other Government of Canada departments, reports to Canadians on the state of the environment and describes Canada's progress on key environmental sustainability issues using the Canadian Environmental Sustainability Indicators (CESI). The indicators, built on rigorous methodology, are added to and updated as new, high quality data become available. The CESI series includes the following climate change indicators: temperature (updated 2016), precipitation (updated 2016), sea ice (new in 2016) and snow cover (in 2017).

8.5 Climate Services

The Pan-Canadian Framework on Clean Growth and Climate Change committed to, among other actions, improve access to data and information on climate science through provision of national and regional climate services, supporting climate adaptation decision-making across Canada. In 2017, efforts were formally initiated to develop and implement a Canadian Centre for Climate Services. The initial focus for the Centre is to improve dissemination of climate data and scenarios information from Environment and Climate Change Canada and other federal departments. The program will also focus on strategic engagement of stakeholders and on building regional capacity for climate services.

The initiative is being led by Environment and Climate Change Canada. Key partners include other federal departments, provincial and territorial ministries, and existing and newly-emerging regional climate organizations. The following paragraphs describe some of the existing climate consortia in Canada and the focus of their work:

- 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 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 Prairie Adaptation Research Collaborative (PARC) is a partnership of the governments of Canada, Alberta, Saskatchewan and Manitoba mandated to pursue climate change impacts and

adaptation research in the Prairie Provinces. PARC's objective is to generate practical options to adapt to current and future climate change.
- The Ontario Climate Consortium, coordinated by a Secretariat, contributes to climate resilient communities in Ontario through the generation and mobilization of knowledge that enables effective climate change action.

Examples of climate-science related information which is currently produced by Environment and Climate Change Canada, and which will be disseminated through the Centre include:
- The Climate Trends and Variations Bulletin, an informational product based on adjusted and/or homogenised Canadian climate data. Environment and Climate Change 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. Visit https://www.ec.gc.ca/sc-cs/default.asp?lang=En&n=A3837393-1 for more information.
- Output from both the global and regional models, available to the public via Environment Canada's Canadian Centre 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. Visit http://climate-modelling.canada.ca/climatemodeldata/ for more information.
- Climate change scenarios provided by Environment and Climate Change Canada to a broad range of users through the Canadian Climate Data and Scenarios website. The scenarios are based on climate projections from different Coupled Model Intercomparison Project Phase 5 climate models. A range of variables are available on a common grid, primarily aimed at supporting climate change adaptation in the Canadian federal government, but also publicly available to other stakeholders. This website also provides access to the historical Adjusted and Homogenized Canadian Climate Data Records, by station and for gridded data products. Visit http://climate-scenarios.canada.ca for more information.

Building on the breadth of existing climate services offerings, these incremental efforts to centralize the provision of national and regional climate services will further support climate adaptation decision-making across Canada.

CHAPTER 9

Education, Training, and Public Awareness

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 to encourage collective action on the part of all Canadians. The education, training, and public awareness chapter provides key examples of these initiatives in Canada.

9.1 General Policy Towards Education, Training, and Public Awareness

Canada's Constitution allocates the responsibility for education to provincial and territorial jurisdictions. As a result, Canada does not have a national education policy or curriculum. Rather, education policy is set according to the requirements of each of the thirteen provincial and territorial governments across the country. Coordination between provinces and territories occurs through the Council of Ministers of Education, Canada. The Council has included education for sustainable development as one of the key activity areas in Learn Canada 2020, its framework to enhance Canada's education systems, learning opportunities, and overall education outcomes at all levels.

9.2 Primary and Secondary to Post-Secondary Education

9.2.1 Primary and Secondary Education

Education in Canada is typically divided into four pillars: early childhood learning and development; primary to secondary education; post-secondary education; and adult learning and skills development. Climate change is taught across a range of subjects and grades, but is traditionally part of 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-governmental 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 easily access diverse resources and to allow teachers to align teaching activities with required education curriculum outcomes.

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 prominently in most Canadian universities with several 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 Yukon College Post-Degree Certificate in Climate Change Policy aims to provide students with an understanding of the causes, economics, and impacts of climate change, and the tools to analyze and communicate the financial, environmental, and socio-economic aspects of mitigation and adaptation efforts.[1]

Within Canada, a number of partnerships exist between government scientists and academia in the realm of climate research. These partnerships and networks 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.

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. It also funds the Economics and Environmental Policy Research Network, a partnership supported by Environment and Climate Change Canada and hosted by the University of Ottawa's Institute of the Environment.

Massive Open Online Courses (MOOCs)

MOOCs are offered by universities around the world, and are becoming an increasingly popular platform for learning and formal education. Canada's University of British Columbia piloted Climate Literacy: Navigating Climate Change Conversations, enabling 17,000 students from around the world to explore the basic concepts and terms needed to understand the science of climate change, and available mitigation, adaptation, and policy options.

9.2.3 Networks of Centres of Excellence

Networks of Centres of Excellence are research networks that mobilize Canada's research talent in the academic, private, public, and not-for-profit sectors and apply it to the task of developing the economy and improving the quality of life of Canadians. Canada's Networks of Centres of Excellence program has been in place since 1989 and connects researchers, highly qualified personnel, administrators, managers, and directors, across public, academic, private, and not-for-profit sectors. Through the involvement and investment of all these groups, the networks are capable of overcoming larger-scale challenges through the conduct, application and mobilization of knowledge generated through supported research and development activities. ArcticNet (centered at Laval University, Québec) and the Marine Environmental Observation Prediction and Response Network (centered at Dalhousie University, Nova Scotia) 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).[2]

Social Mobilization on Climate Change Using Digital Media

The University of British Columbia's Social Mobilization on Climate Change Using Digital Media is a research cluster that focuses on the design and testing of digital media to enhance learning and influence behaviour. The cluster includes scholars in Climate Change Engagement, Education, Psychology, Visualization & Gaming. It works with partners in government, education and the technology industry to explore how communities can be mobilized through new technologies and social practices to foster climate literacy and action.

9.3 Public Information Campaigns

9.3.1 Web and Social Media

Web

The web and social media are extensively used by governments and others to deliver information about climate change.

Canada.ca/ClimateAction provides information on actions that the Government of Canada has taken domestically and internationally to address climate change, and up-to-date information on topics such as Canada's approach to reducing GHG emissions, climate change impacts and adaptation, international climate change partnerships and negotiations, and Canada's international climate change financing.

