Court of Appeal File No.: **C65807**

COURT OF APPEAL FOR ONTARIO

IN THE MATTER OF A REFERENCE to the Court of Appeal pursuant to section 8 of the *Courts of Justice Act*, RSO 1990, c. C.34, by Order-in-Council 1014/2018 respecting the constitutionality of the *Greenhouse Gas Pollution Pricing Act*, Part 5 of the *Budget Implementation Act, 2018, No. 1*, SC 2018, c. 12

RECORD OF THE ATTORNEY GENERAL OF ONTARIO

VOLUME II OF IV

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MINISTRY OF THE ENVIRONMENT AND CLIMATE CHANGE

ONTARIO'S CLIMATE CHANGE UPDATE 2014

Ontario

Minister's Message

Climate change is a tremendous force disrupting and challenging every facet of our lives, from our homes and businesses to the activities, food and places we enjoy and often take for granted. We must act now to protect our health, wellbeing and work together towards a cleaner, brighter future.

Ontario has the skills, technological knowledge and capacity to be a world leader in finding and demonstrating solutions to climate change.

Where we live, where we work and how we move between our homes and our jobs determines the largest share of our greenhouse gas emissions. To keep reducing emissions with a growing population, we need to build for the future. More energy-efficient buildings, smart urban planning, low-carbon transportation options, and green infrastructure are just some of the solutions we need. And, as the world transitions to a low carbon economy, we need to design products for our children, not the dump.

Our government is already making strides in all of these areas – through investments in transit, our regional planning initiatives, and our energy and environmental policies, and there is more to do.

This report reflects on Ontario's actions towards addressing climate change and I am proud of the progress we have made to date. However, our government has set important targets for 2020 and 2050 that will require new approaches to adaptation, mitigation and science.

Let's rise to the challenge of fighting climate change and leave future generations with an essential legacy: a healthy and beautiful planet.

Glen Murray
Minister of the Environment and Climate Change

This Report

Ontario reports regularly on climate change progress. Regular, transparent reporting supports the observation of trends in the economy and society that influence greenhouse gas emissions. In addition, it enables the assessment of policies, programs and other actions as well as the forecasting of future trends. Finally, the report helps to highlight areas for further action.

We determined these targets as part of a coordinated global effort to avoid the dangerous impacts of climate change on our planet and quality of life, but also to help ensure a cleaner future for Ontario.

We expect to achieve our 2014 target, the first of three targets set out in the province's plan. While we are more than two thirds of the way to meeting our 2020 target, we know we have to act quickly to meet the target. Ontario uses 1990 as a base year for its targets, which is common practice and aligns with the United Nations Framework Convention on Climate Change (UNFCCC) and the Kyoto Protocol. Some jurisdictions such as the Government of Canada (which uses 2005) have adopted different base years for targets. All nations reporting to the UNFCCC report historical emissions back to 1990.

In 1990, GHG emissions in Ontario were 177 megatonnes (Mt). In 2012, according to the Government of Canada's latest National Inventory Report (the Inventory), emissions in Ontario were down to 167 Mt (or 5.9%[2] below 1990 levels). Since 2007, emissions are down in Ontario by about 35 Mt (or 17%) driven primarily by the phase-out of coal-fired electricity generation. As of April 2014, Ontario no longer uses coal to generate electricity and has reintroduced legislation to ensure that, if passed, coal-burning generation on the electricity grid will never happen again.[3]

This report provides an update of Ontario's greenhouse gas emissions (GHGs) and progress towards the targets set out in the 2007 Climate Change Action Plan.[1]

The targets are:

- 2014 target: 6% below 1990 levels
- 2020 target: 15% below 1990 levels
- 2050 target: 80% below 1990 levels

Total GHG emissions forecast for 2014 are 165 Mt, which is below the target of 167 Mt. **This means Ontario is expected to not only achieve, but surpass its 2014 target.** Given current policies and trends, emissions in 2020 are forecast to be 170 Mt — which would achieve 69% of the emission reductions required[4] to meet the 2020 target.

1 Ontario, *Go Green: Ontario's Climate Change Action Plan* (Toronto: Queen's Printer for Ontario, 2007).

2 5.9% is the per cent reduction. This number is the accurate ratio when using the unrounded numbers; in 1990, actual emissions were 177,248 Mt and in 2012 were 166,878 Mt.

3 Bill 9, Ending Coal for Cleaner Air Act, 2014, 1st Session, 41st Legislature, Ontario.

4 Progress is calculated as the ratio of projected reductions in emissions (from Business as Usual) to reductions required to meet the target.

Overview of Sections

The information presented in this report is based on Environment Canada's *National Inventory Report 1990–2012: Greenhouse Gases Sources and Sinks*, released in April 2014.[5] Ontario relies on this report to evaluate historical emission changes in several sectors of the provincial economy. Its underlying data also forms the basis of the emission forecasts in this report.

SECTION 1

Summarizes the major sources of emissions in the province, long- and short-term trends, and the province's updated emission forecasts to 2014, 2020 and 2030.

SECTION 2

Breaks down emissions by sector — discussing the key factors influencing GHG emissions and the impacts of specific policies.

SECTION 3

Describes the modelling approach and associated uncertainty.

5 The Inventory is available here: http://unfccc.int/national_reports/annex_i_ghg_inventories/national_inventories_submissions/items/8108.php.

SECTION 1

ECONOMY-WIDE EMISSION TRENDS AND FORECAST

Sources of Emissions

Ontario's estimated GHG emissions comprise GHGs that are emitted *within* the province's boundaries — for instance, from buildings, vehicles and industrial plants operating in Ontario.

Estimated GHG emissions do *not* include "consumption-based emissions" from the production of fuels, goods and services outside the province that are bought or consumed inside Ontario. This approach to estimating GHGs is consistent with most other jurisdictions, including the Government of Canada.

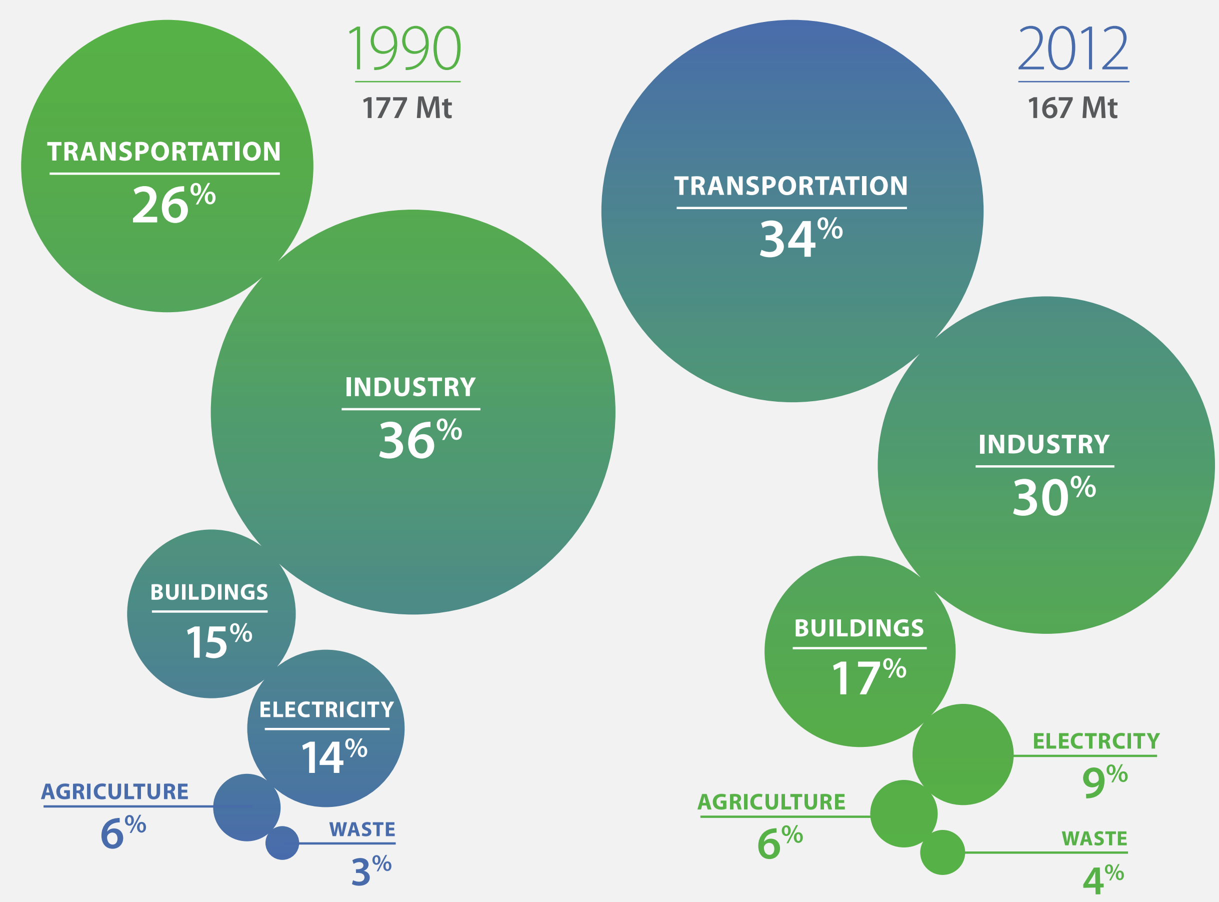
GHG emissions come from virtually all aspects of Ontario's society and economy. The main sources by far are the fossil fuels used to heat homes, run vehicles, power industries and generate electricity. But GHGs also come from waste disposed in landfills, some industrial processes, livestock, fertilizer use, and from appliances leaking refrigerants. In this report, sources are categorized into the economic sectors described in **Table 1** (further detail is also provided in Section 3: Methodology).

TABLE 1 Sector Descriptions

Sector	Sources of Greenhouse Gas Emissions
Transportation	The combustion of fossil fuels such as diesel, gasoline and propane by passenger and commercial vehicles on and off roads, as well as rail and Ontario's share of domestic marine and air travel
Industry	Some industrial processes and stationary combustion of fossil fuels such as coke, natural gas and coal used in mining; pipelines; construction; greenhouses; production of cement, iron and steel, chemicals, paper and wood products; and other manufacturing
Buildings	The combustion of fossil fuels such as natural gas in residential, commercial and institutional buildings for space and water heating
Electricity	Generating electricity and heat by electric utilities using fossil fuels such as natural gas
Agriculture	Enteric fermentation, manure management and fertilizer application
Waste	Solid waste disposal on land, wastewater handling and waste incineration

The "land use, land use change and forestry" sector also plays an important role in both adding GHGs to and removing GHGs from the atmosphere. This sector reflects the role of forests, grasslands, croplands, wetlands and settlements in the carbon cycle. Forests and other lands can absorb and store carbon for long periods — these are known as carbon sinks. However, carbon sinks can also release carbon back into the atmosphere as conditions change and organic material degrades. Many of these processes are natural; however, how forests and croplands are managed and land use is changed from forest to agricultural lands or other uses can have a climate impact. The federal government models and reports these emissions and removals at a national level in the National Inventory Report. However, in accordance with UN accounting conventions, Canada's emissions and removals of GHGs from the Land Use, Land Use Change and Forestry sector are *not* included in Canada's National Inventory totals. Therefore, these sources and sinks are not included in Ontario's assessment of GHGs at this time. As better data become available, Ontario will consider how to incorporate these into its accounting and targets.

FIGURE 1 Emissions by Sector, 1990 and 2012



Source: the 2014 National Inventory Report: 1990–2012 data

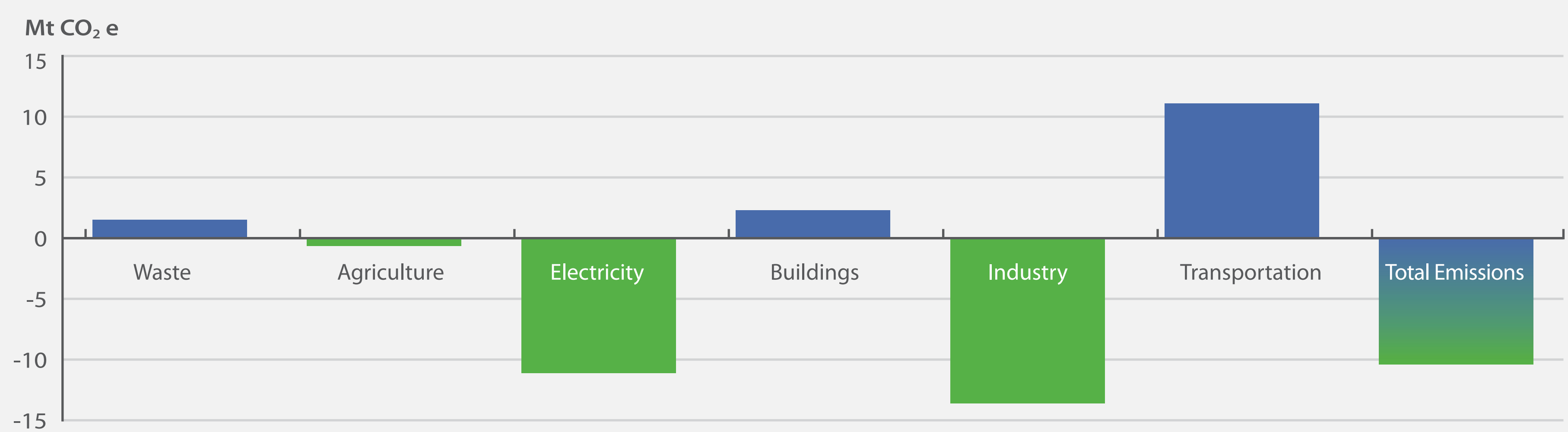
Ontario's emissions in 2012

For 2012, Ontario's GHG emissions are estimated to be 167 megatonnes (Mt). The 1990 and 2012 shares of emissions by sector are shown in Figure 1. Over these 22 years, the distribution of emissions by sector in Ontario has changed, reflecting changes in the economy and the electricity sector. The share of emissions in the transportation sector has grown from 26% in 1990 to 34% in 2012, while the share of industrial emissions has declined from 36% to 30%. Note that 2012 emissions do not yet reflect the full impact of the closure of coal-fired electricity in the province.

Long-term trends in Ontario's emissions (1990–2012)

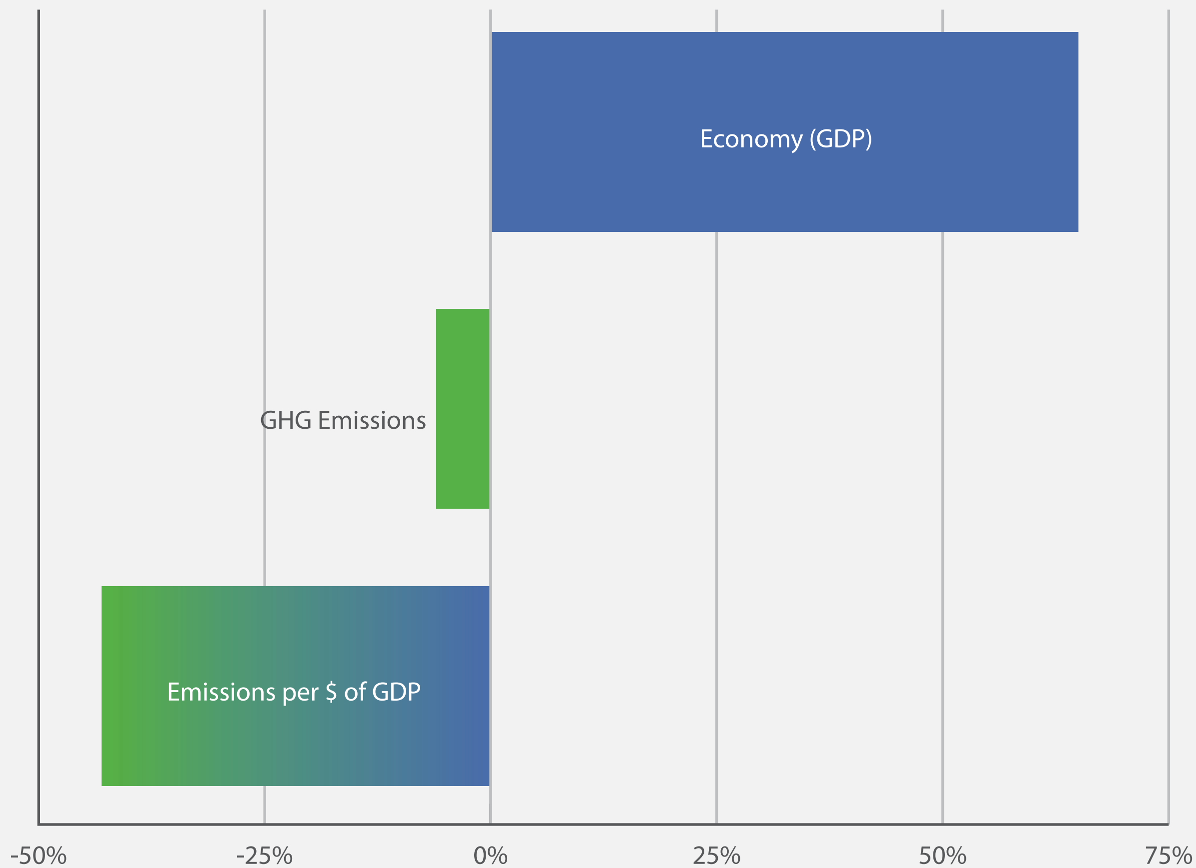
Figure 2 shows the percentage changes in emissions from 1990–2012.

FIGURE 2 Long-Term Changes in Ontario Emissions by Sector, 1990–2012



Source: The 2014 National Inventory Report 1990-2012 data

FIGURE 3 Changes in Key Drivers of Emissions, 1990-2012



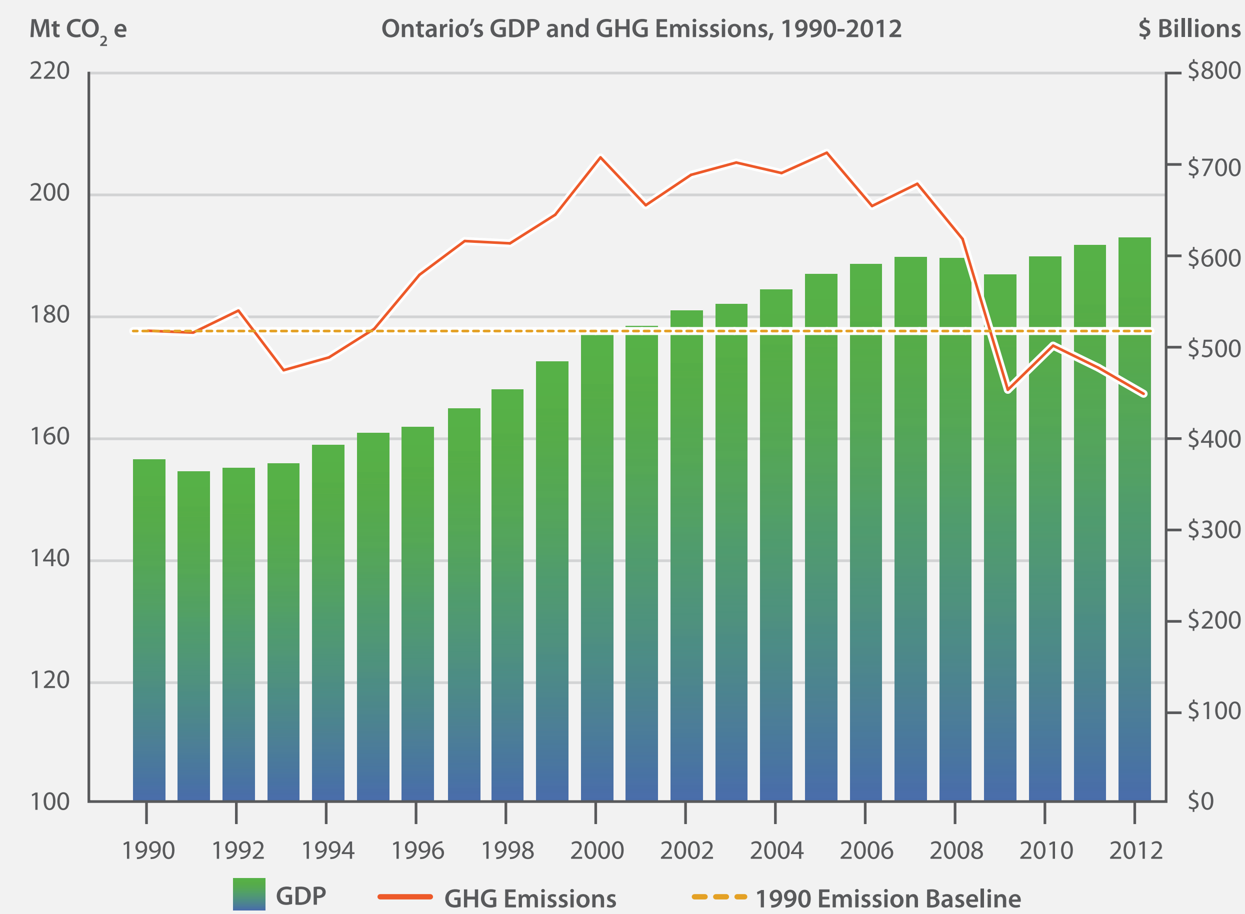
Sources: the 2014 National Inventory Report: 1990–2012 data; *National Energy Use Database (2014); Statistics Canada CANSIM Tables 127 0001 and 127 0007; Ontario Ministry of Finance*, Long-Term Report on the Economy *(2014)*

Greenhouse gas emissions are influenced by population and economic growth as well as by the use and sources of energy that support that growth. Over the period 1990–2012, Ontario's population and economy have grown steadily — putting upward pressure on greenhouse gas emissions. However, over the same period Ontario has reduced the carbon emitted from electricity generation, and made improvements in the energy efficiency of buildings, industries and vehicles.

Figure 3 shows the economy is one driver of emissions in Ontario. Other drivers such as population, housing stock and the number of passenger vehicles have all increased significantly since 1990. Yet, over the same period, emissions have declined.

From 1990–2012, Ontario's emissions fell by 5.9%; **Figure 4** shows this long-term trend compared with GDP. Emissions grew from 1990 to the early 2000s, then stabilized and declined in recent years. Improved energy efficiency, the changing mix of electricity generation and the shifting composition of Ontario's industrial base are mitigating the impact on greenhouse gas emissions of population and economic growth.

FIGURE 4 Long-Term Trends

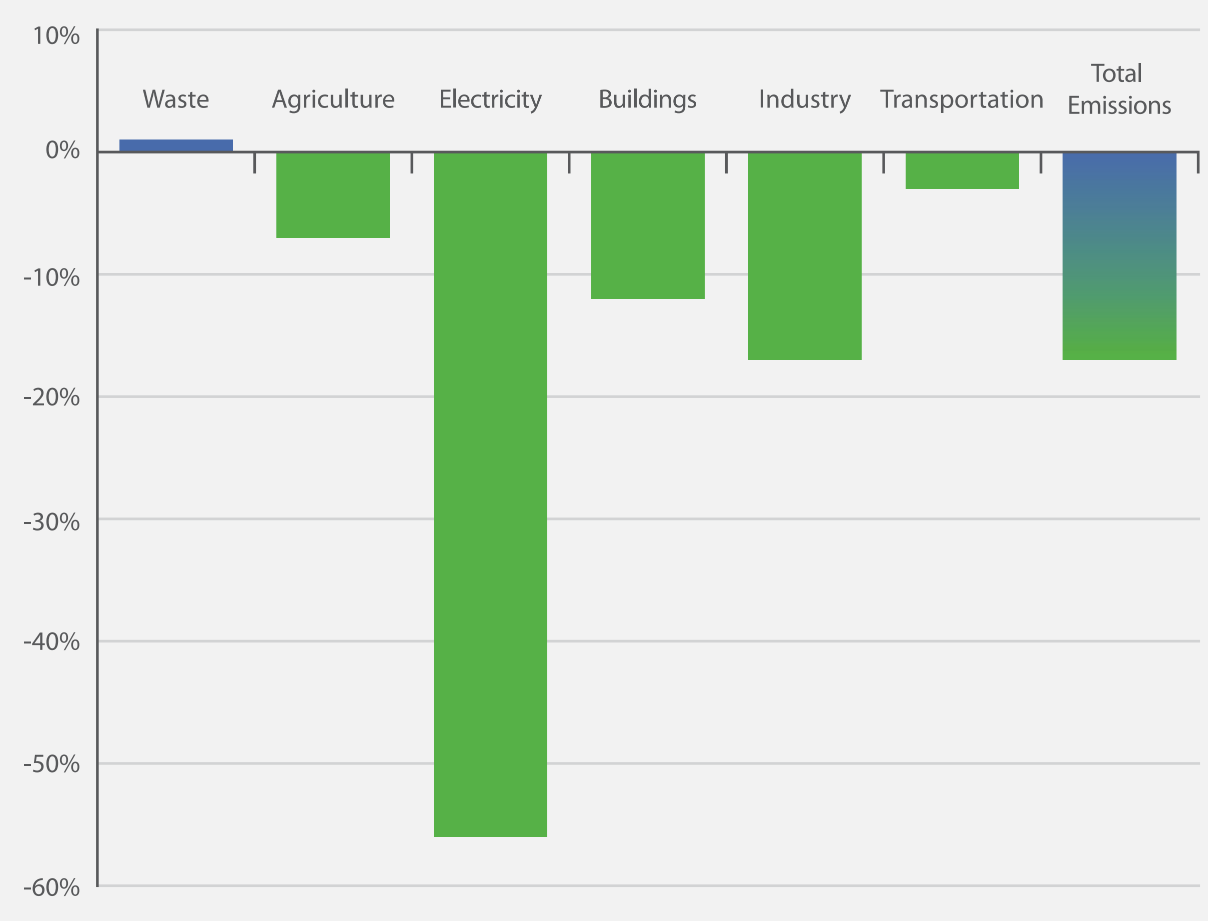


Sources: the 2014 National Inventory Report: 1990–2012 data; *Ontario Ministry of Finance*, Long-Term Report on the Economy *(2014)*

Short-term trends in Ontario's emissions (2007–2012)

In 2007, Ontario released a Climate Change Action Plan that set out its emissions reduction targets and identified policies intended to help meet those targets. Since 2007, total emissions in Ontario have declined by approximately 34 Mt or 17%. The greatest reductions are in the electricity and industrial sectors (see **Figure 5**). The reduction in electricity is attributable to the phasing out of coal-fired electricity generation. The reduction in the industry sector is attributable to reduced production — including plant closures — and improved emissions intensity. Buildings' emissions also declined as energy efficiency improved due to policies and programs in the sector. See Section 2 for more detail on sectoral trends.

FIGURE 5 Short-Term Changes in Ontario Emissions by Sector, 2007–2012

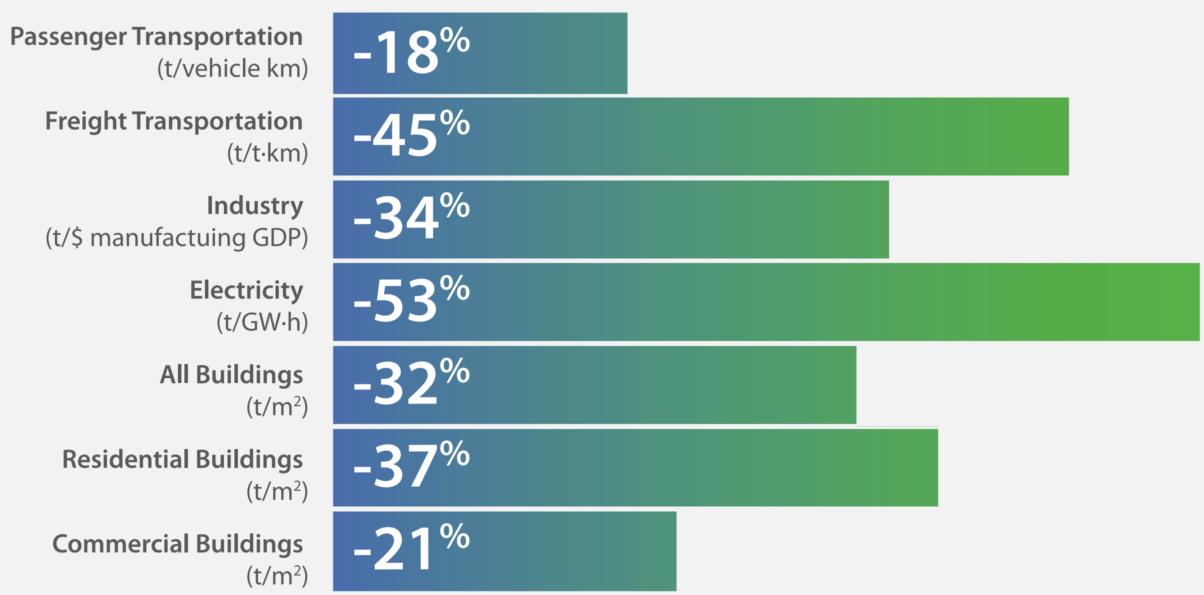


Source: the 2014 National Inventory Report: 1990–2012 data

Emission Intensities

Emission intensities across most sectors improved between 1990 and 2012, which indicates a trend towards a less carbon-intense economy. Figure 6 depicts emission intensities based on greenhouse gas drivers such as buildings, electricity, industry and transportation. Trends in specific sectors are described in more detail in Section 2 of this report.

FIGURE 6 Changes in Emission Intensities of Key Activities, 1990–2012



Sources: the 2014 National Inventory Report: 1990–2012 data; *National Energy Use Database (2014); Statistics Canada CANSIM Tables 127 0001 and 127 0007; Ontario Ministry of Finance,* Long-Term Report on the Economy *(2014)*

TRANSPORTATION

Between 1990 and 2012, emissions per passenger vehicle kilometre travelled in Ontario decreased by 18% while emissions per freight tonne-kilometre decreased by 45%. Passenger vehicle intensity saw most of its decrease after 2006. Most of the improvements in freight intensity occurred before 2000.

INDUSTRY

In the industrial sector, most emissions are generated by manufacturing industries. Figure 6 shows the emission intensity of overall manufacturing, calculated as emissions per dollar of manufacturing GDP. In 2012, emissions intensity was 34% lower than in 1990. Note that this figure does not show the variability across the sector and should not be taken to mean that every industry has reduced its emissions since 1990.

BUILDINGS

In the buildings sector, the measurement of emissions per unit of floor space gives an indication of changes in the "carbon intensity" of the sector, which is linked to energy use and the type of energy being used. **Figure 6** shows changes in emission intensity, measured as emissions per square metre of floor space in residential and commercial/institutional buildings.

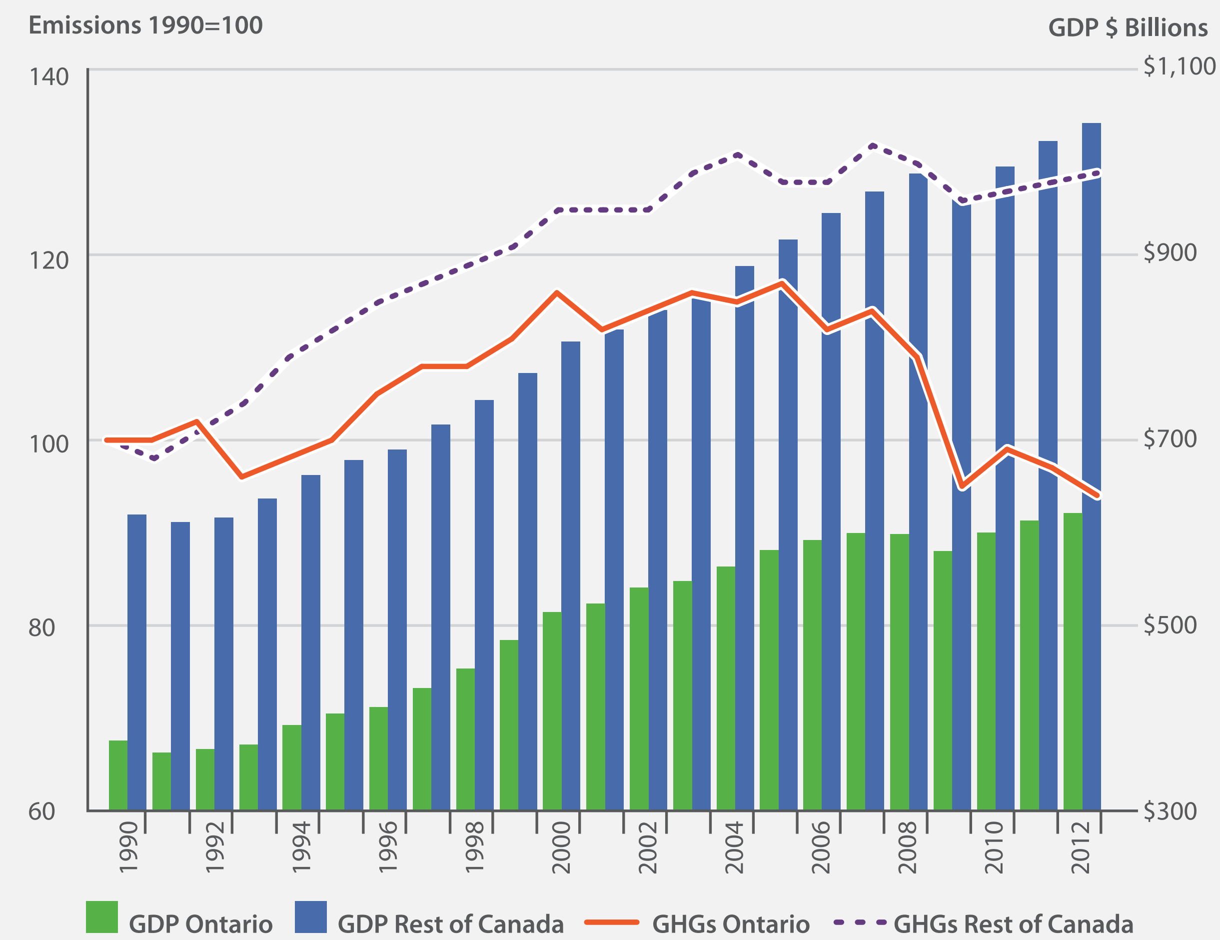
Building emission intensities improved by about 32% from 1990–2012, in both the residential (37%) and the commercial/institutional (21%) sub-sectors.

ELECTRICITY

In the electricity sector, emissions per unit of electricity generated (tonnes per gigawatt-hour) give an indication of changes in the emission intensity of electricity generation at Ontario's utilities. **Figure 6** shows changes in the emission intensity relative to the base year 1990.

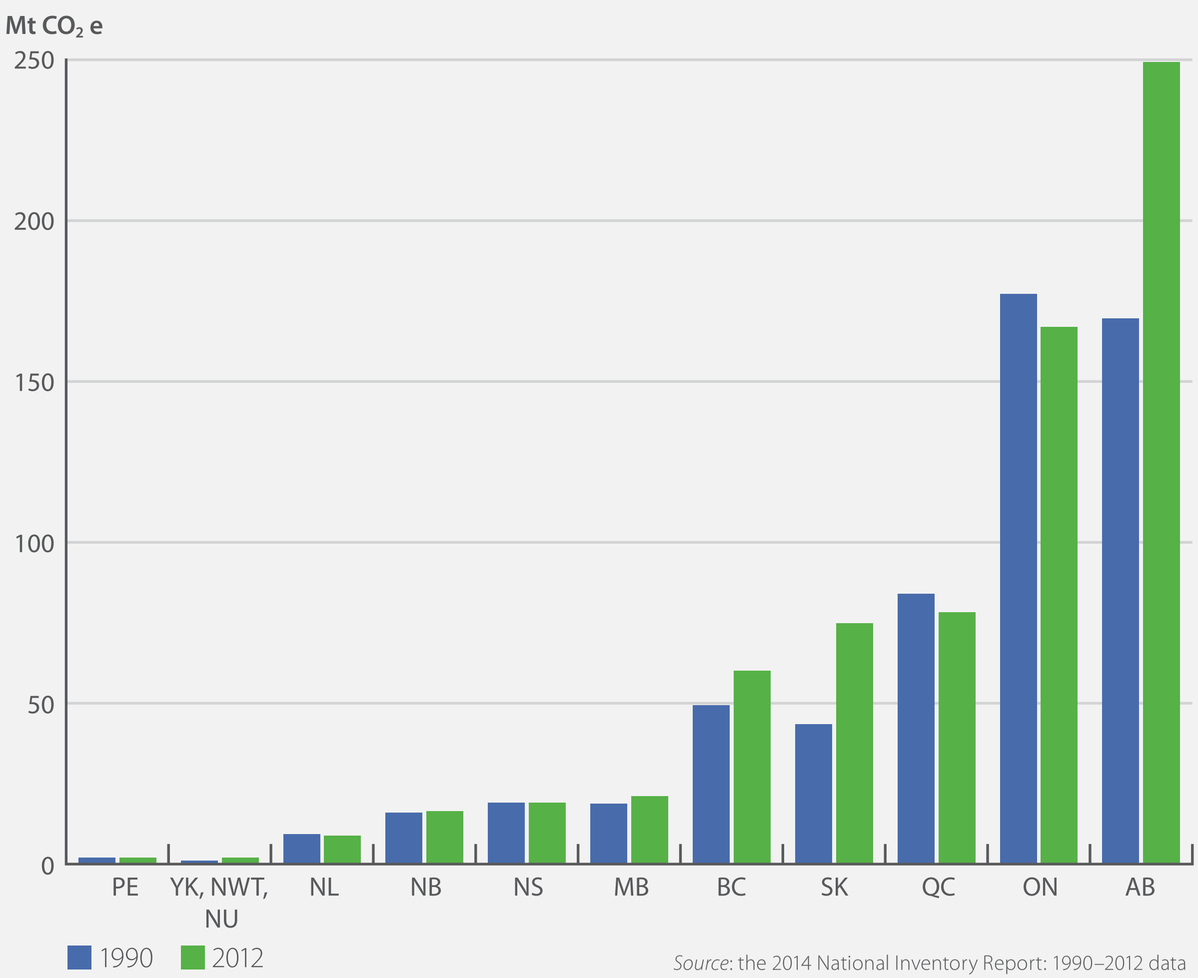
Emission intensity improved by about 53% from 1990–2012. This means that greenhouse gases (tonnes of carbon dioxide equivalent) per gigawatt-hour of electricity generated was less than half what it was in 1990.

FIGURE 7 Changes in GHG Emissions, 1990–2012 (Ontario and the Rest of Canada)



Source: the 2014 National Inventory Report: 1990–2012 data; *Statistics Canada CANSIM Table 384 0038*

FIGURE 8 Provincial/Territorial Emissions, 1990 and 2012



Source: the 2014 National Inventory Report: 1990–2012 data

Interprovincial Comparisons

Greenhouse gas emission trends across Canada are quite different than those in our province, with clear increases in areas of expanded resource development and slower growth or decreases in other areas. Overall, Canada's emissions have increased 18.2% since 1990 but have declined in recent years, primarily because of the significant reductions in Ontario. **Figure 7** compares emission changes in Ontario to those of Canada overall.

Emission profiles and trends vary significantly across Canada. **Figure 8** shows the change in emissions by province since 1990.

TABLE 2 Provincial/Territorial Emission Intensities, 2012

Province/ Territory	Emission Intensity of the Economy (Mt CO_2 eq./$ billion GDP)	Rank
QC	0.24	1
YK, NWT, NU	0.27	2
ON	**0.27**	**3***
BC	0.29	4
NL	0.32	5
MB	0.39	6
PE	0.40	7
NS	0.53	8
NB	0.58	9
AB	0.86	10
SK	1.28	11

Province/ Territory	Emissions per Capita (t/capita)	Rank
QC	9.69	1
ON	**12.32**	**2**
BC	12.96	3
PE	13.30	4
MB	16.63	5
NL	17.03	6
YK, NWT, NU	17.92	7
NS	20.03	8
NB	21.70	9
AB	63.81	10
SK	68.84	11

Sources: the 2014 National Inventory Report: 1990–2012 data; *Statistics Canada CANSIM Tables 051 0001 and 384 0038*
* YK, NWT, NU's emission intensity is lower. When rounding the number, it appears to be equal to Ontario.

In contrast to Ontario's stable-to-declining emissions, the national trend is one of increasing emissions. In 2012, Canada's GHG emissions totalled 699 Mt, an increase of 18% since 1990. However, increases by province vary. Ontario and Quebec are the only jurisdictions in Canada with significantly declining greenhouse gas emissions. Ontario's emissions decreased by 6% and Quebec's decreased by 7%. In absolute emissions, Ontario's decrease of 10 Mt since 1990 is the largest in Canada.

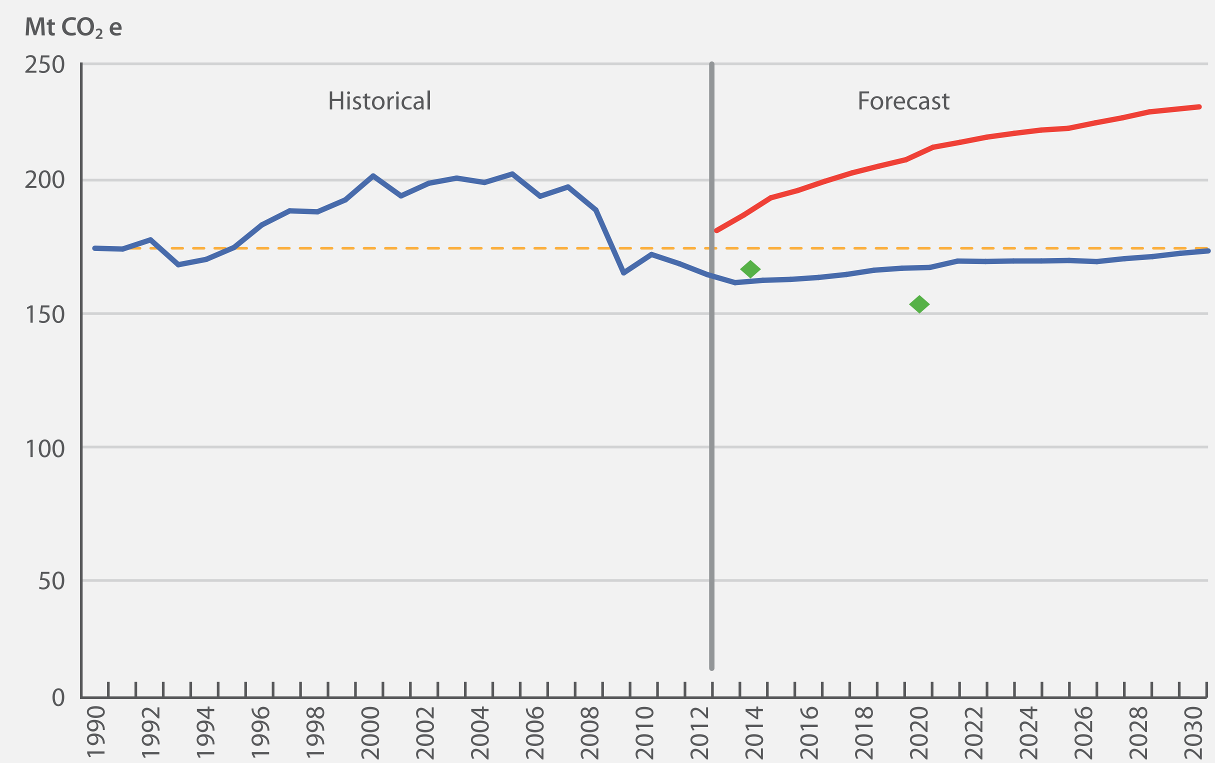
Both the emission intensity of Ontario's economy — measured as emissions per unit of GDP — and per capita emissions are among the lowest in Canada (see **Table 2**).

Emission Forecast to 2030

Figure 9 shows historical and forecast emissions for the province out to 2030. This forecast takes into consideration provincial and federal policies up to March 2014 that are expected to affect emissions, including Ontario's regional transportation plan for the Greater Toronto and Hamilton Area.[6] The initiatives section below describes the transportation plan further.

In addition, in order to illustrate the progress Ontario is making towards its 2007 Climate Change Action Plan targets, a "business as usual" (BAU) emission projection is also forecast. The BAU is an estimate of what Ontario's emissions would have been in the absence of policies introduced since CCAP. The BAU provides a reasonable estimate of what GHG emission levels would have been if the CCAP had not been in place, taking into account actual economic, demographic and activity trends.

FIGURE 9 Ontario's Historical and Forecast Emissions, 1990–2030



Source: the 2014 National Inventory Report: 1990-2012 data; MOECC forecast

[6] The transportation plan is called *The Big Move: Transforming Transportation in the Greater Toronto and Hamilton Area* (November 2008 Metrolinx); updates to the plan as of February 2013 were also incorporated http://www.metrolinx.com/thebigmove/en/ .

Table 3 shows the most recent forecast of progress to Ontario's GHG targets. Since the 2012 progress report, Ontario's progress to its greenhouse gas targets has improved. The main reason for these improvements is the 2013 revision of the *Long-Term Energy Plan* and its associated energy demand and clean energy generation forecasts. Furthermore, both the recent historical emission data and current economic forecasts are slightly lower than in 2012. Lower, more conservative economic forecasts tend to translate into lower emissions trends, since lower economic growth generally means lower energy-consuming activity and lower energy use.

TABLE 3 Projected Reductions, Progress and Gaps to Targets

2014 Update	2014	2020
Annual Projected Reductions (Mt)	26	42
Progress to Target	expected to surpass target	69%
Gap (Mt)	expected to surpass target	19
2012 Report	**2014**	**2020**
Annual Projected Reductions (Mt)	31	42
Progress to Target	91%	60%
Gap (Mt)	3	28

Initiatives

Ontario has undertaken a wide range of initiatives to reduce greenhouse gas emissions throughout the economy. Examples from specific sectors will be highlighted in the sections following. Many efforts are inter-related (such as the phase-out of coal-fired electricity generation with increases in renewable generation and conservation) or have overlapping impacts (such as federal vehicle efficiency standards with Ontario's ethanol blending requirements for gasoline). Therefore, estimated impacts are grouped by sector. Ontario's climate change initiatives cross all emission sources and economic sectors and represent a combination of short-, medium- and long-term reductions. The initiatives considered for this report include activities that are both within and outside the direct control of the Ontario Government, including federal policies that affect provincial emissions. New initiatives announced after March 2014 have *not* been included in the forecast, such as Ontario's proposal for *Reducing Coal Use in Energy-Intensive Industries*[7] and any new initiatives in *Moving Ontario Forward*,[8] the government's plan to make available nearly $29 billion over the next 10 years for investments in transit, transportation and other critical infrastructure projects across the province.

Table 4 shows the expected impact of initiatives by sector in 2014 and 2020.

[7] Environmental Bill of Rights Registry Number 012 1559.

[8] *Building Opportunity and Securing Our Future Act (Budget Measures), 2014*, S.O. 2014, c. 7. Note that any projects included in The Big Move and funded out of Moving Ontario Forward are included in the current emissions projections. Many projects that have already been announced in the Greater Golden Horseshoe Growth Plan have also been included in estimates.

TABLE 4 Emission Reductions by Sectoral Initiatives

Sector	Initiative	Projected Reductions (Mt)	
		2014	2020
Transportation	The Big Move regional transportation plan and Greater Golden Horseshoe Growth Plan[9] Passenger vehicle efficiency regulations Freight truck speed limiter regulation Municipal hybrid bus purchase and Green Commercial Vehicle programs[10] Ethanol in Gasoline regulation[11] Greener Diesel regulation[12]	1.9	4.6
Industry	Natural gas utility conservation programs	0.3	0.8
Buildings	Greater Golden Horseshoe Growth Plan Natural gas utility conservation programs Building Code amendments Residential retrofits	0.9	2.3
Electricity	Long-Term Energy Plan: coal phase-out; Feed-In Tariff program; residential, commercial and industrial demand management programs; and related electricity plans	20.5	32.5
Agriculture and Waste	Biogas Financial Assistance Program Landfill Gas Collection and Control regulation[13]	1.5	1.8
	All initiatives	**26.0**	**41.9**

Emission reductions for all initiatives together may differ from the sum of individual initiative reductions due to interaction between them.

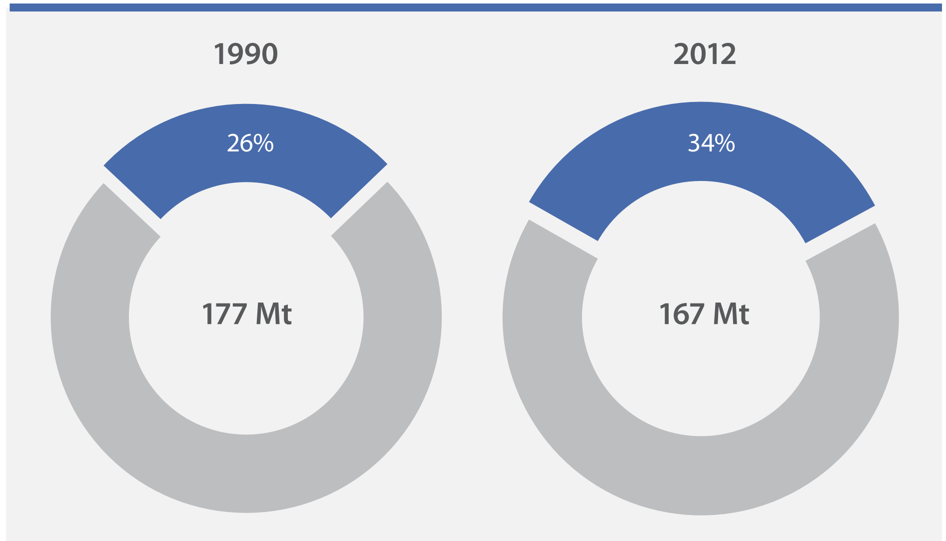
[9] The regional transportation plan is an official long-term plan, produced by Metrolinx. However, capital projects are approved and funded individually as the plan is implemented over 25 years and may be subject to change. Therefore, modelling for this initiative is inherently more uncertain than for other initiatives.
[10] The Green Commercial Vehicle Program ended in 2012.
[11] O. Reg. 535/05 made under the *Environmental Protection Act.*
[12] O. Reg. 97/14 made under the *Environmental Protection Act.*
[13] O. Reg. 216/08; O. Reg. 217/08 made under the *Environmental Protection Act.*

SECTION 2

EMISSIONS BY SECTOR

This section provides specific information about GHG emissions by sector, including a description of the main sources, drivers of trends, a sector-specific forecast and sectoral initiatives.

Transportation Sector



Transportation Emissions

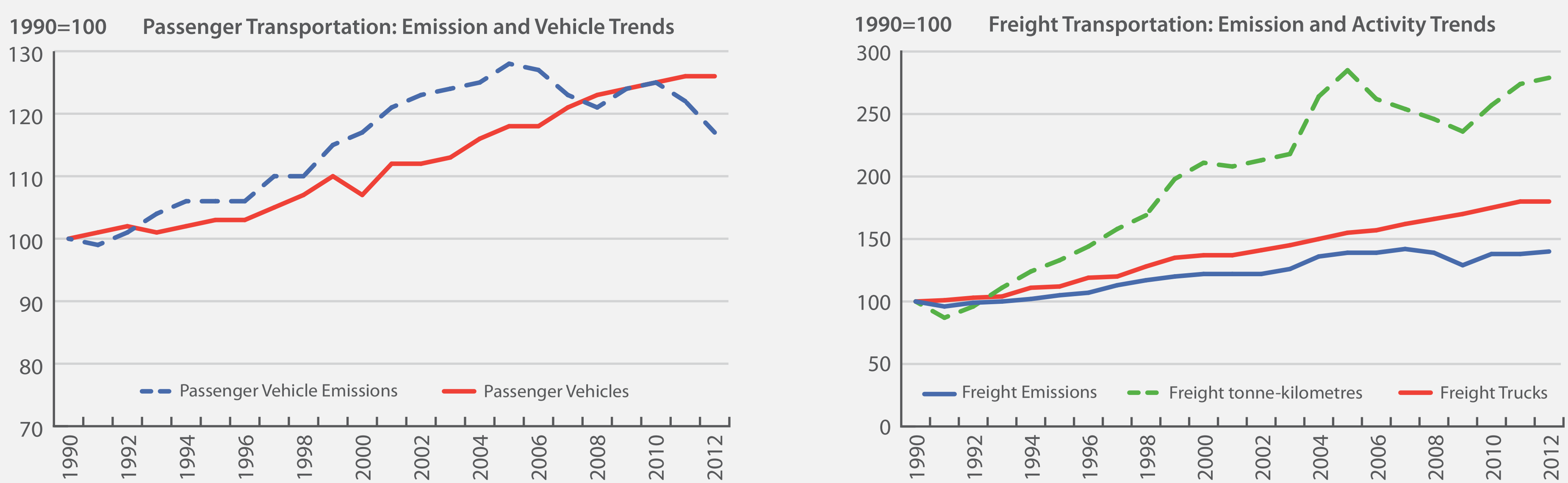
1990: 45.5 Mt
2012: 56.6 Mt
% Change: +24%

For 2012, the transportation sector represents approximately 34% of Ontario's greenhouse gas emissions. Transportation GHGs are emitted from combustion of fossil fuels in vehicles, mainly gasoline and diesel, and mostly from road travel. The largest sources are passenger cars and light-duty trucks, accounting for over half of the sector's emissions. The remainder come from other modes of transportation such as freight trucking and domestic air, ship and rail travel. International air and marine travel are not included in the Inventory. It should be noted that while public transit vehicles (i.e., buses, commuter trains, etc.) are sources of emissions, transit use contributes to reducing overall emissions levels by removing car trips from the road.

TRENDS

Emissions in the transportation sector have grown by 24% since 1990; road transportation is responsible for the greatest increase. **Figure 10** shows how historical emission levels have changed from 1990 to 2012 for passenger vehicles and freight transportation compared to changes in the number of vehicles and amount of freight in tonne-kilometres. A tonne-kilometre represents the measure of freight [tonne] carried over the distance of a kilometre. Through the 1990s, emissions increased as travel increased with population and economic activity. Furthermore, specialization and globalization in the economy have increased the distances freight is shipped. Vehicle efficiency improvements, along with other policies, have contributed to these trends flattening in recent years.

FIGURE 10 Historical Trends in Transportation



Source: the 2014 National Inventory Report: 1990–2012 data; *National Energy Use Database (2014)*

IMPACT OF INITIATIVES

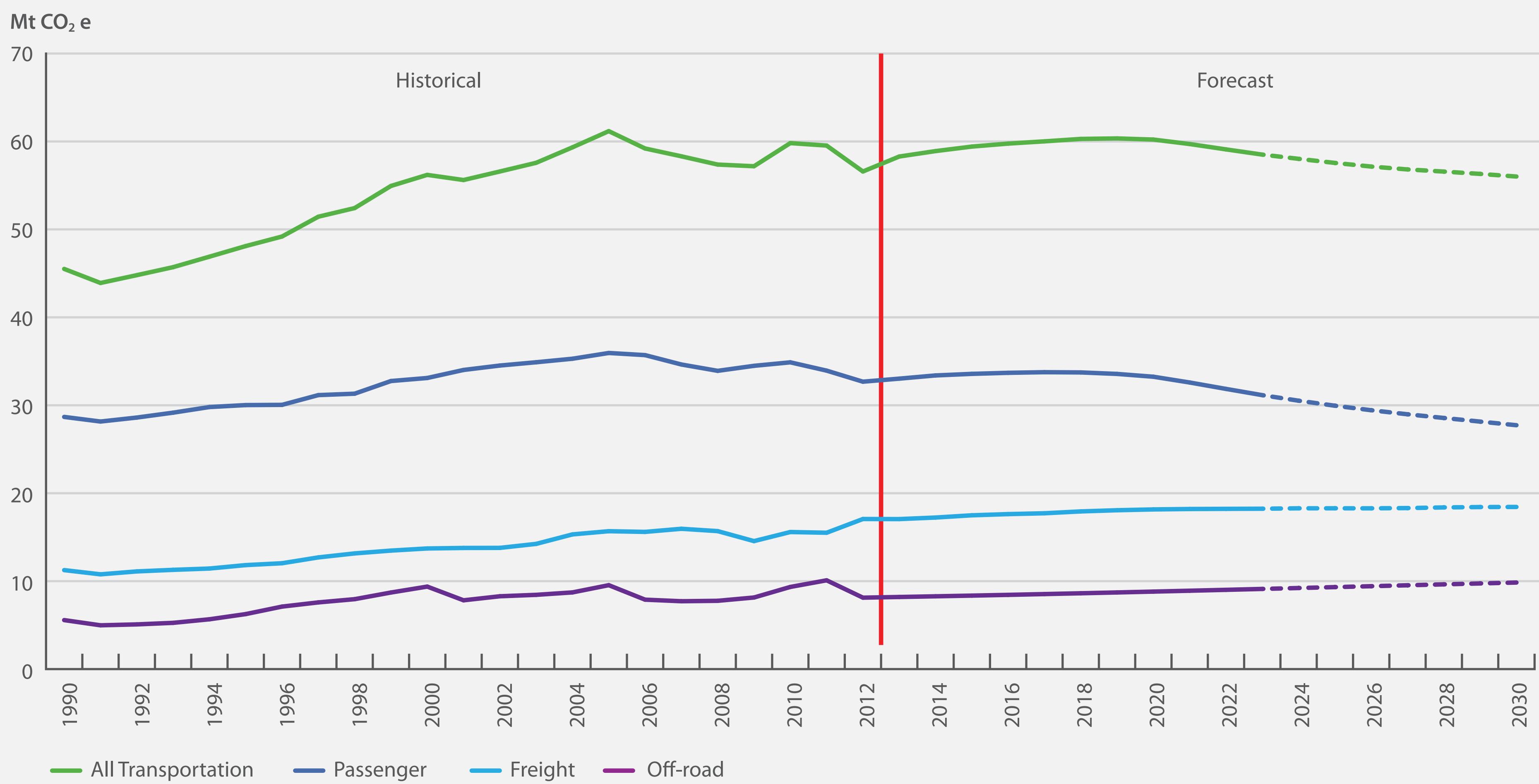
Many policies contribute to more carbon-efficient transportation. Ontario's Ethanol in Gasoline regulation (O. Reg. 535/05) has improved vehicle emission intensities in recent years. The recently introduced Greener Diesel regulation promotes the use of diesel fuels with better environmental performance. Combined with federal fuel efficiency standards, these regulations are expected to continue to improve intensities. Speed limiter requirements for freight trucks also contribute modest reductions.

Investments in public transit; the Provincial Policy Statement, 2014; and Ontario's Growth Plan encourage and promote a shift from individual car trips to car-pooling, land use, densities and mix of uses that minimize length and number of vehicle trips, and encourage the use of transit, walking and cycling — which in turn leads to fewer vehicle kilometres travelled and the associated emissions. For example, in 2012, there was an increase of more than 193 million passenger trips on municipal transit systems, compared to 2003. This has removed approximately 161 million car trips from Ontario roads.

Several major transit projects underway in the Greater Toronto and Hamilton Area (GTHA), Ottawa and Waterloo will come into service by 2020, which are projected to result in overall GHG reductions. As these lines mature and additional transit investments are made, positive impacts will continue beyond 2020.

Figure 11 shows forecast emissions from passenger, freight and off-road transportation out to 2030. The combined impact of transportation initiatives is forecast to be about 4–5 Mt from the business-as-usual projection in 2020. The impacts of current policies do not entirely offset increases that will come from population and economic growth, so near-term emissions are forecast to rise. However, emission growth after 2020 is expected to be tempered by increasing impacts of policies.

FIGURE 11 Historical and Forecast Transportation Emissions

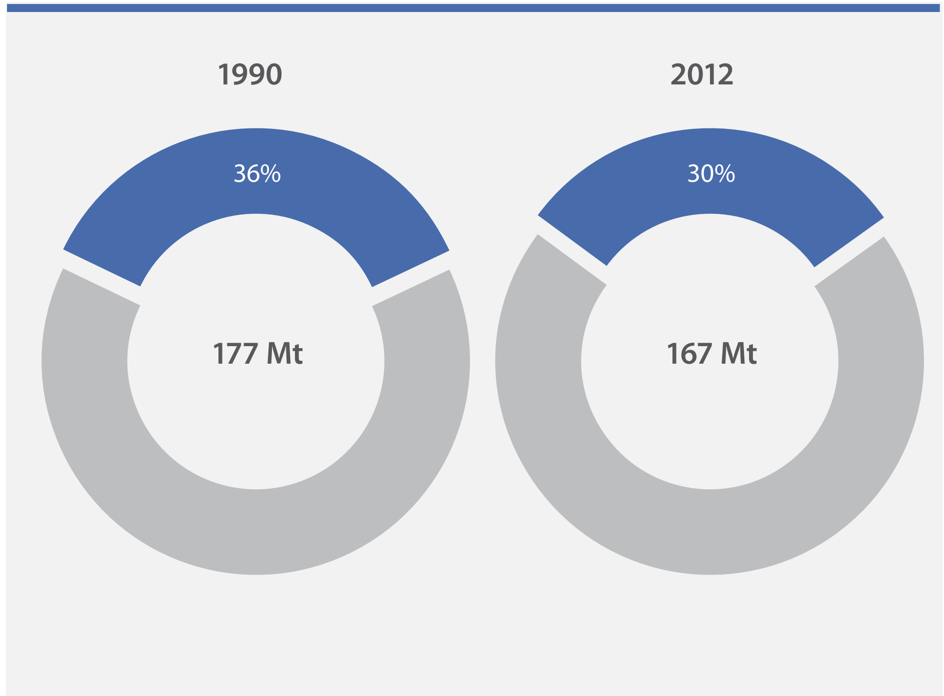


Source: the 2014 National Inventory Report: 1990–2012 data; MOECC forecast

Industrial Sector

In 2012, the industrial sector represents approximately 30% of Ontario's greenhouse gas emissions. Emissions in this sector come from the combustion of fossil fuels, such as natural gas and fuel oil. Some industrial processes themselves emit greenhouse gases. For example, when limestone is transformed into clinker, a precursor to cement, the process releases CO_2. These are called "process emissions."

Large industrial emitters in Ontario are required to report their greenhouse gas emissions.[14] Since small emitters are not required to report, this facility data does not represent the entire industrial sector in Ontario. However, this data is used to corroborate the trends estimated below.



Industrial Emissions

1990: 63.9 Mt
2012: 50.3 Mt
% Change: -21%

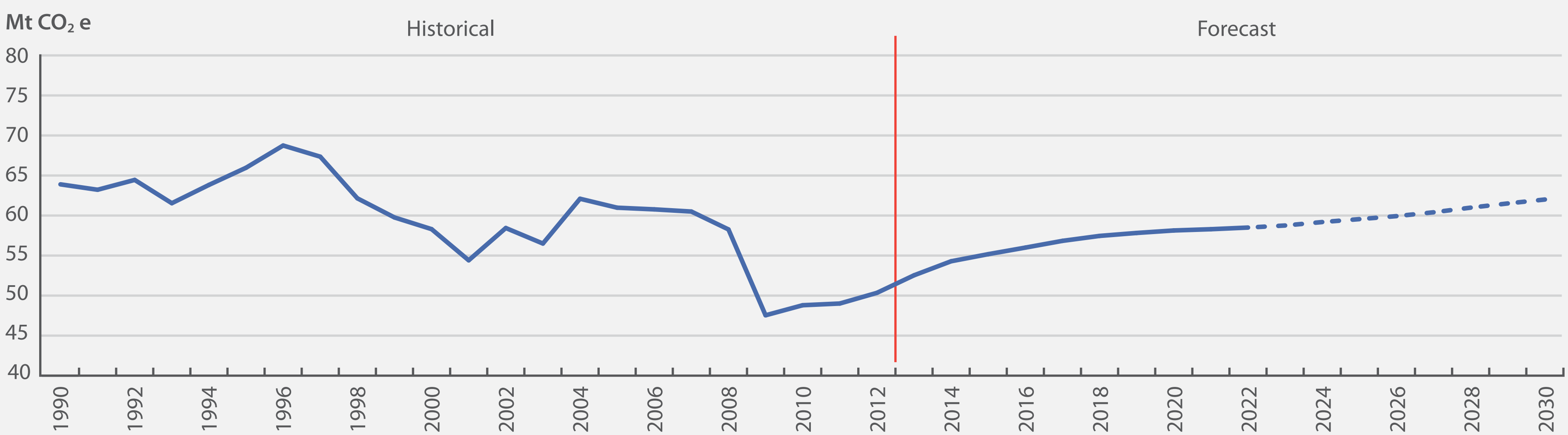
[14] Ontario's industrial emitters' report can be found here: http://www.ontario.ca/environment-and-energy/greenhouse-gas-emissions-reporting-facility.

TRENDS

Ontario's industrial emissions have dropped by 21% since 1990. In some cases, this was due to improvements in energy efficiency. This was also due to shifts in the economy from a predominance of manufacturing to a more diversified economy with a greater share of service industries. The overall improvement does not tell the story of significant variability across industries. For example, pulp and paper production has declined significantly and so too have emissions. Ontario's only adipic acid production plant reduced its emissions when it installed a catalytic emission abatement system in 1997. In 2009 this plant was indefinitely idled.

Figure 12 shows historical emissions from 1990–2012 and forecast emissions to 2030. Emissions decreased 10 Mt (17%) over the 2007–2012 period. This sharp drop was due to the recession; since then, emissions have been increasing. As the economy grows, it will be important to take the opportunity to find ways to level or decrease emission trends.

FIGURE 12 Industrial Emission Trend



Source: the 2014 National Inventory Report: 1990–2012 data; MOECC forecast

In the industrial sector, most emissions are generated by the manufacturing subsector (see Section 3: Methodology for more detail). In 2012, the emission intensity of manufacturing industries, calculated as emissions per dollar of manufacturing GDP, was 34% lower than in 1990.

IMPACT OF INITIATIVES

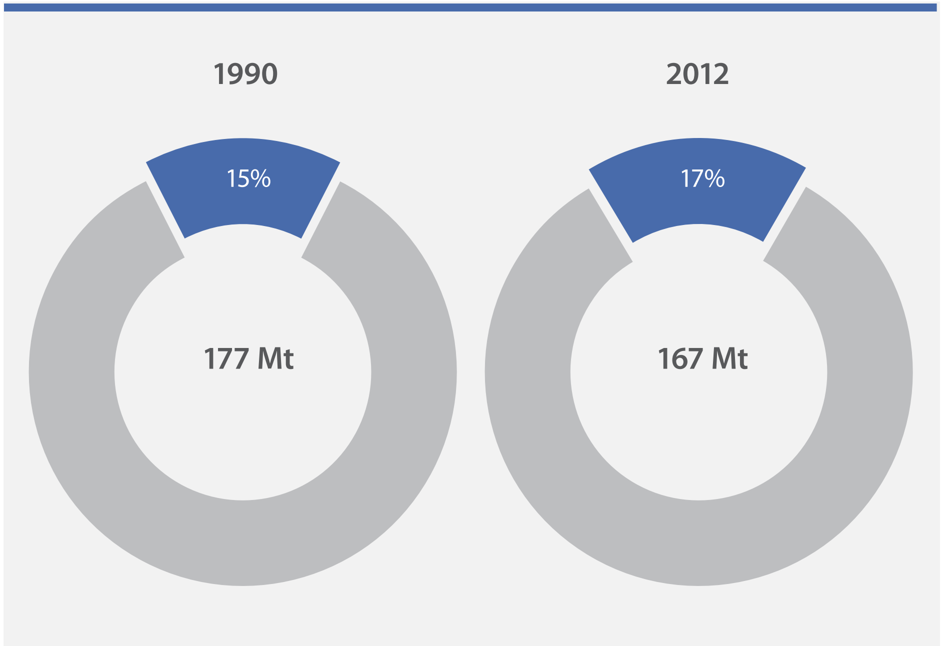
By 2020, total industrial emissions are projected to increase by 15% from the 2012 level, both combustion and process emissions. The carbon intensity of those emissions, measured as emissions per dollar of manufacturing GDP, is projected to decrease. This expected future decrease will likely be consistent with an existing decreasing trend (see **Figure 6**, p. 10).

Natural gas demand-side management programs are expected to reduce approximately 1 Mt of GHGs annually by 2020, compared to business as usual.

Looking ahead to 2020 and beyond, we will look to continue to work with industry towards the goals of clean-tech innovation and high resource productivity. Ideally, highly resource-efficient industries would increase profits and maintain a competitive edge in the global marketplace while reducing greenhouse gas emissions.

Buildings Sector

In 2012, the buildings sector represents approximately 17% of Ontario's greenhouse gas emissions. This sector includes emissions related to fossil fuel combustion — primarily natural gas — for space heating, water heating and other direct emission sources in residential, commercial and institutional buildings. While buildings also use a significant amount of electricity for lighting, air conditioning and appliances, these are considered *indirect emissions* resulting from electricity use and are included in electricity sector emissions.



Buildings Emissions

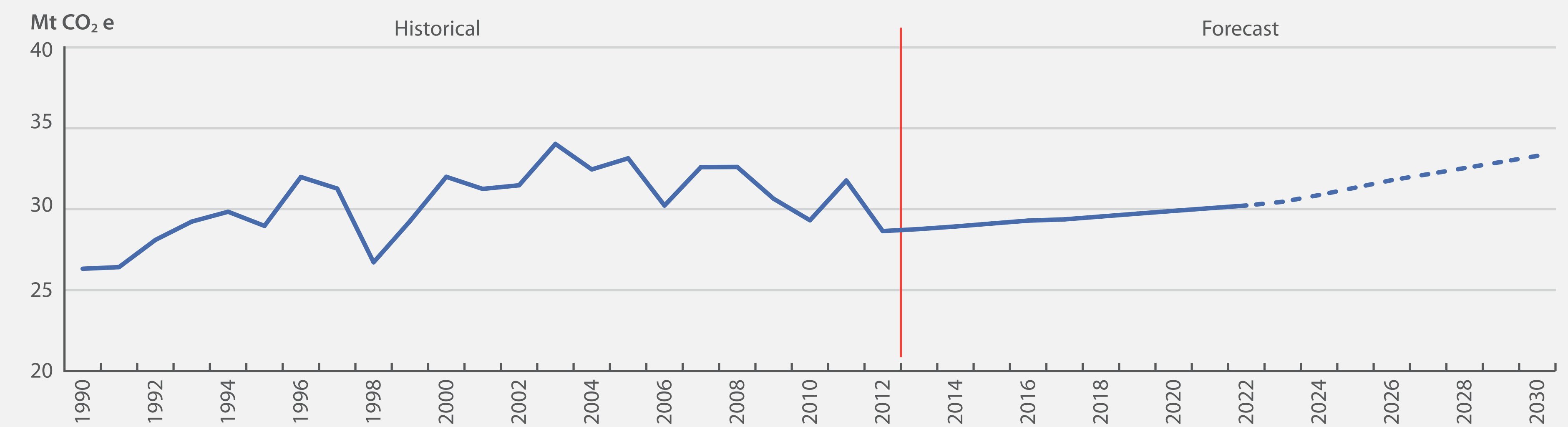
1990: 26.3 Mt
2012: 28.7 Mt
% Change: +9%

TRENDS

In Ontario, emissions in the buildings sector have grown steadily since 1990 along with population and the economy. These trends are expected to continue.

Figure 13 shows historical emissions from 1990–2012 and an emission forecast out to 2030. Annual fluctuations in historical emissions can be attributed to changes in heating demand due to weather and changes in activity in the commercial sector. Building emission intensity improved by about 32% from 1990–2012. This was due to improvements in both the residential (37%) and the commercial/institutional (21%) segments of the sector.

FIGURE 13 Buildings Sector Emission Trend



Source: the 2014 National Inventory Report: 1990–2012 data; MOECC forecast

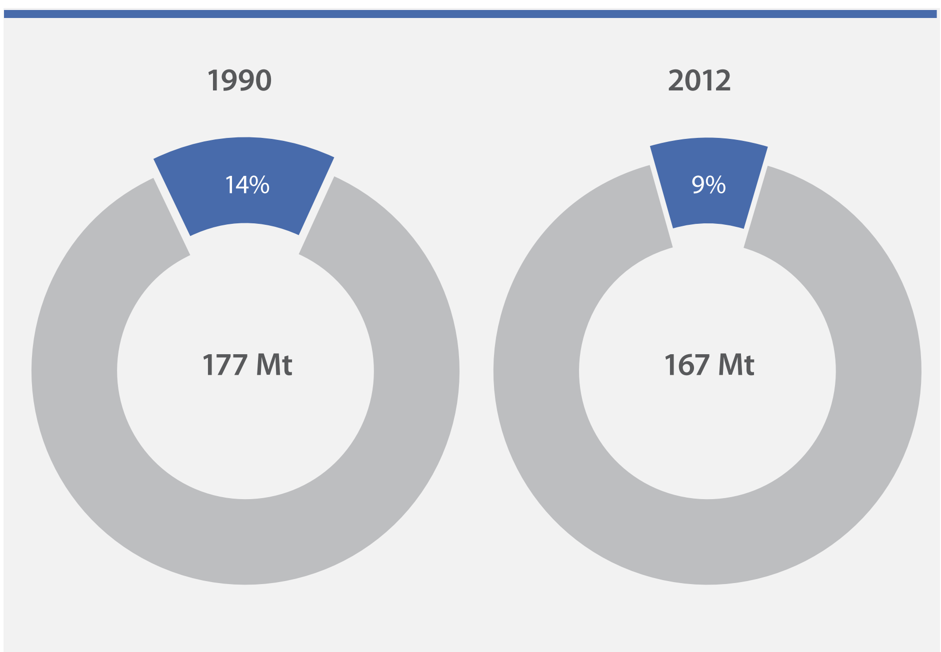
IMPACT OF INITIATIVES

Recent changes to the Ontario Building Code mandate more efficient new buildings. For building stock already constructed, property owners have added insulation, sealed cracks, upgraded windows and have taken advantage of incentives from utilities and government. New furnace standards require higher efficiency appliances. As a result of these and other initiatives, the energy use per square metre in Ontario has decreased by more than 30% (see **Figure 6**, p. 10). The Provincial Policy Statement, 2014 promotes compact land use and development forms that will contribute to the reduction of greenhouse gas emissions from the building sector and the built environment. The expected combined impact of all of the activities described here will be about 2–3 Mt from the business-as-usual projection in 2020.

However, these improvements are not expected to completely counteract emission growth in building space overall — emissions are projected to rise in the coming years.

Electricity Utilities

In 2012, the electricity sector emitted approximately 9% of Ontario's greenhouse gases. Greenhouse gases are emitted from electric generation burning fossil fuels — natural gas or coal in the province. Note that Ontario fully eliminated coal as a source of electricity generation in April 2014. Emissions from the sector are driven by the demand for electricity and the carbon intensity of the generation source.



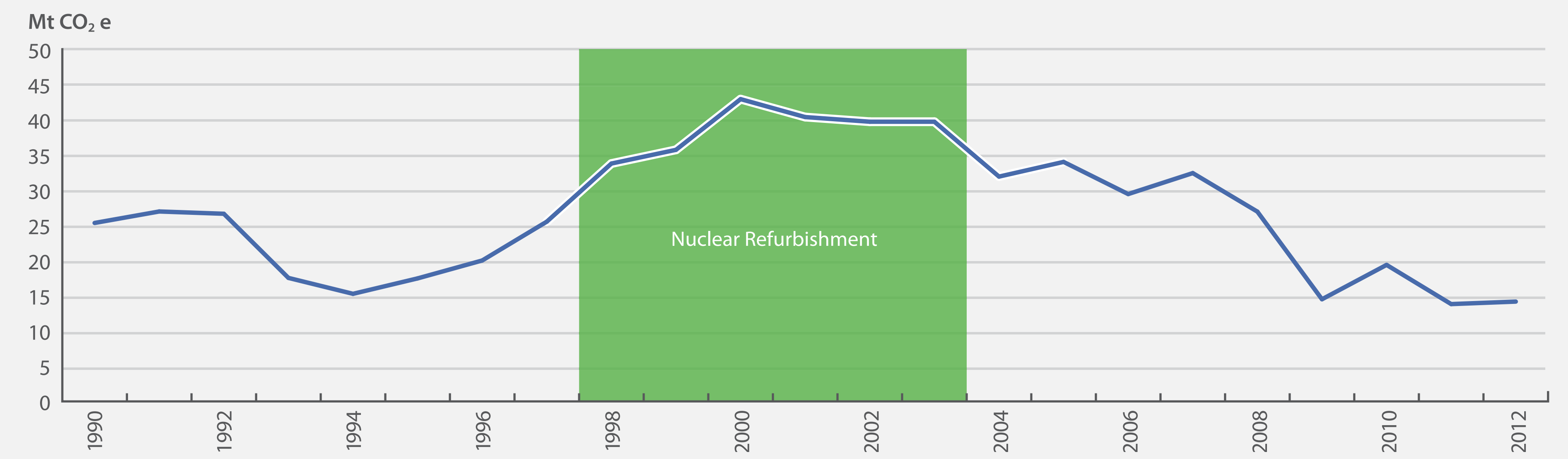
Electricity Emissions

1990: 25.5 Mt
2012: 14.5 Mt
% Change: -43%

TRENDS

There was a sharp increase in Ontario's electricity emissions from the early 1990s to 2000, when coal-fired power plants represented a larger portion of energy generation. Emissions peaked in 2000 at around 70% above 1990 levels and have been decreasing ever since (see **Figure 14**).

FIGURE 14 Electricity Generation Historical Emissions, 1990–2012



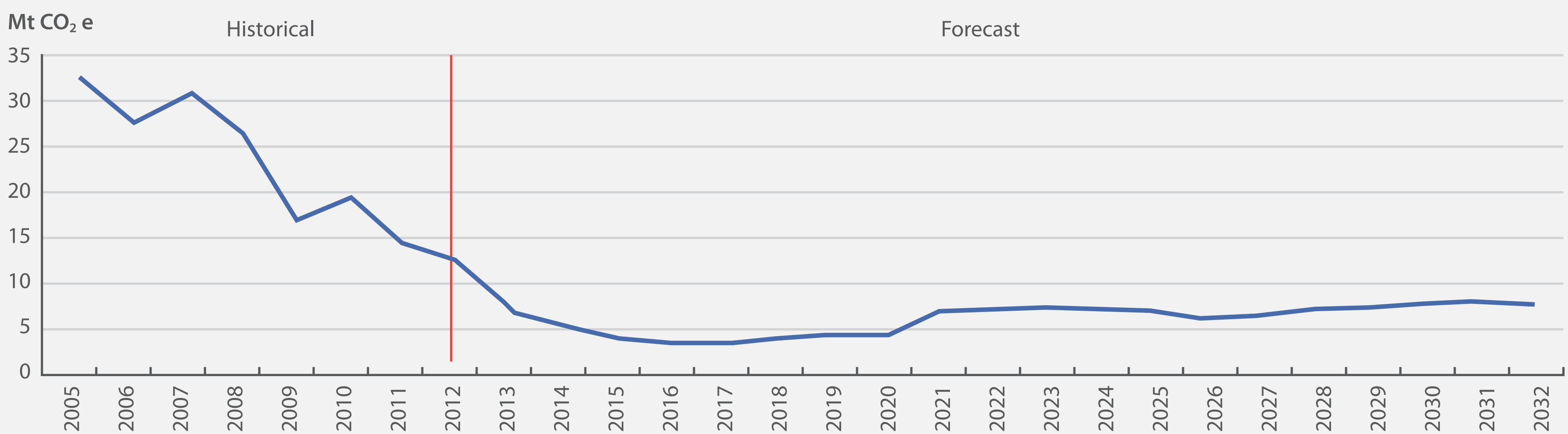
Source: the 2014 National Inventory Report: 1990–2012 data

Since 2007, electricity emissions have decreased due to the phase-out of coal-fired electricity (see above). Emissions in 2012 were about the same as in 2011. Phasing out coal-fired electricity has improved the intensity of electricity in Ontario. Combined with demand management, this reduces the use of fossil fuels by electricity utilities.

IMPACT OF INITIATIVES

Phasing out coal-fired electricity generation is the single largest climate change initiative in North America to date and with associated electricity policies is projected to reduce Ontario's emissions by 32.5 Mt in 2020 from business-as-usual (see **Figure 15**).

FIGURE 15 Electricity Sector Greenhouse Gas Emission Forecast



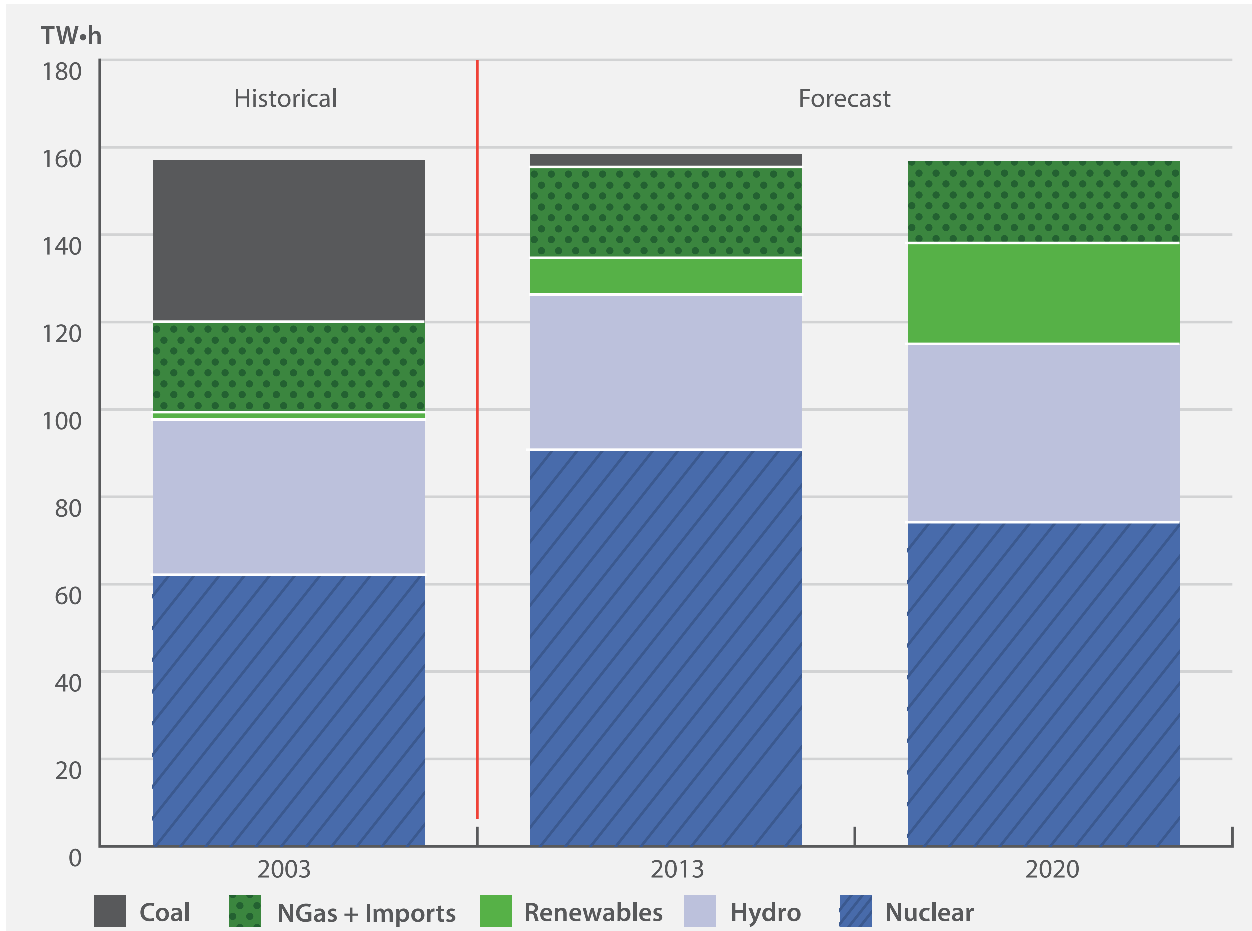
Source: Achieving Balance: Ontario's Long-Term Energy Plan *data (2013)*

Between 2010 and 2014, the Ontario Government reduced the use of coal in power plants, closing or converting all generating units at these plants. *The Green Energy and Green Economy Act*, 2009 and the 2013 *Long-Term Energy Plan* have replaced coal with hydroelectric power, nuclear power, renewable electricity generation, demand management and conservation (see **Figure 16**). In the near term, the power grid will also rely on natural gas generation, so emissions from this sector many increase, especially during the refurbishment of some nuclear plants.

We also note that Ontario's reductions in the carbon intensity of electricity generation means households, businesses and industries have a smaller carbon footprint. This change also provides opportunities for electricity to be a low-carbon alternative to other, more carbon-intense energy sources. For example, the carbon footprint of the operation of an electric vehicle in Ontario is substantially lower not only than that of a gasoline vehicle but also of an electric vehicle used in a jurisdiction dependent on coal-fired electricity.

In the future, we will continue to look to further develop Ontario's clean energy sources and new technologies, as well as promote energy and resource efficiency and conservation across government, and among businesses and individuals.

FIGURE 16 Ontario's Electricity Production by Source

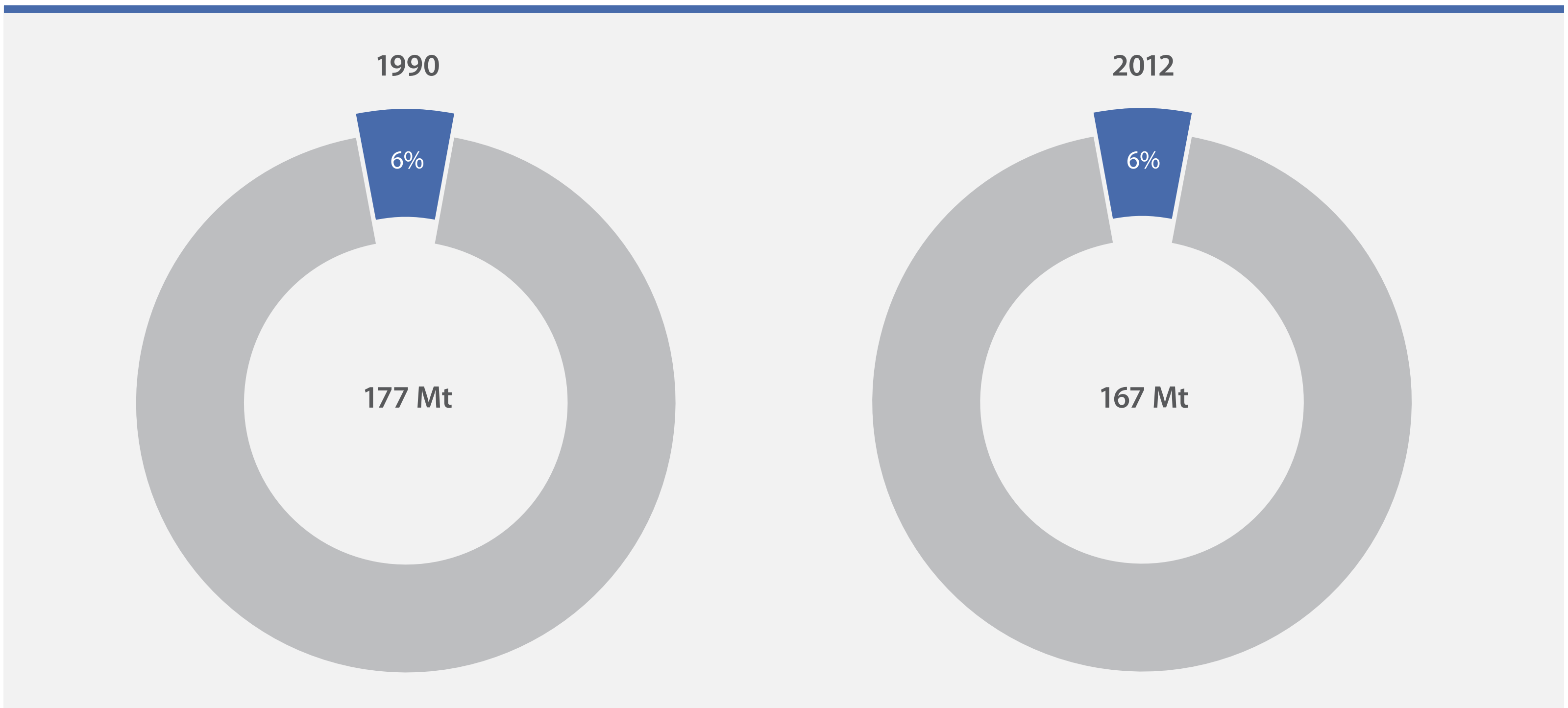


Sources: Ontario's Long-Term Energy Plan: Building Our Clean Energy Future *(2010)*; Achieving Balance: Ontario's Long-Term Energy Plan *data (2013)*

Agriculture Sector

Agriculture has numerous roles with respect to greenhouse gas emissions and the carbon cycle. Many agricultural activities are sources of GHG emissions, while others *remove* carbon from the atmosphere and store it in soils. According to the UN accounting conventions, emissions and removals of GHGs from agricultural lands are part of the Land Use, Land Use Change and Forestry (LULUCF) sector, which are estimated but *not* included in Inventory totals. Ontario does not include LULUCF emissions and removals in this report. Emissions from fossil fuels used in agricultural equipment like combines and tractors are included in the transportation sector, while emissions from fuels used to heat greenhouses are included in the industrial sector.

For the purposes of this report, emissions from the agriculture sector are restricted to livestock and crop production. A more detailed description of the sources can be found in the Inventory.



Agriculture Emissions

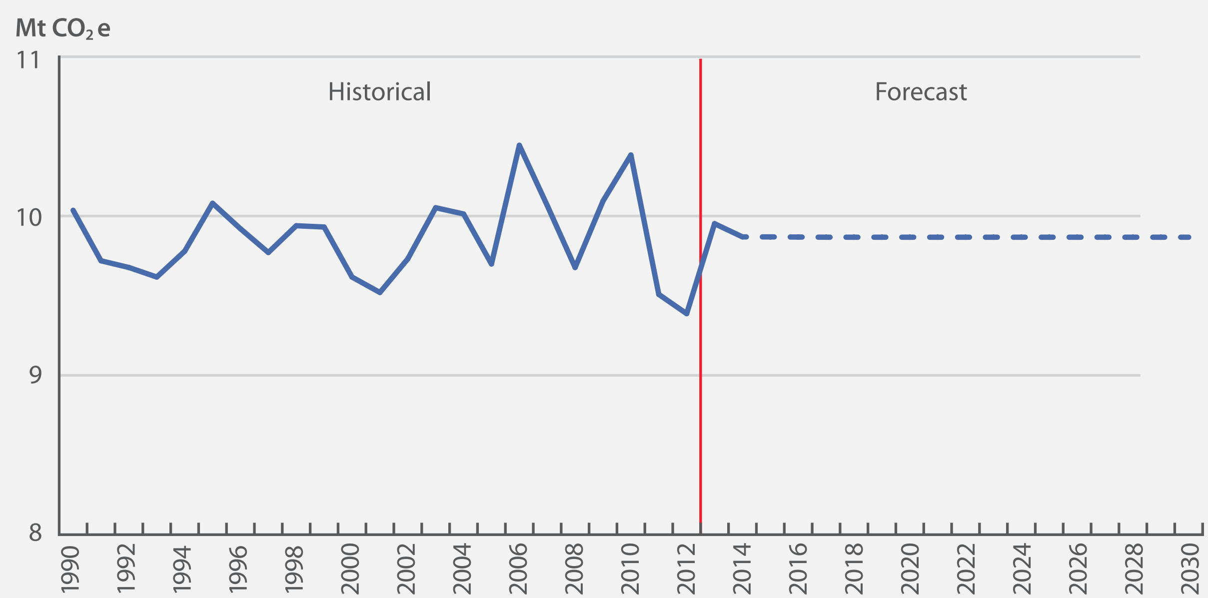
1990: 10.0 Mt
2012: 9.4 Mt
% Change: -6.5%

TRENDS

In 2012, the agricultural sector was responsible for 9.4 Mt (6%) of total GHG emissions in Ontario (6.5% below 1990 levels). Most of the agricultural emissions accounted for in this sector are from the application of nitrogen-based fertilizers and manure to agricultural soils (55%), followed by methane from the digestive processes of livestock (enteric fermentation (29%)) and manure management (16%).

The agriculture sector emissions have remained fairly constant since 1990 (see **Figure 17**).

FIGURE 17 Agriculture Forecast Emissions to 2030



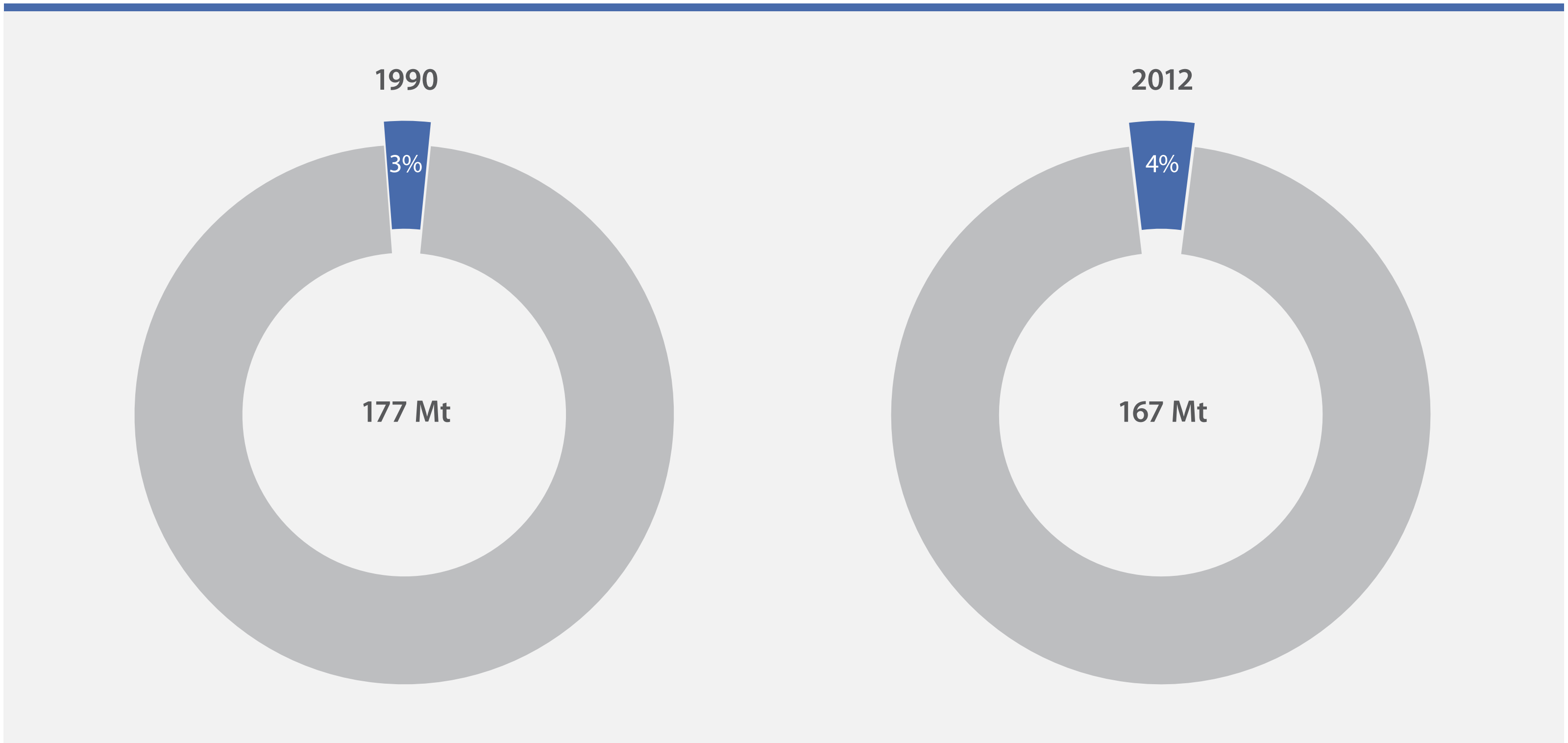
Source: the 2014 National Inventory Report: 1990–2012 data; MOECC forecast

While the direct emissions from agriculture in Ontario are relatively small, the sector plays a critical role in the carbon cycle and the production of biofuels, which can displace fossil fuels in other sectors. On-farm biogas facilities (which were funded under the Ontario Biogas Systems Financial Assistance Program) are expected to achieve a reduction of 11 kilotonnes in 2020. Tillage practices can have an impact on emissions from agricultural soil; however, most of this impact is accounted for in the cropland category of the LULUCF sector and is not included in Ontario's inventory or forecast at this time.

Waste Sector

Emissions from Ontario's waste sector are primarily methane from the disposal of solid waste on land and, to a lesser extent, emissions from wastewater handling and waste incineration. Methane is generated from the decomposition of organic material over time in a landfill. The rate of methane generated depends on the amount and nature of the waste disposed and the conditions of the landfill.

Emissions from landfills are determined using a simulation model to account for the slow, long-term generation and release of these emissions.



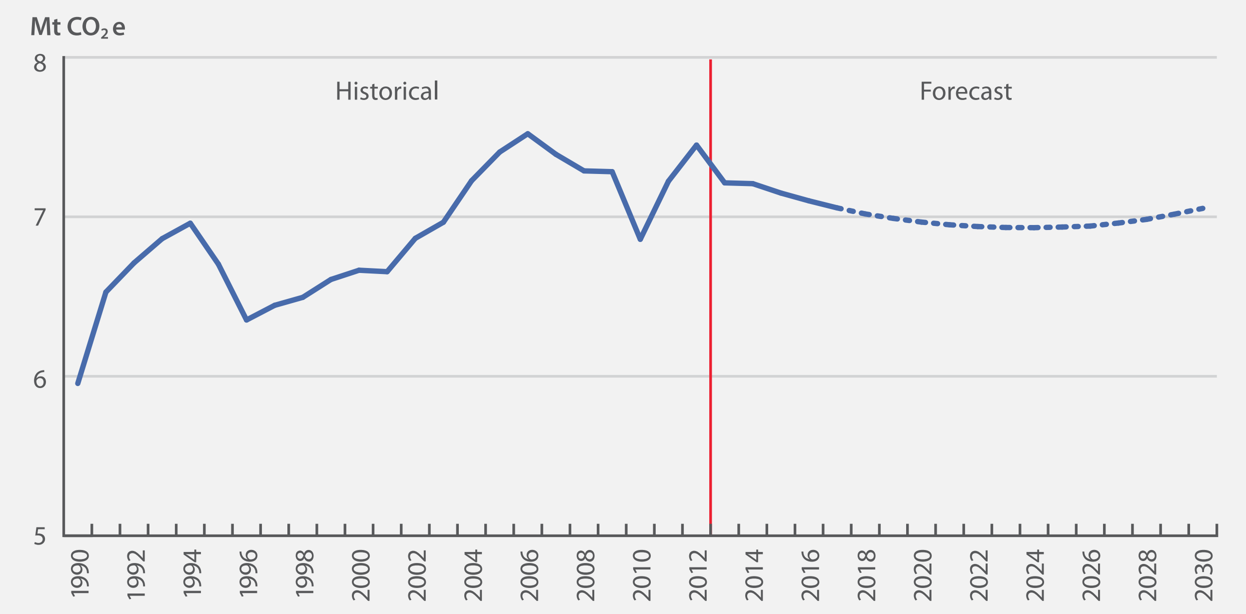
Waste Emissions

1990: 5.9 Mt
2012: 7.5 Mt
% Change: +25%

TRENDS

In 2012, the waste sector in Ontario was responsible for 7.5 Mt (4%) of the total GHG emissions in Ontario. Most of these (92%) came from methane emitted by public and private landfills. **Figure 18** shows the emission trend and forecast for the waste sector. From 1990–2012, emissions grew by 25% as waste disposal on land increased. There are initiatives underway to reverse this trend that could be expanded; for example, by diverting organic matter from landfill and capturing or destroying the methane generated. Methane from landfill gas can also be used to generate electricity or heat.

FIGURE 18 Waste Forecast Emissions to 2030



Source: the 2014 National Inventory Report: 1990–2012 data; MOECC forecast

IMPACT OF INITIATIVES

Waste emissions are expected to remain relatively stable in coming years. Ontario has implemented regulations[15] requiring large landfills to capture and destroy methane generated. To date, 31 landfills are capturing landfill gas and these systems are expected to reduce emissions by 1.8 Mt in 2020.

[15] O. Reg. 216/08; O. Reg. 217/08. Made under the *Environmental Protection Act*.

SECTION 3

METHODOLOGY

How Ontario estimates GHG emissions

Ontario's approach reflects Canada's *National Inventory Report 1990–2012*. Each year, Environment Canada submits an updated Inventory to the United Nations Framework Convention on Climate Change (UNFCCC) secretariat.[16]

Historical emissions in Ontario's report are taken from the latest Inventory, which covers the period 1990–2012. As discussed in the introduction (see p. 5), the data cover most activities in Ontario's economy that influence GHGs but do *not* include impacts relating to land use, land-use change, and forestry at this time.

The Inventory uses numerous categories defined by UNFCCC reporting protocols. It is important to be aware that these often do not match categories used by many sources of economic, industrial and environmental data. For Ontario's report, the categories are rolled up into six key sectors (see **Table 1** on p. 4).

It should also be noted that international air and marine transport are currently not included in national inventories. In this report, the pipeline transportation of petroleum products is included in the industry sector. In addition to pipelines, the main non-manufacturing subsectors included in industry are mining, construction, energy emissions from agriculture and forestry. Emissions from manufacturing comprise more than two thirds of the industry sector, which is why its intensity is calculated using manufacturing GDP.

Improvements in the *National Inventory Report*

Environment Canada continually works to refine the data and methods used to estimate national and provincial emissions. These refinements lead to recalculations or re-statements of emission estimates for the whole time period of the Inventory (dating back to 1990). This means that provincial 1990 base year emissions and historical trends can change with each release of the Inventory — which consequently influences Ontario's emission forecasts and assessment of progress. These recalculations and improvements are documented in each Inventory Report. The improvements made to the inventory since the 2013 report have not significantly changed Ontario's overall emissions or their general breakdown.

[16] Canada's submission can be found here: http://unfccc.int/national_reports/annex_i_ghg_inventories/national_inventories_submissions/items/8108.php.

Emission modelling overview

Ontario's emission forecast has been updated to reflect new Inventory data, macroeconomic forecasts,[17] demographic forecasts,[18] 1–2 more years of program compliance data and the latest Long-Term Energy Plan.[19] This forecast takes into consideration provincial and federal policies up to March 2014 whose impacts on emissions are expected to be significant and can be estimated with reasonable confidence, as well as Ontario's regional transportation plan for the Greater Toronto and Hamilton Area.[20]

Reporting on the progress of Climate Change Action Plan initiatives and projecting future emissions are essential to understanding Ontario's progress towards meeting its targets. Ontario's model is updated periodically to incorporate the latest data available and refinements based on best practices. In addition, the projections of emission reductions are adjusted as required to incorporate data collection and changes to programs or policies.

This information was used to create:

- A *Business-as-Usual* (BAU) projection (assumes underlying historical emission trends continue without impact from reduction initiatives while taking account of the current economic and demographic outlook for Ontario)
- A *Climate Change Action Plan* (CCAP) projection (includes the anticipated future impact of emission reduction initiatives)

Uncertainty

The emission forecasts estimated in this report are based on a single set of economic, demographic, energy, and policy assumptions (except for the absence of policies in the BAU case). As with any modelling of this kind, there are significant uncertainties inherent in this projection.

Projections used to forecast Ontario's emissions usually start with historical emissions. Historical data from the Inventory are estimates of emissions of each greenhouse gas in each sector in each year. They are subject to a range of uncertainties.[21] Generally, uncertainties associated with time series trends and aggregated totals are much lower than those associated with individual gases, sectors, years and provinces. Unfortunately, the Inventory only analyses uncertainties in the national inventory; no assessment is made of uncertainties in provincial breakdowns. At the national level, total emissions from the Inventory's "Energy" category had the least uncertainty, followed (in increasing levels of uncertainty) by "Industrial Process Emissions," "Solvent and Other Product Use," "Waste" and ending with "Agriculture" with the highest levels of uncertainty.

[17] Consistent with Ministry of Finance's projections in Ontario's *Long-Term Report on the Economy* (April 2014).

[18] Consistent with Ministry of Finance's projections in Ontario's *Long-Term Report on the Economy* (April 2014).

[19] Ministry of Energy, *Achieving Balance: Ontario's Long-Term Energy Plan* (November 2013).

[20] Metrolinx, *The Big Move: Transforming Transportation in the Greater Toronto and Hamilton Area* (November 2008); updates to the plan as of February 2013 were also incorporated http://www.metrolinx.com/thebigmove/en/. Note that, although the regional transportation plan is an official long-term plan, capital projects are approved and funded individually as the plan is implemented over 25 years and may be subject to change. Therefore, modelling for this initiative is inherently more uncertain than for other initiatives.

[21] For a more detailed analysis of estimate uncertainty, see Annex 7 of the *National Inventory Report 1990–2012* (2014).