The environment and natural resources theme on Canada.ca provides detailed information on Environment and Climate Change Canada's climate change science and research. It features key reports, such as the *National Inventory Report and Canada's Emissions Trends*, which provide annual updates on Canada's historical GHG emissions and progress in reducing GHG emissions. It also features the Canadian Environmental Sustainability Indicators program, which provides key climate indicators, including annual GHG emissions at the local level. Ministerial announcements related to the Government of Canada's domestic and international action on climate change are also communicated to the public via Canada.ca.

Natural Resources Canada's (NRCan) departmental website nrcan.gc.ca provides detailed information about energy efficiency as a fuel source and conservation methods in Canada. It features energy efficiency trends and data as well as energy efficiency tips and practices by sector via the Office of Energy Efficiency and its program web pages.

Social Media

Environment and Climate Change Canada actively promotes climate change awareness through its social media channels. Its Twitter, Facebook, Youtube, and Instagram accounts are used to highlight Government of Canada climate change initiatives, to promote public engagement opportunities, and to promote national and international events such as World Environment Day, Canadian Environment Week, Clean Air Day, World Water Day, and Earth Hour. Environment and Climate Change Canada's Twitter account @environmentca is a particularly important channel for communication with the public.

Natural Resources Canada uses its official Twitter, YouTube, LinkedIn, Flickr, and Instagram accounts to engage Canadians in conversations about energy, to promote national events such as Forest Week, and to highlight energy efficiency initiatives of value to Canadians. Natural Resources Canada manages official Facebook and Twitter channels to promote the energy efficiency movement in Canada and to help Canadians reduce their energy footprint and save on utility costs. Natural Resources Canada also utilizes a LinkedIn account for its Canadian Industry Program for Energy Conservation.

Several provinces and territories have also embraced social media as a platform for communicating climate change-related activities in their jurisdictions. For example, Ontario's Ministry of the Environment and Climate Change has a Twitter account and British Columbia's Climate Action Toolkit has a LinkedIn group for knowledge sharing and collaboration.

ECCC Kids Online Engagement: Interactive Website & #Back2SchoolChallenge

Climatekids.ca, a new interactive website, was launched August 31, 2017. Aimed at kids between the ages of 8 and 15, it is a centralized space for them to get informed, get involved, play and learn about climate change on an attractive, user-friendly platform.

This website generates national awareness of climate change directly with youth and indirectly with parents, grandparents, and caregivers. The website encourages youth to be part of the solution by making changes in their homes, schools, and communities to reduce their carbon footprint for a more sustainable and clean future.

Following the launch of the site, a social media campaign was instrumental in attracting kids and their families from over 70 countries to visit and to take part in the conversation.

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.

National Youth Summit on Climate Change

National Youth Summit on Climate Change (2016)

The Minister of Environment and Climate Change hosted a National Youth Summit on Climate Change on November 23, 2016 in Ottawa, Ontario. Over 100 youth from the Ottawa-Gatineau region attended the Summit, with more joining the conversation online and reaching well over 500,000 Canadians on social media through #YouthClimateAction. Participants heard from experts on climate change, discussed issues that included sustainable food systems, transportation, clean energy, and communicating climate science, and offered innovative solutions that could be implemented at home and in their communities.

National Youth Summit on Clean Growth and Climate Change (2018)

The Minister of Environment and Climate Change will be hosting a second Youth Summit on Clean Growth and Climate Change in Spring 2018. The objective of the Youth Summit is to engage Indigenous and non-Indigenous youth in a clean growth and climate change dialogue focusing on adaptation by raising awareness, educating, creating a groundswell and challenging them to take action in their communities. The Youth Summit will target senior secondary students (Grade 12) and post-secondary students.

Climate Change is Here–Visual Display

Through the Canada Science and Technology Museum's partnerships with Environment and Climate Change Canada, Natural Resources Canada, and Sustainable Development Technology Canada, the Museum's outdoor visual display 'Climate Change is Here' highlights Canadian research in the field of climate change, and the technologies developed to help mitigate it. This display is based on the striking imagery of the award-winning National Geographic Magazine.

9.4 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.

The Government of Canada offers training for Canadian consumers and businesses on the skills they need to improve energy use through Natural Resources Canada's Office of Energy Efficiency initiatives. Since 1997, more than 30,000 representatives of industrial, commercial, and institutional organizations from across Canada have enrolled in Dollars to $ense workshops offered by the Office of Energy Efficiency. 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 2016, Natural Resources Canada expanded and completely remodeled and updated the Dollars to $ense training material before selecting the Canadian Institute for Energy Training as the sole licensee for delivering the workshops across the country.

After nearly three decades of financial support for the local delivery of building science and energy efficiency training in residential construction under the R-2000 Standard[3]/EnerGuide Rating System/ENERGY STAR for New Homes banners, Natural Resources Canada's Office of Energy Efficiency continues to collaborate with industry to produce and enhance its professional web-based training programs. A new exam system is based on competency profiles and associated learning objectives, and is delivered in all provinces and territories in both official languages. This ensures a consistent level of knowledge across the country and promotes a high standard in the field of energy efficiency assessments.

In the transportation sector, the Office of Energy Efficiency training initiatives include FleetSmart, Fuel Management 101, SmartDriver, and Auto$mart.

- FleetSmart provides access to training, educational tools, and information that help heavy-duty commercial and institutional fleet owners and managers improve the fuel efficiency of their operations.
- The SmartDriver suite of six training curricula promote energy efficiency as a cost-effective and responsible way to reduce fuel costs and the environmental impact of fleet operations.
- An updated web-based version of SmartDriver for Highway Trucking presents fuel-efficient driving strategies in a flexible suite of online, in-class, and on-road training formats for drivers of tractor-trailers.
- Auto$mart provides driver educators with information kits to teach students critical defensive driving techniques and relate road safety to fuel efficiency, the mitigation of climate change, and other environmental concerns. The new Auto$mart curriculum continues to engage new student drivers while an enhanced ecoDriving online course has been developed and includes multimedia components for personal vehicle drivers and improved online functionality for smartphone access.

In the federal government sector, Natural Resources Canada's Office of Energy Efficiency also provides input and expertise into training for federal procurement officers and federal executives to ensure that energy efficiency, conservation, and sustainability are core considerations in their policies and practices.

Provincial and territorial governments also offer a variety of training activities related to climate change mitigation and adaptation. For example, the Government of Québec's Climate Change Action Plan includes training activities for healthcare professionals, municipalities, the tourism industry, and community organizations. 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.

9.5 Resource or 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 and Climate Change Canada, Transport Canada, and Health Canada), provincial and municipal governments, utilities, and climate focused non-governmental organizations. (Further information on resource and information centres that focus on climate change adaptation is presented in Chapter 6: Vulnerability, Assessment, Climate Change Impacts and Adaptation Measures).

In 2017, efforts were initiated to develop and implement a Canadian Centre for Climate Services. The Centre will provide national leadership and a “whole of government” approach to ensuring consistent and equitable access to credible, useful, and timely climate information products, tools, and services to help Canadians better understand current and expected changes in order to make decisions that build resilience to climate change. The focus of the Centre will be to improve dissemination of climate data and information from Environment and Climate Change Canada and other federal departments through an online climate information portal. The program will also focus on strategic collaboration with stakeholders and on building regional capacity for climate services. The initiative is being led by Environment and Climate Change Canada. Key partners include other federal departments, provincial and territorial ministries, and existing and newly-emerging regional climate organizations.

Canada brings clean energy solutions to decision makers globally, as a member of the Clean Energy Solutions Centre, by providing technical expertise through the Centre’s Ask an Expert service on its world-leading RETScreen Clean Energy Management Software (RETScreen). Developed by Natural Resources Canada, RETScreen is the world’s foremost clean energy decision making software which has helped to significantly reduce costs associated with identifying and assessing potential clean energy projects.

9.5.1 Providing Energy Efficiency Information

Accessibility of information is an important consideration to enable Canadians to make energy efficient choices. Natural Resources Canada’s Office of Energy Efficiency gathers a wide range of energy efficiency data and maintains a variety of energy efficiency resources including analysis, reports, information directories, and tools which are available to public and private sector organizations and the Canadian public. Energy management information is accessible from the Office of Energy Efficiency’s website.

Online information directories, such as the Directory of Energy Efficiency and Alternative Energy Programs in Canada and the EnerGuide Appliance Directory, are maintained by the Office of Energy Efficiency. Comprehensive reports and documents are also available both in print and online. For example, the Fuel Consumption Guide 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. The Office of Energy Efficiency provides a handbook for homeowners called Keeping the Heat In that describes energy saving strategies with ‘how-to’ instructions on how to make their homes more energy efficient. The Office of Energy Efficiency also publishes Heads Up: Building Energy Efficiency, which provides information on the issues and initiatives affecting the energy efficiency of the Canadian buildings sector. Published since 1996, Heads Up: Building Energy Efficiency currently has over 12,000 subscribers.

The Office of Energy Efficiency also offers a wide range of tools to make energy efficiency information more easily accessible. For example, a national building energy benchmarking tool enables 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. The EnerGuide Rating System for houses provides customized energy upgrade reports for home owners to guide them to smart home energy renovation actions. Finally, a Searchable Product List shows energy consumption data for all products regulated in Canada for Energy Efficiency and for products eligible for ENERGY STAR certification, which helps consumers make wise purchase decisions.

Energy Efficiency Labelling Programs

The Office of Energy Efficiency 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 for new and existing houses and personal vehicles. EnerGuide labels can be affixed to the product alone or placed in product information books, and have a standardized design. 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 new EnerGuide label provides an expanded range of indicators specific to a vehicle's technology and fuel type. Indicators include a vehicle's city, highway, and combined fuel-consumption rating, as well as annual fuel costs and environmental indicators for carbon dioxide emissions and smog ratings.

The international ENERGY STAR symbol complements the EnerGuide label in many cases, and identifies specific models that are tested and certified to meet or exceed stringent levels of energy efficiency. For "early adopter" consumers who seek premium energy efficiency performance, ENERGY STAR offers its Most Efficient designation every year to a select number of product categories. 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.

Each year, the Canada's ENERGY STAR issues awards to top performers among its 1,500+ public and private sector participants, including Canadian utilities, home builders, retailers, manufacturers, and advocacy organizations.

9.6 Involvement of the Public and Non-Governmental Organizations

9.6.1 Public Engagement

Engaging the public was an essential part of developing the Pan-Canadian Framework on Clean Growth and Climate Change. On April 22, 2016, the Minister of Environment and Climate Change announced the launch of Let's Talk Climate Action, an interactive website to seek input from Canadians, including Indigenous Peoples, on how to address climate change. From April 22, 2016 to September 27, 2016, Canadians from coast to coast to coast submitted over 13,000 ideas and comments to the online conversation on climate change and clean growth. Approximately 2,000 more Canadians submitted input via mail and email. Town hall meetings were also held across the country by communities and organizations, Members of Parliament with their constituencies, and by Environment and Climate Change Canada.

In March 2016, four working groups were established by Canada's First Ministers in the Vancouver Declaration on Clean Growth and Climate Change, tasked with preparing reports in four areas: carbon pricing mechanisms, specific mitigation opportunities, adaptation and resilience, and clean technology, innovation and jobs. The ideas, solutions, and comments submitted through the above-mentioned engagement processes informed the working group reports. The working groups, which met from April 2016 to September 2016, also held several roundtables with non-governmental organizations, academics, and industry representatives. The reports they produced were made public and contained a suite of options to be considered by ministers. Ministers considered the options and provided recommendations to First Ministers. This resulted in First Ministers adopting the Pan-Canadian Framework on Clean Growth and Climate Change, Canada's plan to address climate change, on December 9, 2016.

In February 2016, Canadians were asked to review and comment on the Government of Canada's draft *2016–2019 Federal Sustainable Development Strategy*, which is Canada's primary vehicle for sustainable development planning and reporting. The Strategy, which includes a chapter addressing the goal of Taking Effective Action on Climate Change, provides Canadians with a whole-of-government picture of federal sustainable development priorities. Engagement was accomplished through an accessible, online electronic strategy, an interactive online discussion space called Let's Talk Sustainability, stakeholder meetings, teleconferences, webinars, and through social media. Stakeholder outreach is on-going through meetings, webinars, and social media.