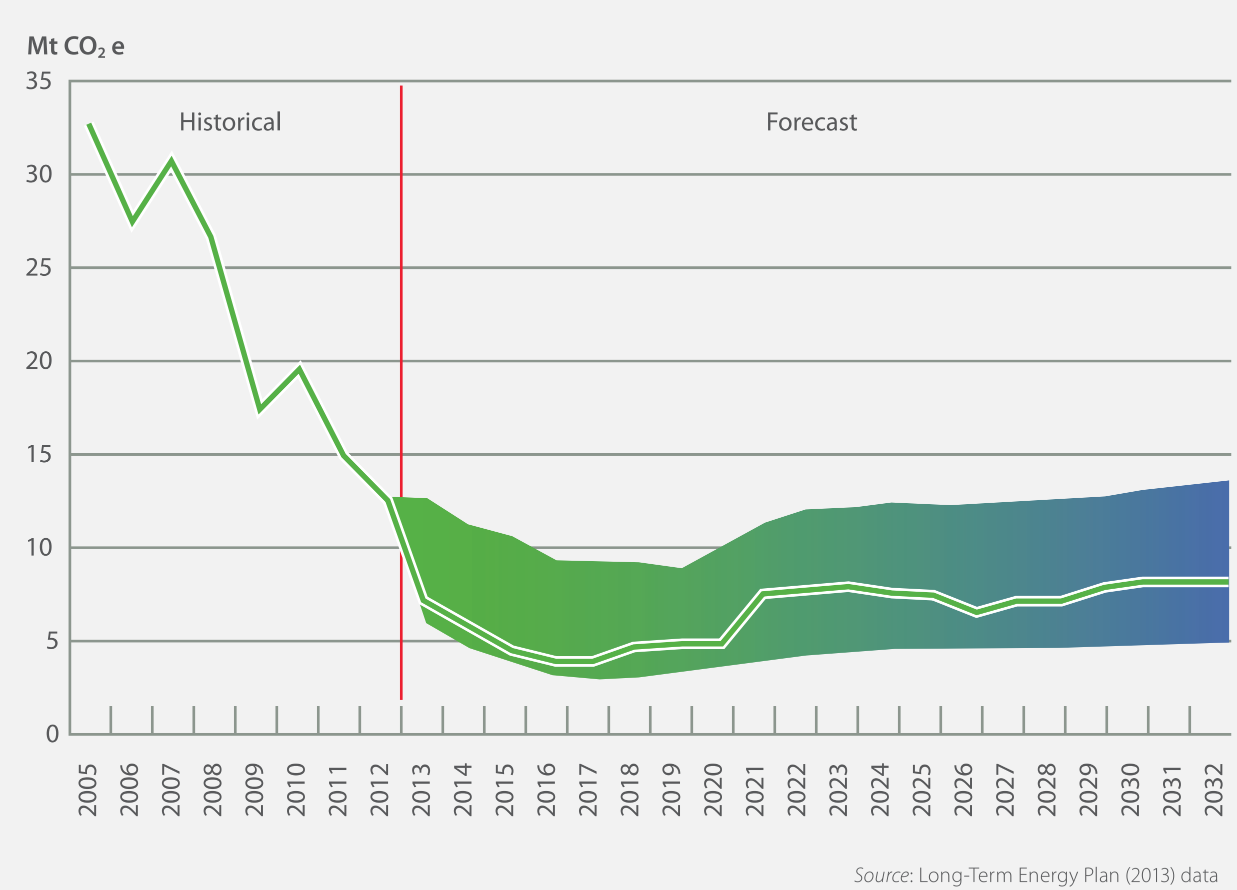
Although the uncertainty in Ontario's forecast is not quantified, the following points can be made about the forecast:

- Trends over time should be less uncertain than individual years
- Policy case emissions should be less uncertain than BAU
- Total aggregate emissions should be less uncertain than sectoral emissions
- Nearer-term (pre-2020) emissions should be less uncertain than later (post-2020) emissions

As a rough example of the model's sensitivity, if in 2020 both real GDP and population were 1% higher than forecast, the projected non-electricity emissions would be almost 1 Mt greater (about 0.5% of non-electricity emissions). This change is a generalized effect — the increase could be significantly higher or lower depending, for example, on whether energy-intensive manufacturing's output is higher than that of the service sector.

On the electricity side, the 2013 *Long-Term Energy Plan* contains a reasonable range for the projected sector emissions (see **Figure 19**). Electricity emissions are sensitive to weather — more frequent hot summer afternoons, especially combined with higher GDP, would increase emissions much further.

FIGURE 19 Range of Electricity Sector GHG Emissions



Source: Long-Term Energy Plan (2013) data

Third-party validation

To provide confidence in the province's forecasts, Ontario has periodically had its emission forecasting methodology and assumptions validated by independent third parties. Starting in 2009, Ontario was the first jurisdiction to undertake a validation of its forward-looking emission reduction forecasts. Validation ensures these are reasonable and align with best practices where available. For Ontario's 2012 climate change report, Ontario retained Navius Research Inc., who concluded the estimates were a fair representation of greenhouse gas forecasts using current best practices in GHG emission forecasting and evaluation of GHG mitigation programs.[22] Since no significant methodological changes were incorporated into the model since Navius's conclusion, the current report has not been validated. Ontario expects that its next report will contain new initiatives and possibly changes to methodologies.

[22] Ontario, *Climate Vision: Climate Change Progress Report* (2012), Appendix C.

Learn more about Ontario’s efforts to address climate change by visiting:

Ontario.ca/climatechange

Ontario

Government of Canada Gouvernement du Canada

Clean Growth and Climate Change

Putting a price on pollution: how it will work

Find out more

Where do Canada's emissions come from and what are we doing to reduce them

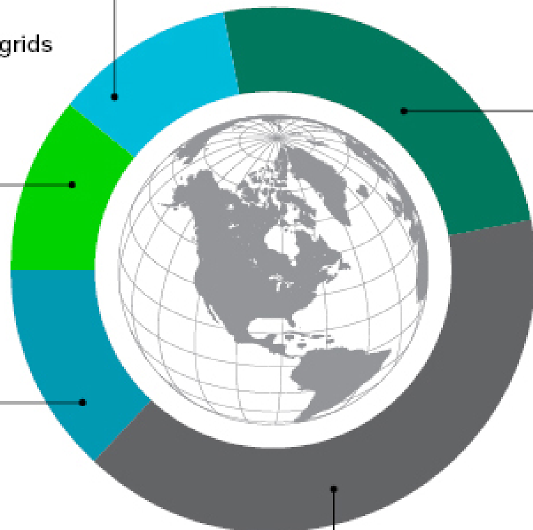
Actions to reduce emissions

11%

HOMES AND BUILDINGS
- Supporting home and building retrofit programs across Canada
- Historic investment in energy efficient social housing
- Model codes for new and existing buildings to improve energy efficiency - net-zero code by 2030
- Energy efficient appliance standards and programs
- Supporting Indigenous communities and governments as they improve the energy efficiency of their homes and buildings
- Phasing out hydrofluorocarbons used in refrigerators and air conditioning systems

ELECTRICITY
- Phasing out pollution from coal-fired electricity
- Increasing investment in renewable energy
- Increasing investment in transmission lines and smart grids
- Supporting rural and remote communities to reduce reliance on diesel

11%



25%

TRANSPORT
- Historic investment in public transit
- Deployment of electric vehicle charging stations
- Zero-emissions vehicle strategy
- Stringent vehicle emissions standards
- Cleaner fuels for vehicles - Clean Fuel Standard

13%

FORESTRY, AGRICULTURE AND WASTE
- Supporting renewable fuels and bioproducts
- Cleaner innovative agriculture (e.g., zero till agriculture, climate resilient crops, precision agriculture)
- Conserving more nature for carbon sequestration
- Reforestation
- Reducing waste including plastic pollution

40%

INDUSTRY
- Historic investment in clean tech and clean business solutions
- Reducing methane in oil and gas sector by 40-45%
- Clean Fuel Standard
- Improving industrial energy efficiency

▶ Long description

Tracking progress

1. Canada's share of clean, non-emitting electricity is already 80%, making Canada's electricity system one of the cleanest in the world. We have set a goal to increase this number to 90% by 2030.

2. We have invested $200 million in the Emerging Renewable Power Program to support renewable power technologies.
3. We are investing $100 million in Smart Grid projects.
4. We have invested in more than 1,000 public transit projects, are building more than 1,000 electric vehicle charging stations, and have invested in more than 50 projects to support cycling and other forms of active transportation.
5. We have announced the $2 billion Low Carbon Economy Fund to support provinces and territories, as well as municipalities, businesses, not-for-profit organizations, and Indigenous communities and organizations by funding projects that reduce carbon pollution, create jobs, and reduce energy usage.
6. We have invested more than $2.3 billion in funding for clean technology in Canada, including:
   a. $256.3 million for 65 Canadian clean tech companies through SDTC
   b. $40 million for four Canadian clean tech companies through BDC, the first wave of a total of $700 million
   c. $542 million in working capital for 189 Canadian clean tech companies through EDC, facilitating over $1.5 billion in Canadian clean tech exports
7. We are seeing strong performance by Canada's clean technology sector, including:
   a. An increase in the value of Canada's clean technology industry of 4.9% over 4 years, from $25.3B in 2013 to $26.7B in 2016
   b. An increase in Canadian clean technology jobs of 1.2% over 4 years, from 175,494 in 2013 to 177,620 in 2016
   c. Exports by Canadian clean technology firms totalling $7.8 billion in 2016
   d. An increase in Canada's ranking in the 2017 Global Cleantech Innovation Index (GCII) from 7th in the last index (2014) to 4th place in 2017
   e. Thirteen Canadian companies are on the 2018 Global Cleantech 100, up from 11 in 2017
   f. Four Canadian companies are among the 10 finalists for the $20M Carbon XPRIZE, by far the most-well represented country out of the finalists
8. Nearly 30 projects in Indigenous and Northern communities are being funded with over $60 million in Northern REACHE funding announced since 2016, a program established to reduce Northern communities' reliance on diesel for heating and electricity. In addition, the Clean Energy for Rural and Remote Communities program will support Indigenous Peoples in reducing their reliance on diesel for heat and energy.
9. The federal government, provincial/territorial governments, major Canadian municipalities and major electric and gas utilities are supporting 268 energy efficiency programs and incentives across the country to help families save money and create jobs.
10. We are funding for more than 350 projects to improve Canada's resilience to the effects of a changing climate, including for Indigenous communities and the North.
11. We are supporting social housing through the National Housing Strategy, a 10 year, $40B plan that will invest in the construction and repair of affordable housing units with a minimum 25% better energy efficiency.

Canada's climate action plan

Pricing pollution is just one part of the plan.

See the climate action plan

Climate action map

See what else we're doing across Canada.

Explore the climate action map

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Long Combination Vehicle (LCV) Program

The Long Combination Vehicle (LCV) Program supports the efficient movement of goods across the province and beyond.

A typical LCV is up to 40 metres long, consisting of a tractor pulling two full-length semitrailers. A standard LCV replaces two 23-metre tractor-trailers.

MTO gradually introduced LCVs onto Ontario roadways by issuing a limited number of permits to a limited number of carriers. This has allowed for a carefully controlled and closely monitored program as part of an effort to build a stronger, greener economy.

The Canada Safety Council reports that LCVs are involved in at least 40% fewer collisions than regular tractor-trailers.

Economic Benefits

- LCVs are good for manufacturers and consumers. They allow Ontario retailers and manufacturers to bring light-weight, bulky goods to market at a lower cost.

Environmental Benefits

- By using less fuel to carry goods, LCVs reduce the greenhouse gas emissions (GHGs) associated with shipping goods by approximately one-third.

Safety

- LCVs have been on the road in Western Canada, Quebec, and numerous American states for decades. They have an excellent safety record, with fewer collisions reported than single-trailer trucks.
- A major study of LCV operations in Alberta showed that LCVs of the type allowed in Ontario had 60 per cent fewer collisions than the conventional tractor-trailers they replace.
- As each LCV replaces two conventional tractor-trailers, the number of collisions is expected to be reduced by 80% as compared to moving the same freight by conventional tractor-trailer.

Requirements and Restrictions

Rules for LCVs include that they:

- Can only operate on designated divided highways (primarily 400-series highways).
- Can only access destination terminals within two kilometres of highway interchanges, and only if routes have been carefully assessed and approved.
- Must have special safety equipment, including enhanced braking requirements and an electronic stability control system.
- May not drive in or through the Greater Toronto Area or the City of Ottawa during rush hours.
- May not carry more weight than existing multi-axle tractor-trailers.
- May not operate at the start and end of long weekends.
- May not carry dangerous goods that would require a warning on the vehicle's exterior.
- May not carry livestock.
- Must avoid driving in bad weather or slippery conditions.
- May not exceed 90km/hr.

Special requirements for LCV drivers include that they:

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- Must be experienced tractor-trailer operators with a good safety record.
- Must obtain and carry an LCV Driver's Certificate based on specialized and comprehensive training and road testing.

Learn more about the LCV program

- Read the Ontario LCV Program Conditions
- LCV Program - Primary Network Maps (PDF - 871 KB)
- LCV Program Questions and Answers
- Find LCV Permit and Origin / Destination application forms

Recommended for you

- Commercial vehicle operator's registration
- Oversize-overweight permits
- Commercial vehicle safety

Ontario

Greener diesel regulation

Learn about environmentally friendly diesel fuels and the new laws that apply to diesel supply companies in Ontario.

Overview

By law, Ontario requires fuel companies to provide more environmentally friendly diesel fuels, known as bio-based diesel fuels. This helps:

- reduce air pollutants
- improve air quality
- cut greenhouse gas emissions in the transportation sector — the largest contributor of greenhouse gas emissions in Ontario

What is bio-based diesel fuel

There are 2 types commonly available:

1. **Biodiesel** is a clean-burning renewable fuel made from vegetable oils, recycled frying oils, and animal fats. A vehicle using biodiesel-blended diesel emits lower amounts of greenhouse gases and other pollutants. You can use biodiesel-blended diesel fuel as you would diesel fuel, however, your vehicle may need additional maintenance.
2. **Renewable diesel** is made from the same materials as biodiesel but it is processed differently. It is almost the same chemically as regular diesel. You can use it anywhere you would use regular diesel.

New diesel rules

Ontario is introducing rules to lower the environmental impact of diesel fuel. These rules will reduce air pollutants, improve air quality and cut greenhouse gas emissions in the transportation sector (the largest contributor of greenhouse gas emissions in Ontario).

New bio-based diesel requirements

The province has set minimums for the amount of bio-based diesel in the diesel fuel distributed, used, and/or sold in Ontario.

The content requirements will be phased-in over 3 years from 2014 to 2017. The first compliance period spans 21 months, beginning April 1, 2014 and ending December 31, 2015. Subsequent periods follow the calendar year. The requirements are as follows:

In **2014/15**, 2% of the total volume of diesel fuel must be bio-based. The bio-based diesel component of this blend must have 30% lower greenhouse gas emissions than standard petroleum diesel.

In **2016**, 3% of the total volume of diesel fuel must be bio-based. The bio-based diesel component of this blend must have 50% lower greenhouse gas emissions than standard petroleum diesel.

In **2017**, 4% of the total volume of diesel fuel must be bio-based. The bio-based diesel component of this blend must have 70% lower greenhouse gas emissions than standard petroleum diesel.

Compliance reports

Under these new rules, suppliers must also complete and file compliance reports.

Reports are due by March 31 of the year following the compliance period. For example, you must file by March 31, 2017 for the 2016 compliance year.

Your report must confirm:

- the amount of diesel and bio-based diesel in diesel fuel that you have placed in the Ontario market
- the environmental performance specifications of the bio-based diesel.

You must keep a copy of your compliance reports and related records for **7 years**. The document, Guide and Director's Directions – Renewable Fuel Content Requirements for Petroleum Diesel Fuel (http://www.downloads.ene.gov.on.ca/envision/env_reg/er/documents/2015/012-4413_FinalGuide.pdf) , can help you complete your report.

How to submit a report

E-mail us (mailto:fuels-report@ene.gov.on.ca) to request the latest reporting form.

You can return the form via E-mail (mailto:fuels-report@ene.gov.on.ca) or mail it to:

Assistant Director, West Central Region
Ministry of the Environment and Climate Change
Ellen Fairclough Building
12th Floor, 119 King St W
Hamilton ON L8P 4Y7
Re: Ontario Regulation 97/14 (Greener Diesel)

Who must comply

Fuels suppliers who:

- import diesel fuel into the province — and use or sell it in Ontario (wholesale or retail)
- manufacture or blend diesel fuel — and use or sell it in Ontario (wholesale or retail)
- acquire diesel fuel through an inter-refiner agreement — and use or sell it in Ontario (wholesale or retail)

Source law

You can find a complete set of provincial laws related to this activity in:

- Environmental Protection Act (http://www.e-laws.gov.on.ca/html/statutes/english/elaws_statutes_90e19_e.htm)
- Ontario Regulation 97/14 (http://www.e-laws.gov.on.ca/html/source/regs/english/2014/elaws_src_regs_r14097_e.htm)

Quality standard requirements

You must ensure your blended fuel meets certain standards before it's distributed - for use or sale - in the Ontario market.

1. For low-level (0-5%) bio-based diesel blends, the latest standards are set out in:

   Canadian General Standards Board (CGSB) standard CAN/CGSB – 3.520-2011 – Automotive Diesel Fuel Containing Low Levels of Biodiesel (B1-B5) (https://www.scc.ca/en/standardsdb/standards/26268)
2. For mid-level (6-20%) bio-based diesel blends, standards are set out in:

   Canadian General Standards Board (CGSB) standard CAN/CGSB – 3.522-2011 – Diesel Fuel Containing Biodiesel (B6-B20) (https://www.scc.ca/en/standardsdb/standards/26270)

   American Society for Testing and Materials (ASTM) standard ASTM – D7467-13 – Standard Specification for Diesel Fuel Oil, Biodiesel Blend (B6 to B20) (http://www.astm.org/Standards/D7467.htm)
3. For high-level (21-100%) bio-based diesel blends, standards are set out in:

   Canadian General Standards Board (CGSB) document CAN/CGSB – 3.524-2011 – Biodiesel (B100) for Blending in Middle Distillate Fuels (https://www.scc.ca/en/standardsdb/standards/26272)

   American Society for Testing and Materials (ASTM) document ASTM – D6751-12 – Standard Specification for Biodiesel Fuel Blend Stock B100 for Middle Distillate Fuels (http://www.astm.org/Standards/D6751.htm)

Updated: June 28, 2018
Published: October 14, 2015

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Highway 401 Expansion Project

» About the Project
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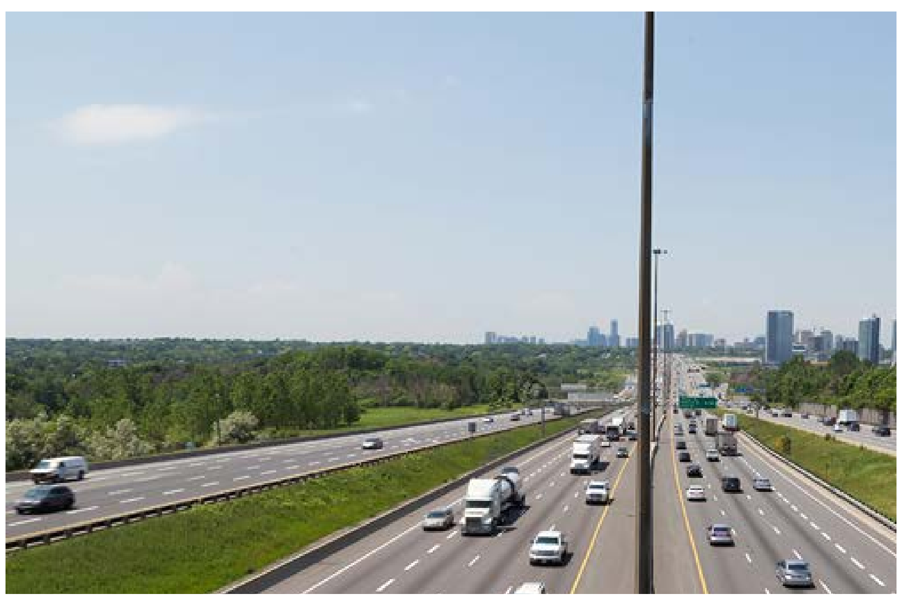
Location:
Greater Toronto Area

Project Type:
DBF - Design Build Finance

Infrastructure Type:
Transportation

Contract Value:
To be announced at Financial Close

Estimated Value for Money:
To be announced at Financial Close



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About the Project:

The Highway 401 expansion project is approximately 18 kilometers long and is located within the western part of the Greater Toronto Area, from the Credit River in Mississauga to Regional Road 25 in Milton.

Status

Request for Qualifications:
Mar 29, 2017

Prequalified Bidders Selected:
Sep 29, 2017

Request for Proposals:
Feb 28, 2018

Winning Bidder Selected:

Construction Begins:

Construction Ends:

Latest News

- Request for Proposals Closed - Nov. 6, 2018
- Request for Proposals

Features

- 12 lane core-collector system from the Credit River to Winston Churchill Boulevard;
- 10 lanes from Winston Churchill Boulevard to Highway 407 ETR/

Issued - Mar. 7, 2018

» Prequalified Bidders Selected - Sept. 29, 2017

Highway 401 interchange;
- 12 lane core-collector system from Highway 407 ETR/ Highway 401 interchange to east of the James Snow Parkway;
- 10 lanes from the James Snow Parkway to west of Regional Road 25;
- Median HOV lanes; and
- Support facilities and features - drainage, lighting, signage, ATMS, carpool lots etc.

Community and Green Benefits

- reduced traffic congestion, greenhouse gases and fuel consumption
- improved quality of life for commuters by reducing daily travel time

Economic Benefits

Design and construction of the project will generate employment opportunities, produce significant benefits for commuters.

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- Metrolinx
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- Request for Qualifications Issued - Apr. 10, 2017
- Prequalified Bidders Selected - Sept. 29, 2017
- Request for Proposals Issued - Mar. 7, 2018
- Request for Proposals Closed - Nov. 6, 2018

- Request for Proposals

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Ministry review of the Gardiner Expressway and Lake Shore Boulevard East reconfiguration environmental assessment

The ministry's evaluation of the environmental assessment for a project to address current problems and opportunities along the Gardiner Expressway and Lake Shore Boulevard East corridor, from Jarvis Street to Leslie Avenue.

On this page

Environmental Assessment Act, R.S.O. 1990, Subsection 7(1)

This Review is subject to the provisions of *Ontario Regulation 616/98* which sets out a deadline for the completion of this document. This paragraph and the giving of the Notice of Completion are the notices required by subsection 7(3) of the *Environmental Assessment Act* (EAA).

The Review documents the ministry's evaluation of the Environmental Assessment (EA) and takes comments from government agencies, the public, and Indigenous communities into consideration.

Executive summary

Who

The City of Toronto and Waterfront Toronto

What

Ministry Review of an Environmental Assessment (EA) for the proposed undertaking which includes:

1. The removal of the existing Gardiner Expressway east of Cherry Street to the Don Roadway, and the construction of a new elevated expressway link with the Don Valley Parkway.
2. The construction of a realigned Lake Shore Boulevard East (to be moved further north from its current location) from Cherry Street to Don Roadway, with new ramps to and from the Gardiner Expressway.
3. Reconstruction of Lake Shore Boulevard East of the Don River to Logan Avenue including a reconstructed Don River Bridge.
4. Public Realm Improvements that would extend the full length of the corridor from Jarvis Street to Leslie Street (e.g. streetscaping, multi-use trail, landscaping, etc.).

When

EA submitted: January 27, 2017

EA amended: April 28, 2017

Construction period is estimated to occur between 2018 and 2025. The project is expected to meet transportation demand until 2031 and beyond.

Where

The 2.4 kilometre portion of the Gardiner Expressway and Lake Shore Boulevard East, from approximately Lower Jarvis Street to approximately Leslie Street, north of the Keating Channel, in the City of Toronto.

Why

For decades there have been calls to consider reconfiguration options for this transportation corridor that would better balance modes of transportation and create new and improved connections between the City and the waterfront. More recently, urgency to manage deteriorating components of the elevated structure and to invest significant money in the long-term rehabilitation of the Gardiner Expressway have ignited interest to consider alternative configurations for this infrastructure. The expressway surface (deck) and concrete barriers east of Jarvis Street are in poor condition and are considered to be at the end of their service life.

Conclusions

The Ministry Review concludes that the Environmental Assessment (EA) was prepared in accordance with the approved Terms of Reference (ToR) and contains sufficient information to assess the potential environmental effects of the proponents' undertaking. The EA demonstrated that the City of Toronto and Waterfront Toronto will be able to meet the objectives set out in various City land use plans and transportation plans. Most of the issues raised by government agencies during the EA process were addressed in the EA and future commitments. A number of standard conditions are proposed in order to ensure that the project proceeds as outlined and persons and agencies with an interest in the project will continue to be consulted.

Environmental assessment process

The *Environmental Assessment Act* (EAA) provides a proponent driven planning process designed to incorporate the consideration of the environment into decision-making by assessing the effects of an undertaking on the environment. In Ontario, the EAA sets out the general contents for the preparation of an Environmental Assessment, as well as the Ministry of the Environment and Climate Change's (MOECC or ministry) evaluation process. For those proponents and undertakings subject to the EAA, approval under the EAA is required before the undertaking can proceed.

Proponents address a wide range of potential effects on the natural, social, cultural, and economic environments to ensure the protection, conservation, and wise management of the environment. An EA determines, on the basis of the environmental effects, if an undertaking should proceed, and if so, how environmental effects can be managed or mitigated.

EAs may identify a problem or opportunity, consider alternative ways of addressing the problem or opportunity, evaluate the environmental effects of the alternatives and select a preferred undertaking from the alternatives. The proponent must consider actions to avoid, reduce and mitigate potential environmental effects. While preparing the EA, the proponent completes various studies and consults with interested stakeholders including government agencies, the public and affected Indigenous communities to evaluate the alternatives and determine the preferred undertaking. Once the undertaking is approved, the proponent is required to monitor and demonstrate compliance with standards, regulations and guidelines of the EAA approval.

1.1 Terms of reference

Preparing an EA is a two-step application to the Minister of the Environment and Climate Change

(Minister). The first step requires the proponent to prepare and submit a Terms of Reference (ToR) to the ministry for review and approval. The ToR is the work plan or framework for how the EA will be prepared.

On November 30, 2009, the Minister approved the City of Toronto's and Waterfront Toronto's (proponents') ToR. The ToR established the purpose of the study, which was to determine the future of the eastern portion of the elevated Gardiner Expressway and Lake Shore Boulevard from approximately Lower Jarvis Street to just east of the Don Valley Parkway (DVP) at Logan Avenue. The rationale for the undertaking was identified, and included five project goals: to revitalize the waterfront, reconnect the City with the lake, balance modes of travel, achieve sustainability, and create value.

The ToR identified problems and opportunities to be addressed. Problems to be addressed include a deteriorated Gardiner Expressway that needs major repairs and a disconnected waterfront. Key opportunities include revitalizing the waterfront through city building, creating new urban form and character, and new public realm space.

The ToR identified four study lenses—transportation and infrastructure, urban design, economics and environment—through which the EA study was to be prepared. The ToR provided an overview of the existing environment and potential effects, identified "alternatives to" the undertaking which included the Maintain, Improve, Replace and Remove alternatives, and identified that alternative methods (locations and designs) of carrying out the undertaking would be developed as part of the EA.

The ToR set out how the proponents would evaluate alternatives and assess potential environmental effects and benefits of the alternatives.

The ToR included a monitoring strategy and monitoring schedule, and included a consultation plan for consultation with the public, Indigenous communities, and government agencies during the preparation of the EA.

1.2 Environmental assessment

Once the ToR is approved by the Minister, the proponents can proceed to the second step of the EA process and carry out the EA. The EA must be prepared in accordance with the approved ToR and the requirements of the EAA. Once the proponents have carried out the EA, including consultation, the EA is submitted to the ministry for review and a decision.

A draft EA was made available to the public and agencies between July 21, 2016 and September 6, 2016. On January 27, 2017, the proponents submitted the Gardiner Expressway and Lake Shore Boulevard East Reconfiguration EA and Urban Design Study to the ministry for approval for the proposed undertaking. The EA submission comment period ended on March 17, 2017.

The EA was circulated for review to local government agencies known as the Government Review Team (GRT). The GRT, including federal, provincial, and local government agencies, reviewed the EA to ensure that the information and conclusions of the EA were valid, based on their agencies' mandates. The public and Indigenous communities also had an opportunity to review the EA and submit their comments to the ministry. All comments received by the ministry are considered by the Minister before a decision is made about the undertaking.

Based on comments received from the ministry, the proponents amended the EA to clarify the net environmental effects (after mitigation) associated with the consideration of the various "alternatives to" (the Maintain, Improve, Replace and Remove alternatives), update the Indigenous communities consultation record, provide additional studies on cultural and archaeological resources, and include additional commitments to further work and consultation. The EA was amended by the proponents in April 2017 and a copy of the amended EA and supporting documents were included on the proponents' web site.

1.3 Ministry review

The EAA requires the ministry to prepare and publish a review of the EA, known simply as the Ministry Review (Review). The Review is the ministry's evaluation of the EA. The purpose of the Review is to determine if the EA has been prepared in accordance with the approved ToR, meets the requirements of the EAA, and whether the evaluation in the EA is sufficient to allow the Minister to make a decision about the proposed undertaking.

The Review outlines whether the information contained in the EA supports the recommendations and conclusions for the selection of the proposed undertaking. Ministry staff, with input from the GRT, evaluates the technical merits of the proposed undertaking, including the anticipated environmental effects and the proposed mitigation measures. The Review also provides an overview and analysis of the public, government agency, and Indigenous community comments on the EA and the proposed undertaking.

The Minister of the Environment and Climate Change considers the conclusion of the Review when making a decision. The Review itself is not the decision-making mechanism. The Minister's decision on the undertaking described in the EA will be made following the end of the five-week comment period on the Review. The Minister's decision is subject to the approval of the Lieutenant Governor in Council.

The Review comment period allows the GRT, the public, and Indigenous communities to see how their concerns with the EA and the proposed undertaking have been considered. During the Review comment period, anyone can submit comments to the ministry on the EA, the undertaking, and the Review. In addition, anyone can request that the Minister refer the EA, or any matter relating to the EA, to the Environmental Review Tribunal for a hearing if they believe that there are significant outstanding environmental effects that the proponents have not considered in the EA. Requests for a hearing can only be made during this comment period. The Minister will consider all requests and determine if a hearing is necessary.

A Notice of Completion of the Review was published indicating that the Review has been completed and is available for a five-week comment period. Copies of the Review have been placed in the same public record locations where the EA was available as well as the ministry website. Copies have been distributed to the GRT members and potentially affected or interested Indigenous communities. Those members of the public who submitted comments during the EA comment period have been notified where to view copies of the Review.

The proposed undertaking

Historical context

Construction on the Frederick G. Gardiner Expressway began in 1955, a time when Toronto's waterfront was still considered a heavy industrial area. Since the late 1980s, the City of Toronto has taken interest in reducing the barrier effect of expressway on the waterfront through the downtown area. In 1991, the Royal Commission on the Future of the Toronto Waterfront produced a study which examined the retention, removal, or burial of the expressway between Dufferin and Leslie streets. Between 1999 and 2001, the 1.3 kilometre segment of expressway between the Don River and Leslie Street was dismantled.

In 2003, Toronto City Council approved the Central Waterfront Secondary Plan which identified the reconfiguration of the Gardiner expressway as one of 23 key priorities. As a result, the City asked Waterfront Toronto (previously Toronto Waterfront Revitalization Corporation) to review three alternatives for the existing expressway:

1. replace the entire elevated expressway with a combination of tunnels and at-grade roads
2. retain the elevated expressway with enhancements and relocate Lake Shore Boulevard from beneath it
3. remove the elevated expressway east of Spadina Avenue and replace it with a "great street" similar to University Avenue

In 2004, Waterfront Toronto's third alternative (identified above) was recommended for further consideration, however a detailed review found that the cost of this alternative had risen significantly from earlier estimates. This resulted in the proponents identifying that the less developed eastern waterfront area offered a greater opportunity to shape new city development patterns. In July 2008, City Council authorized the proponents to jointly undertake an Individual EA for the 2.4 kilometre section of the Gardiner Expressway east of Jarvis Street).

Study area and purpose

Two study areas were identified: an urban design and environmental effects study area, which includes lands in the vicinity of the proposed undertaking, and the system study area, which includes the broader area that would be affected by changes in traffic patterns and volumes. Please see Figure 1 for a map of these areas.

The study area is highly urbanized with a mixture of uses located east of downtown Toronto. The existing local air quality and noise in the study area are typical of a highly urbanized environment and are similar to other areas with major transportation features such as the Gardiner Expressway, Lake Shore Boulevard, and the rail corridor.

The study area is traversed by a major east/west rail corridor used by Metrolinx/GO Transit for commuter rail and also includes Metrolinx/GO Transit's storage train yard to the north of the Gardiner Expressway and Lake Shore Boulevard. Also, Hydro One has transmission facilities within a north/south transmission corridor to the west of the Don River.

North of the rail corridor, a mix of well established land uses include residential, commercial and retail, recreational, and office space. South of the rail corridor, land uses mainly consist of underutilized low density employment, industrial, and commercial uses. The Keating Channel Precinct is currently underutilized and contains no active land uses that support the population or employment.

The study area is also traversed by the Don River which flows south then west into the Keating Channel to Lake Ontario. The approved Don Mouth Naturalization and Port Lands Flood Protection Project EA proposed by the Toronto Region and Conservation Authority, the City of Toronto and Waterfront Toronto proposes major improvements to the southern Don River involving relocating the mouth of the river south of the Keating Channel and providing flood protection from more frequent and intense storm and rainfall events expected due to climate change. Numerous infrastructure projects as well as secondary plans are proposed for future developments associated with the Keating Channel area in the southern study area and the Port Lands area south of the study area.

Due to the heavy urbanization of the area in the past, there is little native natural habitat and wildlife in the study area. Some habitat has regenerated on former industrial sites along the banks of the Don River and along the shoreline of Lake Ontario. In recent years, improvements to parks, open space, and the waterfront have contributed to improved aquatic and terrestrial habitat. The approved Don Mouth Naturalization and Port Lands Flood Protection project will result in further aquatic and terrestrial habitat enhancement in the long term (until 2031).

The Gardiner Expressway is considered to be an important transportation corridor for the City of Toronto. It traverses the length of the downtown area and connects to the Queen Elizabeth Way and Highway 427 to the west, and to the DVP and Lake Shore Boulevard east of the downtown area and the central waterfront area. Lake Shore Boulevard spans the city limits from the West (to Mississauga) to Woodbine Avenue in the east, where it connects to Kingston Road.

The purpose of the EA is to address the deteriorating condition of the elevated sections of the Gardiner Expressway that extends 2.4 kilometres from Jarvis Street to east of the DVP at Logan Avenue (see Figure 1). The deck and concrete barriers are in poor condition and considered to be at the end of their service life. Since 2012, incidents of falling concrete have occurred along the corridor, including the area east of Jarvis Street. Several project goals have also been identified as part of the undertaking, which include: revitalize the waterfront, reconnect the City with the lake, balance modes of travel, achieve sustainability, and create value. Under the sustainability goal, the project is proposed to accommodate City plans for flood protection and flood conveyance in the study area which will build resiliency to climate impacts.

Description of the proposed undertaking

As stated in Section 6 of the EA, the Gardiner East Project includes five distinct components (refer to Figures 2 and 3 in the Review):

1. Removal of the existing elevated expressway east of Cherry Street and the construction of a new elevated expressway link with the DVP located to the north of its current location.
2. Construction of a realigned Lake Shore Boulevard from Cherry Street to Don Roadway with new ramps to and from the Gardiner Expressway. The road will be relocated north of its current location west of the Don River to free lands for land use development on the north side of the Keating Channel.
3. Reconstruction of Lake Shore Boulevard east of the Don River to Logan Avenue including a reconstructed Don River Bridge on Lake Shore Boulevard.
4. Public Realm Improvements from Jarvis Street to Leslie Street (e.g. streetscaping, multi-use trails including bike trails, greenspaces, landscaping, etc.).

In addition, other works the proponents are doing which do not require an approval under the EAA include the rehabilitation of the existing elevated Gardiner Expressway surface from Jarvis Street to Cherry Street.

The description of the undertaking was provided in Section 5.2.2 of the EA. The preferred alternative, Hybrid 3, includes:

- Remove ramps that extend over the east of the Don River to Logan Avenue
- Remove the existing DVP-Gardiner connection and rebuild it to run through the Keating Channel Precinct further north (closer to the rail corridor) and construct a new “tighter” (130 m radius) ramp connection to the DVP with a lowered speed limit

- Widen the Metrolinx Don River/DVP Rail Bridge underpass to the east to allow for a more northern DVP-Gardiner ramp location
- Construct a new two-lane Lake Shore Boulevard-Gardiner ramp westbound on and eastbound off connections east of Cherry Street
- Construct a new Lake Shore Boulevard alignment that runs mid-block through the Keating Channel Precinct plan area

If EAA approval is granted, the undertaking will be completed in accordance with the terms and provisions outlined in the EA proposed conditions of approval, and will include the details outlined above. In addition, the proponents must still obtain all other legislative approvals it may require for the undertaking.

Construction timing and cost

Construction is expected to be staged, commencing in 2018 and lasting until 2025. The capital cost of the project is 569 million dollars.

Figure 1: Gardiner Expressway and Lake Shore Boulevard East reconfiguration EA and urban design study areas

Download Figure 1 (JPG)

This map displays the two study areas for the project. The Transportation System study area extends from Spadina Avenue to the west, Woodbine Avenue to the east, Dundas Street East to the north and the shore of Lake Ontario to the south (Port Lands area). The Urban Design and Environmental Effects study area extends from Jarvis Street to the west, Logan Avenue to the east, King Street to the north and Commissioner's street to the south. The map also identifies features such as the Don River, Lake Ontario and the Toronto Harbour.

Figure 2: The preferred alternative

Download Figure 2 (JPG)

This figure illustrates the preferred alternative for the undertaking. There are seven numbered areas identifying what component of the undertaking would be implemented in each area. For example, from Jarvis to Cherry Street, public realm improvements would be implemented along Lake Shore Boulevard. The figure illustrates the location for the proposed realignment of the elevated Gardiner expressway link to the Don Valley Parkway, the reconfigured Lake Shore Boulevard, and the adjacent neighbourhoods and parkland.

Figure 3: Conceptual illustration of the preferred alternative

Download Figure 3 (JPG)

Figure 4: Alternative methods/designs

Download Figure 4 (JPG)

An illustration of the three alternative methods of implementing the undertaking. Hybrid 1 option is the furthest south alignment, closest to the Keating Channel. The Hybrid 2 option mostly follows along Lake Shore Boulevard. The Hybrid 3 alignment is furthest north, or closest to the rail tracks. All three options curve north to connect to the Don Valley Parkway.

Results of the ministry review

The Review provides the analysis of the EA. The Review is not intended to summarize or present the information found in the EA. For information on the decision making process, refer to the EA. The EA and supporting documentation outlines the EA planning process and demonstrates how the proponent has selected the preferred undertaking and made the final decision.

3.1 Conformance with ToR and EAA

3.1.1 Ministry analysis

The ministry coordinated an analysis of the EA with the GRT that looked at whether the requirements of the ToR have been met. The ministry has concluded the EA followed the framework outlined in the ToR and has addressed the commitments made in the ToR. In addition, the EA as amended has satisfied the requirements of the EAA.

Appendix A summarizes this analysis and identifies how the ToR requirements have been addressed in the EA.

3.1.2 Consultation

One of the key requirements of the EAA is pre-submission consultation completed during the preparation of the EA. This consultation is the responsibility of the proponent and must be taken prior to the submission of the EA to the minister. It must be in accordance with the consultation plan outlined in the ToR.

Once the EA is submitted to the ministry, additional ministry driven consultation occurs during the EA comment period. The GRT, the public, and affected Indigenous communities are provided with the opportunity to review the EA and to submit comments to the ministry on whether the requirements of the ToR had been met, on the EA itself, and on the proposed undertaking. All comments received by the ministry during the EA comment period were forwarded to the proponents for a response. Summaries of the all comments received along with the proponents’ responses are included in Tables 1-2. Copies of the submissions are also available in Appendix B.

Government Review Team

Consultation with the GRT was conducted throughout the EA process. This included pre-submission discussions, technical meetings with ministry staff, four meetings with the Technical Advisory Committee and key members of the GRT, and providing an opportunity to review the draft EA. Many of the comments provided on the draft EA were incorporated into the final EA.

Members of the GRT were provided copies of the final EA for their review during the seven-week EA submission comment period. Comments on the final EA were received from the MOECC, Ministry of Natural Resources and Forestry (MNRF), Toronto Region Conservation Authority (TRCA), Metrolinx, Ministry of Tourism, Culture and Sport (MTCS), and Hydro One.

The GRT commented on species at risk, cultural heritage, coordination with existing and proposed future infrastructure projects, and acceptance by the ministry of the air quality assessment undertaken for the project. Refer to Section 3.3 for discussion on these comments.

All comments received by the ministry were forwarded to the proponents for a response. A summary of the comments and the proponents' responses can be found in Table 1.

Public consultation

The proponents used a variety of consultation methods to consult with the public including public notices, public forums, a Stakeholder Advisory Committee consisting of 40 key interest groups, stakeholder workshops and working groups, individual stakeholder meetings, online engagement, and a Facilitator's Office which acted as the "one-window" point of contact for the project. Five rounds of public consultation based on the technical work completed for each phase of the study were held between May 2013 and January 2016. Nearly 30,000 points of contact were achieved with citizens (including website visits).

The proponents made the draft EA and its supporting documents available on the project website for members of the public to comment. Forty-five individuals and stakeholders submitted feedback as part of the voluntary review of the draft EA report. Stakeholder organizations that provided comments included the West Don Lands Committee, First Gulf, Lafarge Canada Inc., Castlepoint Numa, and the Ontario Society of Professional Engineers. Comments were made on the Remove alternative, the preferred alternative (Hybrid 3), the importance of public realm improvements, balancing transportation modes, public consultation, project cost and use of public funds, the role of the Gardiner East in the GTA transportation network, and construction phasing and impacts. A summary of participant feedback is included in Appendix B of the EA. It outlines the concerns that were voiced and the proponents' responses. The EA was revised to reflect the public input received on the draft EA.

The Notice of Submission of the final EA was published on January 17, 2017 in the Toronto Star. A contact database was maintained throughout the EA process. Fifty-three interested persons and three interested parties (Castlepoint Group, the West Don Lands Committee, and the St. Lawrence Neighbourhood Association) submitted comments on the EA. These comments largely mirrored comments on the draft EA with the selection of the preferred alternative, its cost and its effects on the environment being the most prominent concerns. Refer to Section 3.3 for discussion on these comments.

Indigenous community consultation

In addition to the EAA requirement that interested persons be consulted, proponents are required to consult with Indigenous communities who have credibly asserted or established Aboriginal or treaty rights that may potentially be negatively impacted by the proposed undertaking.

The proponents developed a list of potentially impacted Indigenous communities and provided them with information on the EA throughout the process. The initial list of Indigenous communities that were contacted included:

- Alderville First Nation
- Beausoleil First Nation
- Chippewas of Georgina Island First Nation
- Chippewas of Rama First Nation
- Curve Lake First Nation
- Hiawatha First Nation
- Mississaugas of Scugog First Nation
- Moose Deer Point First Nation
- Mississaugas of the New Credit First Nation

This list was developed in consultation with MOECC, Aboriginal Affairs and Northern Development Canada, and Ministry of Indigenous Relations and Reconciliation.

Formal study notices were circulated to Indigenous communities. Correspondence invited the communities to participate during the ToR phase of the study and each round of EA consultation. Also, an opportunity to meet one-on-one was provided to each community. During preparation of the EA, the above communities were kept informed of the progress of the EA, and received a copy of the Draft EA to review and provide comments on. The following is a summary of the comments received by Indigenous communities during the preparation of the EA.

The Hiawatha First Nation corresponded with the project team and advised that they had an interest in the project. Project materials were provided and an offer to meet was made by the proponents, however, a meeting was never held as the community did not request to meet.

Curve Lake First Nation sent a letter to the proponents on July 11, 2013 acknowledging receipt of the notice of Public Information Centre (PIC) 1 and broadly outlined what the Curve Lake First Nation's interest may be in the project (limited to archaeological interests). The Curve Lake First Nation was sent a copy of the draft EA as requested. The First Nation subsequently advised that they did not require to be sent any further meeting notices.

Alderville First Nation sent a letter on October 7, 2013 to the proponents advising that the Gardiner East EA is deemed as having minimal potential to impact First Nations' rights. Accordingly, they have requested to be kept apprised of any archaeological findings, burial sites, or any environmental impacts should they occur. The proponents agreed to further consult in this regard as may be appropriate.

The Mississaugas of the New Credit First Nation provided a letter in early 2016 to the proponents stating an interest in the project. A meeting was held on May 5, 2016 at the Mississaugas of the New Credit First Nation reserve. A copy of the draft EA was also sent to the Mississaugas of the New Credit First Nation on July 29, 2016. The proponents followed up with the community, however further comments were not provided by the community.

On October 5, 2016, the MOECC provided additional direction about the Indigenous communities and identified that the Kawartha Nishnawbe First Nation should be contacted. The proponents then sent correspondence to the Kawartha Nishnawbe First Nation to determine whether they had an interest in the EA. No response has been received to date. The proponents will continue their efforts to confirm if the Kawartha Nishnawbe First Nation has any interest in the project.

The Mississaugas of Scugog indicated on February 1, 2017 that they were satisfied and had no comments on the EA.

3.1.3 Conclusion

The EAA requires that the proponent consult with all interested persons during the preparation of the EA and report on the results of that consultation. The EA adequately describes the consultation that was undertaken and the outcomes of the various consultation activities and events. The EA documents how input received throughout the consultation program influenced the study, and ultimately the preferred alternative. The proponents have undertaken an extensive consultation program as part of the ToR and EA.

The ministry is satisfied that the level of consultation undertaken with the public, Indigenous communities, and GRT was appropriate for this proposed undertaking.

Overall, the ministry believes that the proponents provided sufficient opportunities for the public, interested stakeholders, government agencies, and Indigenous communities to be consulted during the preparation of the EA. The proponents have committed to continue to engage Indigenous communities, interested stakeholder groups, and agencies during detail design, construction, and operation of the proposed undertaking.

The ministry is satisfied that the consultation carried out meets the requirements of the EAA and is consistent with the approved ToR.

3.2 EA process

Alternatives and evaluation process

The EAA provides a planning process that requires a proponent to identify a problem or opportunity, consider alternative ways of addressing the problem or opportunity, evaluate the potential effects of those alternatives against select environmental criteria (noise, air quality including greenhouse gas emissions, cultural heritage, water quality, etc.) and then select a preferred alternative.

Through the review of the final EA, staff of the ministry determined whether or not the proponents followed the EA process and incorporated commitments in the approved ToR into the final EA that was submitted for review and a decision.

The EA was prepared in accordance with section 6.1(2) of the EAA. This included an analysis of "alternatives to" (functionally different ways to solve the problem/opportunity) and alternative methods (locations and designs) for the proposal as outlined in the ToR.

The "alternatives to" that the proponents examined in the EA were:

- Maintain (or "Do Nothing")
- Improve
- Replace
- Remove (or Boulevard)
- Other alternatives (the Optimized Remove and Hybrid options)

The initial evaluation of alternative solutions resulted in the identification of the Remove alternative as the technically preferred alternative. This technical recommendation was then reviewed by the City's Public Works and Infrastructure Committee (PWIC) in March 2014. Through EA consultation activities stakeholders and members of the public identified an interest in considering a solution that could maintain the Gardiner Expressway–DVP connection while also achieving removal of the Gardiner Expressway east of the Don Roadway.

After considering the City Staff report and public input, the PWIC recommended that the proponents review the recommended “alternative to” (Remove) to mitigate traffic congestion concerns (Optimized Remove option), prepare an additional “alternative to” that combined the Maintain and Replace alternatives, and evaluate these alternatives against the EA environmental criteria (Hybrid option).

The Hybrid “alternative to” (a combination of the Maintain and Replace alternatives) was developed, and evaluated against the Optimized Remove alternative. This work was undertaken and reported in the May 2015 Interim Report that was made publically available. Consultation was undertaken with the public, government agencies, and stakeholders during the development and evaluation of the “alternatives to”. Stakeholders were highly divided regarding their preferred solution as the Hybrid alternative performed better for transportation movement of goods (goods movement) and automobile travel times, maintained a connection with the DVP, and had less construction impacts. The Remove alternative was preferred on the basis of urban design, cost, and environmental effects. Regardless of which alternative was selected, both met the goals of revitalizing the waterfront and enabling planned development and transit improvements in the study area. Additionally, the public realm improvements described in the EA such as the multi-use pathway and additional greenspace were proposed for both alternatives.

As both alternatives offered different advantages and disadvantages, the 2015 Interim Report recommended that the decision on the preferred “alternative to” should be made by City Council, which the proponents considered to be appropriate as Council represented the citizens of the City of Toronto. After significant Council debate on the advantages and disadvantages of the two “alternatives to”, City Council endorsed the Hybrid as the preferred alternative and directed City staff to develop and evaluate alternative methods (locations and designs) that would mitigate any negative impacts associated with a Hybrid alternative.

Upon direction by City Council, three alternative methods were selected from a broader list of concepts, some of which were not carried forward following public and stakeholder input and an analysis of issues and constraints. The alternative methods (designs and locations) carried forward are (please see Figure 4):

1. Hybrid 1, which includes maintaining the existing elevated Gardiner Expressway through the Keating Channel Precinct along the north edge of the Keating Channel
2. Hybrid 2, which includes rebuilding the DVP-Gardiner connection further north than Hybrid 1
3. Hybrid 3, which includes rebuilding the DVP-Gardiner connection further north than Hybrid 2

For all three alternative methods, streetscaping, intersection improvements, and other public realm improvements were proposed for Lake Shore Boulevard. From Cherry Street to the Don Roadway, a new Lake Shore Boulevard alignment would be constructed, that would be situated farther north to run mid-block through the future Keating Channel Precinct. All alternative methods include the removal of the

Logan Avenue on-off ramps and improvements to the existing multi-use pathway.

The evaluation approach for the alternative methods can be found in Section 5.3 of the EA report. The comparative evaluation of the alternative methods can be found in Section 5.4 of the EA. From this evaluation, Hybrid 3 was found to be the preferred alternative to the undertaking as it has less potential to impact Don Mouth Naturalization and Port Lands Flood Protection sediment management activities area, provides greater land value creation (development opportunity) than the other two alternatives, and opens up a greater section of Lake Shore Boulevard to light and air, allowing for additional public realm improvements in this area (e.g. additional tree planting).

The ministry found that the proponents followed a logical and transparent decision making process that was outlined in the EA. The proponents assessed a reasonable range of alternatives and outlined the advantages and disadvantages of each “alternative to” and alternative method. As the proponents went through each stage of assessment and “alternatives to” and alternative methods were developed, an increasing level of detail was provided on potential effects, proposed mitigation, and net effects of the proposed undertaking. The mitigation measures are commitments that the proponents made to reduce potential negative effects and enhance potential positive effects of the undertaking.

Refer to Appendix A of this Review for the ministry’s analysis of how the EA met the requirements of the EAA and the approved ToR.

Source water protection

The proponents’ consideration of source water protection is described in Section 6.6. In the study area, there are no source wellhead protection areas or issue contributing areas, as defined in the Source Protection Plan for the Credit Valley-Toronto and Region-Central Lake Ontario. The footprint of the Gardiner Expressway and Lake Shore Boulevard are expected to remain approximately the same, so substantial increases to the permeable area are unlikely. The conceptual design has no material impact on the Don River flood conveyance. This will be confirmed during the detailed design phase by the TRCA and the proponents.

Climate change and cumulative effects

The proponents’ consideration of climate change and cumulative effects was outlined in Section 6.7 and 6.8 of the EA.

Climate change

Several climate change related initiatives have been undertaken by the proponents over the past 10 years including the 2007 Toronto’s Climate Change Action Plan, 2008 Climate Change Adaption Strategy, and 2012 Future Weather and Climate Driver Study. The City developed a target to reduce greenhouse gas emissions by 80% from 1990 levels by 2050. Specific to the undertaking, the proponents considered effects of the undertaking on climate change and effects of climate change on the undertaking. The project is not expected to increase the use of automobiles, so this is not expected to contribute to a greater amount of greenhouse gases over the existing and future conditions. The project provides upgraded non-motorized (pedestrian and cycling) infrastructure which may promote a shift to using these modes of travel. The project would create new development opportunities in the Keating Channel precinct by providing transit-accessible urban housing close to downtown. Corridor greening would increase the vegetation in the area which may have a positive effect on human health and species habitat. The increased tree canopy along Lake Shore Boulevard may also help offset the urban heat island effect that the existing and planned paved surfaces in the area contribute to.

From Cherry Street to Don Roadway, a key climate change consideration is regional flood protection and flood protection for the built form. The frequency, intensity, and duration of rainfall and storm events is anticipated to increase due to climate change, which will make flood protection and flood conveyance more critical in the future. Flood protection is being considered in the Don Mouth Naturalization and Port Lands Flood Protection Project EA which is planned in the study area. For the proposed Gardiner project, stormwater management options to improve water quality and address water quantity would be considered during detail design. Existing stormwater drainage from the Gardiner Expressway is collected and discharged to the ground beneath the expressway in some areas or discharged to City sewers in other areas. East of Cherry Street, there are eight stormwater outfalls without any stormwater management quality or quantity controls. The project would result in additional stormwater controls that would contribute to managing the effects from climate change and extreme weather in the study area and result in an overall improvement of stormwater management along the project right-of-way. Stormwater management measures recommended in the EA for the project right-of-way include using low impact development (LID) measures such as stormwater planters, enhanced grass swales, and perforated pipes to meet enhanced level sediment removal (80% of total suspended solids). This commitment is documented in Section 6.5.2.6 of the EA Report.

The reconstruction of the new Gardiner Expressway-DVP connection through the Keating Channel Precinct would consider the use of more sustainable construction materials than what currently exists. For example, the project would be constructed using the latest advancements in concrete use and manufacturing. It would be built to withstand extreme weather events and better withstand roadway salting effects, and is expected to have a lifespan of 100 years. By increasing the lifespan of the undertaking, greenhouse gas emissions (from making new concrete, trucking materials to the site, from using construction equipment etc.) would be reduced compared to an undertaking with a shorter life span. The reuse of demolition debris to reduce the use of new material would also be considered.

Cumulative effects

The proponents considered cumulative effects of the project as part of the assessment. The project is not anticipated to negatively contribute to cumulative effects in the study area during operation as it will not provide additional auto capacity, therefore greenhouse gas emissions will not increase. Noise, dust and vibration are not anticipated to increase from the future existing conditions (the Maintain or ‘Do Nothing’ alternative). However, increased pedestrian and cycling infrastructure and green space from the project would result in a positive effect over existing conditions.

There are several projects and activities in the project study area that are planned to be carried out at the same time including the Don Mouth Naturalization and Port Lands Flood Protection Project, future development as identified in City Precinct and Master Plans, and the realignment of Cherry Street. Cumulative effects are mostly anticipated to be construction based (e.g. disturbance from dust, noise and/or traffic delays) and would subside during operation. Cumulative effects from construction will be minimized through coordination with other construction projects. For example, the construction of the Gardiner East project and the Don Mouth Naturalization and Port Lands Flood Protection project would be coordinated to ensure that erosion and sediment management are minimized.

Considerations and commitments

Section 9 of the EA outlines conclusions, next steps, and commitments to future work. Some key considerations to be taken into account during detail design include the Metrolinx Rail Bridge, the new Gardiner/DVP ramp crossings of the Don River, Don Roadway, Lake Shore Boulevard and Rail Spur crossing of the Don River, realignment of Cherry Street, and safety measures for the ramps with tighter turn radii. This section also describes how traffic would be addressed during construction and how the undertaking would be coordinated with other infrastructure/planning projects such as the Don Mouth Naturalization and Port Lands Flood Protection Project EA and Villiers Island Precinct Plan.

Commitments and monitoring for the proposed undertaking can be found in Section 6.10 of the EA.

3.2.1 Conclusion

Overall, the ministry in consultation with the GRT is satisfied with the proponents’ decision making process, including demonstrating the rationale for the preferred alternative. The EA contains an explanation of the problem that prompted the EA and the opportunities that can be realized as part of the proposed undertaking. A reasonable range of “alternatives to” and alternative methods were considered and it is evident that public and agency input was considered in creation, evaluation, and selection of these alternatives.

The EA provides a description of the potentially affected environment in the study area and identifies the potential effects of the alternatives. Net effects are identified and commitments to monitoring and contingency made to ensure any potential negative effects from the undertaking are minimized. The proponents have considered the effects of climate change, cumulative effects on the undertaking, and considered the effects the project has on climate change and source water protection.

The EA adequately described the advantages and disadvantages of the proposed undertaking to the environment based on potential environmental effects. Requirements of the EAA for consultation with the public, GRT, and Indigenous communities have been met. The ministry is satisfied that the EA has been completed in accordance with the approved ToR and meets the requirements of the EAA.

3.3 Comments on the undertaking

Comments on the proposed undertaking were submitted to the ministry by the GRT and interested persons during the 7-week EA submission public, government agency, and Indigenous community comment period. The ministry made follow-up phone calls with the Indigenous communities identified as having an interest in the project, to find out whether they received the EA and had any comments. However, no comments were received from Indigenous communities during this comment period.

Public comments

A total of 53 interested persons submitted comments on the EA. Additionally, comments were submitted from Castlepoint Group (developers), West Don Lands Committee (which includes a number of neighbourhood associations), and St. Lawrence Neighbourhood Association. For more information on the proponents' responses to these comments and the ministry's conclusions, please see Table 2 in the Review appendices.

Selection of the preferred alternative to

The majority of comments received cited concerns with the process for selecting the preferred "alternative to" and concern that the Remove alternative should have been selected as it was superior in meeting the goals of the study, such as connecting the City with the waterfront, balancing transportation modes, protecting human health, and is more cost effective. Members of the public are concerned that the decision on the preferred alternative was politically biased and not based on transparent decision-making.

The EA demonstrates how a wide range of stakeholders and members of the public were engaged in the development of the "alternatives to" including the Hybrid option. The ToR allowed for other alternatives to be identified, therefore the Hybrid alternative is consistent with the approach provided in the approved ToR.

The proponents' rationale for the selection of the Hybrid alternative over the Remove alternative was documented in the EA Report. Please see section 3.2 of the Review for more information. The ministry is satisfied that the preferred alternative is linked to the goals of the EA study. The preferred alternative was selected by City Council, who believes it provides an appropriate balance between the goals of waterfront revitalization/development and accommodating goods movement and traffic flow. The proposed undertaking is anticipated to improve connectivity with the waterfront by:

1. Realigning the Gardiner Expressway further north to allow for a better connection between future

development in the Keating Channel Precinct and the waterfront

2. Improving intersections along Lake Shore Boulevard and adding a multi-use trail, enabling better and safer pedestrian and cycling facilities between the City and waterfront

The proponents were required to make a difficult decision about what preferred alternative to select to proceed through the EA process while considering the various trade-offs with the two alternatives and considering the stakeholder input provided.

The proponents are ultimately responsible for the selection of the preferred alternative. The ministry considers these concerns to be addressed in the EA. Please see Section 3.2 and the proponent's response in Table 2 in the appendices for more detailed responses to these concerns.

Environmental and human health effects from the project

Members of the public are concerned with the air quality impacts from dust and noise on the Gardiner as it exists today and also concerned that these impacts would occur due to the proposed undertaking. The impact to air quality from greenhouse gas emissions compared to the Remove "alternative to" was also stated as a concern. Members of the public commented that they were concerned with the safety of pedestrians crossing intersections on Lake Shore Boulevard below the elevated Gardiner Expressway currently, and wanted to ensure an improvement to safety was part of the undertaking.

An Air Quality and Greenhouse Gas Impact Assessment Report was prepared as part of the EA. The report adequately describes the existing and future predicted air quality conditions. During operation of the proposed undertaking, traffic levels will be similar to conditions that currently exist, and as a result no additional air quality impacts or greenhouse gas emissions over the future existing conditions are expected from the proposed undertaking. The ministry reviewed this report and has no outstanding concerns with its findings.

During construction, the preferred alternative is anticipated to result in air quality effects from the operation of construction equipment, excavation of soils and demolition of the existing expressway and ramps. Mitigation such as applying water and dust suppressants to minimize dust, good maintenance of equipment, minimizing idling, and using on-site concrete making to minimize concrete truck traffic are proposed.

The existing noise levels in the study area are typical of a major transportation corridor in a highly populated urban area.

Construction activities such as pile driving and drilling will generate noise and vibration effects. Between Cherry Street and the Don River, the closest sensitive receptors are approximately 300 metres away. From the Don Roadway to Logan Avenue some warehouse businesses could experience noise and vibration effects during construction. The proponents propose to follow municipal noise by-laws, install vibration monitoring equipment, as well as monitor and follow up on noise and vibration complaints. During operation, traffic volumes would be similar to existing conditions therefore additional noise and vibration effects are not anticipated. Future development proposals near the proposed project will need to meet the City of Toronto noise study requirements to assess noise effects on new residents or businesses and propose mitigation to reduce noise impacts.

With respect to the potential project's impact to the natural environment and species habitat, approximately 2.5 hectares of low quality vegetation (e.g. invasive species) will be removed due to the proposed undertaking. Based on preliminary estimates, an area of approximately 3 hectares will be planted within the roadway corridor. This amount would be confirmed during the design process for the public realm improvements (currently ongoing). Mitigation such as avoiding construction during the bird breeding season is proposed, and the proponents have committed to complete a Species at Risk (SAR) screening as part of the future design work and to apply mitigation where required. Additional trees would be planted along the Lake Shore Boulevard corridor, improving existing terrestrial habitat. The MNRF indicates that is has no outstanding concerns with the EA.

The proposed undertaking includes the creation of significant improved and new green space and a multi-use trail that would lie north of Lake Shore Boulevard. The multi-use trail is anticipated to improve pedestrian and cyclist safety and promote walking and cycling. Intersections would be improved along Lake Shore Boulevard to increase pedestrian safety. These improvements could include reducing pedestrian crossing distances, reducing turn lanes, and adding visual aids for crossing.

Regarding water quality, the proposed project would allow for an improvement in stormwater management that would contribute to an improvement in local surface water quality (see Section 3.2).

Considering the responses from government review agencies and the proponents, review of the EA, and supporting documentation, the ministry is satisfied that the undertaking is not expected to contribute to greater environmental effects than currently experienced in the study area, which is a busy urban environment. The project proposes to increase greenspace and stormwater management measures. Therefore, the ministry is satisfied that concerns with the potential environmental and health impacts from the project have been considered.

As a number of commitments have been made by the proponents in the EA to monitor and mitigate the environmental effects of the undertaking where required, the ministry recommends that standard conditions of approval on monitoring and reporting be imposed on the undertaking if approved to ensure that the commitments in the EA are honoured.

Other comments

Other comments were made regarding: support of the Hybrid (preferred) alternative, consistency of mapping throughout the EA report, traffic study results, accessibility of the EA documents, consideration of health impacts, proponents' issuing of non-competitive contracts, assurance of implementation of the public realm improvements, Metrolinx's involvement in the EA, significance of the Gardiner Expressway as a transportation corridor in the City, and the EA report's inherent bias towards the value of automobile travel over other modes of travel. Some requests were made for a hearing with the Environmental Review Tribunal. Responses to these concerns can be found in Table 2 in the appendices.

Government Review Team comments

Species at risk

The MNRF recorded several Species at Risk in the study area, and indicated that the proponents must notify the MNRF if any work may cause harm to these listed species. The proponents committed to completing a Species at Risk screening in advance of any construction disturbance and keeping MNRF informed of this work. The proponents committed to incorporating any required mitigation measures into contract documents, as appropriate.

The MNRF indicated that it is satisfied with the proponents' response.

Archaeology and built/cultural heritage

The MTCS had raised concerns that the EA relied on an Archaeological Baseline Conditions Report which was not intended to satisfy Archaeological Assessment requirements and was not consistent with Stage 1 Archaeological Assessment requirements. The MTCS commented that leaving formal Archaeological Assessment work to the preliminary or detailed design stage does not allow for potential effects on archaeological resources to be evaluated based on full information of those resources.

The MTCS also commented that it was not clear from any of the EA documentation whether any attempt had been made to determine the existence of previously unrecognized cultural heritage resources in the study area.

As a result, the proponents submitted a revised Stage 1 Archaeological Assessment which focused on the lands in the vicinity of the preferred design alternative being completed (Hybrid 3). The MTCS reviewed this report and it received clearance. The report concluded that the potential for Indigenous archaeological resources was essentially nil, due to extensive disturbance from past developments. Potential for the presence of significant Euro-Canadian archaeological resources exist, related to the 1870 Don Breakwater and the circa 1880 Toronto Dry Dock. The report recommends that construction excavations in the area of potential for these features be subject to a program of archaeological monitoring to document their remains, if any, prior to their removal.

A Cultural Heritage Resources Assessment for Built Heritage Resources and Cultural Heritage Resources was completed in April 2017 for the proposed preferred alternative (Hybrid 3) and sent to the MTCS. A total of ten cultural heritage resources were identified within and/or adjacent to the Hybrid 3 study area. Four of these ten cultural heritage resources—which include a bridge, rail corridor, and the Keating Channel—may be impacted by the proposal. The report concluded that during detail design, the identified resources should be further evaluated to assess impact, and appropriate mitigation measures applied if necessary. Regarding the four resources potentially impacted, the report recommends that these should be evaluated during detail design to confirm that there are no further effects that cannot be mitigated.

On April 25, 2017 the MTCS accepted this report and provided follow-up comments which the proponents addressed through commitments.

The MOECC requested that both of these studies be available on the project website. The ministry is satisfied that the commitments made by the proponents address the comments made by the MTCS.

Coordination with other projects in the study area

Metrolinx recommended coordination of planning and construction schedules to ensure that any conflicts are avoided or at least minimized. Metrolinx also stated that the proposed plans for Metrolinx's Union Station Rail Corridor East Enhancements project include public realm improvements associated with retaining walls and bridge modifications (i.e. extensions) in the study area, which would need to be coordinated with the Gardiner undertaking.

Hydro One is also concerned about the impacts to several of its planned infrastructure and development projects in the area and how these could affect their transmission infrastructure if not planned and coordinated in consultation with Hydro One.

The proponents committed to continue to engage with Metrolinx and Hydro One in the advancement of the design for the project to determine how all of the various proposed projects can be coordinated and accommodated. Both agencies have indicated that they are satisfied with the proponents' responses.

Air quality

The MOECC reviewed responses in the EA provided by the proponents on the ministry's comments on the draft EA about the air quality impact assessment including the modelling and data used. The MOECC indicated that its comments were addressed in the final EA.

Indigenous community consultation

Some comments were made by the MOECC and the TRCA on the documentation of Indigenous community consultation activities in the EA, and consideration of the project's potential to impact Indigenous communities. The proponents responded by amending the EA documentation to include more information on consultation undertaken with Indigenous communities. The proponents also included a commitments table outlining their commitments to continue dialogue with Indigenous communities as the project progresses.

Toronto and Region Conservation Authority comments

Detailed comments on the EA were received from TRCA regarding potential impacts to TRCA's Don Mouth Naturalization and Port Lands Flood Protection EA. This included the sediment management area, mapping errors, proposed features of TRCA's project which should be identified during the detailed design, the potential impacts of the new ramps and piers on flow conveyance of the Don River through the area between the railway embankment and Lake Shore Boulevard, habitat restoration, further permits required from TRCA, and the need for ongoing consultation with the conservation authority.

TRCA suggested a meeting with the proponents be held once this project reaches detailed design to discuss implementation, phasing, TRCA approvals, and next steps. The proponents agreed to work with TRCA to address any issues and coordinate the two projects during the detailed design phase.

The TRCA indicated that it is satisfied with the proponents' responses for the purposes of the EA.

3.3.1 Conclusion

Ministry staff are satisfied that the proposed Gardiner Expressway and Lake Shore Boulevard East Reconfiguration would be designed and operated to comply with the ministry's standards. Ministry staff are also satisfied that the environmental effects of the proposed undertaking can be managed through the commitments made in the EA, through proposed conditions of approval or through additional work that must be carried out by the proponents in support of future approval applications if the undertaking as described in the EA is approved.

Summary of the ministry review

The Review has explained the ministry's analysis for the Gardiner Expressway and Lake Shore Boulevard East Reconfiguration.

This Review concludes:

- The EA complies with the requirements of the approved ToR and has been prepared in accordance with the EAA. The amended EA has provided sufficient information to enable a decision to be made about the application to proceed with the undertaking.
- The amended EA has assessed and evaluated "alternatives to" and alternative methods to arrive at the preferred undertaking, assessed the potential environmental effects of the "alternatives to", alternative methods, the proposed undertaking, and provides a description of mitigation and monitoring measures to address the potential negative environmental effects of the proposed undertaking or a commitment has been made to address them through additional work that would

be completed as part of future approval requirements.

- If the proposed undertaking is approved under the EAA, there are several standard conditions imposed such as the requirement to conduct and report on the results of compliance monitoring and to develop a protocol for responding to complaints received during all the phases of the undertaking.

What happens now

The Review will be made available for a five-week comment period. During this time, all interested parties, including the public, GRT, and Indigenous communities can submit comments to the ministry about the proposed undertaking, the EA and/or the Ministry Review. At this time, anyone can make a written request that the Minister refer either all or part of the EA to the Environmental Review Tribunal for a hearing if there are significant outstanding environmental concerns that have not been considered.

At the end of the Review comment period, ministry staff will make a recommendation to the Minister concerning whether the EA has been prepared in accordance with the ToR, the requirements of the EAA, and whether the proposed undertaking should be approved. When making a decision, the Minister will consider the purpose of the EAA, ToR, EA, the Review, comments submitted during the EA, Review comment periods, and any other matters the Minister may consider relevant.

The Minister will make one of the following decisions:

- Give approval to proceed with the undertaking
- Give approval to proceed with the undertaking subject to conditions
- Refuse to give approval to proceed with the undertaking

Prior to making that decision, the Minister may also refer either part of or the entire EA to mediation or to the Environmental Review Tribunal for a decision.

If the Minister approves, approves with conditions, or refuses to give approval to the undertaking, the Lieutenant Governor in Council must concur with the decision.

5.1 Additional approvals required

If EAA approval is granted, the City of Toronto and Waterfront Toronto will still require other legislative approvals to design, construct, and operate this undertaking. Section 1.4 of the EA outlines additional approvals that may be required. These approvals may include:

- MOECC Permit to Take Water under the *Ontario Water Resources Act*

Toronto and Region Conservation Authority Regulation of Development, *O. Reg. 166/06* Interference with Wetlands and Alterations to Shorelines and Watercourses regulations

- Aquatic Habitat Toronto Project Review
- City of Toronto Road Occupancy Permit, Road Cut Permit, Tree Removal Permits, Permit for Installation/Relocation of Public Utilities, Local Hydro Utility Building Permit, Toronto Sewer Use Bylaw, and Noise Bylaw Exemption

These approvals cannot be issued until approval under the EAA is granted.

The undertaking is not subject to Canadian *Environmental Assessment Act* requirements. A Navigation Protection Act permit may be required from Transport Canada due to construction of new piers for the reconstructed Expressway.

5.2 Modifying or amending the proposed undertaking

Chapter 8 of the EA describes the modifying or amending procedures for the proposed undertaking. If approved, proposed changes to the undertaking will be documented by the proponents and in consultation with MOECC staff would be classified as minor or major changes. Minor changes to the undertaking would include proposed project design refinements that do not trigger additional regulatory approval, although they may require consultation meetings with directly impacted stakeholders. Major changes to the project are more significant changes to the undertaking that may require additional regulatory approval and/or additional stakeholder consultation. Major changes may require an amendment to the undertaking approved in the EA and approval by the ministry.

In addition, the proponents may use the Municipal Engineers Association's Municipal Class EA to consider and document changes to components of the undertaking that are listed as activities under the Municipal Class EA. Project changes may be considered as part of separate Municipal Class EA studies or as individual activities under the Municipal Class EA. In either case, the minimum consultation requirements outlined in the Municipal Class EA will be required to be met.

Public record locations

The public record for this environmental assessment can be reviewed during normal business hours at the following ministry office:

Ministry of the Environment and Climate Change
Environmental Approvals Branch
135 St. Clair Avenue West, 1st floor
Toronto, Ontario

M5V 1P5

Tel: 416-314-8001

Toll-free: 1-800-461-6290

Fax: 416-314-8452

The Review and Notice of Completion are also available at the following locations:

Toronto City Hall Library
100 Queen Street West, Main Floor
Toronto, Ontario
M5H 2N3

Waterfront Toronto
20 Bay Street, Suite 1310
Toronto, Ontario
M5J 2N8

Making a submission

A five-week public review period ending on July 28, 2017 will follow publication of this Review. During this time, any interested parties can make submissions about the proposed undertaking, the environmental assessment or this Review. Should you wish to make a submission, please send it to:

Director
Environmental Approvals Branch
Ministry of the Environment and Climate Change
135 St. Clair Avenue West, 1st floor
Toronto, Ontario
M4V 1P5

Fax: 416-314-8452

Re: Gardiner Expressway and Lake Shore Boulevard East Reconfiguration
Environmental Assessment and Urban Design Study
Attention: Ms. Dorothy Moszynski, Project Officer

All personal information included in a submission—such as name, address, telephone number and property location of requester—is collected, maintained and disclosed by the ministry for the purpose of transparency and consultation. The information is collected under the authority of the *Environmental*

Assessment Act or is collected and maintained for the purpose of creating a record that is available to the general public as described in s.37 of the *Freedom of Information and Protection of Privacy Act*. Personal information that is submitted will become part of a public record that is available to the general public unless a request is made that personal information remain confidential. For more information, contact the ministry's Freedom of Information and Privacy Coordinator.

Appendix A: *Environmental Assessment Act* and terms of reference requirements of the environmental assessment

EA decision making process	EAA and ToR requirements	Description and characteristics of the requirements
Problem and opportunities	Identify an existing problem or opportunity. Purpose of the Undertaking: section 6.1(2)(a)	The EA should contain a brief explanation of the problem or opportunity that prompted the proposed activity. If a specific undertaking has been identified provide a brief description.

Analysis of the EA

The purpose of the EA study is to determine the future of the Gardiner Expressway from approximately Lower Jarvis Street to east of the Don Valley Parkway (DVP) at Logan Avenue.

The purpose of the undertaking is to address the deteriorating condition of this 2.4 km section of the Gardiner Expressway. The deck and concrete barriers of the elevated sections of the Gardiner Expressway are in poor condition, and considered to be at the end of their service life. Since 2012, incidents of falling concrete have occurred along the corridor, including the area east of Jarvis Street. Additionally, the purpose of the undertaking is to address a waterfront disconnected from the city in this area.

The undertaking is proposed to address several opportunities:

- Revitalize the Waterfront
- Create a Sustainable Waterfront
- Generate and Capture Economic Value
- Balance Transportation Modes

Chapter 2.0 of the EA presents the purpose of and rationale for the undertaking. The ministry is satisfied that the EA clearly identifies the existing problem and opportunities and clearly indicates the purpose of the undertaking.

EA decision making process	EAA and ToR requirements	Description and characteristics of the requirements
Alternatives	Description and Statement of the Rationale for the Alternatives to: Alternative to section 6.1(2)(b)(iii)	"Alternatives to" represent functionally different ways of addressing the problem or opportunity. A reasonable range of "alternatives to" should be identified and evaluated. The proponent should be able to justify that it has considered a reasonable range of alternatives. The "do nothing" alternative to should be included in the evaluation and will represent the "bench mark" situation.

Analysis of the EA

The EA included a description and rationale for the study focused on the development and evaluation of alternative solutions for the deteriorating Gardiner Expressway East.

The ToR explained that alternative solutions and designs to be considered in the EA would be limited to "land based" travel modes and to those physically located in the study area. They would be developed to accommodate a transportation planning horizon year of 2031.

The City of Toronto and Waterfront Toronto (proponents) have undertaken studies in the past to examine potential "alternatives to" for the reconfiguration of the Gardiner Expressway and Lake Shore Boulevard. These studies have included the development of conceptual designs to better understand the technical feasibility and challenges to implementing the "alternatives to". Further, as part of this study, a case study analysis was completed in March 2009 that examined how other cities around the world have dealt with their aging elevated roadways.

Based on this past work and input obtained through the EA ToR public and agency consultation process, the "alternatives to" were identified to include:

- Maintain (or "Do Nothing")
- Improve
- Replace
- Remove (or Boulevard)

- Other alternatives

An explanation of each alternative to the undertaking can be found in Chapter 4: Description and Evaluation of Alternative Solutions.

The assessment and evaluation of the alternative solutions was based on a set of evaluation criteria such as transit impact, safety for pedestrians, commuter travel time, aquatic and terrestrial environment, life cycle cost, and measures that represent the broad definition of the environment and consider both qualitative and quantitative (i.e., numerical) data. These criteria and measures are organized on the basis of the four study lenses and 16 criteria groups. The four study lenses, as outlined in the EA ToR are: Transportation and Infrastructure, Urban Design, Economics, and Environment.

Once potential effects of each alternative were identified, the proponents used a three-part process to evaluate alternatives and select the preferred alternative to as identified in the ToR. First, the relative importance of each criteria group/criteria was identified. While public was asked to provide input on the relative importance of criteria groups, relative weighting was not applied to the criteria groups. Second, the order of preference ranking of the alternatives by criteria group/criteria was determined. Table 4.2 of the EA presents the criteria and measures, compares the advantages and disadvantages of each “alternative to” or solution, and identifies the preference ranking of the alternatives to.

Third, the appropriate evaluation methodology was selected and applied. The ToR identified that the proponents would use a qualitative paired comparison approach to make trade-offs through reasoned argument. Tables 4.4 to 4.6 of the EA contain paired comparisons of the Maintain vs. Improve alternatives to, Improve vs. Replace alternatives to, and Improve vs. Remove alternatives to.

The initial evaluation of “alternatives to” resulted in the identification of the Remove alternative as the technically preferred alternative. This technical recommendation was presented to the Toronto Public Works and Infrastructure Committee (PWIC), who directed the proponents to consider additional mitigation of auto travel time impacts associated with the Remove alternative, and develop and evaluate an additional “alternative to” – the Hybrid.

Chapter 4.4 of the EA describes how the Hybrid and Optimized Remove “alternatives to” were identified. Chapter 4.4.5.4 describes how both of these “alternatives to” were evaluated in a final paired comparison, which considered a similar set of criteria used to originally compare the four “alternatives to”. Additional studies (goods movement, economic competitiveness) and input from the public, agencies, and interested parties were considered as part of the evaluation.

The transportation model results for both “alternatives to” were compared to the future ‘maintain’ baseline (which is the Do Nothing alternative). The advantages and disadvantages of the Do Nothing were understood from the first comparison of “alternatives to”, and the Remove alternative was also in a paired-comparison with the Do Nothing/Maintain alternative. The Hybrid “alternative to” could be considered as a combination of past “alternatives to” (Maintain and Replace).

Table 4.9 illustrates the comparison between the Hybrid and Optimised Remove alternatives and provides an explanation on how both alternatives had comparable benefits and trade-offs. While the number of evaluation lens/criteria group preferences appears to be in favour of the Remove alternative, the EA states that selecting the alternative based only on the number of evaluation lens/criteria group preferences was not appropriate as this approach would not consider the variation in the magnitude and period of the effect/benefit, scale of users affected, certainty of forecast, and mitigation measures available. Due to highly divisive opinions and no clear preference for either alternative, the decision regarding the preferred alternative was forwarded to Toronto City Council, the elected representatives of the citizens of Toronto. After significant deliberations Council selected the Hybrid “alternative to” as preferred, as detailed in Chapter 4.5 of the EA. This alternative was considered by Council to achieve an appropriate balance between the goals of city building and accommodating the City’s transportation demands.

The ministry is satisfied that a reasonable range of alternatives were studied and that the “maintain” option satisfies the requirements of the EAA and ToR as the “Do Nothing” baseline. The ToR allowed for other alternatives to be identified (Chapter 6.1), thus the identification and evaluation of “alternatives to” in the EA is consistent with the approach provided in the approved ToR.

EA decision making process	EAA and ToR requirements	Description and characteristics of the requirements
Alternatives	Description and Statement of the Rationale for the Alternatives methods: Alternative Methods section 6.1(2)(b)(ii)	“Alternative methods” include a description of different ways of implementing the preferred “alternative to”. A reasonable range of “alternative methods” should be identified and outlined.

Analysis of the EA

Chapter 5: Design Alternatives of the EA explains how the alternative methods were formulated, and describes the methodology followed to identify the preferred alternative method for implementing the undertaking.

Three alternative methods were selected from a broader list of concepts, some of which were not carried forward following public/stakeholder input and an analysis of issues and constraints. These three Hybrid alternative methods were then compared:

- Hybrid Design Alternative 1: this method involves removing the existing Logan Avenue ramps, maintaining the existing Gardiner Expressway through the Keating Channel Precinct along the north edge of the Keating Channel Precinct; constructing new two lane eastbound off-ramp and westbound on-ramp connections east of Cherry Street, constructing new approach roads to the new ramps east of Cherry Street, and realigning Lake Shore Boulevard mid-block through the Keating Channel Precinct.
- Hybrid Design Alternative 2: Similar to Hybrid 1, however the new ramps would connect with a planned Munitions Street extension, and the DVP-Gardiner connection would be rebuilt further north than Hybrid 1.
- Hybrid Design Alternative 3: Similar to Hybrid 2 but the Gardiner/DVP connection would be further north, and the rail bridge underpass (south-east of Corktown Common park) would be widened to the east.

Table 5-2 in Chapter 5 outlines the decision making process used in evaluating the alternative methods to determine the preferred undertaking. The methodology used to evaluate alternatives is consistent with the approved ToR.

The ministry is satisfied that an adequate description of the different ways of implementing the alternative solution was provided, and a reasonable range of alternative methods were evaluated using a broad range of environmental criteria and measures.

EA decision making process	EAA and ToR requirements	Description and characteristics of the requirements
Evaluation	Description of the Environment: section 6.1(2)(c)(i)	Proponents must consider the broad definition of the environment including the natural, biophysical, social, economic, built and cultural conditions. The EA must provide a description of the existing environmental conditions in the study area. The EA must identify those elements of the environment that may be reasonably expected to be affected, either directly or indirectly, by the proposed undertaking and/or the alternatives.

Analysis of the EA

The section of the Gardiner Expressway and Lake Shore Boulevard that is being examined for reconfiguration extends 2.4 kilometres from approximately Lower Jarvis Street to east of the DVP at Logan Avenue. Two study areas were considered in the EA:

1. Urban Design and Environmental Effects Study Area: includes the lands in the vicinity of the section of the Gardiner Expressway and Lake Shore Boulevard that is being considered for reconfiguration. These are the areas that could potentially experience disruption effects and be transformed through redevelopment opportunities. This is expected to include lands south of King Street to the waterfront, and from Lower Jarvis Street to approximately Leslie Street. This study area includes the precincts of East Bayfront, West Don Lands, and Keating Channel, as well as portions of the Port Lands and South of Eastern areas.
2. Transportation System Study Area: includes the area that could be affected by changes in traffic patterns and volumes. The lands that extend from Dundas Street to Lake Ontario and from Spadina Avenue to Woodbine Avenue will be subject to a detailed level transportation assessment. The study area includes the transportation network of transit (subway, streetcar, and GO Transit service), and vehicular traffic including goods movement and emergency vehicles, and the pedestrian and cycling networks. Transportation initiatives, traffic behaviours and modal splits at a city-wide or regional level were also considered in the transportation assessment. This study area is also referred to as the “Transportation Study Area” in the EA Report.

The proponents followed a planning approach for the EA whereby environmental constraints and opportunities were considered within the context of the environment as broadly defined under the EAA (i.e., the natural environment as well as the social, economic and cultural heritage and other “environments” relevant to the undertaking). The description of the potentially affected environment (otherwise known as the baseline conditions) was prepared based on this approach.

Chapter 3 of the EA outlines the potentially affected environment. The baseline conditions document the natural, social, economic, urban design, infrastructure and transportation environments of the various precincts and neighbourhoods that exist in the study area.

To assess and evaluate the alternatives, two baseline condition horizon years were established: 1) 2013 representing existing or near term conditions and 2) 2031 representing the long term future operating condition.

The ministry is satisfied that a broad definition of the environment was considered and a description of existing environmental conditions in the study area provided. Additionally, a reasonable planning horizon was considered in the EA, and the studies found in the appendices are complete.

EA decision making process	EAA and ToR requirements	Description and characteristics of the requirements
Evaluation	Description of	Both positive and negative environmental effects should be discussed.

Potential Environmental Effects: section 6.1(2)(c)(ii)	The EA must identify methods and studies used to analyze the potential environmental effects. The methods used are contingent on the type of project. Impact assessment methods and criteria used during the evaluation should be identified. The methods chosen must be clear, traceable and replicable so that interested parties can understand the analysis and logic used throughout the EA.

Analysis of the EA

The EA clearly identified the potential effects of the project activities for the preferred undertaking on the environment.

Chapter 6: Description of Undertaking Effects Assessment, along with detailed studies in the appendices, outline the potential effects of the proposed undertaking and preferred design. The studies undertaken as part of the EA include:

- Cultural heritage
- Archaeology
- Natural environment
- Soils and groundwater
- Stormwater management
- Air quality
- Noise
- Existing infrastructure
- Transportation/goods movement
- Urban design and public realm
- Economics/economic competitiveness
- Land valuation

The EA assesses both positive and potential negative effects of the undertaking. The evaluation method included identifying proposed monitoring and mitigation measures to minimize or avoid any potential negative environmental effects of the preferred undertaking being considered as part of the EA process. The EA Report identifies the net effects of the undertaking during both construction and operation.

Table 6-1 in the EA describes construction period project/environmental component interaction, Table 6-2 describes construction period net effects, and Table 6-3 describes net effects during operation of the undertaking.

The assessment of the undertaking was based on environmental evaluation criteria and measures that were developed by the proponents and consulting team that reflect the study area, project characteristics and input from stakeholders throughout the course of the EA. The criteria reflect the four study lenses (transportation and infrastructure, urban design, economics, and environment) and for each criterion, one or more measures were developed. Potential effects to source water protection, cumulative effects, effects from climate change, and effects to climate change were discussed.

A list of connected key plans and studies considered in the EA are found in the EA Report and additional studies are referenced in Appendix L including:

- Lower Yonge Transportation Master Plan
- Lower Don Lands (Master Plan EA and Villiers Island Precinct Plan
- Don Mouth Naturalization and Flood Protection EA
- Port Lands and South of Eastern Transportation and Servicing Master Plan EA
- Metrolinx Expansion Plans/Projects
- First Gulf Development Official Plan Amendment (OPA)
- City of Toronto Official Plan
- Central Waterfront Plan
- Royal Commission on the Future of the Toronto Waterfront: Report 15—The Toronto Central Waterfront Transportation Corridor Study
- Royal Commission on the Future of the Toronto Waterfront Final Report: Regeneration—Toronto's Waterfront and the Sustainable City
- Toronto Waterfront Revitalization Task Force: Our Toronto Waterfront—Building Momentum
- Toronto Staff Report: Review of the Gardiner/Lake Shore Corridor Proposal Contained in the Central Waterfront Secondary Plan
- Provincial Policy Statement
- Growth Plan for the Greater Golden Horseshoe
- King-Parliament Secondary Plan
- West Don Lands Precinct Plan
- East Bayfront Precinct Plan
- Keating Channel Precinct Plan (in progress)

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- Lower Yonge Precinct Plan (in progress)
- PATH Pedestrian Network Master Plan
- York/Bay/Yonge Gardiner Interchange Reconfiguration EA (in progress)

The evaluation method in the EA was clear, traceable, replicable, and appropriate for a major transportation project in an urban area.

EA decision making process	EAA and ToR requirements	Description and characteristics of the requirements
Evaluation	Description of the Actions Necessary to Prevent, Change, Mitigate or Remedy the Environmental Effects: section 6.1(2)(c)(iii)	A description of future commitments, studies, and a work plan may be included as part of the actions necessary to prevent, change, mitigate or remedy environmental effects for each alternative for the ultimate purpose of comparing them. The ToR says: The effects assessment will need to consider the potential for effects on both the existing environment as well as the expected future conditions of the study area (as is reflected in current plans and proposals). Also to be considered in the evaluation are mitigation measures that could be implemented to reduce the effects; as such the evaluation will consider the residual or “net” effects of each alternative. For the preferred alternative, mitigation measures to reduce the effects and the residual or “net” effects of the undertaking will be described.

Analysis of the EA

Overall, the EA provides a description of the commitments to prevent, change, mitigate, or remedy potential environmental effects.

The ministry during its review of the EA recommended that the proponents amend the EA to include more information on mitigation that was proposed and considered for the alternatives to. The proponents included this information (Table 4-1a) in the revised EA which was posted to the project website.

Based on the construction period interactions presented in Table 6-1 and Table 6-2 presents a summary of the project's potential construction-related effects and proposed mitigation measures, and identifies the net residual effects. Table 6-3 presents a summary of the projected project operations period related effects, proposed mitigation and monitoring measures, and net residual effects.

As the proponents went through each stage of assessment and alternatives to and alternative methods were developed, an increasing level of detail was provided on potential effects, proposed mitigation, and net effects of the proposed undertaking.

Commitments to monitoring are discussed in Chapter 6.10 of the EA. An effects monitoring strategy has been developed and is summarized in Chapter 6.10.1. Table 6-5 summarizes proposed construction effects monitoring and Table 6-6 summarizes EA commitments and compliance monitoring.

A commitments summary table (Table 6-7 in the EA) was added by the proponents as requested by the ministry, to address comments made by agencies during the ministry Review.

Commitments to future work are also contained in Chapter 9.1, and include detailed design work, completion of a detailed constructability and staging plan, the need to consider the advancement of other projects and plans in the project area, an update of the Keating Channel Precinct Plan and Public Realm Plan development.

EA decision making process	EAA and ToR requirements	Description and characteristics of the requirements
Evaluation	Evaluation of Advantages and Disadvantages to the Environment: section 6.1(2)(d)	The preferred alternative should be identified through this evaluation.

Analysis of the EA

Chapter 4.3.1 describes the evaluation approach used to identify the advantages and disadvantages of the "alternatives to". To compare advantages and disadvantages, both construction effects and long-term operations effects were identified and assessed based on the criteria and definitions noted in the EA.

Quantitative and qualitative data was collected and considered.

Chapter 4.3.2 describes the results of the assessment and evaluation of the four initial alternative solutions. The evaluation matrix was presented in Table 4.2 and Table 4.3 summarized alternatives preference ranking by criteria group. A detailed review of the results followed, and Chapter 4.3.2.2 outlined how public input was considered in decision making. To identify a trade-off among alternatives, a paired comparison approach was used and results were presented in Table 4.4 to Table 4.6.

While the majority of those consulted (approximately 60%) indicated support for the Remove alternative, the City of Toronto Public Works and Infrastructure Committee in March 2014 advised the proponents to develop and analyze additional alternatives. The Optimized Remove and Hybrid alternatives were developed and studies on Goods Movement and the City's Economic Competiveness were undertaken to evaluate these alternatives' advantages and disadvantages to the environment. Table 4.9 in Chapter 4.4.5.4 compares the Optimized Remove and Hybrid Alternatives to.

Advantages and disadvantages of the three alternative methods: Hybrid 1, 2, and 3 were presented in Chapter 5.

The proponents have clearly demonstrated how the advantages and disadvantages of the alternative solutions and designs were evaluated to identify the preferred undertaking.

EA decision making process	EAA and ToR requirements	Description and characteristics of the requirements
Evaluation	Description of Consultation with Interested Stakeholders: section 6.1(2)(e)	A description of stakeholder consultation that occurred during the preparation of the EA needs be documented and should include consultation methods used, frequency of consultation, dates that events occurred, target audience, descriptions of key milestones for which stakeholders are providing input and comments received. The EA must identify any Indigenous community consultation efforts that have been made including methods for identifying potentially interested First Nations, who was consulted, when and how consultation occurred and any comments received from First Nations. The EA should outline conflict resolution techniques used by the proponent to resolve outstanding issues with any stakeholders. There must be clear

documentation as to how issues and concerns have been addressed.

Analysis of the EA

Chapter 7 of the EA provides a consultation program overview; documenting key consultation activities, and summarizing major consultation events. The detailed record of consultation can be found in Appendix B.

Between 2009 and 2016, nearly 30,000 connections were made on the project in a variety of in person and online engagement opportunities. Five rounds of public consultation, based on the technical work completed for each phase of the EA study, were held between May 2013 and January 2016. Key consultation methods included public forums, a Stakeholder Advisory Committee, public notices, a project website, a Technical Advisory Committee, Toronto Committee and Council meetings, Waterfront Toronto Board meetings, and the creation of a Facilitator's Office.

Chapter 7.2.6 describes consultation with Indigenous communities. The potentially-interested communities were identified as:

- Alderville First Nation (FN)
- Beausoleil FN
- Chippewas of Georgina Island FN
- Chippewas of Rama FN
- Curve Lake FN
- Hiawatha FN
- Mississaugas of Scugog Island FN
- Moose Deer Point FN
- Mississaugas of the New Credit FN

Letters and emails were sent to each of the communities advising of the five public information centres. The proponents corresponded with several communities (Hiawatha FN, Alderville FN, Curve Lake FN and met with the Mississaugas of the New Credit FN.

Chapter 7.2.7 summarizes the release of the draft EA for voluntary review. Stakeholders and the public were invited to review the draft EA Report during the 45-day voluntary review period, between July 21, 2016 and September 6, 2016, and provide comments to the project team via the Facilitator's Office. Forty-five individuals and groups/agencies submitted feedback as part of the Voluntary Review of the Draft EA Report, including the West Don Lands Committee, First Gulf, Lafarge Canada Inc., Castlepoint Numa, and the Ontario Society of Professional Engineers.

Chapter 7.3 describes the influence of consultation on the EA. For example, two alternative solutions were proposed by two third-party teams which were further refined and evaluated by the proponents/consultants.

The EA demonstrates how public and agency input received throughout the EA process informed the results of the EA.

In response to comments made by agencies on the EA and advice from the MOECC the proponents conducted additional studies (a Cultural Heritage Resource Assessment and Stage 1 Archaeological Assessment) which were completed in April 2017. The proponents also included additional commitments to coordination with agencies on other projects in the study area as the proposed Gardiner project advances, and ongoing consultation with agencies and Indigenous communities. In addition, the proponents committed to completing a Species at Risk Screening and applying any required mitigation. These additional studies and commitments were included in the amended EA and appendices, which are available on the project website.

The EAA requires that the proponents consult with all interested persons during the preparation of the EA and report on the results of that consultation. The ministry is satisfied that the proponents appropriately carried out the consultation plan that was outlined in the approved ToR.

Overall, the ministry is satisfied that the proponents provided sufficient opportunities for the public, interested stakeholders and Indigenous communities to be consulted during the preparation of the EA.

EA decision making process	EAA and ToR requirements	Description and characteristics of the requirements
Selection process	Proposed Undertaking. Description and Statement of the Rationale for the undertaking: section 6.1(2)(b)(i)	The description of the undertaking should specify what the proponent is seeking approval for under the EAA. The description should include information on the location, attributes, dimensions, emissions etc. The evaluation process should identify which is the preferred undertaking.

Analysis of the EA

The evaluation process in Chapters 4 and 5 of the EA explains why alternatives were chosen and why the preferred undertaking was selected.

Chapter 6 provides a description of the preferred undertaking.

The EA documents how the preferred undertaking addresses the problem and opportunity statement.

In the EA, Chapter 6.10 outlines commitments to monitoring. Chapter 9.1 details commitments of future work. For example, in Chapter 9.1.1-detail design, effects to features such the Metrolinx Rail Bridge, Don River, the Don Roadway, and Cherry Street would need to be considered, and minimized. A review of safety measures for tight ramps and recommendations would be undertaken. Chapter 9.1.2 outlines a construction detour route review and Chapter 9.1.3 outlines coordination with other infrastructure and planning projects. A commitment to completing a public realm implementation phasing and funding strategy is described in Chapter 9.1.4.

The EA was amended as suggested by the ministry to include additional commitments to consultation, coordination with agencies and future work.

Standard conditions including compliance monitoring and reporting, and public recordkeeping are recommended by the ministry to ensure all commitments in the EA are carried out.

EA decision making process	EAA and ToR requirements	Description and characteristics of the requirements
Next steps & additional commitments	Additional ToR Commitments	Outline any further commitments made by the proponent.

Analysis of the EA

Waterfront Toronto and the City of Toronto committed to preparing a comprehensive list of commitments during the EA process. These commitments are detailed in Table 1-1 of the EA, which references the section of the ToR in which the commitment was made and the corresponding chapter in the EA where the commitment was addressed. These included preparing a comprehensive list of commitments and a monitoring plan for the undertaking, how consultation will be undertaken, and how alternatives would be evaluated.

If approved, next steps for the project include detailed design and construction staging plans, the completion of a Public Realm Phasing and Implementation Strategy, and construction and effects monitoring.

EA decision making process	EAA and ToR requirements	Description and characteristics of the requirements
Next steps & additional commitments	Additional approvals	Outline additional approval requirements. Provide sufficient detail about the nature of the approval.

Analysis of the EA

If EA approval is granted, the proponents will still require other legislative approvals to construct and operate the undertaking. Chapter 1.4 of the EA outlines additional municipal and provincial approvals that may be required, including:

- MOECC Permit to Take Water under the *Ontario Water Resources Act* (for digging during construction)
- Toronto and Region Conservation Authority Regulation of Development, *O. Reg. 166/06* Interference with Wetlands and Alterations to Shorelines and Watercourses Regulations
- Project Review by Aquatic Habitat Toronto
- City of Toronto Road Occupancy Permit, Road Cut Permit, Tree Removal Permits, Permit for Installation/Relocation of Public Utilities, Local Hydro Utility Building Permit, Toronto Sewer Use Bylaw, and Noise Bylaw Exemption

The proponents have also committed to undertaking a Species at Risk Screening.

Appendix B: Submissions received during the initial comment period

Submissions are available in hard copy at the public record locations listed in this ministry review.

Table 1: Government Review Team comment summary table

Comment #1

Submitter

Ministry of Natural Resources and Forestry (MNRF)

Summary of comments

Species at Risk (SAR) recorded in the vicinity include Piping Plover (endangered), Peregrine Falcon (special concern), Chimney Swift (threatened), and Eastern Whip-poor-will (threatened). There is potential for endangered bats (i.e. Eastern Small-footed Myotis, Little Brown Myotis, Northern Myotis, and Tri-Coloured Bat) in cavities.

Additional natural heritage information including information on wetlands and Areas of Natural and Scientific Interest (ANSI) can be obtained through Land Information Ontario (LIO).

Absence of information from MNRF does not mean the absence of species/features.

Approval from MNRF may be required if work proposed could cause harm to any species that receive protection under the *Endangered Species Act*, 2007.

Proponent's response

The proponents will complete a SAR screening well in advance of any disturbance to the project footprint to determine the need for any additional mitigation, investigations, or permitting. The MNRF will be kept informed of this work. Should mitigation measures be required, the proponents will ensure that these measures are incorporated into contract documents as appropriate.

The commitment to complete a SAR screening prior to construction and continuing to consult with MNRF has been noted in the revised EA which will be placed on the project web site.

Status

The MNRF indicated that it is satisfied with this response.

Comment #2

Submitter

Ministry of Tourism, Culture and Sport (MTCS) & Ministry of Citizenship and Immigration

Summary of comments

Archaeological Resources

This EA report relies on an "Archaeological Baseline Conditions Report" to identify potential for archaeological impacts. This baseline conditions report notes the archaeological sites that have already been documented in the study area, and recommends a comprehensive Stage 1 Archaeological Assessment Report be completed if any work involving subsurface impacts be required as part of project implementation. While this baseline conditions report was submitted to the MTCS archaeological review team and entered into the register, it was not subjected to technical review, since it recommended further work and was not intended to satisfy the Archaeological Assessment requirements.

During an EA study, archaeological fieldwork should be completed up to such a stage as is necessary to fully determine the archaeological resources to be potentially impacted by the alternative(s) being carried forward. It is possible that the typical approach of carrying out Stage 2 and if necessary Stage 3 work is not appropriate to this context given the highly disturbed study area and well-documented archaeological resources. However, at the very least, Stage 1 should be completed to fully determine whether archaeological potential exists in parts of the study area that may be subjected to ground disturbance. Leaving formal Archaeological Assessment work to the preliminary or detailed design stage does not allow for potential effects on archaeological resources to be evaluated based on full information of those resources.

Built Heritage Resources and Cultural Heritage Landscapes

The Cultural Heritage Baseline Conditions Report for this EA study lists cultural heritage resources in the study area that have existing recognition such as the properties designated under Part IV of the *Ontario Heritage Act* or listed on the municipal register. It is not clear from any of the EA documentation that any attempt has been made to determine the existence of previously unrecognized cultural heritage resources. An EA study in an area with cultural heritage potential would normally include a Cultural Heritage Assessment Report and/or Heritage Impact Assessment that would screen the study area for potential cultural heritage resources, assess each potential resource according to the criteria in *Ontario Regulation 9/06* to determine whether they indeed have cultural heritage value or interest, determine whether the proposed undertaking has the potential to impact cultural heritage resources, both newly and previously identified, and recommend mitigation measures for these impacts.

As this process has not been carried out, determinations regarding potential effects on built heritage resources and cultural heritage landscapes are made solely based on municipally recognized resources, and may not capture all potential impacts on the cultural environment.

Proponent’s response

A call with MTCS was held on March 30, 2017 to discuss these comments. A Revised Stage 1 Archaeological assessment has been prepared and has been submitted to MTCS. This report will be posted on the project web site. As well, the Stage 2 work commitments have been included in a commitments table that will be included in the revised EA and also be posted on the project web site.

Regarding built cultural heritage resources, a full Cultural Heritage Resource Assessment (CHRA) report has been prepared and submitted to MTCS. Recommendations from this report are included in an EA commitment table in the revised EA. The CHRA Report and revised EA will be placed on the project web site.

Status

MTCS has reviewed and cleared the Stage 1 Archaeological Assessment completed for the project. The

MTCS indicates that its comments have been addressed.

In the revised EA the proponents have committed to subjecting construction excavations in the area of the potential Euro-Canadian archaeological resources to a program of archaeological monitoring to document any remains, if any, prior to their removal.

MTCS has reviewed the Cultural Heritage Resources Assessment report and offers the following comments: While the assessment has identified properties within the Keating Channel Precinct as having potential cultural heritage value of interest, the report states that the Hybrid Design Alternative 3 is unlikely to directly impact these properties. That being said, the report recommendation that if the project designs change significantly further site-specific impact assessment may be appropriate, should be followed.

MTCS note the EA commitment to conducting further assessment to identify opportunities to document on the elevated expressway structure for archival purposes. MTCS supports this commitment.

Comment #3

Submitter

Metrolinx

Summary of comments

Metrolinx has provided comments throughout the Gardiner East project, and most recently in a letter dated May 12, 2016.

As previously stated, Metrolinx (as well as other organizations) have numerous initiatives currently underway or planned for this area, and these works may overlap with the Gardiner project. Coordination of planning and, ultimately, construction schedules will be required to ensure that any conflicts are avoided or at least minimized. The intent will be to ensure that existing and planned Metrolinx infrastructure, expansion programs, and operations are not adversely impacted by the Gardiner East EA proposed works. To be specific, this would include (but is not limited to) the following:

- Current and future railway service and operations (mainline tracks and track speeds to be maintained at all times)
- Railway corridor expansion work for additional mainline track(s)
- Track alignments (vertical and horizontal)
- Electrification infrastructure (e.g. gantry, overhead contact system portals, Don Yard paralleling station, grounding) and signal system requirements
- Signal bridge and turnouts west of the Don Rail Bridge
- Any infrastructure (buried or otherwise) supporting rail corridor operations (including but not limited

to railway signals, communications and fibre optics)

In June 2016 Metrolinx and the Government of Ontario announced that a new integrated Regional Express Rail/SmartTrack station (East Harbour) will be constructed at the former Unilever site (northeast corner of Lake Shore Boulevard and Don Roadway). The preferred design for this station has station platforms on all four future mainline tracks servicing local and express GO service. There will also be consideration for yard tracks leading west into Don Yard, pedestrian walkways, and other 'add-on' station components. Metrolinx will continue to work with the proponents as the design and funding commitments of this station progresses.

The Gardiner East project includes public realm improvements that extend from Jarvis Street to Leslie Street. Within this area, Metrolinx has proposed expansion and modifications within the portion of the Union Station Rail Corridor (USRC) east of Yonge Street west to the proposed Canal Track south of Eastern Avenue, and south of the rail corridor for the planned expansion of Don Yard and acquisition of Wilson Yard (USRC East Enhancements project). The proposed plans for the USRC East Enhancements project include public realm improvements associated with retaining walls and bridge modifications (i.e. extensions) in the study area. The proponents are currently finalizing their Public Realm Phasing and Implementation Plan for the Gardiner East corridor. Metrolinx is committed to working closely with the proponents to coordinate plans for both the Gardiner East and USRC East Enhancements projects.

Proponent's response

The proponents acknowledge Metrolinx's plans as outlined in their letter including the proposed East Harbour rail station.

The proponents will continue to engage with Metrolinx in the advancement of the design for the Gardiner project to determine how all of the various proposed projects can be coordinated and accommodated. This commitment has been included in the revised EA which has been posted to the project website.

Status

Metrolinx indicated that it is satisfied with this response.

The ministry recommends standard conditions such as annual reporting where project updates, including consultation with agencies, will be documented to further address Metrolinx's comments.

Comment #4

Submitter

Ministry of the Environment and Climate Change, Central Region

Summary of comments

A review of the air quality impact assessment supporting the Final Gardiner EA was conducted.

Overall, previous comments were addressed in Section 3.1.5.1 "Air Quality" and Table 3-3 of the final EA.

The only comments that were not addressed in Appendix H "Air Quality and Greenhouse Gas Impact Assessment Report" are as follows:

1. All references to Canada Wide Standard should be replaced by Canadian Ambient Air Quality Standards (CAAQS) as it was done in the EA document.
2. Section 3 "Background Air Quality" of Appendix H refers to the Dillon Consulting memo dated August 22, 2013 which is supposed to be included in Appendix H. This memo is not attached, and should be included, since it should be part of the air quality impact assessment report.

In summary, the proponents have addressed previous comments and provided a rationale as to why certain aspects of an air quality impact assessment were not presented in Appendix H, such as cumulative impacts and concentrations at the most impacted receptor. No further comments are provided at this time.

Proponent's response

The August 22, 2013 memo was included in the revised EA and posted on the project website.

Status

The ministry is satisfied with this response.

Comment #5

Submitter

Ministry of the Environment and Climate Change: Aboriginal Consultation Advisor, Environmental Approvals Access and Service Integration Branch

Summary of comments

The proponents have clearly carried-out an extensive engagement program, including informative notifications, follow-up communications, and meetings or repeated attempts to arrange meetings with all potentially affected communities.

It is requested that the summary of consultation in Chapter 7 and/or the record of consultation in Appendix B be updated to be aligned and consistent with each other (e.g. July 2013 letter from Curve Lake First Nation not in record of consultation, clarify October 2013 letter or email from Alderville First Nation, early 2016 letter from the Mississaugas of the New Credit First Nation not in record of consultation). It is also requested that all individual issues (questions, comments, and concerns) raised in these correspondences, and at the May 6, 2016 meeting with the Mississaugas of the New Credit First Nation, including responses to them, be included in the Record of Consultation in Appendix B, and summarized accordingly in Chapter 7.

Finally, it is recommended that First Nation-specific issues and responses be presented in tables separate from local residents, community groups, and government agencies, etc.

Further, the MOECC acknowledged that the proponents have amended the EA and record of consultation

The proponents also added the following paragraph to the Consultation Section:

> "No specific comments on the EA study or the project have been received by First Nations at the time of the completion of this EA Report. As such, no summary of comments has been prepared. The project co-proponents are committed to engaging with interested First Nation communities as part of the future project design and construction stages.

MOECC still recommend that the proponents include a summary table, by community, identifying key issues raised and how they have been or will be addressed. For example, Curve Lake First Nation states in their July 11, 2013 letter:

> "Should excavation unearth bones, remains or other evidence of a native burial site or any archaeological findings, we must be notified without delay…

This is an example of an issue raised that should be addressed in the EA or included in the conditions of approval and should be included in a summary of such issues.

Proponent's response

The noted letters that were not included in Appendix B to the EA Report have been included as part of the revised EA appendix, which is posted on the proponents' website. Also included in the revised appendix are the notes from the meeting that was held with the Mississaugas of the New Credit First Nation.

No specific issues or concerns regarding the EA study or the project have been submitted by any First Nation communities. As a result, the preparation of a comment-response table is not applicable.

Status

The EA has been amended to state:

> The project co-proponents will continue to engage with indigenous communities who have expressed an interest in the project and will notify these communities of any archaeological findings that may be encountered during construction.

The ministry is satisfied with this response.

Comment #6

Submitter

Ministry of Economic Development and Growth

Summary of comments

We are satisfied with the EA and we have no comments.

Proponent's response

No response required.

Status

N/A

Comment #7

Submitter

Toronto and Region Conservation Authority (TRCA)

Summary of comments

The Don Mouth Naturalization and Port Lands Flood Protection Project environmental assessment (DMNP EA) is misidentified in a number of ways throughout the document. To be more accurate, please represent the appropriate terminology when referencing this project. Please use the acronym 'DMNP EA' once defined the first time at the beginning of the document.

Proponent's response

Comment noted. The appropriate terminology for the DMNP will be used in the future in the advancement of the design for the project.

Status

The TRCA has indicated that it is satisfied with the proponents' response. The TRCA acknowledged that some of the comments made were advisory only, without editing the final EA, and those other comments should be considered as the project proceeds through the detail design stage.

Comment #8

Submitter

Toronto and Region Conservation Authority (TRCA)

Summary of comments

On page 3-28 of the EA, references are made to components of the DMNP EA. Similar references are made in Figure 3-34. TRCA suggests additional emphasis be placed on the sediment management area, dockwall and operations required north of Lake Shore Boulevard, in the vicinity of the Gardiner. A map developed during the due diligence of the area may be helpful. This sediment management area is a critical issue for the intersection of the DMNP with the Gardiner, as it must function properly to allow for the DMNP to proceed. Without an effective area to operate the sediment facility, critical flood protection will not be achieved.

Proponent’s response

The project proponents acknowledge TRCA’s request for additional emphasis be placed on the sediment management area, dockwall and operations required north of Lake Shore Boulevard, in the vicinity of the Gardiner. This proposed infrastructure will be considered in future design stages of the undertaking.

Status

The TRCA has indicated that it is satisfied with this response.

Comment #9

Submitter

Toronto and Region Conservation Authority (TRCA)

Summary of comments

On page 3-38 of the EA, regarding the Don Valley Parkway (DVP), the report should mention that grade separations are required to the immediate east of the DVP previously connected the former Unilever operations on the north and south side of the railway embankment. These are critical for flood conveyance and as part of the impacts for the selection of the preferred alternative for the Gardiner. Please clearly identify this requirement, either in this part of the report or in its own subsection.

Proponent’s response

The noted required grade separations are being considered in the ongoing work to advance the design of the Gardiner East project.

Status

The TRCA has indicated that it is satisfied with this response.

Comment #10

Submitter

Toronto and Region Conservation Authority (TRCA)

Summary of comments

With reference to Figure 3-23 (similar to Figures 3-27, 4.6, 4.10, 5-8 to 5-10), the map does not recognize the necessary widening of the Don River north of Lake Shore Boulevard. Nor does the map depict the sediment and debris management operating yards: it was simply identified as the part of the Keating Precinct. Portraying this area as green public use incorrectly depicts the footprint required for the sediment management area, and under represents the issue for relocation or modification of the future crossings. The maps from the due diligence report should be used for this area. In addition to the figures noted above, Figure 3-30, bullet 27, should consist of bullets 21 and 27 combined, until such time the area is deemed not required for sediment management.

Proponent’s response

The proponents recognize the importance of the Don River mouth widening as well as the need for sediment debris management yards.

The maps developed through the recent due diligence work for the DMNP, includes advancing the facility design, will be considered in the advancement of the design for the Gardiner East project.

Status

The TRCA has indicated that it is satisfied with this response.

Comment #11

Submitter

Toronto and Region Conservation Authority (TRCA)

Summary of comments

Further to the above, in Figures 5-3 to 5-6, the sediment management area should be expanded in dashed lines to reflect the area shown in the due diligence report. The combined sewer overflow shaft is no longer on the west side of the Don River.

Proponent’s response

The maps developed through the recent due diligence work for the DMNP will be considered in the advancement of the design for the Gardiner East project.

Status

The TRCA has indicated that it is satisfied with this response.

Comment #12

Submitter

Toronto and Region Conservation Authority (TRCA)

Summary of comments

In Figure 3-30, bullet 22, please note the proposed pedestrian bridge is not in conformance with the due diligence report. Please remove the bridge, as no bridge is proposed for this location.

Proponent’s response

The pedestrian bridge over the Keating Channel as shown in the noted figure is not part of the undertaking.

Status

The TRCA has indicated that it is satisfied with this response.

Comment #13

Submitter

Toronto and Region Conservation Authority (TRCA)

Summary of comments

In Figure 3-30, bullet 24, the hydro transformer station location is incorrect. It is actually located south of the hydro bridge crossing. Additionally, in bullet 25, it should be mentioned that this needs relocation and removal, since other DMNP EA items are being shown in this map.

Proponent’s response

Comments noted.

Status

The TRCA has indicated that it is satisfied with this response.

Comment #14

Submitter

Toronto and Region Conservation Authority (TRCA)

Summary of comments

In Figure 3-30, bullet 29, the pedestrian bridge crossing should be removed with the implementation of the DMNP EA. The depicted pedestrian bridge over Keating Channel, east of the Munition Street crossing, is not in the due diligence report.

Proponent's response

Included in the revised EA is a revised Figure 3-30 that notes that this pedestrian bridge is no longer proposed.

Status

The TRCA has indicated that it is satisfied with this response.

Comment #15

Submitter

Toronto and Region Conservation Authority (TRCA)

Summary of comments

The depicted infilling of Keating Channel to the east from Munition Street, on the south side of the channel, is not in conformance with the due diligence report.

Proponent's response

The maps developed through the recent due diligence work for the DMNP will be considered in the advancement of the design for the Gardiner East project.

Status

The TRCA has indicated that it is satisfied with this response.

Comment #16

Submitter

Toronto and Region Conservation Authority (TRCA)

Summary of comments

The weir on the north side of Lake Shore Boulevard is no longer being depicted in a semi-circular configuration. Please see the due diligence report.

Proponent's response

The maps developed through the recent due diligence work for the DMNP will be considered in the advancement of the design for the Gardiner East project.

Status

The TRCA has indicated that it is satisfied with this response.

Comment #17

Submitter

Toronto and Region Conservation Authority (TRCA)

Summary of comments

Figure 5-7 as above, while there is a small industrial dockwall area depicted in these renderings for the sediment management area, it is likely to be too small to accommodate the sediment operations. These operations will likely need to extend further south on the west bank to address dredging and debris management operations.

Proponent's response

Comments noted. The renderings are conceptual and were developed to illustrate the difference in the general alignments of the three Hybrid designs.

Status

The TRCA has indicated that it is satisfied with this response.

Comment #18

Submitter

Toronto and Region Conservation Authority (TRCA)

Summary of comments

Regarding hybrid options 2 and 3, opportunities to further improve conveyance and sediment management operations if Lake Shore Boulevard and the adjacent Harbour Lead could be raised. This option should be a possible consideration, given the phased approach.

Proponent's response

Comments noted. The potential to raise the grade of the Lake Shore Boulevard and Harbour Lead crossing of the Don River will be examined in future design stages of the project.

Status

The TRCA has indicated that it is satisfied with this response.

Comment #19

Submitter

Toronto and Region Conservation Authority (TRCA)

Summary of comments

Further to the above and to page 9-5, TRCA requests confirmation the Gardiner team will be exploring opportunities for realigning and reconfiguring the Lake Shore Boulevard crossing, in coordination with the DMNP EA and the Port Lands team.

Proponent's response

Yes, the proponents will consult with TRCA in the future design work for the Lake Shore Boulevard crossing of the Don River.

Status

The TRCA has indicated that it is satisfied with this response.

The proponents have committed to continuing to consult with TRCA in the amended EA, which is posted on the project website.

Comment #20

Submitter

Toronto and Region Conservation Authority (TRCA)

Summary of comments

Figures 5-14 to 5-16 depict more accurately the Keating Channel conditions east of the future Munition Street, and are more reflective of the due diligence report. TRCA suggests text be provided earlier in the EA where those features were noted, and the elimination of these elements from the design.

Proponent's response

Comment noted.

Status

The TRCA has indicated that it is satisfied with this response.

Comment #21

Submitter

Toronto and Region Conservation Authority (TRCA)

Summary of comments

On page 5-48, the potential impacts of the new ramps and piers on flow conveyance through the area between the railway embankment and Lake Shore, is not clearly discussed. The structure of the ramps potentially creates an impediment to flood conveyance. It is possible Hybrid 3 does cause such an impact, hence the above direction to widen the grade separation of the railway embankment. This grade separation would ensure sufficient space for the new ramps to be raised above the future regulatory flood event level. Also of concern is the vertical clearance provided in the sediment management area to allow for dredging and management of the debris and sediment on the west bank of the river and the adjacent sediment management operations yard. These key issues were touched on in the write-up, but not discussed in any detail.

Proponent's response

Comments noted. The proponents will consult with TRCA in the future design work regarding the new Gardiner-DVP ramps to address the noted concerns.

TRCA will also be invited to participate in the multi-agency coordinating committee that has been established to plan the various projects on the Don Mouth area. One of the goals of this committee will be to minimize impact and disruption to TRCA's planned initiatives.

Status

The TRCA has indicated that it is satisfied with this response.

The proponents have committed to continuing to consult with TRCA in the amended EA, which is posted on the project website.

Comment #22

Submitter

Toronto and Region Conservation Authority (TRCA)

Summary of comments

Page 6-5 begins to discuss the configuration of the new ramps over the Don River, however specific discussion related to the need to raise the soffit of the ramps on the east side of the river is missing. Doing so would ensure no conflict with the regulatory flood levels, and that soffit elevations over the river and west bank (the sediment management dockwall area) are sufficient to permit dredging and dockside removal of debris from the river. As the final equipment needs have not been defined, allowing vertical clearances for manual dredges and loaders on the river and on the dock beneath the ramps is important.

Proponent's response

Comments noted. The proponents will consult with TRCA in the future design work regarding the new Gardiner-DVP ramps to address the noted concerns.

Status

The TRCA has indicated that it is satisfied with this response. The proponents have committed to continuing to consult with TRCA in the amended EA, which is posted on the project website.

Comment #23

Submitter

Toronto and Region Conservation Authority (TRCA)

Summary of comments

Page 6-33 discusses the loss of terrestrial habitat features. Suggested mitigation measures include the creation of new green space north of Lake Shore Boulevard, on the west of the Don River. The amount of habitat that can likely be created in this area is limited as much of the area will be required for sediment and debris management operations. While a trail connection will be required with some associated greenspace, the extent of functional habitat in that area may be limited.

Proponent's response

Comments noted. The location of new greenspace areas will be confirmed in future public realm design work that is committed to by the proponents.

Status

The TRCA has indicated that it is satisfied with this response.

Comment #24

Submitter

Toronto and Region Conservation Authority (TRCA)

Summary of comments

Page 6-38 discusses microclimate, however the detailed discussion table is not consistent with the summary table that identified removal of vegetation as a negative impact on microclimate during construction. Similarly, as noted on page 6-23, the removal of the elevated decks will change the microclimate in the area permanently, as well during construction.

Proponent’s response

Comment noted. Potential vegetation removal in the Keating Channel Precinct during construction has the potential for effects on micro-climate in that area. It is noted that much of this same vegetation would also be removed by other planned projects in the area. The planned landscaping that is included as part of the undertaking will offset vegetation removal and possible microclimate effects.

Status

The TRCA has indicated that it is satisfied with this response.

Comment #25

Submitter

Toronto and Region Conservation Authority (TRCA)

Summary of comments

Page 6-39 discusses impacts on First Nations Communities. The new Water Claim submitted in September 2016 by the Mississaugas of the New Credit should be noted for consideration during detailed design.

Proponent’s response

Comment noted. The proponents are open to continued engagement activities with the Mississaugas of the New Credit First Nation. To date, specific comments on the project have not been received.

Status

The TRCA has indicated that it is satisfied with this response.

Comment #26

Submitter

Toronto and Region Conservation Authority (TRCA)

Summary of comments

Page 6-43 discusses consistency/impacts on other projects. While TRCA agree that the Gardiner preferred alternative can be implemented with little to no effect on the approved DMNP EA, it should be noted that continued engagement with the Port Lands project team is required as a mitigation measure. Continued engagement will ensure effective design and implementation to maximize opportunities between both projects, to confirm the design process of the Gardiner improves conveyance through this reach, and to provide for effective and efficient sediment and debris management operations. The concept as shown currently provides the potential for no impacts. Continued integration and modeling during design will ensure this conclusion remains true.

Proponent's response

The proponents will consult and engage with TRCA in the future design work regarding the new Gardiner-DVP ramps to address the noted concerns.

Status

The TRCA has indicated that it is satisfied with this response. The proponents have committed to continuing to consult with TRCA in the amended EA, which is posted on the project website.

Comment #27

Submitter

Toronto and Region Conservation Authority (TRCA)

Summary of comments

Page 6-46 discusses impacts on Don River flood conveyance operations. This discussion should also involve the new Lake Shore Boulevard bridge alignment and railway spur conditions. Opportunities for improved conveyance and sediment management access were previously discussed in the EA. As noted above, continued engagement with the Port Lands team is important to determine all the efficiencies and synergies in design and implementation of the Lake Shore crossing location, and soffit clearances from a flood conveyance and sediment management perspective.

Proponent's response

In advancing the design for the Lake Shore Boulevard crossing of the Don River the potential to improve river conveyance will be explored in consultation with TRCA.

Status

The TRCA has indicated that it is satisfied with this response. The proponents have committed to continuing to consult with TRCA in the amended EA, which is posted on the project website.

Comment #28

Submitter

Toronto and Region Conservation Authority (TRCA)

Summary of comments

Similar to the remarks above, page 6-60 of the EA states the Gardiner project will not have material impact on Don River flood conveyance. This is overstated, as the level of detail does not allow for such a strong statement. TRCA agrees the preferred alternative allows for flood conveyance and sediment management based on the existing high level of concept design. It is the commitment from the Gardiner team, however, to ensure an integrated design process will proceed between the DMNP Project and Gardiner in this area, to ensure the conveyance and sediment management considerations continue to be addressed.

Proponent's response

The proponents will consult and engage with TRCA in the future design work for the Gardiner project and are committed to undertaking an integrated design process to ensure that the objectives of the DMNP are not negatively impacted.

Status

The TRCA has indicated that it is satisfied with this response. The proponents have committed to continuing to consult with TRCA in the amended EA, which is posted on the project website.

Comment #29

Submitter

Toronto and Region Conservation Authority (TRCA)

Summary of comments

Please develop comprehensive plans for erosion and sediment control (ESC), grading, and phased construction at detailed design. Please, refer to the Greater Golden Horseshoe Conservation Authorities' Erosion and Sediment Control Guideline for Urban Construction for guidance (https://trca.ca/planning-permits/procedural-manual-and-technical-guidelines/).

Proponent's response

Comment noted. A comprehensive ESC plan will be developed in advance of construction. This plan is committed to in the EA Report (Tables 6.2 and 6-6).

Status

The TRCA has indicated that it is satisfied with this response.

Comment #30

Submitter

Toronto and Region Conservation Authority (TRCA)

Summary of comments

Although natural heritage within the study area is limited, please develop a restoration plan that will provide a net ecological gain for these works. TRCA has guidelines for restoration that should be referenced. As noted above, any restored natural areas should incorporate the need for sediment removal operations.

Proponent's response

As outlined in Table 6.2, the project proponents are committed to the development of new green space and will integrate with the Port Lands Biodiversity Strategy. The noted guideline document will be considered.

Status

The TRCA has indicated that it is satisfied with this response.

Comment #31

Submitter

Toronto and Region Conservation Authority (TRCA)

Summary of comments

Permits in accordance with *Ontario Regulation 166/06* are required from TRCA prior to project construction in TRCA regulated areas. During detailed design, a pre-design brief should be composed, summarizing all TRCA requirements and technical commitments made during the EA stage. This pre-design brief, together with the comments in this letter, should be used to develop the permit submission. For further information, please refer to TRCA's Planning and Development Procedural Manual, as well as our web page on infrastructure planning.

Proponent's response

The proponents will seek the required permits from TRCA under *Ontario Regulation 166/06*.

Status

The TRCA has indicated that it is satisfied with this response.

Comment #32

Submitter

Toronto and Region Conservation Authority (TRCA)

Summary of comments

TRCA suggests a meeting with the proponents be held once this project reaches detailed design, to discuss implementation, phasing, TRCA approvals, and next steps.

Proponent's response

Agreed. The proponents will consult with TRCA in the future design work for the Gardiner project.

Status

The TRCA has indicated that it is satisfied with this response. The proponents have committed to continuing to consult with TRCA in the amended EA, which is posted on the project website.

Comment #33

Submitter

Hydro One

Summary of comments

Hydro One deferred commenting on the Gardiner Expressway Reconfiguration EA pending a meeting with the proponents. On April 3, 2017 Hydro One met with the proponents and discussed opportunities to work together as the design progresses. There are underground and above ground transmission facilities within the Expressway study area and the proposed footprint of the expressway reconfiguration.

Hydro One understands that the project design is in its early stages, and that there will be opportunities to discuss potential effects on Hydro One's facilities including possible relocation.

The proponents informed us that there are several other projects in the same immediate area including the Coxwell Bypass, new Metrolinx yards and station, and Donlands Rehabilitation. These projects may also impact our facilities and possibly conflict with decisions about needed Expressway accommodation. Hydro One does not want to relocate facilities and then find further changes are necessary for subsequent projects.

At this point, it is unclear to what extent the cumulative effects of multiple projects will be addressed by this EA process. Given the different planning horizons and state of progress, formation of a coordinating body that could develop a long term plan for the area does seem prudent (i.e. and could be a reasonable outcome of this assessment).

Hydro One will be providing drawings to the proponents showing the location of our facilities and expect to meet with them at regular intervals as the project develops.

Proponent's response

The proponents will consult with Hydro One as part of future design phases to ensure that impacts to Hydro One assets in the study area are minimized. Hydro One will also be invited to participate in the multi-agency coordinating committee that has been established to plan the various projects on the Don Mouth area. One of the goals of this committee will be to minimize impact and disruption to Hydro One's assets.

Status

Hydro One has indicated that it is satisfied with this response. The proponents have committed to continuing to consult with Hydro One in the amended EA, which is posted on the project website.

Table 2: Public comment summary table

Selection of the preferred alternative

Summary of comments

The West Don Lands Committee and the St. Lawrence Neighbourhood Association, along with many members of the public who commented on the EA, strongly supported the Remove "alternative to".

A member of the public is concerned that the Hybrid 3 undertaking was selected, when the Remove alternative to was originally recommended earlier by City Councilors, City of Toronto staff, former Mayors, the former City Head Planner, respected architects and various other experts.

A member of the public is concerned that the outcome of the EA process does not reflect the ToR.

Several members of the public believe that the Remove alternative best meets the Gardiner East EA goals and is the only possible choice under the ToR. The EA clearly demonstrates the economic, environmental, and social benefits of removing the expressway and enhancing the existing Lake Shore Boulevard.

A member of the public is concerned with poor precedent setting by selecting an alternative, despite clear and overwhelming evidence that another alternative is better on all accounts laid forth by an EA.

A member of the public is concerned that the preferred alternative has inequitable impact/benefit distribution.

A member of the public commented that it has been seen in other North American cities (such as San Francisco, Portland, and Milwaukee) that expressway removals are generally beneficial along multiple axes.

Several members of the public are concerned that the decision to pursue another alternative, not originally considered while carefully establishing the original list of considered alternatives, seems to have come out of a submission from a private developer to essentially modify the Maintain alternative. The way this was inserted into the Provincially mandated EA process is problematic, and risks undermining public confidence in the EA process if private interests can subvert the evaluation of alternatives at such a late stage.

Several members of the public are concerned that the preferred solution was chosen for political reasons as opposed to good evidence and planning.

Several members of the public are concerned that the cost of the preferred Hybrid alternative is greater than the Remove alternative.

Proponents' response

The EA process followed for the Gardiner project is consistent with the ToR, has been rigorous, thorough and well documented involving a wide range of stakeholders and members of the public.

During the course of the EA study many alternatives were offered by stakeholders and reviewed and assessed. After an initial technical recommendation for the Remove alternative in 2014, the EA study team was directed by Toronto City Council to determine if the travel times of the Remove alternative could be improved and to develop and assess a Hybrid alternative.

Both alternatives are technically viable although offer different advantages and disadvantages. Public and stakeholder opinions on the alternatives varied with some comments stating that the Gardiner infrastructure is integral to the City's transportation system while others noting that the east Gardiner largely only serves as a DVP ramp and presents a barrier between the City and the Waterfront.

The evaluation of the Remove alternative to against the Hybrid alternative to (as documented in the publicly-released May 2015 Interim Report and the final EA Report), considered all study goals. The key trade-offs as identified in the reporting included:

- **Remove (Boulevard)** has a lower cost, higher revenue to the City from public land redevelopment, creates a lively Lake Shore Boulevard, facilitates better connections to the waterfront and is to result in less greenhouse gas emissions.
- **Hybrid** maintains an expressway connection function and level of service between the Gardiner Expressway and DVP, has lower auto travel and goods movement times, and less construction disruption.

Through the EA process a strong technical case to select one alternative over the other was not identified. With or without the Gardiner Expressway, the waterfront/downtown core will grow just as it has in the recent past, and traffic congestion in the City will increase even with new transit projects being developed.

The rationale for the selection of the Hybrid alternative to over the Remove alternative to has been fully documented in the EA Report. This decision required a trade-off between two very important (and related) City priority issues: traffic congestion and City building/prosperity (understanding that traffic congestion is a product of City growth and prosperity).

As documented in Section 6.9 of the EA Report, the preferred undertaking contributes to the achievement of all the study goals presented in the ToR. Ultimately it provides an appropriate balance between the important goals of City building and accommodating the City's transportation demands.

The decision regarding the two alternatives (Optimized Remove and Hybrid) was presented to City Council which was considered to be appropriate as they are representatives of the community. City Council reviewed and considered the technical evaluation results at their June 10-12, 2015 meeting. After significant Council debate on the trade-offs and advantages and disadvantages of the two alternatives, as presented in the technical reports, City Council endorsed the Hybrid as the preferred solution and further directed City staff to develop and evaluate alternative methods that would mitigate any negative impacts associated with the Hybrid solution.

The undertaking includes measures to improve future City place-making, which will contribute to the promotion of active transportation modes though a new multi-use trail and is consistent with and will accommodate transit plans along the waterfront.

Status

The ministry is satisfied that the alternatives identified in the EA conform to the ToR, which allowed other alternatives to be considered in the EA process.

The ministry is satisfied that the City of Toronto and Waterfront Toronto (proponents) in their EA documented their decision-making process for alternatives selection in a transparent manner.

While the number of evaluation lens/criteria group preferences appears to be in favour of the Remove alternative, the EA notes that selecting the alternative based only on the number of evaluation lens/criteria group preferences was not appropriate as this approach would not consider the variation in the magnitude and period of the effect/benefit, scale of users affected, certainty of forecast, and mitigation measures available.

The proponents consider Toronto City Council as a democratically-elected representation of the people of the City of Toronto, and thus found it appropriate to task Council with selecting the preferred alternative, as recommended in the May 2015 Alternative Solutions Interim Evaluation Report—Addendum and May 6, 2015 Toronto City Staff report to the Public Works and Infrastructure Committee.

Impact of connectivity with the waterfront

Summary of comments

A few member of the public are concerned that a raised expressway cuts the city off from the new development expected in the port lands.

A member of the public commented that between Jarvis Street and Cherry Street, the preferred alternative maintains the physical and psychological barrier between the city and the water to a significant degree. East of Cherry Street, the Gardiner Expressway and Lake Shore Boulevard East diverges from a stacked roadway configuration to a parallel arrangement that increases the roadway footprint, which actually worsens the physical and psychological barrier.

A member of the public commented that even with public realm improvements, the preferred alternative is inferior to how better connectivity could be achieved by the Optimized Remove alternative to.

Proponents' response

Under the Hybrid 3 design, the Gardiner Expressway east of Cherry Street will be realigned further north allowing for a better connection between future development in the Keating Channel Precinct and the waterfront (Keating Channel).

As described in Section 6.4 of the EA report, the undertaking is to include significant improvements to the public realm, streetscape and intersections along Lake Shore Boulevard. Furthermore, Section 9.1.4 of the EA Report outlines a public realm implementation strategy. These proposed improvements will directly address the issue of pedestrian and cyclist movement along and across the corridor to improve the connection between the waterfront and the rest of the City.

Status

The ministry is satisfied that the proponents appropriately considered the effects of the preferred alternative on connectivity.

In support of hybrid alternative

Summary of comments

A member of the public commented that the Gardiner Expressway East EA should conclude and be approved as soon as possible. The hybrid design as approved by Toronto Council should proceed as recommended.

Castlepoint Numa (developers) commented that Hybrid 3 appropriately addresses several of the criteria outlined in the ToR, including promoting stronger access to the waterfront.

Proponents’ response

Comment and support for the preferred undertaking is noted.

Status

The ministry acknowledges support for the project.

Accessibility

Summary of comments

A member of the public commented that:

- The website is not very accessible to the public.
- It is not reasonable to expect the public to review extensive EA documents with a 15 page overly-technical Executive Summary.
- To properly engage with the public the proponents need to create a digestible summary of key issues that should be evaluated by the layman without requiring technical expertise or the amount of time that is needed to review these EA documents.

A member of the public commented that democratic participation hinges upon an accessible sharing of information by the government. This request to “participate” is frankly set up to not receive commentary rather than to truly engage the public.

Proponents’ response

The EA study has included an extensive consultation process that included multiple public engagement opportunities (face to face and on-line) and information releases. The study has involved significant amount of work and as such, to properly summarize the work undertaken, and to meet EAA requirements for the executive summary, this length of document was required. An attempt was made to prepare the executive summary in plain language. The proponents continue to be available to respond to any questions of a technical nature that the public or stakeholders may have.

Status

The ministry is satisfied that the proponent undertook a robust consultation program and attempted to address concerns with website accessibility. The ministry is satisfied with this response.

Effect on human health and safety

Summary of comments

Several members of the public are concerned that the “Hybrid alternative to” has a larger impact on human health than the Remove “alternative to”.

A member of the public is concerned that it is currently dangerous to cross Lake Shore Boulevard under the Gardiner Expressway, and comment that slowing traffic is preferred.

Members of the public are concerned with the noise and dust from the Gardiner Expressway.

Proponents' response

A key health related issue that was raised and considered in the EA was air emissions. Future air emissions of the alternatives were determined through quantitative modelling. The reduction in road capacity associated with the Remove alternative (i.e. fewer roadway lanes) would result in a corresponding decrease in vehicles in the study area. As a result, the air quality modeling work showed a reduction in future vehicle air emissions over the future baseline or "Do Nothing" scenario. This health benefit of the Remove alternative was considered in the EA process along with many other considerations.

Through the consideration of all the evaluation criteria, including those that are health related, the Hybrid alternative was determined to be the preferred alternative. The key alternatives trade-offs that were considered in the decision process leading to the selection of the Hybrid alternative as preferred are documented in Section 4.5 of the EA Report.

The Hybrid alternative was considered, for the most part, to be a continuation of the existing condition with respect to future vehicle volumes. The Hybrid is expected to attract a similar number of vehicles in the study area as would the future "Do Nothing" alternative. The attraction of vehicles to the downtown area is a result of growth and prosperity in the City, including the downtown area.

To contribute to improved health conditions, the Gardiner East project includes a new multi-use pathway along Lake Shore Boulevard that will support active modes of transportation within the downtown. In addition, the City continues to pursue enhancements to the transit system that is to include capacity improvements to surface and sub-surface rail systems, which will reduce dependence on the automobile for downtown access.

Finally, as outlined in Section 6.9 of the EA Report, the project involves the creation of significant improved/new green space that would lie north of the Lake Shore Boulevard creating a new green ribbon, which will support improved air quality and provide stormwater quality and quantity controls. In addition, tree plantings and other landscaping are proposed along the Lake Shore Boulevard corridor, particularly from the future Munition Street intersection east where the overhead structure and at-grade boulevard will be newly separated, thereby improving planting conditions and overall streetscape environment.

It is expected that the public realm improvements that are planned for Lake Shore Boulevard and committed to in the EA Report will address issues with dust and noise. The improvements could include landscaping, measures to address traffic noise and improvements to the intersections to facilitate an easier and more enjoyable crossing of Lake Shore Boulevard for pedestrians.

Status

The ministry is satisfied that the proponents' response addresses the concerns raised.

The EA documents the project's potential effects to the environment, including human health and safety; proposed mitigation; and makes commitments to future monitoring, mitigation and consultation.

The ministry is recommending that conditions of approval be imposed which will require monitoring and reporting on how the commitments made in the EA are being met as the project progresses, if approved.

Environmental sustainability

Summary of comments

A member of the public commented that in the later stages of the study, the comprehensive sustainability and environmental component of the EA ToR was reduced to only consider the Don River naturalization, but this is only one small part of what the Gardiner East EA was intended to consider at the outset of the project.

A member of the public commented that the preferred alternative to will worsen public health, air and water quality, noise pollution, and greenhouse gas emissions when compared with other alternatives that were recommended in previous stages of the EA. These issues seem to have been increasingly neglected as the EA progressed, with no effort made to even attempt to meaningfully mitigate these environmental effects in the final submission.

Proponents' response

The proposed undertaking will not add to roadway capacity or result in additional vehicles operating in the study area. As described in Table 6.3 and Section 6.7 of the EA Report, the preferred undertaking will result in similar future air emissions, greenhouse gas (GHG) emissions, and noise effects as the future "Do Nothing" alternative.

In regards to contributing to the sustainability goal of the ToR, as outlined in Section 6.9 of the EA Report, the project involves the creation of significant improved/new green space that would lie north of the Lake Shore Boulevard creating a new green ribbon. In addition, tree plantings are proposed along the Lake Shore Boulevard corridor, particularly from the future Munition Street intersection east where the overhead structure and at-grade boulevard will be newly separated, thereby improving planting conditions and overall streetscape environment. In regards to water quality, the rebuild of the Gardiner will allow for an improvement in the manner in which stormwater runoff is managed that should contribute to an improvement in local surface water quality. This commitment is documented in Section 6.5.2.6 of the EA Report.

Finally, the rebuild of the new Gardiner Expressway-DVP connection through the Keating Channel Precinct will consider the use of more sustainable construction materials as outlined in Section 6.9 of the EA Report.

Status

The ministry is satisfied that the proposed undertaking's effects to the environment were documented in the EA and considered in decision-making, including the selection of alternatives to and alternative methods.

The EA details mitigation measures that were applied to the potential effects assessment to determine the project's proposed net effects. The proponents' commitments to monitoring and mitigation were outlined in the EA, and additional commitments were added in the amended EA which is publicly available on the project website.

The ministry is recommending conditions of approval be imposed that would require the proponents to monitor and report on the commitments made in the EA.

Through the commitments to mitigation and monitoring and recommended conditions of approval, the ministry is satisfied that the project's potential effects on the environment and environmental sustainability would be addressed.

Alternatives assessment and selection

Summary of comments

A member of the public commented that, given the clarity of the ToR and the subsequent rigorous review in the EA, why was there not a strong technical case to choose one alternative over the other?

A member of the public was concerned that assumptions and projections regarding implementation of new higher order transit alternatives to driving were calculated to favour the desired option.

A member of the public is concerned that the remaining rail corridor still represents a significant barrier, which was ignored or discounted in all evaluations. Strange given "Reconnect the City with the Lake" was one of the five ToRs. How can the goal of reconnecting the City with the lake be addressed when a huge and busy rail corridor is to remain?

A member of the public was concerned that the option of burying the controlled access expressway from Jarvis all the way to Dundas (on the DVP) was not presented for consideration. This option would have by far the greatest positive impact on the public realm and on land values, satisfying 3 of the stated ToR objectives to an extent no other option could come close to.

Proponents' response

The rationale for the selection of the Hybrid alternative over the Remove alternative has been fully documented in the EA Report. This decision required a trade-off between two very important (and related) City priority issues: traffic congestion and City building/prosperity (understanding that traffic congestion is a product of City growth and prosperity). Through the EA process a strong technical case to select one alternative over the other was not identified.

The noted preference to retain the elevated expressway is consistent with the preferred undertaking.

With or without the Gardiner, the waterfront/downtown core will grow just as it has in the recent past, and traffic congestion in the City will increase – even with new transit projects being developed. Both alternatives are technically viable although offer different advantages and disadvantages. Public and stakeholder opinions on the alternatives varied with some comments stating that the Gardiner Expressway infrastructure is integral to the City's transportation system while others noting that the east Gardiner largely only serves the DVP and presents a barrier between the city and the waterfront.

As documented in Section 6.9 of the EA Report, the preferred undertaking contributes to the achievement of all the study goals. Ultimately it provides an appropriate balance between the important goals of City building and accommodating the City's transportation demands.

The rail corridor and the street underpasses were not part of the EA scope of work. The proponents remain committed to improving the connection to the waterfront. Opportunities to improve the underpasses in regards to pedestrian experience and personal security are being considered in the advancement of public realm in the area by public and private partners.

Burying the highway was examined during the ToR phase and it was determined not to be technically desirable for the defined project study area. Due to the relatively short distance of the corridor section under study, with a tunnel, much of its length would include open cuts for the transition area between at/above grade expressway and the tunnel sections. These open cut sections would result in a greater barrier to the waterfront. Burying the expressway was also found to have a significant cost over the other alternatives.

Status

The ministry is satisfied with the proponents' responses.

Public realm improvements

Summary of comments

Castlepoint Numa (developers) commented that they understand that the proponents have begun to develop a Public Realm Phasing and Implementation Strategy. It is important that the public realm strategy be considered and implemented at the same time as the EA. This will properly address all of the issues in proceeding with Hybrid 3 since there is significant crossover between the public realm and other matters, including pedestrian crossings, intersection design, stormwater and other services management, amongst other things, and there will be efficiency and potential cost savings in reviewing these in a comprehensive manner.

The West Don Lands Committee commented that intersection reconstruction at Jarvis, Sherbourne, Parliament and Cherry to address both pedestrian safety and aesthetic concerns is an issue of critical importance to the community. The creation of a multi-use trail along the north side of Lake Shore Boulevard, which includes a much needed commuter bike route and the introduction of green infrastructure, is a welcome initiative.

A high priority must be placed on identifying and implementing additional public realm improvements in order to maximize the opportunities to ameliorate the negative effects of the Hybrid 3 decision on this segment.

The St. Lawrence Neighbourhood Association commented that this project has a significant impact on the St. Lawrence neighbourhood as well as new neighbours to the south of the waterfront lands as they continue to be developed. It must be stressed that public realm, though costly, is of utmost importance and cannot be compromised.

Proponents’ response

Improving the public realm within the Gardiner East EA study area is an important component of the undertaking. A commitment to integrating public realm into the design and delivery of this project was first made as part of the 2009 ToR for the Gardiner Expressway and Lake Shore Boulevard Reconfiguration. This commitment is repeated in the final EA and Urban Design Study's formal “Purpose and Rationale of the Undertaking”, which includes Revitalizing the Waterfront, and Reconnecting the City with the Lake, as two of five key project goals.

On March 30, 2016, Toronto City Council again re-affirmed this commitment to enhancing the public realm, when Council directed City staff to prepare an implementation strategy for proposed Gardiner East EA public realm improvements, and to report back to Council with recommended funding, delivery and phasing options.

As directed by Council, the proponents are presently collaborating on creation of the Gardiner East public realm implementation strategy, and have begun a process of stakeholder consultation to review draft recommendations respecting funding, delivery and phasing options. Furthermore, the proponents have recently engaged a specialized consultant team to advance the public realm concepts illustrated within the EA report to a level of design detail proportionate to preliminary engineering design work also getting underway. Stakeholders will be engaged as part of this public realm design process.

This early coordination of engineering and public realm design decisions will help to ensure the proponents meet their commitment to both rehabilitating the Gardiner and Lake Shore Boulevard corridor's transportation infrastructure, while simultaneously assisting to revitalize the waterfront by improving connectivity and creating an enhanced urban environment.

Status

The ministry is satisfied that the EA documents the proponents' commitment to improving the public realm in the study area and engaging stakeholders as the project progresses.

Ongoing consultation

Summary of comments

The St. Lawrence Neighbourhood Association commented that a robust community consultation strategy should continue through the detailed design and implementation phases, should the EA Report be approved.

Proponents' response

Comment noted. The proponents intend to continue with community engagement through to project implementation stage as is committed to in Table 6.6 of the EA Report.

Status

The ministry is satisfied with this response. Commitments to ongoing consultation are made in the revised EA which is publicly available on the project website.

Refer to EA tribunal

Summary of comments

Members of the public request that the Minister refers the EA to the Environmental Review Tribunal for consideration in an apolitical setting.

Proponents' response

The EA has followed a process that was consistent with the ToR, was thorough and rigorous, and provided extensive opportunities for public consultation and engagement. The EA Report has fully documented the process that was undertaken and includes a rationale for the undertaking.

Status

A request that the Minister refer the EA for the Environmental Review Tribunal can be made after the Ministry Review is published.

Auto transport bias

Summary of comments

A member of the public commented that the Transportation and Infrastructure study lens has an inherent bias towards the value of automobile travel. Whereas its analysis of impacts of the four alternatives on walking and cycling is limited to movement patterns and safety, the analysis of automobile impacts has a number of additional criteria that confer more value on auto trips. The EA has two separate criteria focused on impacts on travel time, including one for “commuters”, as well as one on the overall road network and choices for drivers. This analysis completely negates the impact of the project on utilitarian pedestrian and cycling trips. The preconception that driving trips are the only ones with utilitarian value is a significant flaw in the structure of the analysis.

Proponents’ response

A total of 17 criteria were considered in the evaluation under the Transportation and Infrastructure Lens. These were organized by criteria groups that reflected major modes of transportation: Automobiles, Transit, Pedestrians, Cycling and Movement of Goods. As such, all modes of transportation were considered in the evaluation of alternatives. The difference in impact on travel times for the two alternatives (Remove and Hybrid) was most significant on the auto commuter. The impact of the alternatives on commuters using other modes of travel (pedestrian, cyclists, transit) would be similar. As well, both alternatives include a new proposed multi-use pathway along the corridor and as such, both have the potential to facilitate increased active modes of commuting.

Status

The EA and supporting documentation demonstrate that potential effects to all road users (cyclists, pedestrians, motorized vehicle users, and transit users) were considered in the evaluation of potential effects, proposed mitigation and net effects of the alternatives to and alternative methods. The ministry is satisfied with this response.

Travel time increase and traffic studies

Summary of comments

A member of the public understands that one of the main reasons that the Hybrid alternative was selected over the Remove alternative was the belief that the Remove alternative could lead to travel time increases of up to 10 minutes for some commuters. However, it appears the 10 minute travel time is based on a Canadian Automobile Association-commissioned study conducted by the University of Toronto and is significantly at odds with the 2-3 minute increase stated in studies commissioned by the City of Toronto. This demonstrates that the EA studies were vulnerable.

A member of the public is concerned that the Gardiner Expressway East is currently underutilized.

A member of the public is concerned that the sole objective in the ToR regarding vehicular traffic capacity was to "balance modes of travel." This objective completely ignores the maintenance of existing traffic capacity. Moreover, it embeds in the objectives of the entire EA the assumption that there will be "decreased dependence on the private automobile", which has no basis in fact.

Proponents' response

The traffic modelling completed for the EA was undertaken by Dillon Consulting Ltd. It utilized the City's regional transportation model that is consistent with industry standard approaches to traffic forecasting and is consistent with other City traffic modelling exercises. The EA team met and engaged with the University of Toronto modelling team. The differences in results were largely attributed to different assumptions used in the modelling and how the results were reported.

A consultant report was released in May 2015 that identified all of the trade-offs between Remove and Hybrid alternatives. The decision between these two alternatives required a trade-off between two very important (and related) City priority issues: traffic congestion and City building/prosperity (understanding that traffic congestion is a product of City growth and prosperity). Through the EA process a strong technical case to select one alternative over the other was not identified. With or without the Gardiner, the waterfront/ downtown core will grow just as it has in the recent past, and traffic congestion in the City will increase, even with new transit projects being developed. Both alternatives are technically viable although offer different advantages and disadvantages. Public and stakeholder opinions on the alternatives varied with some comments stating that the Gardiner infrastructure is integral to the City's transportation system while others noting that the east Gardiner largely only serves as a DVP ramp and presents a barrier between the city and the waterfront.

The traffic modelling completed for the EA study was done for future conditions (2031), with the demand in existing roadways projected to increase because of City growth. As such, the use that we see today on the East Gardiner will increase (more vehicles will be in the road) as the waterfront and downtown further develops.

Status

The proponents have provided a satisfactory response to address the comments made regarding traffic studies.

Medical officer of health study

Summary of comments

A few members of the public raised concerns with the report prepared by the City of Toronto's Medical Officer of Health and how it was considered in the EA process.

The City of Toronto's Medical Officer of Health prepared a report, "Rapid Health Impact Assessment on the Alternative Solutions for the Gardiner Expressway and Lake Shore Boulevard East Reconfiguration". The report assessed the relative impacts of the two alternative solutions from a public health lens. The findings of this assessment overwhelmingly supported the Remove alternative, which was preferred or equally preferred in 10 of the 11 health impact criterion.

The Board of Health, however, voted not to adopt the report, thereby ensuring it would not come before Council as part of the consideration of alternative solutions. The vote not to adopt was led by Councillors supportive of the Hybrid alternative. In a fair and unbiased process, decisions should be made with as much information as possible, not through the suppression of valuable information.

Accepting the health impact analysis would have added no additional time to the process, but would have added another valuable input to inform decision-making.

Proponents' response

In May 2015, the Chair of the Toronto Board of Health requested completion of a health impact assessment (HIA) for the "alternatives to" in the Gardiner EA by the Medical Officer of Health. In June 2015, the Toronto Medical Officer of Health submitted a HIA report to the Board of Health. It included recommendations that the findings in the HIA report be submitted to City Council and that a health lens be considered in Phase 2 of the EA. The HIA report provided a high level assessment of the health benefits of the Remove and Hybrid alternatives to.

The HIA summary from the report was distributed to all Council members as a communication at the City Council meeting of June 10, 2015 during consideration of the City staff report on the updated evaluation of Gardiner EA alternatives to. As such, through the distribution of the HIA report summary to Council as well as the interim EA reporting that included the consideration of many health related issues (e.g. air emissions), Council was well informed of the potential effects to health from the alternatives under examination.

The issues raised in the HIA report were largely considered in the EA, including the evaluation of the alternatives. In the HIA report, "health" was interpreted in the broadest sense including the consideration of transportation, urban design, environment and economic criteria. These same criteria were considered in the EA alternatives evaluation process along with other non-health related criteria such as environmental, construction, movement of goods, cost, etc. In total the evaluation considered 60 different measures.

A key health related issue that was raised in the HIA and considered in the EA was air emissions. Future air emissions of the alternatives were determined through quantitative modelling. The reduction in road capacity associated with the Remove alternative (i.e. fewer roadway lanes) would result in a corresponding decrease in vehicles in the study area. As a result, the air quality modeling work showed a reduction in future vehicle air emissions over the future baseline or “Do Nothing” scenario. This health benefit of the Remove alternative was considered in the EA decision process along with many other considerations.

Through the consideration of all the evaluation criteria, including those that are health related, the Hybrid alternative was determined to be the preferred alternative. The key alternatives trade-offs that were considered in the decision process leading to the selection of the Hybrid alternative as preferred are documented in Section 4.5 of the EA Report.

The Hybrid alternative was considered, for the most part, to be a continuation of the existing condition with respect to future vehicle volumes. The Hybrid is expected to attract a similar number of vehicles in the study area as would the future “Do Nothing” alternative. The attraction of vehicles to the downtown area is a result of growth and prosperity in the City, including the downtown area.

To contribute to improved health conditions, the East Gardiner project does include a new multi-use pathway along Lake Shore Boulevard to support active modes of transportation to the downtown. In addition, the City continues to pursue enhancements to the transit system that is to include capacity improvements to surface and sub-surface rail systems, which will reduce dependence on the automobile for downtown access.

Finally, as outlines in Section 6.9 of the EA Report, the project involves the creation of significant improved and new green space that would lie north of the Lake Shore Boulevard creating a new green ribbon.

Status

The ministry is satisfied that the proponents have clearly explained how issues raised in the HIA were largely considered in the EA. The ministry is satisfied with this response.

Metrolinx involvement

Summary of comments

A member of the public is surprised that the EA is not co-presented by Metrolinx.

Proponents’ response

Metrolinx is a stakeholder in the EA process and has been consulted with throughout the study process. It has also provided comments on the EA Report.

Status

The ministry is satisfied with this response. Please see Table 1 in this appendix for Metrolinx's comments and the proponents' responses.

False claim

Summary of comments

A member of the public commented that the EA report falsely claims that the Gardiner is one of the "most significant transportation corridors in the city". This is false, as the expressway is only used by a small fraction of commuters and businesses, inaccessible to most transit users, pedestrians and cyclists.

Proponents' response

Based on traffic volume data, the Gardiner Expressway is a significant transportation corridor in the City.

Status

The ministry is satisfied with this response.

Mapping

Summary of comments

A member of the public is concerned with the general consistency of the mapping throughout the report.

Proponents' response

Comment noted.

Status

The proponents provided some additional mapping, which the ministry has included in its review.

Non-competitive contract

Summary of comments

A member of the public requested and received a copy of PW 19.2 report dated February 15, 2017, to Public Works and Infrastructure Committee "Non-competitive Contract with MMM Group for Engineering Design Services for the Deck Replacement of the F.G. Gardiner Expressway from Jarvis Street to Cherry Street, including Associated Public Realm Improvements".

This person asks how frequently "non-competitive" contracts are issued.

Proponents' response

The procurement process referenced was conducted in accordance with all applicable clauses of the Toronto Municipal Code, and received unanimous City Council approval on March 29, 2017.

Please see the following link for additional details: http://app.toronto.ca/tmmis/viewAgendaItemHistory.do?item=2017.PW19.2

Status

The ministry is satisfied with this response.

Updated: June 28, 2018
Published: June 22, 2017

Related

Gardiner Expressway and Lake Shore Boulevard Reconfiguration

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Regional Express Rail – Davenport Diamond Rail Grade Separation

Location:
Greater Toronto Area

Project Type:
DBF - Design Build Finance

Infrastructure Type:
Transit

Contract Value:
To be announced at Financial Close

Estimated Value for Money:
To be announced at Financial Close

About the Project:

Announced in 2014 by the Province of Ontario, RER will transform the Greater Toronto and Hamilton Area over the next decade. Metrolinx will transform the GO rail network into an RER system that will bring 15-minute, two-way, all-day, electrified GO service to communities across the region. System-wide RER infrastructure upgrades will include: adding tracks, expanding stations, electrification of the rail network, new locomotives and train control systems to enable more frequent service.

Status

Request for Qualifications:
Aug 17, 2017

Short-list Bidders Selected:
Dec 15, 2017

Request for Proposals:
Feb 28, 2018

Winning Bidder Selected:

Construction Begins:

Construction Ends:

Latest News

- Request for Proposals Issued - Feb. 28, 2018
- Short Listed Proponents Named - Dec. 15, 2017
- Request for Qualifications Issued - Aug. 17, 2017

Features

To help increase capacity on the Barrie Corridor, work is required at the Davenport Diamond, which includes:

- construction of a grade separation structure between the north/south GO Rail corridor and east/west CP Rail corridor to minimize delays to GO service
- implementation of a pedestrian underpass to restore east/west connection at Paton Road
- erection of retaining walls forming the approaches of the grade separation structure, topped with noise barrier walls and superimposed cladding to minimize impacts on the community
- construction of a rail guideway offset within the corridor during construction to accommodate a temporary diversion track and a temporary rail diamond
- modification of an existing at-grade road crossing at Wallace Avenue to become a road under rail grade separation
- public realm enhancements, including artwork on the structure cladding and new pedestrian and cyclist routes
- provisions for future electrification implemented within upgraded rail infrastructure to accommodate future electrified GO train service

Community and Green Benefits

- reduced traffic congestion, greenhouse gases and fuel consumption
- improved quality of life for commuters by reducing daily travel time

Economic Benefits

Design and construction of the project will generate employment opportunities, produce significant benefits for commuters.

Terms of Use

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Announcements

- **Request for Qualifications Issued - Aug. 17, 2017**
- **Short Listed Proponents Named - Dec. 15, 2017**
- **Request for Proposals Issued - Feb. 28, 2018**

Documents

- **Request for Proposals**

FR

High speed rail

High speed trains running between Toronto and Windsor could cut your journey time in half, create economic opportunities, and reduce congestion and greenhouse gases.

Learn what high speed rail means to you and your community.

On this page

We're moving ahead with plans to build high speed rail between Toronto and Windsor, a first for Ontario and Canada. Currently, we are in the early stages of the planning, design and environmental assessment work.

Over the next 60 years, the economic benefits from high speed rail are expected to yield over $20 billion from:

- passenger travel time savings
- automobile operating cost savings

400

- greenhouse gas reduction benefits
- benefits from reduced congestion on roads

There's a lot to be done to realize these benefits, including planning, design, and environmental assessments (EA). This will include engagement with the general public, Indigenous communities, businesses and municipalities who could be affected.

Have your say

We want to hear from you during the planning, design and EA process! Your input will help inform the evaluation process and will influence decision making. Have your say and sign up for our mailing list to stay up-to-date on the program.

What it can do

High speed rail has the potential to:

- increase transit options
- reduce travel times by 40-60%
- attract new visitors, businesses and talent to the province
- reduce greenhouse gas emissions

We will update this page as we continue to reach important milestones.

How high speed rail is different

In Ontario, we define high speed rail as a system as a rail system that operates at or above 250 km/h on dedicated tracks or at 200 km/h on existing tracks. High speed rail allows commuters to travel smoothly and quickly over longer distances that are currently a barrier to same-day travel.

Here are some key differences between high-speed rail and other types of rail service:

	Long-distance passenger rail	Commuter rail	High speed rail
Speed	80 – 160 km/h	130 – 175 km/h	175 – 300 km/h

Power	Diesel-electric	Diesel-electric	Electric
Tracks	Some parts shared with freight rail	Some parts shared with freight rail	Exclusive to passenger service
Typical station distance	15-30 km apart	30-50 km apart	50-100 km apart

High speed rail is in place across Europe, Japan and the east coast of the United States. Canada is the only G8 country without a high speed rail system.

Why the Toronto-Windsor corridor

The Toronto-Windsor corridor is a growing region that is currently home to **more than 7 million people** and **3.4 million jobs**. By 2040 the region is expected to be home to over **11 million people**. High speed rail will support the transportation needs of this growing population.

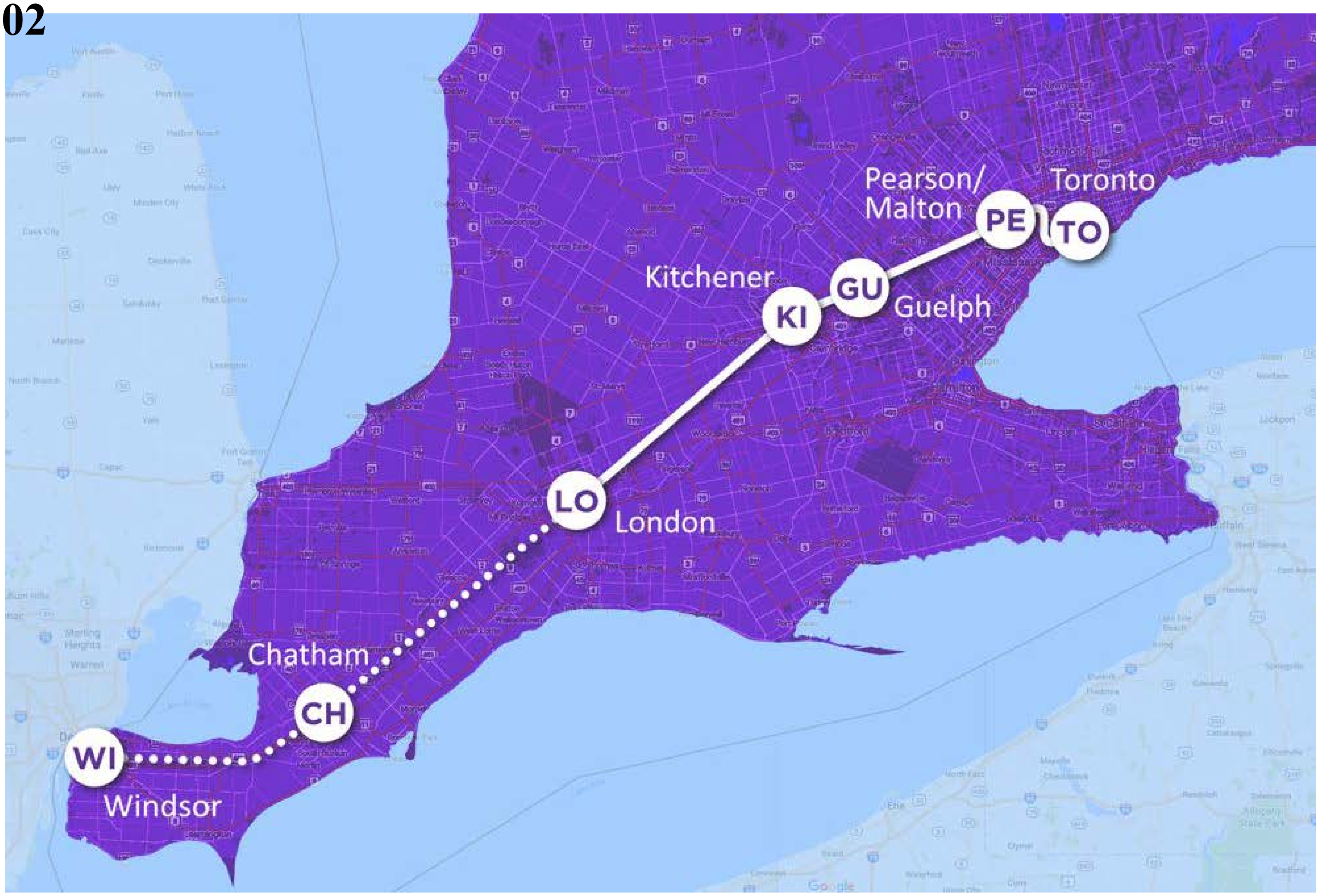
This region is an ideal candidate for high-speed rail because it's:

- a hub for leading start-ups, research institutions, and manufacturing and agricultural sectors
- home to existing regional transit systems and Canada's largest and busiest airport
- growing faster than its current transportation network can accommodate

7 proposed station stops

The proposed high speed rail system will include 7 stops, constructed in two phases:

Phase 1: Toronto → Pearson Airport/Malton → Guelph → Kitchener-Waterloo → London
Phase 2: London → Chatham → Windsor



This map demonstrates a concept level route only.

The environmental assessment, public and stakeholder input and the planning and design process will help us confirm the station locations and final route.

Toronto Union

Potential location

The existing Union GO station: 141 Bay St., Toronto

Estimated journey time to…

- Pearson Airport/Malton: 16 minutes
- Guelph: 39 minutes
- Kitchener-Waterloo: 48 minutes
- London: 73 minutes
- Chatham: 102 minutes

Connected systems

- TTC
- VIA Rail
- Union Pearson (UP) Express
- GO Transit

- Windsor: 124 minutes

Related projects

- GO Regional Express Rail expansion
- GO Rail Network Electrification

Pearson Airport/Malton

Potential location

The existing Malton GO Station: 3060 Derry Rd. E, Mississauga

Estimated journey time to…

- Toronto Union: 16 minutes
- Guelph: 23 minutes
- Kitchener-Waterloo: 32 minutes
- London: 57 minutes
- Chatham: 86 minutes
- Windsor: 108 minutes

Connected systems

- Planned connections to Pearson International Airport Terminals 1 and 3
- TTC
- GO Transit
- Union Pearson (UP) Express
- Brampton Transit
- Mississauga Transit
- Opportunity for future partnership with the Greater Toronto Airports Authority on multimodal hub plan

Related projects

- GO Rail Network Electrification

Guelph

Potential location

The existing Guelph central station: 79 Carden St.

Estimated journey time to…

- Toronto Union: 39 minutes
- Pearson Airport/Malton: 23 minutes

Connected systems

- Guelph Transit
- GO Transit

- Kitchener-Waterloo: 9 minutes
- London: 34 minutes
- Chatham: 63 minutes
- Windsor: 85 minutes

Related projects

- GO Regional Express Rail expansion

Kitchener-Waterloo

Potential location

The King/Victoria Transit Hub, a new multimodal station slightly west of the existing VIA Rail station

Estimated journey time to…

- Toronto Union: 48 minutes
- Pearson Airport/Malton: 32 minutes
- Guelph: 9 minutes
- London: 25 minutes
- Chatham: 54 minutes
- Windsor: 76 minutes

Connected systems

- LRT – Waterloo's ION Light Rail Transit system
- Grand River Transit buses
- GO Transit

Related projects

- Waterloo ION light rail

London

Potential location

The existing London railway station: 205 York St.

Estimated journey time to…

- Toronto Union: 73 minutes
- Pearson Airport/Malton: 57 minutes
- Guelph: 34 minutes
- Kitchener-Waterloo: 25 minutes
- Chatham: 29 minutes
- Windsor: 51 minutes

Connected systems

- Shift – London's planned bus rapid transit system
- Station is close to the existing Greyhound bus terminal

Related projects

- Shift bus rapid transit project

- Thames Valley corridor plan (pdf)

Chatham

Potential location

The existing Chatham VIA Rail station: 360 Queen St.

Estimated journey time to…

- Toronto Union: 102 minutes
- Pearson Airport/Malton: 86 minutes
- Guelph: 63 minutes
- Kitchener-Waterloo: 54 minutes
- London: 29 minutes
- Windsor: 22 minutes

Connected systems

- Chatham-Kent Transit

Windsor

Potential location

A new station near the downtown.

Estimated journey time to…

- Toronto Union: 124 minutes
- Pearson Airport/Malton: 108 minutes
- Guelph: 85 minutes
- Kitchener-Waterloo: 76 minutes
- London: 51 minutes
- Chatham: 22 minutes

Connected systems

- Transit Windsor

Path to delivering high speed rail

Work to bring high speed rail to Ontario involves three main streams.

1. Corridor planning, design and environmental assessment (EA)

The first phase of the corridor planning and EA work will be completed in two coordinated segments. The first segment from Toronto to Kitchener-Waterloo is within the existing GO Regional Express Rail corridor and will be coordinated with Metrolinx.

The segment between Kitchener-Waterloo and London is a new corridor, and will follow the Ontario individual EA process. Development and approval of an EA Terms of Reference is the first step in the individual EA process, and will establish the process to be followed for the planning, design and EA study. We've retained WSP Group Canada LTD to assist with preparing the EA Terms of Reference.

Consultations

We're committed to engaging with stakeholders, municipalities, the agricultural sector, and Indigenous communities in the Toronto-Windsor corridor. There will be a number of consultation opportunities throughout the planning, design and EA process which will allow us to better understand the thoughts and views of community members and provide opportunities to learn more about high speed rail. More details regarding these opportunities will be available as the program moves forward.

2. Corporate and financial design

High speed rail is a completely new mode of transportation for Canada and all aspects of the project must be explored in detail. This work is in early stages and we will develop more detailed cost estimates over time as the project proceeds through the EA process. We will need to do additional design work, service planning, modelling, and stakeholder engagement before the overall cost can be determined.

3. Regulatory and standards development

We will coordinate with Transport Canada, VIA Rail and other regulatory bodies to develop regulatory and safety standards.

Optimizing connections with GO Transit, VIA Rail, local and intercity transit will be critical to the success of the service. We'll be working closely with rail and transit service providers and our municipal partners as corridor planning and environmental assessment work for high speed rail advances. No decisions made preclude the future expansion of high speed rail or the development of other rail services in the region.

High speed rail environmental assessment

An environmental assessment is a legislated planning and decision-making process that ensures governments and public bodies consider potential environmental effects before beginning an infrastructure project.

For high speed rail, this means considering how all aspects of the project (e.g. how stations and facilities are built, track locations, energy requirements, expected ridership, parking needs) could affect all aspects of the environment. This includes the land (e.g. in environmentally sensitive areas), water quality, air quality, noise or vibration levels and much more. During the development of the EA Terms of Reference there will be engagement with Indigenous communities and consultation with affected parties including the general public, the agricultural sector, municipalities, other transportation service providers and regulatory agencies.

EA Terms of Reference

The EA Terms of Reference will be developed in consultation with a wide range of stakeholders and will provide a framework for completing the subsequent planning, design, and EA study. The final EA Terms of Reference document will include:

- purpose of the project
- rationale for the project
- description of, and rationale for, the alternatives that will be evaluated during the subsequent planning, design and EA study
- approach that will be used to assess and evaluate alternatives during the subsequent planning, design and EA study
- description of the existing environment and potential effects of the project on the environment
- approach to accommodating new circumstances
- mitigation and monitoring commitments
- consultation plan that will be applied during the subsequent planning, design and EA study

The route identified in the Special Advisor's Report is a concept route only. High speed rail is a priority initiative and the EA Terms of Reference will be scoped to identify and evaluate route alternatives for high speed rail from Kitchener-Waterloo to London.

Timeline

We've retained a consultant, WSP, to develop the EA Terms of Reference, and issued a Notice of Study Commencement. Here's what our team will be working on to prepare the Terms of Reference:

Spring/Summer 2018

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- Develop an engagement and consultation approach for the EA study
- Outline the purpose of the project
- Develop options for how to best implement high speed rail, from route alignment to new technologies
- Assess issues raised by communities and noting environmental conditions

Late Summer 2018

- Issue Interim Report 1. This is a technical document that will be combined with a second interim report to create the draft Terms of Reference.

Fall 2018-Early 2020

- Continue development of an approach to evaluating options for implementing high speed rail
- Identify options for addressing potential impacts
- Ensure that the Terms of Reference is flexible so it can accommodate new circumstances as the project moves forward

2020

- Publish the final draft Terms of Reference and submit to the Ministry of the Environment and Climate Change for approval

Engaging Indigenous communities

We will work with Indigenous communities in the corridor at all stages of the high-speed rail project to ensure they are meaningfully engaged in the initiative.

Digital mapping

We're starting work on a number of fronts to deliver high speed rail, including background studies to inform corridor planning and design and the development of standards and service planning.

Part of the early development work included the creation of a base map of an area between Guelph and London. To develop an accurate map, aerial photographs are taken following markers on the ground that pin point known coordinates that serve as references in the map making process. This map will be used to help planners define and consider a range of corridor alternatives.

No decisions have been made regarding final route alignment. We are interested in hearing from stakeholders and the general public as we move forward with the planning and design of high speed rail.

Project timeline

2031

High speed rail extension to Windsor projected to be complete

2025

High speed rail between Toronto and London projected to be complete

September 2018

Public outreach expected to begin

April 2018

Ontario announces initial investment of $11 billion for high speed rail

March 2018

Ontario issues Notice of Study Commencement

May 2017

Ontario announces we're moving ahead with preliminary design work on the high speed rail project and investing $15 million in a comprehensive environmental assessment

December 2016

Ontario's Special Advisor on high speed rail submits his recommendations for high speed rail in the Toronto-Windsor corridor

October 2015

Ontario appoints David Collenette as Special Advisor on High Speed Rail

December 2014

Ontario announces plans to proceed with an environmental assessment and consultations for high speed rail in the Toronto-Windsor corridor

Getting your input

We want feedback and input from the people, Indigenous communities, businesses, municipalities and agencies that could be impacted by high speed rail. This is a crucial part of the planning process and will help shape how we move the project forward. We are creating a database with the issues and views brought forward to us. This will influence decision making and help us to develop mitigation measures.

Some of the issues we have heard from you so far include the potential impact of high speed rail on farmland, road access and travel patterns, and wildlife. All of these issues, and more, will be taken into consideration during the EA process.

We know how important it is to hear what people are saying and we take your input and views seriously. As the program moves forward we will be hosting public engagement sessions, with the first planned for September 2018. In the meantime, we welcome you to email us with any of your questions or concerns.

Want to stay up-to-date on the high speed rail program? Subscribe to our mailing list.

Updated: July 6, 2018
Published: October 23, 2017

Related

Special Advisor for High Speed Rail: Final Report

News release: Bringing High Speed Rail to the Toronto-Windsor Corridor

BuildON: Ontario's infrastructure plan

Infrastructure Ontario

Hurontario Light Rail Transit

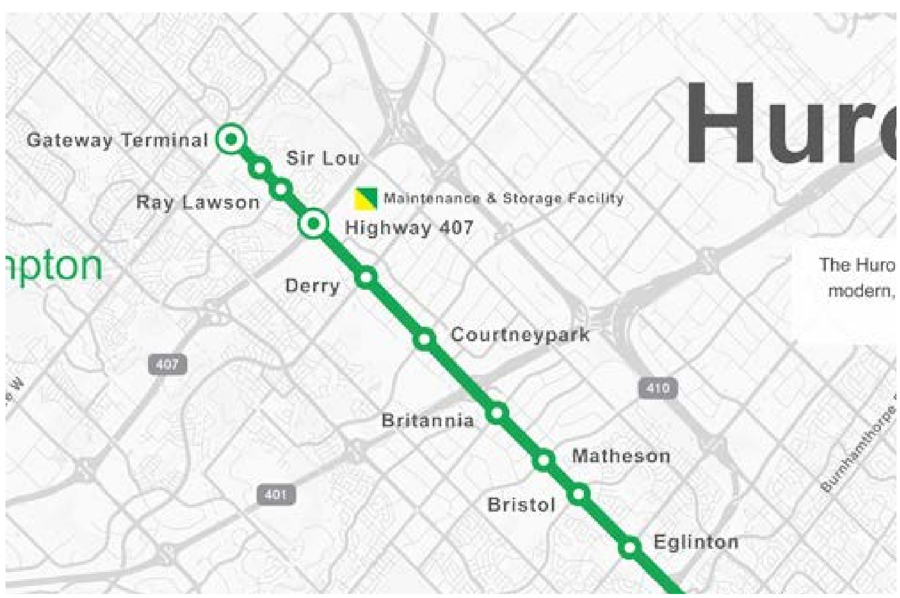
Location:
Mississauga - Brampton

Project Type:
DBFOM - Design Build Finance Operate Maintain

Infrastructure Type:
Transit

Contract Value:
To be announced at Financial Close

Estimated Value for Money:
To be announced following Financial Close



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About the Project:

The Hurontario Light Rail Transit (LRT) project is part of the Ontario Government's commitment to expand transit in the Greater Toronto and Hamilton Area. The LRT will run along Hurontario Street in Mississauga and Brampton and be fully integrated with municipal transit systems.

Status

Request for Qualifications:
Oct 18, 2016

Short-list Bidders Selected:
Jun 06, 2017

Request for Proposals:
Aug 17, 2017

Winning Bidder Selected:

Construction Begins:

Construction Ends:

Latest News

Features

» Request for Proposals Issued - Aug. 17, 2017
» Short Listed Proponents Named - June 6, 2017
» Request for Qualifications Issued - Oct. 18, 2016

The project includes:

- 20 kilometres of new dedicated rapid transit between Port Credit GO Station in Mississauga to the Gateway Terminal at Steeles Avenue in Brampton
- 22 surface stops with connections to GO Transit's Milton and Lakeshore West rail lines, Mississauga MiWay, Brampton Transit, and the Mississauga Transitway BRT
- A maintenance and storage facility for the light rail vehicles at Highway 407

Community and Green Benefits

- increased reliability and comfort for passengers riding on the LRT system
- reduced traffic congestion, greenhouse gases and fuel consumption
- improved quality of life for commuters by reducing daily travel time
- a reduced number of buses travelling along Hurontario Street

Economic Benefits

Design and construction of the LRT will generate employment opportunities, produce significant benefits for commuters as well as revitalize development along Hurontario Street.

Terms of Use

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Related Links

- Metrolinx

Announcements

- Request for Qualifications Issued - Oct. 18, 2016
- Short Listed Proponents Named - June 6, 2017
- Request for Proposals Issued - Aug. 17, 2017

Documents

- Request for Proposals

YouTube

FR

Report greenhouse gas (GHG) emissions

Learn the rules and how to report greenhouse gas emissions through annual and mid-year reports.

Effective August 1, 2018, we've made changes to the existing greenhouse gas emissions reporting framework. This is to clarify the reporting requirements as part of the orderly wind down of the cap and trade program. You'll have to submit a mid-year report on greenhouse gas emissions (if you were registered as a capped participant in the cap and trade program) by October 1, 2018. This is in addition to the annual report.

On this page

Submit an annual and mid-year report

Annual report

The entities who must report and verify their greenhouse gas (GHG) emissions include:

- fuel suppliers that first place 200 litres or more of fuel per year on the Ontario market

- electricity importers emitting greater than zero tonnes of GHG emissions
- natural gas distributors emitting 25,000 tonnes or more of GHG emissions per year
- facilities generating 25,000 tonnes or more of GHG emissions per year from one or more of the activities listed in Table 2 of *Schedule 2 of O. Reg. 390/18*

The entities who must report, but are not required to verify their GHG emissions unless they are capped participants as defined in O.Reg 390/18., include:

- natural gas distributors emitting more than 10,000 tonnes but less than 25,000 tonnes of GHG emissions.
- facilities generating more than 10,000 tonnes but less than 25,000 tonnes of GHG emissions from one or more of the activities listed in Table 2 of *Schedule 2 of O. Reg. 390/18*

Mid-year report

All capped participants (Mandatory and Voluntary) who were registered in the cap and trade program as of July 3, 2018 must submit a mid-year 2018 report **no later than October 1, 2018**. The period the report must cover is **from January 1 to July 3, 2018**.

The participants who must submit a mid-year report include:

- facilities that generated more than 10,000 tonnes but less than 25,000 tonnes of GHG emissions from one or more of the activities listed in *Schedule 2 of O. Reg. 390/18* and opted into the cap and trade program
- fuel suppliers that first placed 200 litres or more of fuel per year on the Ontario market
- electricity importers who emitted greater than zero tonnes of GHG emissions
- natural gas distributors who emitted 25,000 tonnes or more of GHG emissions per year
- facilities that generated 25,000 tonnes or more of GHG emissions per year from one or more of the activities listed in Schedule 2 of O. Reg. 390/18

Refer to section 10 and section 13 of O.Reg.390/18 for more details on who is required to report.

The law

Overview

Ontario filed a new reporting regulation, Greenhouse Gas Emissions: Quantification, Reporting and Verification (*O. Reg. 390/18*), under the *Environmental Protection Act*, with an effective date of August 1,

2018. These changes were made to provide regulated cap and trade participants with certainty on what their reporting requirements are as part of the orderly wind down of the cap and trade program. The new regulation has taken the place of the Quantification, Reporting and Verification of Greenhouse Gas Emissions Regulation (*O. Reg. 143/16*), which was repealed on the date the new regulation came into force (i.e. August 1, 2018).

To prepare emissions reports for 2017 and onward, please refer to the summary table of past and current GHG reporting regulations and guidelines below.

Which law applies to you

Use the following table to determine which version of the guideline to follow when quantifying and reporting the GHG emissions your facility emitted in a given year.

Summary table of past and current GHG reporting regulations and guidelines

Reporting Regulation

Reporting year	Act	Regulation	Regulation name	Effective date	Guideline version
2017 (if report was submitted before August 1, 2018)	*Climate Change Mitigation and Low-carbon Economy Act, 2016*	*O. Reg. 143/16*	Quantification, Reporting And Verification Of Greenhouse Gas Emissions	Jan. 1, 2017	Guideline for Quantification, Reporting and Verification of Greenhouse Gas Emissions - 2017
2017 (if report is being submitted after August 1, 2018)	*Environmental Protection Act, 1990*	*O. Reg. 390/18*	Greenhouse Gas Emissions: Quantification, Reporting and Verification	Aug. 1, 2018	Guideline for Quantification, Reporting and Verification of Greenhouse Gas Emissions - 2017
2018 and onward	*Environmental Protection Act, 1990*	*O. Reg. 390/18*	Greenhouse Gas Emissions: Quantification, Reporting and Verification	Aug. 1, 2018	Guideline for Quantification, Reporting and Verification of Greenhouse Gas Emissions - 2018

Mid-year 2018	*Environmental Protection Act, 1990*	*O. Reg. 390/18*	Greenhouse Gas Emissions: Quantification, Reporting and Verification	Aug. 1, 2018	Guideline for Quantification, Reporting and Verification of Greenhouse Gas Emissions - 2018

What to report

The list of activities below is identified under *O. Reg. 390/18*- Greenhouse Gas Emissions: Quantification, Reporting, and Verification. If you engage in activities outlined in this list and meet or exceed any applicable reporting thresholds, you must report these greenhouse gas emissions.

Table 2 Activities – Section 5 of the Regulation

Source of Greenhouse Gas	Standard Quantification Method	Appendix in Guideline	Reporting and Verification Threshold
Adipic acid production	ON.50 - ON.55	1	Emissions count towards threshold of 10kt for reporting and 25kt for verification
Ammonia production	ON.80 – ON.85	2	Emissions count towards threshold of 10kt for reporting and 25kt for verification
Carbonate use	ON.180 –ON.185	3	Emissions count towards threshold of 10kt for reporting and 25kt for verification
Cement production	ON.90 – ON.95	4	Emissions count towards threshold of 10kt for reporting and 25kt for verification
Coal storage	ON.100 – ON.105	5	Emissions count towards reporting threshold of 10kt- no verification
Copper and nickel production	ON.260 – ON.265	6	Emissions count towards threshold of 10kt for reporting and 25kt for verification
Electricity generation	ON.40 – ON.45	7	Emissions count towards threshold of 10kt for reporting and 25kt for verificationEmissions

			associated with cooling units and fugitive emissions from geothermal activity count towards threshold of 10kt for reporting – no verification
Ferroalloy production	ON.270 – ON.275	9	Emissions count towards threshold of 10kt for reporting and 25kt for verification
General stationary combustion	ON.20 – ON.26	10	Emissions count towards threshold of 10kt for reporting and 25kt for verification
Glass production	ON.140 – ON.145	11	Emissions count towards threshold of 10kt for reporting and 25kt for verification
HCFC-22 production and HFC-23 destruction	ON.120 – ON.125	12	Emissions count towards threshold of 10kt for reporting and 25kt for verification
Hydrogen production	ON.130 – ON.135	13	Emissions count towards threshold of 10kt for reporting and 25kt for verification
Indirect useful thermal energy use	ON.190 - ON.195	14	Emissions count towards threshold of 10kt for reporting and 25kt for verification
Iron and Steel production	ON.150 – ON.155	15	Emissions count towards threshold of 10kt for reporting and 25kt for verification
Lead production	ON.160 – ON.165	16	Emissions count towards threshold of 10kt for reporting and 25kt for verification
Lime production	ON.170 – ON.175	17	Emissions count towards threshold of 10kt for reporting and 25kt for verification
Magnesium production	ON.290 – ON.295	18	Emissions count towards threshold of 10kt for reporting and 25kt for verification
Nitric acid production	ON.310 – ON.315	21	Emissions count towards threshold of 10kt for reporting and 25kt for verification
Operation of equipment for a transmission system	ON.230 – ON.235	22	Emissions count towards threshold of 10kt for reporting and 25kt for verification

or a distribution system (electricity)			
Operation of equipment related to natural gas	ON.350 – ON.357	23	Emissions count towards reporting threshold of 10kt- no verification
Petrochemical production	ON.300 - ON.305	24	Emissions count towards threshold of 10kt for reporting and 25kt for verification
Petroleum refining	ON.200 – ON.205	26	Emissions count towards threshold of 10kt for reporting and 25kt for verification
Phosphoric acid production	ON.340 – ON.345	27	Emissions count towards threshold of 10kt for reporting and 25kt for verification
Primary aluminum production	ON.70 – ON.75	28	Emissions count towards threshold of 10kt for reporting and 25kt for verification
Pulp and paper production	ON.210 – ON.215	29	Emissions count towards threshold of 10kt for reporting and 25kt for verification
Refinery fuel gas use within a petroleum refinery	ON.30 – ON.35	30	Emissions count towards threshold of 10kt for reporting and 25kt for verification
Soda ash production	ON.220 – ON.225	31	Emissions count towards threshold of 10kt for reporting and 25kt for verification
Zinc production	ON.240 – ON.245	32	Emissions count towards threshold of 10kt for reporting and 25kt for verification

Other Activities – Section 4 of the Regulation

Source of Greenhouse Gas	Standard Quantification Method	Appendix in Guideline	Reporting and Verification Threshold
Electricity importation	ON.60 – ON.65	8	Emissions greater than zero tonnes of CO2e for reporting and verification
Natural gas	ON.400 –	20	Emissions associated with NGD threshold 10kt for

distribution	ON.406		reporting and 25kt for verification
Petroleum product supply	ON.390 – ON.395	25	Equal or greater than 200 litres of petroleum products for both reporting and verification

When to report

Annual report

You must submit a GHG report every year by **June 1**, for the previous year's reporting period.

Example: June 1, 2018, for the reporting year 2017.

See: past GHG emissions report

Mid-year report

The deadline to submit your mid-year report is October 1, 2018.

How to submit a report

Annual report

You must submit an annual GHG emissions report using Environment and Climate Change Canada's Single Window System.

This system allows you to submit, view and update your information using Environment and Climate Change Canada applications.

Mid-year report

Please note, for the mid-year 2018 report, you **cannot** submit through the Single Window System.

You must submit the mid-year 2018 report to us at: 2018GHGReporting@ontario.ca

Verify an annual and mid-year report

GHG verification

GHG verification is an independent quality assurance process providing confidence that GHG emissions data:

- is accurate enough to meet the requirements set out in the reporting regulation;
- adheres to a specific set of criteria such as ISO 14064-3.

When to verify

By law, you must have the greenhouse gas report verified if:

- your activity (or activities) releases 25,000 tonnes or more of greenhouse gases (GHGs) in a year, or exceeds another verification threshold listed in the table above; and
- GHGs come from non-biomass related emissions and from activities identified as requiring verification

Third-party verification

The third-party verifier will evaluate your report to determine if:

- any errors in emissions due to measurements or calculations are fewer than 5%
- any errors in production data are fewer than 0.1% (starting in 2017) – for mid-year 2018 report, production data is not required to be verified
- the report was prepared according to the rules and guidelines under the law

This could include:

- reviewing your documentation
- reviewing your data controls and information management systems
- visiting your facility, headquarters or other locations
- developing a verification report

See: ISO 14064-3

Who can verify

You can find a list of eligible organizations that can verify emissions reports at:

- Standards Council of Canada (SCC)
- American National Standards Institute (ANSI)

Submit proof of verification

Annual report

Once your GHG report has been verified, you must submit the verification statement and a verification report you get from the third party organization.

You submit this statement for your annual report through Environment and Climate Change Canada's Single Window System.

Mid-year report

Please note, for the mid-year 2018 report, you **cannot** submit through the Single Window System.

Submit the verification statement and verification report for your mid-year report to us at: 2018GHGReporting@ontario.ca.

Deadline for verification statements and verification reports

Annual report

Verification statements and verification reports for your annual GHG emissions report must be submitted by **September 1** for the previous year reporting period.

Example: September 1, 2018, for the reporting year 2017.

Mid-year report

For the mid-year 2018 report, the deadline to submit verification statements and verification reports is **December 1, 2018**.

Verification rules for third-party verifiers

As the accredited organization verifying a GHG report, you must:

- submit an assessment form the Compromised Impartiality Assessment form for **every** GHG report you review
- include a mitigation plan if your Compromised Impartiality Assessment form indicates that there may be a conflict of interest
- provide your client with a verification statement and a verification report to confirm that you have reviewed their GHG report

Submit a Compromised Impartiality Assessment form

This form must be submitted by all accredited verification bodies (AVBs) before completing the verification of an emissions report. The AVB is required to assess the potential for any compromised impartiality in conducting the verification and report it to the Director in accordance with section 17 of *O. Reg. 390/18*.

To submit an assessment form for the 2017 reporting year and onward:

1. download a Compromised Impartiality Assessment form
2. complete and save the form electronically
3. submit the form via e-mail to: ghgverification@ontario.ca

If you require a Compromised Impartiality Assessment form for previous reporting years, please email ghgverification@ontario.ca.

Submit mitigation plans

You must be impartial when reviewing a GHG report.

If you determine that a conflict of interest exists related to GHG report you are verifying you must submit a mitigation plan to the Ministry of the Environment, Conservation and Parks.

You must send mitigation plans to:

Mail:
GHG Verification Program
Ministry of the Environment, Conservation and Parks
4th Floor
40 St. Clair Avenue West
Toronto ON M4V 1M2

E-mail: ghgverification@ontario.ca

Complete the verification statement and verification report

As the accredited verification body (AVB), you must provide your client with a verification statement and verification report to confirm you have reviewed their GHG report. This requirement is outlined in sections 18 and 21 of *O. Reg. 390/18*.

To properly complete a verification statement, you must use the applicable verification statement template.

Annual report

For the 2017 reporting year and onward, there are two different templates based on activity type.

Download

1. Verification Statement Template — Specified GHG Activities
2. Verification Statement Template — Other Activities (NGD, PPS, EI)

There is no template for the verification report. It is up to the third-party verifier to determine how they would like to format the report but must include at a minimum the information set out in the reporting regulation

Note that the deadline for the owner/operator of a facility to submit the verification statement and a verification report to the ministry is September 1, for the previous year reporting period.

Example: September 1, 2018 for the reporting year 2017.

If you require a Verification Statement Template for previous reporting years, please email ghgverification@ontario.ca.

Mid-year report

For Verification Statement Templates related to the verification of mid-year 2018 reports, please email us at: 2018GHGReporting@Ontario.ca.

For the mid-year 2018 report, the deadline to submit verification statements and verification reports is December 1, 2018.

Attestation form

Fuel suppliers and capped participants submitting an attestation to the Ministry, declaring the amount of petroleum product received by the capped participant can use the Capped Participant Attestation Form.

Annual report

For annual reporting requirements, the attestation can be submitted through Environment and Climate Change Canada's Single Window System along with the annual GHG report by June 1, for the previous year's reporting period.

Download the Capped Participant Attestation Form

For more information

If you have questions about greenhouse gas emissions reporting, please contact:

Tel: 416-649-4480

Toll-free: 1-855-815-6400

Email: ghgreporting@ontario.ca

If you require previous versions of the Guideline, please email ghgreporting@ontario.ca.

Updated: September 13, 2018
Published: March 20, 2014

Related

Climate Vision: Progress Report

Climate Ready: Adaptation Strategy and Action Plan

Climate Change Update

Rate

Topics

Climate change Air quality

the name of healthier communities, ecological protection and economic prosperity.

2014 Energy consumption and greenhouse gas emission report

The Ministry of Infrastructure's provincewide, five year (2014-2018) energy conservation strategy and report on progress in meeting greenhouse gas emissions reduction targets for the government's property portfolio.

On this page

Executive summary

Ontario is a Canadian leader in transparent reporting of energy consumption data, and is the first jurisdiction in Canada to publicly post information on a building by building basis, and by type of energy source. On January 1, 2013 the Ontario Facilities Energy Consumption Directive came into effect. The directive requires public reporting on how the government's energy consumption is tracking against energy conservation targets. The government had two public conservation targets:

1. Electricity reduction - a 20% reduction by 2012 over 2002/03 baseline
2. Green House Gas emissions - 19% reduction by end of 2014 and 27% reduction by end of 2020 over 2006 baseline

The Ministry of Infrastructure is responsible for rolling-up all ministry specific information and reporting against government-wide energy conservation targets.

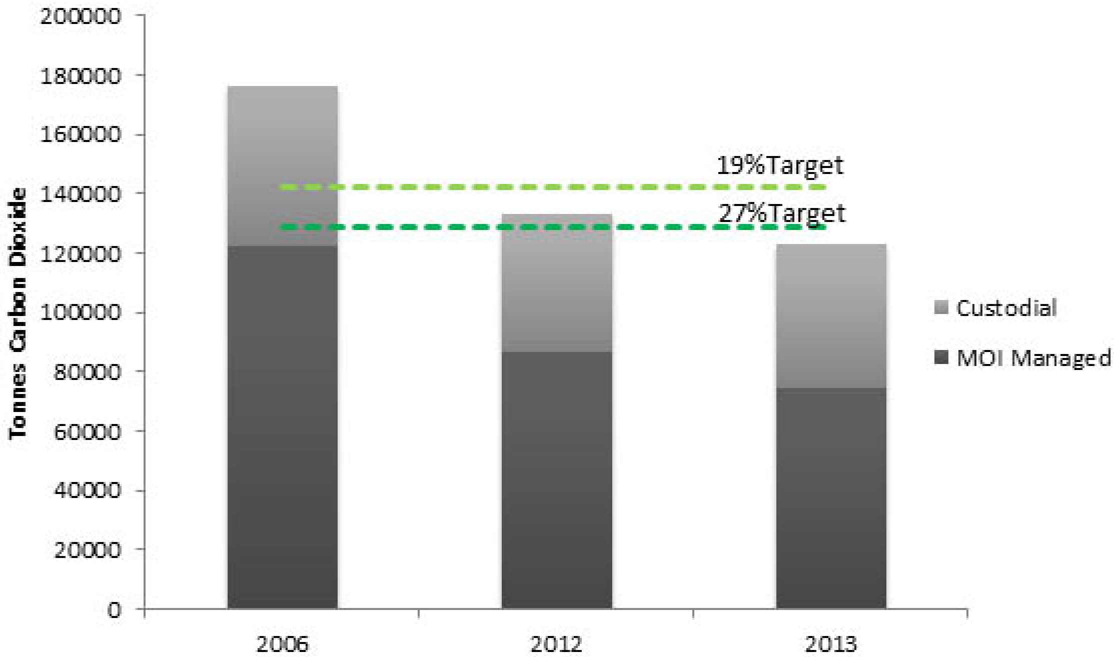
By end of 2012, the government achieved its 20% reduction in electricity consumption target. Provincial government-owned facilities have reduced greenhouse gas emissions by 30.2% at the end of 2013 over a baseline set in 2006.

The government is continuing to work towards reducing greenhouse gas emissions through energy conservation measures such as building retrofits, retro-commissioning and adoption of new standards and guidelines. These energy reduction programs, paired with cleaner electricity generation in Ontario (through phase out of coal and increased renewable energy), have provided an additional positive impact to targets.

This is the third report that is moving Ontario to annual reporting of energy consumption. To date, eight years of data is now publicly available spanning 2006 to 2013. The first Energy Plan covered the 2006 baseline year through 2010. The second Energy Plan covered the 2011 & 2012 data. The third Energy Plan (current plan) will cover 2013 calendar year data. Subsequent reports will report data for the previous calendar year.

The government uses an internally developed methodology which incorporates elements of the World Resources Institute's Greenhouse Gas Protocol. The protocol provides guidance for reporting greenhouse gases. Elements of the protocol were adapted into an internal methodology for applicability to the government's realty portfolio.

Chart 1 – emissions reduction targets achieved



Overview

Ministries with operational control of government facilities are required to post an annual 5-Year Energy Plan and report on their energy consumption for the previous calendar year. Five provincial ministries are impacted: Ministry of Infrastructure (primary responsibility for most government facilities), Ministry of Natural Resources (provincial parks), Ministry of Community Safety and Correctional Services (adult detention centres), Ministry of Children and Youth Services (youth detention centres), Ministry of Transportation (truck inspection stations).

Although each ministry is responsible for its own plan, the Ministry of Infrastructure has the responsibility to report on all government facilities. Ministries that directly operate government owned buildings and facilities (have day-to-day operational control) are defined as a Custodial Ministry.

The objective of this Energy Plan is to:

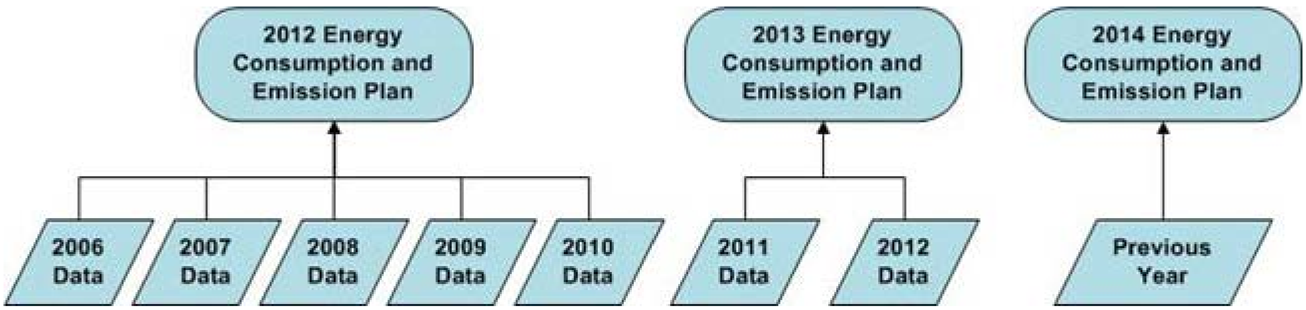
- report government's progress in meeting greenhouse gas emissions reduction targets across all ministries within the government's owned realty portfolio
- establish a baseline, methodology and a strategy to achieve energy conservation targets for the Ministry of Infrastructure owned realty portfolio that is directly managed by its service provider, Infrastructure Ontario.

The Ministry of Infrastructure is faced with the challenge of reducing emissions while maintaining performance and client satisfaction within the managed portfolio. The strategy will focus on activities and actions designed to improve operational efficiency that will result in reductions in electricity, fuel and steam consumption, which will ultimately lower greenhouse gas emissions and utility costs.

Timeline

The first Energy Plan covered the 2006 baseline year through 2010. The second Energy Plan covered the 2011 & 2012 data. The third Energy Plan (current plan) will cover 2013 calendar year data, and subsequent reports will report on data on the previous calendar year (Figure 1-1).

Figure 1 – five year energy plan



Target summary

Greenhouse gas emissions targets

In 2009, the government approved the Green Transformation Strategy that set greenhouse gas emissions reduction targets of a:

- **19% reduction** by end of 2014 over 2006 baseline
- **27% reduction** by end of 2020 over 2006 baseline

These reduction targets apply to government flight, fuel and facilities. Government facilities typically account for approximately 75% of provincial greenhouse gas emissions.

The government's realty portfolio falls primarily within the responsibility of the Ministry of Infrastructure and its realty agent, Infrastructure Ontario. Five other ministries, Ministry of Community Safety and Correctional Services, Ministry of Community and Youth Services, Ministry of Education, Ministry of Transportation, and the Ministry of Natural Resources, have day to day operational control of certain types of facilities that they directly operate and are required to report separately on the energy consumption in those facilities. Within this group of Ministries, the Ministry of Infrastructure is responsible for base-building equipment (end of life replacements). The Ministry of Transportation and the Ministry of Natural Resources have complete building responsibilities including base-building equipment and operational control.

The Ministry of Infrastructure is also responsible for reporting government-wide progress to achieving the targets.

Electricity reduction targets

In response to the 2003 Northeast Blackout, the Ontario Government set targets to reduce electricity consumption by government, including government buildings. The initial target was a reduction of 10% by 2007 over a 2002/03 baseline. In 2007, the government established a more aggressive 20% reduction by 2012 over a 2002/03 baseline. The 20% electricity reduction target was achieved, and has been validated by an independent third party.

New equivalent kilowatt hour target

Going into fiscal year 2014/15 the Ministry of Infrastructure set a new internal target that encompasses all fuel types. The new target will be an annual 2% equivalent kilowatt hour reduction that better aligns with the overall greenhouse gas emissions reduction targets. A reduction in this target directly impacts the achievement of building related greenhouse gas emissions. This is an internal government target that has never been publically announced. This specific target provides an in-year energy reduction target as opposed to the broader greenhouse gas emissions targets for 2014, and 2020.

Portfolio description

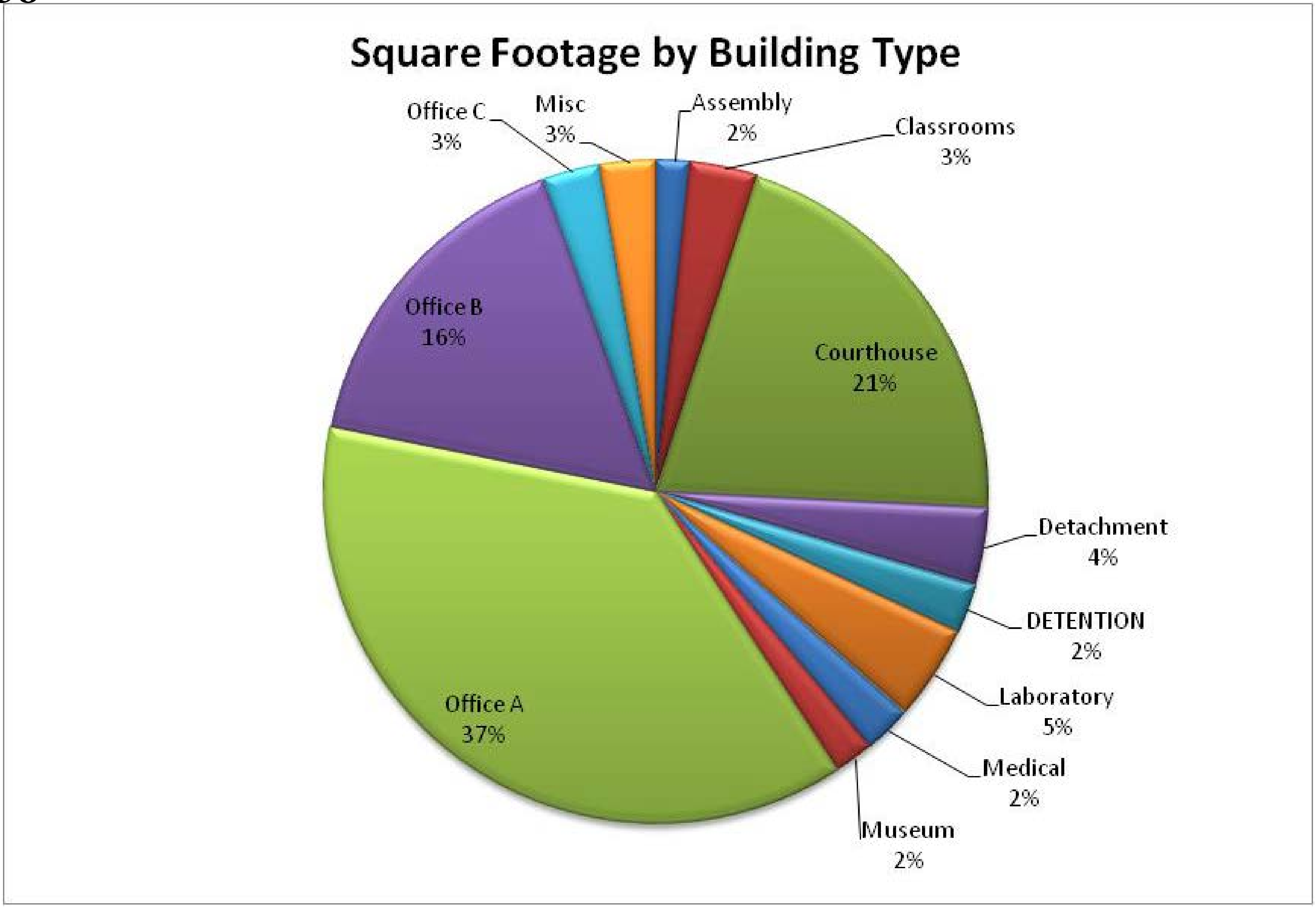
The Ministry of Infrastructure realty portfolio that is operated by Infrastructure Ontario is spread throughout the province, consisting of various usage types; inclusive of, but not limited to the following:

- courthouses - Buildings consisting of courtrooms, holding cells and office space.
- detachments - Emergency operation's home base facilities, also policing home base facilities.
- laboratories - Building used for experimental studies and/or testing and/or research requiring special purpose improvements
- offices - General administration of program delivery
- other - Example includes Ontario Science Centre

Infrastructure Ontario operates the real estate portfolio on behalf of the Ministry of Infrastructure. The portfolio consists of about 50 million square feet of buildings and structures, encompassing approximately 850 core buildings.

A breakdown of the portfolio square footage can be found in Figure 1-2 Portfolio Overview.

Figure 1-2 portfolio overview of square footage by building type



Challenges and opportunities

The average building age in the realty portfolio is 49 years. These facilities produce a unique set of challenges including aging structures, aging equipment and heritage considerations. Many times equipment such as boilers, chillers and building automation systems are dated and at the end of their useful life, and could now be replaced with modern and more efficient options.

Reporting boundaries, fuel types and calculations

Overview of the 2006 baseline

A full review of the realty portfolio was completed in 2009 to select which facilities and building types would be subject to energy conservation efforts and were appropriate to be included in the 2006 reporting baseline. Within the Ministry of Infrastructure portfolio, 455 baseline buildings were selected and classified as Target Class Facilities. There facilities include buildings where Infrastructure Ontario has a high level of operational control and could influence change. Buildings that were excluded are defined as Non-Target Class Facilities. Non-Target Class Facilities were identified where energy conservation could have a direct health and safety risk or negatively impact government program delivery. Further details can be found in the Section 5.0 of this report.

Overview of the 2013 data set

Infrastructure uses the World Resources Institute Corporate Reporting Standard as guidance for annual building selection and reporting. Through divestitures, acquisitions and new construction projects, the portfolio is constantly evolving and as such, the baseline evolves with it. The updated building count for the 2013 reporting year is 450.

Fuel types and scope

This report accounts for the following fuel types and scope emissions. Scope 1 emissions can be explained as fuel burned on-site (example: the operation of a boiler). Scope 2 emissions can be explained as a delivered fuel type where the energy was generated off-site and delivered to the building (example: electricity generated by a mixture of fuel types and delivered to the building). This report does not include any Scope 3 emissions (e.g. those found emitting from leased facilities) as they would be the responsibility of the private sector landlord to report, since MOI has no operational control of the buildings.

- electricity (Scope 2)
- natural gas (Scope 1)
- fuel oil (2) (Scope 1)
- propane (Scope 1)
- steam (Scope 2)
- hot water (Scope 2)
- chilled water (Scope 2)

Each fuel type results in different emissions. For example, electricity used to run a chiller during the summer will have much higher emissions than a comparable building cooled using chilled water from deep lake water cooling. Or, a boiler using fuel oil could potentially have higher emissions than a boiler using natural gas. Although certain fuel types can be more emission intensive than others, Infrastructure Ontario has to select the right fuel types for the right facilities. For instance, a building in Northern Ontario may not have natural gas infrastructure and it is the responsibility of Infrastructure Ontario to identify the best, most efficient, and energy conscious fuel types and systems to ensure continuation of program delivery.

Emissions calculations

Every building has associated fuels used to heat and cool it, and each fuel results in different emissions. Emissions captured under the scope of this report include Carbon Dioxide (CO_2), Methane (CH_4) and

Nitrous Oxide (N_2O). Factors considered when calculating GHG's include emission factors, global warming potential (GWP), unit conversion factors and fuel consumption. Example 1.1 outlines a step by step walkthrough of how emissions would be calculated for a natural gas account.

Example 1.1 - a step by step walkthrough of how emissions would be calculated for a natural gas account.

Step 1 - annual Building Consumption: 136,331 m^3

Step 2 - factors:

- CO_2 - 1879 g/m^3
- CH_4 - .037 g/m^3 with GWP = 21 (Second Assessment)
- N_2O - .035 g/m^3 with GWP = 310 (Second Assessment)

Step 3 – calculation:

136,331 x ((1879 + (.037 x 21) + (.035 x 310)) / 1,000,000) =257.75 tonnes CO_2e

Emission factor risks

Cleaner electricity generation has positively impacted the reduction in emissions from provincial buildings. Reduced reliance on coal has reduced emissions factors, resulting in greater emissions savings in government buildings. Although this is a positive shift provincially, the government cannot continue to rely on reduced emission factors to help hit GHG targets.

From 2016-2032 the province will be undertaking a refurbishment of the nuclear power generators at the Bruce and Darlington power plants. During this time natural gas is going to be depended on to be a flexible swing resource, which will increase electricity generated by natural gas. Since nuclear power has relatively few attributable greenhouse gas emissions, increasing the natural gas production will increase emissions factors for the Province's electricity sector. The challenge for the Ministry of Infrastructure is that the 2020 provincial greenhouse gas target ends at a time when there will be three large nuclear power generators down, and that, coupled with risks of atypical weather patterns, could increase the emissions factors considerably.

Portfolio performance

Tables 1.1 and 1.2 outline the equivalent kilowatt hour used and the associated tonnes CO_2 emitted during calendar year 2013 in comparison to the 2006 baseline.

Table 1.1

This table outlines the equivalent kilowatt hour used and the associated tonnes CO_2 emitted during calendar year 2013 in comparison to the 2006 baseline.