On April 21, 2017, Canada's Minister of Natural Resources launched Generation Energy, a six-month, cross-country dialogue on the future of energy in Canada. Through Generation Energy, the Government of Canada asked individual Canadians, stakeholders and experts to create a vision for energy in Canada and to explore pathways to getting there. Canadians across the country shared their ideas and participated in over 30 events, helping define Canada's energy future through attending workshops and roundtables, completing online polls and quizzes and submitting ideas and reports on the website www.generationenergy.ca. The dialogue culminated in a National Forum on October 11–12, 2017, which brought stakeholders together to discuss and debate pathways to an affordable, low carbon energy future. A report is being prepared that will inform an overarching vision, guiding principles and a narrative for Canada's low-carbon energy future.

9.6.2 Involvement of 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

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.

Smart Prosperity Institute

The Smart Prosperity Institute is a national research network and policy think tank delivering research and work with public and private partners to advance practical policies and market solutions for a stronger, cleaner economy. A key initiative of the Institute, the Smart Prosperity Initiative, was launched in 2016 by Canadian leaders from business, think tanks, labour, Indigenous Peoples, youth, and non-governmental organization communities to advocate for Canada's transition to a green economy.

Clean Energy Canada

Clean Energy Canada is a climate and clean energy think tank within the Centre for Dialogue at Simon Fraser University, British Columbia. The organization works to accelerate Canada's transition to clean and renewable energy systems through the production and distribution of original research and analysis, including economic modelling and public-opinion research.

Canadian Energy Efficiency Alliance

The Canadian Energy Efficiency Alliance is the country's leading independent advocate promoting the economic and environmental benefits of energy efficiency. The not-for-profit works with the federal and provincial governments and stakeholders to ensure energy efficiency is a priority for all sectors of the economy. By monitoring, examining and developing energy efficient public policy ideas, programs and standards, the Alliance is an effective resource for policy makers, businesses, consumers, energy companies and environmental groups.

9.7 Participation in International Activities

Canada engages in a number of collaborative international initiatives that involve sharing experiences and best practices, and working towards common climate change goals:

- The Climate and Clean Air Coalition, which seeks concerted action on short-lived climate pollutants. Canada holds a seat as co-chair of the Working Group from 2016 to 2018.
- The Clean Energy Ministerial, a high-level global forum that brings together 25 major economies to facilitate international collaboration to promote policies and best practices that accelerate the transition to a global clean energy economy.
- The Arctic Council, the leading intergovernmental forum promoting cooperation, coordination, and interaction among the Arctic States, Arctic Indigenous communities, and other Arctic inhabitants on common Arctic issues such as sustainable development and environmental protection.
- The Petersburg Dialogue, which provides the opportunity for countries to engage in an informal exchange of experiences on international climate policy in support of the UNFCCC negotiating process.
- The 46th session of the Intergovernmental Panel on Climate Change (IPCC), which Canada hosted in Montréal, Québec, September 2017. This session gathered hundreds of scientists and representatives from 195 countries to advance the science of climate change and decide upon the scope of the sixth IPCC assessment report.
- Mission Innovation, a global partnership of 22 countries and the European Union that aims to double government investment in clean energy innovation (research and development) over five years, increase international collaboration, and encourage private sector leadership.
- The Global Methane Initiative (GMI), a voluntary partnership that aims to accelerate the development and the deployment of clean energy technologies to help meet Canada's climate change objectives and address clean energy security concerns. In 2016, Canada assumed the role of GMI Co-Chair.
- The Organisation for Economic Cooperation and Development (OECD), an international economic organization that provides a unique forum where governments work together on public policy issues, compare and exchange experiences and best practices, and seek answers to common problems through enhanced global cooperation. Canada supports the OECD's work on the environment focuses on a variety of topics, notably climate change.
- The Carbon Pricing Leadership Coalition, where Canada is taking an active and high profile approach, both domestically and internationally, in championing carbon pricing as an important policy instrument for combatting climate change.
- The Carbon Market Platform, a forum for a strategic dialogue on developing carbon markets and pricing mechanisms for the successful implementation of the UNFCCC Paris Agreement. The Platform brings together a diverse group of countries with a common interest in developing effective, sustainable, and ambitious carbon markets.
- In partnership with international organizations, from February 20–24, 2017 Canada co-hosted three informal workshops on carbon markets in Ottawa which were successful in enabling rich discussions between carbon market negotiators, UNFCCC officials, and non-government carbon market experts.
- Canada, China, and the European Union agreed to convene a Ministerial Meeting on Climate Action with ministers from major economies and other key actors in multilateral climate discussions. This meeting took place in Montréal, Québec on September 15–16, 2017, and focused on advancing multilateral negotiations on the implementation of the Paris Agreement, as well as domestic efforts to implement climate commitments and nationally determined contributions.

Internationally, Canada is sharing its expertise, innovation, and clean technology to help developing countries achieve their climate change goals and reduce air pollution.

One of the core aims of the Paris Agreement is to make all financial flows consistent with a pathway towards low-emission, climate-resilient development. This goal requires all actors—public and private—to transition to green and sustainable investments and accelerate clean growth. Canada is delivering $2.65 billion to support developing countries—especially the poorest and most vulnerable—in their transition to low-carbon and climate-resilient economies. More information on Canada's climate financing can be found in Chapter 7: Financial Resources and Transfer of Technology.

Canada's Advancement of Gender in International Climate Change Negotiations

Gender equality and climate change are key priorities for the Government of Canada and are paramount to the successful implementation of the Paris Agreement. In support of the Lima work programme on gender,[4] which calls on Parties to assist with training and raising awareness for female and male delegates on issues related to gender balance and to build the skills and capacity of female delegates, Canada partnered with the Women's Environment and Development Organization to hold two events in 2017. A two-day informal consultation on the development of the gender action plan under the UNFCCC was held in September 2017 and a gender and climate change workshop, which focused on developing skills for female negotiators from developing countries, was held in October 2017. The outcomes of the consultations helped to stimulate and guide discussions on the gender action plan during the 23rd Conference of the Parties to the United Nations Framework Convention on Climate Change.

Local communities and Indigenous Peoples platform

Environment and Climate Change Canada co-hosted, in full partnership with Indigenous Peoples of Canada, an Informal Dialogue on operationalizing the local communities and Indigenous Peoples' platform under the UNFCCC, held in Ottawa, Ontario on September 11–12, 2017. The Informal Dialogue was attended by over 60 participants, including: developed and developing country government representatives; international and domestic Indigenous Peoples; and representatives from environmental non-governmental organizations and international organizations. This event was successful in advancing discussions on options regarding specific functions and governing structures for the platform, and how it will be implemented going forward. Negotiations on these details were initiated at the 23rd Conference of the Parties in November 2017, where Canada was recognized for its leadership in reaching an agreement on its overall functions and to launch the operations of the platform. The first activity of the platform will be a workshop co-chaired by a Party and Indigenous representative on implementing the functions, which could inform negotiations by all Parties that will resume in spring 2018 for fully operationalizing the platform.

Further information on Canada's international activities is included in other chapters of this report.

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ANNEX:

Canada's 3rd Biennial Report to the UNFCCC

Section 1: Introduction

Canada is pleased to present its *3rd Biennial Report* (BR) to the United Nations Framework Convention on Climate Change (UNFCCC). For 2018, Canada is presenting its BR as an annex to the *7th National Communication*. Given the complementarity between these two documents, where information required by the BR is already reported in the National Communication, including tabular information, cross-references to relevant sections of the National Communication are provided below. Please also refer to Canada's BR common tabular format (CTF) to view required by the BR guidelines.

Section 2: Information on GHG Emissions and Trends

Canada's *National Inventory Report* (NIR) is prepared and submitted annually to the UNFCCC by April 15 of each year, in accordance with revised *Guidelines for the preparation of national communications by Parties included in Annex I to the Convention, Part I: UNFCCC reporting guidelines on annual inventories* (UNFCCC Reporting Guidelines).[a]

The inventory greenhouse gas (GHG) estimates include carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), perfluorocarbons (PFCs), hydrofluorocarbons (HFCs), sulphur hexafluoride (SF_6), and nitrogen trifluoride (NF_3) in the following five sectors defined by the Intergovernmental Panel on Climate Change (IPCC): Energy, Industrial Processes and Product Use, Agriculture, Waste, and Land Use, Land-Use Change and Forestry (LULUCF). The GHG emission and removal estimates contained in Canada's GHG inventory are developed using methodologies consistent with the 2006 Intergovernmental Panel on Climate Change (IPCC) *Guidelines for National Greenhouse Gas Inventories*. In line with the principle of continuous improvement, the underlying data and methodology for estimating emissions are revised over time; hence, total emissions in all years are subject to change as both data and methods are improved.

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[a] The most recent report is entitled *National Inventory Report 1990–2015: Greenhouse Gas Sources and Sinks in Canada*, and is available online at: http://unfccc.int/national_reports/annex_i_ghg_inventories/national_inventories_submissions/items/10116.php.

In 2015, the most recent annual dataset in this report, Canada's GHG emissions were 722 megatonnes of carbon dioxide equivalent (Mt CO_2 eq), a net decrease of 16 Mt in total emissions or 2.2% from 2005 emissions. Annual emissions fluctuated between 2005 and 2008, dropped in 2009, and gradually increased thereafter.

In 2015, the Energy Sector (consisting of Stationary Combustion Sources, Transport, and Fugitive Sources) emitted 587 Mt of greenhouse gases, or 81% of Canada's total GHG emissions. The remaining emissions were largely generated by the Agriculture (8%) and Industrial Processes and Product Use (7%) sectors, with minor contributions from the Waste Sector (3%). The LULUCF Sector was a sink in 2015, with net removals of 34 Mt, a 3 Mt reduction from the net removals of 37 Mt in 2005.

The CTF Table 1 of Canada's 3rd BR contains the same information as the Common Reporting Format Table 10 in Canada's 2017 NIR. Information on Canada's GHG emissions and trends is provided in Chapter 3: Canada's Greenhouse Gas Inventory of Canada's *7th National Communication*. For a more elaborate analysis of recent historical GHG emission and removal trends, please see Chapter 2 of Canada's 2017 NIR.

Canada's National Inventory Arrangements

Canada's inventory arrangements for the estimation of anthropogenic emissions from sources and removals by sinks of all GHGs not controlled by the Montréal Protocol encompasses the institutional, legal and procedural arrangements necessary to ensure that Canada meets its reporting obligations. These arrangements, including formal agreements and descriptions of the roles and responsibilities of the various contributors to the preparation and submission of the national GHG inventory, are fully documented in Canada's inventory archives.

There have been no changes to the National Inventory Arrangements since Canada's BR2. Additional information on Canada's national inventory arrangements can be found in Chapter 3: Canada's Greenhouse Gas Inventory of Canada's *7th National Communication* and in Chapter 1: Introduction of Canada's 2017 National Inventory Report.

Section 3: Quantified Economy-Wide Emission Reduction Target

Under the Paris Agreement, Canada has committed to reduce its GHG emissions by 30% below 2005 levels by 2030. Under the 2009 Copenhagen Accord, Canada committed to reduce its emissions by 17% below 2005 levels by 2020.

Table 2(a)(i): 2030 Emission Reduction Target

BASE YEAR	2005
Emission reduction target (% of base year)	30% below 2005
% of 1990	15.4% below 1990 levels, based on the 2017 emission inventory
Period for reaching target	2030

Table 2(a)(ii): 2020 Emission Reduction Target

BASE YEAR	2005
Emission reduction target (% of base year)	17% below 2005
% of 1990	0.3% above 1990 levels, based on the 2017 emission inventory
Period for reaching target	2020

Canada's GHG emission reduction targets are economy-wide, covering all sectors and gases. In addition to reporting information by IPCC sector, Canada also reports information on historical and projected emissions according to the following economic sector categories: electricity, transportation, oil and gas, heavy industry, buildings, agriculture, and waste and others. This sectoral categorization allows for a better understanding of emissions as they relate to economic trends and policies, and is developed by reallocating the relevant proportion of emissions from various IPCC subcategories. Chapter 3: Canada's Greenhouse Gas Inventory of Canada's *7th National Communication* describes the relationship between these two sectoral categorizations in greater detail.

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		
NF_3	2005		
IPCC SECTORS COVERED		**ECONOMIC SECTORS COVERED**	
Energy	Yes	Oil and Gas	Yes
		Electricity	Yes
Transportation	Yes	Transportation	Yes
Industrial Processes	Yes	Heavy Industry	Yes
		Buildings	Yes
Agriculture	Yes	Agriculture	Yes
Waste	Yes	Waste and Others	Yes
LULUCF*	Yes	LULUCF*	Yes

*LULUCF = Land Use, Land-use Change and Forestry.