Infrastructure Ontario	2006 equivalent kilowatt hour	2012 equivalent kilowatt hour	2013 equivalent kilowatt hour	2012 percentage change vs. 2006	2013 percentage change vs. 2006
Electricity	326,195,629	264,865,624	252,880,450	(18.8)	(22.5)
Natural gas	225,496,655	231,946,624	250,196,481	2.9	11.0
Fuel oil	3,282,168	3,544,902	3,858,930	8.0	17.6
Chilled water	1,956,641	2,902,929	2,409,688	48.4	23.2
Propane	3,061,507	2,086,053	2,840,429	(31.9)	(7.2)
Steam	68,300,283	67,701,999	62,662,912	(0.9)	(8.3)
Hot water	1,262,590	2,369,408	2,625,438	87.7	107.9
Total	**629,555,472**	**576,059,853**	**577,474,328**	**(8.5)**	**(8.3)**

Table 1.2

This table outlines the equivalent kilowatt hour used and the associated tonnes CO_2 emitted during calendar year 2013 in comparison to the 2006 baseline. All values subject to change.

Infrastructure Ontario	2006 CO_2e	2012 CO_2e	2013 CO_2e (estimated)	2012 percentage change vs. 2006	2013 percentage change vs. 2006
Electricity	62,349	25,427	10,874	(59.2)	(82.6)
Natural gas	40,410	41,566	44,837	2.9	11.0
Fuel oil	830	896	976	8.0	17.6
Chilled water	15	22	19	48.6	26.7
Propane	638	435	592	(31.8)	(7.2)

Steam	18,131	17,972	16,635	(0.9)	(8.3)
Hot water	283	531	588	87.5	107.8
Total	**122,657**	**86,850**	**74,520**	**(29.2)**	**(39.2)**

Data analysis

The data presented in tables 1.1 and 1.2 above outline the energy consumption and emissions output for the applicable years shown. To better understand these tables, a few key points to consider are:

- Estimated emissions for 2013 are drastically reduced due to the coal phase out in 2013. Electricity emissions for 2013 are estimated based on projections from the 2013 Ontario Long Term Energy Plan
- 2013 data will be re-reported in 2014 with emission factors updated in the Environment Canada National Inventory Report
- Electricity was still a key focus in 2013 as seen in a 3.7% reduction over 2012
- November and December of 2013 were colder than a typical year thus driving up natural gas and propane consumption and emissions

Water

2014 is the first year that water use is being reported. Although no targets have been set for water, the province is gathering and analyzing data in anticipation of a water reduction program. Preliminary datasets by building type are outlined in table 1.3. This analysis will allow IO to set a baseline for water use and evaluate where the portfolio performance stands in comparison to peers.

Table 1.3

This table outlines preliminary datasets for Annual Water Consumption by building type, results for 2013 annual water consumption and intensity.

Infrastructure Ontario	2013 annual water consumption (m^3)	2013 annual water intensity (100 m^3/ft^2)
Agriculture	4,589	26.51
Assembly	41,072	12.49
Classrooms	60,378	9.17
Courthouse	203,263	4.85

Detachment (OPP)	70,761	11.15
Detention	13,127	4.01
Garage - vehicle	8,971	5.64
Laboratory	210,289	24.15
Medical	24,793	16.69
Museum	8,553	2.22
Office A	458,469	6.14
Office B	109,938	4.23
Office C	20,033	4.21
Public Info	13,771	50.26
Storage A	5,500	2.44
Warehouses	153	3.21

Energy reduction strategies

The Ministry of Infrastructure Energy Program will change focus beginning in 2014/15 where fiscal restraints have pulled back funding. The focus will now be to optimize the existing portfolio and revisit past energy projects to draw on lessons learned.

Since 2004, the energy program has had dedicated funding to implement energy conservation measures in government buildings. The main focus till 2012 was on electricity reduction, which has resulted in the province saving $11 million in avoided electricity costs annually. Where the electricity target focused on primarily electricity, the new all fuel type (equivalent kilowatt hour) target changes the focus of the energy program by looking at all building systems and fuel types in a holistic manner to ensure that all buildings are operating as efficiently as possible. The holistic view encourages the overall analyses of buildings as a single system and allows for investigation into how systems like lighting and heating and ventilation interact with each other and how the tenants interact with the building. Also, various internal guides and standards continue to be applied to project and operations schedules to bring buildings up to efficiency standards. Furthermore, a retro-commissioning program is underway which identifies opportunities for energy reduction as well as generates information that can be fed into the capital repair program – intended to keep the Ministry of Infrastructure realty assets in a state of good repair.

Energy conservation measures

With the removal of dedicated funding for energy conservation, the Ministry of Infrastructure continues to work to achieve the annual 2% equivalent kilowatt hour reduction target in support of province-wide greenhouse gas emissions reduction targets. The following initiatives and programs will help to achieve this target.

Retro-commissioning

This program began in 2012 and has since been implemented in 16 government facilities. The program is a three step process that reports on the operation of buildings and identifies opportunities for improvements. The process is summarized as follows:

- report – Conduct a full building analysis of all building systems (boilers, chillers, building automation systems, lighting, etc.). Once the investigation is completed a report is compiled with an outline of each system, as well as any opportunity for improvements or potential capital projects.
- low cost/no cost measures – These measures are identified in the report and are easy fixes such as schedule changes and system maintenance. Typical energy savings from these measures are 5%.
- capital projects – These measures are identified in the report and would require considerable capital to implement. Considerations are given to end of life equipment as well as projects that make financial sense (good simple payback, internal rate of return, life cycle costing etc.). Previously these projects would have been funded by an energy specific Ministry of Infrastructure budget, however in these times of fiscal restraint, capital projects generated from retro-commissioning reports will be pulled into the capital repair project queue.

Capital repair program and standards integration

The Capital Repair Program is used to organize and set out all repairs to government buildings. It encompasses everything from boilers to windows to leaky roofs. There are two streams in which this program operates:

- Imminent Breakdown – a database generates projects based on the end of useful life (as defined by industry standards) equipment. By tracking and identifying projects, Infrastructure Ontario can get ahead of potential breakdowns that could affect service program delivery.
- Reactive – because of the nature and age of government facilities the program needs to react to unforeseen failures. For example, a roof starts leaking before the end of its useful life, and it needs to be repaired to avoid affecting service program delivery.

The Infrastructure Ontario energy team's goal is to ensure the adoption of energy standards and guidelines into the Capital Repair Program processes. For example, a replaced boiler must meet efficiency standards, or a newly-installed roof must be insulated to a certain standard. Previously, energy initiatives were treated separately and had a separate decision-making process. Now, the new standards and guidelines require incorporating energy savings potential into day-to-day operations. The three main guidelines under development are outlined below.

- Design Guideline: a project based guideline for setting energy standards for new projects.
- Commissioning Guideline: a project based guideline that ensures that systems have been installed per manufacturers' specifications, and ensures that systems run as efficiently as possible.
- Building Performance Optimization Guideline: An operational based guideline to set standards for efficient building operation.

Smart green portfolio

A smart green portfolio is a key performance initiative that utilizes advanced automation and integration to measure, monitor, control and optimize operations and maintenance at the lowest cost and environmental impact over the building lifecycle.

The program takes a holistic approach to energy conservation while incorporating other important building systems. The vision of the program (for its larger buildings) is to integrate its control systems for lighting, security, heating/ventilation/air conditioning into one enhanced building automation system. The integration of systems allows for improved automation interaction, occupant comfort and overall building performance.

New technology

The province has been progressively looking at new technology as a way to curb energy consumption. The province has installed a number of solar projects as well as ground source heat pumps. More aggressively, IO has recently completed a feasibility study with Queen's University to investigate the potential of fuel cells and their applicability for use in government buildings.

Energy services company

The government is investigating the viability of leveraging an Energy Service Agreement structure as a means to renew building assets that will be funded from the energy consumption savings. Energy efficiency service providers could design, install, maintain and finance the cost of energy efficient retrofits for select buildings. The government would avoid upfront capital costs as 100% of the project cost is financed by the Energy Service Agreement. These innovative agreements are distinct from traditional Energy Services performance contracting in multiple respects, including: (1) energy efficiency service providers assume ownership and maintenance responsibility for project assets over the lifetime of the project; (2) building owners are not required to arrange their own financing and do not assume responsibility for principal and interest payments; and (3) building owners do not bear the risk of whether an Energy services Company is willing and able to stand behind its performance guarantee – energy efficiency service providers are compensated only if energy savings are realized. The Ministry of Infrastructure is exploring the feasibility of this type of model within the context of the government's existing realty funding model.

Measurement and verification

Infrastructure Ontario has established Measurement and Verification requirements for its energy projects in order that it can substantiate savings from energy conservation measures, and differentiate these savings from other factors that would affect energy demand in the portfolio (e.g. weather variation or changes in usage).

The purpose is to verify the energy savings resulting from activities that influence the energy consumption of a facility. This verified information will be used to improve the business models of future proposed projects. The objective is to:

1. Facilitate economic analysis of implementing energy saving measures by establishing a high confidence level in reported energy savings that are obtained through energy related projects.
2. Establish a process to ensure that all significant project activities related to energy undergo an appropriate level of measurement and verification.
3. Provide a method for improving accuracy of reported progress toward energy goals on a portfolio wide basis.

The process for implementing measurement and verification across the portfolio will be developed over the course of the next 5 years, with an increasing number of projects being targeted for this process over time. The delivery model for these services is being developed by service providers, and will explore opportunities to synchronize with equipment commissioning and other quality control initiatives to get improved value for money.

Sub metering

Project (dollar) decisions are based on the benchmarking and consumption trends available within a building. A sub-metering program allows for real-time usage vs. a monthly utility bill and can provide a better understanding of how the building/equipment operates. Using Ministry of Infrastructure funding, Infrastructure Ontario has put in place more than 80 building level electricity sub-meters. When additional funding becomes available, this program will expand natural gas and water real-time meters (and further electricity meters).

Benchmarking

In 2013 the energy team undertook a market evaluation of benchmarking systems and how to best use benchmarking for government buildings. The approach taken was to have an internal system to benchmark building types within the portfolio and use external systems to benchmark to industry. Through each of these systems Infrastructure Ontario can now better evaluate performance and identify opportunities for energy conservation measures.

Internal benchmarking uses basic statistical analysis to evaluate how each building type performs against other similar building types in its group. Because of the nature of government operations, internal benchmarking allows for comparison of building types (labs, hangars, etc.) not typically found in external benchmarking programs such as Energy Star Portfolio Manager.

The Federal Government has adopted the Energy Star Portfolio Manager as its primary benchmarking system and Ontario has followed suit. In support of this program, Infrastructure Ontario has uploaded three years of energy data for 49 office buildings representing 9 million square feet. The Energy Star Portfolio Manager is currently being evaluated by the energy team for its applicability to the portfolio.

Enterprise – wide summary

Overview

In the *Green Energy Act, 2009*, the Government of Ontario committed to ensuring that the Government conserve energy and use energy efficiently in conducting its affairs. In addition, it highlights governments role promoting and expanding energy conservation by all Ontarians and in encouraging all Ontarians to use energy efficiently.

To address these commitments, the Green Energy Act sets out a number of principles, including:

1. Requiring ministries responsible for government owned facilities to report to the Minister of Infrastructure on energy consumption and GHG emissions associated with the facilities; and
2. Specifying other requirements as the Minister considers appropriate relating to energy and water conservation, energy efficiency, the adoption of renewable energy technologies and the adoption of technologies and services that promote the efficient use of water and reduce negative impacts on Ontario's water resources.

Greenhouse gas emission reporting

On January 1, 2013 the Ontario Facilities Energy Consumption Directive (the Directive) came into effect.

The requirements of the Directive demonstrate the following fundamental principles:

- ministries make accountable choices for energy use, ensuring value for money;

ministries conserve energy and use energy efficiently; and

- information is managed efficiently and effectively across ministries.

Enterprise Progress Report – greenhouse gas emissions

Greenhouse gas emissions from 2006 -2013

The table below shows Greenhouse Gas Emissions from 2006 -2013 and the comparisons of the percentage of change from 2012 and 2013 versus 2006. All values subject to change.

Reporting entity	2006 tonnes CO_2e	2012 tonnes CO_2e	2013 tonnes CO_2e	2012 percentage change vs. 2006	2013 percentage change vs. 2006
IO	122,657	86,850	74,520	(29.2)	(39.2)
MCSCS	34,394	25,195	22,722	(26.7)	(33.9)
EDU	9,477	8,440	7,783	(10.9)	(17.9)
MCYS	5,411	5,020	4,662	(7.2)	(13.8)
MNR	3,750	3,139	2,165	(16.3)	(42.3)
MTO	302	282	134	(6.6)	(55.6)
AFP (IO)	-	4,031	10,958	N/A	N/A
Total	**175,991**	**132,957**	**122,944**	**(24.5)**	**(30.1)**

Roles and responsibilities

Most government operations are accommodated in facilities which are comprised of land, parking areas, landscaping, structures and buildings. For the purpose of the Directive, all energy consumption utilized at a facility level will be allocated to buildings with the exception of provincial parks which will be tracked at the facility (or park) level. This will be reported on an annual basis.

A rolling five year Energy Consumption and Greenhouse Gas Emissions Report will be required from Infrastructure Ontario and each custodial ministry related to the government-owned facilities over which they have direct operational control.

Infrastructure Ontario

Infrastructure Ontario is a crown agency that oversees the day-to-day operations of the Ministry of Infrastructure real estate portfolio and implements Ministry policies for buildings, lands, and leases.

Infrastructure Ontario has three separate responsibilities outlined within the Directive:

- reporting emissions publicly for Ministry of Infrastructure-owned facilities, this includes:
  - Infrastructure Ontario -managed
  - Alternative Financing Procurement facilities
- reporting on government-wide energy conservation status
- a five year energy conservation strategy for Infrastructure Ontario managed facilities

Infrastructure Ontario – alternative financing procurement

This model brings together private and public sector expertise in a unique structure that transfers the risk of project cost increases and scheduling delays typically associated with traditional project delivery.

For the Directive, these sites are required to report their greenhouse gas emissions; however, Infrastructure Ontario does not have direct operational control of the facilities (managed by private service providers). The reporting result is included as a separate line item to track this sector progress.

Custodial ministries

Custodial ministries have day-to-day operational control over their own facilities. These ministries include:

- Ministry of Transportation
- Ministry of Education
- Ministry of Child and Youth Services
- Ministry of Community Safety and Correctional Services
- Ministry of Natural Resources

Custodial Ministries have two primary responsibilities outlined within the Directive:

- reporting emissions publicly for facilities managed on a day-to-day basis
- a five year energy conservation strategy (for each Custodial Ministry)

Methodology

World Resource Institute protocol

This is an international protocol for greenhouse gas emissions accounting. Infrastructure Ontario will follow this accounting standard as a guideline in its reporting of the enterprise greenhouse gas baseline.

Examples of applied principles outlined within this protocol include: tracking inventories, buying, selling, demolishing, and adding buildings.

Target class vs. non-target class facilities

Target Class Facilities are a subset of all government-owned facilities that have been identified as having energy conservation potential. Energy consumption at Target Class Facilities is required to be reported to both the Ministry of Infrastructure and publicly as a requirement of the Directive. Reporting is to be done at the building level within each facility. This accounts for 96% of the total energy consumed by government-owned facilities.

Non-Target Class Facilities include other government-owned facilities where is does not make sense to conserve energy due to safety considerations or programmatic impacts and constraints. Although energy consumption associated with these facilities/buildings are not required to be reported, ministries are encouraged to include any success stories associated with conservation efforts at Non-Target Class facilities through annual reporting cycles, where appropriate.

Target class and non-target class facilities by ministry

This table shows Custodial target class facilities versus non-target class facilities for the Ministries of Transportation, Natural Resources, Education, Community Safety Correctional Services and Child Youth Services.

Ministry	Custodial target class facilities	Custodial non-target class facilities
Ministry Transportation	Truck Inspection Stations	Patrol Yards, Remote Airports, Street Lights
Ministry Natural Resources	Parks	Fish Hatcheries, Ranger Camps, Forward Fire Stations
Ministry Education	Provincial Schools	all facilities included
Ministry Community Safety Correctional Services	Adult Detention Centres	all facilities included
Ministry Child Youth Services	Youth Detention Centres	all facilities included

Data reporting purpose

Preparation of Energy Consumption and greenhouse gas emissions plans will help articulate the government's energy conservation progress. Publication of the reports will provide a model and benchmark for the broader public sector. Reports also facilitate sharing of best practices and continuous improvement. Reports will include energy consumption in government-owned facilities, proposed measures to increase conservation efforts and progress since the previous Report.

The ministries that are impacted by the Directive are ministries that have direct operational control over government owned facilities.

Data set: notes and comments by Ministry for 2013 reporting period

Ministry of Community Safety and Correctional Services- 54 facilities reported.

Ministry of Child and Youth Services - 27 facilities reported.

Ministry of Education - 65 facilities reported.

Ministry of Natural Resources -75 parks reported.

Ministry of Transportation - 29 sites reported.

Infrastructure Ontario/Alternative Procurement - 24 sites reported.

Infrastructure Ontario does not have operational control of these buildings, but maintains a responsibility to report on them. Alternative Procurement sites are not required to report emissions on its hospitals.

- For the 2013 report, only fully operational facilities are being reported. There are 24 facilities reporting in 2013.
- These sites will register zero consumption for the 2006 Baseline year and will only add to the Enterprise-wide emission inventories as more sites are added (regardless of how energy efficient).

Infrastructure Ontario-managed: 450 buildings are reported which range from large laboratories to small office buildings. All data post-2009 are tracked and supported by CB Richard Ellis. CB Richard Ellis is the property management, and land service provider. The CB Richard Ellis responsibilities include capturing and tracking inventories which directly supports greenhouse gas reporting requirements.

Updated: October 9, 2018
Published: March 15, 2016

Energy conservation

Chapter 6. Responding to the Challenge of Climate Change

On this page

Ontario is taking a leading role in Canada and abroad in the global fight against climate change. The energy sector will play a role in meeting the challenge. The robust supply of electricity will give it a central task in assisting the transition to a clean economy. At the same time, Ontario must strengthen its energy infrastructure and make it more resilient to lessen the damage that climate change can cause.

What we heard from you

- Support increased electrification of transportation
- Support options for home storage, including electric vehicle (EV) batteries

- Microgrids can help resiliency and northern communities
- Customers will decide which technologies work best
- Modernize regulations and rate designs
- Integrate conservation programs with initiatives announced in the Climate Change Action Plan
- Government support needed for research and development
- Distributed generation will transform conventional networks
- Introduce renewable natural gas into Ontario's natural gas supply

Ontario's cap and trade program came into effect on January 1, 2017. The cap and trade program is a flexible, market-based program that sets an annual cap for greenhouse gas (GHG) emissions, with the targets becoming more stringent over time. The cap will be lowered each year to enable Ontario to meet its GHG reduction targets.

Cap and trade creates a market to provide incentives to reduce emissions. Large emitters must have enough allowances to cover their GHG emissions. Switching from high carbon fossil fuels to lower carbon alternatives, including renewable fuels, is one way for large emitters to reduce emissions.

Putting a price on carbon through cap and trade will also impact the operation of the fuels market. Renewable alternatives do not incur cap and trade costs and, consequently, will become relatively more attractive than carbon intensive fuels. This could increase the adoption and use of fuels like renewable natural gas, ethanol and renewable diesel. Similarly, in the transportation sector, lower carbon alternatives like natural gas may become more attractive compared to diesel.

Some companies are currently allocated free allowances in recognition of their exposure to international trade and/or the amount of energy they need to use. Companies that emit more than their allocation can buy additional allowances through government auctions or from other companies that have more allowances than emissions.

Under the *Climate Change Mitigation and Low-Carbon Economy Act, 2016*, proceeds from Ontario's cap and trade auctions will be used to reduce the province's GHG emissions by helping Ontarians shift away from higher carbon fuels and reduce their energy consumption. Proceeds are projected to be $1.8 billion in 2017-18 and $1.4 billion annually, starting in 2018-19. These funds will help to fight climate change, reduce greenhouse gas emissions and transition Ontario to a low-carbon economy.

Putting a price on carbon through cap and trade will have a significant impact on the operation of the electricity market in Ontario. It will encourage a transition away from generation that uses fossil fuels towards a clean imports and generation that are free of GHG emissions. It will also encourage more efficient natural gas generation. As Ontario moves forward with Market Renewal, the cost of carbon will become increasingly important in the economics of electricity generation. Market Renewal has the potential to create a framework that effectively incorporates emerging clean technologies into our supply mix.

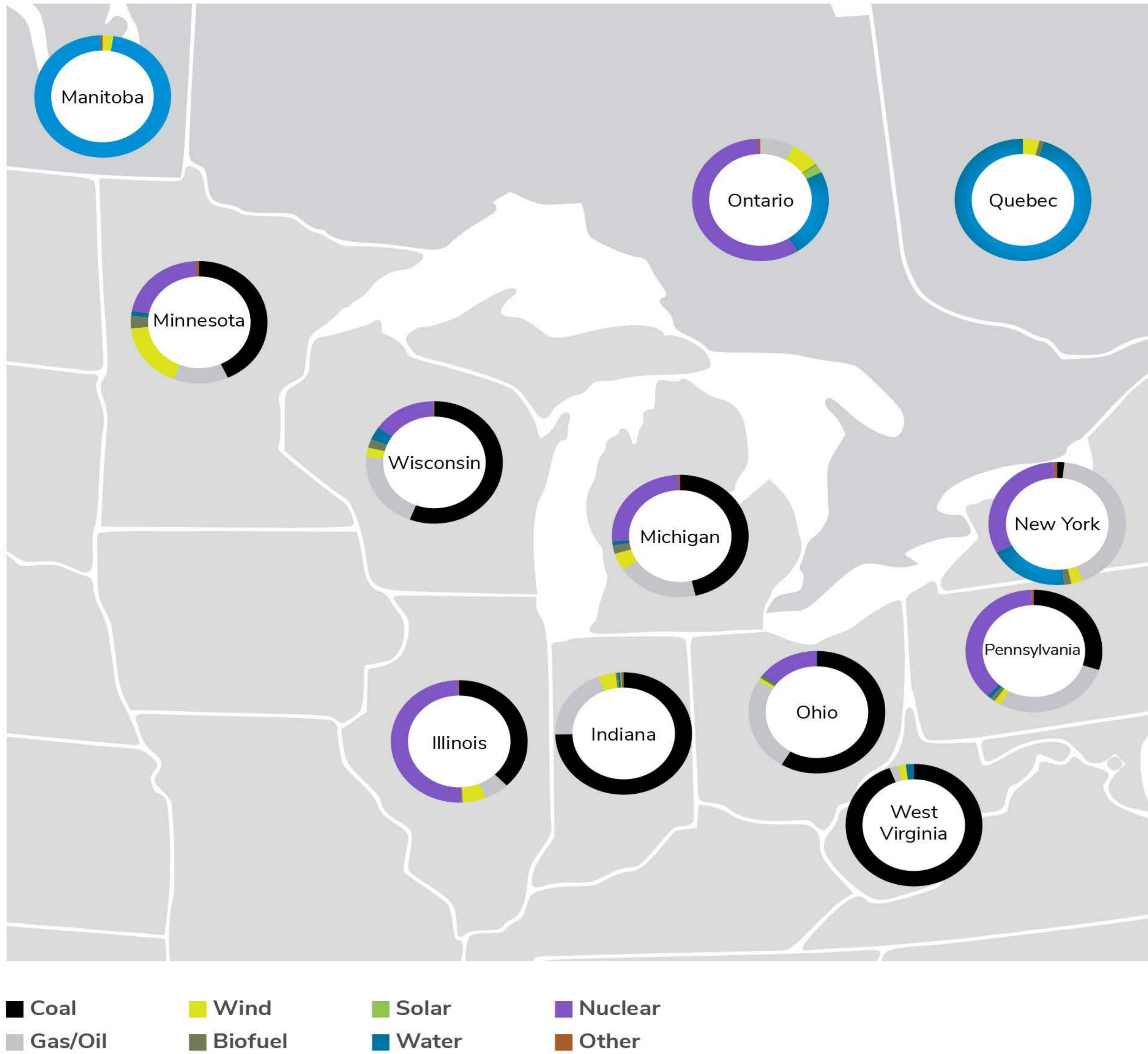
Together, cap and trade and Market Renewal initiatives can help to ensure electricity sector emissions remain well below historical levels, while also helping to meet our climate change and GHG reduction commitments.

Building on a clean electricity system

About 90 per cent of the electricity used in Ontario in 2016 was free of GHG emissions, generated from sources such as water, nuclear, wind, solar and bioenergy. Our investments in these types of clean generation sources, along with the elimination of coal-fired electricity generation, have significantly reduced GHG emissions in the province.

In comparison to neighbouring states such as Michigan, Minnesota, Ohio, Pennsylvania and New York, which still rely heavily on fossil fuel-fired electricity generation, Ontario has a much cleaner electricity system. We have accomplished this without the abundant hydroelectric resources enjoyed by Québec and Manitoba.

Figure 18: Ontario's clean generation mix



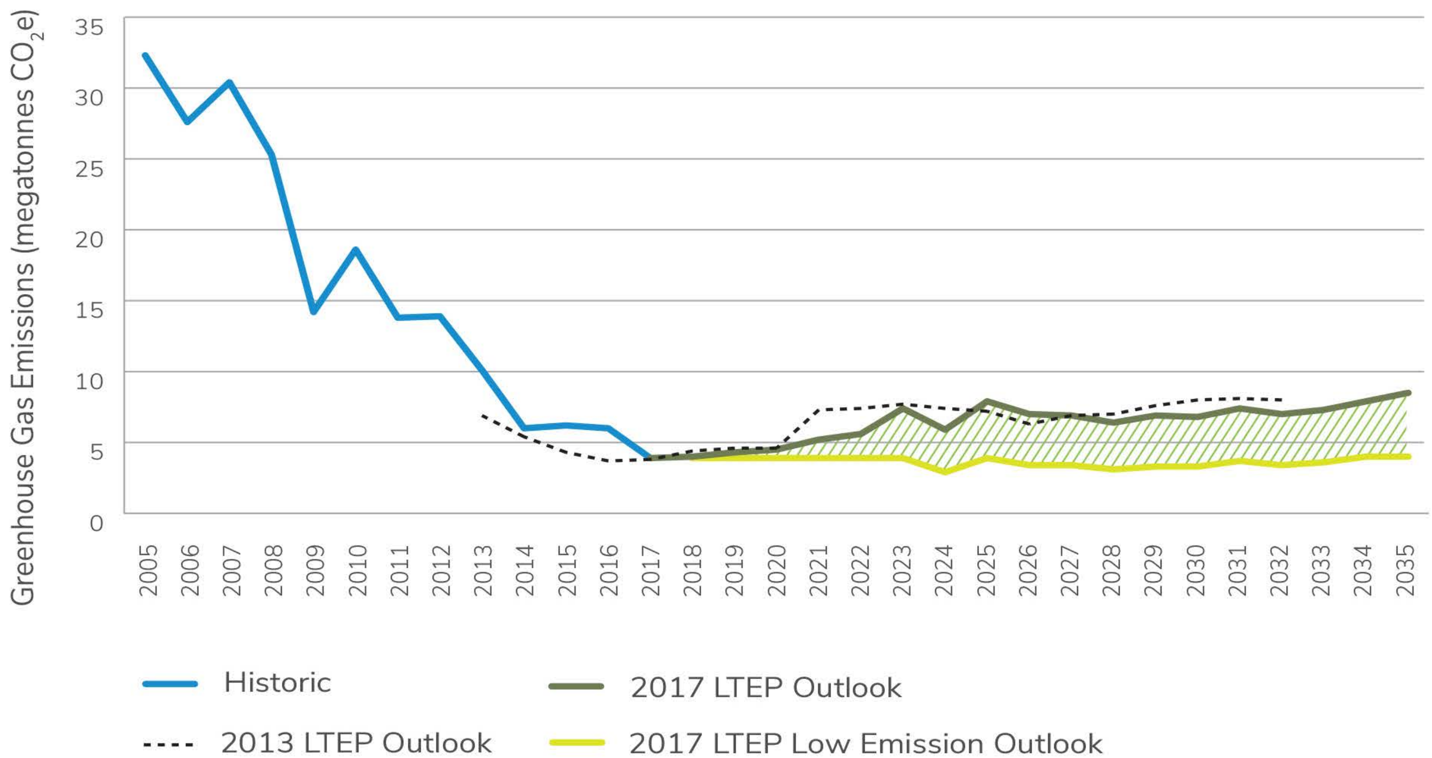
Source: IESO, U.S. Energy Information Administration, Manitoba Hydro, Hydro Quebec

Note: Generation data for US states is from 2015; Ontario, Manitoba and Quebec data is from 2016. Ontario generation data includes both transmission-connected and distribution-connected (embedded generation). Data for Manitoba, Quebec and US states is for transmission-connected generation only.

- Larger version of figure 18
- Accessible description of figure 18
- Data for figure 18

Thanks to these investments, Ontario's electricity sector is forecast to account for only about two per cent of Ontario's total GHG emissions in 2017 and the emissions are forecast to be more than 80 per cent below 1990 levels. As shown in figure 19, emissions are expected to remain well below historical levels and to be relatively flat over the planning period. Ontario will continue to look for ways to keep GHG emissions in the electricity sector low, and work with carbon-free market participants to meet the Province's emissions targets.

Figure 19: Electricity sector GHG emissions outlook



Source: IESO, Environment and Climate Change Canada

- Larger version of figure 19
- Accessible description of figure 19
- Data for figure 19

These investments have significantly decarbonized Ontario's electricity sector, leaving it well positioned to help the province move towards a low-carbon economy and meet its emission reduction commitments. Ontario's clean and reliable electricity system gives the province a strong foundation on which to pursue increased electrification, including the use of more EVs.

The province's robust supply of energy will also allow it to combine different energy sources into integrated energy systems that provide new services for homeowners and businesses. Natural gas will continue to play a critical role in space and water heating, but we must use it as efficiently as possible and supplement it with the next generation of clean energy technologies, such as ground-source and air-source heat pumps. Proceeds from cap and trade auctions will help fund the further application of these technologies. By making the best use of our existing energy sources and infrastructure, a more integrated energy system will allow the Province to chart the most effective course for achieving its goals for reducing GHG emissions.

Renewable energy success

Ontario is Canada's leader in installed wind and solar power. There is more wind and solar capacity in Ontario than in any other province or territory. When you add hydroelectric generation and bioenergy into the mix, renewables accounted for 40 per cent of Ontario's electricity supply mix in 2015, up from 26 per cent in 2005. Currently, Ontario has 18,300 megawatts (MW) of wind, solar, hydroelectric and bioenergy generation capacity in operation or under development.

The introduction of the Large Renewable Procurement (LRP) process in 2014 resulted in strong competition between developers of large renewable projects, drove down prices and secured clean, reliable generation. This significantly reduced the costs of wind and solar energy, saving money for electricity ratepayers.

The results of the final Feed-in-Tariff (FIT) procurement were announced in September 2017, with a total of 390 contracts offered for small-scale renewable energy projects representing about 150 MW of clean generation.

A highlight of Ontario's renewable energy programs has been the success that individuals, schools, municipalities, co-operatives and Indigenous communities have had in participating in clean energy projects. In the FIT 5 procurement, more than 80 per cent of successful applications had Indigenous, municipal, public sector or community participation. From smaller home or farm-sized projects to larger community-scale projects, Ontarians are using renewable energy to help meet their community's electricity needs and reduce their demand on the provincial electricity grid.

Since 2009, prices paid for new electricity from FIT and microFIT projects have been reduced between 50 and 75 per cent, reflecting the decreasing costs of equipment and ensuring value to ratepayers.

As a result of annual price reviews, revised procurement totals and the introduction of competitive procurement for large renewable energy projects, the FIT, microFIT and LRP initiatives are expected to cost at least $3 billion less than forecast in the 2013 LTEP.

Communities benefiting from renewable energy

The Municipality of Chatham-Kent is widely recognized as one of Ontario's leading green energy communities, which has helped spur local economic development. The municipality has received significant benefits for hosting a number of wind energy projects. Recent and proposed wind projects will deliver an estimated $27 million in community benefits and property tax revenue over a 20-year period for the municipality.

Renewable energy companies have also invested heavily in the social fabric of the community through partnerships with local organizations for sponsorship of projects such as splash pads.

A strong renewable future

The Province's renewable energy policies have made Ontario's electricity supply mix cleaner, and are providing real benefits for communities and municipalities. Recognizing this success, *Delivering Fairness and Choice* is focused more on outcomes rather than specifying targets and technologies. With a solid foundation of electricity provided by renewable energy, Ontario can now focus on new opportunities for innovation, modernization and exporting our expertise. Ontario is poised to take advantage of advances being made in distributed energy resources and smart-grid technologies that can help deliver a more efficient and cleaner electricity system. The government remains committed to having an electricity system where renewable energy generation plays an essential role, supporting the goals of the Climate Change Action Plan.

Wind

Wind power has become an important source of clean electricity for Ontario. There were only 15 MW of installed capacity in Ontario in 2003, compared with 4,800 MW today. That is enough wind energy to power approximately 1.4 million homes each year.

Wind Power is also being produced more efficiently. Turbines use state-of-the-art controls to adjust their blades and orientation to get the maximum output of energy in changing wind conditions. The Independent Electricity System Operator (IESO) has been able to send instructions to renewable energy generators since 2013 to stop producing electricity when it is not required to meet provincial needs. Actively controlling wind energy generation results in the more efficient operation of the electricity system.

Solar

Ontario has become a North American leader in the development of solar photovoltaic (PV) systems with about 2,300 MW of capacity online, enough to power about 300,000 homes each year. Solar power can help the electricity system to meet Ontario's needs on hot and sunny days when air conditioning use is highest. Advances in solar PV technology have seen improved performance and a significant decline in costs, resulting in more cost-effective solar generation. Solar PV systems also support ongoing modernization of the grid. They can be large or small, and can be located close to where electricity is needed. Solar PV systems can also be paired with other innovative technologies like energy storage. These advantages mean that solar PV will continue to be a valuable asset for Ontario's distribution systems, and can help improve the operation of the electricity grid in the future.

Hydroelectric

Most of Ontario's supply of renewable energy continues to come from the province's hydroelectric facilities, which provided 23 per cent of Ontario's total generation in 2015. Ontario has approximately 8,800 MW of installed hydroelectric capacity.

Assessments over the years, including the November 2013 Northern Hydro Assessment - Waterpower Potential in the Far North of Ontario, have identified significant remaining waterpower potential in the province. These potential resources are mostly concentrated in Northern Ontario and major transmission enhancements would be required to effectively contribute to Ontario's electricity supply.

Additionally, there are opportunities to redesign older hydroelectric projects to improve performance by using new, more efficient turbines.

Bioenergy

Bioenergy refers to electricity that is generated by burning biomass, such as plant or animal by-products and wastes. It also describes biogas and landfill gas, which is methane gas produced by the decomposition of organic matter that is then burned in a generator to produce electricity. Ontario currently has about 500 MW of bioenergy generation capacity in operation.

Going forward, the shift toward Renewable Natural Gas (RNG), a low-carbon fuel produced by the decomposition of organic materials, gives biogas producers an additional market opportunity. Bioenergy systems also support the implementation of the Province's Strategy for a Waste-Free Ontario.

Shifting to lower carbon gasoline and diesel

Delivering Fairness and Choice recognizes the commitment in the Climate Change Action Plan to introduce a Renewable Fuel Standard (RFS) for gasoline. This is an important step towards reducing GHG emissions from the transportation sector. Since it uses the existing fuels infrastructure, an RFS standard is one of the more flexible and cost-effective ways to increase the use of renewable and low-carbon fuels.

The use of renewable and low-carbon transportation fuels can be expanded by:

- Increasing the use of renewable liquid fuels in existing vehicles. Drop-in fuels such as ethanol can be mixed with gasoline to produce blended fuels and can be used the same way as regular gasoline;

- Having existing fuel stations offer higher blends of ethanol and bio-based diesel;
- Making renewable liquid fuels available to more regions of the province;
- Adding biofuels to the crude oil that Ontario refineries process; and
- Lowering the carbon intensity of renewable fuels produced by Ontario manufacturers.

Delivering Fairness and Choice acknowledges there are other ways to achieve deep reductions in emissions and transform the transportation sector. While current outlooks predict an increased electrification of light-duty vehicles and the use of alternative fuels, including bioenergy for long-haul road freight and aviation, technological innovation remains inherently unpredictable. The technology-neutral approach of the RFS lets the alternatives compete on their merits.

Shifting to renewable natural gas

Natural gas remains a reliable and cleaner option for many Ontarians, and will continue to play an important role in the province's energy supply mix. Homeowners, businesses and industries use natural gas for space heating, domestic hot water, steam and process heat. There were about 3.6 million natural gas customers in Ontario in 2016. Natural gas was also used to generate about 10 per cent of Ontario's electricity in 2015.

Ontario is looking at using renewable natural gas to lower the carbon intensity of the natural gas that people burn. RNG is a low-carbon fuel produced by the decomposition of organic materials found in landfills, forestry and agricultural residue, green bin and food and beverage waste, as well as in waste from sewage and wastewater treatment plants. Because it comes from organic sources, the use of RNG does not release any additional carbon into the atmosphere. As an added benefit, it can use the existing natural gas distribution system and replace the use of conventional natural gas in today's stoves and furnaces.

The government will continue to work with industry partners and the Ontario Energy Board (OEB) to introduce a requirement that natural gas contain some renewable content, fulfilling a commitment of the Climate Change Action Plan.

The government is also investing proceeds from the auctions in the carbon market to help introduce RNG in the province. The investment will help consumers with the cost of shifting to RNG, as it currently costs more than conventional natural gas.

Integrated energy solutions

Renewable energy technologies can be the foundation for innovative integrated clean energy systems that provide the space heating, cooling, and energy storage solutions that help to address the climate change challenges facing Ontario.

Power-to-gas

Electrolysis, also known as power-to-gas, uses surplus electricity to break down water molecules into hydrogen and oxygen. The hydrogen can then be stored in the vast storage system that currently exists for natural gas in Ontario and transported in existing natural gas pipelines and used to heat homes and fuel vehicles.

Power-to-gas could potentially become a new and important link between the province's electricity and natural gas systems. The Independent Electricity System Operator (IESO) recognizes this, and has already awarded a contract to Hydrogenics, an Ontario-based manufacturer of electrolysis and fuel cell technology, which will deliver two MW of storage capacity in the Greater Toronto Area.

Heating and cooling with renewable energy technologies

Ontario aims to reduce greenhouse gas (GHG) emissions by increasing the use of low-carbon technologies, such as solar, air- and ground-source heat pumps, to heat and cool Ontario homes and businesses.

This has the potential to deliver a big payoff in the fight against climate change. Space heating accounts for approximately 75 per cent of the total fuels energy demand in Ontario homes, making it an important area to target for reducing GHG emissions.

The government will continue to work with its agencies, including the IESO and the Green Ontario Fund, to encourage the deployment of thermal and alternative technologies for residential, commercial, industrial and institutional buildings. This will involve planning how to integrate the technologies and the delivery of conservation and low-carbon technology programs into the province's energy system.

Solar air and hot water heating

A typical residential solar hot water system can supply between 40 to 60 per cent of a home's hot water needs. Solar air systems capture air warmed by the sun and circulate it to heat buildings.

Ground source and air source heating and cooling

Ground-source heat pumps, also known as geothermal energy systems, use buried pipes to absorb heat from the ground and transfer it to a home or building, and can reduce heating bills by up to 70 per cent. Air-source heat pumps take air from outside, extract the heat and transfer it to the air inside a home or building. A heat pump, running on electricity, concentrates the heat from both sources, and moves it to where it is needed. The same systems can also be used to provide cooling in the summer; and more advanced air-source systems can even provide domestic water heating.

In July 2017, the Save on Energy Heating and Cooling Incentive program began offering incentives of up to $4,000 to help Ontarians who live in electrically-heated homes to purchase and install air-source heat pumps.

District heating and cooling

District energy systems generate and supply heating and cooling, domestic hot water and electricity for blocks or neighborhoods in a community.

District heating and cooling can use local energy resources such as biomass, geothermal energy and mechanical waste heat from industrial operations to reduce GHG emissions.

Implementation can be made easier if underground district energy pipes are incorporated into the initial design of new residential or commercial developments. When used in more densely populated areas, district energy systems can be more cost-effective than providing heating and cooling systems for each individual building.

Enwave Energy Corporation

Enwave Energy Corporation is a Toronto-based company that provides sustainable energy services in Toronto, Windsor and numerous American cities, including Chicago, Houston, Los Angeles and Portland, OR. In each community, the company operates highly efficient thermal energy plants that distribute steam, hot water and/or chilled water to customer buildings. Customers benefit from reduced operating costs, lower emissions, and increased reliability.

Enwave generates chilled water, steam, hot water and electricity which is distributed to more than 155 buildings in downtown Toronto. Their Deep Lake Water Cooling system is one of the world's largest sustainable cooling systems, using Lake Ontario to recycle energy from more than 70 buildings in downtown Toronto to the city's potable water system. Currently, this system reduces peak electrical demand by 61MW, with plans underway to expand.

The London system is a Combined Heat and Power (CHP) system that currently provides 15MW of electricity to the grid, and serves 60 customers with a steam and chilled water system. There are plans to increase the CHP plant capacity by an additional 18MW in the near future.

Near and net zero carbon emission buildings

The Climate Change Action Plan aims to reduce emissions in the building sector by encouraging the construction of near net zero and net zero carbon emission homes and buildings. To help create a pathway to these new building standards, the electricity and natural gas conservation frameworks will continue to support the development and enhancement of high efficiency, low-carbon homes and buildings. New programs will also be offered through the Green Ontario Fund.

New high-performance standards for space and water heating equipment could significantly reduce the energy use, environmental footprint and GHG emissions of new and existing homes and buildings and lower consumers' energy costs.

Working with the federal and other provincial governments, Ontario is exploring opportunities to develop markets for new high efficiency technologies, such as air source heat pumps, supporting the joint aspirational goals on achievable energy performance levels and the transition to a low-carbon economy.

In addition, planned updates to the Ontario Building Code would make a significant contribution to reducing GHG emissions in the building sector and support Ontario's Climate Change Action Plan.

An important part of transitioning to near and net zero energy or carbon emission buildings is to minimize their energy use. Generally, the most cost-effective way is to first improve their energy efficiency, with increased insulation, advanced air sealing, and high efficiency heating and cooling systems. Once that has been done, some type of on-site renewable energy generation is generally required to achieve net zero energy or carbon emission status. The government is taking steps to expand and enhance its net metering framework, which would give building owners increased opportunities to integrate renewable energy generation and energy storage technologies.

Reid's Heritage Homes - Guelph

Reid's Heritage Homes built five net zero homes in Guelph in 2016. These homes were the first in Canada to meet new net zero home standards set up by the Canadian Home Builders' Association.

Key features include:

- Air source heat pumps;
- High efficiency water heaters;
- Increased insulation values in exterior walls, attic and basement;
- Advanced air sealing to avoid air leakage;

Right sized mechanicals and energy recovery ventilators; and

- Solar panels.

West 5 - Sifton Properties Limited - London

The West 5 development in London is Ontario's first sustainable, net zero community. It will have a total of 2,000 apartments, condominiums and townhomes along with 400,000 sq. ft. of commercial and retail space, and a 1.6-acre central park. Construction of West 5 will create about 2,500 jobs over 10 years.

Key features include:

- Solar panels and solar streetlights
- Solar parkades
- Green roofs
- EV charging stations
- Community gardens
- Rainwater harvesting

Climate change adaptation

Ensuring a resilient energy supply

Ontarians need to have a reliable supply of energy, not just for for their economic prosperity but for their basic health and safety. In order to provide vital energy services to Ontarians, the province's energy system must remain resilient and able to withstand a changing climate.

The facilities and equipment that currently generate, transmit and distribute energy across the province can be threatened by the extended heat waves, high winds, severe rainfall and ice storms that come with climate change. Climate change may also lower the flows of rivers and the water levels and temperatures of lakes, possibly reducing the ability to generate electricity.

To address these concerns, Ontario's energy organizations are taking a number of actions that will ensure the province's energy system is better prepared to meet extreme weather events:

- Together with several partner organizations, the IESO studied Ontario's transmission system and found it resilient enough to substantially withstand most extreme weather scenarios. However, the study recommended continued monitoring and refinement of climate scenarios.
- More local distribution companies are making adaptation and system resilience a priority. Both Toronto Hydro and the former Horizon Utilities (now part of Alectra Utilities) conducted vulnerability assessments of their systems. A leader in this regard in Canada, Toronto Hydro is addressing climate change vulnerabilities by improving its engineering practices and tools, such as its load forecasting model, and installing more resilient equipment on its system. In its last rate application, Toronto Hydro identified extreme weather as a driver for its capital and maintenance expenditures.
- Local distribution companies (LDCs) such as Oshawa PUC Networks, Veridian and Whitby Hydro are developing adaptation plans to match the adaptation planning done by their local transit, water and communications authorities.

Building on its current activities, the government will strengthen the ability of the energy industry to prepare for the effects of climate change and integrate its impacts into their operational and infrastructure planning.

The government and its agencies will facilitate the exchange of information and knowledge among utilities and other partners to allow them to share best practices and increase their ability to adapt to climate change. Since these activities are best co-ordinated with other public services, the Province will encourage utilities to work with municipalities and other public and private infrastructure operators. This knowledge-sharing platform will be a key first step to help with the following initiatives:

- The government will help develop a vulnerability assessment of the energy distribution sector so utilities can develop state-of-the-art strategies to manage risk. This will complement the vulnerability assessment done of the transmission system in 2015.
- The OEB will give utilities guidance on cost-effectively integrating climate change adaptation into their planning and operations. The IESO will ensure that climate change adaptation is considered and integrated into the bulk system and regional planning processes.

Adaptation initiatives by local distribution companies

Building on its distribution system vulnerability assessment, the former Horizon Utilities (now part of Alectra Utilities), developed a long-term plan for adapting to climate change. The plan considers the risk of flooding when planning infrastructure, and improvements to the LDC's geographic information and outage management system reduce response times.

Hydro Ottawa focused its storm hardening initiative, completed in 2015, on revising the schedule for removing and trimming overhanging tree branches. As a result, public safety has been increased, the distribution system is less vulnerable to damage from high winds and ice storms, and the LDC's budget for vegetation management was reduced by $750,000.

Summary

- Ontario remains committed to a clean electricity system that includes renewable energy generation and supports the goals of the Climate Change Action Plan.
- The government will encourage the construction of near net zero and net zero carbon emission homes and buildings to reduce emissions in the building sector.
- The government is proposing to expand the options for net metering to give building owners more opportunities to access renewable energy generation and energy storage technologies.
- The government will continue to work with industry partners to introduce renewable natural gas into the province's natural gas supply and expand the use of lower-carbon fuels for transportation.
- Building on current activities, the government will strengthen the ability of the energy industry to anticipate the effects of climate change and integrate its impacts into its operational and infrastructure planning.

Accessible descriptions

Figure 18: Ontario's clean generation mix

Figure 18 is a map of Ontario and some nearby U.S. states. Manitoba and Quebec are also shown. On the map, pie charts indicate the generation mix of a number of U.S. states and Manitoba and Quebec. The U.S. states depicted are: Minnesota, Michigan, Wisconsin, Pennsylvania, New York, Illinois, Indiana, Ohio and West Virginia.

Figure 18 shows that Ontario’s generation mix is very clean in comparison to the U.S. states shown. A number of states still rely heavily on coal and/or gas/oil as their primary generation source. Apart from New York and Illinois, all of the states depicted have more than 50 per cent of their generation coming from emitting sources. Some states, such as Indiana and West Virginia, rely on emitting sources for more than 94 per cent of their total generation. In comparison, Ontario has a clean mix, with only 8 per cent of its generation coming from gas/oil. Manitoba and Quebec have very clean generation mixes as well, due to their abundant hydro resources.

Electricity generation - % of total								
State/province	Coal	Gas/oil	Wind	Biofuel	Solar	Water	Nuclear	Other

New York	1.7%	42.3%	2.9%	1.6%	0.1%	18.7%	32.1%	0.7%
Pennsylvania	30.1%	28.2%	1.6%	1.1%	0%	1.2%	37.4%	0.4%
Illinois	38.0%	5.8%	5.5%	0.3%	0%	0.1%	50.2%	0.1%
Indiana	75.2%	19.1%	4.3%	0.4%	0.2%	0.4%	0%	0.4%
Michigan	46.6%	19.5%	4.2%	2.2%	0%	1.3%	25.8%	0.4%
Ohio	58.8%	24.9%	1.0%	0.7%	0%	0.4%	14.3%	0%
Wisconsin	56.0%	20.5%	2.4%	2.4%	0%	3.5%	15.1%	0.1%
Minnesota	43.3%	13.0%	17.2%	3.2%	0%	1.5%	21.1%	0.7%
West Virginia	94.1%	2.0%	1.9%	0%	0%	1.9%	0%	0%
Manitoba	0%	0%	2.7%	0%	0%	97.1%	0%	0.3%
Quebec	0%	0%	4.0%	1.0%	0%	95.0%	0%	0%
Ontario	0%	8.2%	6.8%	0.5%	2.2%	23.3%	58.5%	0.4%

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Figure 19: Electricity sector GHG emissions outlook

Figure 19 is a line chart showing electricity sector emissions. The vertical axis is labeled "Greenhouse Gas Emissions" in megatonnes CO2e in increments of 5 from 0 to 35. The horizontal axis lists all years from 2005 to 2035. Four lines are shown: Historic, 2013 LTEP Outlook, 2017 LTEP Outlook and 2017 LTEP Low Emissions Outlook.

The historic emissions line begins in 2005 and ends in 2016. The 2013 LTEP Outlook forecast begins in 2013, and projected lower emissions than historic levels from 2014 to 2017. The 2017 LTEP Outlook forecast begins in 2017 and mostly projects lower emissions than the 2013 LTEP Outlook through to 2035. Emissions could come in lower than forecast, and a scenario with emissions maintained at close to 2017 levels is also shown.

Greenhouse gas emissions CO2e (megatonnes)

Year	Historic	2013 LTEP outlook	2017 LTEP outlook	2017 LTEP low emissions outlook	2017 LTEP outlook difference
2005	32.3	n/a	n/a	n/a	n/a
2006	27.6	n/a	n/a	n/a	n/a
2007	30.4	n/a	n/a	n/a	n/a
2008	25.3	n/a	n/a	n/a	n/a
2009	14.2	n/a	n/a	n/a	n/a
2010	18.6	n/a	n/a	n/a	n/a
2011	13.8	n/a	n/a	n/a	n/a
2012	13.9	n/a	n/a	n/a	n/a
2013	10.1	6.9	n/a	n/a	n/a
2014	6	5.4	n/a	n/a	n/a
2015	6.2	4.3	n/a	n/a	n/a
2016	6	3.7	n/a	n/a	n/a
2017	3.9	3.8	3.9	n/a	n/a
2018	n/a	4.4	4.0	3.9	0.1
2019	n/a	4.6	4.3	3.9	0.4
2020	n/a	4.6	4.5	3.9	0.6
2021	n/a	7.3	5.2	3.9	1.3
2022	n/a	7.4	5.6	3.9	1.7
2023	n/a	7.7	7.4	3.9	3.5
2024	n/a	7.4	5.9	2.9	3.0
2025	n/a	7.2	7.9	3.9	4.0

2026	n/a	6.3	7.0	3.4	3.6
2027	n/a	6.9	6.9	3.4	3.6
2028	n/a	7.0	6.4	3.1	3.3
2029	n/a	7.6	6.9	3.3	3.6
2030	n/a	8.0	6.8	3.3	3.5
2031	n/a	8.1	7.4	3.7	3.7
2032	n/a	8.0	7.0	3.4	3.6
2033	n/a	n/a	7.3	3.6	3.7
2034	n/a	n/a	7.9	4.0	3.9
2035	n/a	n/a	8.5	4.0	4.5

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The Ontario Culture Strategy

Telling our stories, growing our economy

Ontario

Culture is everyday good living, a way of life, shared histories, values, beliefs, vitality, beauty, pride, play, sport, recreation, leisure, fashion, cultural industries, entertainment, live music, photography, publishing, architecture, civic spaces, art, design, interactive digital media, watching television, movies, learning, trying new things, language, books and magazines, crafts, humour, amateur and professional theatre, dance, opera, pow wows, maple syrup festivals, agricultural festivals, farmers' markets, cultural institutions, museums, archives, historical societies, built heritage and cultural heritage landscapes, fishing, hunting and trapping, social interaction, social cohesion, citizen engagement, sustainability, the products of artists and entrepreneurs. Culture is tangible and intangible. Culture means good mental health, good relationships and enlarged spirits. Culture provides joy. Libraries are sanctuaries for many people. Food defines who we are and where we are from. Music is an essential part of human experience. Archaeology is very important to complement or fill gaps in the written record. Culture is the sharing of creative knowledge, skills and talents. It is volunteering, donating and working selflessly to build strong communities. Culture is bold. It is creativity and imagination. It is reflection and creative thinking. It is knowledge and understanding. It is innovation and technology. It is provocation and exploration of new ideas. Art must be democratic but must also go beyond consensus to be edgy and challenge us. Culture is an expression of our identity and history. It is an explanation and exploration of who we are. It is how we enjoy ourselves. It helps us understand where we live and presents Ontario to the rest of the world. It fosters awareness. It is our wilderness and our friendliness. Culture starts with gaining an accurate understanding of the historical accomplishments of African/Black people. It is a community's past, present and future. Culture is what unites Franco-Ontarians and reflects them back to themselves. It is a means of intergenerational transmission.

Contents

Kim Adams
(Canadian b. 1951).

Bruegel-Bosch Bus
1997-ongoing
sculpture-installation
1960s Volkswagen bus,
figurines, mixed media.

Art Gallery of Hamilton.

Acquired with the assistance of the York Wilson Endowment Award at The Canada Council for the Arts, and with funds from The E. Muriel Baker Estate, The Russell Nelson Eden Estate, and the Walter and Duncan Gordon Foundation, 2001.

Inside front and back covers: In our public engagement process, we asked people to describe culture. These are some of the words and phrases you used.

Minister's message

Arts and culture inspire us, bring us together and make our communities and economy stronger. They give us opportunities for self-expression and have the potential to transform lives, especially for our children and youth.

In September 2015, the Ontario government set out to create the province's first Culture Strategy, starting with a public engagement process, Culture Talks, to ask what culture means to you and your community. Through large town halls, small group discussions, meetings with Indigenous partners and communities, an online dialogue and written submissions, thousands of you shared your perspectives and priorities with us.

We heard clearly that culture matters deeply to Ontarians, that it is an essential part of individual and community well-being. We heard, too, that culture includes an almost limitless array of human experiences and expressions. Thank you for your tremendous response. Your input helped shape the Ontario Culture Strategy.

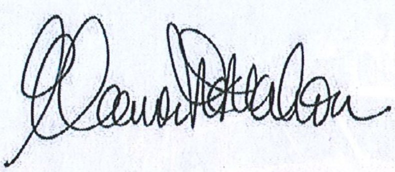
I would like to thank my colleague, the Honourable Michael Coteau, Minister of Children and Youth Services and the Minister Responsible for Anti-Racism, for his leadership of the public engagement process and the development of the Culture Strategy, as the former Minister of Tourism, Culture and Sport. Minister Coteau and I are grateful to the members of the Culture Strategy Advisory Group for their dedication, advice and valuable insights throughout the process of creating the Culture Strategy.

Ontario's diversity, in both people and places, is one of our greatest strengths. We have unique urban, rural and Northern communities, and communities formed through shared origins, histories, lived experiences and languages. This diversity is reflected in our creative expressions and it is what makes arts and culture in Ontario distinct and remarkable.

Opportunities to experience arts and culture should be available to everyone, and our diverse voices should be heard and celebrated. The government of Ontario, our culture and tourism agencies, and many other dedicated organizations and individuals, including artists and volunteers, work hard every day in communities across Ontario to make sure this happens.

This Strategy builds on all of that work by focusing government support where it is needed most: to promote cultural engagement and inclusion, strengthen culture in communities, maximize the contributions of culture and creativity to our knowledge economy and promote the value of the arts throughout government.

I am excited to launch Ontario's first Culture Strategy. We will continue the dialogue we began with Culture Talks as we move forward to implement the Strategy and strengthen the arts and culture sector for all Ontarians.



Honourable Eleanor McMahon
Minister of Tourism, Culture and Sport

Culture Strategy Advisory Group

We thank the members of our Culture Strategy Advisory Group for their dedication, advice and valuable insights throughout the process of creating the Ontario Culture Strategy.

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Art Gallery of Hamilton

Jim Fleck
Business for the Arts

Georges Haroutiun
Applied Arts magazine

Jane Hilton
Ontario Library Association

Rose Jacobson
Picasso PRO

Randy Lennox
Bell Media

Tanya Matanda
Art Gallery of Ontario volunteer

Chris McDonald
Hot Docs Canadian International Documentary Festival

Mark Monahan
RBC Ottawa Bluesfest, CityFolk and the Festival of Small Halls

Tory Tronrud
Thunder Bay Museum, Lakehead University and *Ontario History*

Catherine Voyer-Léger
Alliance culturelle de l'Ontario

Nancy Webster
Young People's Theatre

Ron Williamson
ASI (Archaeological and Cultural Heritage Services) and Museum of Ontario Archaeology

Ontario's **stories**

The Global Savages Sunrise Ceremony on Wikwemikong Bay.
Photo provided by Debajehmujig Storytellers.

Introduction

Ontario's stories are rooted in the rich diversity of our landscapes and peoples.

Our vast and varied landscape spans more than a million square kilometres, from Hudson Bay and the boreal forests of the Far North to the Great Lakes and deciduous forests of the south, and from the Manitoba border in the west to the banks of the Ottawa River in the east. Ontario encompasses 444 municipalities and is covered by 46 treaties and other agreements between First Nations and the Crown.

Ontario is home to over 13 million people: Indigenous peoples with deep ties to the land and water; Francophones who celebrated 400 years in Ontario in 2015; disability and Deaf[1] communities with specific cultural and linguistic identities; people from many different ethno-cultural backgrounds who strive to retain their languages and traditions; and many more diverse communities. We have all helped to weave the fabric of today's Ontario and our stories continue to evolve in exciting ways as our population grows and changes.

Our stories are reflected in our languages, value systems, beliefs, cultural identities, traditions, and the food we lovingly prepare and share. They are embodied in artifacts, heritage buildings and places, cultural and natural landscapes, and in the land itself.

We tell our stories through film and television, music and opera, visual arts and interdisciplinary arts, media arts and interactive digital media like video games and apps, theatre and dance, books and magazines and crafts.

We tell our stories through the architecture of the buildings and spaces we inhabit and that inspire us, the design that adds value to just about everything we touch and use, and the fashion we choose for function and style.

Art galleries, museums, science centres, cultural centres, archives, historical societies, Friendship Centres and public libraries act as storehouses of knowledge and culture, telling our stories, giving us windows onto the world and bringing the world to us.

We celebrate our stories together at pow wows and Rendezvous events, historical re-enactments and multi-sport games, through art and theatre in the park, at music and film festivals, cultural and multicultural festivals, food and agricultural festivals, and at annual events like Doors Open Ontario and Culture Days.

And all of this, of course, is only the beginning. We tell our stories in many other ways.

Culture matters to Ontarians

In fall 2015, we began the process of developing the Culture Strategy with an extensive public engagement process. This was the first time Ontario had held such a far-reaching dialogue with individuals and communities across the province and with all culture sectors about the value and significance of culture. Thousands of people participated through town halls, written submissions and an interactive digital platform. We held smaller community conversations with Francophones, youth, seniors, ethno-cultural communities, newcomers, people with disabilities and people who are Deaf. We also held meetings with Indigenous partners and communities. We reported back with "Culture Talks: A Summary of What We Heard from Ontarians."[2]

What did we mean by "culture"?[3] We neither defined nor limited its meaning. We wanted to discover what it means to Ontarians and their communities and we learned that it means many different and important things. The response was remarkable for both volume and passion. On the inside front and back covers, we have collected some of the hundreds of ways people defined culture and described why it is important to them.

From every corner of the province, in many different voices and in many different words, the overwhelming message we heard was that culture matters profoundly to Ontarians.

Culture enriches every part of our lives

Culture gives free flight to our imaginations, lifts our spirits, entertains us, gives us hope and inspires us in unexpected and sometimes life-changing ways. It gives shape, context and understanding to our experiences and the experiences of others. It can challenge us, ask difficult questions, make us wonder and motivate us to find answers. It reflects and re-imagines our world. Culture connects us and creates community identity, cohesion, vibrancy and prosperity.

As our public engagement process made clear, culture is a fundamental, organic and vital part of our lives and our community life. Many people spoke or wrote about culture as a fourth pillar of community sustainability and well-being, alongside social equity, economic health and environmental responsibility.[4] Participation in arts, culture and recreation is an indicator of quality of life in the Canadian Index of Wellbeing.[5]

Art in the Moment gallery tour at the AGO. Photo by the Art Gallery of Ontario.

Culture influences our well-being at all stages of life. In the early years, at school, and through after-school and community-based arts and culture programs, children develop creativity, cross-cultural understanding and often a lifetime connection to arts and culture. Along with techniques for self-expression, youth learn collaboration, problem-solving, leadership, and entrepreneurial and professional skills. For at-risk youth especially, engagement in arts and culture is linked to improved social skills and higher academic achievement.

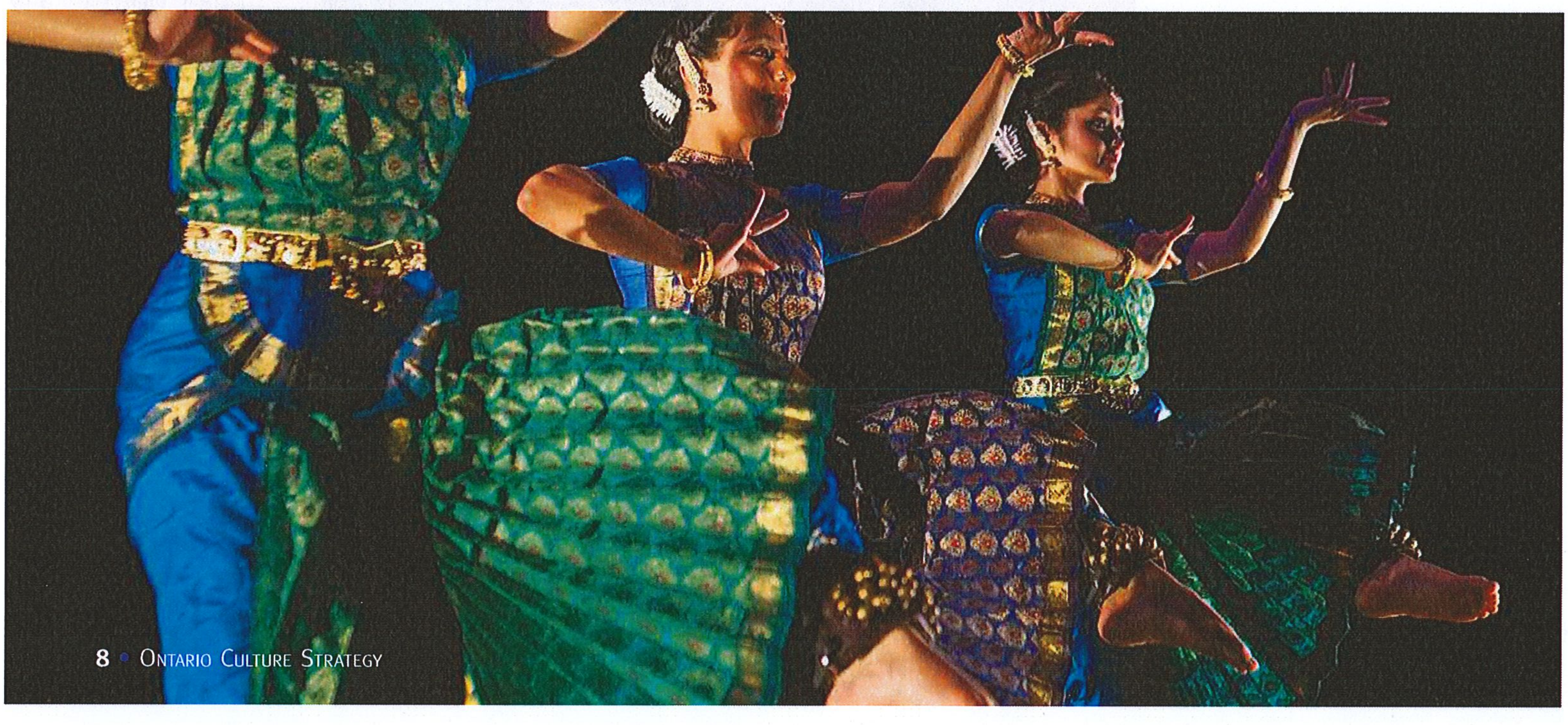
Through the many learning opportunities offered by individual artists, arts organizations, galleries, museums, science centres, botanical gardens and public libraries, arts and cultural experiences support lifelong learning and help develop the talent and skills of Ontarians of all ages. A growing body of research also shows that opportunities to engage with arts and culture build confidence and improve physical and mental health, especially for our seniors.

Ontario's rich and diverse cultural heritage[6] gives our communities identity and character, and it enhances our sense of place and pride in where we live. Conserving our cultural heritage reflects what we value about our past, what we have learned from it and what we want future generations to know. Kingston's limestone buildings, Windsor's Walkerville, Cobalt's mine headframes and the Kinomaage-Waapkong ("The Teaching Rocks") in Petroglyphs Provincial Park are just a few examples from across the province.

Heritage buildings and districts can revitalize downtown cores and main streets, creating desirable neighbourhoods and supporting local economic development. Reusing buildings also cuts down on landfill waste, protects greenfield land and can reduce greenhouse gas emissions. One report comparing buildings of equivalent size and function found that building reuse almost always offers environmental savings over demolition and new construction.[7] As architect Carl Elefante put it, "The greenest building is...one that is already built."[8]

Ontario's outstanding cultural institutions, attractions, festivals and events infuse our communities and our province with energy and vitality — and contribute to economic development and tourism. Spending by arts and culture tourists generates about $3.9 billion in GDP and supports about 61,000 jobs in the province.[9]

Culture also supports the economy through direct and indirect job creation. In 2014, culture contributed about $25.3 billion, or nearly four per cent, to Ontario's GDP, supporting almost 280,000 jobs.[10] Engagement in arts and culture is a catalyst for creative thinking and innovation, and communities where arts and culture thrive attract creative, talented and skilled people to live and work there. These are essential qualities in the knowledge economy and vital to Ontario's future growth and prosperity.



Overview of the Culture Strategy

The Gryphon Trio is joined by violist Paul Coletti for a performance at Koerner Hall during the Toronto Summer Music Festival. Photo by Peter Alberti.

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Publicity image for Sampradaya Dance Creations for the production of *Prayoga* staged at Meadowvale Theatre in Mississauga. Photo by On Up Photography.

Input into the Strategy

The Culture Strategy reflects the input we received during our public engagement process, as well as research we undertook to gather information on culture in Ontario, investigate key trends affecting the sector and look at how jurisdictions around the world are responding to similar trends.[11] Both the research and public input identified Ontario's increasing diversity and digital technology as two of the greatest impacts on culture in Ontario, now and in the years to come.

While we were developing the Strategy, the Truth and Reconciliation Commission of Canada released its final report, which shed light on the brutalities committed at residential schools and set out a path toward reconciliation for all Canadians.[12] The report exposes the terrible truth that the residential school system was specifically intended to destroy Indigenous identities and cultures. In our discussions with Indigenous partners and communities, we learned that reconnecting children and youth with their traditional cultures and languages is an urgent priority. The Journey Together:

Visit to the AGO through the Institute for Canadian Citizenship's 'Ahlan Canada' program. Photo by Andrew Williamson Photography.

Ontario's Commitment to Reconciliation with Indigenous Peoples is a plan for working with Indigenous partners to address the legacy of residential schools, close gaps and remove barriers.[13] The plan seeks to create a culturally relevant and responsive justice system, support Indigenous cultures and reconcile relationships with Indigenous peoples.

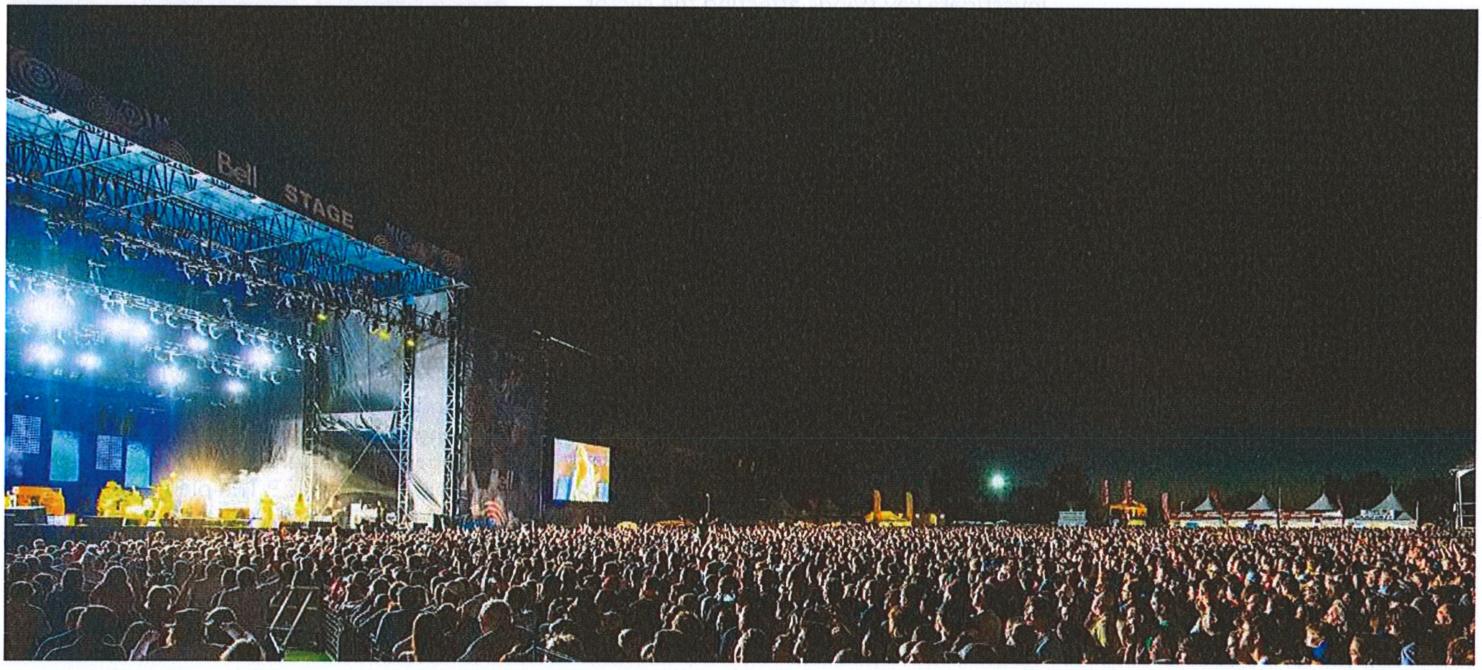
Walk Off The Earth performing at CityFolk in Ottawa. Photo by Steve Gerecke.

Ontario continues to work with the Chiefs of Ontario to address issues around Indigenous heritage and burial sites in response to the report of the 2007 Ipperwash Inquiry.[14] We also built on two other critical relationship agreements in developing the Culture Strategy. In August 2015, the Chiefs of Ontario and the Government of Ontario signed an historic Political Accord to guide the relationship between First Nations and the province. The Accord affirms that First Nations have an inherent right to self-government, that the relationship between Ontario and First Nations must be based upon respect for this right and commits the parties to work together on issues of mutual interest.[15]

In April 2014, the Métis Nation of Ontario and the Government of Ontario renewed the Framework Agreement[16] to advance reconciliation between the Crown and the Métis people through actions including improving the well-being of Métis children, families and communities. In charting our path forward, understanding and respect for Indigenous cultures will play a key role.

Guided by a vision and principles

Everything we do as we implement the Culture Strategy will be guided by a vision and principles. We invited feedback on the vision and principles during our public engagement process and we are confident that they reflect the values that are important to Ontarians.



Working toward four overarching goals

The Culture Strategy sets out four overarching goals for the next five years: promote cultural engagement and inclusion, strengthen culture in communities, fuel the creative economy and promote the value of the arts throughout government. These goals reflect our commitment to removing barriers and increasing opportunities for cultural participation. They also balance the important social and economic benefits of culture and reinforce the vital role artists and arts organizations play in communities, in the creative economy and in helping to build a more inclusive society. Each goal includes strategies and actions.

Building on the work of our agencies and attractions

Ontario's agencies and attractions undertake their own processes to respond to changes that affect their mandates. For example, two of our granting partners have completed planning and redesign processes recently. The Ontario Arts Council, our principal conduit for support to artists and the broader arts sector, launched its new strategic plan in 2014.[17] The Ontario Trillium Foundation introduced its new investment strategy in 2015, focusing on six action areas to improve and enrich people's lives.[18] The Culture Strategy builds on and complements these initiatives, as well as the business planning work of all of our partner agencies.

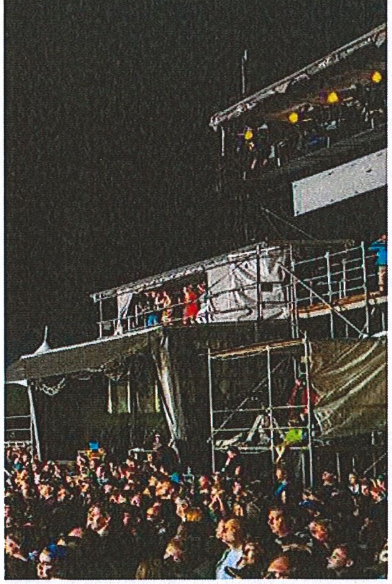
Photo provided by the Ontario Science Centre.

Culture and tourism agencies and attractions

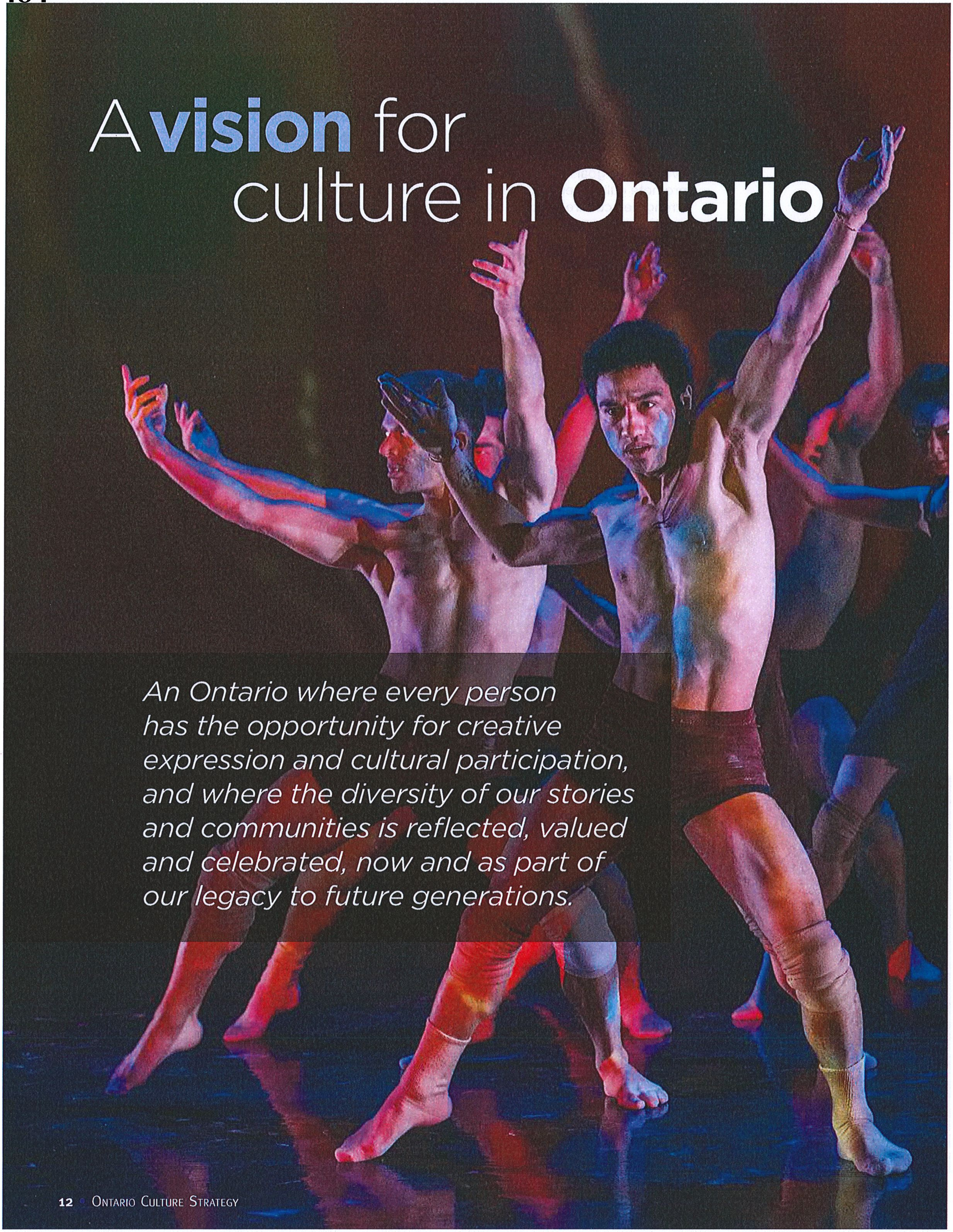
Ontario's culture and tourism agencies and attractions are centres of excellence and innovation. For residents and visitors, they offer opportunities for learning, recreation, enjoyment and entertainment.

- Art Gallery of Ontario
- Fort William Historical Park
- Huronia Historical Parks
- McMichael Canadian Art Collection
- Metro Toronto Convention Centre
- Niagara Parks Commission
- Ontario Arts Council
- Ontario Heritage Trust
- Ontario Library Service - North
- Ontario Media Development Corporation
- Ontario Place Corporation
- Ontario Science Centre
- Ontario Tourism Marketing Partnership Corporation
- Ontario Trillium Foundation
- Ottawa Convention Centre
- Royal Botanical Gardens
- Royal Ontario Museum
- Science North
- Southern Ontario Library Service
- St. Lawrence Parks Commission

RBC Bluesfest in Ottawa.
Photo by Steve Gerecke.



A **vision** for culture in **Ontario**



An Ontario where every person has the opportunity for creative expression and cultural participation, and where the diversity of our stories and communities is reflected, valued and celebrated, now and as part of our legacy to future generations.

Backbone,
Red Sky Performance.
Photo by Rita Taylor.

Principles to guide government support for culture

Creativity and innovation

Culture exposes us to new ideas and inspires new ways of thinking. Support for culture should help to nourish and reward creativity, exploration, experimentation and innovation.

Quality of life and economic development

Culture contributes significantly to both quality of life and economic development in Ontario. Support for culture should help to enrich our lives, strengthen and animate our communities and build a dynamic business environment in Ontario.

Diversity and inclusion

Ontario's rich diversity is one of our greatest strengths. We should all have the opportunity to participate in Ontario's diverse cultural life, regardless of age, background, language, ability or where we live in the province. Support for culture should recognize people with disabilities and people who are Deaf as cultural and linguistic communities with unique identities, experiences and values.

Respect for Indigenous peoples

Indigenous cultures, languages and heritage represent distinct identities, histories and ways of life. Ontario is committed to reconciliation by strengthening and transforming its relationship with Indigenous communities and by implementing changes that reflect Indigenous priorities.

Collaboration and partnerships

The talents and contributions of many people and organizations make our culture sector strong and vibrant. Support for culture should encourage collaboration and partnerships among provincial ministries and agencies; municipal, provincial/territorial, federal and Indigenous partners; not-for-profit arts and culture organizations; the private sector; and all communities and individuals.

Public value and accountability

Government investment in culture should be guided by what Ontarians value and by what makes a positive difference in the lives of individuals and communities. This ministry, its agencies and the organizations we fund are accountable for achieving the best possible outcomes within available resources.

Goal 1:

Promote cultural engagement and inclusion

Focus on removing barriers and increasing opportunities for cultural participation

Lead Storyteller and Cultural Elder from Debajehmujig Storytellers crossing the New Meuse river in Rotterdam, as The Global Savages bring their stories to Europe. Photo by Peter Van Beek.

Our first goal flows directly from our vision for culture — an Ontario where every person has the opportunity for creative expression and cultural participation.

In our engagement process, we heard from members of some communities who still experience barriers to accessing culture funding and to participating fully in the cultural life of our province, including people from Indigenous, Francophone, and ethno-cultural communities, people with disabilities, people who are Deaf, and people living in rural and remote areas of the province. We need to do better at removing barriers and increasing opportunities for everyone.

There are many inclusive practices that we can learn from and build on. The following are just a few examples from our agencies and attractions to show the range of programs aimed at reaching out to and including all of Ontario's communities:

- The Ontario Heritage Trust has created an online gallery and educational resources to promote greater understanding of Franco-Ontarian heritage.
- The Art Gallery of Ontario and the Royal Ontario Museum have recently partnered with the Institute for Canadian Citizenship to pilot their Ahlan welcome program which connects newcomers with cultural attractions, experiences and people in their communities.[19]
- Science North delivers science programs for Northern and Indigenous communities, including five remote communities it serves by chartered plane through a partnership with Northern Nishnawbe Education Council.
- In 2015-16, the Ontario Arts Council established its first Deaf and Disability Arts Projects program to support projects by artists who are Deaf or who have a disability.
- The McMichael Canadian Art Collection developed and shared its guide, "The Art of Inclusion," a seven-step process for designing and delivering accessible programs in arts and culture organizations.

Active engagement with arts and culture has enormous benefits for people of all abilities and at all stages of life. During Culture Talks, parents, educators and many others stressed the importance of arts and culture in education, not only for their intrinsic value but also for their role in developing critical and creative thinking skills that support success in school, in life and in the future workforce. The arts also provide engaging and innovative ways to teach many other subjects, including math and science.

The Ministry of Education is an important partner in providing opportunities for cultural engagement for children and youth — from its guiding document for early years curriculum development[20] and its policy for French-language schools[21] to the provincial curriculum (Kindergarten to Grade 12), which provides a foundation for appreciation of arts and culture, to the Pathways to Success program for high school students who want to build careers in culture.[22] The ministry's renewed vision for education promotes a learning environment that respects and values Ontario's cultural diversity, creating a space where diversity is recognized as a contributor to success. In collaboration with First Nations, Métis and Inuit communities and education partners, the Ministry of Education is also developing a plan to incorporate Indigenous histories and cultures into the mandatory public education curriculum.[23]

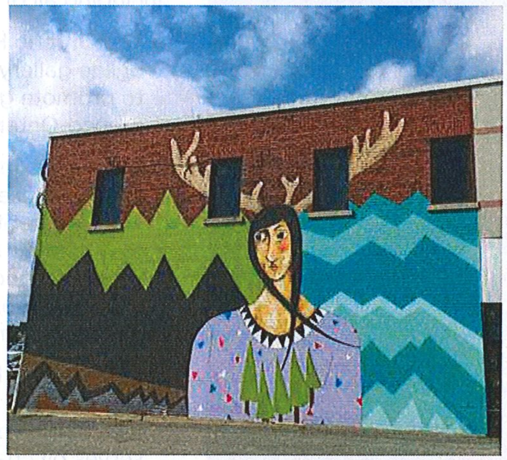
Ontario's agencies and attractions offer a wide range of programs to complement the school curriculum and programs. The Ontario Arts Council supports arts programming and activities in school and community settings through its Artists in Education, Aboriginal Artists in Schools, Artists in Residence (Education), and Arts Education Projects and Organizations programs. The Royal Ontario Museum's Youth Cabinet brings together Indigenous and non-Indigenous youth to develop online museum content. The Southern Ontario Library Service and Ontario Library Service — North coordinate Club Amick, a book club for First Nation children attending Kindergarten to Grade 6 in Ontario's remote communities.

Museums, galleries, public libraries and other arts and culture organizations also provide engaging educational and intergenerational learning experiences, co-op placements, summer employment and volunteer opportunities for people of all ages. The availability of arts and culture activities helps to build age-friendly communities. For seniors, there is a strong connection between cultural engagement and general well-being and active living.

Over the next two decades, Ontario will experience a large demographic shift, with the number of seniors expected to double by 2036.[24] The Ontario government has been working with agencies, stakeholders, regions and municipalities to create initiatives to support older adults to remain active contributors to the cultural life of our communities.

We are also working on laying the foundation for developing a more formal and lasting relationship with Indigenous communities to engage on a broad range of cultural interests and priorities. We want to open up a meaningful dialogue to explore together how we can support Indigenous cultures, nourish cultural vitality and promote the contributions of Indigenous cultures to all Ontarians and the world. We also want to help facilitate stronger relationships between Indigenous communities and museums and other culture organizations.

This goal reflects our commitment to inclusion with strategies to further reduce barriers and encourage greater participation in culture by all communities, inspire the next generation, and strengthen our relationship with Indigenous communities.



Dear Sudbury mural by Danielle Daniel.
Photo by Danielle Daniel.

Strategy 1

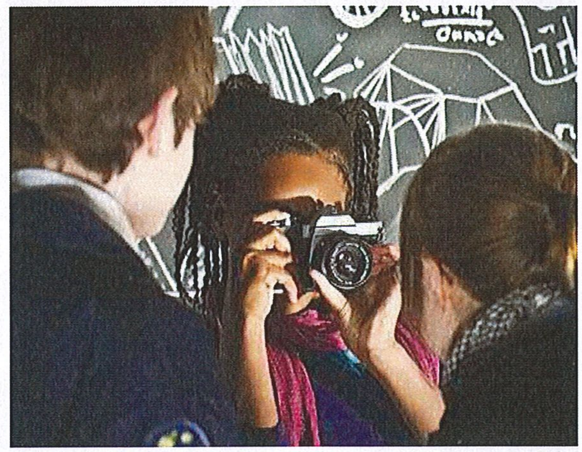
Reduce barriers and encourage greater participation in culture

- Bring together Ontario government granting partners to share best practices and increase access and inclusion throughout the application and assessment process, and ensure that representatives of communities who may face barriers to accessing culture funding are actively involved in the discussions, including Indigenous, Francophone and ethno-cultural communities, people with disabilities and people who are Deaf, and people living in rural and remote areas.
- Continue to support culture agencies, organizations and other partners to remove barriers for people with disabilities and people who are Deaf to increase opportunities for creation and participation in arts and culture.
- Identify and promote ways to increase opportunities for Ontario's seniors to engage with arts and culture in their communities in many different ways, including as artists, mentors, volunteers and participants.

Strategy 2

Inspire the next generation and help youth build careers in the culture sector

- Continue to identify and promote opportunities for collaboration and partnerships between the culture and education sectors to increase opportunities for participation in arts and culture and learning through the arts.
- Develop a new fund to support publishers in creating curriculum-linked learning resources aimed at fostering the use of diverse Canadian content in schools.
- Build new community partnerships to support high school students interested in further learning or exploring careers in arts and culture by offering more Specialist High Skills Major and co-op placements, dual credit programs and other opportunities available through the Ministry of Education's Pathways to Success program.
- Continue to support Ontario's culture agencies, attractions and organizations in offering opportunities for children and youth to engage with arts and culture and in promoting youth engagement in the heritage sector.
- Support youth cultural camps in Indigenous communities to build leadership and promote awareness of traditional knowledge and languages through daily hands-on activities.



On the set of the Canadian Film Centre's short film *Oliver Bump's Birthday*, from director Jordan Canning. Photo by Krystina Pucci, provided by the Canadian Film Centre.

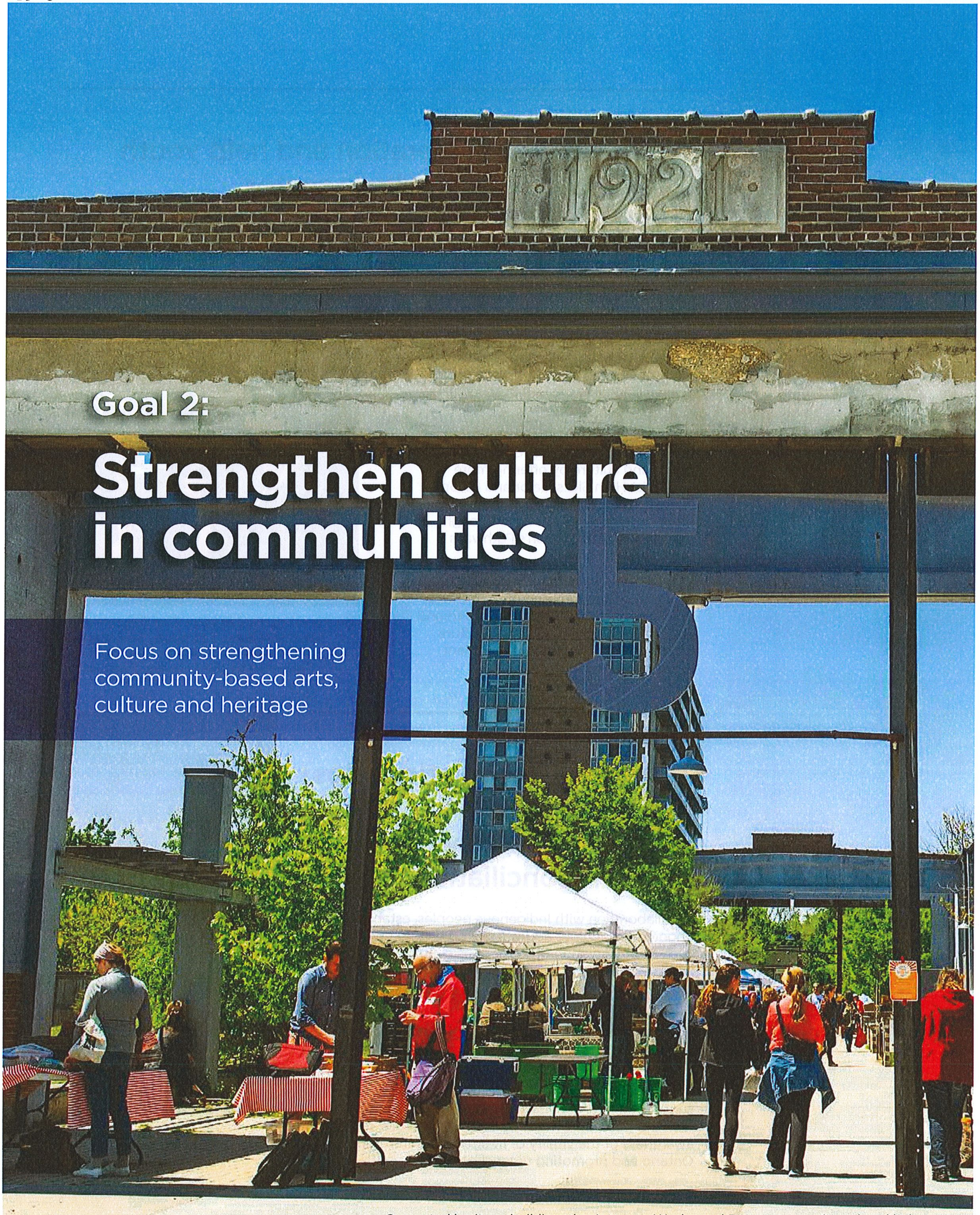
Strategy 3

Strengthen our relationships with Indigenous communities and work toward reconciliation

- In collaboration with Indigenous peoples, establish an ongoing dialogue to address shared culture priorities, such as preservation of Indigenous cultural heritage and languages and participation in all aspects of Ontario's cultural life.
- Help facilitate cross-cultural understanding between First Nations, Métis and Inuit communities and museums and other culture organizations to create stronger relationships and partnerships.
- Provide an Indigenous Cultural Revitalization Fund to support cultural activities in Indigenous communities, with the goals of revitalizing cultural practices, raising awareness of the vitality of Indigenous cultures in Ontario and promoting reconciliation.

Expected results

- There will be fewer barriers to accessing culture funding.
- People of all ages and abilities will have more opportunities to engage with arts and culture.
- Youth will have more information and supports available to help them pursue careers in the culture sector.
- There will be stronger relationships between Indigenous communities, the province and culture organizations to support Indigenous culture priorities.

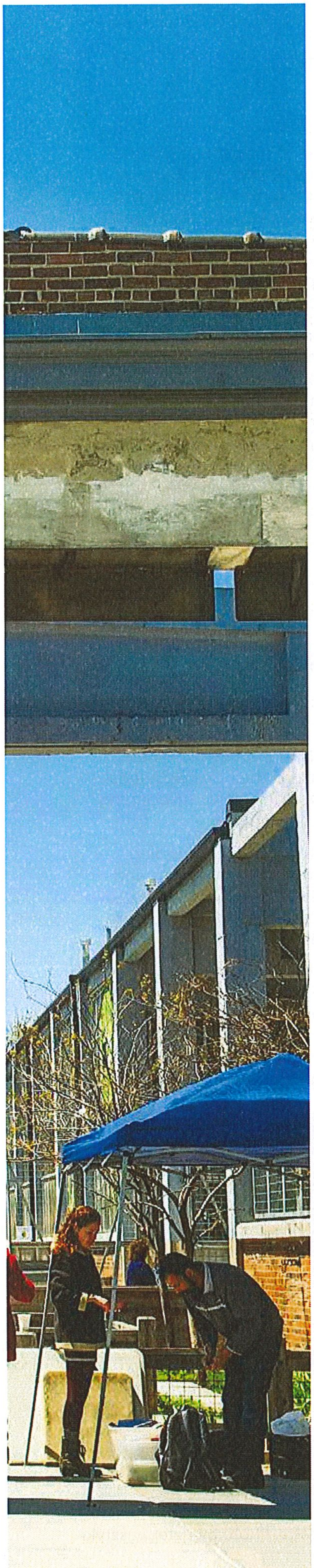


Goal 2:

Strengthen culture in communities

Focus on strengthening community-based arts, culture and heritage

Converted heritage building, the Artscape Wychwood Barns community cultural hub.
Photo by Ted Chai Photography.



This goal focuses on strengthening culture where most of us experience it — close to home, in our communities. The places we live are one type of community. Other communities are formed by the bonds people share through history and identity.

Municipalities are key partners in supporting local arts, culture and heritage. Over the past decade, 69 municipalities, representing nearly three-quarters of Ontario's population, have developed cultural plans to integrate culture into local decision-making and help achieve broader priorities like creating jobs and promoting tourism. Some First Nations and Métis communities have also identified and documented their cultural resources and developed cultural plans to help preserve and revitalize their distinct heritage and languages.

Municipalities play a key role in preserving our cultural heritage. Under the Ontario Heritage Act, they designate properties or areas that are of value to their communities to conserve them for future generations. Under provincial planning legislation, municipalities protect cultural heritage and archaeological sites and must consider the interests of Indigenous communities in the process.

Archaeological sites can include the remains of Indigenous settlements, battlefields such as those from the War of 1812, pioneer settlements and shipwrecks. More than 80 per cent of Ontario's archaeological sites are Indigenous in origin and some sites are more than 10,000 years old. Archaeological artifacts like fragments of pottery and stone, arrowheads and pipes tell us a great deal about the lives of the people who left them behind.

All of Ontario's culture agencies support cultural vitality in communities through programs for all ages: the Ontario Trillium Foundation invests in community-based initiatives to enrich people's lives through arts, culture and heritage; the Ontario Heritage Trust identifies, protects, renews and promotes Ontario's heritage in all its forms — cultural and natural, tangible and intangible; and the Ontario Arts Council supports and nourishes professional artists and arts organizations in communities throughout the province. Its programs also focus on under-served or under-represented communities, including Northern, Indigenous and Francophone communities, youth, artists who are Deaf, artists with disabilities, and arts professionals of colour.[25]

Uncle Tom's Cabin Historic Site.
Photo provided by the Ontario Heritage Trust.

This goal complements the work of our agencies by focusing on public libraries, First Nation public libraries and heritage organizations, which the ministry funds directly. It aims to build the capacity of all not-for-profit arts and culture organizations and to continue supporting the volunteers who dedicate their time to sustaining culture.

Our 265 public libraries and 45 First Nation public libraries serve over 99 per cent of Ontario's population. They are supported by the Southern Ontario Library Service and Ontario Library Service - North, which provide coordination, training and program delivery. In addition to making printed and digital resources available, public libraries have become essential spaces for access to cultural experiences, technology and community life. Libraries offer important services like education opportunities, employment and small business support, newcomer programs and access to government information.

Community museums, historical societies, historic sites, archives and other heritage organizations conserve and promote our cultural heritage through their collections, interpretive displays and diverse programming. They act as research centres and community spaces for public education, dialogue and knowledge-sharing. Ontario has museums devoted to science and technology, television, planes, trains, fashion, textiles, shoes, canoes, dance, theatre, sports and more.

This goal also recognizes that sharing and celebrating our diverse cultures enrich our lives, build cross-cultural understanding, and encourage us to take pride in where we live and what we have accomplished together. An example on a grand scale is the arts and culture festival that accompanied the 2015 Pan Am and Parapan Am Games. Over 38 days, more than 1.4 million residents and visitors participated in arts and culture events, including music, theatre, dance, visual arts and fashion.

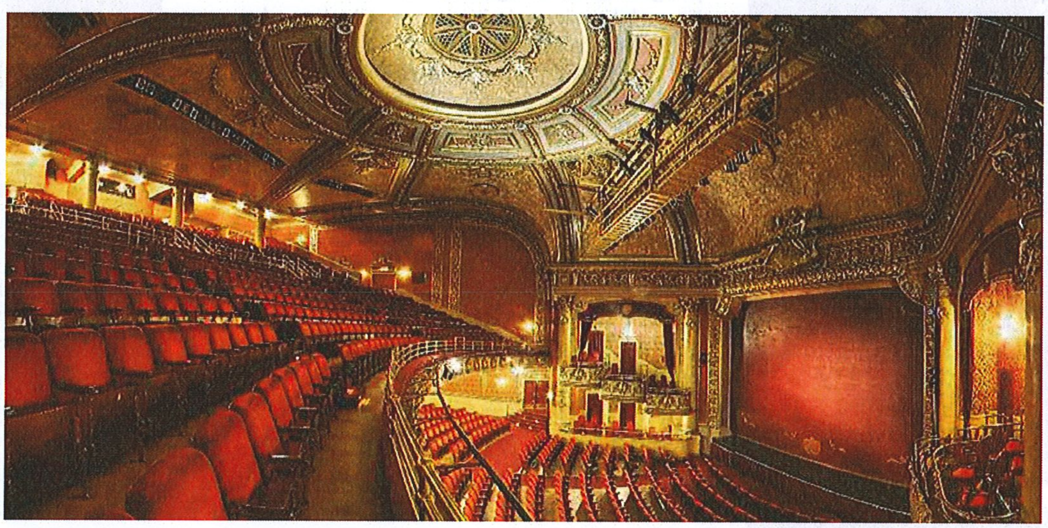
Ontario's culture and tourism attractions like the Art Gallery of Ontario, Huronia Historical Parks and Fort William Historical Park work with Indigenous partners to deliver compelling programming for residents and visitors. They help increase our understanding of Indigenous histories and cultures and celebrate the vitality of Indigenous artistic expressions, including modern Indigenous music and visual arts. Both Indigenous and non-Indigenous participants in our engagement process called for more opportunities to learn about and appreciate Indigenous cultures.

This goal builds on the work of our agencies and attractions and many other partners and organizations. Its strategies aim to strengthen community-based culture organizations, conserve and promote Ontario's diverse cultural heritage, and connect people and communities through sharing and celebrating our diverse heritage and cultures.

Strategy 1

Help build strong community-based culture organizations

- Work with government partners and culture stakeholders to maximize the use of public libraries, museums, galleries and other culture facilities as community hubs and explore opportunities to integrate arts and culture activities and spaces into schools and other community facilities.
- Review and update provincial funding programs for public libraries to build the capacity of libraries serving rural and remote communities, improve digital services and support leadership and innovation.
- Work with First Nation public libraries to better understand their unique needs and identify opportunities for responding through improved supports.
- Review and update provincial funding programs for community museums and heritage organizations to build capacity, strengthen leadership and support more diverse organizations.
- Collaborate on the continued implementation of the Ontario Volunteer Action Plan[26] and promote the Partnership Grant Program,[27] which helps build the capacity of the not-for-profit sector, including arts and culture organizations.



Elgin Theatre. Photo by Peter Lusztyk.

Strategy 2

Conserve and promote Ontario's diverse cultural heritage

- Help heritage property owners use clean, low carbon technologies, and enable the province to develop and share expertise on heritage and energy conservation, by leveraging opportunities for energy efficiency improvements through Ontario's Climate Change Action Plan.
- Provide online access to information about Ontario's cultural heritage, including designated heritage properties and provincial heritage properties.
- Develop additional tools to help communities identify and protect their cultural heritage, including guidance on cultural heritage landscapes, cultural planning, and the interests of Indigenous communities in conserving cultural heritage, to support municipalities in implementing the Provincial Policy Statement (2014).[28]
- Work with the Ministry of Government and Consumer Services and heritage organizations to support local archives to promote, preserve and facilitate access to Ontario's diverse documentary memory for current and future generations.
- Work with Indigenous partners, archaeologists, museums and other stakeholders to develop a framework to improve conservation of archaeological artifacts so that current and future generations can learn about and understand our past.
- Review the Standards and Guidelines for Consultant Archaeologists to reflect the evolving practice of archaeology in land use and development contexts, including the engagement of Indigenous communities and the care of artifacts.

Strategy 3

Connect people and communities by sharing and celebrating our diverse heritage and cultures

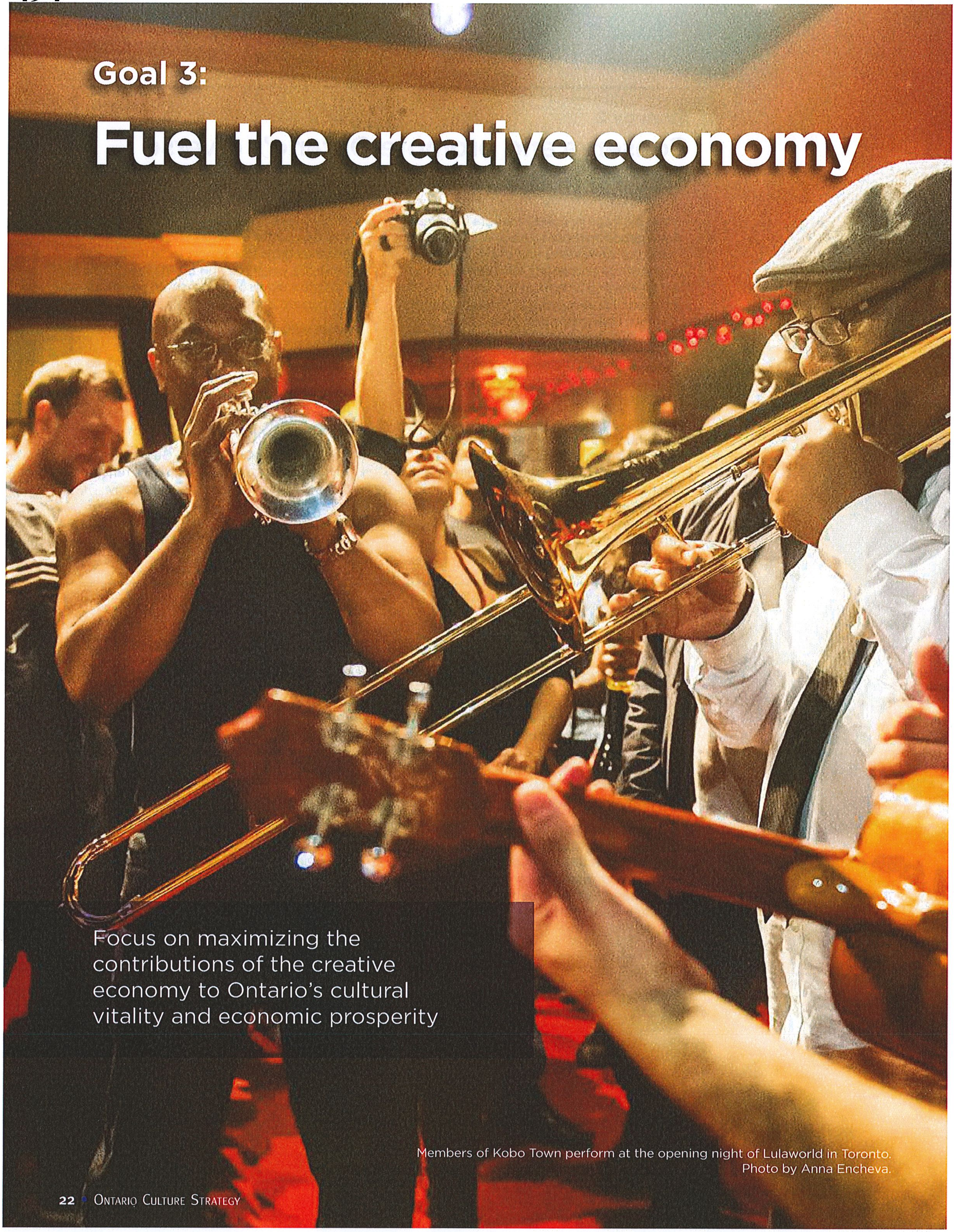
- Bring together culture and tourism agencies and attractions and Indigenous partners to increase public awareness and understanding of Indigenous histories, cultural heritage, knowledge and ongoing contributions to arts and culture in Ontario.
- Collaborate with sport and recreation partners to explore more opportunities to integrate cultural engagement into community recreation and sport, and to encourage cultural celebrations as a part of multi-sport games held in Ontario.
- Celebrate Canada's 150th anniversary with special programming through our culture agencies, all year long, to highlight the important role of arts and culture in the rich history of our province and our country.
- Continue to engage with the Government of Québec to facilitate and foster information exchanges, work collaboratively on common issues and develop joint projects under the Agreement for Cooperation on Culture between the Government of Ontario and the Government of Québec relating to the arts, cultural industries,[29] public libraries and heritage.