Table 2(c): Global Warming Potential (GWP) Values

GASES	GWP VALUES
CO_2, CH_4, N_2O, HFCs, PFCs, SF_6, NF_3	As per the IPCC *4th Assessment Report*

Table 2(d): Approach to the LULUCF sector

Canada's recent Nationally Determined Contribution, submitted in May 2017, notes that Canada is examining its approach to accounting in the LULUCF sector towards its 2030 emission reduction target. It also indicates that Canada will exclude the impacts of natural disturbances and use the IPCC production approach to accounting for harvested wood products. This approach applies to Canada's 2020 emission reduction target as well. The historical estimates for LULUCF from 1990–2015 found in Canada's 2017 NIR exclude for the first time the impacts of natural forest disturbances that occurred in the historical period. Work continues to develop LULUCF estimates that focus on anthropogenic emission and removals as a basis for improved reporting and accounting for LULUCF. As such, Table 2(d) has not been provided.

Table 2(e): Approach to market based mechanisms

The federal government, in cooperation with provincial and territorial governments and relevant partners, will continue to explore which types of tools related to the acquisition of internationally transferred mitigation outcomes may be beneficial to Canada and will advance a robust approach to the implementation of Article 6 of the Paris Agreement. A first priority is ensuring any cross-border transfer of mitigation outcomes is based on rigorous accounting rules, informed by experts, which result in real reductions.

The federal government will work with Ontario, Québec, and other interested provinces and territories, as well as with international partners, to ensure that allowances acquired through international-emissions trading are counted towards Canada's international target. As Canada is still examining its approach, Table 2(e) has not been provided.

Section 4: Progress in Achievement of Quantified Economy-Wide Emission Reduction Targets and Relevant Information

A. Mitigation Actions and their effects[b]

Domestic Institutional Arrangements

Canada is a decentralized federation, and the environment and climate change are policy areas of concurrent jurisdiction. In recognition of the need for a coordinated national approach, on December 9, 2016 Canada's federal, provincial and territorial governments took the historic step of adopting the Pan-Canadian Framework on Clean Growth and Climate Change (the Pan-Canadian Framework), a comprehensive plan to reduce emissions across all sectors of the economy,

[b] For further information on mitigation actions and their effects, please see Chapter 4: Policies and Measures of Canada's *7th National Communication*.

stimulate clean economic growth, and build resilience to the impacts of climate change.

The Pan-Canadian Framework is now the overarching framework for the coordination and implementation of climate change policy across Canada, and is under the responsibility of all the Canadian First Ministers (the Prime Minister and Provincial and Territorial Premiers) who endorsed it.[c] First Ministers have tasked specific ministers with implementing the Pan-Canadian Framework actions that are within their mandates. Longstanding mechanisms to support interjurisdictional coordination on environmental policies play a key role in the implementation of the Pan-Canadian Framework, including federal/provincial/territorial ministerial councils and tables such as the Canadian Council of Ministers of the Environment.

The Government of Canada is also partnering with three National Indigenous Organizations—the Assembly of First Nations, Inuit Tapiriit Kanatami, and the Métis National Council—to establish three separate engagement tables to support the implementation of the Pan-Canadian Framework and to advance broader clean growth and climate change priorities.

Policies and Measures to reduce emissions

The Pan-Canadian Framework consists of four main pillars: (1) pricing carbon pollution; (2) complementary measures to further reduce emissions across the economy; (3) measures to adapt to the impacts of climate change and build resilience; and (4) actions to accelerate innovation, support clean technology, and create jobs. Under each of these pillars, federal, provincial and territorial governments are undertaking over 50 concrete actions to reduce GHG emissions and enhance resilience. For a comprehensive narrative description of Canada's key policies and measures by economic sector, with an emphasis on those measures that have been recently adopted, please see Chapter 4 of Canada's *7th National Communication*.

National Communication Table 1 within the annex of Chapter 4: Policies and Measures provides information on core mitigation measures planned or already implemented by federal, provincial, and territorial governments, including those committed to under the Pan-Canadian Framework. Policies and measures are presented in accordance with Canada's economic sector categories, with cross-cutting measures appearing first. Within the sectoral groupings, federal measures appear first, followed by provincial and territorial measures from west to east.

Priority has been given to those policies and measures that have the most significant impact on sectoral GHG emissions. To provide additional context, information is also included on key supporting and enabling measures, such as clean technology policies, investment programs, as well as efforts to green government operations.

As much as possible direct mitigation impacts have been estimated for key policies, provided by the implementing entity. Where mitigation estimates were not provided, Canada has indicated the reason why they were not included (see notation legend within the Annex of Chapter 4: Policies and Measures). For example, mitigation estimates were not provided for measures that are still under development, and/or for those measures where it is difficult to estimate the direct mitigation impact, such as for supporting measures. The methodology for estimating expected emissions reductions from individual measures may vary by implementing entity and have been included on an as-provided basis. An estimate of the total mitigation impact of policies and measures—including interactive effects—is provided in Chapter 5: Projections and the Total Effects of Policies and Measures of Canada's *7th National Communication*.

[c] Manitoba and Saskatchewan decided not to join the Pan-Canadian Framework at this time.

B. Estimates of emission reductions and removals and the use of units from the market-based mechanisms and LULUCF

As described in Section 2 above, Canada is examining its approach to the use of internationally-transferred mitigation outcomes (market-based mechanisms), as well as its approach to accounting for LULUCF emissions toward its emissions reduction targets.

Section 5: Projections

For its *7th National Communication* and *3rd Biennial Report*, Canada has presented projections using both a "with measures" scenario and a "with additional measures" scenario.

The "with measures" scenario includes actions taken by governments, consumers and businesses put in place over the last two years, up to September 2017. This scenario does not account for all measures of the Pan-Canadian Framework as a number of them are still under development.

Taking into consideration all climate change policies and measures that have been announced in Canada and for which enough information is available, a "with additional measures scenario" has also been developed. The "with additional measures" scenario accounts for those additional policies and measures that are under development but have not yet been fully implemented, some of which were announced as part of the Pan-Canadian Framework (e.g. pan-Canadian carbon pricing). This scenario is provided for the purposes of presenting progress to Canada's 2030 target and to better demonstrate the expected impact of the Pan-Canadian Framework.

Under this scenario, emissions in 2030 would be 583 Mt, a 232 Mt decline from projections included in the "with measures" scenario in the BR2. This decline, equivalent to approximately a third of Canada's emissions in 2015, is widespread across all economic sectors, reflecting the breadth and the depth of the Pan-Canadian Framework.