Expected results

- There will be more recognition and use of public libraries and other culture facilities as community hubs.
- Ontarians will gain greater understanding of cultural heritage conservation and there will be more tools to assist in conserving Ontario's unique cultural heritage.
- Funding will be targeted to support a greater diversity of organizations and key priorities (e.g., digital services).
- Cultural heritage conservation will be more inclusive of Indigenous communities and perspectives.
- Ontarians will be more aware of Indigenous contributions to arts and culture in the province.

Goal 3:

Fuel the creative economy



Focus on maximizing the contributions of the creative economy to Ontario's cultural vitality and economic prosperity

Members of Kobo Town perform at the opening night of Lulaworld in Toronto.
Photo by Anna Encheva.

All parts of Ontario's culture sector contribute to a strong creative economy: professional artists; the cultural industries (including film and television production, interactive digital media, music recording and performance, and book and magazine publishing); the wider creative industries (like architecture, design, fashion, advertising, broadcasting and industries that support them); and Ontario's cultural institutions, organizations, galleries, science centres, museums, heritage sites, festivals and events.

Companies and workers in the creative economy develop, create, produce, perform and present world-class work and compelling experiences, supply creative services or fill supporting knowledge-based roles. Their economic impact resonates throughout the province in the thriving interactive digital media sector in Southwestern Ontario, the vibrant fashion district in Toronto, the award-winning theatre community in Stratford and the growing film and television production industry in Sudbury.

Some components of the creative sector have a global reach, such as our entrepreneurial Ontario Science Centre and Science North, which have been exporting their creative services and products for more than two decades. To build on our success, we need to remain competitive nationally and grow the economic and cultural impact of our creative sector internationally.

The creative economy is expected to become even more important to Ontario's prosperity as we continue to shift from a manufacturing and resource-based economy to one dependent on knowledge and innovation. Digital content is constantly evolving and introducing new possibilities, such as augmented and virtual reality. Digital technology and distribution are creating new opportunities for our artists and creative-sector entrepreneurs and transforming the traditional cultural industries.

Ontario's postsecondary, training and research institutions, like OCAD University, York University's 3D Film Innovation Consortium, the Canadian Film Centre, and Sheridan College with its Screen Industries Research and Training Centre partnership, lead the way in responding to these changes by incubating cutting-edge technologies and developing exceptional creative talent.

In the knowledge economy, people are Ontario's most important resource. Now and for the future, we need a cultural workforce with the technical skills to address the challenges and maximize the opportunities presented by a global digital economy. Culture workers, whether they are independent artists, entrepreneurs or leaders of arts and culture organizations, also need business skills to succeed in an increasingly competitive arena. Ontario's diversity is our key competitive strength and our cultural workforce must reflect our diversity by actively engaging members of Indigenous, ethno-cultural and Deaf and disability communities, as well as newcomers to Ontario.

Ontario is well positioned for success in this dynamic environment. The Ontario Arts Council provides funding to Ontario's professional artists and arts organizations, supporting their contributions to the cultural vitality and economic prosperity of Ontario. Arts, culture and the creative industries are identified as a priority economic sector in the Growth Plan for Northern Ontario. The Northern Ontario Heritage Fund Corporation[30] provides funding to film and television productions that create jobs and training opportunities for Northern residents.

The Ontario Media Development Corporation (OMDC) provides business development services and funding for growth for our cultural industries and seeks out investment opportunities for the province. It acts as the hub of Ontario's creative economy, brokering international deals at OMDC's International Financing Forum during the Toronto International Film Festival, supporting industry-led initiatives like Interactive Ontario's GameON: Ventures, and Magazines Canada's MagNet Conference, managing the Ontario Music Office and Ontario Film Commission, and celebrating Ontario authors through the annual Trillium Book Award and *Prix littéraire Trillium*. Ontario also offers over $400 million in cultural media tax credits to attract investment and jobs to our province and supports the wider creative industries through its broader economic agenda.

This goal builds on this support and on the work of many other partners and organizations. Its strategies focus on making Ontario a culture leader, at home and internationally, and on strengthening Ontario's culture workforce.

On the set of the Canadian Film Centre's feature film *Molly Maxwell*, from director Sara St. Onge. Photo provided by the Canadian Film Centre.

Strategy 1

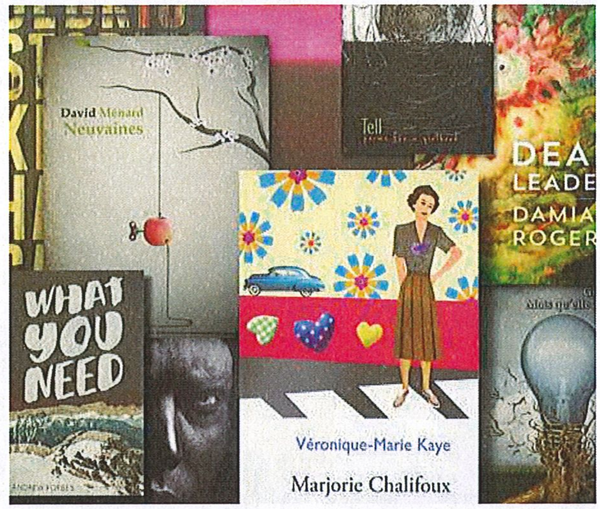
Make Ontario a culture leader at home and internationally

- With the permanent Ontario Music Fund as a foundation, continue to build Ontario as a leading North American centre for music production and performance, as well as spur music tourism by setting a vision and directions to further the development of the Ontario Live Music Strategy.
- Continue to work with Ontario's growing interactive digital media companies to build a globally competitive industry that can innovate and succeed in the next generation of interactive entertainment, including video games, augmented and virtual reality, mobile content and cross-platform storytelling.
- Establish a public/private film and television industry advisory panel to examine priority issues facing the industry and collaborate on strategies to promote the growth, innovation and global expansion of Ontario's film and television sector.
- Help ensure Ontario's competitiveness as a top production jurisdiction by modernizing the suite of tax credits for screen-based productions.
- Seek opportunities to grow the culture sector within the framework of the Business Growth Initiative by working with partner ministries to foster innovation and help scale up companies:
  - Explore the development of entrepreneurship and commercialization programs designed for the arts and cultural industries, including the promotion of partnerships between firms and across sectors to share risk and maximize expertise.
  - Explore the development of risk capital programs, designed with an entertainment focus, that reflect the business models and rapid product development cycles of the arts and cultural industries.
  - Attract investment that increases Ontario's productivity, creativity and global competitiveness in the culture sector.
  - Explore opportunities to strengthen the use of design as a key competitive advantage in the knowledge economy, for example by promoting the application of design in manufacturing and technology.
  - Accelerate the creation and adoption of new disruptive technologies[31] to strengthen the culture sector's role in the knowledge economy.
- Work with the Ministry of Infrastructure and other ministries to inform the development of a long-term infrastructure plan for Ontario to better understand and work toward addressing the needs of the culture sector.
- Collaborate with government partners and the tourism industry to identify opportunities to grow cultural tourism in Ontario, including Francophone tourism and Indigenous-led tourism, and offer authentic and compelling visitor experiences.
- Continue to engage with the federal government to help ensure the health of Ontario's broadcasting and production industries.

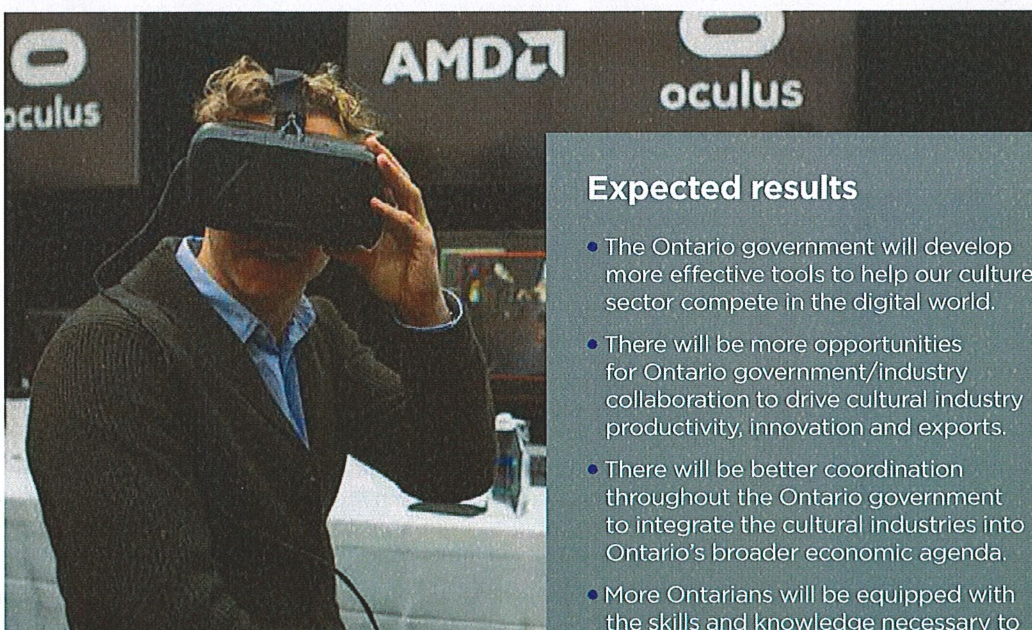
Strategy 2

Strengthen Ontario's culture workforce

- Develop a better understanding of the impact of the digital transformation on culture and as a first step work with partners to organize a digital culture symposium to bring together stakeholders from all culture sectors to share experiences and expertise, build capacity to address digital challenges and take advantage of new opportunities.
- Increase awareness and uptake of the Canada-Ontario Job Grant[32] among employers in the culture sector to assist them in developing their workforces through employer-led digital skills and other training.
- Help ensure that Ontario's culture workforce is positioned to succeed in the knowledge economy by creating opportunities to enhance technical and business skills training and foster learning opportunities for arts and culture sector students and workers, for example through experiential learning, including internships and mentorships, and other forms of professional and skills development.
- Explore ways for provincial and federal immigration programs to contribute to the growth and success of Ontario's culture sector and eliminate barriers to the successful integration of cultural workers.
- Engage federal, provincial and territorial culture partners on strategies to improve the socioeconomic status of artists and to improve support for culture-related infrastructure.



Selection of books shortlisted for the 2016 Trillium Book Award/*Prix littéraire Trillium*. Photo by Andy Schoenhofer and Rebecca Langstaff.



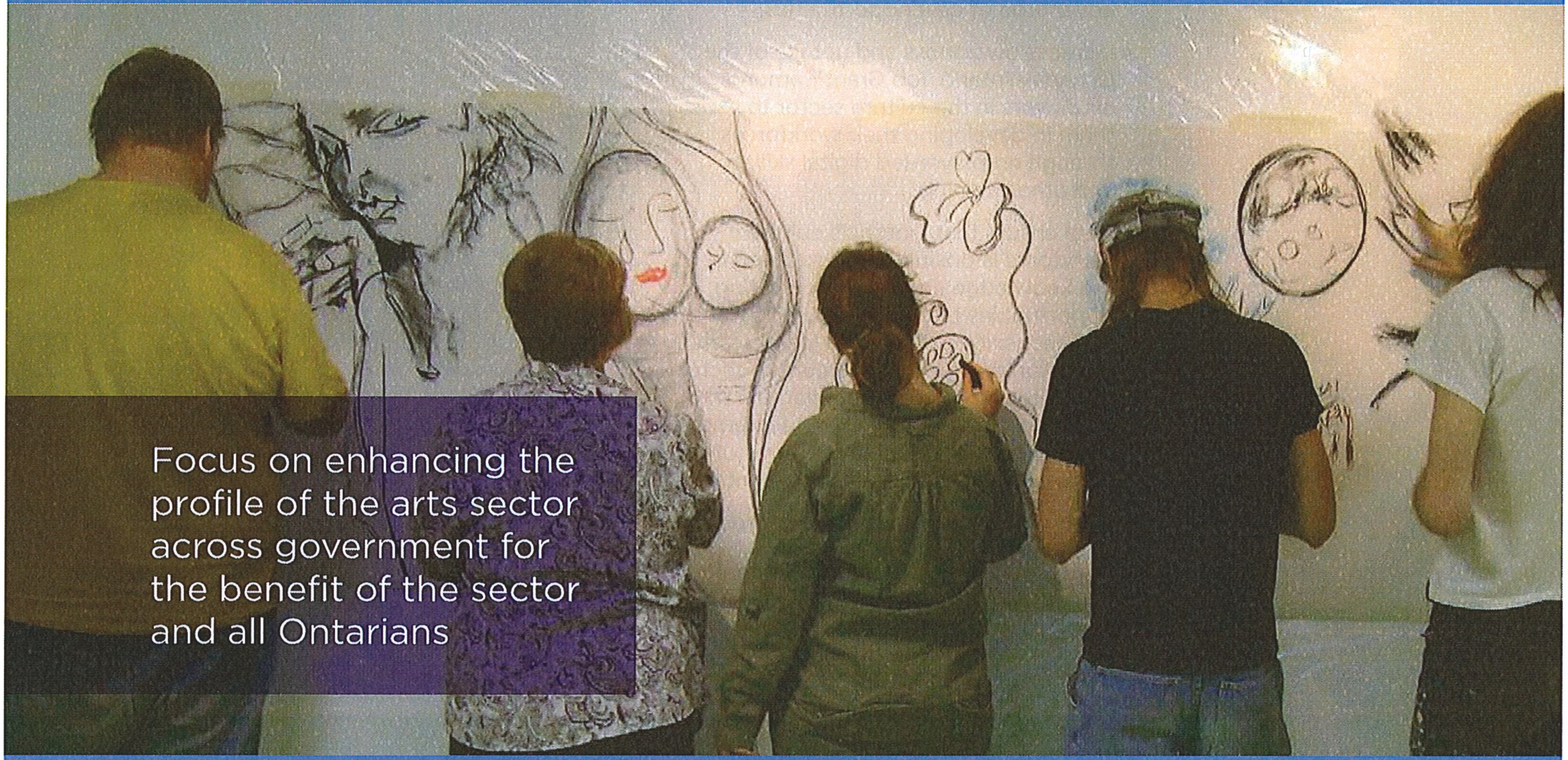
Virtual reality headset.
Photo provided by the Canadian Film Centre.

Expected results

- The Ontario government will develop more effective tools to help our culture sector compete in the digital world.
- There will be more opportunities for Ontario government/industry collaboration to drive cultural industry productivity, innovation and exports.
- There will be better coordination throughout the Ontario government to integrate the cultural industries into Ontario's broader economic agenda.
- More Ontarians will be equipped with the skills and knowledge necessary to contribute to the creative economy.

Goal 4:

Promote the value of the arts throughout government



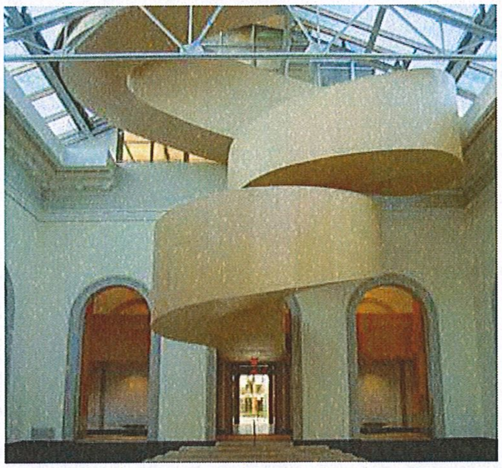
Focus on enhancing the profile of the arts sector across government for the benefit of the sector and all Ontarians

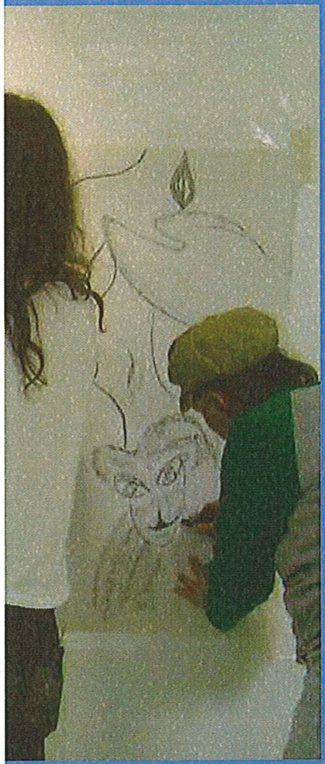
A Fuzion drawing workshop at Creative Works Studio, an Inner City Health Program of St. Michael's Hospital. Photo by Marlena Zuber.

Jurisdictions around the world have recognized that, in addition to their important intrinsic value, the arts contribute to our lives and our communities in many other ways. Ontario has more than 58,000 professional artists working in over 200 communities across the province. We will promote the contributions of artists and the broader arts sector throughout the Ontario government with an Arts Policy Framework. The Framework will build on the Status of Ontario's Artists Act, which recognizes artists' invaluable contributions to Ontario's economy, quality of life and sense of identity.

Ontario's diverse arts sector comprises:

- Professional and amateur artists, including Indigenous and Francophone artists, artists who are Deaf and artists with disabilities
- Both not-for-profit and commercial arts organizations, including facilities such as theatres, galleries and studios
- Community arts councils and service and trade associations
- Disciplines such as dance, literary arts, music, theatre, visual arts, media arts, multidisciplinary arts, and new art forms and practices often inspired by digital possibilities
- A large supporting workforce, including technicians, administrators, fundraisers, marketers and many others
- Thousands of volunteers who assist arts organizations and provide leadership as board members
- Arts educators and educational institutions and organizations





Frank Gehry's sculptural staircase at the AGO. Photo by the Art Gallery of Ontario.

The Arts Policy Framework will help increase awareness within government of the size, scope and diversity of Ontario's arts sector and of the many opportunities available to integrate the arts into a range of policy and program areas. In turn, this will create new opportunities for artists and arts organizations to engage with other sectors. The Framework will also encourage and support government ministries and agencies to consider the needs and potential contributions of artists and arts organizations when they develop or review policies and programs.

The Framework will provide a toolkit to all Ontario ministries and agencies that will include facts about Ontario's arts sector, links to key sector organizations and associations, best practices and case studies, information on monitoring and measuring outcomes and links to additional resources.

One example of integrating the arts with other sectors is the Creative Engagement Fund to Stop Sexual Violence and Harassment in Ontario.[33] The Ontario Women's Directorate has partnered with the Ontario Arts Council to deliver the $2.25 million fund. Professional artists, not-for-profit community organizations and sexual violence experts are collaborating to address the issues at the heart of sexual violence and harassment. By stimulating discussion, transforming perspectives, and offering new tools to name and take action on sexual violence and harassment, the fund's artistic projects will help us imagine a better and healthier future. These are three of the 11 successful applicants to date, announced in May 2016:

- FESFO (*Fédération de la jeunesse franco-ontarienne*) is leading a project called "It's Never Okay for Franco-Ontarian Youth," a multidisciplinary arts program to engage Franco-Ontarian youth in dialogue and action on sexual violence and harassment.
- LAMPHEAD is delivering a youth-led video animation project called "Get Consent" to explore the issue of consent and offer youth in downtown Toronto practical skills to make sure they have positive, healthy relationships.
- The Institute for Research and Development on Inclusion and Society's "Witness" project is exploring, through dance, video and theatre performances, the stories of refugee women who have experienced sexual violence.

Strategy

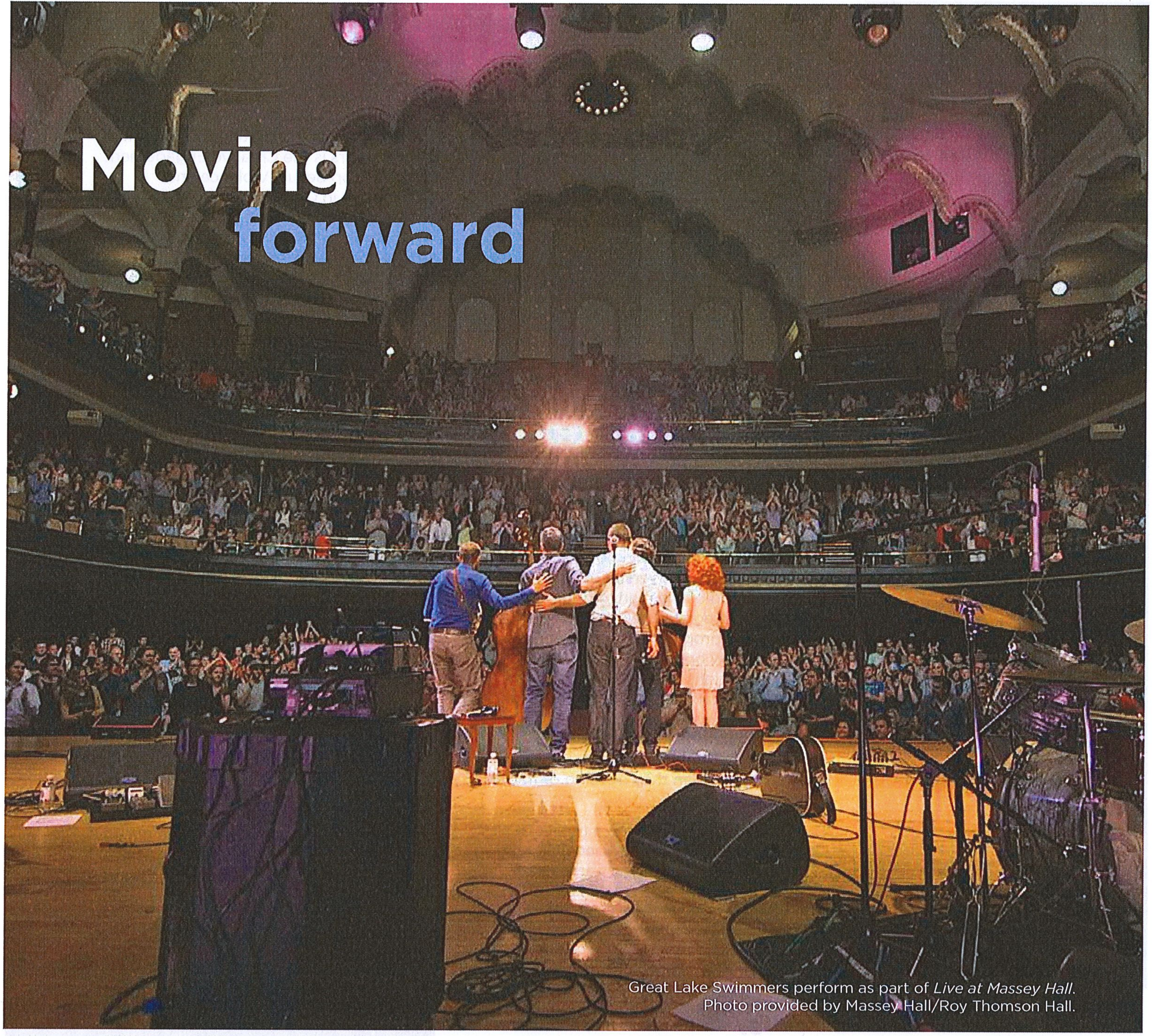
Inspire greater integration of the arts into public policy and programs

- Develop an Arts Policy Framework in collaboration with Ontario's culture agencies, actively promote the Framework to government ministries and agencies and monitor how well it is working.

Expected results

- The Arts Policy Framework will be a catalyst for creative and innovative integration of the arts to advance Ontario's social and economic objectives.
- Awareness of Ontario's diverse arts community will be increased within the Ontario government and its agencies.
- Ontario government ministries and agencies will have more tools to consider the needs and contributions of artists and arts organizations in their policies and programs.
- Artists and arts organizations will have new opportunities to engage with other sectors in government.

Moving forward



Great Lake Swimmers perform as part of *Live at Massey Hall*.
Photo provided by Massey Hall/Roy Thomson Hall.

Implementing the Culture Strategy

The Culture Strategy contains actions to guide the government's support for culture over the next five years. We can implement some actions in the short term, within the next one to two years. Two examples are bringing together government granting partners to share best practices and increase access and inclusion (Goal 1) and working with First Nation public libraries to better understand their unique needs (Goal 2).

Others actions will take longer because they require more input from partner ministries, agencies and stakeholders, engagement with Indigenous partners and communities and other levels of government, or policy and program development. Examples include developing a framework to improve conservation of archaeological artifacts (Goal 2) and seeking opportunities to grow the culture sector within the framework of the Business Growth Initiative (Goal 3).

In the next phase of this initiative, we will develop a plan to guide the implementation of the Culture Strategy and track our progress in meeting its commitments.

Measuring and reporting on progress

The expected results for each goal in the Culture Strategy provide a broad idea of what we want to achieve. As we implement the Strategy, we will develop objectives that are more specific, along with performance measures for individual actions. In five years, we will publish a special progress report on the implementation of the Culture Strategy. This will allow us to take stock of what we have accomplished and what we still need to achieve.

Our agencies undertake their own planning processes to respond to changes and emerging needs and set their courses for the future. The Ontario Arts Council's "Vital Arts and Public Value: A Blueprint for 2014-2020" and the Ontario Trillium Foundation's new investment strategy, mentioned earlier, are two examples. All provincial agencies report on their activities through business plans, financial reports and annual reports. In addition, all agencies' mandates undergo review at least every seven years to ensure that they are consistent with government priorities and policy objectives.

Continuing the dialogue

The Culture Strategy public engagement process began a conversation about the future of arts and culture in Ontario. Implementation of the Strategy will establish new channels of communication to continue the dialogue.

We will seek input from stakeholders and Indigenous partners about proposed changes at key implementation points, such as when we review funding programs and when we develop a framework to improve conservation of archaeological artifacts.

New avenues for in-depth discussion introduced in the Strategy include the public/private advisory panel to examine priority issues facing the film and television industry and an ongoing dialogue with Indigenous communities to address culture priorities.

Opportunities to collaborate, learn, exchange ideas and share expertise are other important ways for us to continue the dialogue and stimulate action. Culture and tourism agencies and attractions and Indigenous partners will explore ways to raise public awareness about Indigenous histories and contributions to arts and culture and the digital symposium for the culture sector will focus on sharing knowledge and strategies.

We learned a great deal through Culture Talks. As we implement Ontario's Culture Strategy, continuing the dialogue will assist us in achieving the goals Ontarians helped us set. We will engage a great many individuals, partners, organizations and communities in that dialogue. By encouraging and facilitating broader collaboration and partnerships, the Culture Strategy will be a catalyst for renewed creative and economic energy in the culture sector and in communities across Ontario.

Children learning about the Jewish holiday, Purim. Photo provided by Bonnechere Union Public Library.

Endnotes

1 The Canadian Hearing Society's definition of "Culturally Deaf" refers to "individuals who identify with and participate in the language, culture and community of Deaf people, based on a sign language." Canadian Hearing Society. Glossary of Terms.

2 Ministry of Tourism, Culture and Sport. "Culture Talks: A Summary of What We Heard from Ontarians." April 27, 2016.

3 In this document, we use "culture" or "arts and culture" to underscore that we are talking about culture in its broadest sense, including but not exclusively meaning creative expressions related to cultural identity. The arts include craft, dance, literary arts, media arts, music, opera, theatre, visual arts and many creative combinations of these disciplines.

4 Jon Hawkes. "The Fourth Pillar of Sustainability: Culture's essential role in public planning." Cultural Development Network (Vic). 2001. See also Sustainable Kingston. "Four Pillars of Sustainability." Sustainable Kingston.

5 Canadian Index of Wellbeing. "How are Ontarians Really Doing? A Provincial Report on Ontario Wellbeing." April 2014.

6 Cultural heritage includes built heritage, cultural heritage landscapes, archaeology, museums and heritage organizations.

7 Preservation Green Lab. "The Greenest Building: Quantifying the Environmental Value of Building Reuse." National Trust for Historical Preservation. 2011.

8 Carl Elefante. "The Greenest Building Is...One That Is Already Built." Forum Journal: The Journal of the National Trust for Historic Preservation 21, no. 4 (Summer 2007).

9 Generated by the Ministry of Tourism, Culture and Sport from: Statistics Canada. Travel Survey of Residents of Canada, Summary Tables, 2012 and International Travel Survey, Summary Tables, 2012.

10 Statistics Canada. Provincial and Territorial Culture Indicators, 2010 - 2014.

11 Communications MDR. "Environmental Scan of the Culture Sector: Ontario Culture Strategy Background Document." Ministry of Tourism, Culture and Sport. 2016.

12 Truth and Reconciliation Commission of Canada. "Honouring the Truth, Reconciling for the Future: Summary of the Final Report of the Truth and Reconciliation Commission of Canada." 2015.

13 Ontario. "The Journey Together: Ontario's Commitment to Reconciliation with Indigenous Peoples."

14 Ipperwash Inquiry. Report of the Ipperwash Inquiry. 2007.

15 Ontario. "First Nations, Ontario Sign Political Accord." August 24, 2015.

16 Ontario. "Ontario and Métis Nation Renew Framework Agreement." April 17, 2014.

17 Ontario Arts Council. "Vital Arts and Public Value: A Blueprint for 2014-2020." 2014.

18 Ontario Trillium Foundation. "What We Fund: Our Investment Strategy."

19 Ahlan Canada.

20 Ministry of Education. "How Does Learning Happen? Ontario's Pedagogy for the Early Years." 2014. The document endorses the value of the arts in supporting expression, identifying the arts as one of the four foundational conditions necessary for children to grow and flourish.

21 Ministry of Education. "Politique d'aménagement linguistique de l'Ontario pour l'éducation en langue française." 2004. This document is the Ministry of Education's distinct educational policy for Ontario's French-language schools.

22 Ministry of Education. "Specialist High Skills Major Policy and Implementation Guide." 2014. In 2016-17, the Specialist High Skills Major program is being expanded to train students in skills identified as valuable in today's economy, including innovative thinking, problem solving, creativity and entrepreneurship.

23 Ontario. "Ontario Implementing New Indigenous Training and Education Requirements." February 17, 2016.

24 Ontario. Seniors.

25 The Ontario Arts Council's definition of "arts professionals of colour" is based on the Government of Canada's definition of "visible minorities," which is "persons, other than Aboriginal peoples, who are non-Caucasian in race or non-white in colour."

26 Ontario. "Ontario's Volunteer Action Plan."

27 Grants Ontario.

28 Ministry of Municipal Affairs. "Land Use Planning: Provincial Policy Statement." 2014.

29 Cultural industries include film and television production, interactive digital media (e.g., video games, apps), the music industry and book and magazine publishing.

30 Ontario. Northern Ontario Heritage Fund Corporation.

31 A "disruptive technology" is an innovative product or process that displaces established technology and may challenge existing firms or create a completely new industry.

32 Ministry of Advanced Education and Skills Development. "Canada-Ontario Job Grant."

33 Ontario Arts Council. Creative Engagement Fund.

Culture is passing on deep and rich cultural traditions, including folk culture practices and arts. It is teachings and customs. It is human and natural history. It is a healing component of life. It is processing the past and creating a new better future by admitting what is difficult from the past and moving toward healing. Culture is what differentiates somewhere from anywhere. It contributes to sense of place and state of mind. It makes places vibrant and unique. It is the cultural heritage of the community over time. It is key to city building and transformation. It is the strong ties that bind physical place to human experience and vice versa. Culture determines the success and greatness of societies. It is gathering and celebrating together as a community. Culture is the heart of a community. It is about family and friends. It is being able to participate freely, safely and joyously in family traditions. It is being able to participate freely in political discourse. It is a shared experience. It is a joyful community. Culture is our relationship with the environment. It is connection to the land, water, medicine, fish, food and everything we do. It is awareness of the natural environment. For Northern Indigenous communities, cultural heritage broadly reflects language, economy, spirituality and deeply personal relationships with landscapes. It is the core of contemporary communities who are struggling to survive in a rapidly changing world. Culture is inclusion. It is enriched by diversity. It is personal culture and heritage. It is ethnicity. It is multiculturalism. It is how we connect with and learn about one another. Culture is the telling of our stories, and the listening to others' stories and finding points of intersection, commonalities and the universalities of the human spirit and the human endeavour. Culture should not be understood as the stories we tell, but the relationships we have. Culture means something different to every Ontarian. The way that each and every Ontarian lives their day-to-day life defines part of our culture. Culture presents a vision of human experience. It provides hope and a sense of belonging. It allows us to dream of the future.

Cover art • *Nightless Night* by Lora Northway

Thunder Bay artist Lora Northway working on her mixed media painting *Nightless Night*, 2014 © copyright. Photo by Dee Laroque.

Lora Northway is an exhibiting artist, arts educator and curator in Thunder Bay, Ontario. She received her Honours Bachelor of Fine Arts from Lakehead University and a Certificate in Arts Education from York University. Inspired by her family's immigration to Canada in 1901, her stylistic references include Finnish textiles, pattern and myth, with a local and contemporary vernacular.

Alongside her studio practice, she is a co-coordinator for Definitely Superior Artist-Run Centre (Premier's Award for Excellence in the Arts winner), founder of the Die Active Art Collective, Neechee Studio Indigenous Youth Collective, and co-founder of inVISIBLEink LGBTQ youth collective. She has received numerous awards and grants, including the Ontario Arts Council Emerging Artist and Northern Arts grants. She also developed and delivered a conference on "Youth Arts Engagement in the North" for 25 Indigenous youth leaders from Northern communities.

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Disponible en français.
Available in alternative formats.

ISBN 978-1-4606-8228-9 (Print)
ISBN 978-1-4606-8229-6 (HTML)
ISBN 978-1-4606-8230-2 (PDF)

Ontario

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Building with wood

Information and resources for your mass timber, tall wood or wood bridge construction project.

On this page

Overview

Mass timber are large engineered wood products that include wood panels, beams and columns used for constructing floors, walls and roofs in larger buildings.

Pre-fabricated paneling systems that make a wider range of wood buildings possible include:

- cross laminated timber (CLT)
- parallel strand lumber (PSL)
- laminated veneer lumber (LVL)
- laminated strand lumber (LSL)
- glued laminated timber (glulam)

Building with these wood systems is efficient and results in high-quality construction.

There are multiple wood construction programs and resources to help you with your wood construction project. This includes funding for eligible projects and program guides to support compliance, innovation and industry best practices.

Benefits of building with wood

The benefits of building with wood include:

- being proven fire safe for builders, occupants, and fire service officials
- being structurally comparable to concrete and steel buildings in strength
- storing carbon to less the impact of climate change
- lower greenhouse gas emissions from construction by not using energy-intensive materials
- lower buildings costs with cheaper materials and quicker construction time
- providing safe and reliable flexibility under seismic loading (earthquake impacts)
- efficient and effective solution for our increasing housing needs.
- supporting our sustainable forest management policies

Mass Timber Program

The Mass Timber Program is for developers, builders, researchers, educators, trades people, fire safety officials, and municipal building officials. The program is encouraging mass timber construction as part of our Five-Year Climate Change Action Plan to decrease greenhouse gas emissions in building construction.

The Mass Timber Program's goal is to encourage expertise that will help build mass timber buildings and promote the use of wood in buildings by:

- demonstrating the use of mass timber in place of steel and concrete in design, construction, and fire safety
- funding post-secondary education institutions to teach technical training, and create tools for professional and trades with using wood in construction
- partnering with researchers, universities, and colleges to establish a tall wood research institute in Ontario that will train design professionals, engineers, contractors, and wood product manufacturers

You can receive funding from the Mass Timber Program for your project if it:

- is a mass timber (tall wood) building demonstration project that has incremental costs (like engineering or construction) related to seeking alternative solutions approval because it is making use of structural wood in place of steel and concrete in design and construction
- provides a training program to support sector-wide skills and expertise with mass timber products

- provides a research partnership between post-secondary institutions to develop a centre for mass timber innovation that will undertake research and product development

Eligibility

Not-for-profit organizations and organizations incorporated or registered in Canada are eligible.

How to apply

Any project in Ontario that meet the criteria above are eligible for funding. **To get more information, to send a proposal, or to check the status of a submitted proposal, please email masstimber@ontario.ca**

Tall wood demonstration projects

We are providing funding to help with the costs of constructing mass timber buildings. Our program is providing funding for the development of tall wood buildings in Ontario that are 7 storeys and above. Eligible costs include those related to additional design, approval and construction activities.

Demonstration projects show the use of innovative wood building solutions in high-rise construction and other potential large wood frame buildings. They also show the ability of mass timber buildings to maintain Ontario's high fire safety standards for both the public and fire service personnel.

Natural Resources Canada created the Green Construction through wood (GCWood) Program to encourage greater use of wood in construction projects in Canada. The GCWood program will provide funding for tall wood building demonstration projects while helping grow a greater awareness of, and domestic capacity for, innovative tall wood buildings. Visit Natural Resources Canada for more information.

If your demonstration project is located in Ontario, in addition to federal funding, the project may be eligible for provincial funding under the Ontario Mass Timber Program.

Eligibility

Not-for-profit organizations and organizations incorporated or registered in Canada are eligible.

How to apply

We appreciate your interest in our program. The call for an Expression of Interest for tall wood building demonstration projects for 2017 is now closed. To get more information or to check on the status of an existing application please email masstimber@ontario.ca.

Ontario's Tall Wood Building Reference

Working with our partners, we've created a resource providing background and references to assist applicants, reviewers and designers as they consider using wood in buildings. The document is the first of its kind and provides guidance for meeting requirements under Alternative Solutions of the Ontario Building Code for developing wood buildings above six storeys.

The Tall Wood Building Reference aligns with our two primary objectives related to the Ontario Building Code:

- help increase opportunities for designers and builders to create innovative, flexible and affordable new buildings
- maintain our high fire safety standards for both the public and fire service personnel

Ontario's Tall Wood Building Reference (PDF)

Accessibility

We are committed to providing accessible customer service. If you need accessible formats or communications supports, please contact us at MNRF.Feedback@ontario.ca.

Updated: June 28, 2018
Published: November 1, 2017

Rate

in the resource sector and supporting outdoor recreation opportunities.

FR

Handling excess soil

Learn how to sustainably manage and reuse excess soil in Ontario.

On this page

About excess soil

Excess soil is soil that has been dug up, typically during construction activities. It must be moved off site because it can't or won't be reused at the development site.

Managing excess soil is a significant concern in urban centres and surrounding communities (including suburban municipalities, rural areas, and Indigenous communities) because of:

- limited reuse opportunities
- illegal dumping
- potential impacts of soil contamination on human health and the environment

Resources for dealing with excess soil

Management of Excess Soil – A Guide for Best Management Practices

Our excess soil best management practices guide explains how to manage excess soil once dug up, during the transportation of the soil, and at the site where the soil can be reused.

Canadian Urban Institute municipal by-law language tool

The Canadian Urban Institute's site alteration by-law language tool provides flexibility for local decision making and site-specific considerations when incorporating best management practices. It provides examples of language and guidance for Ontario municipalities to consider when creating or updating by-laws.

Fact sheet for importing soil onto agricultural land

The Importation of Soil onto Agricultural Land fact sheet provides a brief overview of regulatory requirements, best management practices and guidance to help farmers limit impacts to farmland.

Co-ordinated Land Use Planning Review

The Growth Plan for the Greater Golden Horseshoe, the Greenbelt Plan, the Oak Ridges Moraine Conservation Plan and the Niagara Escarpment Plan all contain new excess soil policies developed in 2017 as a result of the Co-ordinated Land Use Planning Review.

Importance of excess soil management

Managing excess soil is a growing concern in the Greater Toronto Area (GTA) and surrounding rural municipalities. As urban areas intensify, opportunities to reuse soil at a development site become limited, which results in excess soils needing to be moved elsewhere.

While most excess soil can be reused safely, some excess soil may have limited levels of contaminants and care must be taken when determining where it may be reused.

Improper management of excess soil can negatively affect ground or surface water quality and/or quantity in natural areas such as agricultural lands. It is also associated with local issues like noise, dust, truck traffic, road damage, erosion, drainage and other social, economic, health and environmental concerns.

Local reuse and proper management and tracking of excess soil can significantly reduce greenhouse gas emissions, illegal dumping, inappropriate relocation, road damage and costs associated with transportation and landfilling.

Policy framework to manage excess soil

We released the Excess Soil Management Policy Framework in 2016 to:

- protect human health and the environment from inappropriate relocation of excess soil
- provide more opportunities for reuse

- reduce greenhouse gas emissions associated with transporting excess soil

The framework is guided by key goals and principles, and includes 21 regulatory and non-regulatory actions, delivered in partnership with other ministries and interested parties.

Since we released the framework, several actions have been completed that include:

- establishing an Excess soil Engagement Group and three Sub Working Groups
- releasing a fact sheet on excess soil for agricultural properties
- creating a municipal bylaw language tool
- developing excess soil policies in the Growth Plan for the Greater Golden Horseshoe, Greenbelt Plan, and Oak Ridges Moraine Conservation Plan

We also support innovation through pilot projects and case studies identifying opportunities for reuse and supporting sustainable management of excess soil. Some projects underway relate to storm water pond reuse and electronic soil transport tracking system. Feedback on these pilots will help to inform changes to guidance, templates and the online registry before the regulation comes into effect.

New proposed regulation

We're proposing new regulatory rules to improve the way excess soil is managed in communities. Let us know your thoughts on the proposal.

The proposed regulation would also:

- clarify how excess soil can be reused
- clarify the responsibility of the owner of the excess soil source site in different circumstances
- include new direction to ensure excess soil is properly assessed for potential contaminants and relocated to appropriate receiving sites

Changes are also being made to remove regulatory barriers to facilitate brownfield redevelopment.

This proposal has been developed following significant engagement with stakeholders from across sectors including:

- industry
- municipalities
- municipal agencies

- conservation authorities
- consultants
- environmental non-government organizations (ENGOs)
- members of the public

The proposal is the next step in the process that includes:

- draft regulation
- new standards and sampling direction
- changes to suport brownfields redevelopment (*Ontario Regulation 153/04 Record of Site Condition*) and *enhance clarity to Regulation 347 General Waste*

The new regulation would be phased in over three years. This would allow for the necessary guidance, education, outreach and training and to integrate the requirements into new contracts.

Following the comment period and review of comments, we anticipate working with groups to finalize the regulation.

Updated: April 25, 2018
Published: April 16, 2018

Related

Excess Soil Management Policy Framework

Excess Soil Best Management Practices Guide

Excess Soil Management Regulatory Proposal

Rate

Conservation and Parks

The Ministry of the Environment, Conservation and Parks works to protect and sustain the quality of Ontario's air, land, and water. We also coordinate Ontario's actions on climate change in the name of healthier communities, ecological protection and economic prosperity.

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Law and safety
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Travel and recreation

FR

Afforestation

This indicator estimates the area of afforestation in Ontario.

On this page

Indicator importance

Forests sequester (take up and store) significant amounts of carbon from the atmosphere. When land is converted to forest, growing trees increase the carbon intake capacity of that land and the carbon stored in forest plants and soils.

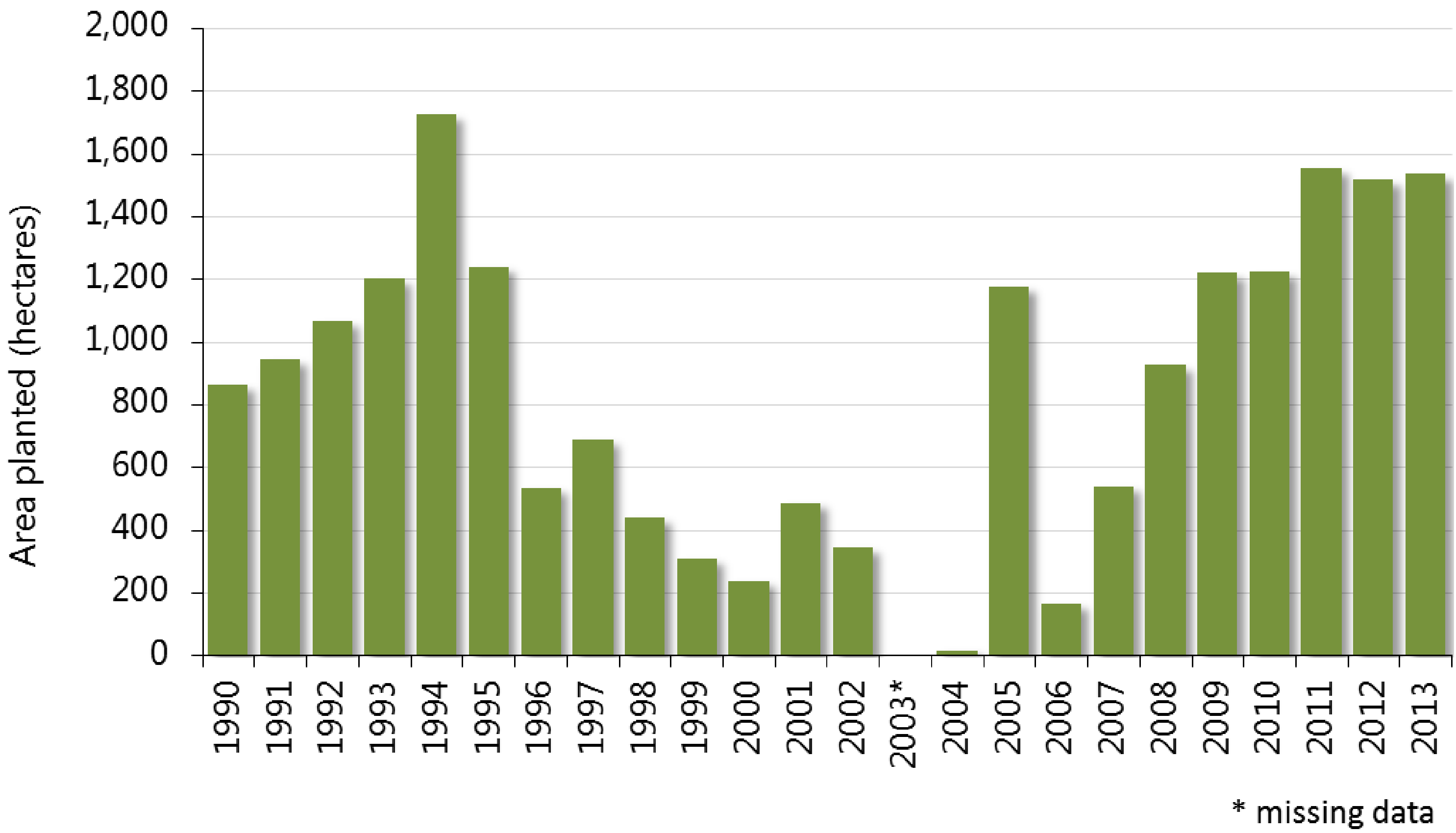
Therefore, afforestation can be a cost-effective greenhouse gas mitigation option. Afforestation efforts offset, to some degree, forest loss due to development and are often associated with the conversion of old fields back to forest, particularly in southern Ontario.

Status of the indicator

Status:	Trend:	Data:	Extent:
Mixed/Fair	Improving	Partial	Provincial

Indicator trends

Area of afforestation



What's monitored

In the Kyoto Protocol, afforestation is defined as the "direct human-induced conversion of land that has not been forested for a period of at least 50 years to forest land" (UNFCCC 2001). Canada uses the definition of 1 hectare minimum area and 25% canopy cover of trees that have the potential to reach 5 metres height at maturity.

Using this definition, we estimated afforestation from records of tree planting on previously non-forested lands. Data quality has improved significantly with the introduction of Ontario's 50 Million Tree Program, which maintains detailed records for planting efforts on private lands.

A longer term estimate of afforestation is available for private lands, mainly in southern Ontario. Afforestation data for public lands in Ontario is not available. Therefore, data are rated as partially adequate.

Understanding the trend

A total of 9,910 hectares was afforested in 2004-2013. Annual rates of afforestation increased in the early 1990s, declined sharply to a low of 21 hectares in 2004 and since then have increased to just over 1,500 hectares in 2013 (see chart above), largely as a result of government afforestation initiatives.

During 2009-2013, afforestation remained high at 1,200-1,500 hectares annually. This coincides with the introduction of Ontario's 50 Million Tree Program.

This program, funded by the Ministry of Natural Resources and Forestry and administered by Forests Ontario and other partners, provides funding and information for landowners willing to plant trees on their property.

The goal of the program is to plant 50 million trees by 2025. To date, more than 20 million trees have been planted, creating more than 10,500 hectares of new forests across Ontario.

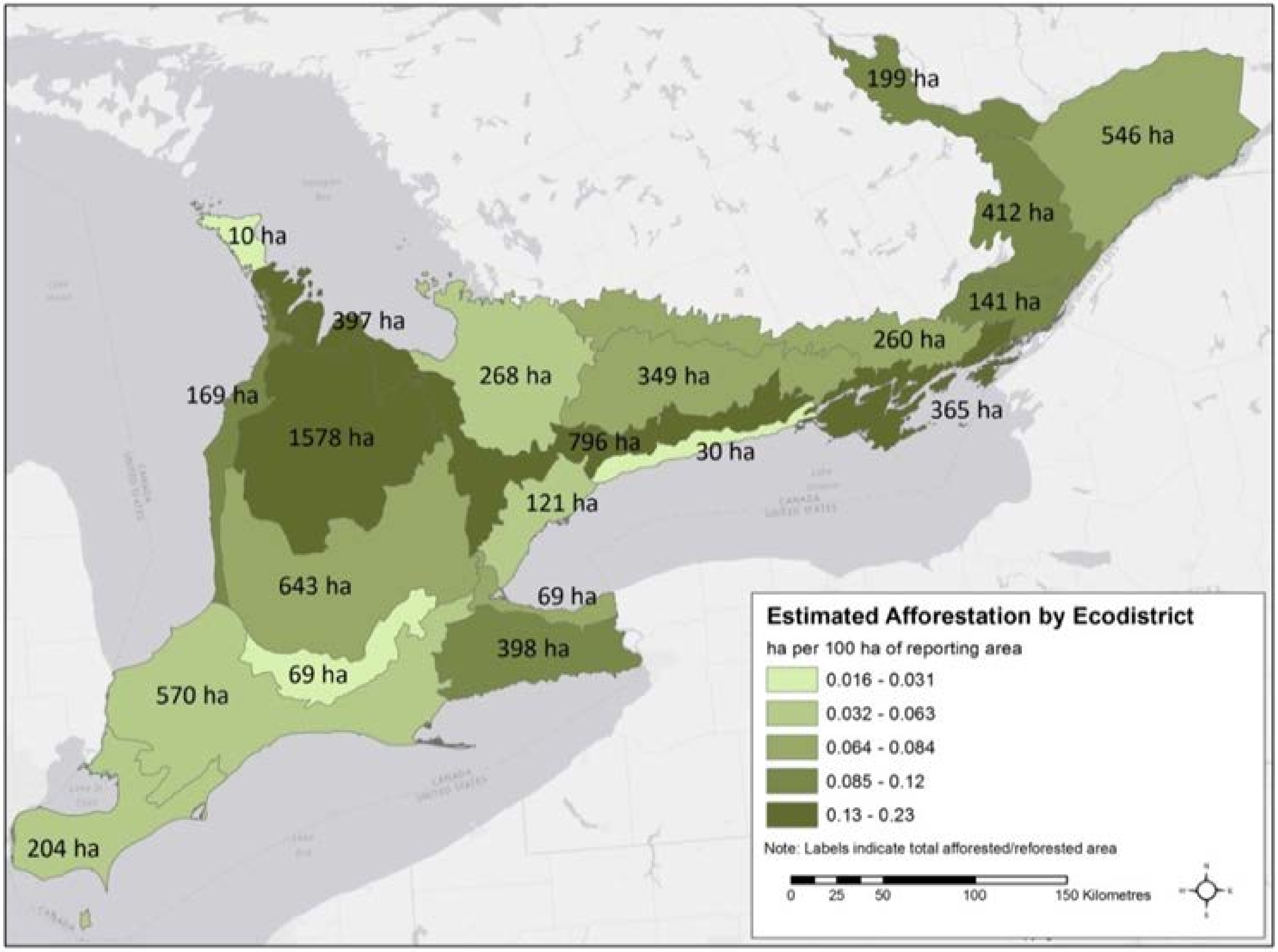
The current rate of afforestation reported here likely underestimates the total area planted, since it only includes planting efforts through the 50 Million Tree Program and other projects of Forests Ontario. Natural old-field conversion to forested land is not included.

Although afforestation declined sharply through the late 1990s and early 2000s, the provincial commitment to afforestation has been well received by landowners, resulting in continued increases in annual planting areas, which is why the trend of this indicator is considered to be improving.

Map

Area of afforestation by ecodistrict in southern Ontario for 2008-2013

520



Metadata

Criterion:

Monitoring forest contributions to global ecological cycles

Element:

Monitoring forest and landscape carbon balance

Indicator:

Afforestation

Indicator last updated:

April 2015

Update frequency:

As available

Data extent:

Provincial - view map

Source:

50 Million Tree Program data

Download data:

Text CSV file for chart A

Updated: June 28, 2018

Published: June 16, 2017

Related

Forest indicators

Forest carbon

Forest regeneration

Private land forestry

Rate

Topics

Forestry

Ministry of Natural Resources and Forestry

The Ministry of Natural Resources and Forestry protects Ontario's biodiversity while promoting economic opportunities in the resource sector and supporting outdoor recreation opportunities.

Contact Us

Topics

Arts and culture

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Driving and roads

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Environment and energy

FR

Forest sector’s use of fossil fuels

This indicator monitors changes in energy sources for Ontario’s pulp and paper sector and Canada’s solid wood product sector (e.g. lumber and fibreboard).

On this page

Indicator importance

Ontario’s forest industry uses large amounts of energy. To reduce greenhouse gas emissions as well as energy costs, the industry has been using waste-wood biomass from the wood manufacturing process and black liquor from chemical pulping to generate energy.

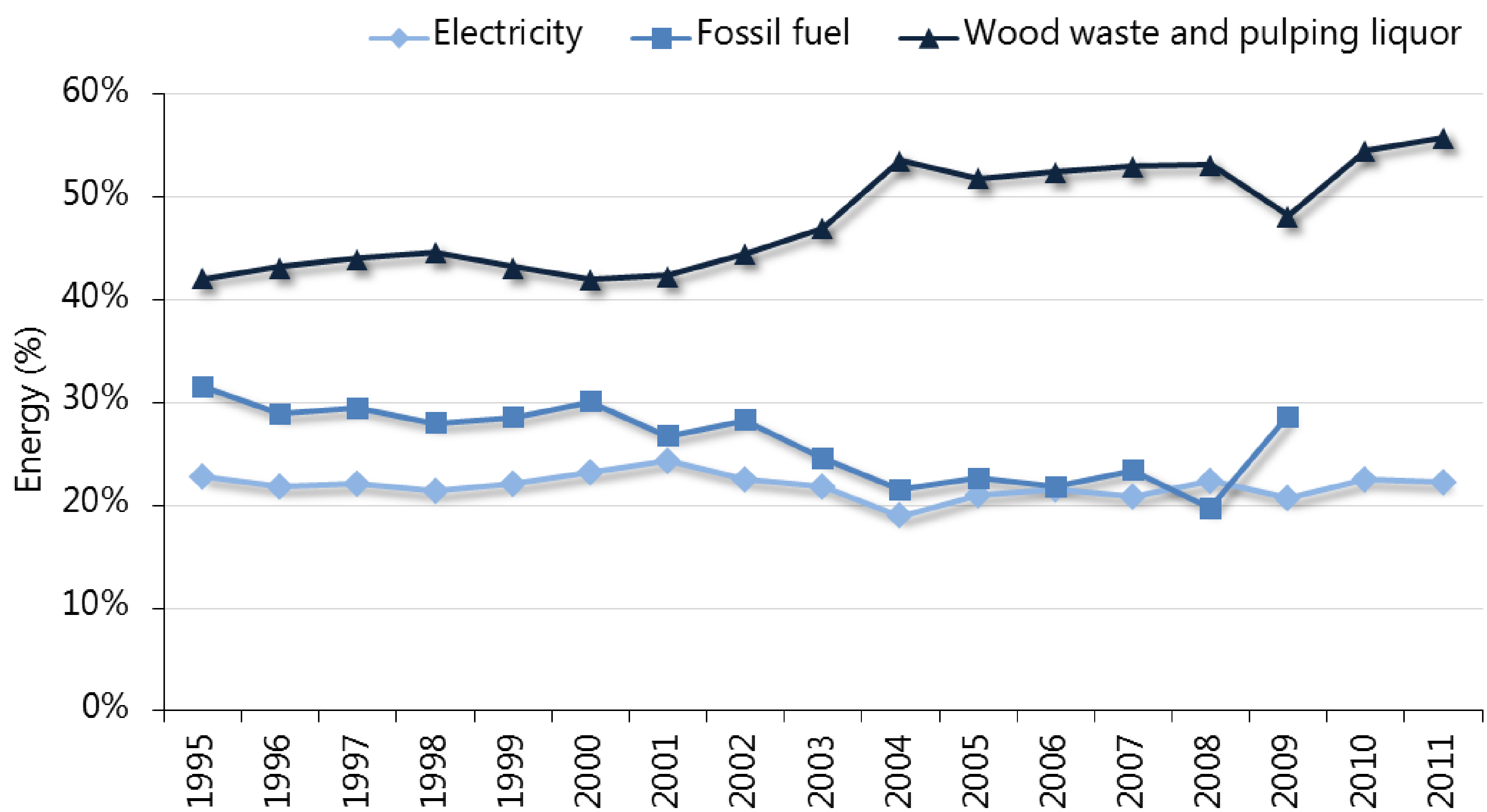
Substituting fossil fuels with wood-based fuels can provide greenhouse gas mitigation benefits. Monitoring the forest industry’s energy consumption is important for assessing its overall carbon balance and potential contributions to greenhouse gas mitigation.

Status of the indicator

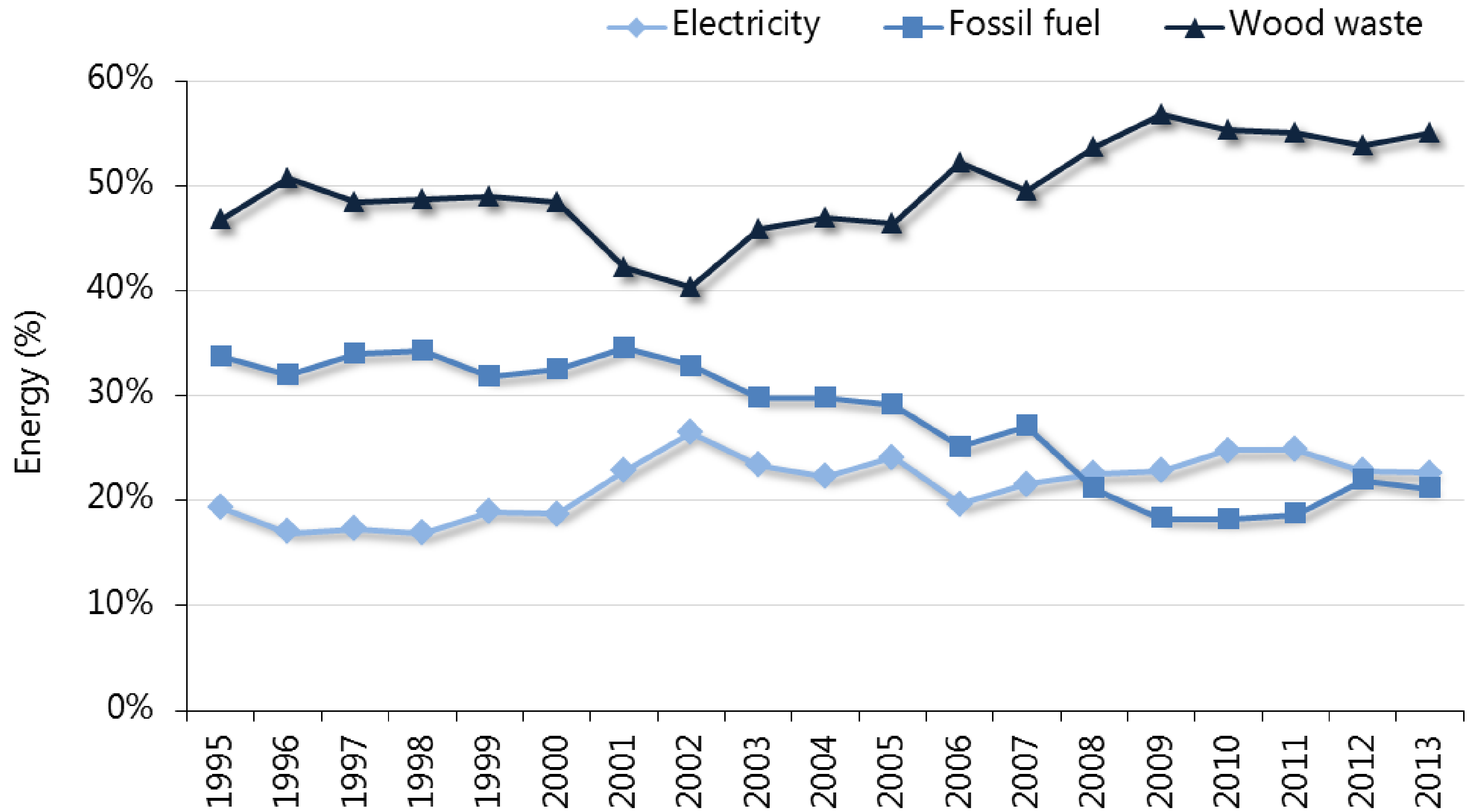
Status:	Trend:	Data:	Extent:
Good	Mixed/No change	Adequate	Provincial

Indicator trends

Energy sources for Ontario’s pulp and paper sector



Energy sources for Canadian wood product manufacturing



What's monitored

The amount of energy used from each source (electricity, fossil fuels and waste wood) is compared to the total amount of energy used from all sources. This provides a trend that is less influenced by fluctuations in forest industry production and mill closures.

Natural Resources Canada's Office of Energy Efficiency collects and reports total energy use and greenhouse gas emissions by industry and province. Energy use data for Ontario's pulp and paper sector — one of the most energy-intensive sectors — has been reported since 1990.

Total energy use and greenhouse gas emissions for Canada's solid wood product sector are recorded by the Canadian Industrial Energy End-Use Data and Analysis Centre. Currently, the centre does not separate energy use data by province.

Understanding the trend

Approximately 7.5% of industrial energy in Ontario is derived from wood biomass and almost all of this biomass energy is consumed by the pulp and paper sector to replace fossil fuel (natural gas).

Overall, substitutions of fossil fuels with waste-wood fuels have shown continuous improvement. However, the percentage of wood-based energy reduced noticeably in 2009, while fossil fuel use increased. Thus, the trend is assessed as mixed.

Since 2003 — with the exception of 2009 — the pulp and paper sector has sourced over 50% of its energy from waste wood, with an all-time high of 55.8% in 2011 (see chart Fuel sources for Ontario's pulp and paper sector).

This is an improvement from the late 1990s and early 2000s when waste wood accounted for roughly 43% of the energy source. Therefore, the state is assessed as good.

Canada's solid wood product sector increased its use of wood-based energy from 40.3% in 2002 to an average of 55.3% in 2009-2013 (see chart Fuel sources for Canadian wood product manufacturing).

In comparison, in 2002-2009 the percentage of energy produced from fossil fuels decreased from 32.9% to 18.5%, and remained stable during 2009-2013 (varying from 18.3% to 22.1%). Thus, both the state and trend for Canada's solid wood product sector are assessed as good.

Overall, the data is ranked as adequate as long-term energy consumption data is available for the two forest industry sectors.

Metadata

Criterion:
monitoring forest contributions to global ecological cycles

Element:
monitoring forest industry sector carbon balance

Indicator:
reducing forest sector's use of fossil fuels

Indicator last updated:
April 2015

Update frequency:
every 5 years

Data extent:
Provincial – view map

Source:
Canada Industrial Energy End-Use Data and Analysis Centre; Natural Resources Canada

Download data:
Text CSV file for chart A and B

Updated: June 28, 2018
Published: June 16, 2017

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Landfill gas capture : a guideline on the regulatory and approval requirements for landfill gas

Requirements for the capture of landfill gas and how to get approval of the landfill gas facilities under Part V (waste management) and Section 9 (air and noise emissions) of the Environmental Protection Act.

On this page

Preface

Ontario Regulation 232/98 ("*O. Reg. 232/98*") and Revised Regulations of Ontario 1990, *Regulation 347* (General Waste Management) ("*Regulation 347*") under the *Environmental Protection Act* (*EPA*) were amended in June 2008 and resulted in requirements for landfill gas collection and flaring (burning), or use, for new, expanding and operating landfills larger than 1.5 million cubic metres.

This Guideline describes the regulatory and approval requirements for the capture of landfill gas and the information needed to obtain approval of the landfill gas facilities under Part V (waste management) and Section 9 (air and noise emissions) of the *EPA*.

Section 15 of *O. Reg. 232/98* sets out the regulatory requirements for new or expanding landfill sites. Sections 11.1, 11.2, 11.3 and 11.5 of *Regulation 347* set out the regulatory requirements for operating landfills. Reporting requirements for greenhouse gas reductions for new, expanding and operating sites are set out in Section 11.4 of *Regulation 347*.

The requirements set out in the regulations are developed through the approvals process and implemented through a Part V certificate of approval (or provisional certificate of approval).

Provisions have also been included in *Regulation 347* concerning any operating landfills that have taken voluntary early action to capture landfill gas that give them an additional 7 years (until June 30, 2016) before these systems need to be assessed for improvements, if any, prior to implementation by means of a Part V certificate of approval.

The regulations do not apply to closed landfills, landfills associated with forest products operations or coal ash landfills. The regulations also provide for submission of a report, if appropriate, showing that a landfill does not generate gas of significant concern and that landfill gas facilities may not be needed.

The description of the regulatory requirements in this Guideline is given for convenience only. Reference should be made to the current relevant legislation and regulations to determine the exact requirements.

This Guideline may be amended from time to time.

Introduction (1.0)

The decomposition of the organic component of municipal waste in landfills produces landfill gas containing about 50% methane (CH_4) and 50% carbon dioxide (CO_2). Methane is a potent greenhouse gas as it has a global warming potential 21 times that of carbon dioxide. As a result landfills are considered a significant source of greenhouse gas emissions.

Landfill gas also contains trace amounts of other compounds, such as hydrogen sulphide, mercaptans and non-methane organics. These other compounds may cause odours or affect local air quality.

Landfill gas emissions can be controlled by installing a network of collection wells and directing the gas by fans to facilities for use of the gas (e.g. for electricity generation or use by a nearby industry), or for flaring (i.e. burning). Simply burning the methane to convert it to carbon dioxide reduces its global warming potential by about 95%. Use of the methane for energy purposes can further reduce greenhouse gas emissions by replacing other energy sources, such as natural gas or coal.

New Landfill Gas Regulations

O. Reg. 232/98 and *Regulation 347* under the *EPA* were amended in June 2008 and resulted in requirements for landfill gas collection and flaring (burning), or use, for new, expanding and operating landfills larger than 1.5 million cubic metres.

The new regulations amend the existing requirements for control of the atmospheric emissions of landfill gas in Section 15 of *O. Reg. 232/98* (in place since 1998) primarily by:

1. changing the landfill size trigger to 1.5 million cubic metres; and,
2. applying the requirements to operating sites, in addition to new or expanding landfills.

Section 15 of *O. Reg. 232/98* (as amended) sets out the requirements for new or expanding landfills. Sections 11.1, 11.2, 11.3 and 11.5 of *Regulation 347* (as added) set out the requirements for operating landfills. Reporting requirements for greenhouse gas reductions for new, expanding and operating sites are set out in Section 11.4 of *Regulation 347*.

For an operating site, landfill owners must submit design reports by June 30, 2009 with facilities in completed or interim completed site areas to be installed and operating by December 31, 2010. For a new or expanding site, gas facilities would be installed following site approval, in accordance with the conditions specified in the Part V *EPA* certificate of approval for the site.

Ministry of the Environment Provisions have also been included in *Regulation 347* concerning operating landfills that have taken voluntary early action to capture landfill gas that give them an additional 7 years (until June 30, 2016) before these systems need to be assessed for improvements. Any improvements would then be implemented by means of a Part V certificate of approval.

The regulations do not apply to closed landfills, landfills associated with forest products operations or coal ash landfills. The regulations also provide for submission of a report, if appropriate, showing that a landfill does not generate gas of significant concern and that landfill gas facilities may not be needed.

This Guideline

This Guideline describes the regulatory and approval requirements for the capture of landfill gas, and the information needed to obtain approval for landfill gas facilities under Part V (waste management) and Section 9 (air and noise) of the *EPA*. The type of information needed to show, if appropriate, that landfill gas capture may not be necessary is also described.

A sample application package for approval of landfill gas collection and control facilities under Part V and Section 9 of the *EPA* is available on the Ministry website (see Section 3.4 of this Guideline).

Regulatory and approval requirements (2.0)

Amendments to *O. Reg. 232/98* and *Regulation 347* under the *EPA* result in requirements for landfill gas collection and flaring (i.e. burning), or use, for new, expanding and operating landfills larger than 1.5

million cubic metres.

This section of the Guideline describes the regulatory and approval requirements that apply for new or expanding landfills and operating landfills, including any operating sites that have taken voluntary early action to capture landfill gas. This section also describes the regulatory requirements for reporting landfill greenhouse (methane) gas reductions and the provisions for the submission of a report to show that gas facilities may not be needed.

The description of the regulatory requirements in this Guideline is given for convenience only. Reference should be made to the current relevant legislation and regulations to determine the exact requirements.

New or Expanding Landfills (2.1)

O. Reg. 232/98 under the *EPA* results in requirements for landfill gas collection and flaring (burning), or use, for new or expanding landfills larger than 1.5 million cubic metres. In the case of an expanding landfill, the 1.5 million cubic metres refers to the total of the existing and proposed new volumes. The required report on the design (and operation, maintenance and monitoring) of the landfill gas facilities would be included in the review and approval of the landfill.

Submission of a Design Report

Subsection 15(1) of *O. Reg. 232/98* requires the preparation of a report on the design (and operation, maintenance and monitoring) of landfill gas facilities for new or expanding landfills. The design report would be submitted as part of the overall application for approval of the proposed new or expanding site under Part V (waste management) of the *EPA*.

Approval and Implementation

Approval and implementation of the landfill gas facilities for new or expanding landfills would be dealt with in the certificates of approval issued for the site under Part V (waste management) and Section 9 (air and noise) of the *EPA*.

The overall application for approval of a proposed new or expanding landfill under Part V of the *EPA* should identify the requirement to capture landfill gas and should include the conceptual design of the landfill gas system for the entire site. Detailed design of the gas system and its implementation would be undertaken in phases, as outlined in the conceptual design, and as set out in conditions specified in the Part V certificate of approval. In the case of a site expansion, the detailed design and implementation of the gas facilities for the existing area of the site should be submitted early, following overall approval of the site expansion.

Section 9 Air & Noise Approval

Approval under Section 9 of the *EPA* would be dealt with at the time of detailed design in conjunction with the conditions pertaining to detailed design in the Part V certificate of approval.

Operating Landfills (2.2)

Regulation 347 under the *EPA* requires landfill gas collection and flaring (burning), or use, for operating landfills larger than 1.5 million cubic metres. *Regulation 347* also requires implementation of specific landfill gas facilities by December 31, 2010. The certificate(s) of approval for the landfill sites would be amended to include the landfill gas facilities as approved by the approval Director.

Provisions have also been included in *Regulation 347*, however, concerning any operating landfills that have taken voluntary early action to capture landfill gas that give them an additional 7 years (until June 30, 2016) before these systems need to be assessed for improvements. Refer to Subsection 2.2.1 of this Guideline.

June 30, 2009 Design Report

Section 11.1 of *Regulation 347* applies to operating landfills that have not taken voluntary early action to capture landfill gas.

Section 11.1 does not apply to an operating landfill that has taken voluntary early action to capture landfill gas, and has requested that Section 11.1 not apply, or to a landfill that has previously been required to submit a landfill gas design report pursuant to Subsection 15(1) of *O. Reg. 232/98* (i.e. for purposes of approval of the site as a new or expanding landfill). Refer to Subsection 2.2.1 of this Guideline for the requirements that apply to operating landfills that have taken voluntary early action to capture landfill gas.

Subsection 11.1(1) of *Regulation 347* requires submission of a report on the design (and any possible improvements) of landfill gas facilities for operating landfills by June 30, 2009.

The design report must take into account the requirements in Section 11.3 of *Regulation 347* that landfill gas facilities in completed or interim completed areas of an operating site must be in place and operating by December 31, 2010. A completed or interim completed area is a portion of the site which has reached maximum capacity or has been partially filled but has not received waste during the preceding 6 months (as of, or after, December 31, 2010).

Approval and Implementation

Approval and implementation of the landfill gas facilities would be dealt with through amendments to the certificates of approval issued for the landfill site under Part V and Section 9 of the *EPA*.

The June 30, 2009 design report required by Subsection 11.1(1) of *Regulation 347* should identify the requirement to capture landfill gas and should include the conceptual design of the landfill gas system for the entire site and, at a minimum, the detailed design of the portion of the gas system required to be approved by the Director and be in place and operating by December 31, 2010. Detailed design and implementation of the facilities for the remaining portion of the site would be undertaken in phases, as outlined in the conceptual design, and as set out in conditions in the Part V certificate of approval.

Section 9 Air & Noise Approval

Approval of the landfill gas system under Section 9 of the *EPA* would be dealt with at the time of detailed design in conjunction with the conditions pertaining to detailed design in the Part V certificate of approval. The detailed design of the facilities for purposes of Section 9 approval should include the facilities required, at a minimum, to be in place and operating in completed and interim completed areas of the site by December 31, 2010 should be included in the June 30, 2009 design report. Detailed design and implementation of the facilities for the remaining portion of the site would be dealt with in conjunction with the conditions pertaining to detailed design in the Part V certificate of approval.

Sites That Have Taken Voluntary Early Action (2.2.1)

Section 11.1 of *Regulation 347* (refer to Section 2.2. of this Guideline) does not apply to operating landfills that have taken voluntary early action to capture landfill gas and have requested that Section 11.1 not apply. For these voluntary early action sites, Section 11.2 of *Regulation 347* applies.

Section 11.2 includes provisions that give operating landfill sites that have taken voluntary early action seven years (i.e. to June 30, 2016) before the gas systems operating in the voluntary early action areas of an operating site need to be assessed for possible improvements. After the seven year period, the improvements, if any, would need to be implemented and the facilities operated in accordance with amendments made to the Part V and Section 9 certificates of approval.

Criteria Defining Voluntary Early Action

The criteria defining a landfill site that has taken voluntary early action are set out in Subsection 11.1(6) of *Regulation 347* and include the following:

- the site has a Part V certificate of approval permitting but not requiring, operation of landfill gas facilities,
- the site is operating the voluntary facilities, and
- the owner or operator of the landfill indicates they wish to use Subsection 11.1(6) and requests that Section 11.1 not apply.

The voluntary facilities would have to be approved and in operation by June 30, 2009, the date for submission of design reports under Subsection 11.1(1) and Subsection 11.2(1) of *Regulation 347*.

June 30, 2009 Design Report

Subsection 11.2(1) of *Regulation 347* requires an operating site where voluntary early action has been taken to submit a report by June 30, 2009 that includes the following:

1. Voluntary Early Action Areas:
   The report is to describe the existing gas capture facilities in areas of the site where voluntary early action has been taken to capture landfill gas and to identify that area where these facilities are located (clauses (a) and (b) of Subsection 11.2(1)).

   This provision requires information identifying the location of and describing the existing facilities in the voluntary early action areas of the site. For these areas, the regulation does not require an assessment of or result in implementation of possible improvements to the voluntary gas system.

   This provision essentially gives operating landfill sites that have taken voluntary early action seven years (i.e. to June 30, 2016) before the gas systems operating in the voluntary early action areas of an operating site need to be assessed for possible improvements.

2. Areas Other than Voluntary Early Action Areas:
   The report is to include the design (and operation, maintenance and monitoring) and possible improvements of landfill gas capture facilities for areas of the site other than the voluntary early action areas (clauses (c) and (d) of Subsection 11.2(1)).

   This provision requires information on the assessment and possible improvement of landfill gas facilities in areas of the site other than the voluntary early action areas. The design report must take into account the requirements in Section 11.3 of *Regulation 347* that landfill gas facilities in completed or interim completed areas of an operating site (other than voluntary early action areas) must be in place and operating by December 31, 2010.

   These requirements are similar to those in Section 11.1 that apply to operating landfills that have not taken voluntary early action (refer to Section 2.2 of this Guideline).

June 30, 2016 Design Report

Subsection 11.2(2) of *Regulation 347* requires submission of a report on the design (and operation, maintenance and monitoring) and any possible improvements of landfill gas facilities for the entire operating site, including the voluntary early action areas, by June 30, 2016. All landfills that submitted a report under Subsection 11.2(1) must submit this second report under Subsection 11.2(2).

This requirement essentially ends the seven year period given to sites that have taken voluntary early action before the gas systems operating in the voluntary early action areas of those sites need to be assessed for possible improvements and for those improvements, if any, to be implemented by means of a Part V certificate of approval.

For the areas of the landfill in which voluntary earlier action has not been taken, the June 30, 2016 report would essentially be an update of the June 30, 2009 report.

Approval and Implementation

Approval and implementation of the landfill gas facilities would be dealt with through amendments to the certificates of approval issued for the landfill site under Part V and Section 9 of the *EPA*.

1. Voluntary Early Action Areas:
   For the voluntary early action areas of the landfill, the June 30, 2009 report is limited to identifying and describing the existing gas capture facilities in areas of the site where voluntary early action has been taken to capture landfill gas. To qualify as voluntary early action facilities, approval under Part V and Section 9 of the *EPA* would have already had to have been obtained for these facilities. Amendments to the Part V or Section 9 certificates of approval should not be needed unless the landfill owner wishes to amend the design of the voluntary system (limited to the existing defined area for this system).

   As a result of the June 30, 2016 report, approval and implementation of any improvements to the voluntary facilities and the requirement for operation of these facilities would be dealt with through amendments to the certificates of approval issued for the landfill site.

2. Areas Other than Voluntary Early Action Areas:
   Approval and details of implementation of the landfill gas facilities in areas of the site other than voluntary early action areas based on the June 30, 2009 report would be dealt with in a similar manner as for landfill sites that have not taken voluntary early action (refer to Section 2.2 of this Guideline).

   The June 30, 2009 design report submitted for approval should identify the requirement to capture landfill gas in areas of the site other than voluntary early action areas. The report should include the conceptual design of the landfill gas system for the entire site (other than the voluntary early action areas if they are described separately) and, at a minimum, the detailed design of the portion of the gas system required to be approved by the Director and be in place and operating by December 31, 2010. Detailed design and implementation of the facilities for the remaining portion of the site (other than the voluntary early action areas) would be undertaken in phases, as outlined in the conceptual design, and as set out in conditions in the Part V certificate of approval.

   Any further improvements based on the June 30, 2016 report, which is essentially an update of the June 30, 2009 report, would be dealt with through amendments to the certificates of approval issued for the site.

Section 9 Air & Noise Approval

The landfill gas facilities in the voluntary early action areas of a landfill would already have obtained a Section 9 certificate of approval for those facilities to be operating as voluntary early action facilities.

In areas of the site other than the voluntary early action areas, approval of the gas system under Section 9 would already have been dealt with in response to the submission of the June 30, 2009 design report. The detailed design of the facilities required, at a minimum, to be in place and operating in completed and interim completed areas of the site by December 31, 2010 should have been included in the June 30, 2009 design report. Detailed design and implementation of the facilities for the remaining portion of the site (other than the voluntary early action areas) would be dealt with in conjunction with the conditions pertaining to detailed design in the Part V certificate of approval.

Approval under Section 9 of the *EPA* for the detailed design of any facilities or improvements needed as a result of the June 30, 2016 design report would generally be dealt with in conjunction with the conditions pertaining to detailed design in the Part V certificate of approval. For the (former) voluntary early action areas of the site, the June 30, 2016 design report should include the detailed design and implementation of any facilities or improvements needed for those areas.

Greenhouse Gas Reporting Requirements (2.3)

Section 11.4 of *Regulation 347* requires landfills larger than 1.5 million cubic metres that are operating on or after June 30, 2009 to report annually on the greenhouse gas reductions being achieved by the landfill. Reporting is to begin with the reductions occurring as of June 30, 2009.

The annual greenhouse gas report required by *Regulation 347* is to be submitted to the Director of the Environmental Monitoring and Reporting Branch of the Ministry of the Environment by June 1 of the year following the reporting year. The report for 2009 is to include information only for the period from June 30, 2009 to December 31, 2009.

The report is to include the following information:

1. A statement of the total landfill gas volume collected by the facilities at the site during the year.
2. A statement of the percentage of the volume described in paragraph 1 that was methane gas.
3. A statement of the reductions in landfill gas emissions associated with the burning or use of landfill gas during the year, expressed in units of tonnes of carbon dioxide equivalent and based on a global warming potential of 21 for methane gas.
4. A description of how sound scientific or engineering principles have been used to support the statements required by paragraphs 1, 2 and 3.
5. All calculations and information that support the statements required by paragraphs 1, 2 and 3.

The first report is to be submitted by June 1, 2010 and cover the reporting period of June 30, 2009 to December 31, 2009. If no landfill gas is collected during the first reporting period (i.e. to December 31, 2009) the report is still required and should respond to the reporting requirements as appropriate (e.g. no landfill gas was collected during the year, etc.).

Subsequent annual reports would include the entire reporting year (i.e. January 1 to December 31). The annual reports would continue to be submitted until the Part V, *EPA* Director amends the Part V certificate of approval to indicate that reporting is no longer necessary as the nature and quantity of landfill gas generated by the site is not a significant concern.

No Significant Landfill Gas (2.4)

The regulations provide for submission of a report, if appropriate, to show that landfill gas facilities may not be needed for a site. This provision has been included in *O. Reg. 232/98* for new or expanding sites since 1998 and has been included in *Regulation 347* for operating landfills.

Under Subsection 15(3) of *O. Reg. 232/98* and Subsection 11.1(5) of *Regulation 347*, a landfill owner may submit a report to the Part V, *EPA* Director showing that the nature and quantity of landfill gas generated at a site is not likely to be of significant concern. The factors to be considered in this assessment are the characteristics of the site, the type of waste to be deposited and the rate at which waste is deposited at the site.

The Part V, *EPA* Director would review the report, and if acceptable, determine if landfill gas generated at a site is likely of significant concern and whether gas facilities are required.

If the Director determines that landfill gas generated at a site is not likely to be of significant concern, the regulatory requirements for landfill gas collection and flaring, or use, and for reporting of greenhouse gas reductions do not apply.

Approval guidelines (3.0)

The amendments to *O. Reg. 232/98* and *Regulation 347* under the *EPA* result in requirements for landfill gas collection and flaring (burning), or use, for new, expanding and operating landfills larger than 1.5 million cubic metres.

This section of the Guideline describes the information needed to obtain approval of landfill gas facilities under Part V (waste management) and Section 9 (air and noise) of the *EPA*. This section also describes the type of information needed to show, if appropriate, that a landfill does not generate gas of significant concern and that landfill gas facilities may not be needed.

A sample application package for approval of landfill gas collection and control facilities under Part V and Section 9 of the *EPA* is available on the Ministry website (see Section 3.4 of this Guideline).

Landfill Gas Facilities Are Required (3.1)

The objective of the landfill gas collection and control facilities is to achieve a maximum practical level of landfill gas collection and greenhouse (methane) gas reductions for the landfill. The landfill gas facilities will also reduce emissions of trace amounts of other compounds such as hydrogen sulphide, mercaptans and non-methane organics. These other compounds may cause odours or affect local air quality.

Where landfill gas facilities already exist at a landfill, the facilities must be assessed to determine if they achieve the objective of maximum practical landfill gas collection and greenhouse (methane) gas reduction. Any improvements to the facilities would then be made. (Refer to Subsection 2.2.1 of this Guideline for the regulatory requirements that apply to operating landfills that have taken voluntary early action to capture landfill gas.)

For a proposed landfill expansion, landfill gas facilities are required for the existing approved waste fill zone of the site in addition to the proposed new waste fill zone of the site.

The design guidelines below describe the information needed to obtain approval of landfill gas facilities under Part V (waste management) of the *EPA*. The additional information needed to obtain approval under Section 9 (air and noise) of the *EPA* is described in Subsection 3.1.1 of this Guideline.

Design Guidelines

When designing the landfill gas system for a landfilling site, a number of factors related to the overall site design and operation should be considered. These factors may affect the type and layout of the gas collection system (e.g. horizontal trenches or vertical collection wells), the rate and quantity of gas generated, and the timing of system installation and operation. These factors include:

- the presence of low permeability soil or a bottom liner system preventing lateral migration of landfill gas;
- leachate levels within the landfill;
- site configuration (e.g. landfill slopes, vertical configuration relative to surrounding ground surface, and landfill surface area relative to volume of waste);
- final cover characteristics and limitations (e.g. for groundwater protection and site end use) affecting moisture within the site and potential air intrusion;
- phasing of landfilling and closure operations for each area of the site;
- the type and procedures for daily or intermediate cover affecting hydraulic and landfill gas movement within the landfill;

- any activities to control or alter the moisture content within the landfill, such as leachate recirculation; and
- the type of waste deposited.

Taking these factors into consideration, the plans, specifications and descriptions for the design of the landfill gas collection and control system should include the following:

1. Plans, specifications and descriptions of the design of the landfill gas collection system, including:
    a. spatial design of the collection system including collector orientation (i.e. vertical wells or horizontal trenches), layout and spacing, depth(s) of placement within the landfill and radius of capture zone;
    b. design of the collection pipes including size, material, perforations, granular bedding/envelope, and provisions for stress relief and settlement;
    c. design of header and transmission pipes including size, material, slope, valving, access chambers, condensate control, seepage protection, protection from freezing, bedding and provisions for stress relief and settlement; and
    d. condensate drainage, storage and disposal.
2. Plans, specifications and descriptions of the design of the facilities for landfill gas burning, treatment or utilization, including:
    a. a description of the landfill gas extraction equipment (i.e. blower) and the design of any moisture removal and gas treatment system;
    b. the design, performance characteristics and operational controls for any flare system including:
        i. the type and design of the flare device;
        ii. design combustion temperature and residence time;
        iii. the destruction efficiency of volatile organic compounds;
        iv. operational control systems such as temperature and combustion air control, flame failure detection, automatic ignition system and flame arrester; and
    c. a description of any utilization system for collected landfill gas.
3. Plans, specifications and descriptions of the operation, monitoring and maintenance procedures for the landfill gas system, including:
    a. phasing/timing of system installation, start up and operation -- particularly with respect to integration with overall landfill operation and maximizing landfill gas control;
    b. inspection frequencies and maintenance/replacement procedures for system equipment;
    c. monitoring of landfill gas flow rates and concentrations; and

d. contingency provisions in the event of unexpected component failures.

Please also see the Guide to applying for an Environmental Compliance Approval for more information.

Section 9 Air & Noise Approval (3.1.1)

In addition to obtaining waste management approval for the landfill gas facilities under Part V of the *EPA*, approval for the discharge to the atmosphere from the facilities is required under Section 9 of the *EPA*.

The design guidelines below describe the information needed to obtain approval under Section 9, *EPA* for the air emissions from landfill gas facilities. This information is in addition to the Part V, *EPA* information requirements described in Section 3.1 of this Guideline.

The plans, specifications and descriptions for the design of the landfill gas collection and control system should include the following:

- An Emission Summary and Dispersion Modelling Report prepared in accordance with *Ontario Regulation 419/05*;
- Calculations demonstrating that any landfill gas collection and flaring (burning) systems meet appropriate greenhouse gas destruction efficiencies (i.e. Maximum Achievable Control Technology); and
- Noise Screening or Acoustic Assessment Report demonstrating that the proposed landfill gas collection and flaring systems are capable of operating in compliance with the ministry noise guideline limits.

Please also see the Guide to applying for an Environmental Compliance Approval for more information.

Existing Landfill Gas Facilities May Be Sufficient (3.2)

Operating landfills that already have gas facilities in place are required to submit a report on these facilities to the Part V, *EPA* Director demonstrating if their existing (and future planned) facilities are sufficient. If the existing facilities are not sufficient, the operating landfill is required to include plans for improvement of the facilities. (Refer to Subsection 2.2.1 of this Guideline for the regulatory provisions included in *Regulation 347* concerning operating landfills that have taken voluntary early action to capture landfill gas).

Sufficiency would be determined based on the objective of the gas facilities to achieve a maximum practical level of landfill gas collection and greenhouse gas (i.e. methane) reductions for the landfill, from the perspective of the area in which waste has been deposited and the time period of landfill gas generation.

The Part V, *EPA* design guidelines given in Section 3.1 of this Guideline should be considered in assessing sufficiency and in any plans to improve the facilities.

No Significant Landfill Gas (3.3)

The regulations provide for the submission of a report, if appropriate, to show that gas facilities may not be needed.

Under Subsection 15(3) of *O. Reg. 232/98* and Subsection 11.1(5) of *Regulation 347*, a landfill owner may submit a report to the Part V, *EPA* Director showing that the nature and quantity of landfill gas generated at a site is not likely to be of significant concern. If the report is acceptable, the Part V, *EPA* Director could determine whether landfill gas generated at a site is likely of significant concern and whether gas facilities are required.

The factors to be considered in this assessment are the characteristics of the site, the type of waste to be deposited and the rate at which waste is deposited at the site. The type of information required for such a report includes the following:

- A description and assessment of the available information on the types, composition, quantities and age of the waste that has been landfilled and that is expected to be landfilled for the remaining site life, including an assessment of the concentrations and quantities of landfill gas that is being and may be generated by these wastes.
- Representative measurements and an assessment of the characteristics of the landfilled waste, the concentrations of any landfill gas within the landfilled waste, and the concentrations and quantities of landfill gas being emitted at the surface of the landfilled waste.
- A description and assessment of the characteristics of the site including any design characteristics or operating procedures that may affect the concentrations and quantities of landfill gas that is being and may be generated by the waste.
- Modeling of landfill gas production using the Scholl Canyon model, or other model acceptable to the Director, to estimate gas concentrations, gas quantities and gas generation profile over the time period of generation. Modeling should be done based on site and waste specific conditions, and for comparison, based on site specific conditions and waste conditions typical of mixed municipal waste landfills. An assessment of the results of the modeling should be provided.
- An assessment of the practical ability to collect and use or flare the landfill gas, if any, being generated and expected to be generated in the future at the site.

The potential landfill gas concentrations to be considered in the report include methane (CH_4), carbon dioxide (CO_2), odour causing compounds such as hydrogen sulphide (H_2S), and non-methane organic compounds (NMOCs). Other compounds should also be assessed if considered appropriate for the site.

Sample Application (3.4)

Sample application packages for approval of landfill gas collection and control facilities under Part V and Section 9 of the *EPA* are available on the Ministry website.

Further information on the sample application can be obtained by contacting the Environmental Assessment and Approvals Branch of the Ministry.

Other environmental approvals (4.0)

Proposals for new or expanding landfills and for the use of landfill gas to generate electricity may be subject to other environmental approvals, including approval under the *Environmental Assessment Act* (*EAA*).

This section of the Guideline provides a general description of the approval requirements under the *EAA* for landfills and landfill gas electricity projects.

The need for environmental assessment or any other environmental approval for a particular landfill or landfill gas proposal or project should be determined by contacting the Environmental Assessment and Approvals Branch of the Ministry.

EAA Approval (4.1)

This section of the Guideline provides a general description of the approval requirements for landfills and landfill gas electricity projects.

Ontario Regulation 101/07 under the *EAA* sets out the *EAA* approvals process categories for waste management proposals, including landfills. *Ontario Regulation 116/01* under the *EAA* sets out the *EAA* approvals process categories for electricity projects, including electricity projects using landfill gas as fuel.

Waste Management Projects Regulation (4.1.1)

The Waste Management Projects regulation, *Ontario Regulation 101/07*, sets out the environmental assessment process categories for waste management proposals, including landfills. Waste management projects fall under one of three possible environmental assessment categories. For proposed new or expanding landfills, the three project categories apply as follows:

- Individual Environmental Assessment: Landfills or landfill expansions larger than 100,000 cubic metres.
- Environmental Screening Process: Landfills or landfill expansions between 40,000 and 100,000 cubic metres.

- Exempt from *EAA*: Landfills or landfill expansions smaller than 40,000 cubic metres.

Proposed new landfills larger than 1.5 million cubic metres are subject to individual EA approval, as indicated above, and landfill gas facilities are required for the site under *O. Reg. 232/98*.

Proposed landfill expansions of 40,000 cubic metres or more up to 100,000 cubic metres are subject to the environmental screening process (ESP), and landfill expansions larger than 100,000 cubic metres are subject to individual environmental assessment, as indicated above. Where the proposed expansion increases the total site capacity to more than 1.5 million cubic metres, *O. Reg. 232/98* results in landfill gas facilities being required for the site.

The landfill proponent in either case (ESP or individual EA) should indicate in the environmental assessment that landfill gas facilities are required under *O. Reg. 232/98*. A general description of the design and timing of implementing the gas facilities should also be included in the environmental assessment.

Reference should be made to the Ministry "Guide to Environmental Assessment Requirements for Waste Management Projects" dated March 15, 2007 for information on *O. Reg. 101/07* and the applicable *EAA* requirements.

Electricity Projects Regulation (4.1.2)

The Electricity Projects regulation, *O. Reg. 116/01*, sets out the *EAA* process categories for electricity projects, including electricity projects using landfill gas as fuel. Electricity projects fall under one of three possible *EAA* process categories. For landfill gas projects two project categories apply, as follows:

- Environmental Screening Process: Landfill gas electricity projects generating ≥ 25 MW of electricity.
- Exempt from *EAA*: Landfill gas electricity projects generating < 25 MW of electricity.

A proposed electricity project using landfill gas as fuel and generating ≥ 25 MW of electricity is subject to the Environmental Screening Process (ESP). This requirement applies independently of the size and regardless of the operational status of the landfill

(i.e. operating or closed). Where the landfill is an operating landfill with a total site capacity larger than 1.5 million cubic metres, *Regulation 347* results in landfill gas facilities for collection and flaring being required for the site.

Under *Regulation 347*, operation of the gas collection and flaring facilities would be required regardless of the ongoing viability of electricity generation. The electricity project proponent in this case should indicate in the environmental assessment that landfill gas facilities are required under *Regulation 347*. A general description of the design and timing of implementing the gas facilities should also be included in the environmental assessment.

Reference should be made to the Ministry "Guide to Environmental Assessment Requirements for Electricity Projects" dated March 2001 for information on *O. Reg. 116/01* and the *EAA* Screening process requirements.

Appendix 1 - *O. Reg. 232/98*

The regulatory requirements applicable to proposed new or expanding landfills are set out in Section 15 of *O. Reg. 232/98* pursuant to the *Environmental Protection Act*. Section 11.4 of *Regulation 347* which requires reporting of landfill greenhouse gas reductions also applies to new and expanding landfills (refer to Appendix 2).

Appendix 2 - *Regulation 347*

The regulatory requirements applicable to operating landfills are set out in Sections 11.1 to 11.5 of *Regulation 347* pursuant to the *Environmental Protection Act*. Section 11.4 which requires reporting of landfill greenhouse gas reductions also applies to new and expanding landfills (refer to Appendix 1).

PIBS 6876e

Updated: May 18, 2016
Published: May 18, 2016

and sustain the quality of Ontario's air, land, and water. We also coordinate Ontario's actions on climate change in the name of healthier communities, ecological protection and economic prosperity.

ONTARIO'S FOOD AND ORGANIC WASTE FRAMEWORK:

Action Plan

Ontario

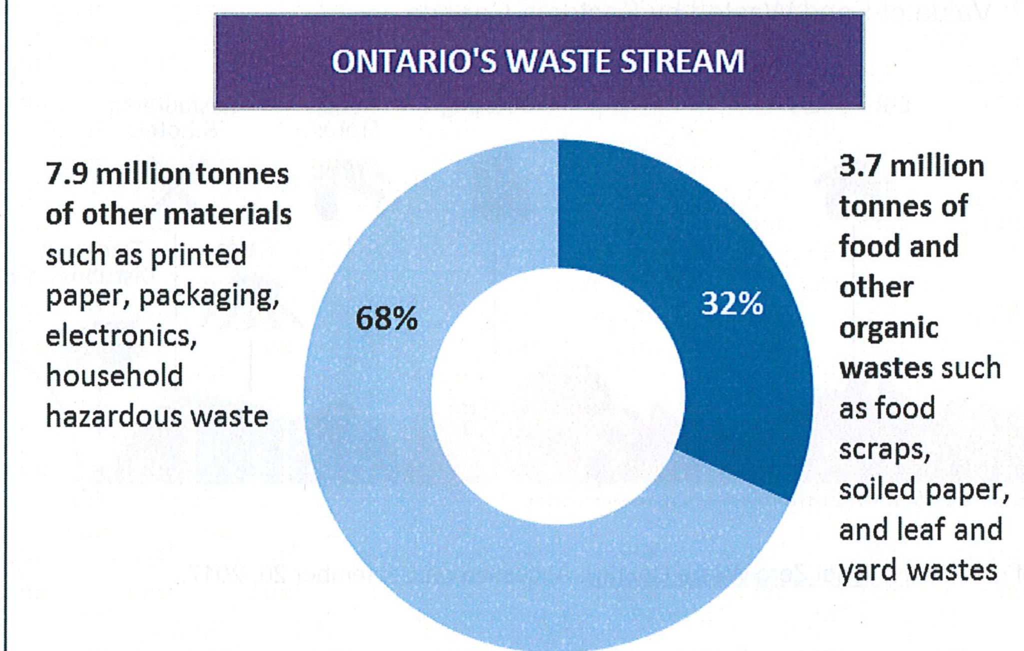
TABLE OF CONTENTS

INTRODUCTION

The Province of Ontario is shifting to a *circular economy*[*]— a system in which materials are never discarded, but reused or recycled into new products and reintegrated into the market.

Managing our resources more effectively will benefit Ontarians, our environment and the economy. It will help the province fight climate change and achieve its goals of a zero waste future with zero greenhouse gas emissions from the waste sector, as set out in the Strategy for a Waste-Free Ontario: Building the Circular Economy, released in February 2017.

Figure 1: Total Waste Generated in Ontario by Type (Estimated Tonnes)



Source: Adapted from Reports on Organic Waste Management in Ontario, prepared for the Ontario Ministry of the Environment and Climate Change, 2015. Note – biosolids are not captured in this chart

[*] Italicized terms in the Food and Organic Waste Framework are defined in the Glossary section. For non-italicized terms, the normal meaning of the word applies.

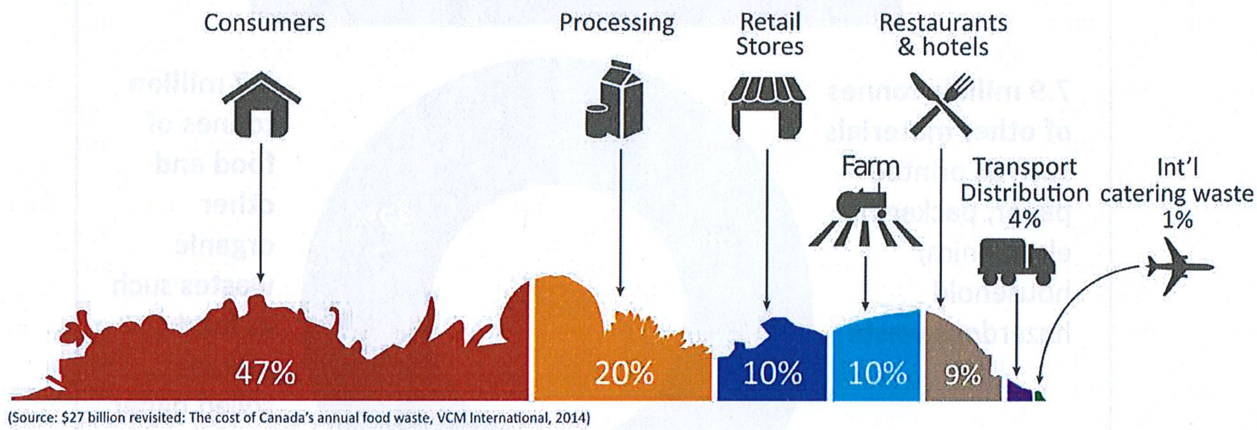
Addressing *food and organic waste* is a big part of the story. In a linear economy, large volumes of food and organic resources are wasted, with few opportunities or incentives to prevent waste before it occurs.

In 2015, Ontarians generated about 3.7 million tonnes of *food and organic waste*, which includes food that could have been eaten or repurposed, as well as unavoidable waste, such as food scraps and vegetable peelings. About 60 per cent of this was sent to landfill.[1]

The amount of food wasted each year is particularly staggering. In Canada, about $31 billion worth of food is wasted annually. This equates to about $868 worth of food wasted per person per year.[2]

Consumers are responsible for the largest share of *food waste*, at approximately 47 per cent of total *food waste*. The remaining *food waste* is generated along the supply chain, where food is grown, processed, transported and sold.

Figure 2: Value of Food Wasted by Sector in Canada

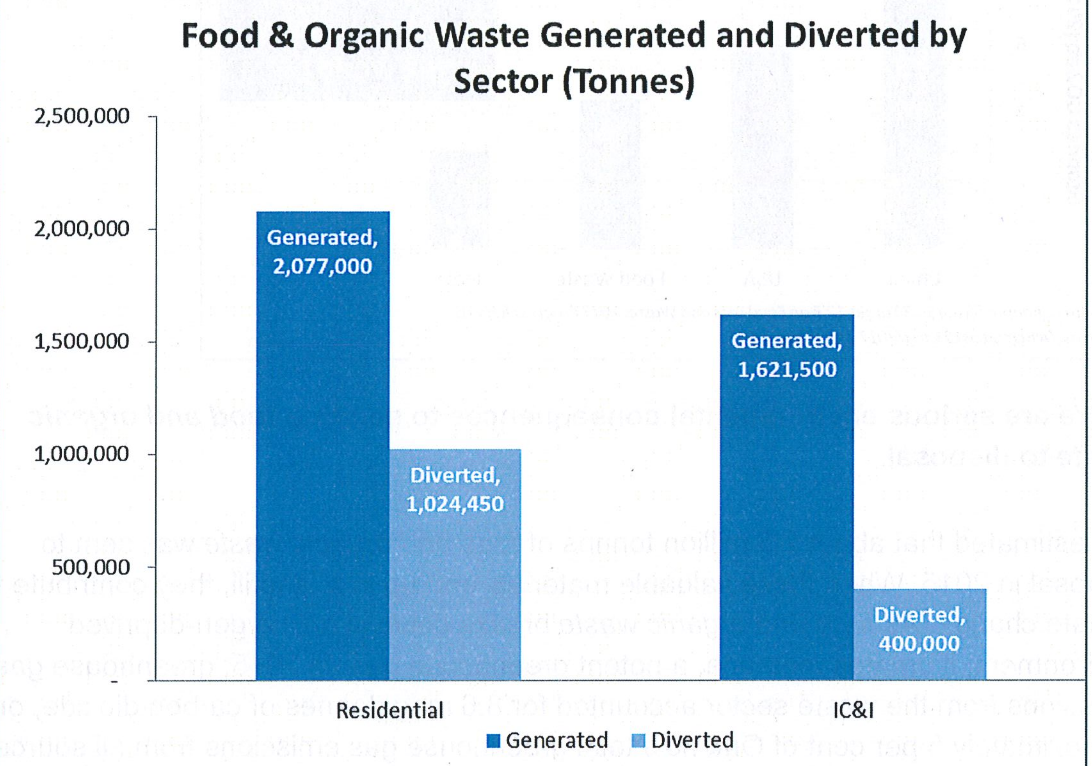


Source of graphic: National Zero Waste Council, Accessed on September 26, 2017.

The residential sector generates about 55 per cent of all *food and organic waste* in Ontario. Municipalities have made good progress in keeping *food and organic waste* from being sent to disposal. In 2015, Ontario's municipalities recovered over one million tonnes of *food and organic waste* from the residential sector, including about 480,000 tonnes of green bin waste and 540,000 tonnes of leaf and yard waste.[3] This translates to a recovery rate of nearly 50 per cent.

The industrial, commercial and institutional (IC&I) sector generates almost 45 per cent of all *food and organic waste* in Ontario. The *food and organic waste* the IC&I sector generates is as diverse as the sector itself.

Figure 3: *Food and Organic Waste* in Ontario

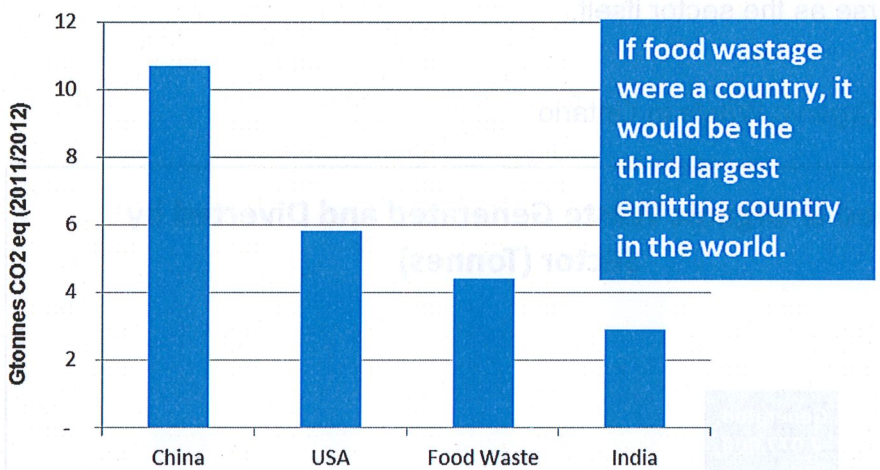


Source: Adapted from Reports on Organic Waste Management in Ontario, prepared for the Ontario Ministry of the Environment and Climate Change, 2015

Some establishments, such as offices, factories and public facilities, generate *food and organic waste* as a result of consumers, residents or employees going about their daily activities. For other sectors, *food and organic waste* is a result of their core purpose as establishments. For example, the food service, wholesale and retail sectors together account for about 72 per cent of all IC&I *food and organic waste* sent to disposal in Ontario each year.[4]

In 2015, Ontario's IC&I sector collected and recovered about 400,000 tonnes of *food and organic waste*. This means that 75 per cent of *food and organic waste* generated in the IC&I sector is sent for disposal. Significant effort moving forward is needed in order to prevent, reduce and recover resources from *food and organic waste*.

Figure 4: Global Greenhouse Gas Emissions related to *Food Waste*



Source: Adapted from SDG Target 12.3 on Food Loss and Waste: 2017 Progress Report, https://champions123.org/2017-progress-report/

There are serious environmental consequences to sending *food and organic waste* to disposal.

It is estimated that about 2.3 million tonnes of *food and organic waste* was sent to disposal in 2015. When these valuable materials end up in a landfill, they contribute to climate change. As *food and organic waste* breaks down in an oxygen-deprived environment, it creates methane, a potent greenhouse gas. In 2015, greenhouse gas emissions from the waste sector accounted for 8.6 megatonnes of carbon dioxide, or approximately 5 per cent of Ontario's total greenhouse gas emissions from all sources.[5]

From farm to table, there are large amounts of land, energy, water and labour used across the food value chain. For illustrative purposes, if global *food waste* was a country, it would be the third-largest emitter of carbon dioxide equivalent, after the United States and China.[6]

Sending *food and organic waste* to landfill is ultimately unsustainable and puts additional strain on our environment by requiring new landfill space. Given projected population growth and economic trends, it is forecasted that Ontario will need 16 new or expanded landfills by 2050, if no progress is made to keep our resources out of landfills.[7]

Reducing *food and organic waste* has environmental and economic benefits.

A *circular economy* presents important environmental and economic benefits.

Reducing *food and organic waste* preserves our natural resources and helps fight climate change. It also saves consumers and businesses money, while improving access to healthy and fresh food for Ontarians.

According to research conducted in the United Kingdom, every dollar spent on *food waste* prevention and reduction returns an average of $14 in financial benefit for businesses.[8]

Turning *food and organic waste* into *compost* and *digestate* creates economic and environmental benefits, which can improve soil health, help reduce erosion, and improve water quality. Similarly, renewable natural gas can be produced from recovered *food and organic waste*, and their use can help reduce our dependence on greenhouse gas-intensive fossil fuels.

Collecting and recovering 1,000 tonnes of *food and organic waste* has been shown to generate 60 per cent more GDP and 40 per cent more jobs than disposal.[9] Current efforts to collect and recover resources from *food and organic waste* through household *food waste, organic waste*, and leaf and yard waste programs support approximately 1,700 direct and indirect jobs in Ontario, and generate over $100 million in GDP.[10]

Further, keeping *food and organic waste* out of landfills can help us fight climate change by reducing greenhouse gas emissions. For example, doubling the province's current recovery rate of *food and organic waste* would lead to a reduction of an additional 1.1 megatonnes in greenhouse gas emissions, which would be equivalent to removing approximately 260,000 cars from Ontario roads each year, and bring us closer to our climate change goals.[11]

Keeping *food and organic waste* out of the disposal stream is a high priority for the province.

To achieve our goals of zero waste and zero greenhouse gas emissions from the waste sector, the province will lead transformative change in how *food and organic waste* is managed.

However, in order to move Ontario towards a truly *circular economy*, efforts should not be limited to recovering nutrients and resources at the end-of-life stage. We must also prevent food from becoming waste in the first place. To build the province's *circular economy*, Ontarians have a role to play in preventing and reducing *food and organic* *waste,* and collecting and reintegrating the materials that become waste into viable end-markets. To this end, both *waste reduction* and *resource recovery* activities are critical.

Vision and Objectives

Vision: A *circular economy* that moves towards zero *food and organic waste* and zero greenhouse gas emissions from the waste sector.

The Food and Organic Waste Framework ("Framework"), including Part A (Food and Organic Waste Action Plan) and Part B (Food and Organic Waste Policy Statement) views *food and organic waste* as a resource rather than a waste. The Framework takes a systems approach to *food and organic waste* generation, management and recovery, recognizing that all stages of supply and production have a role to play in moving towards a *circular economy*.

In developing the Framework, the province considered a number of **key guiding principles**, including:

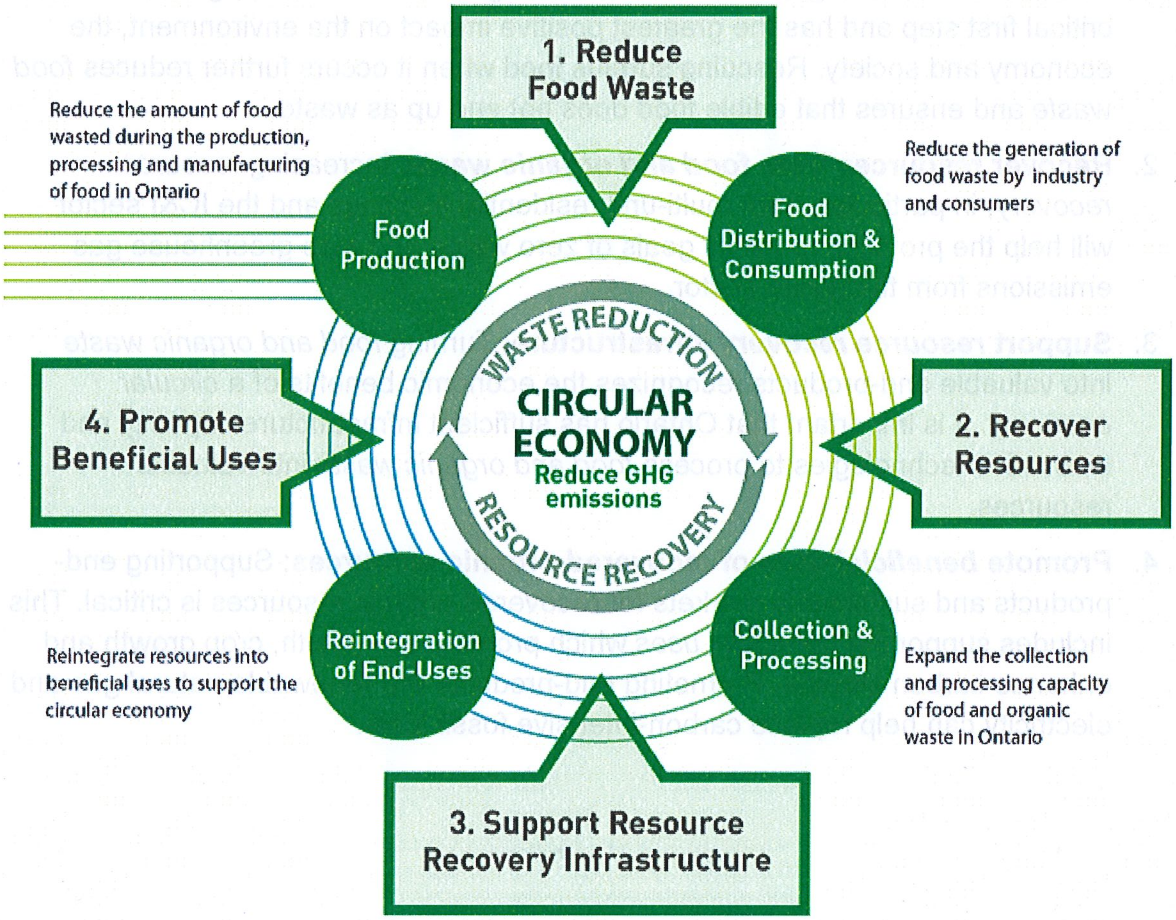
- Encouraging a change in behaviour to help prevent and reduce *food waste* in Ontario.
- Enhancing existing partnerships with stakeholders and building new relationships.
- Building on progress made in Ontario and learning from other leading jurisdictions.
- Collaborating across all levels of government to avoid duplication.
- Supporting an outcome-based approach.
- Using evidence to guide decision-making.
- Using regulatory and non-regulatory tools.
- Creating conditions that support sustainable end-markets.
- Increasing the use of innovative technologies.
- Enabling efficient and effective surplus food redistribution and *food waste* recovery systems.
- Recognizing the administrative impacts and costs to collect and recover organic resources.
- Increasing accountability.

The Framework supports the vision set out in the Strategy for a Waste-Free Ontario: Building the Circular Economy, where waste is seen as a resource that can be recovered, reused and reintegrated to achieve a *circular economy*. It also supports the goals of a zero waste Ontario and zero greenhouse gas emissions from the waste sector.

The Framework strives towards the achievement of the following **objectives**:

1. **Reduce *food and organic waste***: Preventing food from becoming waste is a critical first step and has the greatest positive impact on the environment, the economy and society. Rescuing surplus food when it occurs further reduces *food waste* and ensures that edible food does not end up as waste.
2. **Recover resources from *food and organic waste***: Increasing *resource recovery*, in particular, from multi-unit residential buildings and the IC&I sector will help the province reach its goals of zero waste and zero greenhouse gas emissions from the waste sector.
3. **Support *resource recovery* infrastructure**: Turning *food and organic waste* into valuable end-products recognizes the economic benefits of a *circular economy*. It is important that Ontario has sufficient infrastructure capacity and innovative technologies to process *food and organic waste* into valuable resources.
4. **Promote *beneficial uses* of recovered organic resources**: Supporting end-products and sustainable markets for recovered organic resources is critical. This includes supporting *beneficial uses* which promote soil health, crop growth and enhance carbon storage. Promoting end-products like renewable natural gas and electricity can help replace carbon-intensive fossil fuels.

Figure 5: Food in a Circular Economy



This document outlines Ontario's Framework. Together with the Strategy for a Waste-Free Ontario: Building a Circular Economy and Ontario's Climate Change Action Plan, the Framework will help the province build a *circular economy* and fight climate change. The Framework consists of two complementary components:

- **Part A: Food and Organic Waste Action Plan** which outlines strategic commitments to be taken by the province to address *food and organic waste.*
- **Part B: Food and Organic Waste Policy Statement** under the Resource Recovery and Circular Economy Act, 2016, which provides direction to the province, *municipalities*, the IC&I sector, *owners* and *operators* of *resource recovery systems* and others to further the provincial interest in *waste reduction* and *resource recovery* as it relates *to food and organic waste.*

The Framework includes actions and policies that seek to prevent and reduce *food and organic waste*, rescue surplus food, collect and recover *food and organic waste*, and support *beneficial use* of recovered organic resources.

FOOD AND ORGANIC WASTE ACTION PLAN

Ministry of the Environment and Climate Change

1. Reduce *Food Waste*

1. Province to work with partners to develop promotion and education tools to support *food waste* prevention and reduction

Promotion and education is critical to preventing *food waste* from occurring in the first place. Preventing and reducing *food waste* also helps mitigate environmental impacts associated with food that is grown, processed, transported and offered for sale or sold to consumers – only to be thrown out.

Many Ontarians want to see increased awareness of *food waste*, ultimately leading to behavioural changes and creating a culture of *food waste* avoidance.

As such, the province will work with partners such as Foodland Ontario, *municipalities*, the Industrial, Commercial and Institutional (IC&I) sector, and non-profit organizations to develop educational tools and resources, which could be tailored for various audiences. These could include:

- Standardized promotion and education and guidance materials (e.g. best practices for meal planning and food storage, including tips on how to extend the life of food, such as freezing food where appropriate and safe).
- Demonstrating market opportunities for *imperfect produce* and culled products for producers and processors.
- Exploring opportunities to use digital tools to raise awareness and change behaviour (e.g. using social media, web-based platforms and applications that support *food waste* prevention).

The province will work with interested partners, build on existing efforts and consider any relevant national policies, initiatives or other successful *waste reduction* activities in other comparable jurisdictions.

2. Province to enhance and incorporate *waste reduction* and *resource recovery* activities within schools

The province intends to work with partners to raise awareness and take action to reduce *food and organic waste* and increase *resource recovery* within school communities. Potential actions could include:

- Supporting waste audits in schools which measure the amount of *food and organic waste* and related greenhouse gas emissions.

- Developing communications that will reach audiences in schools of all ages and extend into the broader community, including rural, remote and Northern communities.
- Developing and delivering workshops and skill-building sessions which bring together participants from all levels within the school community.
- Developing guidelines and training to support waste prevention and reduction in schools, especially as it relates to *food and organic waste*.

3. Province to work with the Government of Canada on preventing *food waste*

The province intends to work in co-operation with the Government of Canada to align efforts, where possible, on preventing and reducing *food waste* and greenhouse gas emissions from *food waste*.

The Government of Canada is currently investigating initiatives that will aim to reduce the amount of food being wasted in Canada. Environment and Climate Change Canada's Strategy on Short-Lived Climate Pollutants identifies the intent to consult on strategies to reduce avoidable *food waste* and increase *resource recovery* in order to reduce landfill methane emissions.

In addition, the Government of Canada is also responsible for establishing regulations regarding best before dates for food products. The Canadian Food Inspection Agency is currently undertaking a Food Labelling Modernization Initiative, which includes a review of date labelling formats to simplify their readability and to expand their use. Voluntary date labelling on products that are not subject to date labelling requirements is widely used. However, because the product is not required to have date labels, many different date label formats have evolved that can lead to consumer confusion. As part of the labelling initiative, the Canadian Food Inspection Agency has indicated that clear date labelling needs to be supported with consumer education to improve understanding and use of best before dates.

The province supports the Government of Canada's initiative to clarify current food labelling practices in an effort to reduce consumer confusion and ultimately *food waste*.

The province is working with the Government of Canada as it develops a proposed Food Policy for Canada which will help:

- Address *food waste.*
- Increase access to affordable food, improving health and food safety.
- Conserve soil, water, and air.
- Grow more high-quality food.

4. Province to work with partners to support innovative approaches and tools to rescue surplus food

A number of innovative initiatives have been launched by businesses, social enterprises, non-profit organizations and social agencies to rescue food which would otherwise be destined for disposal. Food service providers, retailers, wholesalers, and producers often donate fresh or prepared culturally-appropriate surplus food to social service agencies, community organizations, and social enterprises that have the capacity to receive, store, refrigerate, and prepare food. These recipients can utilize surplus food for a range of services and initiatives, such as the provision of emergency meals to those in immediate need of food, the development of value-added products, food skills training, or employment and training and job readiness programs related to the food industry.

While the ultimate aim is to have an Ontario where excess food is no longer produced or wasted, the rescue of surplus food can ensure a resource as valuable as food does not go to waste. There are existing laws and programs that support the redistribution of food in Ontario, specifically:

- The Ontario Community Food Program Donation Tax Credit for Farmers, under the Taxation Act, 2007, provides tax credits to persons that donate agricultural products to eligible programs.
- The Ontario Donation of Food Act, 1994 encourages donations, with certain limitations, and protects food donors from liability as a result of injuries caused by the consumption of donated food.

The province will work with partners across sectors to help ensure that surplus food does not become waste. This will help create opportunities for local organizations to meet immediate needs, and engage their communities on food issues. For example, through the 2017 Budget Talks process[12], the province is providing $600,000 to Second Harvest, a *food rescue organization*, to pilot a food rescue program aimed at preventing food from becoming waste. This initiative will build capacity for:

- Food related businesses to donate perishable surplus food.
- Social service organizations to safely transport fresh and nutritious food for distribution.

In addition to such efforts to make better use of surplus food, Ontario also needs to address the key drivers of individual and household food insecurity. The province is developing a Food Security Strategy with a vision where every person has dignified access to high-quality, safe, nutritious and culturally-appropriate food, to support them in leading healthy and active lives.

5. Province to develop food safety guidelines to support the safe donation of surplus food

Food donation occurs where perishable and non-perishable food items are donated by individuals and organizations. Perishable food donation is most common when a grocery store or restaurant donates fresh produce or prepared foods to *food rescue organizations*.

Ensuring that surplus food is safe for human consumption is a common concern for organizations that support food rescue initiatives, such as food retailers and *food rescue organizations*. Food safety is important for perishable food donations and food may not be safe to donate if it has not been handled or stored properly.

Regulation 562 (Food Premises) made under the Health Protection and Promotion Act sets the requirements for operating a food premises, such as safe food handling and preparation, food storage, sanitation, dishwashing and hygiene practices. Food retailers and *food rescue organizations* must also follow these requirements. To support the regulation, the province is proposing to develop guidelines to promote the safe donation of surplus food.

While non-perishable food items are appropriate and most commonly associated with food donations, there is a clear need for more fresh vegetables, fruit, and protein. The guidelines could help identify which healthy food and beverages are most in demand and outline the food safety requirements for donors and for *food rescue organizations* to receive and store safely. The guidelines could also detail unacceptable food donations and examples of foods that are not considered appropriate for donation.

These guidelines, along with other ongoing efforts to support healthy food access and food security, can help improve the quality of foods available so families in need of assistance could have access to healthy and nutritious foods.

6. Province to support research aimed at reducing and recovering *food and organic waste*

To support the objectives of the Framework, the province will continue to support and partner with organizations on research related to *food and organic waste*. Two examples are:

- The Ministry of the Environment and Climate Change research programs and investments in innovation.
- The Ministry of Agriculture, Food and Rural Affairs (OMAFRA) research and knowledge mobilization programs which funds projects in collaboration with the agri-food sector, academic, and research institutions such as the University of Guelph Partnership.

7. Province to develop data collection mechanisms for measuring progress in *waste reduction* and *resource recovery* of *food and organic waste*

Reliable data is the foundation for supporting evidence-based decision-making and measuring progress. There is an opportunity to collect more information and data on *food and organic waste* to improve our current knowledge, including how much is generated and how it is managed. Filling these knowledge gaps through robust data and sound performance metrics is critical to building a better understanding of environmental and economic conditions and assessing policy and its outcomes.

Enhancing data collection will help to:

- Evaluate and assess our progress.
- Measure and focus efforts to prevent and reduce *food and organic waste* and assess effectiveness of behaviour change with regard to *food and organic waste* over time.
- Understand trends, gaps and opportunities to prevent *food waste* and increase the *resource recovery* of *food and organic waste*.
- Improve our understanding of the impacts of the province's polices, and foster continuous improvements.
- Improve transparency and accountability through greater availability of data for public use.

This is especially important in the IC&I sector, where there is limited available data to confirm the extent of current *waste reduction* and *resource recovery* efforts.

The province intends to work with stakeholders to develop mechanisms for creating baseline data related to *food and organic waste*. Once the baseline is established, it can be used to monitor and report on progress in *waste reduction* and *resource recovery*. In developing data collection mechanisms, the province would conduct consultations prior to putting any new requirements in place and would consider:

- Building on and, where appropriate, adopting relevant best practices and data collection initiatives for Ontario.
- Enhancing existing data reported by Ontario *municipalities* and *owners* and *operators* of *waste management systems*.
- Clarifying the scope of data that should be collected and the frequency of reporting.
- Considering measures to ensure confidentiality and reduce potential administrative burden on businesses.

2. Recover Resources from *Food and Organic Waste*

8. Province to amend the 3Rs Regulations to include *food and organic waste* and increase *resource recovery* across the IC&I sector

The IC&I sector presents some of the best opportunities to increase *resource recovery* and build a *circular economy*. *Resource recovery* costs in the IC&I sector are generally lower than in the residential sector. Investment in capacity related to increased *resource recovery* in these sectors has the potential to further improve economies of scale that may translate into additional opportunities in the residential sector.

Ontario's 3Rs Regulations regulate specified actors in the IC&I sector in relation to waste. The regulations target large IC&I actors and do not require the *resource recovery* of *food and organic waste*. O. Reg. 102/94 (Waste Audits and Waste Reduction Work Plans), requires the actors to prepare waste audits of the waste generated at a particular establishment. It also requires waste reduction work plans that include, to the extent reasonable, plans to reduce, reuse and recycle waste. O. Reg. 103/94 (Industrial, Commercial and Institutional Source Separation Programs) requires specified actors in the IC&I sector to develop a source separation program which includes "reasonable efforts" to ensure that separated waste is reused or recycled. Lastly, O. Reg. 104/94 (Packaging Audits and Packaging Reduction Work Plans) requires packaging audits and packaging reduction work plans.

The province intends to consult on amendments to the 3Rs Regulations to include *food and organic waste* to increase *resource recovery* across the IC&I sector. Amendments could consider:

- Different thresholds for establishments based on their sector and facility size, volume of *food and organic waste* generated and geographic population levels.
- Existing efforts by the IC&I sector to support *waste reduction* and *resource recovery*.
- The breadth of *food and organic waste* covered by the regulation.
- The appropriateness of source separation requirements for specific types of *food and organic waste,* and the role of education and awareness activities on how to source separate.
- Efforts to ensure a *beneficial use* for all recovered *food and organic waste*.
- The role of other processing technologies to recover organic resources from disposal streams for *beneficial uses*, where source separation is not feasible.

- Measures to promote the quality of recovered organic material streams, such as requirements to remove *food waste* from packaging or prohibitions on deliberate contamination of source separated streams.
- The need for data gathering and reporting to measure progress, and measures to promote accountability and transparency.
- Potential reduction of administrative burden and consideration of economic impact of new or expanded requirements on the IC&I establishments.

9. Province to ban *food and organic waste* from ending up in disposal sites

The province will develop, consult on, and implement a *food and organic waste* disposal ban regulation under the Environmental Protection Act. The regulation could prohibit the disposal of *food waste* and *organic waste* at waste disposal sites (e.g. landfills, incineration facilities) and support the *beneficial use* of recovered organic resources.

A disposal ban on *food and organic waste* could create new opportunities for *waste reduction*, surplus food rescue, and offer new approaches to *resource recovery* creating value at all levels of the value chain. A disposal ban could drive investment in *resource recovery systems*, create jobs and support innovation in the province. A disposal ban would significantly reduce our reliance on landfills.

In developing the proposed disposal ban the province would consider the breadth of *food and organic waste* covered and the following elements:

- What disposal sites could be impacted by the requirements including:
    - Open and active landfills.
    - Thermal treatment sites.
    - Transfer stations.
- How best to implement a disposal ban, allowing for time to build capacity, which could consider:
    - Time for implementation: The province could consider time needed to support the development of sufficient *food and organic waste* processing infrastructure and capacity to manage additional volumes being recovered before the disposal ban would come in effect.
    - Phased-in timelines and geographical application: Requirements could be phased-in over a number of years for rural, remote and Northern areas of Ontario.
    - Allowances and exemptions: Geographic-based exemptions could be considered (e.g. landfills serving rural, remote, Northern and Indigenous communities, and unorganized territories that do not have regional

processing facilities), and thresholds could be considered for compliance at disposal sites.

    - Compliance and enforcement: The province has a number of compliance and enforcement tools under the Environmental Protection Act to enhance the implementation of the disposal ban, including inspection, administrative penalties, investigation and prosecution.

- To support the successful implementation of the disposal ban, the province could consider:
    - Requirements that also apply to waste generators, waste transporters, owners and operators of transfer stations and disposal sites.
    - Measures to combat potential illegal dumping of waste.

The province will conduct extensive consultations before putting in place any new requirements. Consultations will aim to address implementation and operational challenges, including the necessary time to plan for and build additional *resource recovery systems*, barriers for multi-unit residential buildings and challenges for rural, remote and Northern communities that could be impacted.

10. Province to support *resource recovery* of *food and organic waste* in multi-unit residential buildings

Resource recovery in multi-unit residential buildings in Ontario remains low, including for *food and organic waste*. Common factors for this include:

- Many buildings were built many years ago and designed to manage a single waste stream through a single "garbage" chute.
- These buildings often have limited accessibility to source separation services.
- There are costs associated with developing a multi-stream collection system, including *food waste, organic waste*, blue box materials, and residual garbage.

The province has heard from stakeholders that greater efforts are needed to increase *resource recovery* in multi-unit residential buildings, supported by a review of the Building Code.

The Building Code Act, 1992 and the Building Code govern the construction, renovation, demolition and change of use of buildings. The Building Code is a regulation under the act and sets out technical and administrative requirements, and also addresses building permit issuance and construction inspections. Enforcement of the Building Code is a local responsibility, primarily in the hands of local municipalities.

The province will review the Building Code to assess that the requirements for new construction enable and promote design and construction options that support the *resource recovery* of *food and organic waste* in multi-unit residential buildings.

11. Province to develop best management practices to support effective use of public waste receptacles

Waste receptacles can at times be confusing to use for the public. They are often designed and labelled differently resulting in confusion as to where to deposit materials. Clearer messaging can often result in improved *resource recovery* outcomes.

Although most Ontarians believe recycling is important, this intention does not always translate into action. To help close this “intention-action gap”, an approach beyond traditional educational campaigns can be beneficial. A behavioural sciences approach can help change behaviour and encourage proper recycling.

In an effort to improve the availability and quality of recycling in public spaces, the province will study best practices to support the effective use of public waste receptacles. To support the development of best practices associated with public waste receptacles, the province is working to apply knowledge and methodologies from the behavioural sciences to optimize bin labels to increase accurate recycling behaviour.

The province will examine whether a simple and inexpensive intervention such as the use of behaviourally designed labels and receptacle placement can improve the volume and quality of recovered resources. The province will consider the impacts of new labels that have incorporated behaviourally-based designs, using clear and direct messaging, modern and simple icons, and promoting deeper cognitive engagement. The placement of waste receptacles, when optimized according to analysis of public behaviours and preferences, could also help promote source separation and increase *resource recovery*. The province will make the study and best practices available for use by *municipalities* and the IC&I sector to improve recycling behaviour and the recovery of *food and organic waste*.

3. Support *Resource Recovery* Infrastructure

12. Province to review existing approval processes and requirements for *resource recovery systems* using a modern regulator approach

The province will provide an effective and modern regulatory environment that aligns an activity's permission process with its environmental risk.

Ontario currently has regulatory requirements in place to ensure that *resource recovery systems* have the appropriate approvals and are following standards and practices that are protective of human health and the environment. The province intends to assess new approaches and processes to facilitate approvals, while ensuring appropriate consultation with communities and other interested stakeholders and continued protection of human health and the environment.

Potential changes and process enhancements to be explored could include, but are not limited to:

- Pre-determined setbacks and standards for small-scale and low-risk *food and organic waste* processing sites (e.g. community composting, on-site *food and organic waste* composting and processing, such as vermicomposting), with guidance for project developers and operators, as well as the ability to track and inspect sites.
- Updating the Checklist for Technical Requirements for a Complete Environmental Compliance Approval Submission for all medias (e.g. air, noise, waste – including *food and organic waste*), to reduce risk of incomplete applications.
- Support opportunities for innovative demonstration projects (e.g. waste pilot projects, pilots for innovative technology verification) to assist designing, assessing, or demonstrating the merits of a new technology. The province will consider changes to regulatory requirements associated with demonstration projects for processing *food and organic waste*, including considerations for the role of suitable small-scale and on-site processing activities.

In the 2015 Fall Economic Statement the province committed to implementing a one-year service standard for higher-risk Environmental Compliance Approval requests received after 2017, such as applications related to *food and organic waste* processing sites. This will include the development of a performance measure for meeting the service standard that recognizes the complexities of some approvals. Since the release of the 2015 Fall Economic Statement, the province has taken a number of steps to meet this commitment including:

- Development of an enhanced screening process of Environmental Compliance Approval applications to determine whether all necessary information has been submitted.
- Returning incomplete applications.
- For air and noise approvals, continue with the development of Environmental Activity and Sector Registry approvals for low-risk media applications
- Continued implementation of multi-media Environmental Compliance Approvals for site operations.

The province will continue on its path to becoming a modern regulator by using a risk-based approach focused on electronic service delivery and strategic application of resources. Further, the province will continue to work towards reducing regulatory burden and building an approval system that matches the level of regulatory oversight to the risk to the environment and human health. As such, the province will be completing a review of the approvals process for *resource recovery systems* and determine opportunities for streamlining.

13. Province to require standardized training for *owners* and *operators* of *resource recovery systems* that undertake composting and *anaerobic digestion*

To ensure the proper operation of *resource recovery systems*, minimize nuisance impacts and support high-quality end-products, the province will consider requiring *owners* and *operators* of *resource recovery systems* that undertake composting or *anaerobic digestion* to have training. Training would be developed based on associated environmental risks. Training requirements could be established through regulation or incorporated as a pre-requisite to obtaining or renewing an Environmental Compliance Approval.

Resource recovery systems that include composting or *anaerobic digestion* facilities would be required to have an "operator-in-charge" who has completed the certified training. Other operators at the facilities would be encouraged to complete the training. Training could also be developed and in some cases required for small-scale and low-risk *food and organic waste* processing sites (e.g. community composting, on-site *organic waste* composting and processing).

The province would establish the basic elements of the training curriculum, while the design and delivery of the training program could be undertaken by a third party. Specific components of the training program could include organic processing system components, maintenance, emergency operations, and applicable standards for end-products.

14. Province to review its *D-Series Land Use Compatibility Guidelines* to support the development of *resource recovery systems*

Processing capacity is the critical link in supporting widespread *resource recovery*. When improperly sited or designed, however, *resource recovery systems* can create land use conflicts between neighbouring land uses (e.g. residential areas) that create issues and can hinder *resource recovery*.

While supporting the development of additional *resource recovery* capacity, the province recognizes that further considerations are needed to avoid nuisance and negative impacts on nearby communities as part of the development and implementation of the Framework.

The *D-Series Land Use Compatibility Guidelines* provides direction for land use planning authorities on how to decide whether new development or land uses are appropriate to protect people and the environment. These guidelines identify considerations and criteria to influence buffers, separation distances and other control measures for land use planning proposals to prevent or minimize *adverse effects* from the encroachment of incompatible land uses.

The province will review its *D-Series Land Use Compatibility Guidelines* to ensure that land use planning guidance is up-to-date and to provide further clarity to help determine compatibility of major *resource recovery systems* with adjacent land uses during the planning stages of a facility.

A review of the *D-Series Land Use Compatibility Guidelines* could include:

- Information on how to identify, review and assess the compatibility and proximity of sensitive land uses to *food and organic waste* facilities.
- Consideration of relevant influence areas, buffers and setbacks for *food and organic waste* processes, such as composting, *anaerobic digestion*, rendering, pyrolysis and other treatment.
- Requirements for studies and feasibility analyses to identify and address nuisance impacts as they relate to organic-related odour issues.

Reviewing and considering revisions to the *D-Series Land Use Compatibility Guidelines* will help provide the province, *municipalities*, other planning authorities and *owners* and *operators* of *resource recovery systems* with modern land use planning guidance that reflects the opportunities and pressures faced when siting *resource recovery systems* in Ontario. Revised guidance will assist in the appropriate siting and design for additional *resource recovery systems* needed to ensure that any disposal ban on *food and organic waste* can be successfully implemented.

The review of the *D-Series Land Use Compatibility Guidelines* will build on the land use planning guidance provided in the Food and Organic Waste Policy Statement, as well as the Facility Approval and Siting Considerations included in *Ontario's Compost Quality Standards* and the *Guideline for the Production of Compost in Ontario*.

4. Promote Beneficial Uses

15. Province to support healthy soils with strong standards and clear requirements for the use of soil amendments, while protecting the environment and human health

Given the right conditions, *food and organic waste* can be recovered and reintegrated into the economy. For this to happen, greater effort is needed to support the development of viable and sustainable markets for the end-products created by *resource recovery systems*.

A. Province to review regulatory approaches related to soil amendments

Following appropriate *resource recovery* processes, *food and organic waste* can be used to make valuable end-products. Soil amendments that include *compost*, *digestate* (from *anaerobic digestion*) and biochar (from pyrolysis) can be applied to land by farmers, residents, *municipalities* and landscaping and horticulture industries.

The province recognizes that soil amendments need to be suitable for *beneficial uses*, particularly for farms, to support the long-term agricultural productivity of the land and the production of nutritious food for generations to come. The province's existing standards and requirements for production and use of *compost* and the nutrient management framework for the land application of *biosolids* aim to ensure that soil amendments do not pose any negative impacts to the environment or human health.

Ontario's Compost Quality Standards and the *Guideline for the Production of Compost in Ontario* enable the composting of a broad range of materials and provide guidance for *compost* facility operators, while protecting the environment and human health. Under *Ontario's Compost Quality Standards*, there are three categories of *compost* (AA, A and B), and each have quality standards for metals, pathogens, foreign matter and maturity. *Compost* meeting the AA and A standards is exempt from provincial approvals for transport and use. Other organic resources can be applied to land through an Environmental Compliance Approval or as a Non-Agricultural Source Material on agricultural land, for which a plan may be required.

In addition to satisfying the province's quality standards and restrictions on use, all *compost* end-products sold in the Canadian marketplace must also meet the safety, microbial quality, efficacy, and labelling requirements in the federal Fertilizers Act and regulations, administered by the Canadian Food Inspection Agency.

To support continuous improvement, the province is proposing to review approaches and guidance related to soil amendments, with a focus on addressing specific issues raised by stakeholders, while following best-practices and protecting the environment and human health. Risk-based quality standards will support consistent and safe end-products that have a *beneficial use*. As additional *food and organic waste* processing capacity is developed in Ontario, there will be a need to expand and diversify the end-uses of soil amendments to support demand.

B. Province to promote the on and off-farm end-use of soil amendments made from recovered organic resources

The province will work to further promote the *beneficial use* of soil amendments, such as *compost*, *digestate* and *biosolids*, where appropriate, for site reclamation and soil remediation activities. The province is already implementing the use of soil amendments to remediate sites through Environmental Compliance Approvals (e.g. mine reclamation activities), and will continue to promote the use of soil amendments for this use going forward.

The province will also work with stakeholders (e.g. conservation authorities) to provide information on best practices related to the use of soil amendments, including information for end-users on how *compost*, blended and manufactured soils can be used (e.g. types of crops, landscaping activities, horticulture), and when they should be used (i.e. before planting). The aim of this action is to support demand for soil amendments, through the availability of resources and tools to make informed decisions. The province's proposed excess soil reuse regulation would align with this direction.

Further, in conjunction with other jurisdictions and partners, the province will work towards consistent management of future soil blending and manufacturing activities, including the manufacture of soils and soil blends using organic soil amendments and other recycled materials. Soil blending to improve soil characteristics using added *compost, digestate,* or other soil amendments on-site is being done by conservation authorities and development sites for activities such as tree planting, which could enhance soil moisture holding capacity and help improve soil health.

To support this activity, the province will examine the need for new standards for mixing excess soil with soil amendments such as *compost* to create new end-products and to promote the *beneficial use* of blended materials, for a variety of uses.

C. Province to promote the use of soil amendments as part of the Agricultural Soil Health and Conservation Strategy

The province, in collaboration with its soil health partners, is developing an Agricultural Soil Health and Conservation Strategy for Ontario, which proposes actions to achieve the vision, goals, objectives and concepts presented in the 'Sustaining Ontario's Agricultural Soils: Towards a Shared Vision' discussion document.

Globally, and in Ontario, agricultural soil is at risk from many threats:

- More demands on soils to grow food and bioproducts as a result of increasing global population.
- Adherence to older cropping, tillage and other practices that can degrade soil health.
- Focus on short-term economic gain from cultivated land rather than considering a balanced approach, with longer-term soil health investments and benefits.
- More frequent extreme weather and flooding due to climate change, which can speed up soil degradation.

As a result, many of Ontario's valuable soils are estimated to be losing organic matter, and are at risk of being degraded and eroded. That's why the province along with farm organizations, agri-food businesses, academia, conservation organizations and the Government of Canada are working together to develop this Agricultural Soil Health and Conservation Strategy. It will provide farmers, citizens and the province with a roadmap for protecting and improving agricultural soil so it can remain productive well into the future.

One of the basic principles for improving soil health is to increase soil organic matter, through the application of manure, *compost, digestate* and other soil amendments. It not only builds soil carbon, but also increases biological activity and soil structure, which provide a *beneficial use* to crop production and the environment. However, such organic soil amendments are often not available where they are needed at an affordable cost. The Agricultural Soil Health and Conservation Strategy is expected to include recommendations for building soil organic matter, as well as enabling actions which will support the objectives and actions in the Framework.

16. Province to support development of renewable natural gas including consideration for linkages to *food and organic waste*

The province will support markets for biogas through actions to fight climate change. The Climate Change Action Plan provides financial support to encourage the use of cleaner, renewable natural gas and other low-carbon substitutes in the industrial, transportation and building sectors.

Anaerobic digestion is a process that creates biogas and *digestate* from organic materials like *food and organic waste*, including manure. The biogas created consists primarily of methane and is considered a renewable form of energy that can be used to generate electricity or produce renewable natural gas.

Natural gas for its part is comprised largely of methane. This makes any *food and organic waste* a potential source of methane for renewable natural gas. This renewable natural gas can be directly substituted for conventional fossil-based natural gas.

In 2016, Ontarians consumed over 24.5 billion cubic meters of natural gas in 2016, resulting in over 46 megatonnes of carbon dioxide equivalent emissions. Renewable natural gas is a low-carbon fuel that does not add new carbon to the atmosphere. In fact, renewable natural gas can reduce our greenhouse gas emissions when substituted for fossil natural gas and is compatible with conventional natural gas infrastructure and equipment.

17. Province to support green procurement practices, including the use of end-products, such as *compost* and *digestate*

As increased *food and organic waste* processing is developed, there needs to be a corresponding increase in the availability of markets for the processed end-products such as *compost* and *digestate*.

As signalled in the Strategy for a Waste-Free Ontario: Building the Circular Economy, the province will continue to use its existing procurement policies and practices to encourage and support the purchasing of green products and services, where applicable, including end-products made from recovered organic resources.

The province will lead by example and continue to use its existing procurement practices to support the purchasing of green products and services, where applicable, including end-products made from recovered organic resources in a variety of end-uses. In addition, the province will continue to review its existing procurement policies to ensure procurement rules enable the achievement of government objectives.

5. Timelines

Timelines for Action Plan

The following table outlines implementation **timelines** for the Action Plan:

ACTION	CURRENTLY UNDERWAY	SHORT-TERM (2018-2020)	LONG-TERM (2021 – beyond)
1. Province to work with partners to develop promotion and education tools to support *food waste* prevention and reduction		X	
2. Province to enhance and incorporate *waste reduction* and *resource recovery* activities within schools		X	
3. Province to work with the Government of Canada on preventing *food waste*	X		
4. Province to work with partners to support innovative approaches and tools to rescue surplus food	X	X	
5. Province to develop food safety guidelines to support the safe donation of surplus food		X	
6. Province to support research aimed at reducing and recovering *food and organic waste*	X	X	
7. Province to develop data collection mechanisms for measuring progress in *waste reduction* and *resource recovery* of *food and organic waste*		X	
8. Province to amend the 3Rs Regulations to include *food and organic waste* and increase *resource recovery* across the IC&I sector		X	X

ACTION	CURRENTLY UNDERWAY	SHORT-TERM (2018-2020)	LONG-TERM (2021 – beyond)
9. Province to ban *food and organic waste* from ending up in disposal sites		X (consulting 2018-2019)	X (phased-in beginning 2022)
10. Province to support *resource recovery* of *food and organic waste* in multi-unit residential buildings			X
11. Province to develop best management practices to support effective use of public waste receptacles		X	
12. Province to review existing approval processes and requirements for *resource recovery systems* using a modern regulator approach		X	
13. Province to require standardized training for *owners* and *operators* of *resource recovery systems* that undertake composting and *anaerobic digestion*		X	
14. Province to review its *D-Series Land Use Compatibility Guidelines* to support the development of *resource recovery systems*		X	
15. Province to support healthy soils with strong standards and clear requirements for the use of soil amendments, while protecting the environment and human health	X		
A. Province to review regulatory approaches related to soil amendments		X	
B. Province to promote the on and off-farm end-use of soil amendments made from recovered organic resources		X	X

ACTION	CURRENTLY UNDERWAY	SHORT-TERM (2018-2020)	LONG-TERM (2021 – beyond)
C. Province to promote the use of soil amendments as part of the Agricultural Soil Health and Conservation Strategy		X	X
16. Province to support development of renewable natural gas including consideration for linkages to *food and organic waste*		X	X
17. Province to support green procurement practices, including the use of end-products, such as *compost* and *digestate*	X	X	

MEASURING SUCCESS

Success will depend on the ability to gather data and assess and measure progress. As a province, we need to know how resources are being used, managed and reintegrated into the economy to set priorities and track our success.

To monitor and evaluate progress, the province has identified a number of performance measures, including:

Move towards zero *food and organic waste*

- Reduce *food and organic waste* sent to disposal – as demonstrated by declining tonnes or volume of *food and organic waste* sent to disposal supporting the province's visionary goal of zero waste – aimed at preventing the need for traditional end-of-life waste management solutions.

- Reduce *food waste* across the food supply chain – as demonstrated by *waste reduction* across the IC&I sector.

Reduce greenhouse gas emissions from *food and organic waste*

- Reduce greenhouse gas emissions from *food and organic waste* – as demonstrated by declining tonnes of greenhouse gas emissions from the waste sector (contributing to the overall provincial visionary goal of zero greenhouse gas emissions from the waste sector).

Increase *resource recovery*

- Increase *resource recovery* of *food and organic waste*:
    - The residential sector, as measured by increased access to collection services, including those for single-family dwellings and *multi-unit residential buildings*; and
    - The IC&I sector, as measured by increased *resource recovery* of *food and organic waste* across this sector.

Support evidence-based decision-making

- Improve understanding of *food and organic waste* and its value to improve decision-making – as demonstrated by an increase in available data and the timely collection and reporting of this data; along with support for academic research.

Raise awareness among stakeholders and the public

- As demonstrated by the development of tools to support keeping *food and organic waste* out of disposal, and the implementation of learning activities for children in schools.

Ensure adequate *resource recovery* capacity for *food and organic waste*

- As demonstrated by the additional *resource recovery* capacity to meet the demand of increased *food and organic waste* being recovered.

GLOSSARY

Adverse effect: means one or more of:

i. impairment of the quality of the natural environment for any use that can be made of it,
ii. injury or damage to property or to plant or animal life,
iii. harm or material discomfort to any person,
iv. an *adverse effect* on the health of any person,
v. impairment of the safety of any person,
vi. rendering any property or plant or animal life unfit for human use,
vii. loss of enjoyment of normal use of property, and
viii. interference with the normal conduct of business.

(As defined in the *D-Series Land Use Compatibility Guidelines*.)

Anaerobic digestion: means the decomposition of organic matter by bacteria in an oxygen-limiting environment (as defined in Regulation 347 under the Environmental Protection Act). The biogas generated through *anaerobic digestion* can be used to fuel electrical generators, or it can be further processed into renewable natural gas. The *digestate* may also be used as a soil amendment that is most commonly used in agricultural operations.

Beneficial use: means the use of organic resources recovered from *food and organic waste* to deliver nutrients, organic matter, or moisture to improve soil fertility, soil structure or to help build soils where they do not exist. Use of recovered organic resources for landfill cover is not considered a *beneficial use*. The generation of energy or alternative fuels from recovered *food and organic waste* is not considered a *beneficial use*. The recovery of nutrients, such as *digestate* from *anaerobic digestion*, is considered a *beneficial use* where the *digestate* is used to build new or improve existing soils.

Biosolids: means the residue from a sewage treatment works following treatment of sewage and removal of effluent.

Circular economy: means an economy in which participants strive to minimize the use of raw materials, to maximize the useful life of materials and other resources through *resource recovery*, and to minimize waste generated at the end of life of products and packaging (as defined in the Resource Recovery and Circular Economy Act, 2016).

Compost: means waste treated by aerobic decomposition of organic matter by bacterial action for the production of stabilized humus. *Compost* may be used as a soil amendment that is most commonly used in agricultural, horticultural and landscaping operations, as well as by residents in home gardens.

Compostable products and packaging: means products and packaging made that are intended to be managed at end of life through composting, *anaerobic digestion*, or other processes that result in decomposition by bacteria or other living organisms.

D-Series Land Use Compatibility Guidelines: means the environmental land use planning guides which provide environmental considerations and requirements for industrial land use, sensitive lands, sewage and water services, and private wells (https://www.ontario.ca/page/environmental-land-use-planning-guides).

Digestate: means the solid or liquid material that results from the treatment of *anaerobic digestion* materials in a mixed *anaerobic digestion* facility.

Director: means a Director appointed under section 5 of the Environmental Protection Act for the purposes of s.20.3 of the Act.

Educational Institution: means an operator of an educational institution to which section 14 of O. Reg. 103/94 under the Environmental Protection Act applies as it read immediately before the day this Policy Statement was issued.

Food and organic waste: has the same meaning of *food waste* and *organic waste* when used together.

Food rescue organization: means a non-profit organization that rescues, gleans, transports, prepares and distributes excess or surplus food from food wholesalers, food processors, food retailers, grocery stores and restaurants.

Food waste: means the edible parts of plants and animals that are produced or harvested but that are not ultimately consumed.

Guideline for the Production of Compost in Ontario: means the guideline developed by the Ministry of the Environment and Climate Change to assist proponents of composting facilities, ministry staff and others in the siting, design, and approval of composting facilities. It also provides guidance on the production of compost based on engineering principles, practical experience, and current legislation, to protect public health and the environment (https://www.ontario.ca/page/guideline-production-compost-ontario).

Hospital: means an operator of a public hospital to which section 13 of O. Reg. 103/94 under the Environmental Protection Act applies as it read immediately before the day this Policy Statement was issued.

Hotel and motel: means an owner of a hotel or motel to which section 12 of O. Reg. 103/94 under the Environmental Protection Act applies as it read immediately before the day this Policy Statement was issued.

Imperfect produce: refers to whole and fresh fruits and vegetables that do not meet conventional grade and other non-food safety standards set by packers or retailers whether due to the size, shape or appearance of the item (for example, the presence of blemishes or discolouration), but are otherwise safe to consume and are not affected by rot, mold, insect damage or other contamination.

Large manufacturing establishment: means an owner or operator of a large manufacturing establishment to which section 15 of O. Reg. 103/94 under the Environmental Protection Act applies as it read immediately before the day this Policy Statement was issued.

Local municipality: means a *single-tier municipality* or a *lower-tier municipality* (as defined in the Municipal Act, 2001).

Lower-tier municipality: means a municipality that forms part of an *upper-tier municipality* for municipal purposes (as defined in the Municipal Act, 2001).

Mixed waste processing: means *resource recovery* processes that recover *food waste* or *organic waste* from waste streams where *food and organic waste* is co-mingled with other wastes.

Multi-unit residential building: means an owner of a building to which section 10 of O. Reg. 103/94 under the Environmental Protection Act applies as it read immediately before the day this Policy Statement was issued.

Municipalities: are geographic areas whose inhabitants are incorporated (as defined in the Municipal Act, 2001).

Northern Ontario: means the territorial districts of Algoma, Cochrane, Kenora, Manitoulin, Nipissing, Parry Sound, Rainy River, Sudbury, Thunder Bay and Timiskaming and The Regional Municipality of Sudbury (as defined in O. Reg. 101/94 under the Environmental Protection Act).

Office building: means an owner of a building or group of buildings to which section 9 of O. Reg. 103/94 under the Environmental Protection Act applies as it read immediately before the day this Policy Statement was issued.

Ontario's Compost Quality Standards: means standards developed by the Ministry of the Environment and Climate Change for aerobic composting of organic waste materials, supported by regulatory amendments (https://www.ontario.ca/page/ontario-compost-quality-standards).

Operator: means the person in occupation or having the charge, management or control of a *resource recovery system*.

Organic waste: means inedible parts of plants and animals, as well as other organic material that may be processed along with *food waste*. Examples of *organic waste* can include but are not limited to leaf and yard waste, *compostable products and packaging*, soiled paper, diapers and pet waste.

Owner: means a person that is responsible for the establishment or operation of a *resource recovery system*, or the person that owns the land in or on which a waste disposal site is located.

Resource recovery: means the extraction of useful materials or other resources from things that might otherwise be waste, including through reuse, recycling, reintegration, regeneration or other activities. This includes the collection, handling, and processing of *food and organic waste* for *beneficial uses*. Although energy from waste and alternative fuels are permitted as waste management options, these methods are not considered *resource recovery*. The recovery of nutrients, such as *digestate* from *anaerobic digestion*, is considered *resource recovery*.

Resource recovery system: means any part of a *waste management system* that collects, handles, transports, stores or processes waste for *resource recovery* purposes, but does not include disposal.

Restaurant: means an owner of a restaurant to which section 11 of O. Reg. 103/94 under the Environmental Protection Act applies as it read immediately before the day this Policy Statement was issued.

Retail shopping complex: means an owner of a complex to which section 6 of O. Reg. 103/94 under the Environmental Protection Act applies as it read immediately before the day this Policy Statement was issued.

Retail shopping establishment: means an owner of an establishment to which section 5 of O. Reg. 103/94 under the Environmental Protection Act applies as it read immediately before the day this Policy Statement was issued.

Single-tier municipality: means a municipality, other than an *upper-tier municipality*, that does not form part of an *upper-tier municipality* for municipal purposes (as defined in the Municipal Act, 2001).

Southern Ontario: means the parts of Ontario other than *Northern Ontario* (as defined in O. Reg. 101/94 under the Environmental Protection Act).

Upper-tier municipality: means a *municipality* of which two or more *lower-tier municipalities* form part for municipal purposes (as defined in the Municipal Act, 2001).

Urban settlement areas: means urban areas within *municipalities* (such as cities, towns, and villages) that are built up areas where development is concentrated and which have a mix of land uses.

Waste management systems: means any facilities or equipment used in, and any operations carried out for the management of waste including the collection, handling, transportation, storage, processing or disposal of waste, and may include one or more waste disposal sites.

Waste reduction: means the minimization of waste generated at the end of life of products or packaging, including through activities related to design, manufacturing and material use (as defined in the Resource Recovery and Circular Economy Act, 2016).

ENDNOTES

[1] Reports on Organic Waste Management in Ontario, prepared for the Ontario Ministry of the Environment and Climate Change, 2015.
[2] VCMI, Food Waste in Canada - $27 Billion Revisited, 2014
[3] Resource Productivity and Recovery Authority, 2015 Datacall
[4]Reports on Organic Waste Management in Ontario, prepared for the Ontario Ministry of the Environment and Climate Change, 2015
[5] National Inventory Report 1990-2015: Greenhouse Gas Sources and Sinks in Canada, Part 3, Environment and Climate Change Canada
[6] Food Wastage Footprint and Climate Change, Food and Agriculture Organization of the United Nations, 2015
[7] Ministry of the Environment and Climate Change, 2017
[8] The Business Case for Reducing Food Loss and Waste, Champions 12.3, March 2017
[9]Reports on Organic Waste Management in Ontario, prepared for the Ontario Ministry of the Environment and Climate Change, 2015
[10]Reports on Organic Waste Management in Ontario, prepared for the Ontario Ministry of the Environment and Climate Change, 2015
[11] Ministry of the Environment and Climate Change, 2017
[12] 2017 Ontario Budget

Waste management

What you need to know about how waste is managed in the province, including Ontario's new waste-free Ontario framework.

Ontario residents generate a lot of food and organic waste – 3.7 million tonnes, every year. It is equivalent to filling up the SkyDome in Toronto five times. It comes from our homes, our offices, our businesses. And where does it go? All too often, straight into a landfill, creating greenhouse gas pollution as it breaks down.

The Food and Organic Waste Framework aims to:

- educate people about the importance of preventing and reducing food and organic waste
- set food and organic waste reduction and recovery targets of between 50 and 70 per cent
- help more businesses, condos and apartment buildings across the province collect food and organic waste
- help rescue surplus food from grocery stores, restaurants and hotels

Learn more about the steps Ontario is taking to prevent and reduce food waste in Ontario.

Overview

Ontario is shifting to a circular economy – a new waste management approach where waste is seen as a resource that can be recovered, reused and reintegrated into the production stream.

Ontario's new waste management framework includes new legislation and a strategy to guide progress that will protect the environment, drive innovation, performance and competitiveness, and stimulate economic growth and development.

Shifting Ontario to a circular economy

Ontario has new legislation that lays the foundation to divert more waste from landfills by requiring producers to take full responsibility for recovering resources and reducing waste associated with their products and packaging.

The *Waste-Free Ontario Act* encourages producers to turn more of their waste into new products and will help reduce greenhouse gas pollution by reusing, recycling or composting materials that would otherwise go to landfill.

The *Waste-Free Ontario Act* along with the province's new Strategy for a Waste-Free Ontario: Building the Circular Economy, will:

- encourage businesses to be innovative and design long-lasting, reusable and easily recyclable products
- eliminate industry funding organizations, which set fees that can be passed on to consumers
- encourage companies to look for ways to make their recycling processes more economical while staying competitive
- boost recycling in the business and institutional sectors, which will reduce waste and lower greenhouse gas emissions
- shift the costs of the Blue Box from municipal taxpayers to producers, while continuing to provide convenient collection services for Ontarians
- reduce the amount of food waste and organic materials going to landfills

Waste diversion programs

Ontario has four diversion programs to reuse, recycle or safely dispose of waste. They operate on the producer responsibility principle, where producers are responsible for managing their products and packaging at end-of-life.

The existing programs are the:

- Blue Box Program: recycles printed paper and packaging (plastics, paper, glass, aluminum, steel)
- Municipal Hazardous or Special Waste Program: recycles or properly disposes of paint, antifreeze, batteries, fertilizers and other hazardous or special materials
- Waste Electrical and Electronic Equipment Program: reuses or recycles electronic equipment like computers, televisions and stereos
- Used Tires Program: recycles used tires from passenger, truck and off-road vehicles

The province also has the Ontario Deposit Return Program for beverage and alcohol containers.

In Ontario's circular economy, these programs will continue to operate without disruption until the materials they manage are transitioned to the new framework. Once the materials are transitioned, these programs and the industry funding organizations that operate them will be eliminated.

Waste types

Non-hazardous waste

Non-hazardous waste is generated by households, as well as businesses and organizations in the industrial, commercial and institutional (IC&I) sector. It includes:

- printed paper and packaging (plastics, paper, glass, aluminum, steel, other material)
- organics from food and yard waste
- tires
- cement, metals and glass from construction and demolition

Pharmaceuticals and sharps

Pharmaceutical or sharp producers must establish a minimum number of locations where these products can be collected to be properly disposed of.

A minimum number of collection locations is required, based on the lesser of either a specified percentage of the number of retail locations where products are sold, or a specified percentage of the total number of pharmacies in Ontario as of October 1 in the preceding year. Ontario determines the number of pharmacies accredited under the *Drug and Pharmacies Regulation Act*, in consultation with the Ontario College of Pharmacists.

For 2017, the minimum number of collection locations required is 3,695 and for 2018 it is 3,856.

Find the nearest collection locations.

Food and organic waste

Household food and organic waste mainly includes:

- food waste (cooked or raw)
- surplus food (e.g. non-perishable food suitable for donation)
- yard and garden waste

Industrial, Commercial and Institutional (e.g., restaurants, grocery stores, hospitals, universities, food processors) food and organic waste includes:

- surplus food that is suitable for donation (perishable and non-perishable)
- food waste (cooked or raw)
- food processing/manufacturing waste and by-products
- leaf and yard waste
- other sources of organic materials not listed above including biosolids

Ontario's rules and regulations ensure that food and organic waste is processed and used safely. These rules are specific to the diversion method.

A large amount of organic green bin and leaf and yard wastes are diverted from disposal through municipally operated programs. Please contact your local municipality for more information.

Related legislation

The rules and regulations that guide Ontario's resource recovery and waste reduction include:

- *Resource Recovery and Circular Economy Act, 2016*
- *Waste Diversion Transition Act, 2016*
- *Environmental Protection Act*
- *Environmental Assessment Act*
- *Nutrient Management Act*

The *Environmental Protection Act* addresses waste collection, disposal and environmental approvals, including:

- Landfill design standards under *Reg. 232*
- Standards for disposal sites, the management, tracking and disposal of hazardous and liquid industrial waste under *Reg. 347*
- Requirements for landfill gas collection under *Reg. 217*
- Requirements for municipal Blue Box programs under *O. Reg. 101/94*
- Requirements for IC&I sector to reduce waste and recover resource under '3Rs' regulations: *O. Reg. 102/94*, *O. Reg. 103/94* and *O. Reg. 104/94*
- Requirements for producers of pharmaceuticals and sharps to establish free collection locations across Ontario for pharmaceuticals and sharps they no longer need under *Reg. 298/12*
- Ontario Compost Quality Standards under *Reg. 347* and Guidelines for the Production of Compost

Updated: June 28,

2018
Published: November 28, 2014

Rate

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Waste management

Ministry of the Environment, Conservation and Parks

The Ministry of the Environment, Conservation and Parks works to protect and sustain the quality of Ontario's air, land, and water. We also coordinate Ontario's actions on climate change in the name of healthier communities, ecological protection and economic prosperity.

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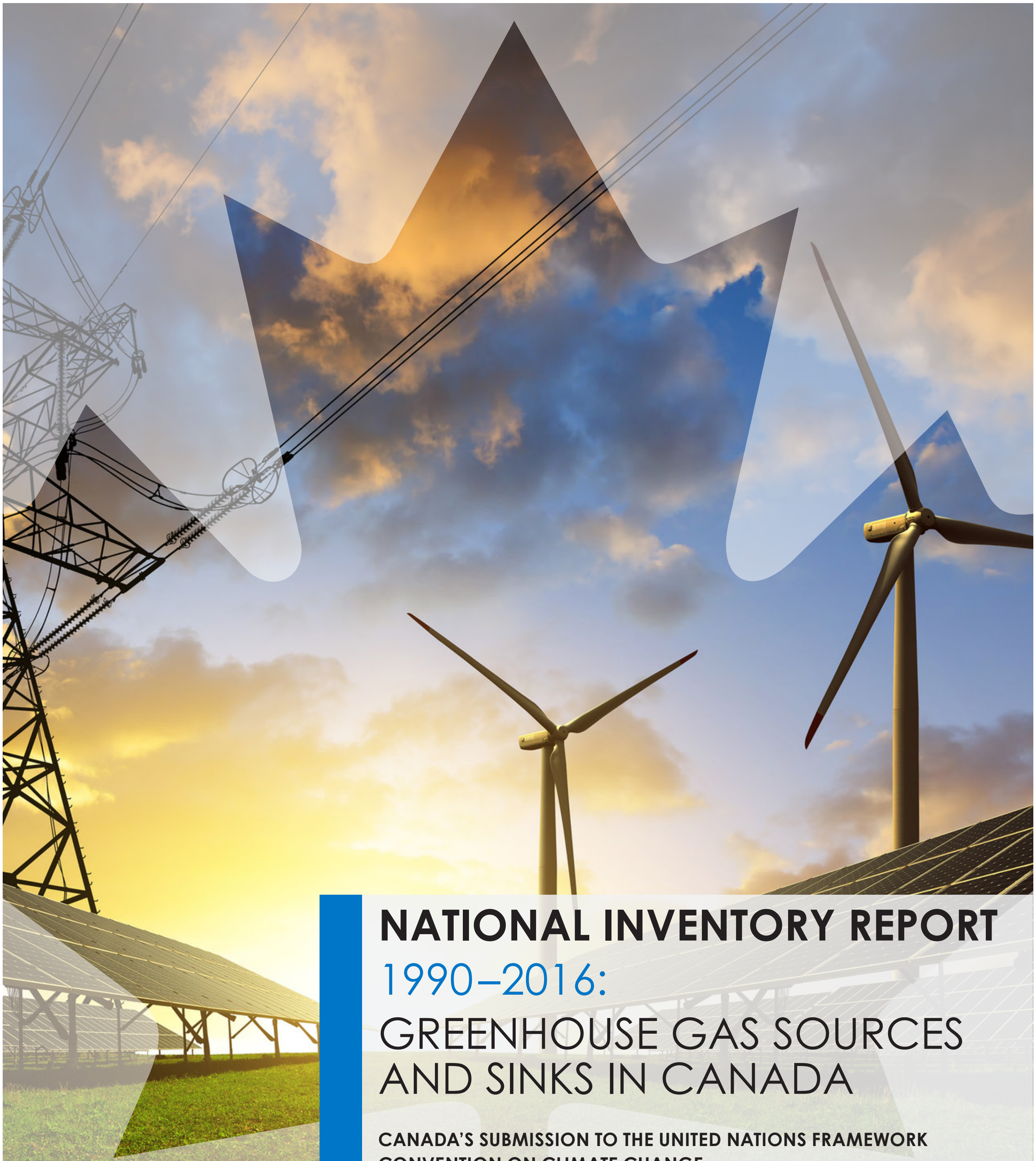

NATIONAL INVENTORY REPORT 1990–2016: GREENHOUSE GAS SOURCES AND SINKS IN CANADA

CANADA'S SUBMISSION TO THE UNITED NATIONS FRAMEWORK CONVENTION ON CLIMATE CHANGE

PART 3

Canada

Library and Archives Canada Cataloguing in Publication

Canada

Main entry under title:
National Inventory Report 1990–2016: Greenhouse Gas Sources and Sinks in Canada

Annual
1990/2018
Issued by the Pollutant Inventories and Reporting Division

Other editions available: Rapport d'inventaire national 1990–2016 : Sources et puits de gaz à effet de serre au Canada

Continues: Canada's Greenhouse Gas Inventory.
The Executive Summary of this report is available on Environment and Climate Change Canada's web site at https://www.canada.ca/en/environment-climate-change/services/climate-change/greenhouse-gas-emissions.html

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I. Canada. Environment and Climate Change Canada.
II. Pollutant Inventories and Reporting Division.
III. Greenhouse gas sources and sinks in Canada.

Cat. No.: En81-4/1E-PDF
ISSN: 2371-1329

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Aussi disponible en français

List of Common Acronyms, Abbreviations and Units

Acronymns and Abbreviations

CAC	Criteria Air Contaminant
CANSIM	Statistics Canada's key socioeconomic database
CEPA 1999	*Canadian Environmental Protection Act, 1999*
CESI	Canadian Environmental Sustainability Indicators
CFC	chlorofluorocarbon
CFS	Canadian Forest Service
ECCC	Environment and Climate Change Canada
EF	emission factor
GDP	gross domestic product
GHG	greenhouse gas
GHGRP	Greenhouse Gas Reporting Program
HFC	hydrofluorocarbon
HWP	harvested wood products
IPCC	Intergovernmental Panel on Climate Change
IPPU	Industrial Proccesses and Product Use
LULUCF	Land Use, Land-use Change and Forestry
N/A	not available
MSW	municipal solid waste
NIR	National Inventory Report
NMVOC	non-methane volatile organic compound
NPRI	National Pollutant Release Inventory
ODS	ozone-depleting substance
OECD	Organisation for Economic Co-operation and Development
PFC	perfluorocarbon
POP	persistent organic pollutant
QA	quality assurance
QC	quality control
RESD	Report on Energy Supply and Demand in Canada
UNECE	United Nations Economic Commission for Europe
UNFCCC	United Nations Framework Convention on Climate Change

Chemical Formulas

Al	aluminium
Al_2O_3	alumina
CaC_2	calcium carbide
$CaCO_3$	calcium carbonate; limestone
$CaMg(CO_3)_2$	dolomite (also $CaCO_3 \cdot MgCO_3$)
CaO	lime; quicklime; calcined limestone
CF_4	carbon tetrafluoride
C_2F_6	carbon hexafluoride
CH_3OH	methanol
CH_4	methane
C_2H_6	ethane
C_3H_8	propane
C_4H_{10}	butane
C_2H_4	ethylene
C_6H_6	benzene
$CHCl_3$	chloroform
CO	carbon monoxide
CO_2	carbon dioxide
CO_2 eq	carbon dioxide equivalent
H_2	hydrogen
H_2O	water
H_2S	hydrogen sulphide
HCFC	hydrochlorofluorocarbon
HCl	hydrochloric acid
HF	hydrogen fluoride
HNO_3	nitric acid
K_2CO_3	potassium carbonate
Mg	magnesium
$MgCO_3$	magnesite; magnesium carbonate
MgO	magnesia; dolomitic lime
N	nitrogen
N_2	nitrogen gas
Na_2CO_3	sodium carbonate; soda ash
Na_3AlF_6	cryolite
NF_3	nitrogen trifluoride
NH_3	ammonia
NH_4+	ammonium
NH_4NO_3	ammonium nitrate
N_2O	nitrous oxide
N_2O-N	Nitrous oxide emissions represented in terms of nitrogen
NO	nitric oxide
NO_2	nitrogen dioxide
NO_3-	nitrate
NO_x	nitrogen oxides
O_2	oxygen
SF_6	sulphur hexafluoride
SiC	silicon carbide
SO_2	sulphur dioxide
SO_x	sulphur oxides

Notation Keys

IE	included elsewhere
NA	not applicable
NE	not estimated
NO	not occurring

Units

g	gram
Gg	gigagram
Gt	gigatonne
ha	hectare
kg	kilogram
kha	kilohectare
km	kilometre
kt	kilotonne
kWh	kilowatt-hour
m	metre
Mg	megagram
Mha	megahectare
mm	millimetre
Mt	megatonne
MW	megawatt
PJ	petajoule
t	tonne
TWh	terrawatt-hour

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ANNEX 8

IPCC SECTOR ROUNDING PROTOCOL

A rounding protocol has been developed for the emission and removal estimates presented by activity sectors defined by the Intergovernmental Panel on Climate Change (IPCC) (Annexes 9 & 11) in order to reflect their uncertainty levels. The accuracy of a value is reflected by presenting the emission and removal estimates rounded to an appropriate number of significant figures based on the uncertainty of the category in question. The number of significant figures to which each source and sink category has been rounded, using the rounding rules provided in this protocol, can be found in Table A8–1.

A large number of the uncertainty ranges that are used for the various categories were developed using Monte Carlo analysis, as performed by ICF Consulting (ICF Consulting 2004, 2005), using the 2001 inventory estimates submitted in the NIR 2003. Default uncertainty values published by the IPCC (IPCC/OECD/IEA 1997; IPCC 2001; IPCC 2006) and those resulting from expert elicitation were also utilized for some ranges. Since 2004-2005, many methodological changes, refinements and updates, including updates to the uncertainty parameters themselves, have been made. The uncertainty ranges have been calculated around the mean values established by these analyses.

For a more complete description of the analysis of uncertainty in Canada's emission estimates, please refer to Annex 2, which includes tables of current uncertainty values. Recent updates to uncertainty estimates are provided in the respective sectoral chapters.

The following uncertainty values have been used to establish the number of significant figures (up to a maximum of 2 decimal places) to which the estimates have been rounded:

- uncertainty greater than 50%: one significant figure;
- uncertainty between 10% and 50%: two significant figures: and
- uncertainty less than 10%: three significant figures.

This rounding protocol does not apply to estimates presented by Canadian Economic Sectors (Annexes 10 & 12) which have been rounded to the nearest 1 Mt and 0.1 Mt for National-level estimates (Annex 10) and provincial/territorial-level estimates (Annex 12), respectively.

All calculations, including the summing of emission totals, were made using unrounded data. The rounding protocol was applied only after the calculations had been completed. The reader should also note that formatting this report limits the maximum number of decimal places and, therefore, even though a zero entry is recorded, some emissions may exist in that category (zero emissions are identified with a dash "-"). As a result of these procedures, individual values in the emission tables may not add up to the subtotals and/or overall totals.

Table 8–1 Number of Significant Figures Applied to IPCC Sector GHG Summary Tables

Greenhouse Gas Categories	Number of Significant Figures							
	CO_2	CH_4	N_2O	HFCs	PFCs	SF_6	NF_3	TOTAL
TOTAL	**3**	**2**	**2**	**2**	**2**	**2**	**1**	**3**
ENERGY	**3**	**2**	**1**					**3**
a. Stationary Combustion Sources	**3**	**1**	**1**					**3**
Public Electricity and Heat Production	3	2	1					3
Petroleum Refining Industries	2	1	1					2
Mining and Upstream Oil and Gas Production	3	1	1					3
Manufacturing Industries	3	2	1					3
Iron and Steel	3	1	1					3
Non Ferrous Metals	3	2	1					3
Chemical	3	2	1					3
Pulp and Paper	3	1	1					3
Cement	3	1	1					3
Other Manufacturing	3	1	1					3
Construction	3	1	1					3
Commercial & Institutional	3	3	1					3
Residential	3	1	1					3
Agriculture & Forestry	3	1	1					3
b. Transport	**3**	**2**	**2**					**3**
Domestic Aviation	3	1	1					3
Road Transportation	3	1	2					3
Light-Duty Gasoline Vehicles	3	1	2					3
Light-Duty Gasoline Trucks	3	1	2					3
Heavy-Duty Gasoline Vehicles	3	1	2					3
Motorcycles	3	1	2					3
Light-Duty Diesel Vehicles	3	1	2					3
Light-Duty Diesel Trucks	3	1	2					3
Heavy-Duty Diesel Vehicles	3	1	2					3
Propane & Natural Gas Vehicles	3	1	2					3
Railways	3	1	1					3
Domestic Navigation	3	1	1					3
Other Transportation	3	2	1					3
Off-road Agriculture & Forestry	3	2	1					3
Off-road Commercial & Institutional	3	2	1					3
Off-road Manfacturing, Mining & Construction	3	2	1					3
Off-road Residential	3	2	1					3
Off-road Other Transportation	3	2	1					3
Pipeline Transport	3	2	1					3
c. Fugitive Sources	**2**	**2**	**2**					**2**
Coal Mining		1						1
Oil and Natural Gas	2	2	1					2
Oil	2	2	1					2
Natural Gas	2	2						2
Venting	2	2						2
Flaring	3	2	2					3
d. CO_2 Transport and Storage	**1**							**1**
INDUSTRIAL PROCESSES AND PRODUCT USE	**3**	**2**	**3**	**2**	**3**	**2**	**1**	**3**
a. Mineral Products	**2**							**2**
Cement Production	2							2
Lime Production	2							2
Mineral Product Use	2							2
b. Chemical Industry	**3**	**2**	**3**					**3**
Ammonia Production	3							3
Nitric Acid Production			3					3
Adipic Acid Production			2					2
Petrochemical and Carbon Black Production	3	2	3					3
c. Metal Production	**3**	**1**			**3**	**3**		**3**
Iron and Steel Production	3	1						3
Aluminium Production	3				3	3		3
SF_6 Used in Magnesium Smelters and Casters						3		3
d. Production and Consumption of Halocarbons, SF_6 and NF_3				**2**	**2**	**2**	**1**	**2**
e. Non-Energy Products from Fuels and Solvent Use	**2**							**2**
f. Other Product Manufacture and Use	**1**		**2**		**2**	**2**		**2**
AGRICULTURE	**1**	**2**	**2**		**2**	**2**		**2**
a. Enteric Fermentation		**2**						**2**
b. Manure Management		**2**	**1**					**2**
c. Agricultural Soils			**2**					**2**
Direct Sources			2					2
Indirect Sources			1					1
d. Field Burning of Agricultural Residues		**1**	**1**					**1**
e. Liming, Urea Application and Other Carbon-Containing Fertilizers	**1**							**1**
WASTE	**1**	**2**	**1**					**2**
a. Solid Waste Disposal		**2**						**2**
b. Biological Treatment of Solid Waste		**1**	**1**					**1**
c. Wastewater Treatment and Discharge		**2**	**1**					**2**
d. Incineration and Open Burning of Waste	**1**	**1**	**1**					**1**
LAND USE, LAND-USE CHANGE AND FORESTRY	**2**	**2**	**2**					**2**
a. Forest Land	**2**	**2**	**2**					**2**
b. Cropland	**2**	**2**	**1**					**2**
c. Grassland		**1**	**1**					**1**
d. Wetlands	**2**	**2**	**2**					**2**
e. Settlements	**2**	**2**	**2**					**2**
f. Harvested Wood Products	**2**							**2**

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ANNEX 9

CANADA'S GREENHOUSE GAS EMISSION TABLES BY IPCC SECTOR, 1990–2016

In this National Inventory Report, emission estimates are primarily presented for each of the activity sectors defined by the Intergovernmental Panel on Climate Change (IPCC): Energy, Industrial Processes and Product Use, Agriculture, Land Use, Land-use Change and Forestry, and Waste. This is consistent with the categorization outlined in the UNFCCC reporting guidelines on annual inventories for Parties included in Annex I to the Convention (Decision 24/CP.19).[1]

This annex contains summary tables (Table A9–1 to Table A9–3) illustrating national GHG emissions by year, by gas and by IPCC sector. National GHG emissions allocated to Canadian economic sectors are provided in Annex 10 of this report.

Canada's greenhouse gas emission tables are also available in electronic file format online at https://open.canada.ca.

1 Available online at http://unfccc.int/resource/docs/2013/cop19/eng/10a03.pdf.

Table A9–1 **GHG Source/Sink Category Description**

GHG Source/Sink Categories	
ENERGY	
a. Stationary Combustion Sources	
Public Electricity and Heat Production	Emissions from fuel consumed by utility electricity generation and steam production (for sale)
Petroleum Refining Industries	Emissions from fuel consumed by petroleum refining industries
Mining and Upstream Oil and Gas Production	Emissions from fuel consumed by:
	- Metal and non-metal mines, coal mines, stone quarries, and gravel pits
	- Oil and gas extraction industries
	- Mineral exploration and contract drilling operations
Manufacturing Industries	Emissions from fuel consumed by the following industries:
	- Iron and Steel (steel foundries, casting and rolling mills)
	- Non-ferrous metals (aluminium, magnesium and other production)
	- Chemical (fertilizer manufacturing, organic and inorganic chemical manufacturing)
	- Pulp and Paper (primarily pulp, paper, and paper product manufacturers)
	- Cement and other non-metallic mineral production
	- Other manufacturing industries not listed (such as automobile manufacturing, textiles, food and beverage industries)
Construction	Emissions from fuels consumed by the construction industry – buildings, highways etc.
Commercial & Institutional	Emissions from fuel consumed by:
	- Service industries related to mining, communication, wholesale and retail trade, finance and insurance, real estate, education, etc.)
	- Federal, provincial and municipal establishments
	- National Defence and Canadian Coast Guard
	- Train stations, airports and warehouses
Residential	Emissions from fuel consumed for personal residences (homes, apartment hotels, condominiums and farm houses)
Agriculture & Forestry	Emissions from fuel consumed by:
	- Forestry and logging service industry
	- Agricultural, hunting and trapping industry (excluding food processing, farm machinery manufacturing and repair)
b. Transportation	Emissions resulting from the:
Domestic Aviation	- Consumption of fossil fuels by aircrafts flying domestically with Canadian purchased fuel
Road Transportation	- Consumption of fossil fuels (including non-CO_2 emissions from ethanol and biodiesel) by vehicles licensed to operate on roads
Railways	- Consumption of fossil fuels (including non-CO_2 emissions from biodiesel) by Canadian railways
Domestic Navigation	- Consumption of fossil fuels (including non-CO_2 emissions from ethanol and biodiesel) by Canadian registered marine vessels fuelled domestically
Others – Off-road	- Consumption of fossil fuels (including non-CO_2 emissions from ethanol and biodiesel) by combustion devices not licensed to operate on roads
Others – Pipeline Transport	- Transportation and distribution of crude oil, natural gas and other products
c. Fugitive Sources	Intentional and unintentional releases of greenhouse gases from the following activities:
Coal Mining	- Underground and surface mining, abandoned underground coal mines
Oil and Natural Gas	- Conventional and unconventional oil and gas exploration, production, transportation and distribution
d. CO_2 Transport and Storage	Intentional and unintentional releases of greenhouse gases from the transport and storage of carbon dioxide
INDUSTRIAL PROCESSES AND PRODUCT USE	Emissions resulting from the following process activities:
a. Mineral Products	- Cement production, lime production, and mineral product use (which includes glass production, other uses of soda ash, magnesite use, and limestone and dolomite use)
b. Chemical Industry	- Production of ammonia, nitric acid, adipic acid, carbide and petrochemicals. Petrochemical production includes production of carbon black, ethylene dichloride, ethylene, methanol and styrene
c. Metal Production	- Aluminum production, iron and steel production, and magnesium production and casting
d. Production and Consumption of Halocarbons, SF_6 and NF_3	- By-product production of HFC-23; use of HFCs and/or PFCs in air conditioning units, refrigeration units, fire extinguishers, aerosol cans, solvents, foam blowing, semiconductor manufacturing and electronics industry, and use of SF_6 and NF_3 in semiconductor manufacturing
e. Non-Energy Products from Fuels and Solvent Use	- Non-energy use of fossil fuels (including solvents and lubricants) that are not accounted for elsewhere under the Industrial Processes and Product Use Sector
f. Other Product Manufacture and Use	- Use of N_2O as an anaesthetic and propellant; use of urea in selective catalytic reduction (SCR) equipped vehicles; use of SF_6 and PFCs in electrical equipment
AGRICULTURE	Emissions resulting from the:
a. Enteric Fermentation	- Eructation of CH_4 during the digestion of plant material by (mainly) ruminants
b. Manure Management	- Release of CH_4 and N_2O due to microbial activity during the storage of feces, urine and bedding materials from the cleaning of barns and pens
	- Indirect N_2O emissions from volatilization and leaching of nitrogen from animal manure during storage
c. Agricultural Soils	
Direct sources	- Direct N_2O emissions from Synthetic fertilizer, manure on cropland, pasture range and paddock, crop residue, tillage, summerfallow, irrigation and cultivation of organic soils
Indirect Sources	- Indirect N_2O emissions from volatilization and leaching of animal manure nitrogen, synthetic fertilizer nitrogen and crop residue nitrogen
d. Field Burning of Agricultural Residues	- CH_4 and N_2O emissions from crop residue burning
e. Liming, Urea Application and Other Carbon-containing Fertilizers	- Direct emissions of CO_2 from the application of lime, urea and other fertilizers containing carbon
WASTE	Emissions resulting from:
a. Solid Waste Disposal	- Municipal solid waste management sites (landfills) and dedicated wood waste landfills
b. Biological Treatment of Solid Waste	- Composting of municipal solid waste
c. Wastewater Treatment and Discharge	- Domestic and industrial wastewater treatment
d. Incineration and Open Burning of Waste	- Municipal solid, hazardous and clinical waste, and sewage sludge incineration
LAND USE, LAND-USE CHANGE AND FORESTRY	Emissions and removals resulting from:
a. Forest Land	- Managed forests and lands converted to forests; includes growth and anthropogenic disturbances related to forest management but excludes fire and most insect disturbances
b. Cropland	- Management practices on lands in annual crops, summerfallow and perennial crops (forage, specialty crops, orchards); immediate and residual emissions from lands converted to cropland
c. Grassland	- Managed agricultural grassland
d. Wetlands	- Peatlands disturbed for peat extraction, or land flooded from hydro reservoir development
e. Settlements	- Forest and grassland converted to built-up land (settlements, transport infrastructure, oil & gas infrastructure, mining, etc); urban tree growth
f. Harvested Wood Products	- Use and disposal of harvested wood products manufactured from wood coming from forest harvest and forest conversion activities in Canada

Table A9–2 2016 GHG Emission Summary for Canada

Greenhouse Gas Categories	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
	kt CO_2 eq																										
TOTAL[1]	**603 000**	**596 000**	**613 000**	**614 000**	**635 000**	**652 000**	**673 000**	**688 000**	**696 000**	**709 000**	**732 000**	**721 000**	**725 000**	**742 000**	**744 000**	**732 000**	**723 000**	**745 000**	**724 000**	**682 000**	**694 000**	**700 000**	**707 000**	**716 000**	**716 000**	**714 000**	**704 000**
ENERGY	**481 000**	**471 000**	**489 000**	**489 000**	**507 000**	**521 000**	**538 000**	**554 000**	**564 000**	**579 000**	**601 000**	**593 000**	**595 000**	**608 000**	**604 000**	**595 000**	**586 000**	**610 000**	**591 000**	**559 000**	**570 000**	**573 000**	**574 000**	**584 000**	**588 000**	**585 000**	**572 000**
a. **Stationary Combustion Sources**	**285 000**	**280 000**	**290 000**	**284 000**	**290 000**	**297 000**	**306 000**	**313 000**	**318 000**	**331 000**	**352 000**	**348 000**	**351 000**	**361 000**	**353 000**	**342 000**	**334 000**	**354 000**	**338 000**	**316 000**	**319 000**	**320 000**	**319 000**	**322 000**	**325 000**	**322 000**	**317 000**
Public Electricity and Heat Production	94 300	95 700	102 000	92 900	95 200	98 500	98 100	110 000	123 000	120 000	132 000	133 000	128 000	133 000	126 000	125 000	119 000	124 000	116 000	99 900	102 000	94 200	91 000	87 200	84 300	87 000	83 800
Petroleum Refining Industries	17 000	16 000	17 000	17 000	16 000	16 000	19 000	19 000	18 000	17 000	17 000	18 000	19 000	20 000	22 000	20 000	20 000	20 000	19 000	19 000	19 000	18 000	19 000	18 000	18 000	17 000	17 000
Mining and Upstream Oil and Gas Production	40 800	38 300	40 400	42 700	44 500	46 000	45 500	44 000	47 300	59 300	63 300	65 700	68 700	72 100	70 300	68 000	71 900	80 300	76 700	78 800	81 300	82 800	89 300	93 400	96 400	96 000	99 900
Manufacturing Industries	56 200	54 000	53 000	50 800	54 300	56 100	57 700	57 800	54 800	55 900	56 000	51 700	51 400	49 300	51 000	48 100	46 300	47 200	44 600	39 900	41 200	44 200	43 700	44 800	44 900	44 000	42 200
Iron and Steel	4 950	4 960	5 290	5 390	6 020	5 780	6 150	6 160	6 230	6 330	6 210	5 010	5 860	5 530	5 830	5 550	5 550	6 000	5 770	4 290	4 980	5 290	5 500	5 580	6 030	5 640	5 500
Non Ferrous Metals	3 310	2 700	2 940	2 830	3 430	3 220	4 010	3 890	3 880	3 690	3 580	3 780	3 520	3 530	3 540	3 660	3 490	3 850	3 830	2 930	3 070	3 430	2 970	3 100	2 920	3 110	2 590
Chemical	8 260	8 650	8 600	8 530	10 000	10 300	9 920	10 200	10 800	11 200	10 700	9 470	9 020	8 150	8 970	8 330	8 890	8 720	8 800	8 880	9 920	11 100	11 000	11 600	12 400	12 400	11 300
Pulp and Paper	15 000	14 000	13 000	13 000	13 000	13 000	13 000	13 000	12 000	13 000	13 000	12 000	11 000	10 000	10 000	8 700	7 500	7 800	6 300	6 400	6 000	6 300	6 000	6 300	6 000	6 200	6 200
Cement	3 970	3 440	3 400	3 470	4 070	4 160	4 130	4 040	4 190	4 460	4 640	4 600	4 970	4 990	5 460	5 420	5 730	5 030	4 900	4 480	4 060	4 290	4 020	3 850	4 020	3 930	3 730
Other Manufacturing	21 200	20 100	19 700	17 600	17 800	19 700	20 000	20 200	17 500	17 600	18 200	17 200	17 000	16 700	16 900	16 400	15 000	15 800	15 000	12 900	13 200	13 800	14 200	14 400	13 500	12 700	12 900
Construction	1 880	1 630	1 760	1 390	1 400	1 180	1 270	1 250	1 120	1 170	1 080	1 030	1 270	1 350	1 420	1 450	1 400	1 400	1 380	1 230	1 520	1 370	1 390	1 290	1 300	1 300	1 280
Commercial and Institutional	25 800	26 500	27 100	28 100	27 500	29 000	29 600	30 100	27 500	29 100	33 000	32 400	33 900	35 100	33 800	32 300	29 400	30 500	30 000	29 800	28 400	30 300	28 400	29 300	31 300	29 800	29 700
Residential	46 500	45 000	45 900	48 100	49 000	47 500	52 200	48 600	43 700	45 300	47 400	44 200	46 700	48 300	46 600	45 600	43 500	47 800	47 200	45 100	42 700	45 800	42 300	43 800	45 600	43 100	39 300
Agriculture and Forestry	2 410	2 740	3 250	3 050	2 540	2 770	2 930	2 920	2 600	2 680	2 570	2 240	2 160	2 300	2 210	2 190	2 110	2 690	2 680	2 600	2 970	3 530	3 650	3 660	3 710	3 510	3 530
b. **Transport[2]**	**146 000**	**141 000**	**145 000**	**148 000**	**155 000**	**159 000**	**164 000**	**170 000**	**173 000**	**178 000**	**179 000**	**177 000**	**179 000**	**183 000**	**188 000**	**192 000**	**191 000**	**195 000**	**194 000**	**187 000**	**197 000**	**197 000**	**197 000**	**202 000**	**200 000**	**202 000**	**199 000**
Domestic Aviation	7 200	6 300	6 300	6 000	6 300	6 600	7 100	7 100	7 400	7 800	7 700	7 100	6 900	7 000	7 500	7 600	7 700	7 700	7 300	6 400	6 400	6 300	7 300	7 600	7 200	7 100	7 100
Road Transportation	81 800	78 000	78 500	79 900	83 700	84 700	88 500	94 500	101 000	106 000	109 000	115 000	117 000	121 000	124 000	129 000	129 000	132 000	132 000	131 000	137 000	139 000	140 000	144 000	141 000	142 000	143 000
Light-Duty Gasoline Vehicles	40 400	38 800	39 100	39 600	40 000	39 300	38 900	39 100	39 500	39 600	39 700	41 000	41 400	41 300	40 800	41 000	40 000	39 300	38 100	37 700	37 400	36 100	35 100	35 300	33 800	34 100	34 100
Light-Duty Gasoline Trucks	19 700	19 100	19 500	20 000	21 900	23 300	24 700	26 400	28 300	30 100	31 100	32 900	34 200	35 600	36 600	37 700	38 100	38 800	38 500	39 400	40 800	40 900	41 500	42 800	42 900	44 700	47 300
Heavy-Duty Gasoline Vehicles	6 120	6 170	6 480	6 950	7 140	6 970	7 720	8 580	9 610	10 000	10 300	11 400	11 500	11 900	12 400	11 600	11 800	11 900	12 000	12 100	12 400	12 000	12 700	13 300	12 200	12 100	12 800
Motorcycles	87	84	82	80	79	76	73	72	71	107	121	142	159	175	187	201	213	223	229	237	246	248	257	259	257	268	283
Light-Duty Diesel Vehicles	467	403	383	379	397	400	409	455	500	537	603	607	646	713	765	605	658	669	621	577	666	797	800	859	867	912	838
Light-Duty Diesel Trucks	153	138	134	138	150	156	182	222	259	294	321	334	346	388	418	321	306	311	343	355	404	464	455	514	633	807	885
Heavy-Duty Diesel Vehicles	13 600	12 200	11 800	12 100	13 100	13 600	15 700	18 900	21 900	24 700	26 500	27 900	27 800	30 200	32 000	37 000	38 100	40 700	42 500	40 800	44 900	48 400	49 400	50 700	50 100	48 800	46 300
Propane and Natural Gas Vehicles	1 200	1 100	1 100	720	910	900	800	760	790	640	520	580	470	430	430	380	300	200	130	63	40	41	31	18	10	8	9
Railways	6 900	6 400	6 700	6 700	6 900	6 300	6 100	6 200	6 000	6 300	6 500	6 500	6 000	6 000	6 200	6 600	6 900	7 400	7 800	5 100	6 500	7 500	7 600	7 300	7 500	7 100	6 500
Domestic Navigation	4 800	5 000	4 800	4 200	4 400	4 100	4 200	4 300	4 900	4 800	4 900	5 400	5 400	6 300	6 700	6 400	5 900	6 500	6 300	6 500	6 800	5 600	5 600	5 200	4 800	4 700	3 800
Other Transportation	46 000	46 000	49 000	51 000	54 000	58 000	58 000	57 000	54 000	53 000	50 000	43 000	44 000	43 000	44 000	43 000	41 000	41 000	40 000	38 000	40 000	39 000	36 000	38 000	40 000	41 000	40 000
Off-Road Agriculture & Forestry	9 000	9 100	9 200	10 000	11 000	12 000	13 000	13 000	12 000	12 000	12 000	11 000	10 000	11 000	11 000	11 000	11 000	11 000	11 000	10 000	11 000	11 000	11 000	11 000	11 000	11 000	9 700
Off-Road Commercial & Institutional	1 500	1 500	1 600	1 700	1 800	2 000	2 000	2 100	2 100	2 000	2 100	2 100	2 100	2 300	2 400	2 400	2 400	2 500	2 500	2 500	2 700	2 700	2 500	2 700	2 800	2 700	2 500
Off-Road Manufacturing, Mining & Construction	9 200	9 100	9 700	10 000	11 000	12 000	12 000	13 000	11 000	11 000	11 000	9 800	10 000	11 000	11 000	10 000	10 000	11 000	11 000	11 000	12 000	12 000	11 000	11 000	12 000	13 000	12 000
Off-Road Residential	240	240	250	280	320	380	450	520	610	690	760	910	1 000	1 100	1 200	1 200	1 200	1 200	1 200	1 200	1 200	1 300	1 200	1 200	1 200	1 200	1 200
Off-Road Other Transportation	19 000	18 000	18 000	18 000	18 000	18 000	18 000	17 000	16 000	15 000	13 000	9 700	9 300	8 700	9 100	7 400	7 200	7 300	7 200	7 200	7 400	5 500	5 300	5 300	5 600	6 000	6 100
Pipeline Transport	6 910	7 650	9 890	10 400	10 800	12 000	12 500	12 600	12 500	12 600	11 300	10 300	10 900	9 120	8 550	10 200	9 700	8 450	7 520	6 360	5 720	5 650	5 730	6 720	7 890	8 160	8 470
c. **Fugitive Sources**	**49 000**	**50 000**	**54 000**	**57 000**	**61 000**	**64 000**	**69 000**	**71 000**	**73 000**	**70 000**	**70 000**	**68 000**	**65 000**	**64 000**	**63 000**	**61 000**	**61 000**	**61 000**	**59 000**	**55 000**	**54 000**	**55 000**	**58 000**	**60 000**	**63 000**	**61 000**	**56 000**
Coal Mining	3 000	3 000	2 000	3 000	3 000	2 000	2 000	2 000	2 000	2 000	2 000	2 000	2 000	1 000	1 000	1 000	1 000	1 000	1 000	1 000	1 000	1 000	1 000	2 000	1 000	1 000	1 000
Oil and Natural Gas	46 000	47 000	52 000	54 000	58 000	62 000	66 000	69 000	71 000	69 000	68 000	66 000	64 000	62 000	62 000	59 000	60 000	59 000	58 000	54 000	53 000	54 000	57 000	59 000	62 000	60 000	55 000
Oil	5 000	5 100	5 500	5 600	5 700	6 100	6 300	6 600	6 400	6 400	6 500	6 800	6 500	6 700	6 800	6 400	6 400	6 400	6 000	5 900	6 000	6 200	6 800	7 200	7 500	7 600	7 500
Natural Gas	13 000	14 000	15 000	15 000	16 000	17 000	19 000	18 000	20 000	19 000	18 000	16 000	14 000	14 000	14 000	14 000	14 000	13 000	13 000	13 000	12 000	12 000	12 000	13 000	13 000	12 000	12 000
Venting	23 000	24 000	27 000	29 000	31 000	33 000	36 000	38 000	37 000	37 000	38 000	38 000	38 000	37 000	36 000	34 000	34 000	34 000	34 000	31 000	30 000	31 000	32 000	32 000	34 000	33 000	29 000
Flaring	4 600	4 400	4 500	4 800	5 100	5 300	5 600	5 800	7 400	5 600	5 700	5 200	5 700	5 300	5 400	5 300	5 700	5 300	4 800	4 300	4 400	4 900	5 500	6 300	7 000	6 700	5 900
d. **CO_2 Transport and Storage**	-	-	-	-	-	-	-	-	-	-	**0.09**	**0.09**	**0.09**	**0.09**	**0.09**	**0.09**	**0.09**	**0.09**	**0.09**	**0.09**	**0.09**	**0.09**	**0.09**	**0.09**	**0.10**	**0.20**	**0.30**
INDUSTRIAL PROCESSES AND PRODUCT USE	**56 700**	**58 100**	**55 800**	**55 100**	**57 000**	**57 800**	**59 700**	**59 600**	**56 000**	**53 700**	**53 200**	**50 800**	**53 200**	**54 900**	**59 100**	**55 300**	**55 700**	**54 400**	**53 600**	**46 700**	**49 500**	**53 000**	**57 300**	**54 400**	**51 900**	**51 400**	**53 400**
a. **Mineral Products**	**8 500**	**7 600**	**7 300**	**7 400**	**8 400**	**9 100**	**8 800**	**9 500**	**9 600**	**9 800**	**10 000**	**9 400**	**9 700**	**9 700**	**10 000**	**10 000**	**10 000**	**10 000**	**9 300**	**7 200**	**7 800**	**8 000**	**8 500**	**7 800**	**7 800**	**8 100**	**7 900**
Cement Production	5 800	4 700	4 800	4 800	5 700	6 500	6 100	6 600	6 800	7 000	7 200	7 000	7 100	7 200	7 500	7 600	7 700	7 700	7 000	5 400	6 000	6 100	6 600	6 000	5 900	6 300	6 200
Lime Production	1 790	1 820	1 830	1 830	1 880	1 890	1 830	1 900	1 880	1 960	1 910	1 680	1 710	1 690	1 820	1 740	1 660	1 620	1 570	1 210	1 400	1 460	1 480	1 390	1 500	1 400	1 360
Mineral Product Use	910	1 000	700	700	850	750	890	990	940	790	910	770	820	790	880	910	880	810	750	610	410	450	440	380	380	410	390
b. **Chemical Industry**	**17 300**	**16 600**	**16 400**	**16 100**	**18 300**	**18 000**	**18 500**	**17 100**	**12 400**	**9 200**	**7 990**	**7 520**	**8 250**	**8 130**	**10 400**	**9 470**	**8 070**	**7 520**	**8 420**	**5 870**	**5 470**	**6 090**	**6 410**	**6 400**	**5 990**	**6 510**	**6 560**
Ammonia Production	2 770	2 750	2 490	2 920	3 030	2 940	2 800	2 800	3 100	3 000	2 960	2 600	2 630	2 630	2 930	2 710	2 780	2 580	2 810	2 400	2 490	2 880	3 000	2 950	2 540	2 850	2 790
Nitric Acid Production	970	1 000	1 000	1 000	920	960	1 100	1 000	1 000	1 100	1 200	1 200	1 200	1 200	1 200	1 200	1 200	1 100	1 200	1 100	1 100	1 100	1 100	990	1 000	1 100	1 000
Adipic Acid Production	10 000	9 600	9 600	8 700	11 000	10 000	11 000	9 500	4 900	1 700	870	770	1 200	1 000	3 000	2 500	1 200	1 400	2 300	640	-	-	-	-	-	-	-
Petrochemical and Carbon Black Production	3 300	3 300	3 300	3 500	3 800	3 800	3 600	3 700	3 500	3 400	3 000	2 900	3 200	3 200	3 400	3 000	2 900	2 400	2 100	1 700	1 900	2 100	2 300	2 500	2 400	2 500	2 700
c. **Metal Production**	**23 800**	**26 800**	**25 600**	**25 400**	**23 900**	**23 500**	**23 200**	**23 000**	**24 000**	**23 200**	**23 400**	**21 400**	**21 300**	**21 000**	**20 500**	**20 200**	**20 700**	**19 300**	**19 000**	**15 900**	**16 200**	**17 100**	**16 900**	**14 800**	**15 000**	**14 000**	**15 600**
Iron and Steel Production	10 500	12 100	12 400	11 900	11 000	11 500	11 300	11 100	11 400	11 600	11 800	10 800	10 600	10 500	10 600	10 300	11 300	11 100	10 800	8 140	9 170	10 100	10 200	8 040	8 930	8 040	9 310
Aluminum Production	10 300	11 200	10 900	11 400	10 700	10 000	10 400	10 300	10 500	9 340	8 890	8 260	7 930	8 130	7 770	8 680	8 080	7 630	7 760	7 540	6 870	6 810	6 470	6 530	5 830	5 720	5 990
SF_6 Used in Magnesium Smelters and Casters	2 960	3 420	2 290	2 110	2 180	2 010	1 560	1 600	2 100	2 160	2 660	2 250	2 800	2 370	2 090	1 230	1 340	489	435	184	183	183	248	213	229	221	266
d. **Production and Consumption of Halocarbons, SF_6 and NF_3[3]**	**980**	**1 100**	**830**	**5**	**5**	**500**	**840**	**1 100**	**1 600**	**2 200**	**2 800**	**3 200**	**3 600**	**4 000**	**4 600**	**5 100**	**5 400**	**6 000**	**6 100**	**6 800**	**7 800**	**8 600**	**9 100**	**9 400**	**10 000**	**11 000**	**12 000**
e. **Non-Energy Products from Fuels and Solvent Use**	**5 800**	**5 600**	**5 300**	**5 900**	**6 000**	**6 300**	**7 900**	**8 500**	**7 800**	**8 700**	**8 400**	**8 600**	**9 900**	**12 000**	**13 000**	**9 700**	**11 000**	**11 000**	**10 000**	**10 000**	**12 000**	**13 000**	**16 000**	**15 000**	**13 000**	**11 000**	**11 000**
f. **Other Product Manufacture and Use**	**370**	**370**	**340**	**360**	**370**	**410**	**350**	**390**	**580**	**590**	**630**	**660**	**510**	**640**	**610**	**530**	**490**	**540**	**540**	**430**	**430**	**400**	**490**	**500**	**400**	**480**	**530**
AGRICULTURE	**47 000**	**47 000**	**49 000**	**50 000**	**52 000**	**54 000**	**56 000**	**56 000**	**56 000**	**57 000**	**57 000**	**57 000**	**56 000**	**58 000**	**60 000**	**60 000**	**59 000**	**59 000**	**59 000**	**57 000**	**56 000**	**55 000**	**57 000**	**59 000**	**58 000**	**59 000**	**60 000**
a. **Enteric Fermentation**	**22 000**	**23 000**	**24 000**	**24 000**	**25 000**	**27 000**	**27 000**	**27 000**	**27 000**	**27 000**	**28 000**	**29 000**	**29 000**	**29 000**	**30 000**	**31 000**	**30 000**	**29 000**	**28 000**	**26 000**	**25 000**	**25 000**	**25 000**	**25 000**	**25 000**	**24 000**	**25 000**
b. **Manure Management**	**6 600**	**6 700**	**7 000**	**7 100**	**7 300**	**7 700**	**7 800**	**7 900**	**8 100**	**8 200**	**8 500**	**8 800**	**8 900**	**9 000**	**9 200**	**9 300**	**9 200**	**8 800**	**8 600**	**8 300**	**8 200**	**8 100**	**8 100**	**8 200**	**8 200**	**8 300**	**8 400**
c. **Agricultural Soils**	**17 000**	**16 000**	**16 000**	**17 000**	**18 000**	**18 000**	**19 000**	**19 000**	**19 000**	**19 000**	**19 000**	**18 000**	**17 000**	**19 000**	**19 000**	**19 000**	**19 000**	**20 000**	**21 000**	**20 000**	**21 000**	**20 000**	**22 000**	**24 000**	**23 000**	**23 000**	**24 000**
Direct Sources	14 000	14 000	14 000	14 000	15 000	15 000	16 000	15 000	16 000	16 000	16 000	15 000	14 000	15 000	16 000	15 000	15 000	16 000	17 000	17 000	17 000	17 000	18 000	20 000	19 000	19 000	20 000
Indirect Sources	3 000	3 000	3 000	3 000	3 000	3 000	3 000	3 000	3 000	3 000	3 000	3 000	3 000	3 000	3 000	3 000	3 000	4 000	4 000	4 000	4 000	4 000	4 000	4 000	4 000	4 000	4 000
d. **Field Burning of Agricultural Residues**	**200**	**200**	**200**	**200**	**200**	**200**	**200**	**200**	**200**	**100**	**100**	**100**	**100**	**100**	**40**	**50**	**50**	**40**	**50**	**50**	**30**	**30**	**40**	**50**	**50**	**50**	**50**
e. **Liming, Urea Application and Other Carbon-containing Fertilizers**	**1 000**	**1 000**	**1 000**	**1 000**	**1 000**	**2 000**	**1 000**	**2 000**	**2 000**	**2 000**	**2 000**	**1 000**	**2 000**	**2 000**	**1 000**	**1 000**	**1 000**	**2 000**	**2 000**	**2 000**	**2 000**	**2 000**	**2 000**	**3 000**	**2 000**	**3 000**	**3 000**
WASTE	**19 000**	**19 000**	**19 000**	**19 000**	**19 000**	**19 000**	**19 000**	**19 000**	**20 000**	**20 000**	**20 000**	**20 000**	**20 000**	**21 000**	**21 000**	**21 000**	**22 000**	**21 000**	**20 000**	**20 000**	**19 000**	**19 000**	**18 000**	**18 000**	**18 000**	**19 000**	**19 000**
a. **Solid Waste Disposal**	**17 000**	**17 000**	**17 000**	**17 000**	**17 000**	**17 000**	**17 000**	**18 000**	**18 000**	**18 000**	**18 000**	**18 000**	**18 000**	**19 000**	**19 000**	**19 000**	**19 000**	**19 000**	**18 000**	**17 000**	**17 000**	**17 000**	**16 000**	**16 000**	**16 000**	**16 000**	**16 000**
b. **Biological Treatment of Solid Waste**	**60**	**60**	**60**	**60**	**70**	**80**	**100**	**100**	**100**	**200**	**200**	**200**	**200**	**200**	**300**	**300**	**300**	**400**	**400**	**400**	**400**	**400**	**400**	**400**	**500**	**500**	**500**
c. **Wastewater Treatment and Discharge**	**940**	**960**	**980**	**990**	**1 000**	**1 000**	**1 000**	**1 000**	**1 000**	**1 000**	**1 000**	**1 000**	**1 000**	**1 000**	**1 100**	**1 100**	**1 100**	**1 100**	**1 100**	**1 100**	**1 100**	**1 100**	**1 100**	**1 100**	**1 100**	**1 100**	**1 100**
d. **Incineration and Open Burning of Waste**	**810**	**820**	**860**	**800**	**840**	**900**	**840**	**690**	**740**	**670**	**750**	**780**	**750**	**650**	**700**	**690**	**670**	**640**	**670**	**640**	**660**	**640**	**540**	**550**	**600**	**640**	**650**
LAND USE, LAND-USE CHANGE AND FORESTRY	**-68 000**	**-74 000**	**-66 000**	**-60 000**	**-61 000**	**-49 000**	**-57 000**	**-59 000**	**-66 000**	**-55 000**	**-41 000**	**-57 000**	**-43 000**	**-49 000**	**-26 000**	**-21 000**	**-28 000**	**-31 000**	**-37 000**	**-49 000**	**-32 000**	**-32 000**	**-34 000**	**-32 000**	**-33 000**	**-26 000**	**-28 000**
a. **Forest Land**	**-210 000**	**-220 000**	**-220 000**	**-210 000**	**-220 000**	**-200 000**	**-210 000**	**-210 000**	**-200 000**	**-200 000**	**-190 000**	**-190 000**	**-180 000**	**-170 000**	**-170 000**	**-160 000**	**-150 000**	**-150 000**	**-160 000**	**-160 000**	**-150 000**	**-160 000**	**-160 000**	**-160 000**	**-160 000**	**-150 000**	**-150 000**
b. **Cropland**	**8 300**	**7 200**	**5 700**	**4 600**	**3 100**	**1 600**	**750**	**-860**	**-2 100**	**-3 200**	**-4 700**	**-5 900**	**-7 300**	**-8 600**	**-9 700**	**-11 000**	**-12 000**	**-12 000**	**-12 000**	**-12 000**	**-12 000**	**-12 000**	**-12 000**	**-12 000**	**-12 000**	**-11 000**	**-11 000**
c. **Grassland**	**600**	**800**	**1 000**	**400**	**1 000**	**300**	**500**	**600**	**700**	**800**	**1 000**	**1 000**	**1 000**	**1 000**	**900**	**900**	**1 000**	**400**	**500**	**400**	**300**	**600**	**2 000**	**2 000**	**800**	**1 000**	**1 000**
d. **Wetlands**	**5 000**	**5 000**	**5 000**	**5 000**	**3 000**	**3 000**	**3 000**	**3 000**	**3 000**	**3 000**	**3 000**	**3 000**	**3 000**	**3 000**	**3 000**	**3 000**	**3 000**	**3 000**	**3 000**	**3 000**	**3 000**	**3 000**	**3 000**	**3 000**	**3 000**	**3 000**	**3 000**
e. **Settlements**	**4 000**	**4 000**	**4 000**	**3 000**	**3 000**	**3 000**	**3 000**	**3 000**	**3 000**	**3 000**	**3 000**	**3 000**	**4 000**	**4 000**	**4 000**	**4 000**	**4 000**	**4 000**	**4 000**	**4 000**	**4 000**	**4 000**	**4 000**	**4 000**	**4 000**	**4 000**	**4 000**
f. **Harvested Wood Products**	**130 000**	**130 000**	**140 000**	**140 000**	**140 000**	**150 000**	**140 000**	**140 000**	**130 000**	**140 000**	**150 000**	**130 000**	**140 000**	**120 000**	**140 000**	**140 000**	**130 000**	**120 000**	**120 000**	**120 000**	**130 000**	**130 000**	**130 000**	**130 000**	**130 000**	**130 000**	**130 000**

Notes:
1. National totals exclude all GHGs from the Land Use, Land-use Change and Forestry Sector.
2. Emissions from ethanol and biodiesel are included in the Transport categories using gasoline and diesel respectively.
3. HFC and PFC consumption began in 1995; HFC emissions occurring as a by-product of HCFC production (HCFC-22 exclusively) only occurred in Canada from 1990–1992 and PFC emissions prior to 1995 are the result of by-product CF_4 emissions from the use of NF_3.
- Indicates no emissions
0.00 Indicates emissions truncated due to rounding
Estimates for the latest year (2016) are based on preliminary energy data; these data, though the best available information at the time of publication, are subject to revision in the next submission year.
National GHG emissions allocated to Canadian economic sectors are provided in Annex 10 of this report.