Figure 1 shows the "with measures" and "with additional measures" projections, as well as the projections presented in Canada's BR2. Going forward, it is expected that further progress will take place, especially as current estimates do not include the full reductions from investment in public transit, clean technology and innovation. Potential increases in stored carbon (carbon sequestration) in forests, soils and wetlands will also contribute to reductions which, for a country such as Canada, could also play an important role in achieving the 2030 target.

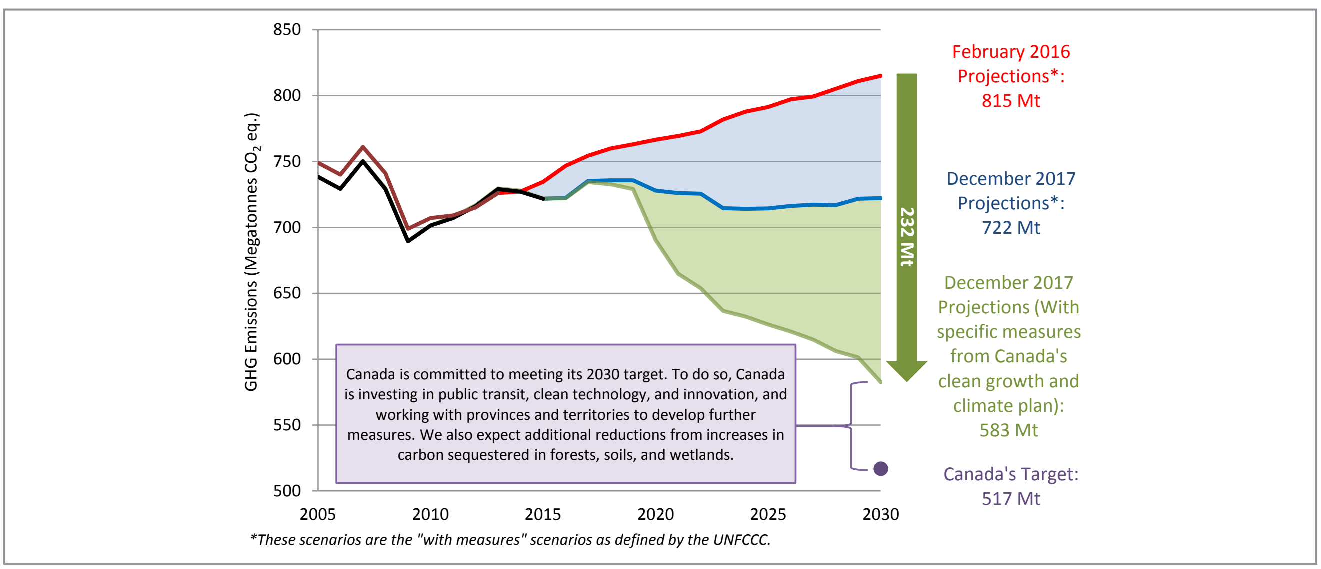

Figure 1: Scenarios of Canadian Emissions to 2020 and 2030 (Mt CO_2 eq) (Excluding Land Use, Land-Use Change and Forestry)

Moreover, these projected emission reductions do not account for additional mitigation measures that could be implemented by the provinces and territories between now and 2030. Emissions reductions from additional future actions will be assessed as new measures are implemented.

Environment and Climate Change Canada (ECCC) updates these projections annually, reflecting the latest historical data and up-to-date future economic and energy market assumptions. However, there is significant uncertainty with regards to key drivers of GHG emissions, such as future world oil and gas prices, economic growth and developments in technologies. Projections therefore fluctuate over time as a result of changes in these key drivers assumptions.

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. Projections are based on ECCC's Energy, Environment and Economy Model for Canada (E3MC), which is internationally recognized and incorporates external data from consistent sources (see Annex 4 in Chapter 5: Projections and the Total Effects of Policies and Measures of the *7th National Communication* for more details). ECCC consults extensively with other government officials, selected experts and provinces and territories on emissions projections.

To view tabular information related to Canada's GHG emissions projections, please see Canada's BR CTF submission and/or Chapter 5: Projections and the Total Effects of Policies and Measures within Canada's *7th National Communication*.

Section 6: Provision of Financial, Technological and Capacity Building Support to Developing Country Parties[d]

A. Finance

One of the core aims of the Paris Agreement is to make all financial flows consistent with a pathway towards low-emission, climate-resilient development. This goal requires all actors—public and private—to transition to green and sustainable investments and accelerate clean growth.

Over 2015 and 2016 Canada delivered over $625 million (M) in public finance alone from various channels to a wide range of mitigation and adaptation initiatives. These initiatives are helping developing countries manage risks and build resilience to the impacts of climate change, deploy clean energy technology, and support climate-smart agriculture in line with low carbon and climate resilient pathways. This support includes:

- $242M as part of Canada's $2.65 billion (B) commitment to significantly scale up climate financing for developing countries by 2020;
- $104M of international assistance projects with a focus on climate change as part of Canada's efforts to integrate climate change considerations into its development funding;
- $6M from Québec to the Least Developed Countries Fund, making Québec the first subnational government to support the fund; and
- $273M from Export Development Canada, Canada's export credit agency, to mobilize private sector finance in sectors such as clean energy.

[d] Tabular information on finance, technology, and capacity building required by the BR guidelines can be found in Canada's BR CTF submission, as well as in Chapter 7: Financial, Technology and Capacity Building Support of Canada's *7th National Communication*.

Supporting Adaptation and Building Climate Resilience

Canada is delivering on its promise to increase support for adaptation by vulnerable countries with new projects launched this year, working through multilateral channels as well as in partnership organizations that make a difference at the community level. Over 2015 and 2016, through its $2.65B commitment, international assistance, and support by provinces, Canada provided over $190M to bilateral and multilateral partners and to non-governmental organizations to support adaptation in developing countries.

Mobilizing Private Sector Investments

The role of the private sector is critical for developing countries' transition to low-carbon and sustainable economies. Therefore, Canada is investing a significant portion of its public climate finance to mobilize private sector investment in developing countries.