Table A9–3 **2016 GHG Emission Summary for Canada**

Greenhouse Gas Categories	Greenhouse Gases									
	CO_2	CH_4	CH_4	N_2O	N_2O	HFCs[4]	PFCs[4]	SF_6	NF_3	TOTAL
Global Warming Potential			25		298			22 800	17 200	
Unit	kt	kt	kt CO_2 eq	kt	kt CO_2 eq	kt CO_2 eq	kt CO_2 eq	kt CO_2 eq	kt CO_2 eq	kt CO_2 eq
TOTAL[1]	**558 000**	**3 800**	**96 000**	**120**	**37 000**	**12 000**	**760**	**460**	**0.20**	**704 000**
ENERGY	**516 000**	**2 000**	**50 000**	**20**	**6 000**	**-**	**-**	**-**	**-**	**572 000**
a. Stationary Combustion Sources	**309 000**	**200**	**6 000**	**9**	**3 000**	**-**	**-**	**-**	**-**	**317 000**
Public Electricity and Heat Production	83 000	5.80	150	1.80	520	-	-	-	-	83 800
Petroleum Refining Industries	17 000	0.30	9	0.10	40	-	-	-	-	17 000
Mining and Upstream Oil and Gas Production	96 700	100	2 600	2	600	-	-	-	-	99 900
Manufacturing Industries	41 700	2.20	56	1.70	510	-	-	-	-	42 200
Iron and Steel	5 460	0.13	3.10	0.10	30	-	-	-	-	5 500
Non Ferrous Metals	2 570	0.05	1.40	0.05	10	-	-	-	-	2 590
Chemical	11 200	0.22	5.50	0.20	60	-	-	-	-	11 300
Pulp and Paper	6 000	1	30	0.80	200	-	-	-	-	6 200
Cement	3 710	0.17	4.30	0.05	10	-	-	-	-	3 730
Other Manufacturing	12 700	0.62	15	0.50	100	-	-	-	-	12 900
Construction	1 270	0.02	0.57	0.03	10	-	-	-	-	1 280
Commercial and Institutional	29 500	0.56	14	0.70	200	-	-	-	-	29 700
Residential	35 400	100	3 000	2	700	-	-	-	-	39 300
Agriculture and Forestry	3 500	0.06	1.60	0.10	30	-	-	-	-	3 530
b. Transport[2]	**195 000**	**42**	**1 100**	**12**	**3 600**	**-**	**-**	**-**	**-**	**199 000**
Domestic Aviation	7 000	0.30	7	0.20	60	-	-	-	-	7 100
Road Transportation	140 000	9	200	8.20	2 400	-	-	-	-	143 000
Light-Duty Gasoline Vehicles	33 500	2.80	70	1.80	550	-	-	-	-	34 100
Light-Duty Gasoline Trucks	46 400	3.90	97	2.50	750	-	-	-	-	47 300
Heavy-Duty Gasoline Vehicles	12 400	0.45	11	1.10	330	-	-	-	-	12 800
Motorcycles	279	0.11	2.70	0.01	1.60	-	-	-	-	283
Light-Duty Diesel Vehicles	817	0.02	0.40	0.07	20	-	-	-	-	838
Light-Duty Diesel Trucks	863	0.02	0.60	0.07	20	-	-	-	-	885
Heavy-Duty Diesel Vehicles	45 500	2	50	3	800	-	-	-	-	46 300
Propane and Natural Gas Vehicles	9.04	0	0.10	0	0.05	-	-	-	-	9.20
Railways	5 850	0.30	8	2	700	-	-	-	-	6 500
Domestic Navigation	3 730	0.30	9	0.10	30	-	-	-	-	3 800
Other Transportation	38 300	30	800	1	400	-	-	-	-	40 000
Off-Road Agriculture & Forestry	9 590	0.40	10	0.30	100	-	-	-	-	9 700
Off-Road Commercial & Institutional	2 410	4	90	0.08	20	-	-	-	-	2 500
Off-Road Manufacturing, Mining & Construction	11 400	2	40	0.50	200	-	-	-	-	12 000
Off-Road Residential	1 090	2	60	0.03	9	-	-	-	-	1 200
Off-Road Other Transportation	5 640	20	400	0.10	40	-	-	-	-	6 100
Pipeline Transport	8 200	8.10	200	0.20	70	-	-	-	-	8 470
c. Fugitive Sources	**13 000**	**1 700**	**43 000**	**0.10**	**40**	**-**	**-**	**-**	**-**	**56 000**
Coal Mining	-	50	1 000	-	-	-	-	-	-	1 000
Oil and Natural Gas	13 000	1 700	41 000	0.10	40	-	-	-	-	55 000
Oil	220	290	7 200	0.10	30	-	-	-	-	7 500
Natural Gas	110	480	12 000	-	-	-	-	-	-	12 000
Venting	7 500	870	22 000	-	-	-	-	-	-	29 000
Flaring	5 300	21	520	0.02	5	-	-	-	-	5 900
d. CO_2 Transport and Storage	**0.30**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**0.30**
INDUSTRIAL PROCESSES AND PRODUCT USE	**38 800**	**3.10**	**77**	**4.54**	**1 350**	**12 000**	**760**	**460**	**-**	**53 400**
a. Mineral Products	**7 900**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**7 900**
Cement Production	6 200	-	-	-	-	-	-	-	-	6 200
Lime Production	1 360	-	-	-	-	-	-	-	-	1 360
Mineral Product Use	390	-	-	-	-	-	-	-	-	390
b. Chemical Industry	**5 430**	**3**	**75**	**3.50**	**1 100**	**-**	**-**	**-**	**-**	**6 560**
Ammonia Production	2 790	-	-	-	-	-	-	-	-	2 790
Nitric Acid Production	-	-	-	3.50	1 000	-	-	-	-	1 000
Adipic Acid Production	-	-	-	-	-	-	-	-	-	-
Petrochemical and Carbon Black Production	2 600	3	75	0.04	13	-	-	-	-	2 700
c. Metal Production	**14 500**	**0.08**	**2**	**-**	**-**	**-**	**750**	**271**	**-**	**15 600**
Iron and Steel Production	9 310	0.08	2	-	-	-	-	-	-	9 310
Aluminum Production	5 240	-	-	-	-	-	750	4.70	-	5 990
SF_6 Used in Magnesium Smelters and Casters	-	-	-	-	-	-	-	266	-	266
d. Production and Consumption of Halocarbons, SF_6 and NF_3[3]	**-**	**-**	**-**	**-**	**-**	**12 000**	**3.50**	**1.20**	**0.20**	**12 000**
e. Non-Energy Products from Fuels and Solvent Use	**11 000**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**11 000**
f. Other Product Manufacture and Use	**30**	**-**	**-**	**1**	**300**	**-**	**11**	**190**	**-**	**530**
AGRICULTURE	**3 000**	**1 100**	**29 000**	**96**	**29 000**	**-**	**-**	**-**	**-**	**60 000**
a. Enteric Fermentation	**-**	**990**	**25 000**	**-**	**-**	**-**	**-**	**-**	**-**	**25 000**
b. Manure Management	**-**	**160**	**3 900**	**10**	**4 000**	**-**	**-**	**-**	**-**	**8 400**
c. Agricultural Soils	**-**	**-**	**-**	**81**	**24 000**	**-**	**-**	**-**	**-**	**24 000**
Direct Sources	-	-	-	67	20 000	-	-	-	-	20 000
Indirect Sources	-	-	-	10	4 000	-	-	-	-	4 000
d. Field Burning of Agricultural Residues	**-**	**1**	**40**	**0.04**	**10**	**-**	**-**	**-**	**-**	**50**
e. Liming, Urea Application and Other Carbon-containing Fertilizers	**3 000**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**3 000**
WASTE	**470**	**690**	**17 000**	**3.50**	**1 000**	**-**	**-**	**-**	**-**	**19 000**
a. Solid Waste Disposal	**-**	**660**	**16 000**	**-**	**-**	**-**	**-**	**-**	**-**	**16 000**
b. Biological Treatment of Solid Waste	**-**	**10**	**300**	**0.60**	**200**	**-**	**-**	**-**	**-**	**500**
c. Wastewater Treatment and Discharge	**-**	**18**	**450**	**2**	**700**	**-**	**-**	**-**	**-**	**1 100**
d. Incineration and Open Burning of Waste	**470**	**0.30**	**7**	**0.60**	**200**	**-**	**-**	**-**	**-**	**650**
LAND USE, LAND-USE CHANGE AND FORESTRY	**-30 000**	**63**	**1 600**	**2**	**610**	**-**	**-**	**-**	**-**	**-28 000**
a. Forest Land	**-150 000**	**16**	**410**	**0.68**	**200**	**-**	**-**	**-**	**-**	**-150 000**
b. Cropland	**-11 000**	**3**	**80**	**0.20**	**50**	**-**	**-**	**-**	**-**	**-11 000**
c. Grassland	**-**	**40**	**900**	**1**	**300**	**-**	**-**	**-**	**-**	**1 000**
d. Wetlands	**2 000**	**0.90**	**20**	**0.05**	**10**	**-**	**-**	**-**	**-**	**3 000**
e. Settlements	**3 000**	**5**	**100**	**0.20**	**50**	**-**	**-**	**-**	**-**	**4 000**
f. Harvested Wood Products	**130 000**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**130 000**

Notes:

1. National totals exclude all GHGs from the Land Use, Land-use Change and Forestry Sector.
2. Emissions from ethanol and biodiesel are included in the Transport categories using gasoline and diesel respectively.
3. HFC and PFC consumption began in 1995; HFC emissions occurring as a by-product of HCFC production (HCFC-22 exclusively) only occurred in Canada from 1990–1992 and PFC emissions prior to 1995 are the result of by-product CF_4 emissions from the use of NF_3.
4. IPCC's Fourth Assessment Report provides global warming potentials (GWPs) for the various species of HFCs and PFCs. Chapter 1, Table 1-1 of this report provides a list of GWPs used.

\- Indicates no emissions

0.00 Indicates emissions truncated due to rounding

Estimates for the latest year (2016) are based on preliminary energy data; these data, though the best available information at the time of publication, are subject to revision in the next submission year.

National GHG emissions allocated to Canadian economic sectors are provided in Annex 10 of this report.

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Annex 10

CANADA'S GREENHOUSE GAS EMISSION TABLES BY CANADIAN ECONOMIC SECTOR, 1990–2016

This annex contains summary tables illustrating national GHG emissions for the period 1990–2016 by Canadian economic sector (Table A10–2), as well as the relationship (crosswalk) between the economic sectors and the Intergovernmental Panel on Climate Change (IPCC) sectors presented in Annex 9 of this report (Table A10–3). In addition, Table A10–1 provides a brief description of each economic sector.

Although not a mandatory reporting requirement, reallocating emissions from IPCC sectors to Canadian economic sectors is useful for the purpose of analyzing trends and policies, as most people associate GHG emissions with a particular economic activity (e.g. producing electricity, farming or driving a car). This re-allocation simply re-categorizes emissions under different headings, but does not change the overall magnitude of Canadian emission estimates. Estimates for each economic sector includes emissions from energy-related and nonenergyrelated processes.

Reallocation of Emissions from IPCC Sector to Canadian Economic Sector

In general, the reallocation of emissions from IPCC sector to economic sector involves aggregating emissions from stationary combustion, fugitive sources, transportation, industrial processes, agriculture and waste into the appropriate economic sector. In many cases, the stationary combustion emissions for a specific IPCC sector are the same as that for the corresponding economic sector with some notable exceptions.

First, unlike allocation for the IPCC sectors, all utility-owned cogeneration facilities that produce steam or electricity for on-site use are reallocated from Electricity to the relevant economic sector. The relevant economic sectors include Natural Gas Production & Processing, Oil Sands, Mining, Pulp and Paper, Chemicals and Fertilizers, Service Industry, and Light Manufacturing. This is generally accomplished by analyzing and reallocating data by sector from the *Electric Power Thermal Generating Station Fuel Consumption Survey* (Statistics Canada 2016).

Second, Lime and Gypsum is split out from the IPCC category Other Manufacturing and reported as an economic sector on its own, while all other industries included in the IPCC category are allocated to the economic sector Light Manufacturing. Constituent sectors include all other manufacturing industries not already accounted for in identified IPCC manufacturing categories (e.g. Iron and Steel, Chemicals, etc.). Examples include automobile manufacturing, textiles, food and beverage industries, etc.

Third, emissions resulting from the combustion of fuel used to transport oil and natural gas in pipelines accounted for in the IPCC category Pipeline Transport, is divided into the Oil and Natural Gas Transmission and Natural Gas Distribution economic sectors. This division is based on sector-specific fuel combustion data from an upstream oil and gas (UOG) study (Environment Canada 2014).

Fourth, combustion emissions from the Mining and Upstream Oil and Gas Production IPCC category are reallocated to many economic sectors including: Coal Production, Mining, Natural Gas Production and Processing, Conventional Light Oil Production, Conventional Heavy Oil Production, Frontier Oil Production and Oil Sands (Mining, In-situ, Upgrading). A variety of external data sources are used to estimate emissions for the appropriate sectors which are then re-proportioned to align with

Canada's energy balance. These external data sources include:

- **Mining** – Metal and non-metal mining fuel consumption data from the Canadian Industrial Energy End-Use Data and Analysis Centre (CIEEDAC) database on *Energy, Production and Intensity Indicators for Canadian Industry* (CIEEDAC 2016).
- **Coal Production** – Fuel consumption estimates for the coal mining industry are based on the *Compilation of a National Inventory of Greenhouse Gas and Fugitive VOC Emissions by the Canadian Coal Mining Industry* (Cheminfo/Clearstone 2014) and annual coal production data provided by Statistics Canada (see Annex 3.2 for further discussion on this activity data).
- **UOG sectors** – Fuel consumption data for the various UOG sectors, except Oil Sands, is estimated from the UOG study (Environment Canada 2014).
- **Oil Sands** – Fuel consumption data for the Oil Sands industry (including mining and extraction, in-situ and upgrading) is modelled by ECCC and adjusted so that the resultant emissions align with the facility level emissions data that is reported to ECCC through the Greenhouse Gas Emissions Reporting Program (GHGRP) (see Chapter 1 for more information on the GHGRP).

Fifth, emissions from road, rail, marine and air transport are separated into passenger and freight components. Emissions for Other Transportation (Off-road) are reallocated to their relevant economic sectors and to the Transportation category Other: Recreational, Commercial, and Residential.

Sixth, CO_2 captured from waste streams at large industrial facilities (e.g. electric utilities, oil sands upgraders) is presented separately in the economic sectors. It is displayed as a negative number to represent the removal of CO_2 from the specific sector while the source of the CO_2 emissions (e.g. stationary combustion) for the sector is displayed as a gross amount.

In terms of process and product use-related emissions, emissions from mineral products, chemical industry and metal production are reallocated to Heavy Industry and Light Manufacturing. Emissions from consumption of halocarbons, SF_6 and NF_3, which mainly consist of HFC emissions from refrigeration and air conditioning, are reallocated to Transportation and Buildings, where the majority of HFCs are used and emitted. Emissions from non-energy products from fuels and solvent use are reallocated to multiple relevant economic categories. Finally, emissions from other product manufacture and use are mainly distributed to Electricity and Service Industry.

Once all of these sector specific fuel consumption estimates are compiled the data are reconciled by province and by fuel with the fuel consumption data from the *Report on Energy Supply and Demand* (Statistics Canada, 2003–). This ensures that the economic sector estimates match the IPCC sector estimates.

Canada's greenhouse gas emission tables are also available in electronic file format online at https://open.canada.ca.

Table A10–1 **Canadian Economic Sector Descriptions**

Economic Sector	Description
OIL AND GAS	
Upstream Oil and Gas	Stationary combustion, onsite transportation, electricity and steam production, fugitive and process emissions from:
Natural Gas Production and Processing	- natural gas production and processing
Conventional Light Oil Production	- conventional light crude oil production
Conventional Heavy Oil Production	- conventinoal heavy crude oil production
Frontier Oil Production	- offshore and arctic production of crude oil
Oil Sands (Mining, In-situ, Upgrading)	Stationary combustion, onsite transportation, electricity and steam production, fugitive and process emissions from:
Mining and Extraction	- crude bitumen mining and extraction
In-situ	- in-situ extraction of crude bitumen including primary extraction, cyclic steam stimulation (CSS), steam-assisted gravity drainage (SAGD) and other experimental techniques.
Upgrading	- crude bitumen and heavy oil upgrading to synthetic crude oil
Oil and Natural Gas Transmission	Combustion and fugitive emissions from the transport and storage of crude oil and natural gas
Downstream Oil and Gas	Emissions resulting from:
Petroleum Refining	Stationary combustion, onsite transportation, electricity and steam production, fugitive and process emissions from petroleum refining industries
Natural Gas Distribution	Combustion and fugitive emissions from local distribution of natural gas
ELECTRICITY	Combustion and process emissions from utility electricity generation, steam production (for sale) and transmission. Excludes utility owned cogeneration at industrial sites.
TRANSPORTATION	Mobile related emissions including all fossil fuels and non-CO_2 emission from biofuels.
Passenger Transport	Mobile related combustion, process and refrigerant emissions from the vehicles that primarily move people around.
Cars, Light Trucks and Motorcycles	- Light duty cars and trucks up to 4 500 lb. GVWR and motorcycles.
Bus, Rail and Domestic Aviation	- All buses and the passenger component of rail and domestic aviation
Freight Transport	Mobile related combustion, process and refrigerant emissions from the vehicles that primarily move cargo or freight around.
Heavy Duty Trucks, Rail	- Vehicles above 4 500 lb. GVWR and the freight component of rail
Domestic Aviation and Marine	- Cargo/Freight component of domestic aviation and all domestic navigation
Other: Recreational, Commercial and Residential	Combustion emissions from the non-industrial use of off-road engines (e.g., ATVs, snowmobiles, personal watercraft), including portable engines (e.g., generators, lawn mowers, chain saws).
HEAVY INDUSTRY	Stationary combustion, onsite transportation, electricty and steam production, and process emissions from:
Mining	- metal and non-metal mines, stone quarries, and gravel pits
Smelting and Refining (Non Ferrous Metals)	- Non-ferrous Metals (aluminium, magnesium and other production)
Pulp and Paper	- Pulp and Paper (primarily pulp, paper, and paper product manufacturers)
Iron and Steel	- Iron and Steel (steel foundries, casting, rolling mills and iron making)
Cement	- Cement and other non-metallic mineral production
Lime & Gypsum	- Lime and Gypsum product manufacturing
Chemicals & Fertilizers	- Chemical (fertilizer manufacturing, organic and inorganic chemical manufacturing)
BUILDINGS	Stationary combustion and process (i.e. air conditioning) emissions from:
Service Industry	- Service industries related to mining, communication, wholesale and retail trade, finance and insurance, real estate, education, etc.; offices, health, arts, accommodation, food, information & cultural; Federal, provincial and municipal establishments; National Defence and Canadian Coast Guard; Train stations, airports and warehouses
Residential	- personal residences (homes, apartment hotels, condominiums and farm houses)
AGRICULTURE	Emissions resulting from:
On Farm Fuel Use	- Stationary combustion, onsite transportation and process emissions from the agricultural, hunting and trapping industry (excluding food processing, farm machinery manufacturing, and repair)
Crop Production	- Application of inorganic nitrogen fertilizers, decomposition of crop residues, loss of soil organic carbon, cultivation of organic soils, indirect emissions from leaching and volatilization, field burning of agricultural residues, liming, and urea application
Animal Production	- Animal housing, manure storage, manure deposited by grazing animals, and application of manure to managed soils
WASTE	Non-CO_2 Emissions from biomass resulting from:
Solid Waste	- Municipal solid waste management sites (landfills), dedicated wood waste landfills, and composting of municipal solid waste
Waste Water	- Domestic and industrial wastewater treatment
Waste Incineration	- Municipal solid, hazardous and clinical waste, and sewage sludge incineration
COAL PRODUCTION	Stationary combustion, onsite transportation and fugitive emissions from underground and surface coal mines
LIGHT MANUFACTURING, CONSTRUCTION & FOREST RESOURCES	Stationary combustion, onsite transportation, electricty and steam production, and process emissions from (excluding LULUCF):
Light Manufacturing	- all other manufacturing industries not included in the Heavy Industry category above
Construction	- construction of buildings, highways etc.
Forest Resources	- forestry and logging service industry

Table A10–2 **Canada's GHG Emissions by Canadian Economic Sector, 1990–2016**

Greenhouse Gas Categories	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
														Mt CO_2 eq													
NATIONAL GHG TOTAL	**603**	**596**	**613**	**614**	**635**	**652**	**673**	**688**	**696**	**709**	**732**	**721**	**725**	**742**	**744**	**732**	**723**	**745**	**724**	**682**	**694**	**700**	**707**	**716**	**716**	**714**	**704**
OIL AND GAS	**107**	**106**	**116**	**122**	**127**	**133**	**140**	**141**	**146**	**155**	**158**	**158**	**161**	**164**	**162**	**158**	**162**	**168**	**160**	**158**	**160**	**161**	**172**	**180**	**187**	**184**	**183**
Upstream Oil and Gas	**87**	**87**	**97**	**102**	**108**	**114**	**118**	**118**	**124**	**134**	**138**	**137**	**139**	**140**	**137**	**135**	**138**	**144**	**138**	**136**	**137**	**139**	**148**	**156**	**164**	**162**	**161**
Natural Gas Production and Processing	36	35	37	39	41	43	45	43	46	55	59	60	63	64	60	58	57	61	55	52	50	50	52	52	51	47	49
Conventional Oil Production	24	23	26	27	28	31	32	34	35	36	38	36	35	33	32	30	29	31	29	27	27	28	30	32	36	35	30
Conventional Light Oil Production	12	11	11	12	12	12	12	12	12	12	12	12	12	11	12	11	11	12	11	11	11	12	14	16	19	18	16
Conventional Heavy Oil Production	12	12	14	15	16	18	19	22	21	22	24	23	21	19	19	17	17	17	16	14	14	14	15	15	16	15	12
Frontier Oil Production	0	0	0	0	0	0	0	0	2	2	1	1	2	2	2	2	2	2	2	2	2	2	1	2	2	2	2
Oil Sands (Mining, In-situ, Upgrading)	15	16	19	20	21	21	22	23	24	24	25	28	28	32	35	35	40	42	45	48	53	55	59	63	68	70	72
Mining and Extraction	4	5	5	5	5	5	5	5	6	6	6	7	7	9	10	9	11	12	12	13	14	14	14	15	17	17	17
In-situ	5	5	5	5	6	6	6	8	8	8	8	8	8	9	10	11	13	13	17	18	20	22	25	28	30	34	37
Upgrading	6	6	8	10	10	10	10	10	10	11	11	12	13	14	14	14	16	17	16	18	19	19	20	20	20	19	17
Oil and Natural Gas Transmission	12	13	16	16	17	18	19	19	19	19	15	14	13	11	10	12	11	10	9	8	7	7	8	9	10	10	10
Downstream Oil and Gas	**20**	**19**	**19**	**20**	**19**	**19**	**22**	**22**	**22**	**21**	**20**	**21**	**22**	**24**	**25**	**23**	**24**	**24**	**22**	**22**	**23**	**22**	**24**	**24**	**23**	**22**	**22**
Petroleum Refining	18	17	17	18	17	17	20	20	20	19	19	20	21	22	24	22	22	23	21	21	22	20	22	22	21	21	21
Natural Gas Distribution	2	2	2	2	2	2	2	2	2	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
ELECTRICITY	**94**	**96**	**102**	**93**	**95**	**98**	**98**	**109**	**122**	**119**	**129**	**130**	**123**	**127**	**120**	**120**	**114**	**119**	**110**	**95**	**97**	**88**	**85**	**82**	**79**	**81**	**79**
TRANSPORTATION	**122**	**116**	**117**	**118**	**122**	**123**	**127**	**132**	**139**	**144**	**146**	**148**	**149**	**154**	**159**	**162**	**163**	**167**	**167**	**163**	**171**	**171**	**173**	**176**	**173**	**174**	**173**
Passenger Transport	**69**	**66**	**66**	**67**	**69**	**70**	**72**	**74**	**77**	**79**	**81**	**83**	**85**	**87**	**88**	**88**	**88**	**88**	**87**	**86**	**88**	**87**	**87**	**89**	**87**	**90**	**93**
Cars, Light Trucks and Motorcycles	62	60	61	61	64	64	66	68	70	72	73	77	78	80	80	81	81	81	79	80	81	80	80	81	80	83	85
Bus, Rail and Domestic Aviation	7	6	6	5	6	6	6	6	6	7	7	7	7	7	7	7	7	8	7	7	7	7	7	8	7	7	7
Freight Transport	**32**	**31**	**31**	**31**	**32**	**32**	**35**	**39**	**44**	**47**	**49**	**52**	**52**	**55**	**58**	**63**	**64**	**68**	**70**	**66**	**72**	**75**	**77**	**78**	**76**	**74**	**71**
Heavy Duty Trucks, Rail	26	24	25	25	27	26	29	33	37	41	43	46	45	48	50	55	57	60	63	58	64	68	70	72	70	69	66
Domestic Aviation and Marine	6	6	6	6	6	6	6	6	6	6	6	7	7	8	8	8	7	8	7	7	8	7	7	6	6	6	5
Other: Recreational, Commercial and Residential	**21**	**20**	**20**	**20**	**21**	**21**	**20**	**19**	**18**	**18**	**16**	**13**	**12**	**12**	**13**	**11**	**11**	**11**	**11**	**11**	**11**	**9**	**9**	**9**	**10**	**10**	**10**
HEAVY INDUSTRY	**97**	**97**	**94**	**93**	**99**	**100**	**102**	**102**	**96**	**94**	**93**	**87**	**89**	**88**	**92**	**86**	**86**	**85**	**84**	**71**	**73**	**80**	**79**	**77**	**77**	**76**	**75**
Mining	**7**	**6**	**6**	**7**	**8**	**8**	**8**	**9**	**8**	**7**	**8**	**7**	**7**	**7**	**7**	**7**	**7**	**8**	**8**	**8**	**8**	**8**	**8**	**8**	**8**	**8**	**7**
Smelting and Refining (Non Ferrous Metals)	**17**	**18**	**17**	**17**	**17**	**16**	**17**	**17**	**17**	**16**	**16**	**15**	**15**	**15**	**14**	**14**	**14**	**13**	**13**	**12**	**11**	**12**	**10**	**11**	**10**	**10**	**10**
Pulp and Paper	**15**	**15**	**14**	**14**	**14**	**13**	**14**	**14**	**13**	**13**	**13**	**12**	**11**	**11**	**11**	**9**	**8**	**8**	**7**	**7**	**7**	**7**	**7**	**7**	**7**	**7**	**7**
Iron and Steel	**16**	**18**	**18**	**18**	**18**	**18**	**18**	**18**	**18**	**19**	**19**	**17**	**17**	**17**	**17**	**16**	**17**	**18**	**17**	**13**	**14**	**17**	**17**	**15**	**16**	**14**	**15**
Cement	**10**	**8**	**8**	**9**	**10**	**11**	**10**	**11**	**11**	**12**	**12**	**12**	**12**	**12**	**13**	**13**	**14**	**13**	**12**	**10**	**10**	**10**	**11**	**10**	**10**	**10**	**10**
Lime & Gypsum	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**2**	**3**	**3**	**3**	**2**	**3**	**2**	**2**
Chemicals & Fertilizers	**29**	**28**	**28**	**27**	**30**	**31**	**32**	**31**	**27**	**24**	**23**	**22**	**23**	**22**	**26**	**23**	**23**	**23**	**23**	**20**	**21**	**23**	**24**	**24**	**24**	**25**	**23**
BUILDINGS	**74**	**73**	**74**	**78**	**79**	**79**	**85**	**83**	**75**	**79**	**85**	**82**	**87**	**92**	**90**	**86**	**81**	**86**	**86**	**84**	**82**	**87**	**85**	**86**	**88**	**85**	**81**
Service Industry	**27**	**28**	**28**	**30**	**30**	**32**	**33**	**34**	**31**	**34**	**38**	**38**	**40**	**43**	**43**	**40**	**37**	**38**	**39**	**39**	**38**	**41**	**42**	**41**	**42**	**41**	**40**
Residential	**47**	**45**	**46**	**48**	**49**	**48**	**52**	**49**	**44**	**45**	**47**	**44**	**47**	**48**	**47**	**46**	**44**	**48**	**47**	**46**	**43**	**46**	**43**	**45**	**47**	**45**	**41**
AGRICULTURE	**58**	**58**	**60**	**62**	**65**	**68**	**70**	**70**	**70**	**70**	**70**	**68**	**68**	**70**	**72**	**73**	**71**	**71**	**71**	**69**	**69**	**69**	**70**	**73**	**71**	**72**	**72**
On Farm Fuel Use	**11**	**11**	**11**	**12**	**13**	**14**	**14**	**15**	**14**	**13**	**13**	**11**	**11**	**12**	**12**	**12**	**12**	**12**	**12**	**12**	**13**	**14**	**13**	**13**	**13**	**13**	**12**
Crop Production	**15**	**14**	**14**	**15**	**16**	**16**	**17**	**17**	**17**	**17**	**17**	**15**	**15**	**16**	**17**	**16**	**16**	**18**	**19**	**19**	**19**	**19**	**21**	**23**	**22**	**22**	**23**
Animal Production	**32**	**33**	**34**	**35**	**36**	**38**	**39**	**39**	**39**	**39**	**40**	**41**	**42**	**42**	**43**	**44**	**43**	**42**	**40**	**38**	**37**	**36**	**36**	**36**	**36**	**36**	**37**
WASTE	**19**	**19**	**19**	**19**	**19**	**19**	**19**	**19**	**20**	**20**	**20**	**20**	**20**	**21**	**21**	**21**	**22**	**21**	**20**	**20**	**19**	**19**	**18**	**18**	**18**	**19**	**19**
Solid Waste	**17**	**17**	**17**	**17**	**17**	**17**	**17**	**18**	**18**	**18**	**18**	**18**	**19**	**19**	**19**	**19**	**20**	**19**	**18**	**18**	**17**	**17**	**17**	**17**	**16**	**17**	**17**
Wastewater	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**
Waste Incineration	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**
COAL PRODUCTION	**4**	**4**	**4**	**4**	**4**	**4**	**4**	**4**	**4**	**3**	**3**	**3**	**3**	**3**	**3**	**2**	**2**	**3**	**2**	**2**	**3**	**3**	**3**	**3**	**2**	**2**	**2**
LIGHT MANUFACTURING, CONSTRUCTION & FOREST RESOURCES	**28**	**27**	**26**	**24**	**25**	**27**	**27**	**28**	**24**	**25**	**26**	**24**	**24**	**24**	**25**	**24**	**23**	**24**	**23**	**20**	**22**	**23**	**22**	**22**	**21**	**21**	**20**
Light Manufacturing	**21**	**20**	**20**	**18**	**18**	**20**	**20**	**21**	**18**	**18**	**19**	**17**	**17**	**17**	**17**	**17**	**16**	**17**	**16**	**14**	**15**	**16**	**16**	**16**	**15**	**14**	**14**
Construction	**6**	**5**	**5**	**5**	**6**	**6**	**6**	**5**	**5**	**5**	**5**	**5**	**6**	**6**	**6**	**6**	**6**	**6**	**6**	**5**	**6**	**6**	**5**	**5**	**5**	**5**	**5**
Forest Resources	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**

Notes:
Totals may not add up due to rounding.
National GHG emissions allocated to IPCC sectors are provided in Annex 9 of this report.
Provincial/territorial GHG emissions allocated to IPCC sectors are provided in Annex 11 of this report.
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.
Emission estimates for Solid Waste include emissions from municipal solid waste landfills, wood waste landfills and municipal solid waste composting.
0 indicates emissions of less than 0.5 Mt CO_2 eq; truncated due to rounding

Table A10–3 **Relationship between Canada's Economic Sectors and IPCC Sectors, 2016**

	Economic Category Total	National Inventory Category[a]																									
		Energy								Industrial Processes and Product Use							Agriculture				Waste					CO₂ Captured[j]	LULUCF[b]
		Energy: Fuel Combustion				Energy: Fugitive																					
		Stationary Combustion			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		
		Stationary	Industrial Cogeneration: Electricity[c]	Industrial Cogeneration: Steam for Sale																							
	Mt CO_2 equivalent																										
National Inventory Total[a,b]	**704**	**296**	**22.1**	**0.8**	**199**	**20.7**	**5.9**	**29.3**	**574**	**7.9**	**6.6**	**15.6**	**12.0**	**10.8**	**0.5**	**53.4**	**8.4**	**24.7**	**26.6**	**59.7**	**16.4**	**0.5**	**1.1**	**0.6**	**18.7**	**-1.8**	
OIL AND GAS	**183**	**102.0**	**14.1**		**11.0**	**19.5**	**5.9**	**29.3**	**181.7**					**2.1**		**2.1**										**-1.0**	
Upstream Oil and Gas	**161**	**85.0**	**13.8**		**10.8**	**18.4**	**5.7**	**27.9**	**161.5**					**0.2**		**0.2**										**-1.0**	
Natural Gas Production and Processing	49	18.8	8.2		0.2	9.8	1.1	10.4	48.6					0.0		0.0											
Conventional Oil Production	30	7.9	1.7		0.1	2.7	3.5	13.9	29.9					0.0		0.0											
Conventional Light Oil Production	16	2.8	1.5		0.1	1.7	2.1	7.7	16.0					0.0		0.0											
Conventional Heavy Oil Production	12	4.2			0.0	1.0	0.8	6.3	12.3																		
Frontier Oil Production	2	0.8	0.2		0.0	0.0	0.6	0.0	1.7																		
Oil Sands (Mining, In-situ, Upgrading)[c]	72	58.3	3.8		2.2	4.6	1.1	2.6	72.6					0.2		0.2										-1.0	
Mining and Extraction	17	9.6	1.0		2.2	4.3	0.4		17.4					0.1		0.1											
In-situ	37	35.3	1.6			0.3	0.2	0.1	37.5																		
Upgrading	17	13.4	1.1			0.1	0.5	2.6	17.7					0.1		0.1										-1.0	
Oil and Natural Gas Transmission	10				8.4	1.2	0.0	0.9	10.4																		
Downstream Oil and Gas	**22**	**17.0**	**0.4**		**0.1**	**1.1**	**0.2**	**1.4**	**20.2**					**1.9**		**1.9**											
Petroleum Refining	21	17.0	0.4		0.0	0.1	0.2	1.4	19.0					1.9		1.9											
Natural Gas Distribution	1				0.1	1.0	0.0	0.1	1.1																		
ELECTRICITY	**79**	**78.7**		**0.4**					**79.2**						**0.2**	**0.2**										**-0.8**	
TRANSPORTATION[g]	**173**				**169.6**				**169.6**				**3.7**	**0.1**	**0.0**	**3.8**											
Passenger Transport	**93**				**90.4**				**90.4**				**2.1**	**0.0**	**0.0**	**2.1**											
Cars, Light Trucks and Motorcycles	85				83.4				83.4				2.0	0.0	0.0	2.0											
Bus, Rail and Domestic Aviation	7				7.0				7.0				0.2	0.0	0.0	0.2											
Freight Transport	**71**				**69.5**				**69.5**				**1.6**	**0.0**	**0.0**	**1.6**											
Heavy Duty Trucks, Rail	66				65.0				65.0				1.5	0.0	0.0	1.5											
Domestic Aviation and Marine	5				4.6				4.6				0.1	0.0		0.1											
Other: Recreational, Commercial and Residential	**10**				**9.7**				**9.7**																		
HEAVY INDUSTRY	**75**	**30.0**	**6.8**	**0.3**	**3.2**				**40.3**	**7.8**	**6.6**	**15.6**	**0.6**	**3.9**		**34.4**											
Mining	**7**	**3.1**	**1.3**		**2.7**				**7.1**				**0.0**	**0.1**		**0.1**											
Smelting and Refining (Non Ferrous Metals)	**10**	**2.6**	**0.0**	**0.0**	**0.1**				**2.7**	**0.0**		**6.3**		**0.8**		**7.1**											
Pulp and Paper	**7**	**4.8**	**1.7**	**0.1**	**0.1**				**6.7**	**0.0**				**0.0**		**0.0**											
Iron and Steel	**15**	**5.4**	**0.1**	**0.0**	**0.2**				**5.7**			**9.3**		**0.1**		**9.4**											
Cement	**10**	**3.7**			**0.0**				**3.8**	**6.2**				**0.0**		**6.2**											
Lime & Gypsum	**2**	**1.0**			**0.0**				**1.0**	**1.4**				**0.0**		**1.4**											
Chemicals & Fertilizers	**23**	**9.4**	**3.7**	**0.2**	**0.1**				**13.3**	**0.2**	**6.6**		**0.6**	**2.8**		**10.1**											
BUILDINGS	**81**	**68.5**	**0.7**						**69.2**				**7.4**	**4.5**	**0.3**	**12.2**											
Service Industry	**40**	**29.3**	**0.7**						**30.0**				**5.6**	**4.5**	**0.3**	**10.4**											
Residential	**41**	**39.3**							**39.3**				**1.8**			**1.8**											
AGRICULTURE	**72**	**3.4**			**8.8**				**12.3**					**0.0**		**0.0**	**8.4**	**24.7**	**26.6**	**59.7**							
On Farm Fuel Use[h]	**12**	**3.4**			**8.8**				**12.3**					**0.0**		**0.0**											
Crop Production	**23**																		**23.1**	**23.1**							
Animal Production	**37**																**8.4**	**24.7**	**3.5**	**36.6**							
WASTE	**19**																				**16.4**	**0.5**	**1.1**	**0.6**	**18.7**		
Solid Waste[i]	**17**																				**16.4**	**0.5**			**16.9**		
Wastewater	**1**																						**1.1**		**1.1**		
Waste Incineration	**1**																							**0.6**	**0.6**		
COAL PRODUCTION	**2**	**0.5**			**0.5**	**1.3**			**2.3**																		
LIGHT MANUFACTURING, CONSTRUCTION & FOREST RESOURCES	**20**	**12.9**	**0.5**	**0.0**	**6.3**				**19.7**	**0.2**			**0.4**	**0.2**	**0.0**	**0.8**											
Light Manufacturing	**14**	**11.5**	**0.5**	**0.0**	**1.4**				**13.4**	**0.2**			**0.4**	**0.2**	**0.0**	**0.7**											
Construction	**5**	**1.3**			**4.0**				**5.3**					**0.0**		**0.0**											
Forest Resources	**1**	**0.1**	**0.0**		**0.9**				**1.0**					**0.0**		**0.0**											
																											-27.8

ECONOMIC CATEGORY

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.
f 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
h On Farm Fuel Use includes emissions associated with the use of lube oils and greases.
i Emission estimates for Solid Waste include emissions from municipal solid waste landfills, wood waste landfills and municipal solid waste composting.
j Some facilities capture CO_2 emissions. This is displayed as a negative quantity, as it is computed as an emission reduction at the source. Though the CO_2 has been captured, this does not imply permanent storage; some portion may be subsequently re-emitted (for instance, as fugitive releases) in another activity – in such cases, the re-emissions are reported in the economic sectors where they occur.
0 Indicates emissions of less than 0.5 Mt CO_2 eq

Annex 11

PROVINCIAL/ TERRITORIAL GREENHOUSE GAS EMISSION TABLES BY IPCC SECTOR, 1990–2016

This annex contains summary tables (Table A11–1 to Table A11–28) illustrating GHG emissions by province/territory and year for each IPCC sector.

To account for the creation of Nunavut in 1999, separate time series–are provided from 1999 onwards for both the Northwest Territories and Nunavut (Table A11–24 and Table A11–26); emissions for the years 1990–1998 are presented as a combined region in Table A11–28.

Provincial/territorial GHG emissions allocated to Canadian economic sectors are provided in Annex 12 of this report.

Although the UNFCCC reporting guidelines only require reporting national-level information, provincial and territorial information is important, owing to differences in regional emission levels and trends. Note that provincial and territorial emission estimates may not necessarily sum to the national totals due to rounding.

Several Canadian provinces develop independent inventories of provincial GHG emissions, in some cases making use of alternate methodologies, data inputs and/or inclusions/omissions of GHG source categories. While Canada is developing a national emission inventory consistent with IPCC guidelines and international obligations, provincial governments may elect to develop an inventory structure in accordance with specific provincial needs. Environment and Climate Change Canada encourages collaboration with provinces and territories for quality assurance and continuous improvement of this annual National Inventory Report.

Provincial/territorial greenhouse gas emission tables are also available in electronic file format online at https://open.canada.ca.

Table A11–1 **GHG Source/Sink Category Description**

GHG Source/Sink Categories	
ENERGY	
a. Stationary Combustion Sources	
Public Electricity and Heat Production	Emissions from fuel consumed by utility electricity generation and steam production (for sale)
Petroleum Refining Industries	Emissions from fuel consumed by petroleum refining industries
Mining and Upstream Oil and Gas Production	Emissions from fuel consumed by:
	– Metal and non-metal mines, coal mines, stone quarries, and gravel pits
	– Oil and gas extraction industries
	– Mineral exploration and contract drilling operations
Manufacturing Industries	Emissions from fuel consumed by the following industries:
	– Iron and Steel (steel foundries, casting and rolling mills)
	– Non-ferrous metals (aluminium, magnesium and other production)
	– Chemical (fertilizer manufacturing, organic and inorganic chemical manufacturing)
	– Pulp and Paper (primarily pulp, paper, and paper product manufacturers)
	– Cement and other non-metallic mineral production
	– Other manufacturing industries not listed (such as automobile manufacturing, textiles, food and beverage industries)
Construction	Emissions from fuels consumed by the construction industry – buildings, highways etc.
Commercial & Institutional	Emissions from fuel consumed by:
	– Service industries related to mining, communication, wholesale and retail trade, finance and insurance, real estate, education, etc.)
	– Federal, provincial and municipal establishments
	– National Defence and Canadian Coast Guard
	– Train stations, airports and warehouses
Residential	Emissions from fuel consumed for personal residences (homes, apartment hotels, condominiums and farm houses)
Agriculture & Forestry	Emissions from fuel consumed by:
	– Forestry and logging service industry
	– Agricultural, hunting and trapping industry (excluding food processing, farm machinery manufacturing and repair)
b. Transportation	Emissions resulting from the:
Domestic Aviation	– Consumption of fossil fuels by aircrafts flying domestically with Canadian purchased fuel
Road Transportation	– Consumption of fossil fuels (including non-CO_2 emissions from ethanol and biodiesel) by vehicles licensed to operate on roads
Railways	– Consumption of fossil fuels (including non-CO_2 emissions from biodiesel) by Canadian railways
Domestic Navigation	– Consumption of fossil fuels (including non-CO_2 emissions from ethanol and biodiesel) by Canadian registered marine vessels fuelled domestically
Others – Off-road	– Consumption of fossil fuels (including non-CO_2 emissions from ethanol and biodiesel) by combustion devices not licensed to operate on roads
Others – Pipeline Transport	– Transportation and distribution of crude oil, natural gas and other products
c. Fugitive Sources	Intentional and unintentional releases of greenhouse gases from the following activities:
Coal Mining	– Underground and surface mining, abandoned underground coal mines
Oil and Natural Gas	– Conventional and unconventional oil and gas exploration, production, transportation and distribution
d. CO_2 Transport and Storage	Intentional and unintentional releases of greenhouse gases from the transport and storage of carbon dioxide
INDUSTRIAL PROCESSES AND PRODUCT USE	Emissions resulting from the following process activities:
a. Mineral Products	– Cement production, lime production, and mineral product use (which includes glass production, other uses of soda ash, magnesite use, and limestone and dolomite use)
b. Chemical Industry	– Production of ammonia, nitric acid, adipic acid, carbide and petrochemicals. Petrochemical production includes production of carbon black, ethylene dichloride, ethylene, methanol and styrene
c. Metal Production	– Aluminum production, iron and steel production, and magnesium production and casting
d. Production and Consumption of Halocarbons, SF_6 and NF_3	– By-product production of HFC-23; use of HFCs and/or PFCs in air conditioning units, refrigeration units, fire extinguishers, aerosol cans, solvents, foam blowing, semiconductor manufacturing and electronics industry, and use of SF_6 and NF_3 in semiconductor manufacturing
e. Non-Energy Products from Fuels and Solvent Use	– Non-energy use of fossil fuels (including solvents and lubricants) that are not accounted for elsewhere under the Industrial Processes and Product Use Sector
f. Other Product Manufacture and Use	– Use of N_2O as an anaesthetic and propellant; use of urea in selective catalytic reduction (SCR) equipped vehicles; use of SF_6 and PFCs in electrical equipment
AGRICULTURE	Emissions resulting from the:
a. Enteric Fermentation	– Eructation of CH_4 during the digestion of plant material by (mainly) ruminants
b. Manure Management	– Release of CH_4 and N_2O due to microbial activity during the storage of feces, urine and bedding materials from the cleaning of barns and pens
	– Indirect N_2O emissions from volatilization and leaching of nitrogen from animal manure during storage
c. Agricultural Soils	
Direct sources	– Direct N_2O emissions from Synthetic fertilizer, manure on cropland, pasture range and paddock, crop residue, tillage, summerfallow, irrigation and cultivation of organic soils
Indirect Sources	– Indirect N_2O emissions from volatilization and leaching of animal manure nitrogen, synthetic fertilizer nitrogen and crop residue nitrogen
d. Field Burning of Agricultural Residues	– CH_4 and N_2O emissions from crop residue burning
e. Liming, Urea Application and Other Carbon-containing Fertilizers	– Direct emissions of CO_2 from the application of lime, urea and other fertilizers containing carbon
WASTE	Emissions resulting from:
a. Solid Waste Disposal	– Municipal solid waste management sites (landfills) and dedicated wood waste landfills
b. Biological Treatment of Solid Waste	– Composting of municipal solid waste
c. Wastewater Treatment and Discharge	– Domestic and industrial wastewater treatment
d. Incineration and Open Burning of Waste	– Municipal solid, hazardous and clinical waste, and sewage sludge incineration
LAND USE, LAND-USE CHANGE AND FORESTRY	Emissions and removals resulting from:
a. Forest Land	– Managed forests and lands converted to forests; includes growth and anthropogenic disturbances related to forest management but excludes fire and most insect disturbances
b. Cropland	– Management practices on lands in annual crops, summerfallow and perennial crops (forage, specialty crops, orchards); immediate and residual emissions from lands converted to cropland
c. Grassland	– Managed agricultural grassland
d. Wetlands	– Peatlands disturbed for peat extraction, or land flooded from hydro reservoir development
e. Settlements	– Forest and grassland converted to built-up land (settlements, transport infrastructure, oil & gas infrastructure, mining, etc); urban tree growth
f. Harvested Wood Products	– Use and disposal of harvested wood products manufactured from wood coming from forest harvest and forest conversion activities in Canada

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Table A11–2 GHG Emission Summary for Newfoundland and Labrador, Selected Years

Greenhouse Gas Categories	1990	2005	2011	2012	2013	2014	2015	2016
	kt CO_2 eq							
TOTAL	**9 320**	**9 890**	**9 960**	**9 410**	**9 380**	**10 400**	**10 600**	**10 800**
ENERGY	**8 600**	**9 050**	**9 020**	**8 470**	**8 460**	**9 470**	**9 660**	**9 820**
a. Stationary Combustion Sources	**5 550**	**4 780**	**4 490**	**4 190**	**4 600**	**5 130**	**5 030**	**5 050**
Public Electricity and Heat Production	1 640	819	790	769	867	1 210	1 340	1 520
Petroleum Refining Industries	1 000	950	830	1 000	960	910	910	1 000
Mining and Upstream Oil and Gas Production	1 160	1 900	1 860	1 620	1 760	1 870	1 730	1 420
Manufacturing Industries	506	276	146	79	72	40	49	52
Construction	33	24	15	9	6	7	18	5
Commercial and Institutional	320	358	263	203	544	630	599	572
Residential	828	443	573	470	390	453	378	445
Agriculture and Forestry	25	8	18	11	8	11	12	10
b. Transport[1]	**3 010**	**3 360**	**4 040**	**3 750**	**3 290**	**3 680**	**4 050**	**4 110**
Domestic Aviation	190	200	190	230	230	220	210	210
Road Transportation	1 520	2 100	2 710	2 710	2 470	2 820	3 030	3 040
Light-Duty Gasoline Vehicles	651	595	682	720	621	670	674	632
Light-Duty Gasoline Trucks	422	636	944	1 050	944	1 070	1 140	1 150
Heavy-Duty Gasoline Vehicles	82	101	162	206	192	205	220	229
Motorcycles	3	2	7	7	6	8	9	9
Light-Duty Diesel Vehicles	4	5	8	6	6	6	7	7
Light-Duty Diesel Trucks	2	6	6	4	4	5	8	10
Heavy-Duty Diesel Vehicles	358	756	902	718	695	846	971	1 000
Propane and Natural Gas Vehicles	0.05	0.03	0.00	0.00	0.00	0.00	0.00	0.00
Railways	-	-	-	-	-	-	-	-
Domestic Navigation	630	x	560	390	220	210	270	330
Other Transportation	670	x	590	430	370	440	550	540
Off-Road Agriculture & Forestry	25	34	29	20	17	19	25	22
Off-Road Commercial & Institutional	31	48	51	41	39	43	49	20
Off-Road Manufacturing, Mining & Construction	220	280	350	210	180	220	290	320
Off-Road Residential	7	25	x	x	x	27	29	29
Off-Road Other Transportation	380	150	130	130	110	130	150	150
Pipeline Transport	-	x	x	x	x	x	x	-
c. Fugitive Sources	**41**	**910**	**490**	**520**	**570**	**660**	**580**	**650**
Coal Mining	-	-	-	-	-	-	-	-
Oil and Natural Gas	41	910	490	520	570	660	580	650
d. CO_2 Transport and Storage	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
INDUSTRIAL PROCESSES AND PRODUCT USE	**98**	**168**	**262**	**216**	**234**	**210**	**220**	**248**
a. Mineral Products	**64**	**2**	**0.72**	**0.78**	**0.57**	**0.64**	**0.85**	**0.84**
Cement Production	60	-	-	-	-	-	-	-
Lime Production	-	-	-	-	-	-	-	-
Mineral Products Use	4	2	0.72	0.78	0.57	0.64	0.85	0.84
b. Chemical Industry[2]	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
Adipic Acid Production	-	-	-	-	-	-	-	-
c. Metal Production	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
Iron and Steel Production	-	-	-	-	-	-	-	-
Aluminum Production	-	-	-	-	-	-	-	-
SF_6 Used in Magnesium Smelters and Casters	-	-	-	-	-	-	-	-
d. Production and Consumption of Halocarbons, SF_6 and NF_3[3]	**-**	**81**	**140**	**150**	**150**	**160**	**180**	**200**
e. Non-Energy Products from Fuels and Solvent Use	**x**	**x**	**x**	**x**	**x**	**x**	**x**	**x**
f. Other Product Manufacture and Use	**5**	**6**	**5**	**5**	**5**	**5**	**8**	**9**
AGRICULTURE	**55**	**66**	**110**	**140**	**100**	**98**	**92**	**88**
a. Enteric Fermentation	**23**	**31**	**32**	**31**	**32**	**32**	**32**	**30**
b. Manure Management	**17**	**20**	**25**	**25**	**26**	**26**	**26**	**26**
c. Agricultural Soils	**12**	**15**	**19**	**18**	**19**	**19**	**20**	**18**
Direct Sources	10	12	15	15	15	15	16	15
Indirect Sources	2	3	3	3	3	3	4	3
d. Field Burning of Agricultural Residues	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
e. Liming, Urea Application and Other Carbon-containing Fertilizers	**3**	**-**	**40**	**70**	**30**	**20**	**10**	**10**
WASTE	**570**	**610**	**570**	**580**	**590**	**600**	**600**	**600**
a. Solid Waste Disposal	**520**	**570**	**540**	**550**	**560**	**560**	**570**	**570**
b. Biological Treatment of Solid Waste	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
c. Wastewater Treatment and Discharge	**42**	**38**	**31**	**31**	**31**	**31**	**31**	**31**
d. Incineration and Open Burning of Waste	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**

Notes:

1. Emissions from ethanol and biodiesel are included in the Transport categories using gasoline and diesel respectively.
2. Emissions from Ammonia Production, Nitric Acid Production and Petrochemical Production and Carbon Black categories are included in Non-Energy Products from Fuels and Solvent Use as CO_2 eq values within provincial/territorial tables.
3. HFC and PFC consumption began in 1995; HFC emissions occurring as a by-product of HCFC production (HCFC-22 exclusively) only occurred in Canada from 1990–1992 and PFC emissions prior to 1995 are the result of by-product CF_4 emissions from the use of NF_3.

\- Indicates no emissions

0.00 Indicates emissions truncated due to rounding

x Indicates data has been suppressed to respect confidentiality

Estimates for the latest year (2016) are based on preliminary energy data; these data, though the best available information at the time of publication, are subject to revision in the next submission year.

Provincial/Territorial GHG emissions allocated to Canadian economic sectors are provided in Annex 12 of this report

Table A11–3 2016 GHG Emission Summary for Newfoundland and Labrador

Greenhouse Gas Categories	Greenhouse Gases									
	CO_2	CH_4	CH_4	N_2O	N_2O	HFCs[4]	PFCs[4]	SF_6	NF_3	TOTAL
Global Warming Potential			25		298			22 800	17 200	
Unit	kt	kt	kt CO_2 eq	kt	kt CO_2 eq	kt CO_2 eq	kt CO_2 eq	kt CO_2 eq	kt CO_2 eq	kt CO_2 eq
TOTAL	**9 500**	**36**	**910**	**0.47**	**140**	**200**	**0.03**	**4**	**-**	**10 800**
ENERGY	**9 440**	**11**	**280**	**0.30**	**90**	**-**	**-**	**-**	**-**	**9 820**
a. Stationary Combustion Sources	**4 830**	**7**	**200**	**0.10**	**40**	**-**	**-**	**-**	**-**	**5 050**
Public Electricity and Heat Production	1 500	0.03	0.65	0.03	9	-	-	-	-	1 520
Petroleum Refining Industries	1 000	0.03	0.80	0.02	5	-	-	-	-	1 000
Mining and Upstream Oil and Gas Production	1 350	2	59	0.04	10	-	-	-	-	1 420
Manufacturing Industries	51	0.00	0.03	0.00	0.35	-	-	-	-	52
Construction	5	0.00	0.00	0.00	0.02	-	-	-	-	5
Commercial and Institutional	568	0.01	0.15	0.01	3	-	-	-	-	572
Residential	317	4	100	0.05	20	-	-	-	-	445
Agriculture and Forestry	10	0.00	0.00	0.00	0.04	-	-	-	-	10
b. Transport[1]	**4 040**	**0.69**	**17**	**0.16**	**49**	**-**	**-**	**-**	**-**	**4 110**
Domestic Aviation	206	0.01	0.10	0.01	2	-	-	-	-	210
Road Transportation	2 990	0.20	5	0.13	39	-	-	-	-	3 040
Light-Duty Gasoline Vehicles	625	0.05	1	0.02	6	-	-	-	-	632
Light-Duty Gasoline Trucks	1 130	0.09	2	0.04	11	-	-	-	-	1 150
Heavy-Duty Gasoline Vehicles	224	0.01	0.18	0.02	6	-	-	-	-	229
Motorcycles	9	0.00	0.08	0.00	0.05	-	-	-	-	9
Light-Duty Diesel Vehicles	7	0.00	0.00	0.00	0.20	-	-	-	-	7
Light-Duty Diesel Trucks	9	0.00	0.01	0.00	0.20	-	-	-	-	10
Heavy-Duty Diesel Vehicles	984	0.04	1	0.05	20	-	-	-	-	1 000
Propane and Natural Gas Vehicles	0.00	0.00	0.00	0.00	0.00	-	-	-	-	0.00
Railways	-	-	-	-	-	-	-	-	-	-
Domestic Navigation	326	0.03	0.80	0.01	3	-	-	-	-	330
Other Transportation	518	0.50	10	0.02	5	-	-	-	-	540
Off-Road Agriculture & Forestry	21	0.00	0.03	0.00	0.30	-	-	-	-	22
Off-Road Commercial & Institutional	20	0.02	0.50	0.00	0.20	-	-	-	-	20
Off-Road Manufacturing, Mining & Construction	314	0.02	0.60	0.01	4	-	-	-	-	320
Off-Road Residential	27	0.05	1	0.00	0.20	-	-	-	-	29
Off-Road Other Transportation	136	0.40	9	0.00	0.90	-	-	-	-	150
Pipeline Transport	-	-	-	-	-	-	-	-	-	-
c. Fugitive Sources	**560**	**4**	**87**	**0.01**	**2**	**-**	**-**	**-**	**-**	**650**
Coal Mining	-	-	-	-	-	-	-	-	-	-
Oil and Natural Gas	560	4	87	0.01	2	-	-	-	-	650
d. CO_2 Transport and Storage	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
INDUSTRIAL PROCESSES AND PRODUCT USE	**43**	**-**	**-**	**0.01**	**4**	**200**	**0.03**	**4**	**-**	**248**
a. Mineral Products	**0.84**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**0.84**
Cement Production	-	-	-	-	-	-	-	-	-	-
Lime Production	-	-	-	-	-	-	-	-	-	-
Mineral Products Use	0.84	-	-	-	-	-	-	-	-	0.84
b. Chemical Industry[2]	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
Adipic Acid Production	-	-	-	-	-	-	-	-	-	-
c. Metal Production	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
Iron and Steel Production	-	-	-	-	-	-	-	-	-	-
Aluminum Production	-	-	-	-	-	-	-	-	-	-
SF_6 Used in Magnesium Smelters and Casters	-	-	-	-	-	-	-	-	-	-
d. Production and Consumption of Halocarbons, SF_6 and NF_3[3]	**-**	**-**	**-**	**-**	**-**	**200**	**0.02**	**-**	**-**	**200**
e. Non-Energy Products from Fuels and Solvent Use	**x**	**x**	**x**	**x**	**x**	**x**	**x**	**x**	**x**	**x**
f. Other Product Manufacture and Use	**0.60**	**-**	**-**	**0.02**	**4**	**-**	**0.01**	**4**	**-**	**9**
AGRICULTURE	**10**	**2**	**42**	**0.11**	**32**	**-**	**-**	**-**	**-**	**88**
a. Enteric Fermentation	**-**	**1**	**30**	**-**	**-**	**-**	**-**	**-**	**-**	**30**
b. Manure Management	**-**	**0.48**	**12**	**0.05**	**10**	**-**	**-**	**-**	**-**	**26**
c. Agricultural Soils	**-**	**-**	**-**	**0.06**	**18**	**-**	**-**	**-**	**-**	**18**
Direct Sources	-	-	-	0.05	15	-	-	-	-	15
Indirect Sources	-	-	-	0.01	3	-	-	-	-	3
d. Field Burning of Agricultural Residues	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
e. Liming, Urea Application and Other Carbon-containing Fertilizers	**10**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**10**
WASTE	**-**	**24**	**590**	**0.03**	**10**	**-**	**-**	**-**	**-**	**600**
a. Solid Waste Disposal	**-**	**23**	**570**	**-**	**-**	**-**	**-**	**-**	**-**	**570**
b. Biological Treatment of Solid Waste	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
c. Wastewater Treatment and Discharge	**-**	**0.84**	**21**	**0.03**	**10**	**-**	**-**	**-**	**-**	**31**
d. Incineration and Open Burning of Waste	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**

Notes:

1. Emissions from ethanol and biodiesel are included in the Transport categories using gasoline and diesel respectively.
2. Emissions from Ammonia Production, Nitric Acid Production and Petrochemical Production and Carbon Black categories are included in Non-Energy Products from Fuels and Solvent Use as CO_2 eq values within provincial/territorial tables.
3. HFC and PFC consumption began in 1995; HFC emissions occurring as a by-product of HCFC production (HCFC-22 exclusively) only occurred in Canada from 1990–1992 and PFC emissions prior to 1995 are the result of by-product CF_4 emissions from the use of NF_3.
4. IPCC's Fourth Assessment Report provides global warming potentials (GWPs) for the various species of HFCs and PFCs. Chapter 1, Table 1-1 of this report provides a list of GWPs used.

\- Indicates no emissions

0.00 Indicates emissions truncated due to rounding

x Indicates data has been suppressed to respect confidentiality

Estimates for the latest year (2016) are based on preliminary energy data; these data, though the best available information at the time of publication, are subject to revision in the next submission year.

Provincial/Territorial GHG emissions allocated to Canadian economic sectors are provided in Annex 12 of this report

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Table A11–4 GHG Emission Summary for Prince Edward Island, Selected Years

Greenhouse Gas Categories	1990	2005	2011	2012	2013	2014	2015	2016
	kt CO_2 eq							
TOTAL	**1 900**	**2 000**	**2 140**	**2 030**	**1 710**	**1 710**	**1 700**	**1 810**
ENERGY	**1 430**	**1 450**	**1 690**	**1 550**	**1 290**	**1 220**	**1 230**	**1 280**
a. Stationary Combustion Sources	**738**	**615**	**726**	**673**	**537**	**442**	**385**	**372**
Public Electricity and Heat Production	104	5	1	11	4	4	14	15
Petroleum Refining Industries	-	-	-	-	-	-	-	-
Mining and Upstream Oil and Gas Production	1	x	x	x	x	x	-	-
Manufacturing Industries	55	145	143	189	116	75	63	77
Construction	11	x	x	x	x	x	2	3
Commercial and Institutional	159	119	86	73	74	60	56	23
Residential	389	311	455	380	328	288	241	242
Agriculture and Forestry	19	24	30	17	13	12	10	11
b. Transport[1]	**692**	**835**	**960**	**881**	**749**	**779**	**846**	**911**
Domestic Aviation	18	14	17	19	20	19	19	20
Road Transportation	452	616	694	674	580	584	606	640
Light-Duty Gasoline Vehicles	225	240	237	232	199	192	193	203
Light-Duty Gasoline Trucks	122	224	252	255	219	215	219	243
Heavy-Duty Gasoline Vehicles	40	46	46	46	42	39	40	44
Motorcycles	1	1	2	2	1	1	1	2
Light-Duty Diesel Vehicles	1	2	3	3	2	2	3	3
Light-Duty Diesel Trucks	0.45	0.90	0.78	0.68	0.60	0.67	1	1
Heavy-Duty Diesel Vehicles	62	102	154	136	116	133	149	145
Propane and Natural Gas Vehicles	-	-	-	-	-	-	-	-
Railways	-	-	-	-	-	-	-	-
Domestic Navigation	80	89	130	x	63	85	120	140
Other Transportation	140	120	120	x	86	92	100	110
Off-Road Agriculture & Forestry	47	48	51	41	34	36	42	36
Off-Road Commercial & Institutional	5	9	11	9	9	9	9	8
Off-Road Manufacturing, Mining & Construction	14	15	18	15	13	14	17	26
Off-Road Residential	1	x	x	6	x	x	x	x
Off-Road Other Transportation	76	37	34	31	26	28	29	31
Pipeline Transport	-	x	x	x	x	x	x	x
c. Fugitive Sources	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
Coal Mining	-	-	-	-	-	-	-	-
Oil and Natural Gas	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
d. CO_2 Transport and Storage	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
INDUSTRIAL PROCESSES AND PRODUCT USE	6	25	42	42	42	44	46	51
a. Mineral Products	**0.34**	**0.91**	**0.58**	**0.66**	**0.63**	**0.75**	**0.75**	**0.74**
Cement Production	-	-	-	-	-	-	-	-
Lime Production	-	-	-	-	-	-	-	-
Mineral Products Use	0.34	0.91	0.58	0.66	0.63	0.75	0.75	0.74
b. Chemical Industry[2]	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
Adipic Acid Production	-	-	-	-	-	-	-	-
c. Metal Production	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
Iron and Steel Production	-	-	-	-	-	-	-	-
Aluminum Production	-	-	-	-	-	-	-	-
SF_6 Used in Magnesium Smelters and Casters	-	-	-	-	-	-	-	-
d. Production and Consumption of Halocarbons, SF_6 and NF_3[3]	**-**	**20**	**39**	**39**	**39**	**41**	**44**	**48**
e. Non-Energy Products from Fuels and Solvent Use	**x**	**x**	**x**	**x**	**x**	**x**	**x**	**x**
f. Other Product Manufacture and Use	**1**	**2**	**1**	**1**	**1**	**1**	**1**	**1**
AGRICULTURE	380	440	330	360	310	370	350	410
a. Enteric Fermentation	**140**	**130**	**110**	**110**	**110**	**110**	**110**	**110**
b. Manure Management	**54**	**56**	**44**	**44**	**44**	**44**	**43**	**40**
c. Agricultural Soils	**180**	**240**	**180**	**200**	**150**	**210**	**200**	**260**
Direct Sources	150	200	150	170	130	180	170	220
Indirect Sources	30	40	30	30	20	30	30	40
d. Field Burning of Agricultural Residues	**0.09**	**0.20**	**0.10**	**0.20**	**0.20**	**0.20**	**0.20**	**0.20**
e. Liming, Urea Application and Other Carbon-containing Fertilizers	**5**	**5**	**3**	**2**	**2**	**2**	**3**	**3**
WASTE	86	89	77	76	75	73	73	71
a. Solid Waste Disposal	**68**	**66**	**56**	**54**	**53**	**52**	**51**	**50**
b. Biological Treatment of Solid Waste	**-**	**5**	**4**	**3**	**3**	**3**	**3**	**4**
c. Wastewater Treatment and Discharge	**7**	**9**	**9**	**9**	**9**	**9**	**9**	**9**
d. Incineration and Open Burning of Waste	**11**	**9**	**9**	**9**	**9**	**9**	**10**	**9**

Notes:

1. Emissions from ethanol and biodiesel are included in the Transport categories using gasoline and diesel respectively.
2. Emissions from Ammonia Production, Nitric Acid Production and Petrochemical Production and Carbon Black categories are included in Non-Energy Products from Fuels and Solvent Use as CO_2 eq values within provincial/territorial tables.
3. HFC and PFC consumption began in 1995; HFC emissions occurring as a by-product of HCFC production (HCFC-22 exclusively) only occurred in Canada from 1990–1992 and PFC emissions prior to 1995 are the result of by-product CF_4 emissions from the use of NF_3.

\- Indicates no emissions

0.00 Indicates emissions truncated due to rounding

x Indicates data has been suppressed to respect confidentiality

Estimates for the latest year (2016) are based on preliminary energy data; these data, though the best available information at the time of publication, are subject to revision in the next submission year.

Provincial/Territorial GHG emissions allocated to Canadian economic sectors are provided in Annex 12 of this report

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Table A11–5 2016 GHG Emission Summary for Prince Edward Island

Greenhouse Gas Categories	Greenhouse Gases									
	CO_2	CH_4	CH_4	N_2O	N_2O	HFCs[4]	PFCs[4]	SF_6	NF_3	TOTAL
Global Warming Potential			25		298			22 800	17 200	
Unit	kt	kt	kt CO_2 eq	kt	kt CO_2 eq	kt CO_2 eq	kt CO_2 eq	kt CO_2 eq	kt CO_2 eq	kt CO_2 eq
TOTAL	**1 240**	**9**	**220**	**1**	**300**	**48**	**0.01**	**-**	**-**	**1 810**
ENERGY	**1 230**	**2**	**39**	**0.06**	**20**	**-**	**-**	**-**	**-**	**1 280**
a. Stationary Combustion Sources	**331**	**1**	**30**	**0.02**	**6**	**-**	**-**	**-**	**-**	**372**
Public Electricity and Heat Production	15	0.00	0.01	0.00	0.08	-	-	-	-	15
Petroleum Refining Industries	-	-	-	-	-	-	-	-	-	-
Mining and Upstream Oil and Gas Production	-	-	-	-	-	-	-	-	-	-
Manufacturing Industries	77	0.00	0.04	0.00	0.44	-	-	-	-	77
Construction	3	0.00	0.00	0.00	0.01	-	-	-	-	3
Commercial and Institutional	23	0.00	0.01	0.00	0.20	-	-	-	-	23
Residential	202	1	30	0.02	5	-	-	-	-	242
Agriculture and Forestry	11	0.00	0.00	0.00	0.04	-	-	-	-	11
b. Transport[1]	**895**	**0.17**	**4**	**0.04**	**11**	**-**	**-**	**-**	**-**	**911**
Domestic Aviation	20	0.00	0.02	0.00	0.20	-	-	-	-	20
Road Transportation	630	0.05	1	0.03	9	-	-	-	-	640
Light-Duty Gasoline Vehicles	200	0.02	0.43	0.01	2	-	-	-	-	203
Light-Duty Gasoline Trucks	240	0.02	0.54	0.01	3	-	-	-	-	243
Heavy-Duty Gasoline Vehicles	43	0.00	0.04	0.00	1	-	-	-	-	44
Motorcycles	2	0.00	0.02	0.00	0.01	-	-	-	-	2
Light-Duty Diesel Vehicles	2	0.00	0.00	0.00	0.06	-	-	-	-	3
Light-Duty Diesel Trucks	1	0.00	0.00	0.00	0.03	-	-	-	-	1
Heavy-Duty Diesel Vehicles	143	0.01	0.20	0.01	2	-	-	-	-	145
Propane and Natural Gas Vehicles	-	-	-	-	-	-	-	-	-	-
Railways	-	-	-	-	-	-	-	-	-	-
Domestic Navigation	142	0.01	0.30	0.00	1	-	-	-	-	140
Other Transportation	103	0.10	3	0.00	0.90	-	-	-	-	110
Off-Road Agriculture & Forestry	36	0.00	0.04	0.00	0.30	-	-	-	-	36
Off-Road Commercial & Institutional	8	0.01	0.20	0.00	0.06	-	-	-	-	8
Off-Road Manufacturing, Mining & Construction	25	0.00	0.10	0.00	0.30	-	-	-	-	26
Off-Road Residential	x	x	x	x	x	x	x	x	x	x
Off-Road Other Transportation	29	0.09	2	0.00	0.20	-	-	-	-	31
Pipeline Transport	x	x	x	x	x	x	x	x	x	x
c. Fugitive Sources	**-**	**0.00**	**0.00**	**-**	**-**	**-**	**-**	**-**	**-**	**0.00**
Coal Mining	-	-	-	-	-	-	-	-	-	-
Oil and Natural Gas	-	0.00	0.00	-	-	-	-	-	-	0.00
d. CO_2 Transport and Storage	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
INDUSTRIAL PROCESSES AND PRODUCT USE	**2**	**-**	**-**	**0.00**	**1**	**48**	**0.01**	**-**	**-**	**51**
a. Mineral Products	**0.74**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**0.74**
Cement Production	-	-	-	-	-	-	-	-	-	-
Lime Production	-	-	-	-	-	-	-	-	-	-
Mineral Products Use	0.74	-	-	-	-	-	-	-	-	0.74
b. Chemical Industry[2]	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
Adipic Acid Production	-	-	-	-	-	-	-	-	-	-
c. Metal Production	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
Iron and Steel Production	-	-	-	-	-	-	-	-	-	-
Aluminum Production	-	-	-	-	-	-	-	-	-	-
SF_6 Used in Magnesium Smelters and Casters	-	-	-	-	-	-	-	-	-	-
d. Production and Consumption of Halocarbons, SF_6 and NF_3[3]	**-**	**-**	**-**	**-**	**-**	**48**	**0.00**	**-**	**-**	**48**
e. Non-Energy Products from Fuels and Solvent Use	**x**	**x**	**x**	**x**	**x**	**x**	**x**	**x**	**x**	**x**
f. Other Product Manufacture and Use	**0.09**	**-**	**-**	**0.00**	**1**	**-**	**0.00**	**-**	**-**	**1**
AGRICULTURE	**3**	**5**	**130**	**0.94**	**280**	**-**	**-**	**-**	**-**	**410**
a. Enteric Fermentation	**-**	**4**	**110**	**-**	**-**	**-**	**-**	**-**	**-**	**110**
b. Manure Management	**-**	**0.73**	**18**	**0.07**	**20**	**-**	**-**	**-**	**-**	**40**
c. Agricultural Soils	**-**	**-**	**-**	**0.86**	**260**	**-**	**-**	**-**	**-**	**260**
Direct Sources	-	-	-	0.73	220	-	-	-	-	220
Indirect Sources	-	-	-	0.10	40	-	-	-	-	40
d. Field Burning of Agricultural Residues	**-**	**0.01**	**0.10**	**0.00**	**0.04**	**-**	**-**	**-**	**-**	**0.20**
e. Liming, Urea Application and Other Carbon-containing Fertilizers	**3**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**3**
WASTE	**8**	**2**	**58**	**0.02**	**5**	**-**	**-**	**-**	**-**	**71**
a. Solid Waste Disposal	**-**	**2**	**50**	**-**	**-**	**-**	**-**	**-**	**-**	**50**
b. Biological Treatment of Solid Waste	**-**	**0.08**	**2**	**0.01**	**1**	**-**	**-**	**-**	**-**	**4**
c. Wastewater Treatment and Discharge	**-**	**0.25**	**6**	**0.01**	**3**	**-**	**-**	**-**	**-**	**9**
d. Incineration and Open Burning of Waste	**8**	**0.00**	**0.00**	**0.00**	**1**	**-**	**-**	**-**	**-**	**9**

Notes:

1. Emissions from ethanol and biodiesel are included in the Transport categories using gasoline and diesel respectively.
2. Emissions from Ammonia Production, Nitric Acid Production and Petrochemical Production and Carbon Black categories are included in Non-Energy Products from Fuels and Solvent Use as CO_2 eq values within provincial/territorial tables.
3. HFC and PFC consumption began in 1995; HFC emissions occurring as a by-product of HCFC production (HCFC-22 exclusively) only occurred in Canada from 1990–1992 and PFC emissions prior to 1995 are the result of by-product CF_4 emissions from the use of NF_3.
4. IPCC's Fourth Assessment Report provides global warming potentials (GWPs) for the various species of HFCs and PFCs. Chapter 1, Table 1-1 of this report provides a list of GWPs used.

\- Indicates no emissions

0.00 Indicates emissions truncated due to rounding

x Indicates data has been suppressed to respect confidentiality

Estimates for the latest year (2016) are based on preliminary energy data; these data, though the best available information at the time of publication, are subject to revision in the next submission year.

Provincial/Territorial GHG emissions allocated to Canadian economic sectors are provided in Annex 12 of this report

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Table A11–6 GHG Emission Summary for Nova Scotia, Selected Years

Greenhouse Gas Categories		1990	2005	2011	2012	2013	2014	2015	2016
		kt CO_2 eq							
TOTAL		**19 600**	**23 200**	**20 900**	**19 200**	**18 200**	**16 400**	**16 600**	**15 600**
ENERGY		**18 100**	**21 700**	**19 400**	**17 700**	**16 700**	**15 000**	**15 200**	**14 200**
a.	**Stationary Combustion Sources**	**11 600**	**15 500**	**13 500**	**12 200**	**11 600**	**10 400**	**10 100**	**9 190**
	Public Electricity and Heat Production	6 900	10 700	8 450	7 620	7 530	7 200	6 970	6 580
	Petroleum Refining Industries	620	1 100	760	930	820	x	x	x
	Mining and Upstream Oil and Gas Production	85	340	644	542	542	734	570	420
	Manufacturing Industries	776	555	541	528	416	415	399	369
	Construction	50	49	24	21	10	x	x	x
	Commercial and Institutional	797	1 250	913	648	616	545	651	548
	Residential	2 230	1 410	2 030	1 790	1 590	1 460	1 480	1 250
	Agriculture and Forestry	104	96	109	70	38	33	28	24
b.	**Transport[1]**	**4 850**	**5 940**	**5 780**	**5 390**	**4 950**	**4 510**	**5 020**	**4 950**
	Domestic Aviation	290	270	220	240	250	240	240	240
	Road Transportation	2 990	4 060	4 250	4 090	3 750	3 370	3 860	3 850
	Light-Duty Gasoline Vehicles	1 420	1 330	1 260	1 270	1 080	955	1 170	1 180
	Light-Duty Gasoline Trucks	704	1 170	1 260	1 290	1 120	1 010	1 290	1 370
	Heavy-Duty Gasoline Vehicles	158	233	268	281	251	220	267	283
	Motorcycles	5	5	8	9	7	7	9	10
	Light-Duty Diesel Vehicles	29	42	50	43	47	44	44	37
	Light-Duty Diesel Trucks	6	9	9	7	8	8	12	12
	Heavy-Duty Diesel Vehicles	664	1 260	1 390	1 190	1 240	1 120	1 070	961
	Propane and Natural Gas Vehicles	4	3	0.02	0.02	0.01	0.00	0.00	0.00
	Railways	66	110	170	130	100	x	x	x
	Domestic Navigation	570	820	490	380	310	x	x	x
	Other Transportation	920	680	650	550	530	530	600	580
	Off-Road Agriculture & Forestry	86	90	82	63	65	60	63	50
	Off-Road Commercial & Institutional	43	65	71	61	63	67	74	63
	Off-Road Manufacturing, Mining & Construction	230	230	250	190	200	190	210	210
	Off-Road Residential	9	38	39	37	32	31	37	x
	Off-Road Other Transportation	560	220	200	190	170	170	210	220
	Pipeline Transport	-	35	3	4	4	9	6	x
c.	**Fugitive Sources**	**1 700**	**230**	**190**	**180**	**160**	**79**	**53**	**48**
	Coal Mining	2 000	100	80	80	80	1	1	-
	Oil and Natural Gas	51	130	110	95	78	79	52	48
d.	**CO_2 Transport and Storage**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
INDUSTRIAL PROCESSES AND PRODUCT USE		**331**	**492**	**572**	**572**	**634**	**492**	**525**	**546**
a.	**Mineral Products**	**180**	**250**	**200**	**210**	**200**	**190**	**210**	**210**
	Cement Production	180	250	190	210	190	190	200	200
	Lime Production	-	-	-	-	-	-	-	-
	Mineral Products Use	4	3	4	3	4	4	8	8
b.	**Chemical Industry[2]**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
	Adipic Acid Production	-	-	-	-	-	-	-	-
c.	**Metal Production**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
	Iron and Steel Production	-	-	-	-	-	-	-	-
	Aluminum Production	-	-	-	-	-	-	-	-
	SF_6 Used in Magnesium Smelters and Casters	-	-	-	-	-	-	-	-
d.	**Production and Consumption of Halocarbons, SF_6 and NF_3[3]**	**-**	**140**	**220**	**230**	**230**	**240**	**260**	**290**
e.	**Non-Energy Products from Fuels and Solvent Use**	**x**	**x**	**x**	**x**	**x**	**x**	**x**	**x**
f.	**Other Product Manufacture and Use**	**29**	**40**	**40**	**29**	**46**	**40**	**40**	**37**
AGRICULTURE		**480**	**460**	**420**	**420**	**430**	**440**	**430**	**430**
a.	**Enteric Fermentation**	**230**	**210**	**180**	**180**	**180**	**180**	**180**	**170**
b.	**Manure Management**	**95**	**110**	**110**	**110**	**110**	**110**	**110**	**110**
c.	**Agricultural Soils**	**120**	**130**	**120**	**120**	**110**	**120**	**120**	**130**
	Direct Sources	97	100	96	100	93	100	99	110
	Indirect Sources	20	20	20	20	20	20	20	20
d.	**Field Burning of Agricultural Residues**	**0.03**	**0.10**	**0.06**	**0.04**	**0.04**	**0.02**	**0.02**	**0.02**
e.	**Liming, Urea Application and Other Carbon-containing Fertilizers**	**40**	**10**	**10**	**20**	**20**	**20**	**10**	**20**
WASTE		**720**	**560**	**460**	**460**	**470**	**480**	**430**	**430**
a.	**Solid Waste Disposal**	**640**	**460**	**370**	**370**	**380**	**390**	**340**	**340**
b.	**Biological Treatment of Solid Waste**	**-**	**20**	**20**	**20**	**30**	**30**	**30**	**30**
c.	**Wastewater Treatment and Discharge**	**57**	**60**	**46**	**46**	**46**	**45**	**45**	**46**
d.	**Incineration and Open Burning of Waste**	**27**	**16**	**19**	**20**	**19**	**18**	**18**	**21**

Notes:

1. Emissions from ethanol and biodiesel are included in the Transport categories using gasoline and diesel respectively.
2. Emissions from Ammonia Production, Nitric Acid Production and Petrochemical Production and Carbon Black categories are included in Non-Energy Products from Fuels and Solvent Use as CO_2 eq values within provincial/territorial tables.
3. HFC and PFC consumption began in 1995; HFC emissions occurring as a by-product of HCFC production (HCFC-22 exclusively) only occurred in Canada from 1990–1992 and PFC emissions prior to 1995 are the result of by-product CF_4 emissions from the use of NF_3.

\- Indicates no emissions

0.00 Indicates emissions truncated due to rounding

x Indicates data has been suppressed to respect confidentiality

Estimates for the latest year (2016) are based on preliminary energy data; these data, though the best available information at the time of publication, are subject to revision in the next submission year.

Provincial/Territorial GHG emissions allocated to Canadian economic sectors are provided in Annex 12 of this report

Table A11–7 2016 GHG Emission Summary for Nova Scotia

Greenhouse Gas Categories	Greenhouse Gases									
	CO_2	CH_4	CH_4	N_2O	N_2O	HFCs[4]	PFCs[4]	SF_6	NF_3	TOTAL
Global Warming Potential			25		298			22 800	17 200	
Unit	kt	kt	kt CO_2 eq	kt	kt CO_2 eq	kt CO_2 eq	kt CO_2 eq	kt CO_2 eq	kt CO_2 eq	kt CO_2 eq
TOTAL	**14 000**	**35**	**880**	**1**	**370**	**290**	**0.17**	**28**	**-**	**15 600**
ENERGY	**13 800**	**11**	**290**	**0.50**	**100**	**-**	**-**	**-**	**-**	**14 200**
a. Stationary Combustion Sources	**8 900**	**9**	**200**	**0.20**	**70**	**-**	**-**	**-**	**-**	**9 190**
Public Electricity and Heat Production	6 500	0.23	6	0.09	26	-	-	-	-	6 580
Petroleum Refining Industries	x	x	x	x	x	x	x	x	x	x
Mining and Upstream Oil and Gas Production	392	0.99	25	0.01	3	-	-	-	-	420
Manufacturing Industries	359	0.04	0.91	0.03	9	-	-	-	-	369
Construction	x	x	x	x	x	x	x	x	x	x
Commercial and Institutional	544	0.01	0.21	0.01	4	-	-	-	-	548
Residential	1 030	8	200	0.10	30	-	-	-	-	1 250
Agriculture and Forestry	24	0.00	0.01	0.00	0.10	-	-	-	-	24
b. Transport[1]	**4 850**	**1**	**28**	**0.23**	**70**	**-**	**-**	**-**	**-**	**4 950**
Domestic Aviation	235	0.01	0.10	0.01	2	-	-	-	-	240
Road Transportation	3 790	0.30	6	0.16	49	-	-	-	-	3 850
Light-Duty Gasoline Vehicles	1 160	0.09	2	0.04	11	-	-	-	-	1 180
Light-Duty Gasoline Trucks	1 350	0.11	3	0.05	14	-	-	-	-	1 370
Heavy-Duty Gasoline Vehicles	275	0.01	0.23	0.02	7	-	-	-	-	283
Motorcycles	10	0.00	0.09	0.00	0.05	-	-	-	-	10
Light-Duty Diesel Vehicles	36	0.00	0.02	0.00	0.90	-	-	-	-	37
Light-Duty Diesel Trucks	12	0.00	0.01	0.00	0.30	-	-	-	-	12
Heavy-Duty Diesel Vehicles	945	0.04	1	0.05	20	-	-	-	-	961
Propane and Natural Gas Vehicles	0.00	0.00	0.00	0.00	0.00	-	-	-	-	0.00
Railways	x	x	x	x	x	x	x	x	x	x
Domestic Navigation	x	x	x	x	x	x	x	x	x	x
Other Transportation	559	0.80	20	0.02	5	-	-	-	-	580
Off-Road Agriculture & Forestry	49	0.00	0.08	0.00	0.60	-	-	-	-	50
Off-Road Commercial & Institutional	60	0.10	3	0.00	0.50	-	-	-	-	63
Off-Road Manufacturing, Mining & Construction	203	0.03	0.70	0.01	2	-	-	-	-	210
Off-Road Residential	x	x	x	x	x	x	x	x	x	x
Off-Road Other Transportation	204	0.60	20	0.00	1	-	-	-	-	220
Pipeline Transport	x	x	x	x	x	x	x	x	x	x
c. Fugitive Sources	**15**	**1**	**33**	**0.00**	**0.01**	**-**	**-**	**-**	**-**	**48**
Coal Mining	-	-	-	-	-	-	-	-	-	-
Oil and Natural Gas	15	1	33	0.00	0.01	-	-	-	-	48
d. CO_2 Transport and Storage	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
INDUSTRIAL PROCESSES AND PRODUCT USE	**223**	**-**	**-**	**0.03**	**8**	**290**	**0.17**	**28**	**-**	**546**
a. Mineral Products	**210**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**210**
Cement Production	200	-	-	-	-	-	-	-	-	200
Lime Production	-	-	-	-	-	-	-	-	-	-
Mineral Products Use	8	-	-	-	-	-	-	-	-	8
b. Chemical Industry[2]	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
Adipic Acid Production	-	-	-	-	-	-	-	-	-	-
c. Metal Production	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
Iron and Steel Production	-	-	-	-	-	-	-	-	-	-
Aluminum Production	-	-	-	-	-	-	-	-	-	-
SF_6 Used in Magnesium Smelters and Casters	-	-	-	-	-	-	-	-	-	-
d. Production and Consumption of Halocarbons, SF_6 and NF_3[3]	**-**	**-**	**-**	**-**	**-**	**290**	**0.03**	**-**	**-**	**290**
e. Non-Energy Products from Fuels and Solvent Use	**x**	**x**	**x**	**x**	**x**	**x**	**x**	**x**	**x**	**x**
f. Other Product Manufacture and Use	**0.60**	**-**	**-**	**0.03**	**8**	**-**	**0.14**	**28**	**-**	**37**
AGRICULTURE	**20**	**9**	**220**	**0.64**	**190**	**-**	**-**	**-**	**-**	**430**
a. Enteric Fermentation	**-**	**7**	**170**	**-**	**-**	**-**	**-**	**-**	**-**	**170**
b. Manure Management	**-**	**2**	**48**	**0.20**	**60**	**-**	**-**	**-**	**-**	**110**
c. Agricultural Soils	**-**	**-**	**-**	**0.44**	**130**	**-**	**-**	**-**	**-**	**130**
Direct Sources	-	-	-	0.36	110	-	-	-	-	110
Indirect Sources	-	-	-	0.07	20	-	-	-	-	20
d. Field Burning of Agricultural Residues	**-**	**0.00**	**0.01**	**0.00**	**0.00**	**-**	**-**	**-**	**-**	**0.02**
e. Liming, Urea Application and Other Carbon-containing Fertilizers	**20**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**20**
WASTE	**19**	**15**	**380**	**0.10**	**31**	**-**	**-**	**-**	**-**	**430**
a. Solid Waste Disposal	**-**	**13**	**340**	**-**	**-**	**-**	**-**	**-**	**-**	**340**
b. Biological Treatment of Solid Waste	**-**	**0.60**	**20**	**0.04**	**10**	**-**	**-**	**-**	**-**	**30**
c. Wastewater Treatment and Discharge	**-**	**1**	**28**	**0.06**	**20**	**-**	**-**	**-**	**-**	**46**
d. Incineration and Open Burning of Waste	**19**	**-**	**-**	**0.01**	**3**	**-**	**-**	**-**	**-**	**21**

Notes:
1. Emissions from ethanol and biodiesel are included in the Transport categories using gasoline and diesel respectively.
2. Emissions from Ammonia Production, Nitric Acid Production and Petrochemical Production and Carbon Black categories are included in Non-Energy Products from Fuels and Solvent Use as CO_2 eq values within provincial/territorial tables.
3. HFC and PFC consumption began in 1995; HFC emissions occurring as a by-product of HCFC production (HCFC-22 exclusively) only occurred in Canada from 1990–1992 and PFC emissions prior to 1995 are the result of by-product CF_4 emissions from the use of NF_3.
4. IPCC's Fourth Assessment Report provides global warming potentials (GWPs) for the various species of HFCs and PFCs. Chapter 1, Table 1-1 of this report provides a list of GWPs used.

\- Indicates no emissions
0.00 Indicates emissions truncated due to rounding
x Indicates data has been suppressed to respect confidentiality
Estimates for the latest year (2016) are based on preliminary energy data; these data, though the best available information at the time of publication, are subject to revision in the next submission year.
Provincial/Territorial GHG emissions allocated to Canadian economic sectors are provided in Annex 12 of this report

Table A11–8 GHG Emission Summary for New Brunswick, Selected Years

Greenhouse Gas Categories	1990	2005	2011	2012	2013	2014	2015	2016
	kt CO_2 eq							
TOTAL	**16 100**	**20 100**	**18 700**	**16 800**	**14 800**	**14 400**	**14 300**	**15 300**
ENERGY	**14 900**	**18 600**	**16 700**	**14 700**	**12 900**	**12 900**	**12 700**	**13 700**
a. Stationary Combustion Sources	**10 800**	**13 200**	**10 600**	**9 440**	**8 600**	**8 890**	**8 470**	**9 040**
Public Electricity and Heat Production	6 020	8 060	4 920	4 060	4 190	4 390	3 950	4 920
Petroleum Refining Industries	1 200	2 300	2 600	2 500	2 500	x	x	x
Mining and Upstream Oil and Gas Production	126	161	275	221	129	x	x	x
Manufacturing Industries	1 640	1 170	846	841	850	684	764	609
Construction	69	6	19	14	9	10	28	17
Commercial and Institutional	580	602	783	833	320	403	428	385
Residential	1 160	834	983	864	570	617	747	685
Agriculture and Forestry	53	33	117	86	57	60	25	31
b. Transport[1]	**4 060**	**5 210**	**5 930**	**5 050**	**4 110**	**3 820**	**4 090**	**4 440**
Domestic Aviation	140	130	88	100	110	110	110	100
Road Transportation	2 220	3 560	4 200	3 750	3 060	2 770	3 060	3 380
Light-Duty Gasoline Vehicles	904	1 020	1 040	998	817	705	838	929
Light-Duty Gasoline Trucks	517	972	1 210	1 200	997	881	1 080	1 270
Heavy-Duty Gasoline Vehicles	121	194	258	260	215	179	212	247
Motorcycles	3	6	8	9	7	7	8	10
Light-Duty Diesel Vehicles	15	22	27	20	16	16	16	15
Light-Duty Diesel Trucks	6	10	9	6	4	4	6	7
Heavy-Duty Diesel Vehicles	649	1 340	1 650	1 260	1 010	974	891	901
Propane and Natural Gas Vehicles	0.67	0.15	0.00	0.00	0.00	-	0.00	0.00
Railways	130	280	x	270	200	x	x	x
Domestic Navigation	240	380	490	330	240	250	210	190
Other Transportation	1 300	860	x	590	490	x	x	x
Off-Road Agriculture & Forestry	120	170	170	120	95	96	98	86
Off-Road Commercial & Institutional	30	54	66	52	47	45	47	47
Off-Road Manufacturing, Mining & Construction	150	190	230	160	130	130	140	160
Off-Road Residential	5	x	31	x	x	22	25	32
Off-Road Other Transportation	1 000	420	250	240	200	200	240	270
Pipeline Transport	-	x	x	x	x	-	-	x
c. Fugitive Sources	**60**	**220**	**200**	**200**	**190**	**160**	**180**	**190**
Coal Mining	1	0.30	-	-	-	-	-	-
Oil and Natural Gas	60	220	200	200	190	160	180	190
d. CO_2 Transport and Storage	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
INDUSTRIAL PROCESSES AND PRODUCT USE	188	378	994	1 080	910	439	530	567
a. Mineral Products	**91**	**97**	**56**	**57**	**54**	**58**	**55**	**53**
Cement Production	-	-	-	-	-	-	-	-
Lime Production	80	89	53	53	50	54	50	49
Mineral Products Use	11	8	3	3	4	4	4	4
b. Chemical Industry[2]	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
Adipic Acid Production	-	-	-	-	-	-	-	-
c. Metal Production	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
Iron and Steel Production	-	-	-	-	-	-	-	-
Aluminum Production	-	-	-	-	-	-	-	-
SF_6 Used in Magnesium Smelters and Casters	-	-	-	-	-	-	-	-
d. Production and Consumption of Halocarbons, SF_6 and NF_3[3]	**-**	**120**	**210**	**220**	**210**	**210**	**230**	**250**
e. Non-Energy Products from Fuels and Solvent Use	**x**	**x**	**x**	**x**	**x**	**x**	**x**	**x**
f. Other Product Manufacture and Use	**5**	**8**	**6**	**6**	**7**	**6**	**7**	**8**
AGRICULTURE	490	540	450	490	480	510	470	510
a. Enteric Fermentation	**200**	**180**	**160**	**160**	**160**	**160**	**160**	**150**
b. Manure Management	**65**	**79**	**68**	**68**	**69**	**68**	**67**	**62**
c. Agricultural Soils	**160**	**220**	**160**	**190**	**150**	**190**	**180**	**230**
Direct Sources	140	190	140	160	120	160	160	200
Indirect Sources	30	40	30	30	20	30	30	30
d. Field Burning of Agricultural Residues	**0.03**	**0.02**	**0.01**	**0.02**	**0.02**	**0.03**	**0.03**	**0.03**
e. Liming, Urea Application and Other Carbon-containing Fertilizers	**70**	**50**	**60**	**80**	**100**	**90**	**60**	**60**
WASTE	540	610	530	550	560	540	540	540
a. Solid Waste Disposal	**500**	**560**	**480**	**500**	**500**	**490**	**490**	**490**
b. Biological Treatment of Solid Waste	**6**	**20**	**20**	**20**	**20**	**20**	**20**	**20**
c. Wastewater Treatment and Discharge	**32**	**34**	**34**	**35**	**34**	**34**	**34**	**34**
d. Incineration and Open Burning of Waste	**-**	**0.59**	**1**	**1**	**1**	**1**	**0.20**	**-**

Notes:

1. Emissions from ethanol and biodiesel are included in the Transport categories using gasoline and diesel respectively.
2. Emissions from Ammonia Production, Nitric Acid Production and Petrochemical Production and Carbon Black categories are included in Non-Energy Products from Fuels and Solvent Use as CO_2 eq values within provincial/territorial tables.
3. HFC and PFC consumption began in 1995; HFC emissions occurring as a by-product of HCFC production (HCFC-22 exclusively) only occurred in Canada from 1990–1992 and PFC emissions prior to 1995 are the result of by-product CF_4 emissions from the use of NF_3.

\- Indicates no emissions

0.00 Indicates emissions truncated due to rounding

x Indicates data has been suppressed to respect confidentiality

Estimates for the latest year (2016) are based on preliminary energy data; these data, though the best available information at the time of publication, are subject to revision in the next submission year.

Provincial/Territorial GHG emissions allocated to Canadian economic sectors are provided in Annex 12 of this report

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Table A11–9 2016 GHG Emission Summary for New Brunswick

Greenhouse Gas Categories	Greenhouse Gases									
	CO_2	CH_4	CH_4	N_2O	N_2O	HFCs[4]	PFCs[4]	SF_6	NF_3	TOTAL
Global Warming Potential			25		298			22 800	17 200	
Unit	kt	kt	kt CO_2 eq	kt	kt CO_2 eq	kt CO_2 eq	kt CO_2 eq	kt CO_2 eq	kt CO_2 eq	kt CO_2 eq
TOTAL	**13 700**	**35**	**890**	**2**	**440**	**250**	**0.06**	**0.59**	**-**	**15 300**
ENERGY	13 300	8	190	0.50	100	-	-	-	-	13 700
a. Stationary Combustion Sources	**8 840**	**5**	**100**	**0.20**	**70**	**-**	**-**	**-**	**-**	**9 040**
Public Electricity and Heat Production	4 900	0.32	8	0.07	21	-	-	-	-	4 920
Petroleum Refining Industries	x	x	x	x	x	x	x	x	x	x
Mining and Upstream Oil and Gas Production	x	x	x	x	x	x	x	x	x	x
Manufacturing Industries	582	0.10	3	0.08	25	-	-	-	-	609
Construction	16	0	0	0	0.06	-	-	-	-	17
Commercial and Institutional	382	0.01	0.15	0.01	3	-	-	-	-	385
Residential	549	5	100	0.06	20	-	-	-	-	685
Agriculture and Forestry	31	0	0.01	0	0.10	-	-	-	-	31
b. Transport[1]	**4 340**	**1**	**29**	**0.24**	**72**	**-**	**-**	**-**	**-**	**4 440**
Domestic Aviation	102	0.01	0.20	0.00	1	-	-	-	-	100
Road Transportation	3 330	0.20	6	0.16	48	-	-	-	-	3 380
Light-Duty Gasoline Vehicles	916	0.08	2	0.04	11	-	-	-	-	929
Light-Duty Gasoline Trucks	1 250	0.11	3	0.05	15	-	-	-	-	1 270
Heavy-Duty Gasoline Vehicles	241	0.01	0.21	0.02	6	-	-	-	-	247
Motorcycles	10	0.00	0.09	0.00	0.05	-	-	-	-	10
Light-Duty Diesel Vehicles	15	0.00	0.01	0.00	0.40	-	-	-	-	15
Light-Duty Diesel Trucks	7	0.00	0.00	0.00	0.20	-	-	-	-	7
Heavy-Duty Diesel Vehicles	886	0.04	0.90	0.05	10	-	-	-	-	901
Propane and Natural Gas Vehicles	0.00	0.00	0.00	0.00	0.00	-	-	-	-	0.00
Railways	x	x	x	x	x	x	x	x	x	x
Domestic Navigation	190	0.02	0.40	0.01	2.00	-	-	-	-	190
Other Transportation	x	x	x	x	x	x	x	x	x	x
Off-Road Agriculture & Forestry	85	0.01	0.20	0.00	1	-	-	-	-	86
Off-Road Commercial & Institutional	45	0.06	1	0.00	0.40	-	-	-	-	47
Off-Road Manufacturing, Mining & Construction	153	0.02	0.60	0.01	2	-	-	-	-	160
Off-Road Residential	30	0.07	2	0.00	0.20	-	-	-	-	32
Off-Road Other Transportation	252	0.70	20	0.01	2	-	-	-	-	270
Pipeline Transport	x	x	x	x	x	x	x	x	x	x
c. Fugitive Sources	**160**	**1**	**28**	**0.01**	**4**	**-**	**-**	**-**	**-**	**190**
Coal Mining	-	-	-	-	-	-	-	-	-	-
Oil and Natural Gas	160	1	28	0.01	4	-	-	-	-	190
d. CO_2 Transport and Storage	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
INDUSTRIAL PROCESSES AND PRODUCT USE	305	-	-	0.02	6	250	0.06	0.59	-	567
a. Mineral Products	**53**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**53**
Cement Production	-	-	-	-	-	-	-	-	-	-
Lime Production	49	-	-	-	-	-	-	-	-	49
Mineral Products Use	4	-	-	-	-	-	-	-	-	4
b. Chemical Industry[2]	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
Adipic Acid Production	-	-	-	-	-	-	-	-	-	-
c. Metal Production	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
Iron and Steel Production	-	-	-	-	-	-	-	-	-	-
Aluminum Production	-	-	-	-	-	-	-	-	-	-
SF_6 Used in Magnesium Smelters and Casters	-	-	-	-	-	-	-	-	-	-
d. Production and Consumption of Halocarbons, SF_6 and NF_3[3]	**-**	**-**	**-**	**-**	**-**	**250**	**0.03**	**-**	**-**	**250**
e. Non-Energy Products from Fuels and Solvent Use	**x**	**x**	**x**	**x**	**x**	**x**	**x**	**x**	**x**	**x**
f. Other Product Manufacture and Use	**0.50**	**-**	**-**	**0.02**	**6**	**-**	**0.04**	**0.59**	**-**	**8**
AGRICULTURE	60	7	180	0.90	270	-	-	-	-	510
a. Enteric Fermentation	**-**	**6**	**150**	**-**	**-**	**-**	**-**	**-**	**-**	**150**
b. Manure Management	**-**	**1**	**30**	**0.10**	**30**	**-**	**-**	**-**	**-**	**62**
c. Agricultural Soils	**-**	**-**	**-**	**0.79**	**230**	**-**	**-**	**-**	**-**	**230**
Direct Sources	-	-	-	0.67	200	-	-	-	-	200
Indirect Sources	-	-	-	0.10	30	-	-	-	-	30
d. Field Burning of Agricultural Residues	**-**	**0.00**	**0.02**	**0.00**	**0.01**	**-**	**-**	**-**	**-**	**0.03**
e. Liming, Urea Application and Other Carbon-containing Fertilizers	**60**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**60**
WASTE	-	21	520	0.07	21	-	-	-	-	540
a. Solid Waste Disposal	**-**	**20**	**490**	**-**	**-**	**-**	**-**	**-**	**-**	**490**
b. Biological Treatment of Solid Waste	**-**	**0.40**	**9**	**0.02**	**7**	**-**	**-**	**-**	**-**	**20**
c. Wastewater Treatment and Discharge	**-**	**0.79**	**20**	**0.05**	**10**	**-**	**-**	**-**	**-**	**34**
d. Incineration and Open Burning of Waste	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**

Notes:

1. Emissions from ethanol and biodiesel are included in the Transport categories using gasoline and diesel respectively.
2. Emissions from Ammonia Production, Nitric Acid Production and Petrochemical Production and Carbon Black categories are included in Non-Energy Products from Fuels and Solvent Use as CO_2 eq values within provincial/territorial tables.
3. HFC and PFC consumption began in 1995; HFC emissions occurring as a by-product of HCFC production (HCFC-22 exclusively) only occurred in Canada from 1990–1992 and PFC emissions prior to 1995 are the result of by-product CF_4 emissions from the use of NF_3.
4. IPCC's Fourth Assessment Report provides global warming potentials (GWPs) for the various species of HFCs and PFCs. Chapter 1, Table 1-1 of this report provides a list of GWPs used.

\- Indicates no emissions

0.00 Indicates emissions truncated due to rounding

x Indicates data has been suppressed to respect confidentiality

Estimates for the latest year (2016) are based on preliminary energy data; these data, though the best available information at the time of publication, are subject to revision in the next submission year.