Working collaboratively with a number of multilateral organizations, Canada is providing innovative financing aimed at removing risks that can inhibit private sector investment. Risks preventing investment can include high upfront costs or barriers such as lack of awareness of financial benefits of climate investments. These interventions help to scale up the mobilization of private investment in climate-friendly sectors in developing countries and supports developing countries make the shift towards low-carbon and climate resilient development.

Partnering with Multilateral Development Banks to Mobilize Climate Finance and Other Development Partners

Multilateral development banks (MDBs) play a key role in helping developing countries grow their economies and transition toward low-carbon sustainable development. They are doing so by committing large portions of their portfolios to low-carbon and climate-resilient growth, which catalyzes private finance for climate action.

Canada established Canadian facilities at MDBs designed to mobilize private sector financing and investment. Using concessional financing, these facilities enable private investments in areas like clean energy and climate resilience that would not otherwise happen due to market barriers to investments, such as high upfront costs or lack of awareness of financial benefits of climate investments.

Since 2011, it is estimated that Canada's support to these facilities, alongside co-financing from MDBs and from other public sources, have collectively mobilized US$1.7B of private climate investment, approximately $234M of which can be directly attributed to Canada's financial support.

Repayable contributions of approximately $8.88M in 2015 and $18.93M in 2016 have been returned to Canada from multilateral agencies. The successful performance of these projects is demonstrating how using public funding can catalyze investment in climate change action in developing economies.

Details on initiatives supported by Canada can be found in the BR CTF. Table 7 provides 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. This tabular information, as well as further information on Canada's support to climate change action in developing countries, is also provided in Chapter 7: Financial, Technology and Capacity Building Support of Canada's *7th National Communication.*

Canada's National Approach to Tracking

Canada's climate finance is delivered through various federal departments, sub-national governments, and agencies, including Global Affairs Canada, Environment and Climate Change Canada and the International Development and Research Centre. These departments work closely together to track Canada's climate finance to present a comprehensive picture of Canada's contribution to the transition to low carbon and climate resilient economies.

The most up-to-date information on climate finance support from Canada is found on our climate finance website. This interactive website provides detailed project level information, including results achieved. Users can search for projects on this site by country, region, priority sector, year of contribution, and key word.

More information on the methodologies used for reporting Canada's climate finance can be found in Annex 4 of Chapter 7: Financial, Technology and Capacity Building Support of Canada's *7th National Communication*.

B. Technology Development and Transfer and Capacity Building

A significant share of mitigation and adaptation outcomes is achieved through technology development and transfer, and capacity building. Canada believes that improvements to enabling environments for the dissemination and uptake of technologies are important elements of enhancing cooperative action on technology development and transfer. Such efforts are critical to achieving long-term low-carbon growth and sustainable development. Canada is committed to a broad range of actions to advance the development and transfer of clean technologies globally, and build capacities of developing countries through bilateral and multilateral channels.

Since its last report to the UNFCCC, Canada has demonstrated efforts in a number of areas including: forestry and land-use management, clean energy, adaptation, and other cross-cutting sectors. While activities featured in this section focus on capacity-building and technology, it is important to highlight that a portion of Canada's climate change financing has also included technology and capacity building activities, given that this work is often an important component of climate change projects. Additional details of projects and activities funded under Canada's climate financing can be found in Chapter 7 of Canada's *7th National Communication*.

Canada has demonstrated leadership in developing and making globally available tools to support clean energy technology deployment as well as forest sector mitigation and adaptation goals of developing countries. Examples of such tools include the RETScreen Clean Energy Management Software and the Carbon Budget Model, both of which are offered free of charge in multiple languages. Access to these tools is supplemented by a considerable amount of resources and training materials, including case studies, presentations as well as training sessions and workshops.

Canada also engages in the Clean Technology Centre and Network through its National Designated Entity and with the Private Financing Advisory Network, which seeks to connect sources of funds with viable clean energy projects in developing countries. Canada works through Mission Innovation with 21 other countries and the European Union to accelerate innovation to make clean energy widely affordable. Canada is taking action to double its public investments in clean energy research over 5 years, while encouraging collaboration among partner nations, sharing information, and coordinating with businesses and investors. Through its participation in the Clean Energy Ministerial (CEM) and various CEM initiatives, Canada is able to showcase its achievements and expertise related to clean energy technologies, leverage collaborative partnerships, and display global leadership in the global clean energy transition. Additional information on these activities can be found in the Annex of Chapter 7 of Canada's *7th National Communication*, which contains National Communication Tables 9, 10 and 11.This information can also be viewed in Canada's BR CTF submission (BR Tables 8 and 9).

Section 7: Other Reporting Matters

Domestic Arrangements for Self-Assessment

There are several processes in Canada that allow for self-assessment of progress toward emission reduction goals. On behalf of the Auditor General of Canada, the Commissioner of the Environment and Sustainable Development provides objective, independent analysis and recommendations on the federal government's efforts to protect the environment and foster sustainable development. The Commissioner conducts performance audits and is responsible for assessing whether federal government departments are meeting their sustainable development objectives, including on climate change. Reports and audits are tabled in Parliament and provide observations and recommendations for initiatives that require improvement. In addition to arrangements at the federal level, provinces and territories also have their own respective arrangements to audit the effectiveness of environmental policies and programs.

In addition, *Canada's Federal Sustainable Development Act* provides a legal framework for developing and implementing a Federal Sustainable Development Strategy that makes environmental decision-making transparent and accountable to Parliament. The Act requires the development of a Federal Sustainable Development Strategy every three years and it provides a whole-of-government view of federal actions to achieve environmental sustainability, including progress on GHG emission reductions. Progress Reports are also published every few years to review progress towards these indicators. The *2016–19 Federal Sustainable Development Strategy* was published in 2016. Accurate and transparent monitoring, reporting and verification of Canada's GHG emissions and removals are a requirement of the UNFCCC, and regular reporting allows Canada to assess its progress in reducing emissions and combatting climate change, including Canada's NIR, as well as its National Communications and Biennial Reports. In addition to reporting to the UNFCCC, in 2016 *Canada's GHG Emissions Reference Case* report presented analysis and projections of Canada's GHG emissions in the context of its emission targets.

At the federal level, environmental regulations are enforced under relevant legislative authorities. Regulations to reduce greenhouse gas emissions are established under the *Canadian Environmental Protection Act (1999)*. Environmental enforcement officers enforce federal legislation dealing with risks to the environment and biodiversity, and enforce these laws in collaboration with provincial and territorial governments and national and international agencies and organizations.