Provincial/Territorial GHG emissions allocated to Canadian economic sectors are provided in Annex 12 of this report

Table A11–10 GHG Emission Summary for Quebec, Selected Years

Greenhouse Gas Categories		1990	2005	2011	2012	2013	2014	2015	2016
		kt CO_2 eq							
TOTAL		**86 600**	**86 500**	**81 700**	**79 500**	**79 900**	**78 000**	**78 400**	**77 300**
ENERGY		**59 500**	**61 400**	**58 900**	**57 700**	**57 400**	**55 500**	**56 400**	**55 300**
a.	**Stationary Combustion Sources**	**31 400**	**27 400**	**22 700**	**22 300**	**22 400**	**22 300**	**22 500**	**21 200**
	Public Electricity and Heat Production	1 500	622	404	488	371	248	208	237
	Petroleum Refining Industries	3 500	3 700	2 400	2 300	2 100	2 000	2 200	1 900
	Mining and Upstream Oil and Gas Production	824	319	487	1 120	1 080	722	570	648
	Manufacturing Industries	12 300	10 000	8 890	9 000	9 350	9 260	9 440	8 320
	Construction	458	314	347	369	367	374	351	345
	Commercial and Institutional	4 240	5 370	4 980	4 080	4 190	4 700	4 850	4 670
	Residential	8 290	6 680	4 770	4 480	4 440	4 500	4 450	4 600
	Agriculture and Forestry	291	367	462	477	480	469	484	495
b.	**Transport**[1]	**27 700**	**33 600**	**35 800**	**35 100**	**34 700**	**32 900**	**33 500**	**33 800**
	Domestic Aviation	820	750	630	740	730	680	670	700
	Road Transportation	17 800	26 100	28 100	28 100	27 700	26 300	26 700	27 000
	Light-Duty Gasoline Vehicles	10 400	10 700	10 100	9 680	9 540	9 040	9 100	9 050
	Light-Duty Gasoline Trucks	3 490	6 850	7 490	7 390	7 400	7 210	7 470	7 830
	Heavy-Duty Gasoline Vehicles	766	1 600	1 890	2 010	2 020	1 780	1 780	1 870
	Motorcycles	16	71	72	72	71	65	67	70
	Light-Duty Diesel Vehicles	210	151	205	188	191	196	204	190
	Light-Duty Diesel Trucks	57	69	108	93	98	121	155	180
	Heavy-Duty Diesel Vehicles	2 820	6 680	8 220	8 630	8 370	7 880	7 890	7 860
	Propane and Natural Gas Vehicles	2	0.99	0.05	0.05	0.04	0.22	0.20	0.17
	Railways	570	710	890	930	870	780	680	670
	Domestic Navigation	1 400	1 300	950	800	900	740	720	740
	Other Transportation	7 200	4 700	5 300	4 600	4 500	4 500	4 800	4 600
	Off-Road Agriculture & Forestry	1 000	780	970	790	740	690	740	660
	Off-Road Commercial & Institutional	360	450	600	520	550	570	580	680
	Off-Road Manufacturing, Mining & Construction	2 000	1 600	2 300	1 800	1 800	1 700	1 900	1 800
	Off-Road Residential	61	260	290	270	250	240	x	210
	Off-Road Other Transportation	3 700	1 300	1 100	970	930	920	1 000	1 000
	Pipeline Transport	26	338	152	201	268	360	x	189
c.	**Fugitive Sources**	**430**	**390**	**290**	**280**	**270**	**270**	**290**	**310**
	Coal Mining	-	-	-	-	-	-	-	-
	Oil and Natural Gas	430	390	290	280	270	270	290	310
d.	**CO_2 Transport and Storage**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
INDUSTRIAL PROCESSES AND PRODUCT USE		**14 800**	**12 600**	**12 000**	**11 000**	**11 500**	**11 100**	**10 100**	**9 970**
a.	**Mineral Products**	**1 900**	**2 100**	**1 800**	**1 900**	**1 700**	**1 800**	**1 800**	**1 800**
	Cement Production	1 400	1 300	1 200	1 400	1 200	1 200	1 300	1 300
	Lime Production	284	482	455	461	435	469	436	424
	Mineral Products Use	210	260	87	88	71	71	75	70
b.	**Chemical Industry**[2]	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
	Adipic Acid Production	-	-	-	-	-	-	-	-
c.	**Metal Production**	**10 900**	**7 560**	**6 010**	**5 630**	**5 830**	**5 330**	**5 290**	**5 180**
	Iron and Steel Production	-	-	37	32	31	28	27	27
	Aluminum Production	8 660	7 460	5 960	5 580	5 780	5 280	5 240	5 130
	SF_6 Used in Magnesium Smelters and Casters	2 280	103	13	16	22	23	23	25
d.	**Production and Consumption of Halocarbons, SF_6 and NF_3**[3]	**2**	**1 100**	**1 700**	**1 800**	**1 900**	**2 000**	**2 100**	**2 300**
e.	**Non-Energy Products from Fuels and Solvent Use**	**x**	**x**	**x**	**x**	**x**	**x**	**x**	**x**
f.	**Other Product Manufacture and Use**	**80**	**120**	**92**	**130**	**130**	**81**	**140**	**150**
AGRICULTURE		**7 100**	**7 600**	**7 500**	**7 900**	**7 700**	**7 700**	**7 900**	**8 000**
a.	**Enteric Fermentation**	**3 100**	**3 100**	**2 800**	**2 700**	**2 700**	**2 700**	**2 700**	**2 700**
b.	**Manure Management**	**1 300**	**1 700**	**1 700**	**1 700**	**1 700**	**1 700**	**1 700**	**1 700**
c.	**Agricultural Soils**	**2 500**	**2 600**	**2 800**	**3 200**	**3 000**	**3 100**	**3 300**	**3 400**
	Direct Sources	2 100	2 200	2 400	2 700	2 600	2 600	2 800	2 900
	Indirect Sources	400	400	400	500	400	400	500	500
d.	**Field Burning of Agricultural Residues**	**0.40**	**0.30**	**0.20**	**0.20**	**0.20**	**0.20**	**0.20**	**0.20**
e.	**Liming, Urea Application and Other Carbon-containing Fertilizers**	**200**	**200**	**200**	**300**	**300**	**300**	**200**	**200**
WASTE		**5 300**	**4 800**	**3 300**	**3 000**	**3 300**	**3 600**	**3 900**	**4 000**
a.	**Solid Waste Disposal**	**4 600**	**4 300**	**2 700**	**2 500**	**2 800**	**3 100**	**3 500**	**3 500**
b.	**Biological Treatment of Solid Waste**	**-**	**50**	**50**	**70**	**70**	**70**	**70**	**70**
c.	**Wastewater Treatment and Discharge**	**300**	**260**	**280**	**280**	**280**	**280**	**280**	**280**
d.	**Incineration and Open Burning of Waste**	**360**	**270**	**260**	**120**	**120**	**130**	**130**	**130**

Notes:

1. Emissions from ethanol and biodiesel are included in the Transport categories using gasoline and diesel respectively.
2. Emissions from Ammonia Production, Nitric Acid Production and Petrochemical Production and Carbon Black categories are included in Non-Energy Products from Fuels and Solvent Use as CO_2 eq values within provincial/territorial tables.
3. HFC and PFC consumption began in 1995; HFC emissions occurring as a by-product of HCFC production (HCFC-22 exclusively) only occurred in Canada from 1990–1992 and PFC emissions prior to 1995 are the result of by-product CF_4 emissions from the use of NF_3.

\- Indicates no emissions

0.00 Indicates emissions truncated due to rounding

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Estimates for the latest year (2016) are based on preliminary energy data; these data, though the best available information at the time of publication, are subject to revision in the next submission year.

Provincial/Territorial GHG emissions allocated to Canadian economic sectors are provided in Annex 12 of this report

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Table A11–11 2016 GHG Emission Summary for Quebec

Greenhouse Gas Categories	CO₂ → CO_2	CH_4	CH_4	N_2O	N_2O	HFCs[4]	PFCs[4]	SF_6	NF_3	TOTAL
	Greenhouse Gases									
Global Warming Potential			25		298			22 800	17 200	
Unit	kt	kt	kt CO_2 eq	kt	kt CO_2 eq	kt CO_2 eq	kt CO_2 eq	kt CO_2 eq	kt CO_2 eq	kt CO_2 eq
TOTAL	**59 900**	**370**	**9 300**	**17**	**5 100**	**2 300**	**590**	**110**	**0.20**	**77 300**
ENERGY	**52 700**	**70**	**1 800**	**3**	**900**	**-**	**-**	**-**	**-**	**55 300**
a. Stationary Combustion Sources	**19 300**	**60**	**2 000**	**1**	**400**	**-**	**-**	**-**	**-**	**21 200**
Public Electricity and Heat Production	230	0.01	0.16	0.02	5	-	-	-	-	237
Petroleum Refining Industries	1 900	0.04	1	0.02	5	-	-	-	-	1 900
Mining and Upstream Oil and Gas Production	644	0.02	0.58	0.01	4	-	-	-	-	648
Manufacturing Industries	8 200	0.54	14	0.37	110	-	-	-	-	8 320
Construction	342	0.01	0.16	0.01	2	-	-	-	-	345
Commercial and Institutional	4 640	0.09	2	0.10	30	-	-	-	-	4 670
Residential	2 870	60	1 000	0.80	200	-	-	-	-	4 600
Agriculture and Forestry	487	0.01	0.19	0.02	7	-	-	-	-	495
b. Transport[1]	**33 100**	**6**	**160**	**2**	**500**	**-**	**-**	**-**	**-**	**33 800**
Domestic Aviation	689	0.03	0.80	0.02	6	-	-	-	-	700
Road Transportation	26 600	2	50	1	370	-	-	-	-	27 000
Light-Duty Gasoline Vehicles	8 930	0.76	19	0.34	100	-	-	-	-	9 050
Light-Duty Gasoline Trucks	7 720	0.66	17	0.29	85	-	-	-	-	7 830
Heavy-Duty Gasoline Vehicles	1 820	0.06	2	0.16	48	-	-	-	-	1 870
Motorcycles	69	0.03	0.65	0.00	0.38	-	-	-	-	70
Light-Duty Diesel Vehicles	185	0.00	0.09	0.02	5	-	-	-	-	190
Light-Duty Diesel Trucks	175	0.01	0.10	0.01	4	-	-	-	-	180
Heavy-Duty Diesel Vehicles	7 720	0.30	8	0.40	100	-	-	-	-	7 860
Propane and Natural Gas Vehicles	0.17	0.00	0.00	0.00	0.00	-	-	-	-	0.17
Railways	602	0.03	0.90	0.20	70	-	-	-	-	670
Domestic Navigation	732	0.07	2	0.02	6	-	-	-	-	740
Other Transportation	4 460	4	100	0.20	50	-	-	-	-	4 600
Off-Road Agriculture & Forestry	655	0.03	0.80	0.02	7	-	-	-	-	660
Off-Road Commercial & Institutional	648	0.90	20	0.02	6	-	-	-	-	680
Off-Road Manufacturing, Mining & Construction	1 810	0.30	6	0.08	20	-	-	-	-	1 800
Off-Road Residential	202	0.40	10	0.01	2	-	-	-	-	210
Off-Road Other Transportation	961	2	60	0.02	7	-	-	-	-	1 000
Pipeline Transport	183	0.18	5	0.01	1	-	-	-	-	189
c. Fugitive Sources	**210**	**4**	**92**	**0.02**	**6**	**-**	**-**	**-**	**-**	**310**
Coal Mining	-	-	-	-	-	-	-	-	-	-
Oil and Natural Gas	210	4	92	0.02	6	-	-	-	-	310
d. CO_2 Transport and Storage	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
INDUSTRIAL PROCESSES AND PRODUCT USE	**6 860**	**0.00**	**0.01**	**0.23**	**70**	**2 300**	**590**	**110**	**-**	**9 970**
a. Mineral Products	**1 800**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**1 800**
Cement Production	1 300	-	-	-	-	-	-	-	-	1 300
Lime Production	424	-	-	-	-	-	-	-	-	424
Mineral Products Use	70	-	-	-	-	-	-	-	-	70
b. Chemical Industry[2]	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
Adipic Acid Production	-	-	-	-	-	-	-	-	-	-
c. Metal Production	**4 560**	**0.00**	**0.01**	**-**	**-**	**-**	**585**	**30.10**	**-**	**5 180**
Iron and Steel Production	27	0.00	0.01	-	-	-	-	-	-	27
Aluminum Production	4 540	-	-	-	-	-	585	5	-	5 130
SF_6 Used in Magnesium Smelters and Casters	-	-	-	-	-	-	-	25	-	25
d. Production and Consumption of Halocarbons, SF_6 and NF_3[3]	**-**	**-**	**-**	**-**	**-**	**2 300**	**1**	**0.64**	**0.20**	**2 300**
e. Non-Energy Products from Fuels and Solvent Use	**x**	**x**	**x**	**x**	**x**	**x**	**x**	**x**	**x**	**x**
f. Other Product Manufacture and Use	**5**	**-**	**-**	**0.23**	**70**	**-**	**3**	**75**	**-**	**150**
AGRICULTURE	**200**	**150**	**3 900**	**13**	**3 900**	**-**	**-**	**-**	**-**	**8 000**
a. Enteric Fermentation	**-**	**110**	**2 700**	**-**	**-**	**-**	**-**	**-**	**-**	**2 700**
b. Manure Management	**-**	**48**	**1 200**	**2**	**500**	**-**	**-**	**-**	**-**	**1 700**
c. Agricultural Soils	**-**	**-**	**-**	**11**	**3 400**	**-**	**-**	**-**	**-**	**3 400**
Direct Sources	-	-	-	10	2 900	-	-	-	-	2 900
Indirect Sources	-	-	-	2	500	-	-	-	-	500
d. Field Burning of Agricultural Residues	**-**	**0.01**	**0.20**	**0.00**	**0.05**	**-**	**-**	**-**	**-**	**0.20**
e. Liming, Urea Application and Other Carbon-containing Fertilizers	**200**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**200**
WASTE	**98**	**150**	**3 700**	**0.70**	**210**	**-**	**-**	**-**	**-**	**4 000**
a. Solid Waste Disposal	**-**	**140**	**3 500**	**-**	**-**	**-**	**-**	**-**	**-**	**3 500**
b. Biological Treatment of Solid Waste	**-**	**2**	**40**	**0.10**	**30**	**-**	**-**	**-**	**-**	**70**
c. Wastewater Treatment and Discharge	**-**	**5**	**130**	**0.50**	**200**	**-**	**-**	**-**	**-**	**280**
d. Incineration and Open Burning of Waste	**98**	**0.30**	**6**	**0.08**	**20**	**-**	**-**	**-**	**-**	**130**

Notes:

1. Emissions from ethanol and biodiesel are included in the Transport categories using gasoline and diesel respectively.
2. Emissions from Ammonia Production, Nitric Acid Production and Petrochemical Production and Carbon Black categories are included in Non-Energy Products from Fuels and Solvent Use as CO_2 eq values within provincial/territorial tables.
3. HFC and PFC consumption began in 1995; HFC emissions occurring as a by-product of HCFC production (HCFC-22 exclusively) only occurred in Canada from 1990–1992 and PFC emissions prior to 1995 are the result of by-product CF_4 emissions from the use of NF_3.
4. IPCC's Fourth Assessment Report provides global warming potentials (GWPs) for the various species of HFCs and PFCs. Chapter 1, Table 1-1 of this report provides a list of GWPs used.

\- Indicates no emissions

0.00 Indicates emissions truncated due to rounding

x Indicates data has been suppressed to respect confidentiality

Estimates for the latest year (2016) are based on preliminary energy data; these data, though the best available information at the time of publication, are subject to revision in the next submission year.

Provincial/Territorial GHG emissions allocated to Canadian economic sectors are provided in Annex 12 of this report

Table A11–12 GHG Emission Summary for Ontario, Selected Years

Greenhouse Gas Categories	1990	2005	2011	2012	2013	2014	2015	2016
	kt CO_2 eq							
TOTAL	**179 000**	**205 000**	**172 000**	**169 000**	**168 000**	**165 000**	**163 000**	**161 000**
ENERGY	**133 000**	**163 000**	**134 000**	**129 000**	**130 000**	**127 000**	**125 000**	**121 000**
a. Stationary Combustion Sources	**83 300**	**96 900**	**72 300**	**69 400**	**67 300**	**66 100**	**63 200**	**58 900**
Public Electricity and Heat Production	25 800	35 400	14 400	14 300	10 300	6 030	6 250	5 500
Petroleum Refining Industries	6 200	6 900	6 500	6 800	6 100	6 000	5 500	5 200
Mining and Upstream Oil and Gas Production	593	614	820	929	634	645	532	630
Manufacturing Industries	22 000	18 800	16 100	15 900	16 200	16 500	15 800	15 500
Construction	571	637	416	436	361	380	350	341
Commercial and Institutional	9 140	12 800	11 800	10 900	11 900	13 200	12 600	12 200
Residential	18 200	20 700	20 500	18 300	20 200	21 800	20 700	18 100
Agriculture and Forestry	775	1 040	1 650	1 690	1 650	1 500	1 420	1 510
b. Transport[1]	**48 000**	**64 100**	**60 600**	**58 300**	**61 000**	**59 300**	**60 700**	**60 200**
Domestic Aviation	2 200	2 300	1 900	2 200	2 300	2 200	2 200	2 200
Road Transportation	28 600	47 400	47 000	45 000	47 100	45 100	46 000	46 100
Light-Duty Gasoline Vehicles	15 900	16 500	13 800	12 700	13 300	12 700	12 800	12 600
Light-Duty Gasoline Trucks	7 020	15 600	16 300	15 400	16 400	16 200	16 700	17 500
Heavy-Duty Gasoline Vehicles	1 440	3 120	3 390	3 280	3 520	3 270	3 280	3 370
Motorcycles	27	61	84	83	86	85	87	91
Light-Duty Diesel Vehicles	127	217	276	296	326	327	362	336
Light-Duty Diesel Trucks	34	72	145	156	192	241	328	375
Heavy-Duty Diesel Vehicles	3 970	11 800	12 900	13 100	13 200	12 300	12 400	11 800
Propane and Natural Gas Vehicles	68	55	4	4	1	1	1	1
Railways	1 800	1 600	1 300	1 200	1 300	1 400	1 400	1 500
Domestic Navigation	920	860	780	980	1 200	1 200	1 200	1 100
Other Transportation	14 000	12 000	9 600	8 900	9 100	9 300	9 900	9 300
Off-Road Agriculture & Forestry	1 300	1 400	1 300	1 200	1 200	1 100	1 200	1 000
Off-Road Commercial & Institutional	560	960	1 100	960	1 000	1 000	990	1 000
Off-Road Manufacturing, Mining & Construction	3 100	3 300	3 700	3 500	3 300	3 100	3 600	3 400
Off-Road Residential	88	490	520	470	470	480	470	450
Off-Road Other Transportation	7 000	2 800	2 100	1 900	2 000	2 100	2 100	2 200
Pipeline Transport	2 280	3 070	896	844	1 070	1 530	1 550	1 200
c. Fugitive Sources	**1 600**	**1 500**	**1 400**	**1 300**	**1 400**	**1 400**	**1 400**	**1 400**
Coal Mining	-	-	-	-	-	-	-	-
Oil and Natural Gas	1 600	1 500	1 400	1 300	1 400	1 400	1 400	1 400
d. CO_2 Transport and Storage	-	-	-	-	-	-	-	-
INDUSTRIAL PROCESSES AND PRODUCT USE	**30 600**	**25 000**	**22 000**	**24 000**	**22 400**	**22 900**	**22 200**	**24 300**
a. Mineral Products	**3 900**	**4 800**	**3 500**	**3 700**	**3 400**	**3 400**	**3 500**	**3 500**
Cement Production	2 400	3 700	2 700	2 900	2 700	2 700	2 800	2 800
Lime Production	1 090	800	599	607	572	616	573	558
Mineral Products Use	410	320	160	160	130	120	120	110
b. Chemical Industry[2]	**10 300**	**2 550**	-	-	-	-	-	-
Adipic Acid Production	10 000	2 500	-	-	-	-	-	-
c. Metal Production	**11 200**	**11 400**	**10 200**	**10 400**	**8 200**	**9 110**	**8 210**	**9 530**
Iron and Steel Production	10 500	10 300	10 000	10 100	8 010	8 900	8 010	9 290
Aluminum Production	-	-	-	-	-	-	-	-
SF_6 Used in Magnesium Smelters and Casters	687	1 130	170	232	191	205	198	240
d. Production and Consumption of Halocarbons, SF_6 and NF_3[3]	**970**	**2 000**	**3 200**	**3 400**	**3 500**	**3 800**	**4 100**	**4 500**
e. Non-Energy Products from Fuels and Solvent Use	**x**	**x**	**x**	**x**	**x**	**x**	**x**	**x**
f. Other Product Manufacture and Use	**140**	**190**	**140**	**170**	**170**	**150**	**170**	**190**
AGRICULTURE	**10 000**	**10 000**	**9 800**	**9 700**	**10 000**	**9 800**	**9 600**	**10 000**
a. Enteric Fermentation	**4 300**	**4 100**	**3 400**	**3 400**	**3 500**	**3 400**	**3 500**	**3 400**
b. Manure Management	**1 900**	**2 100**	**1 800**	**1 900**	**1 900**	**1 900**	**1 900**	**1 900**
c. Agricultural Soils	**3 900**	**3 700**	**4 300**	**4 200**	**4 600**	**4 300**	**4 100**	**4 400**
Direct Sources	3 300	3 100	3 700	3 600	4 000	3 700	3 600	3 800
Indirect Sources	600	500	600	600	600	600	600	600
d. Field Burning of Agricultural Residues	**4**	**0.60**	**0.30**	**0.40**	**0.30**	**0.30**	**0.30**	**0.30**
e. Liming, Urea Application and Other Carbon-containing Fertilizers	**300**	**200**	**200**	**200**	**200**	**200**	**100**	**200**
WASTE	**5 400**	**7 000**	**6 400**	**6 400**	**6 200**	**5 700**	**5 700**	**5 800**
a. Solid Waste Disposal	**4 800**	**6 300**	**5 600**	**5 600**	**5 400**	**4 800**	**4 800**	**4 800**
b. Biological Treatment of Solid Waste	**50**	**100**	**200**	**200**	**200**	**200**	**200**	**200**
c. Wastewater Treatment and Discharge	**240**	**320**	**320**	**330**	**330**	**330**	**330**	**330**
d. Incineration and Open Burning of Waste	**320**	**290**	**270**	**280**	**290**	**350**	**380**	**380**

Notes:

1. Emissions from ethanol and biodiesel are included in the Transport categories using gasoline and diesel respectively.
2. Emissions from Ammonia Production, Nitric Acid Production and Petrochemical Production and Carbon Black categories are included in Non-Energy Products from Fuels and Solvent Use as CO_2 eq values within provincial/territorial tables.
3. HFC and PFC consumption began in 1995; HFC emissions occurring as a by-product of HCFC production (HCFC-22 exclusively) only occurred in Canada from 1990–1992 and PFC emissions prior to 1995 are the result of by-product CF_4 emissions from the use of NF_3.

\- Indicates no emissions

0.00 Indicates emissions truncated due to rounding

x Indicates data has been suppressed to respect confidentiality

Estimates for the latest year (2016) are based on preliminary energy data; these data, though the best available information at the time of publication, are subject to revision in the next submission year.

Provincial/Territorial GHG emissions allocated to Canadian economic sectors are provided in Annex 12 of this report

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Table A11–13 2016 GHG Emission Summary for Ontario

Greenhouse Gas Categories	Greenhouse Gases									
	CO_2	CH_4	CH_4	N_2O	N_2O	HFCs[4]	PFCs[4]	SF_6	NF_3	TOTAL
Global Warming Potential			25		298			22 800	17 200	
Unit	kt	kt	kt CO_2 eq	kt	kt CO_2 eq	kt CO_2 eq	kt CO_2 eq	kt CO_2 eq	kt CO_2 eq	kt CO_2 eq
TOTAL	**136 000**	**470**	**12 000**	**26**	**7 700**	**4 500.00**	**7**	**300**	**-**	**161 000**
ENERGY	**117 000**	**93**	**2 300**	**5**	**2 000**	**-**	**-**	**-**	**-**	**121 000**
a. Stationary Combustion Sources	**57 600**	**30**	**800**	**2**	**500**	**-**	**-**	**-**	**-**	**58 900**
Public Electricity and Heat Production	5 400	1	35	0.17	49	-	-	-	-	5 500
Petroleum Refining Industries	5 200	0.09	2	0.03	8	-	-	-	-	5 200
Mining and Upstream Oil and Gas Production	621	0.01	0.27	0.03	9	-	-	-	-	630
Manufacturing Industries	15 300	0.46	12	0.38	110	-	-	-	-	15 500
Construction	338	0.01	0.14	0.01	3	-	-	-	-	341
Commercial and Institutional	12 100	0.23	6	0.30	80	-	-	-	-	12 200
Residential	17 100	30	800	0.70	200	-	-	-	-	18 100
Agriculture and Forestry	1 490	0.03	0.67	0.04	10	-	-	-	-	1 510
b. Transport[1]	**58 700**	**13**	**320**	**4**	**1 100**	**-**	**-**	**-**	**-**	**60 200**
Domestic Aviation	2 180	0.07	2	0.06	20	-	-	-	-	2 200
Road Transportation	45 200	3	70	3	870	-	-	-	-	46 100
Light-Duty Gasoline Vehicles	12 300	0.95	24	0.83	250	-	-	-	-	12 600
Light-Duty Gasoline Trucks	17 200	1	32	1	320	-	-	-	-	17 500
Heavy-Duty Gasoline Vehicles	3 280	0.11	3	0.30	89	-	-	-	-	3 370
Motorcycles	90	0.04	0.88	0.00	0.51	-	-	-	-	91
Light-Duty Diesel Vehicles	327	0.01	0.20	0.03	8	-	-	-	-	336
Light-Duty Diesel Trucks	365	0.01	0.20	0.03	9	-	-	-	-	375
Heavy-Duty Diesel Vehicles	11 600	0.50	10	0.70	200	-	-	-	-	11 800
Propane and Natural Gas Vehicles	0.73	0.00	0.01	0.00	0.00	-	-	-	-	0.74
Railways	1 300	0.07	2	0.50	200	-	-	-	-	1 500
Domestic Navigation	1 110	0.10	3	0.03	9	-	-	-	-	1 100
Other Transportation	8 970	10	200	0.30	90	-	-	-	-	9 300
Off-Road Agriculture & Forestry	1 020	0.04	1	0.03	10	-	-	-	-	1 000
Off-Road Commercial & Institutional	995	1	30	0.03	10	-	-	-	-	1 000
Off-Road Manufacturing, Mining & Construction	3 360	0.60	20	0.10	40	-	-	-	-	3 400
Off-Road Residential	420	0.90	20	0.01	4	-	-	-	-	450
Off-Road Other Transportation	2 010	6	100	0.05	20	-	-	-	-	2 200
Pipeline Transport	1 160	1	29	0.03	10	-	-	-	-	1 200
c. Fugitive Sources	**270**	**46**	**1 200**	**0.02**	**7**	**-**	**-**	**-**	**-**	**1 400**
Coal Mining	-	-	-	-	-	-	-	-	-	-
Oil and Natural Gas	270	46	1 200	0.02	7	-	-	-	-	1 400
d. CO_2 Transport and Storage	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
INDUSTRIAL PROCESSES AND PRODUCT USE	**19 300**	**2**	**41**	**0.49**	**146**	**4 500.00**	**7**	**300**	**-**	**24 300**
a. Mineral Products	**3 500**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**3 500**
Cement Production	2 800	-	-	-	-	-	-	-	-	2 800
Lime Production	558	-	-	-	-	-	-	-	-	558
Mineral Products Use	110	-	-	-	-	-	-	-	-	110
b. Chemical Industry[2]	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
Adipic Acid Production	-	-	-	-	-	-	-	-	-	-
c. Metal Production	**9 280**	**0.08**	**2**	**-**	**-**	**-**	**-**	**240**	**-**	**9 530**
Iron and Steel Production	9 280	0.08	2	-	-	-	-	-	-	9 290
Aluminum Production	-	-	-	-	-	-	-	-	-	-
SF_6 Used in Magnesium Smelters and Casters	-	-	-	-	-	-	-	240	-	240
d. Production and Consumption of Halocarbons, SF_6 and NF_3[3]	**-**	**-**	**-**	**-**	**-**	**4 500.00**	**2**	**0.48**	**-**	**4 500**
e. Non-Energy Products from Fuels and Solvent Use	**x**	**x**	**x**	**x**	**x**	**x**	**x**	**x**	**x**	**x**
f. Other Product Manufacture and Use	**7**	**-**	**-**	**0.39**	**120**	**-**	**6**	**62**	**-**	**190**
AGRICULTURE	**200**	**180**	**4 400**	**18**	**5 400**	**-**	**-**	**-**	**-**	**10 000**
a. Enteric Fermentation	**-**	**140**	**3 400**	**-**	**-**	**-**	**-**	**-**	**-**	**3 400**
b. Manure Management	**-**	**39**	**960**	**3**	**1 000**	**-**	**-**	**-**	**-**	**1 900**
c. Agricultural Soils	**-**	**-**	**-**	**15**	**4 400**	**-**	**-**	**-**	**-**	**4 400**
Direct Sources	-	-	-	13	3 800	-	-	-	-	3 800
Indirect Sources	-	-	-	2	600	-	-	-	-	600
d. Field Burning of Agricultural Residues	**-**	**0.01**	**0.20**	**0.00**	**0.07**	**-**	**-**	**-**	**-**	**0.30**
e. Liming, Urea Application and Other Carbon-containing Fertilizers	**200**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**200**
WASTE	**270**	**200.00**	**5 000**	**2**	**450**	**-**	**-**	**-**	**-**	**5 800**
a. Solid Waste Disposal	**-**	**190**	**4 800**	**-**	**-**	**-**	**-**	**-**	**-**	**4 800**
b. Biological Treatment of Solid Waste	**-**	**5**	**100**	**0.30**	**80**	**-**	**-**	**-**	**-**	**200**
c. Wastewater Treatment and Discharge	**-**	**3**	**75**	**0.90**	**300**	**-**	**-**	**-**	**-**	**330**
d. Incineration and Open Burning of Waste	**270**	**0.02**	**0.40**	**0.40**	**100**	**-**	**-**	**-**	**-**	**380**

Notes:

1. Emissions from ethanol and biodiesel are included in the Transport categories using gasoline and diesel respectively.
2. Emissions from Ammonia Production, Nitric Acid Production and Petrochemical Production and Carbon Black categories are included in Non-Energy Products from Fuels and Solvent Use as CO_2 eq values within provincial/territorial tables.
3. HFC and PFC consumption began in 1995; HFC emissions occurring as a by-product of HCFC production (HCFC-22 exclusively) only occurred in Canada from 1990–1992 and PFC emissions prior to 1995 are the result of by-product CF_4 emissions from the use of NF_3.
4. IPCC's Fourth Assessment Report provides global warming potentials (GWPs) for the various species of HFCs and PFCs. Chapter 1, Table 1-1 of this report provides a list of GWPs used.

\- Indicates no emissions

0.00 Indicates emissions truncated due to rounding

x Indicates data has been suppressed to respect confidentiality

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Provincial/Territorial GHG emissions allocated to Canadian economic sectors are provided in Annex 12 of this report

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Table A11–14 GHG Emission Summary for Manitoba, Selected Years

Greenhouse Gas Categories	1990	2005	2011	2012	2013	2014	2015	2016
	kt CO_2 eq							
TOTAL	**18 300**	**20 200**	**19 000**	**20 200**	**20 900**	**20 900**	**20 800**	**20 900**
ENERGY	**12 500**	**12 300**	**11 400**	**12 600**	**12 700**	**13 100**	**12 700**	**12 700**
a. Stationary Combustion Sources	**4 980**	**4 590**	**3 880**	**3 880**	**4 250**	**4 250**	**4 130**	**4 120**
Public Electricity and Heat Production	518	358	123	112	120	127	124	70
Petroleum Refining Industries	-	-	-	-	-	-	-	-
Mining and Upstream Oil and Gas Production	80	97	91	96	107	92	78	59
Manufacturing Industries	1 180	1 470	1 210	1 280	1 220	1 190	1 450	1 540
Construction	63	86	113	108	123	111	104	122
Commercial and Institutional	1 400	1 420	1 220	1 180	1 390	1 450	1 300	1 260
Residential	1 690	1 130	1 080	1 070	1 240	1 250	1 040	1 040
Agriculture and Forestry	43	43	33	37	43	34	32	26
b. Transport[1]	**7 100**	**7 520**	**7 190**	**8 300**	**8 060**	**8 450**	**8 120**	**8 160**
Domestic Aviation	470	540	430	480	500	460	420	410
Road Transportation	3 210	4 160	4 530	5 530	5 410	5 530	5 210	5 410
Light-Duty Gasoline Vehicles	1 510	1 200	1 070	1 280	1 280	1 220	1 130	1 120
Light-Duty Gasoline Trucks	896	1 460	1 600	1 980	2 030	2 080	2 060	2 130
Heavy-Duty Gasoline Vehicles	311	440	431	529	540	496	483	493
Motorcycles	4	4	6	7	8	8	9	9
Light-Duty Diesel Vehicles	8	10	14	17	16	16	14	14
Light-Duty Diesel Trucks	6	15	10	11	10	11	11	12
Heavy-Duty Diesel Vehicles	443	1 020	1 410	1 710	1 540	1 690	1 500	1 620
Propane and Natural Gas Vehicles	30	7	0.16	0.21	0.20	0.09	0.07	0.05
Railways	600	300	x	620	570	660	700	660
Domestic Navigation	0.02	2	x	-	-	-	0.78	-
Other Transportation	2 800	2 500	1 500	1 700	1 600	1 800	1 800	1 700
Off-Road Agriculture & Forestry	1 100	1 300	1 000	1 100	940	970	890	860
Off-Road Commercial & Institutional	40	81	86	91	95	99	92	82
Off-Road Manufacturing, Mining & Construction	190	230	210	220	200	210	220	230
Off-Road Residential	6	44	44	49	46	51	50	50
Off-Road Other Transportation	660	250	170	190	190	210	220	220
Pipeline Transport	848	601	32	13	109	268	311	245
c. Fugitive Sources	**450**	**210**	**370**	**430**	**440**	**440**	**410**	**380**
Coal Mining	-	-	-	-	-	-	-	-
Oil and Natural Gas	450	210	370	430	440	440	410	380
d. CO_2 Transport and Storage	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
INDUSTRIAL PROCESSES AND PRODUCT USE	484	689	964	837	872	818	895	906
a. Mineral Products	**220**	**69**	**63**	**64**	**59**	**64**	**60**	**58**
Cement Production	150	-	-	-	-	-	-	-
Lime Production	61	59	56	57	54	58	54	52
Mineral Products Use	6	10	7	7	6	6	6	6
b. Chemical Industry[2]	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
Adipic Acid Production	-	-	-	-	-	-	-	-
c. Metal Production	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
Iron and Steel Production	-	-	-	-	-	-	-	-
Aluminum Production	-	-	-	-	-	-	-	-
SF_6 Used in Magnesium Smelters and Casters	-	-	-	-	-	-	-	-
d. Production and Consumption of Halocarbons, SF_6 and NF_3[3]	**-**	**190**	**330**	**360**	**380**	**400**	**440**	**480**
e. Non-Energy Products from Fuels and Solvent Use	**x**	**x**	**x**	**x**	**x**	**x**	**x**	**x**
f. Other Product Manufacture and Use	**11**	**17**	**15**	**12**	**11**	**11**	**11**	**15**
AGRICULTURE	4 700	6 400	5 700	5 900	6 600	6 200	6 500	6 600
a. Enteric Fermentation	**1 900**	**3 200**	**2 500**	**2 400**	**2 400**	**2 400**	**2 400**	**2 400**
b. Manure Management	**460**	**870**	**770**	**770**	**790**	**790**	**800**	**820**
c. Agricultural Soils	**2 100**	**2 100**	**2 300**	**2 500**	**3 000**	**2 700**	**3 000**	**3 100**
Direct Sources	1 700	1 600	1 800	2 000	2 400	2 200	2 400	2 500
Indirect Sources	400	400	500	500	600	500	600	600
d. Field Burning of Agricultural Residues	**200**	**10**	**10**	**20**	**20**	**20**	**20**	**20**
e. Liming, Urea Application and Other Carbon-containing Fertilizers	**100**	**200**	**200**	**200**	**300**	**200**	**300**	**300**
WASTE	580	800	840	850	760	760	770	780
a. Solid Waste Disposal	**540**	**750**	**790**	**800**	**710**	**700**	**710**	**720**
b. Biological Treatment of Solid Waste	**0.50**	**2**	**4**	**4**	**6**	**8**	**8**	**8**
c. Wastewater Treatment and Discharge	**39**	**44**	**46**	**46**	**47**	**48**	**48**	**49**
d. Incineration and Open Burning of Waste	**1**	**0.44**	**0.05**	**0.06**	**0.06**	**0.06**	**0.06**	**0.06**

Notes:

1. Emissions from ethanol and biodiesel are included in the Transport categories using gasoline and diesel respectively.
2. Emissions from Ammonia Production, Nitric Acid Production and Petrochemical Production and Carbon Black categories are included in Non-Energy Products from Fuels and Solvent Use as CO_2 eq values within provincial/territorial tables.
3. HFC and PFC consumption began in 1995; HFC emissions occurring as a by-product of HCFC production (HCFC-22 exclusively) only occurred in Canada from 1990–1992 and PFC emissions prior to 1995 are the result of by-product CF_4 emissions from the use of NF_3.

\- Indicates no emissions

0.00 Indicates emissions truncated due to rounding

x Indicates data has been suppressed to respect confidentiality

Estimates for the latest year (2016) are based on preliminary energy data; these data, though the best available information at the time of publication, are subject to revision in the next submission year.

Provincial/Territorial GHG emissions allocated to Canadian economic sectors are provided in Annex 12 of this report

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Table A11–15 2016 GHG Emission Summary for Manitoba

Greenhouse Gas Categories	Greenhouse Gases: CO_2	CH_4	CH_4	N_2O	N_2O	HFCs[4]	PFCs[4]	SF_6	NF_3	TOTAL
Global Warming Potential			25		298			22 800	17 200	
Unit	kt	kt	kt CO_2 eq	kt	kt CO_2 eq	kt CO_2 eq	kt CO_2 eq	kt CO_2 eq	kt CO_2 eq	kt CO_2 eq
TOTAL	**12 700**	**160**	**4 000**	**13**	**3 800**	**480**	**0.39**	**3**	**-**	**20 900**
ENERGY	**12 100**	**15**	**380**	**0.70**	**200**	-	-	-	-	**12 700**
a. Stationary Combustion Sources	**4 020**	**2**	**60**	**0.10**	**40**	**-**	**-**	**-**	**-**	**4 120**
Public Electricity and Heat Production	69	0.00	0.09	0.00	0.85	-	-	-	-	70
Petroleum Refining Industries	-	-	-	-	-	-	-	-	-	-
Mining and Upstream Oil and Gas Production	58	0.00	0.02	0.00	1	-	-	-	-	59
Manufacturing Industries	1 530	0.06	1	0.05	14	-	-	-	-	1 540
Construction	121	0.00	0.06	0.00	0.70	-	-	-	-	122
Commercial and Institutional	1 250	0.02	0.60	0.03	7	-	-	-	-	1 260
Residential	969	2	60	0.04	10	-	-	-	-	1 040
Agriculture and Forestry	26	0.00	0.01	0.00	0.50	-	-	-	-	26
b. Transport[1]	**7 950**	**2**	**40**	**0.57**	**170**	**-**	**-**	**-**	**-**	**8 160**
Domestic Aviation	410	0.02	0.40	0.01	4	-	-	-	-	410
Road Transportation	5 310	0.40	10	0.28	82	-	-	-	-	5 410
Light-Duty Gasoline Vehicles	1 110	0.11	3	0.05	15	-	-	-	-	1 120
Light-Duty Gasoline Trucks	2 100	0.21	5	0.09	27	-	-	-	-	2 130
Heavy-Duty Gasoline Vehicles	479	0.02	0.47	0.04	13	-	-	-	-	493
Motorcycles	9	0.00	0.09	0.00	0.05	-	-	-	-	9
Light-Duty Diesel Vehicles	14	0.00	0.01	0.00	0.40	-	-	-	-	14
Light-Duty Diesel Trucks	12	0.00	0.01	0.00	0.30	-	-	-	-	12
Heavy-Duty Diesel Vehicles	1 600	0.07	2	0.09	30	-	-	-	-	1 620
Propane and Natural Gas Vehicles	0.05	0.00	0.00	0.00	0.00	-	-	-	-	0.05
Railways	591	0.03	0.80	0.20	70	-	-	-	-	660
Domestic Navigation	-	-	-	-	-	-	-	-	-	-
Other Transportation	1 630	1	30	0.05	20	-	-	-	-	1 700
Off-Road Agriculture & Forestry	848	0.04	0.90	0.03	8	-	-	-	-	860
Off-Road Commercial & Institutional	78	0.10	3	0.00	0.70	-	-	-	-	82
Off-Road Manufacturing, Mining & Construction	223	0.05	1	0.01	3	-	-	-	-	230
Off-Road Residential	47	0.10	3	0.00	0.40	-	-	-	-	50
Off-Road Other Transportation	202	0.60	10	0.01	2	-	-	-	-	220
Pipeline Transport	237	0.24	6	0.01	2	-	-	-	-	245
c. Fugitive Sources	**96**	**11**	**280**	**0.00**	**0.09**	**-**	**-**	**-**	**-**	**380**
Coal Mining	-	-	-	-	-	-	-	-	-	-
Oil and Natural Gas	96	11	280	0.00	0.09	-	-	-	-	380
d. CO_2 Transport and Storage	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
INDUSTRIAL PROCESSES AND PRODUCT USE	**371**	**-**	**-**	**0.19**	**56**	**480**	**0.39**	**2**	**-**	**906**
a. Mineral Products	**58**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**58**
Cement Production	-	-	-	-	-	-	-	-	-	-
Lime Production	52	-	-	-	-	-	-	-	-	52
Mineral Products Use	6	-	-	-	-	-	-	-	-	6
b. Chemical Industry[2]	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
Adipic Acid Production	-	-	-	-	-	-	-	-	-	-
c. Metal Production	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
Iron and Steel Production	-	-	-	-	-	-	-	-	-	-
Aluminum Production	-	-	-	-	-	-	-	-	-	-
SF_6 Used in Magnesium Smelters and Casters	-	-	-	-	-	-	-	-	-	-
d. Production and Consumption of Halocarbons, SF_6 and NF_3[3]	**-**	**-**	**-**	**-**	**-**	**480**	**0.05**	**-**	**-**	**480**
e. Non-Energy Products from Fuels and Solvent Use	**x**	**x**	**x**	**x**	**x**	**x**	**x**	**x**	**x**	**x**
f. Other Product Manufacture and Use	**1**	**-**	**-**	**0.04**	**11**	**-**	**0.34**	**2**	**-**	**15**
AGRICULTURE	**300**	**110**	**2 800**	**12**	**3 500**	-	-	-	-	**6 600**
a. Enteric Fermentation	**-**	**95**	**2 400**	**-**	**-**	**-**	**-**	**-**	**-**	**2 400**
b. Manure Management	**-**	**18**	**460**	**1**	**400**	**-**	**-**	**-**	**-**	**820**
c. Agricultural Soils	**-**	**-**	**-**	**10**	**3 100**	**-**	**-**	**-**	**-**	**3 100**
Direct Sources	-	-	-	9	2 500	-	-	-	-	2 500
Indirect Sources	-	-	-	2	600	-	-	-	-	600
d. Field Burning of Agricultural Residues	**-**	**0.50**	**10**	**0.01**	**4**	**-**	**-**	**-**	**-**	**20**
e. Liming, Urea Application and Other Carbon-containing Fertilizers	**300**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**300**
WASTE	**0.06**	**30**	**750**	**0.09**	**28**	-	-	-	-	**780**
a. Solid Waste Disposal	**-**	**29**	**720**	**-**	**-**	**-**	**-**	**-**	**-**	**720**
b. Biological Treatment of Solid Waste	**-**	**0.20**	**5**	**0.01**	**3**	**-**	**-**	**-**	**-**	**8**
c. Wastewater Treatment and Discharge	**-**	**0.97**	**24**	**0.08**	**20**	**-**	**-**	**-**	**-**	**49**
d. Incineration and Open Burning of Waste	**0.06**	**0.00**	**0.00**	**0.00**	**0.00**	**-**	**-**	**-**	**-**	**0.06**

Notes:

1. Emissions from ethanol and biodiesel are included in the Transport categories using gasoline and diesel respectively.
2. Emissions from Ammonia Production, Nitric Acid Production and Petrochemical Production and Carbon Black categories are included in Non-Energy Products from Fuels and Solvent Use as CO_2 eq values within provincial/territorial tables.
3. HFC and PFC consumption began in 1995; HFC emissions occurring as a by-product of HCFC production (HCFC-22 exclusively) only occurred in Canada from 1990–1992 and PFC emissions prior to 1995 are the result of by-product CF_4 emissions from the use of NF_3.
4. IPCC's Fourth Assessment Report provides global warming potentials (GWPs) for the various species of HFCs and PFCs. Chapter 1, Table 1-1 of this report provides a list of GWPs used.

\- Indicates no emissions

0.00 Indicates emissions truncated due to rounding

x Indicates data has been suppressed to respect confidentiality

Estimates for the latest year (2016) are based on preliminary energy data; these data, though the best available information at the time of publication, are subject to revision in the next submission year.

Provincial/Territorial GHG emissions allocated to Canadian economic sectors are provided in Annex 12 of this report

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Table A11–16 GHG Emission Summary for Saskatchewan, Selected Years

Greenhouse Gas Categories		1990	2005	2011	2012	2013	2014	2015	2016
		kt CO_2 eq							
TOTAL		44 700	68 900	69 000	71 300	74 000	77 400	79 500	76 300
ENERGY		35 900	54 700	55 900	57 300	58 800	63 300	65 000	61 400
a.	**Stationary Combustion Sources**	**20 100**	**27 500**	**29 400**	**29 500**	**29 000**	**30 900**	**32 000**	**30 900**
	Public Electricity and Heat Production	11 100	15 200	15 500	16 100	15 000	15 200	16 000	16 000
	Petroleum Refining Industries	630	780	1 000	1 200	1 200	1 200	1 300	1 400
	Mining and Upstream Oil and Gas Production	4 130	7 590	8 450	7 910	8 260	9 610	10 000	9 010
	Manufacturing Industries	792	533	704	808	751	969	851	677
	Construction	70	42	56	37	36	39	67	39
	Commercial and Institutional	985	1 510	1 280	1 110	1 120	1 130	1 110	1 300
	Residential	2 140	1 630	1 800	1 760	1 870	1 870	1 710	1 680
	Agriculture and Forestry	296	256	615	661	772	997	870	783
b.	**Transport[1]**	**9 170**	**11 500**	**14 100**	**14 800**	**16 100**	**16 600**	**16 900**	**16 500**
	Domestic Aviation	260	190	190	220	230	220	220	210
	Road Transportation	3 680	5 120	6 860	7 870	8 620	8 580	8 980	9 050
	Light-Duty Gasoline Vehicles	1 440	1 350	1 300	1 450	1 470	1 300	1 380	1 360
	Light-Duty Gasoline Trucks	1 190	1 700	2 280	2 740	2 920	2 820	3 160	3 310
	Heavy-Duty Gasoline Vehicles	610	767	874	1 050	1 130	885	958	991
	Motorcycles	2	3	6	7	7	7	7	8
	Light-Duty Diesel Vehicles	5	11	19	21	24	25	26	24
	Light-Duty Diesel Trucks	8	39	31	29	31	33	37	36
	Heavy-Duty Diesel Vehicles	386	1 250	2 350	2 570	3 030	3 510	3 420	3 330
	Propane and Natural Gas Vehicles	37	5	0.38	0.62	0.28	0.16	0.14	0.27
	Railways	580	410	720	560	700	720	800	780
	Domestic Navigation	0.09	-	-	-	-	-	-	-
	Other Transportation	4 600	5 800	6 300	6 200	6 600	7 100	6 900	6 400
	Off-Road Agriculture & Forestry	2 100	3 200	3 500	3 300	3 700	3 800	3 900	3 800
	Off-Road Commercial & Institutional	32	77	110	110	130	130	130	53
	Off-Road Manufacturing, Mining & Construction	170	240	350	310	340	390	440	310
	Off-Road Residential	4	34	42	46	48	49	51	58
	Off-Road Other Transportation	720	290	280	310	330	350	370	380
	Pipeline Transport	1 590	1 900	2 070	2 040	2 060	2 320	2 010	1 830
c.	**Fugitive Sources**	**6 700**	**16 000**	**12 000**	**13 000**	**14 000**	**16 000**	**16 000**	**14 000**
	Coal Mining	20	20	20	20	20	20	20	20
	Oil and Natural Gas	6 700	16 000	12 000	13 000	14 000	16 000	16 000	14 000
d.	**CO_2 Transport and Storage**	**-**	**0.09**	**0.09**	**0.09**	**0.09**	**0.10**	**0.20**	**0.20**
INDUSTRIAL PROCESSES AND PRODUCT USE		354	823	1 050	1 000	1 170	842	871	906
a.	**Mineral Products**	**96**	**10**	**9**	**8**	**8**	**9**	**9**	**8**
	Cement Production	87	-	-	-	-	-	-	-
	Lime Production	-	-	-	-	-	-	-	-
	Mineral Products Use	8	10	9	8	8	9	9	8
b.	**Chemical Industry[2]**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
	Adipic Acid Production	-	-	-	-	-	-	-	-
c.	**Metal Production**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
	Iron and Steel Production	-	-	-	-	-	-	-	-
	Aluminum Production	-	-	-	-	-	-	-	-
	SF_6 Used in Magnesium Smelters and Casters	-	-	-	-	-	-	-	-
d.	**Production and Consumption of Halocarbons, SF_6 and NF_3[3]**	**-**	**180**	**330**	**350**	**360**	**390**	**420**	**470**
e.	**Non-Energy Products from Fuels and Solvent Use**	**x**	**x**	**x**	**x**	**x**	**x**	**x**	**x**
f.	**Other Product Manufacture and Use**	**8**	**12**	**9**	**10**	**10**	**10**	**11**	**12**
AGRICULTURE		7 800	13 000	11 000	12 000	13 000	12 000	13 000	13 000
a.	**Enteric Fermentation**	**3 300**	**6 100**	**4 800**	**4 800**	**4 800**	**4 800**	**4 700**	**4 700**
b.	**Manure Management**	**740**	**1 400**	**1 100**	**1 100**	**1 100**	**1 100**	**1 100**	**1 100**
c.	**Agricultural Soils**	**3 500**	**4 600**	**4 700**	**5 400**	**6 300**	**5 700**	**6 000**	**6 300**
	Direct Sources	3 000	3 800	3 800	4 400	5 100	4 600	4 800	5 100
	Indirect Sources	500	900	900	1 000	1 000	1 000	1 000	1 000
d.	**Field Burning of Agricultural Residues**	**70**	**30**	**20**	**20**	**30**	**30**	**30**	**30**
e.	**Liming, Urea Application and Other Carbon-containing Fertilizers**	**200**	**400**	**600**	**700**	**900**	**900**	**900**	**900**
WASTE		590	730	810	820	830	800	800	810
a.	**Solid Waste Disposal**	**540**	**680**	**760**	**770**	**770**	**740**	**750**	**750**
b.	**Biological Treatment of Solid Waste**	**0.02**	**0.60**	**4**	**5**	**5**	**5**	**5**	**5**
c.	**Wastewater Treatment and Discharge**	**44**	**45**	**48**	**49**	**50**	**50**	**50**	**51**
d.	**Incineration and Open Burning of Waste**	**1**	**0.02**	**0.02**	**0.02**	**0.02**	**0.02**	**0.02**	**0.02**

Notes:

1. Emissions from ethanol and biodiesel are included in the Transport categories using gasoline and diesel respectively.
2. Emissions from Ammonia Production, Nitric Acid Production and Petrochemical Production and Carbon Black categories are included in Non-Energy Products from Fuels and Solvent Use as CO_2 eq values within provincial/territorial tables.
3. HFC and PFC consumption began in 1995; HFC emissions occurring as a by-product of HCFC production (HCFC-22 exclusively) only occurred in Canada from 1990–1992 and PFC emissions prior to 1995 are the result of by-product CF_4 emissions from the use of NF_3.

\- Indicates no emissions

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Estimates for the latest year (2016) are based on preliminary energy data; these data, though the best available information at the time of publication, are subject to revision in the next submission year.

Provincial/Territorial GHG emissions allocated to Canadian economic sectors are provided in Annex 12 of this report

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Table A11–17 2016 GHG Emission Summary for Saskatchewan

Greenhouse Gas Categories	Greenhouse Gases CO_2	CH_4	CH_4	N_2O	N_2O	HFCs[4]	PFCs[4]	SF_6	NF_3	TOTAL
Global Warming Potential			25		298			22 800	17 200	
Unit	kt	kt	kt CO_2 eq	kt	kt CO_2 eq	kt CO_2 eq	kt CO_2 eq	kt CO_2 eq	kt CO_2 eq	kt CO_2 eq
TOTAL	**50 500**	**700**	**18 000**	**26**	**7 600**	**470**	**0.23**	**0.38**	**-**	**76 300**
ENERGY	**49 200**	**470**	**12 000**	**2**	**500**	-	-	-	-	**61 400**
a. Stationary Combustion Sources	**30 300**	**20**	**400**	**0.70**	**200**	**-**	**-**	**-**	**-**	**30 900**
Public Electricity and Heat Production	16 000	1	30	0.38	110	-	-	-	-	16 000
Petroleum Refining Industries	1 400	0.03	0.80	0.02	4	-	-	-	-	1 400
Mining and Upstream Oil and Gas Production	8 620	13	330	0.20	60	-	-	-	-	9 010
Manufacturing Industries	670	0.03	0.73	0.02	7	-	-	-	-	677
Construction	38	0.00	0.02	0.00	0.30	-	-	-	-	39
Commercial and Institutional	1 290	0.03	0.65	0.03	8	-	-	-	-	1 300
Residential	1 630	1	30	0.05	10	-	-	-	-	1 680
Agriculture and Forestry	778	0.01	0.36	0.02	5	-	-	-	-	783
b. Transport[1]	**16 100**	**4**	**100**	**0.94**	**280**	**-**	**-**	**-**	**-**	**16 500**
Domestic Aviation	210	0.02	0.40	0.01	2	-	-	-	-	210
Road Transportation	8 890	0.70	20	0.47	140	-	-	-	-	9 050
Light-Duty Gasoline Vehicles	1 330	0.14	4	0.06	19	-	-	-	-	1 360
Light-Duty Gasoline Trucks	3 260	0.32	8	0.13	39	-	-	-	-	3 310
Heavy-Duty Gasoline Vehicles	964	0.04	0.95	0.09	26	-	-	-	-	991
Motorcycles	8	0.00	0.08	0.00	0.04	-	-	-	-	8
Light-Duty Diesel Vehicles	24	0.00	0.01	0.00	0.60	-	-	-	-	24
Light-Duty Diesel Trucks	35	0.00	0.02	0.00	0.90	-	-	-	-	36
Heavy-Duty Diesel Vehicles	3 270	0.10	3	0.20	50	-	-	-	-	3 330
Propane and Natural Gas Vehicles	0.27	0.00	0.00	0.00	0.00	-	-	-	-	0.27
Railways	699	0.04	1	0.30	80	-	-	-	-	780
Domestic Navigation	-	-	-	-	-	-	-	-	-	-
Other Transportation	6 270	3	80	0.20	60	-	-	-	-	6 400
Off-Road Agriculture & Forestry	3 740	0.20	4	0.10	40	-	-	-	-	3 800
Off-Road Commercial & Institutional	51	0.09	2	0.00	0.50	-	-	-	-	53
Off-Road Manufacturing, Mining & Construction	302	0.05	1	0.01	4	-	-	-	-	310
Off-Road Residential	55	0.10	3	0.00	0.50	-	-	-	-	58
Off-Road Other Transportation	350	1	30	0.01	2	-	-	-	-	380
Pipeline Transport	1 770	2	46	0.05	10	-	-	-	-	1 830
c. Fugitive Sources	**2 800**	**450**	**11 000**	**0.02**	**7**	**-**	**-**	**-**	**-**	**14 000**
Coal Mining	-	0.70	20	-	-	-	-	-	-	20
Oil and Natural Gas	2 800	450	11 000	0.02	7	-	-	-	-	14 000
d. CO_2 Transport and Storage	**0.20**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**0.20**
INDUSTRIAL PROCESSES AND PRODUCT USE	**416**	**-**	**-**	**0.08**	**24**	**470**	**0.23**	**0.38**	**-**	**906**
a. Mineral Products	**8**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**8**
Cement Production	-	-	-	-	-	-	-	-	-	-
Lime Production	-	-	-	-	-	-	-	-	-	-
Mineral Products Use	8	-	-	-	-	-	-	-	-	8
b. Chemical Industry[2]	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
Adipic Acid Production	-	-	-	-	-	-	-	-	-	-
c. Metal Production	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
Iron and Steel Production	-	-	-	-	-	-	-	-	-	-
Aluminum Production	-	-	-	-	-	-	-	-	-	-
SF_6 Used in Magnesium Smelters and Casters	-	-	-	-	-	-	-	-	-	-
d. Production and Consumption of Halocarbons, SF_6 and NF_3[3]	**-**	**-**	**-**	**-**	**-**	**470**	**0.04**	**-**	**-**	**470**
e. Non-Energy Products from Fuels and Solvent Use	**x**	**x**	**x**	**x**	**x**	**x**	**x**	**x**	**x**	**x**
f. Other Product Manufacture and Use	**2**	**-**	**-**	**0.03**	10	**-**	**0.18**	**0.38**	**-**	**12**
AGRICULTURE	**900**	**200**	**5 100**	**24**	**7100**	-	-	-	-	**13 000**
a. Enteric Fermentation	**-**	**190**	**4700**	**-**	**-**	**-**	**-**	**-**	**-**	**4 700**
b. Manure Management	**-**	**14**	**350**	**3**	**800**	**-**	**-**	**-**	**-**	**1 100**
c. Agricultural Soils	**-**	**-**	**-**	**21**	**6 300**	**-**	**-**	**-**	**-**	**6 300**
Direct Sources	-	-	-	17	5 100	-	-	-	-	5 100
Indirect Sources	-	-	-	4	1 000	-	-	-	-	1 000
d. Field Burning of Agricultural Residues	**-**	**0.90**	**20**	**0.02**	**7**	**-**	**-**	**-**	**-**	**30**
e. Liming, Urea Application and Other Carbon-containing Fertilizers	**900**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**900**
WASTE	**0.02**	**31**	**790**	**0.08**	**24**	-	-	-	-	**810**
a. Solid Waste Disposal	**-**	**30**	**750**	**-**	**-**	**-**	**-**	**-**	**-**	**750**
b. Biological Treatment of Solid Waste	**-**	**0.10**	**3**	**0.01**	**2**	**-**	**-**	**-**	**-**	**5**
c. Wastewater Treatment and Discharge	**-**	**1**	**30**	**0.07**	**20**	**-**	**-**	**-**	**-**	**51**
d. Incineration and Open Burning of Waste	**0.02**	**0.00**	**0.00**	**0.00**	**0.00**	**-**	**-**	**-**	**-**	**0.02**

Notes:

1. Emissions from ethanol and biodiesel are included in the Transport categories using gasoline and diesel respectively.
2. Emissions from Ammonia Production, Nitric Acid Production and Petrochemical Production and Carbon Black categories are included in Non-Energy Products from Fuels and Solvent Use as CO_2 eq values within provincial/territorial tables.
3. HFC and PFC consumption began in 1995; HFC emissions occurring as a by-product of HCFC production (HCFC-22 exclusively) only occurred in Canada from 1990–1992 and PFC emissions prior to 1995 are the result of by-product CF_4 emissions from the use of NF_3.
4. IPCC's Fourth Assessment Report provides global warming potentials (GWPs) for the various species of HFCs and PFCs. Chapter 1, Table 1-1 of this report provides a list of GWPs used.

\- Indicates no emissions

0.00 Indicates emissions truncated due to rounding

x Indicates data has been suppressed to respect confidentiality

Estimates for the latest year (2016) are based on preliminary energy data; these data, though the best available information at the time of publication, are subject to revision in the next submission year.

Provincial/Territorial GHG emissions allocated to Canadian economic sectors are provided in Annex 12 of this report

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Table A11–18 GHG Emission Summary for Alberta, Selected Years

Greenhouse Gas Categories		1990	2005	2011	2012	2013	2014	2015	2016
		kt CO_2 eq							
TOTAL		**174 000**	**231 000**	**244 000**	**256 000**	**265 000**	**269 000**	**267 000**	**263 000**
ENERGY		**153 000**	**200 000**	**214 000**	**222 000**	**232 000**	**237 000**	**235 000**	**231 000**
a.	**Stationary Combustion Sources**	**96 500**	**129 000**	**140 000**	**145 000**	**151 000**	**154 000**	**156 000**	**157 000**
	Public Electricity and Heat Production	39 600	51 900	48 700	46 900	48 100	49 100	51 300	48 200
	Petroleum Refining Industries	3 000	4 000	3 500	3 800	40	4 300	4 500	4 800
	Mining and Upstream Oil and Gas Production	30 800	50 800	61 400	67 600	71 800	73 400	74 500	79 700
	Manufacturing Industries	10 500	8 860	11 500	10 900	11 800	11 300	10 700	10 300
	Construction	238	171	261	289	306	298	297	307
	Commercial and Institutional	5 040	5 660	5 920	6 330	6 340	6 470	5 830	6 370
	Residential	6 850	7 620	8 840	8 750	8 780	9 160	8 260	7 130
	Agriculture and Forestry	477	240	214	207	211	213	221	237
b.	**Transport**[1]	**22 300**	**34 000**	**38 700**	**40 200**	**42 800**	**44 000**	**41 800**	**39 800**
	Domestic Aviation	1 100	1 300	1 200	1 400	1 500	1 500	1 500	1 400
	Road Transportation	11 600	19 300	25 000	26 100	27 800	28 800	26 900	25 900
	Light-Duty Gasoline Vehicles	4 030	3 630	3 010	3 110	3 290	3 330	3 000	3 020
	Light-Duty Gasoline Trucks	3 260	5 070	5 500	6 010	6 480	6 940	6 820	7 140
	Heavy-Duty Gasoline Vehicles	1 650	3 160	2 880	3 240	3 530	3 350	3 140	3 280
	Motorcycles	13	28	34	38	41	44	43	45
	Light-Duty Diesel Vehicles	21	52	93	92	102	104	94	81
	Light-Duty Diesel Trucks	16	52	88	84	89	112	128	126
	Heavy-Duty Diesel Vehicles	2 170	7 250	13 400	13 600	14 300	14 900	13 700	12 200
	Propane and Natural Gas Vehicles	400	97	3	2	2	0.96	0.96	2
	Railways	1 800	x	x	x	x	2 900	2 500	1 900
	Domestic Navigation	0	x	x	x	x	-	7	4
	Other Transportation	7 900	11 000	9 900	9 600	10 000	11 000	11 000	11 000
	Off-Road Agriculture & Forestry	2 500	3 500	3 600	3 200	3 300	3 200	3 000	2 600
	Off-Road Commercial & Institutional	160	290	320	310	350	400	370	240
	Off-Road Manufacturing, Mining & Construction	1 500	2 500	3 500	3 400	3 800	3 900	3 900	3 200
	Off-Road Residential	20	130	110	110	120	130	120	130
	Off-Road Other Transportation	2 300	930	680	690	720	810	800	790
	Pipeline Transport	1 300	3 210	1 680	1 820	2 190	2 360	2 660	3 540
c.	**Fugitive Sources**	**34 000**	**36 000**	**35 000**	**37 000**	**38 000**	**39 000**	**37 000**	**34 000**
	Coal Mining	400	300	300	300	300	200	300	300
	Oil and Natural Gas	33 000	36 000	34 000	37 000	38 000	39 000	37 000	34 000
d.	**CO_2 Transport and Storage**	**-**	**-**	**-**	**-**	**-**	**-**	**0.04**	**0.09**
INDUSTRIAL PROCESSES AND PRODUCT USE		6 590	10 500	11 300	14 600	12 700	11 200	12 200	11 700
a.	**Mineral Products**	**1 100**	**1 500**	**1 200**	**1 300**	**1 200**	**1 200**	**1 200**	**1 200**
	Cement Production	790	1 100	910	980	900	890	940	930
	Lime Production	108	125	118	119	113	121	113	110
	Mineral Products Use	200	250	160	150	140	140	160	160
b.	**Chemical Industry**[2]	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
	Adipic Acid Production	-	-	-	-	-	-	-	-
c.	**Metal Production**	**-**	**-**	**-**	**-**	**-**	**-**	**0.69**	**0.34**
	Iron and Steel Production	-	-	-	-	-	-	0.69	0.34
	Aluminum Production	-	-	-	-	-	-	-	-
	SF_6 Used in Magnesium Smelters and Casters	-	-	-	-	-	-	-	-
d.	**Production and Consumption of Halocarbons, SF_6 and NF_3**[3]	**0**	**710**	**1 200**	**1 300**	**1 400**	**1 500**	**1 700**	**1 800**
e.	**Non-Energy Products from Fuels and Solvent Use**	**x**	**x**	**x**	**x**	**x**	**x**	**x**	**x**
f.	**Other Product Manufacture and Use**	**17**	**38**	**31**	**37**	**36**	**38**	**40**	**47**
AGRICULTURE		14 000	19 000	17 000	18 000	18 000	18 000	18 000	18 000
a.	**Enteric Fermentation**	**7 800**	**12 000**	**9 300**	**9 500**	**9 500**	**9 500**	**9 400**	**9 600**
b.	**Manure Management**	**1 600**	**2 500**	**2 000**	**2 000**	**2 100**	**2 100**	**2 100**	**2 100**
c.	**Agricultural Soils**	**4 100**	**4 600**	**5 300**	**5 600**	**5 900**	**5 900**	**5 800**	**5 700**
	Direct Sources	3 400	3 700	4 300	4 500	4 800	4 700	4 700	4 600
	Indirect Sources	700	900	1 000	1 000	1 000	1 000	1 000	1 000
d.	**Field Burning of Agricultural Residues**	**4**	**1**	**1**	**1**	**1**	**1**	**1**	**1**
e.	**Liming, Urea Application and Other Carbon-containing Fertilizers**	**300**	**400**	**600**	**700**	**800**	**800**	**900**	**700**
WASTE		1 200	1 700	1 600	1 700	1 800	1 900	1 900	2 000
a.	**Solid Waste Disposal**	**1 100**	**1 500**	**1 400**	**1 500**	**1 600**	**1 700**	**1 700**	**1 700**
b.	**Biological Treatment of Solid Waste**	**-**	**40**	**40**	**40**	**40**	**40**	**40**	**40**
c.	**Wastewater Treatment and Discharge**	**73**	**100**	**120**	**120**	**120**	**120**	**120**	**120**
d.	**Incineration and Open Burning of Waste**	**11**	**34**	**22**	**43**	**46**	**40**	**52**	**52**

Notes:

1. Emissions from ethanol and biodiesel are included in the Transport categories using gasoline and diesel respectively.
2. Emissions from Ammonia Production, Nitric Acid Production and Petrochemical Production and Carbon Black categories are included in Non-Energy Products from Fuels and Solvent Use as CO_2 eq values within provincial/territorial tables.
3. HFC and PFC consumption began in 1995; HFC emissions occurring as a by-product of HCFC production (HCFC-22 exclusively) only occurred in Canada from 1990–1992 and PFC emissions prior to 1995 are the result of by-product CF_4 emissions from the use of NF_3.

\- Indicates no emissions

0.00 Indicates emissions truncated due to rounding

x Indicates data has been suppressed to respect confidentiality

Estimates for the latest year (2016) are based on preliminary energy data; these data, though the best available information at the time of publication, are subject to revision in the next submission year.

Provincial/Territorial GHG emissions allocated to Canadian economic sectors are provided in Annex 12 of this report

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Table A11–19 2016 GHG Emission Summary for Alberta

Greenhouse Gas Categories	CO_2	CH_4	CH_4	N_2O	N_2O	HFCs[4]	PFCs[4]	SF_6	NF_3	TOTAL
	Greenhouse Gases									
Global Warming Potential			25		298			22 800	17 200	
Unit	kt	kt	kt CO_2 eq	kt	kt CO_2 eq	kt CO_2 eq	kt CO_2 eq	kt CO_2 eq	kt CO_2 eq	kt CO_2 eq
TOTAL	**210 000**	**1 700**	**41 000**	**33**	**9 900**	**1 800**	**1**	**3**	**-**	**263 000**
ENERGY	**200 000**	**1 200**	**29 000**	**6**	**2 000**	**-**	**-**	**-**	**-**	**231 000**
a. Stationary Combustion Sources	**154 000**	**80**	**2 000**	**3**	**900**	**-**	**-**	**-**	**-**	**157 000**
Public Electricity and Heat Production	48 000	2	61	0.93	280	-	-	-	-	48 200
Petroleum Refining Industries	4 800	0.08	2	0.02	7	-	-	-	-	4 800
Mining and Upstream Oil and Gas Production	77 400	71	1 800.00	1	400	-	-	-	-	79 700
Manufacturing Industries	10 200	0.31	8	0.27	81	-	-	-	-	10 300
Construction	304	0.01	0.14	0.01	3	-	-	-	-	307
Commercial and Institutional	6 320	0.12	3	0.10	40	-	-	-	-	6 370
Residential	6 930	6	100.00	0.20	60	-	-	-	-	7 130
Agriculture and Forestry	236	0.00	0.11	0.01	2	-	-	-	-	237
b. Transport[1]	**38 800**	**8**	**210**	**3**	**740**	**-**	**-**	**-**	**-**	**39 800**
Domestic Aviation	1 380	0.04	1	0.04	10	-	-	-	-	1 400
Road Transportation	25 500	2	40	1	410	-	-	-	-	25 900
Light-Duty Gasoline Vehicles	2 980	0.29	7	0.13	38	-	-	-	-	3 020
Light-Duty Gasoline Trucks	7 050	0.65	16	0.27	79	-	-	-	-	7 140
Heavy-Duty Gasoline Vehicles	3 190	0.11	3	0.28	84	-	-	-	-	3 280
Motorcycles	45	0.02	0.43	0.00	0.25	-	-	-	-	45
Light-Duty Diesel Vehicles	79	0.00	0.04	0.01	2	-	-	-	-	81
Light-Duty Diesel Trucks	123	0.00	0.08	0.01	3	-	-	-	-	126
Heavy-Duty Diesel Vehicles	12 000	0.50	10	0.70	200	-	-	-	-	12 200
Propane and Natural Gas Vehicles	1	0.00	0.02	0.00	0.01	-	-	-	-	2
Railways	1 690	0.10	2	0.70	200	-	-	-	-	1 900
Domestic Navigation	3	0.00	0.01	0.00	0.03	-	-	-	-	4
Other Transportation	10 200	7	200	0.40	100	-	-	-	-	11 000
Off-Road Agriculture & Forestry	2 600	0.10	3	0.09	30	-	-	-	-	2 600
Off-Road Commercial & Institutional	224	0.50	10	0.01	2	-	-	-	-	240
Off-Road Manufacturing, Mining & Construction	3 140	0.20	6	0.20	60	-	-	-	-	3 200
Off-Road Residential	118	0.30	6	0.00	1	-	-	-	-	130
Off-Road Other Transportation	734	2	60	0.02	5	-	-	-	-	790
Pipeline Transport	3 430	3	83	0.09	30	-	-	-	-	3 540
c. Fugitive Sources	**7 400**	**1 100**	**27 000**	**0.04**	**10**	**-**	**-**	**-**	**-**	**34 000**
Coal Mining	-	10	300	-	-	-	-	-	-	300
Oil and Natural Gas	7 400	1 100	27 000	0.04	10	-	-	-	-	34 000
d. CO_2 Transport and Storage	**0.09**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**0.09**
INDUSTRIAL PROCESSES AND PRODUCT USE	**8 860**	**2**	**37**	**3**	**998**	**1 800**	**1**	**3**	**-**	**11 700**
a. Mineral Products	**1 200**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**1 200**
Cement Production	930	-	-	-	-	-	-	-	-	930
Lime Production	110	-	-	-	-	-	-	-	-	110
Mineral Products Use	160	-	-	-	-	-	-	-	-	160
b. Chemical Industry[2]	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
Adipic Acid Production	-	-	-	-	-	-	-	-	-	-
c. Metal Production	**0.34**	**0.00**	**0.00**	**-**	**-**	**-**	**-**	**-**	**-**	**0.34**
Iron and Steel Production	0.34	0.00	0.00	-	-	-	-	-	-	0.34
Aluminum Production	-	-	-	-	-	-	-	-	-	-
SF_6 Used in Magnesium Smelters and Casters	-	-	-	-	-	-	-	-	-	-
d. Production and Consumption of Halocarbons, SF_6 and NF_3[3]	**-**	**-**	**-**	**-**	**-**	**1 800**	**0.36**	**0.12**	**-**	**1 800**
e. Non-Energy Products from Fuels and Solvent Use	**x**	**x**	**x**	**x**	**x**	**x**	**x**	**x**	**x**	**x**
f. Other Product Manufacture and Use	**8**	**-**	**-**	**0.12**	**36**	**-**	**0.90**	**3**	**-**	**47**
AGRICULTURE	**700**	**410**	**10 000**	**24**	**7 100**	**-**	**-**	**-**	**-**	**18 000**
a. Enteric Fermentation	**-**	**380**	**9 600**	**-**	**-**	**-**	**-**	**-**	**-**	**9 600**
b. Manure Management	**-**	**27**	**690**	**5**	**1 000**	**-**	**-**	**-**	**-**	**2 100**
c. Agricultural Soils	**-**	**-**	**-**	**19**	**5 700**	**-**	**-**	**-**	**-**	**5 700**
Direct Sources	-	-	-	16	4 600	-	-	-	-	4 600
Indirect Sources	-	-	-	4	1 000	-	-	-	-	1 000
d. Field Burning of Agricultural Residues	**-**	**0.02**	**0.60**	**0.00**	**0.20**	**-**	**-**	**-**	**-**	**0.70**
e. Liming, Urea Application and Other Carbon-containing Fertilizers	**700**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**700**
WASTE	**33**	**72**	**1 800**	**0.39**	**120**	**-**	**-**	**-**	**-**	**2 000**
a. Solid Waste Disposal	**-**	**69**	**1 700**	**-**	**-**	**-**	**-**	**-**	**-**	**1 700**
b. Biological Treatment of Solid Waste	**-**	**1**	**30**	**0.06**	**20**	**-**	**-**	**-**	**-**	**40**
c. Wastewater Treatment and Discharge	**-**	**2**	**46**	**0.30**	**80**	**-**	**-**	**-**	**-**	**120**
d. Incineration and Open Burning of Waste	**33**	**0.00**	**0.09**	**0.06**	**20**	**-**	**-**	**-**	**-**	**52**

Notes:

1. Emissions from ethanol and biodiesel are included in the Transport categories using gasoline and diesel respectively.
2. Emissions from Ammonia Production, Nitric Acid Production and Petrochemical Production and Carbon Black categories are included in Non-Energy Products from Fuels and Solvent Use as CO_2 eq values within provincial/territorial tables.
3. HFC and PFC consumption began in 1995; HFC emissions occurring as a by-product of HCFC production (HCFC-22 exclusively) only occurred in Canada from 1990–1992 and PFC emissions prior to 1995 are the result of by-product CF_4 emissions from the use of NF_3.
4. IPCC's Fourth Assessment Report provides global warming potentials (GWPs) for the various species of HFCs and PFCs. Chapter 1, Table 1-1 of this report provides a list of GWPs used.

\- Indicates no emissions

0.00 Indicates emissions truncated due to rounding

x Indicates data has been suppressed to respect confidentiality

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Provincial/Territorial GHG emissions allocated to Canadian economic sectors are provided in Annex 12 of this report

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Table A11–20 GHG Emission Summary for British Columbia, Selected Years

Greenhouse Gas Categories	1990	2005	2011	2012	2013	2014	2015	2016
	kt CO_2 eq							
TOTAL	**51 100**	**63 300**	**59 300**	**60 300**	**60 900**	**60 400**	**59 400**	**60 100**
ENERGY	42 000	51 700	49 300	50 400	51 100	50 800	49 800	49 800
a. Stationary Combustion Sources	**19 300**	**21 800**	**21 600**	**21 700**	**21 300**	**21 400**	**19 800**	**20 500**
Public Electricity and Heat Production	807	1 340	781	510	596	578	504	656
Petroleum Refining Industries	1 200	500	570	610	520	570	590	670
Mining and Upstream Oil and Gas Production	2 670	5 780	8 330	8 820	8 750	8 800	7 530	7 550
Manufacturing Industries	6 520	6 210	4 030	4 120	4 120	4 410	4 410	4 800
Construction	307	114	103	100	68	66	71	96
Commercial and Institutional	2 850	3 060	2 870	2 850	2 620	2 550	2 300	2 330
Residential	4 590	4 680	4 640	4 320	4 270	4 090	3 950	3 990
Agriculture and Forestry	323	75	281	388	385	382	413	409
b. Transport[1]	**18 600**	**24 600**	**22 300**	**23 600**	**24 300**	**24 200**	**25 100**	**24 900**
Domestic Aviation	1 300	1 600	1 100	1 300	1 300	1 300	1 300	1 300
Road Transportation	9 410	15 400	14 500	15 200	16 200	16 200	16 700	17 300
Light-Duty Gasoline Vehicles	3 790	4 410	3 550	3 580	3 650	3 640	3 760	4 030
Light-Duty Gasoline Trucks	2 050	3 870	3 850	4 000	4 170	4 340	4 630	5 160
Heavy-Duty Gasoline Vehicles	924	1 840	1 690	1 740	1 780	1 730	1 720	1 920
Motorcycles	14	21	22	23	24	25	26	29
Light-Duty Diesel Vehicles	44	93	101	114	128	121	131	119
Light-Duty Diesel Trucks	17	45	55	60	76	86	107	111
Heavy-Duty Diesel Vehicles	1 940	4 900	5 190	5 700	6 390	6 270	6 300	5 930
Propane and Natural Gas Vehicles	620	210	32	23	14	7	6	6
Railways	1 400	430	670	690	530	660	660	x
Domestic Navigation	960	2 400	2 200	2 600	2 100	1 900	1 800	x
Other Transportation	5 500	4 800	3 800	3 700	4 100	4 100	4 600	4 500
Off-Road Agriculture & Forestry	710	870	580	570	620	590	660	540
Off-Road Commercial & Institutional	240	330	320	330	360	350	360	290
Off-Road Manufacturing, Mining & Construction	1 300	1 500	1 300	1 300	1 300	1 300	1 400	1 400
Off-Road Residential	35	180	160	160	150	160	170	140
Off-Road Other Transportation	2 300	980	600	610	610	670	730	750
Pipeline Transport	863	998	813	806	1 020	1 040	1 300	1 440
c. Fugitive Sources	**4 100**	**5 400**	**5 400**	**5 100**	**5 400**	**5 200**	**4 900**	**4 400**
Coal Mining	800	1 000	900	1 000	1 000	1 000	900	1 000
Oil and Natural Gas	3 300	4 400	4 500	4 100	4 300	4 100	4 100	3 500
d. CO_2 Transport and Storage	-	-	-	-	-	-	-	-
INDUSTRIAL PROCESSES AND PRODUCT USE	3 310	4 600	3 830	3 900	3 860	3 770	3 640	4 200
a. Mineral Products	**880**	**1 500**	**1 200**	**1 300**	**1 200**	**1 200**	**1 200**	**1 200**
Cement Production	650	1 300	990	1 100	980	970	1 000	1 000
Lime Production	169	188	177	180	169	182	170	165
Mineral Products Use	58	51	23	22	20	21	23	21
b. Chemical Industry[2]	-	-	-	-	-	-	-	-
Adipic Acid Production	-	-	-	-	-	-	-	-
c. Metal Production	**1 670**	**1 220**	**848**	**886**	**759**	**547**	**477**	**867**
Iron and Steel Production	-	-	-	-	-	-	-	-
Aluminum Production	1 670	1 220	847	885	758	546	476	867
SF_6 Used in Magnesium Smelters and Casters	-	1	0.52	0.53	0.54	0.58	0.56	0.57
d. Production and Consumption of Halocarbons, SF_6 and NF_3[3]	-	**610**	**1 100**	**1 200**	**1 200**	**1 300**	**1 400**	**1 600**
e. Non-Energy Products from Fuels and Solvent Use	**x**	**x**	**x**	**x**	**x**	**x**	**x**	**x**
f. Other Product Manufacture and Use	**77**	**95**	**59**	**83**	**77**	**60**	**57**	**57**
AGRICULTURE	2 200	2 700	2 100	2 100	2 200	2 200	2 200	2 300
a. Enteric Fermentation	**1 400**	**1 800**	**1 300**	**1 300**	**1 300**	**1 300**	**1 300**	**1 400**
b. Manure Management	**320**	**440**	**380**	**380**	**380**	**390**	**390**	**400**
c. Agricultural Soils	**480**	**470**	**450**	**420**	**500**	**440**	**450**	**470**
Direct Sources	390	360	350	330	400	340	360	370
Indirect Sources	100	100	90	90	100	90	90	100
d. Field Burning of Agricultural Residues	-	-	-	-	-	-	-	-
e. Liming, Urea Application and Other Carbon-containing Fertilizers	**30**	**20**	**30**	**20**	**30**	**20**	**20**	**30**
WASTE	3 600	4 200	4 100	3 900	3 800	3 700	3 700	3 700
a. Solid Waste Disposal	**3 400**	**4 000**	**3 800**	**3 600**	**3 500**	**3 400**	**3 500**	**3 400**
b. Biological Treatment of Solid Waste	-	**50**	**70**	**80**	**80**	**90**	**90**	**90**
c. Wastewater Treatment and Discharge	**100**	**140**	**150**	**150**	**150**	**150**	**150**	**150**
d. Incineration and Open Burning of Waste	**81**	**79**	**65**	**63**	**61**	**59**	**57**	**54**

Notes:

1. Emissions from ethanol and biodiesel are included in the Transport categories using gasoline and diesel respectively.
2. Emissions from Ammonia Production, Nitric Acid Production and Petrochemical Production and Carbon Black categories are included in Non-Energy Products from Fuels and Solvent Use as CO_2 eq values within provincial/territorial tables.
3. HFC and PFC consumption began in 1995; HFC emissions occurring as a by-product of HCFC production (HCFC-22 exclusively) only occurred in Canada from 1990–1992 and PFC emissions prior to 1995 are the result of by-product CF_4 emissions from the use of NF_3.

\- Indicates no emissions

0.00 Indicates emissions truncated due to rounding

x Indicates data has been suppressed to respect confidentiality

Estimates for the latest year (2016) are based on preliminary energy data; these data, though the best available information at the time of publication, are subject to revision in the next submission year.

Provincial/Territorial GHG emissions allocated to Canadian economic sectors are provided in Annex 12 of this report

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Table A11–21 2016 GHG Emission Summary for British Columbia

Greenhouse Gas Categories	Greenhouse Gases									
	CO_2	CH_4	CH_4	N_2O	N_2O	HFCs[4]	PFCs[4]	SF_6	NF_3	TOTAL
Global Warming Potential			25		298			22 800	17 200	
Unit	kt	kt	kt CO_2 eq	kt	kt CO_2 eq	kt CO_2 eq	kt CO_2 eq	kt CO_2 eq	kt CO_2 eq	kt CO_2 eq
TOTAL	47 800	350	8 800	6	1 700	1 600	170	14	-	60 100
ENERGY	45 300	150	3 600	3	800	-	-	-	-	49 800
a. Stationary Combustion Sources	**19 500**	**30**	**700**	**1**	**300**	**-**	**-**	**-**	**-**	**20 500**
Public Electricity and Heat Production	640	0.19	5	0.05	13	-	-	-	-	656
Petroleum Refining Industries	670	0.01	0.30	0.01	3	-	-	-	-	670
Mining and Upstream Oil and Gas Production	7 100	16	400	0.20	50	-	-	-	-	7 550
Manufacturing Industries	4 630	0.68	17	0.50	150	-	-	-	-	4 800
Construction	95	0.00	0.05	0.00	0.60	-	-	-	-	96
Commercial and Institutional	2 310	0.05	1	0.05	10	-	-	-	-	2 330
Residential	3 680	10	300	0.20	60	-	-	-	-	3 990
Agriculture and Forestry	406	0.01	0.19	0.01	2	-	-	-	-	409
b. Transport[1]	**24 200**	**6**	**140**	**2**	**550**	**-**	**-**	**-**	**-**	**24 900**
Domestic Aviation	1 320	0.06	1	0.04	10	-	-	-	-	1 300
Road Transportation	16 900	1	30	1	400	-	-	-	-	17 300
Light-Duty Gasoline Vehicles	3 920	0.31	8	0.32	95	-	-	-	-	4 030
Light-Duty Gasoline Trucks	4 990	0.40	10	0.53	160	-	-	-	-	5 160
Heavy-Duty Gasoline Vehicles	1 870	0.08	2	0.16	47	-	-	-	-	1 920
Motorcycles	28	0.01	0.27	0.00	0.16	-	-	-	-	29
Light-Duty Diesel Vehicles	116	0.00	0.06	0.01	3	-	-	-	-	119
Light-Duty Diesel Trucks	108	0.00	0.07	0.01	3	-	-	-	-	111
Heavy-Duty Diesel Vehicles	5 820	0.30	6	0.30	100	-	-	-	-	5 930
Propane and Natural Gas Vehicles	6	0.00	0.07	0.00	0.03	-	-	-	-	6
Railways	x	x	x	x	x	x	x	x	x	x
Domestic Navigation	x	x	x	x	x	x	x	x	x	x
Other Transportation	4 380	4	100	0.10	40	-	-	-	-	4 500
Off-Road Agriculture & Forestry	530	0.05	1	0.02	7	-	-	-	-	540
Off-Road Commercial & Institutional	277	0.40	10	0.01	3	-	-	-	-	290
Off-Road Manufacturing, Mining & Construction	1 340	0.20	6	0.06	20	-	-	-	-	1 400
Off-Road Residential	133	0.30	7	0.00	1	-	-	-	-	140
Off-Road Other Transportation	701	2	50	0.02	5	-	-	-	-	750
Pipeline Transport	1 400	1	34	0.04	10	-	-	-	-	1 440
c. Fugitive Sources	**1 600**	**110**	**2 800**	**0.00**	**1**	**-**	**-**	**-**	**-**	**4 400**
Coal Mining	-	40	1 000	-	-	-	-	-	-	1 000
Oil and Natural Gas	1 600	75	1 900	0.00	1	-	-	-	-	3 500
d. CO_2 Transport and Storage	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
INDUSTRIAL PROCESSES AND PRODUCT USE	2 400	-	-	0.13	40	1 600	170	14	-	4 200
a. Mineral Products	**1 200**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**1 200**
Cement Production	1 000	-	-	-	-	-	-	-	-	1 000
Lime Production	165	-	-	-	-	-	-	-	-	165
Mineral Products Use	21	-	-	-	-	-	-	-	-	21
b. Chemical Industry[2]	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
Adipic Acid Production	-	-	-	-	-	-	-	-	-	-
c. Metal Production	**702**	**-**	**-**	**-**	**-**	**-**	**165**	**0.57**	**-**	**867**
Iron and Steel Production	-	-	-	-	-	-	-	-	-	-
Aluminum Production	702	-	-	-	-	-	165	-	-	867
SF_6 Used in Magnesium Smelters and Casters	-	-	-	-	-	-	-	0.57	-	0.57
d. Production and Consumption of Halocarbons, SF_6 and NF_3[3]	**-**	**-**	**-**	**-**	**-**	**1 600**	**0.18**	**-**	**-**	**1 600**
e. Non-Energy Products from Fuels and Solvent Use	**x**	**x**	**x**	**x**	**x**	**x**	**x**	**x**	**x**	**x**
f. Other Product Manufacture and Use	**4**	**-**	**-**	**0.13**	**40**	**-**	**0.61**	**13**	**-**	**57**
AGRICULTURE	30	63	1 600	2	700	-	-	-	-	2 300
a. Enteric Fermentation	**-**	**56**	**1400**	**-**	**-**	**-**	**-**	**-**	**-**	**1 400**
b. Manure Management	**-**	**7**	**170**	**0.80**	**200**	**-**	**-**	**-**	**-**	**400**
c. Agricultural Soils	**-**	**-**	**-**	**2**	**470**	**-**	**-**	**-**	**-**	**470**
Direct Sources	-	-	-	1	370	-	-	-	-	370
Indirect Sources	-	-	-	0.30	100	-	-	-	-	100
d. Field Burning of Agricultural Residues	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
e. Liming, Urea Application and Other Carbon-containing Fertilizers	**30**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**30**
WASTE	47	140	3 600	0.44	130	-	-	-	-	3 700
a. Solid Waste Disposal	**-**	**140**	**3 400**	**-**	**-**	**-**	**-**	**-**	**-**	**3 400**
b. Biological Treatment of Solid Waste	**-**	**2**	**50**	**0.10**	**40**	**-**	**-**	**-**	**-**	**90**
c. Wastewater Treatment and Discharge	**-**	**3**	**65**	**0.30**	**90**	**-**	**-**	**-**	**-**	**150**
d. Incineration and Open Burning of Waste	**47**	**-**	**-**	**0.02**	**7**	**-**	**-**	**-**	**-**	**54**

Notes:

1. Emissions from ethanol and biodiesel are included in the Transport categories using gasoline and diesel respectively.
2. Emissions from Ammonia Production, Nitric Acid Production and Petrochemical Production and Carbon Black categories are included in Non-Energy Products from Fuels and Solvent Use as CO_2 eq values within provincial/territorial tables.
3. HFC and PFC consumption began in 1995; HFC emissions occurring as a by-product of HCFC production (HCFC-22 exclusively) only occurred in Canada from 1990–1992 and PFC emissions prior to 1995 are the result of by-product CF_4 emissions from the use of NF_3.
4. IPCC's Fourth Assessment Report provides global warming potentials (GWPs) for the various species of HFCs and PFCs. Chapter 1, Table 1-1 of this report provides a list of GWPs used.

\- Indicates no emissions

0.00 Indicates emissions truncated due to rounding

x Indicates data has been suppressed to respect confidentiality

Estimates for the latest year (2016) are based on preliminary energy data; these data, though the best available information at the time of publication, are subject to revision in the next submission year.

Provincial/Territorial GHG emissions allocated to Canadian economic sectors are provided in Annex 12 of this report

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Table A11–22 GHG Emission Summary for Yukon, Selected Years

Greenhouse Gas Categories		1990	2005	2011	2012	2013	2014	2015	2016
		kt CO_2 eq							
TOTAL		**533**	**523**	**660**	**652**	**574**	**447**	**488**	**426**
ENERGY		**528**	**510**	**636**	**626**	**548**	**419**	**459**	**396**
a.	**Stationary Combustion Sources**	**222**	**194**	**153**	**145**	**119**	**68**	**68**	**66**
	Public Electricity and Heat Production	94	23	28	19	18	17	19	20
	Petroleum Refining Industries	-	-	-	-	-	-	-	-
	Mining and Upstream Oil and Gas Production	9	75	18	20	5	4	4	4
	Manufacturing Industries	6	-	15	15	15	14	14	15
	Construction	4	2	2	2	2	1	0.62	1
	Commercial and Institutional	77	41	61	64	57	25	25	22
	Residential	31	45	30	26	23	7	5	5
	Agriculture and Forestry	1	8	-	-	-	-	-	-
b.	**Transport**[1]	**306**	**306**	**472**	**470**	**429**	**351**	**391**	**329**
	Domestic Aviation	34	35	40	47	46	39	35	38
	Road Transportation	217	252	407	401	364	260	277	242
	Light-Duty Gasoline Vehicles	71	34	39	36	31	30	31	29
	Light-Duty Gasoline Trucks	31	49	71	68	63	65	69	69
	Heavy-Duty Gasoline Vehicles	14	43	50	50	46	22	22	21
	Motorcycles	0.26	0.24	0.37	0.36	0.33	0.34	0.37	0.36
	Light-Duty Diesel Vehicles	2	0	1	1	1	4	4	3
	Light-Duty Diesel Trucks	0.28	0.51	0.94	0.87	0.78	4	6	5
	Heavy-Duty Diesel Vehicles	96	121	244	244	222	135	145	114
	Propane and Natural Gas Vehicles	1	3	0.94	0.30	0.18	0.10	0.09	0.25
	Railways	-	x	x	x	x	x	x	-
	Domestic Navigation	-	x	x	x	x	x	16	x
	Other Transportation	55	x	x	x	x	x	x	x
	Off-Road Agriculture & Forestry	0.48	0.19	0.21	0.18	0.15	0.63	0.81	3
	Off-Road Commercial & Institutional	3	2	2	2	2	5	6	2
	Off-Road Manufacturing, Mining & Construction	0.69	9	14	12	10	36	46	34
	Off-Road Residential	1	x	x	x	x	x	x	x
	Off-Road Other Transportation	24	7	7	6	5	8	9	9
	Pipeline Transport	-	x	x	x	x	x	x	x
c.	**Fugitive Sources**	**-**	**10**	**11**	**11**	**0.09**	**0.09**	**0.09**	**0.09**
	Coal Mining	-	-	-	-	-	-	-	-
	Oil and Natural Gas	-	10	11	11	0.09	0.09	0.09	0.09
d.	**CO_2 Transport and Storage**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
INDUSTRIAL PROCESSES AND PRODUCT USE		**2**	**10**	**18**	**20**	**20**	**21**	**22**	**24**
a.	**Mineral Products**	**0.13**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
	Cement Production	-	-	-	-	-	-	-	-
	Lime Production	-	-	-	-	-	-	-	-
	Mineral Products Use	0.13	-	-	-	-	-	-	-
b.	**Chemical Industry**[2]	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
	Adipic Acid Production	-	-	-	-	-	-	-	-
c.	**Metal Production**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
	Iron and Steel Production	-	-	-	-	-	-	-	-
	Aluminum Production	-	-	-	-	-	-	-	-
	SF_6 Used in Magnesium Smelters and Casters	-	-	-	-	-	-	-	-
d.	**Production and Consumption of Halocarbons, SF_6 and NF_3**[3]	**-**	**9**	**16**	**18**	**19**	**20**	**22**	**23**
e.	**Non-Energy Products from Fuels and Solvent Use**	**x**	**x**	**x**	**x**	**x**	**x**	**x**	**x**
f.	**Other Product Manufacture and Use**	**0.17**	**0.36**	**0.28**	**0.32**	**0.33**	**0.3**	**0.33**	**0.49**
AGRICULTURE		**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
a.	**Enteric Fermentation**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
b.	**Manure Management**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
c.	**Agricultural Soils**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
	Direct Sources	-	-	-	-	-	-	-	-
	Indirect Sources	-	-	-	-	-	-	-	-
d.	**Field Burning of Agricultural Residues**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
e.	**Liming, Urea Application and Other Carbon-containing Fertilizers**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
WASTE		**2**	**4**	**6**	**6**	**6**	**7**	**7**	**7**
a.	**Solid Waste Disposal**	**0.94**	**2**	**4**	**4**	**4**	**4**	**4**	**4**
b.	**Biological Treatment of Solid Waste**	**-**	**0.20**	**0.40**	**0.40**	**0.40**	**0.40**	**0.50**	**0.40**
c.	**Wastewater Treatment and Discharge**	**1**	**2**	**2**	**2**	**2**	**2**	**2**	**2**
d.	**Incineration and Open Burning of Waste**	**-**	**0.02**	**-**	**-**	**-**	**-**	**-**	**-**

Notes:

1. Emissions from ethanol and biodiesel are included in the Transport categories using gasoline and diesel respectively.
2. Emissions from Ammonia Production, Nitric Acid Production and Petrochemical Production and Carbon Black categories are included in Non-Energy Products from Fuels and Solvent Use as CO_2 eq values within provincial/territorial tables.
3. HFC and PFC consumption began in 1995; HFC emissions occurring as a by-product of HCFC production (HCFC-22 exclusively) only occurred in Canada from 1990–1992 and PFC emissions prior to 1995 are the result of by-product CF_4 emissions from the use of NF_3.

\- Indicates no emissions

0.00 Indicates emissions truncated due to rounding

x Indicates data has been suppressed to respect confidentiality

Estimates for the latest year (2016) are based on preliminary energy data; these data, though the best available information at the time of publication, are subject to revision in the next submission year.

Provincial/Territorial GHG emissions allocated to Canadian economic sectors are provided in Annex 12 of this report

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Table A11–23 2016 GHG Emission Summary for Yukon

Greenhouse Gas Categories	Greenhouse Gases									
	CO_2	CH_4	CH_4	N_2O	N_2O	HFCs[4]	PFCs[4]	SF_6	NF_3	TOTAL
Global Warming Potential			25		298			22 800	17 200	
Unit	kt	kt	kt CO_2 eq	kt	kt CO_2 eq	kt CO_2 eq	kt CO_2 eq	kt CO_2 eq	kt CO_2 eq	kt CO_2 eq
TOTAL	**388**	**0.31**	**8**	**0.02**	**7**	**23**	**0.00**	**0.11**	**-**	**426**
ENERGY	**388**	**0.07**	**2**	**0.02**	**6**	**-**	**-**	**-**	**-**	**396**
a. Stationary Combustion Sources	**64**	**0.03**	**0.60**	**0.00**	**1**	**-**	**-**	**-**	**-**	**66**
Public Electricity and Heat Production	19	0.00	0.03	0.00	0.79	-	-	-	-	20
Petroleum Refining Industries	-	-	-	-	-	-	-	-	-	-
Mining and Upstream Oil and Gas Production	4	0.00	0.00	0.00	0.08	-	-	-	-	4
Manufacturing Industries	15	0.00	0.00	0.00	0.05	-	-	-	-	15
Construction	0.99	0.00	0.00	0.00	0.01	-	-	-	-	1.00
Commercial and Institutional	21	0.00	0.01	0.00	0.20	-	-	-	-	22
Residential	4	0.02	0.60	0.00	0.20	-	-	-	-	5
Agriculture and Forestry	-	-	-	-	-	-	-	-	-	-
b. Transport[1]	**324**	**0.04**	**0.96**	**0.02**	**5**	**-**	**-**	**-**	**-**	**329**
Domestic Aviation	38	0.00	0.08	0.00	0.40	-	-	-	-	38
Road Transportation	238	0.01	0.40	0.01	4	-	-	-	-	242
Light-Duty Gasoline Vehicles	29	0.00	0.07	0.00	0.35	-	-	-	-	29
Light-Duty Gasoline Trucks	68	0.01	0.15	0.00	0.73	-	-	-	-	69
Heavy-Duty Gasoline Vehicles	20	0.00	0.02	0.00	0.51	-	-	-	-	21
Motorcycles	0.36	0.00	0.00	0.00	0.00	-	-	-	-	0.36
Light-Duty Diesel Vehicles	3	0.00	0.00	0.00	0.08	-	-	-	-	3
Light-Duty Diesel Trucks	5	0.00	0.00	0.00	0.10	-	-	-	-	5
Heavy-Duty Diesel Vehicles	112	0.01	0.10	0.01	2	-	-	-	-	114
Propane and Natural Gas Vehicles	0.25	0.00	0.00	0.00	0.00	-	-	-	-	0.25
Railways	-	-	-	-	-	-	-	-	-	-
Domestic Navigation	x	x	x	x	x	x	x	x	x	x
Other Transportation	x	x	x	x	x	x	x	x	x	x
Off-Road Agriculture & Forestry	3	0.00	0.00	0.00	0.03	-	-	-	-	3
Off-Road Commercial & Institutional	2	0.00	0.02	0.00	0.02	-	-	-	-	2
Off-Road Manufacturing, Mining & Construction	34	0.00	0.05	0.00	0.40	-	-	-	-	34
Off-Road Residential	x	x	x	x	x	x	x	x	x	x
Off-Road Other Transportation	8	0.02	0.40	0.00	0.07	-	-	-	-	9
Pipeline Transport	x	x	x	x	x	x	x	x	x	x
c. Fugitive Sources	**0.00**	**0.00**	**0.09**	**-**	**-**	**-**	**-**	**-**	**-**	**0.09**
Coal Mining	-	-	-	-	-	-	-	-	-	-
Oil and Natural Gas	0.00	0.00	0.09	-	-	-	-	-	-	0.09
d. CO_2 Transport and Storage	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
INDUSTRIAL PROCESSES AND PRODUCT USE	**0.06**	**-**	**-**	**0.00**	**0.31**	**23**	**0.00**	**0.11**	**-**	**24**
a. Mineral Products	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
Cement Production	-	-	-	-	-	-	-	-	-	-
Lime Production	-	-	-	-	-	-	-	-	-	-
Mineral Products Use	-	-	-	-	-	-	-	-	-	-
b. Chemical Industry[2]	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
Adipic Acid Production	-	-	-	-	-	-	-	-	-	-
c. Metal Production	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
Iron and Steel Production	-	-	-	-	-	-	-	-	-	-
Aluminum Production	-	-	-	-	-	-	-	-	-	-
SF_6 Used in Magnesium Smelters and Casters	-	-	-	-	-	-	-	-	-	-
d. Production and Consumption of Halocarbons, SF_6 and NF_3[3]	**-**	**-**	**-**	**-**	**-**	**23**	**0.00**	**-**	**-**	**23**
e. Non-Energy Products from Fuels and Solvent Use	**x**	**x**	**x**	**x**	**x**	**x**	**x**	**x**	**x**	**x**
f. Other Product Manufacture and Use	**0.06**	**-**	**-**	**0.00**	**0.31**	**-**	**-**	**0.11**	**-**	**0.49**
AGRICULTURE	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
a. Enteric Fermentation	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
b. Manure Management	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
c. Agricultural Soils	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
Direct Sources	-	-	-	-	-	-	-	-	-	-
Indirect Sources	-	-	-	-	-	-	-	-	-	-
d. Field Burning of Agricultural Residues	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
e. Liming, Urea Application and Other Carbon-containing Fertilizers	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
WASTE	**-**	**0.24**	**6**	**0.00**	**0.89**	**-**	**-**	**-**	**-**	**7**
a. Solid Waste Disposal	**-**	**0.18**	**4**	**-**	**-**	**-**	**-**	**-**	**-**	**4**
b. Biological Treatment of Solid Waste	**-**	**0.01**	**0.30**	**0.00**	**0.20**	**-**	**-**	**-**	**-**	**0.40**
c. Wastewater Treatment and Discharge	**-**	**0.05**	**1**	**0.00**	**0.70**	**-**	**-**	**-**	**-**	**2**
d. Incineration and Open Burning of Waste	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**

Notes:

1. Emissions from ethanol and biodiesel are included in the Transport categories using gasoline and diesel respectively.
2. Emissions from Ammonia Production, Nitric Acid Production and Petrochemical Production and Carbon Black categories are included in Non-Energy Products from Fuels and Solvent Use as CO_2 eq values within provincial/territorial tables.
3. HFC and PFC consumption began in 1995; HFC emissions occurring as a by-product of HCFC production (HCFC-22 exclusively) only occurred in Canada from 1990–1992 and PFC emissions prior to 1995 are the result of by-product CF_4 emissions from the use of NF_3.
4. IPCC's Fourth Assessment Report provides global warming potentials (GWPs) for the various species of HFCs and PFCs. Chapter 1, Table 1-1 of this report provides a list of GWPs used.

\- Indicates no emissions

0.00 Indicates emissions truncated due to rounding

x Indicates data has been suppressed to respect confidentiality

Estimates for the latest year (2016) are based on preliminary energy data; these data, though the best available information at the time of publication, are subject to revision in the next submission year.

Provincial/Territorial GHG emissions allocated to Canadian economic sectors are provided in Annex 12 of this report

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Table A11–24 GHG Emission Summary for Northwest Territories, Selected Years

Greenhouse Gas Categories		1990	2005	2011	2012	2013	2014	2015	2016
		kt CO_2 eq							
TOTAL		**1 220**	**1 560**	**1 410**	**1 530**	**1 370**	**1 500**	**1 720**	**1 610**
ENERGY		**1 200**	**1 530**	**1 380**	**1 490**	**1 330**	**1 460**	**1 680**	**1 560**
a.	**Stationary Combustion Sources**	**604**	**724**	**635**	**756**	**637**	**651**	**678**	**629**
	Public Electricity and Heat Production	91	99	65	65	67	86	123	71
	Petroleum Refining Industries	-	-	-	-	-	-	-	-
	Mining and Upstream Oil and Gas Production	234	380	375	512	387	4	360	396
	Manufacturing Industries	-	x	x	x	x	x	x	x
	Construction	0.83	x	x	x	x	x	x	x
	Commercial and Institutional	192	141	96	88	91	86	92	88
	Residential	85	102	97	88	92	107	102	73
	Agriculture and Forestry	0	2	-	-	-	-	-	-
b.	**Transport**[1]	**580**	**790**	**729**	**715**	**674**	**792**	**987**	**921**
	Domestic Aviation	130	170	120	140	130	110	110	110
	Road Transportation	274	506	502	488	456	324	388	405
	Light-Duty Gasoline Vehicles	39	9	11	12	9	9	11	12
	Light-Duty Gasoline Trucks	25	33	48	53	41	39	52	54
	Heavy-Duty Gasoline Vehicles	15	19	29	33	26	14	18	18
	Motorcycles	0.15	0.11	0.22	0.28	0.20	0.19	0.27	0.29
	Light-Duty Diesel Vehicles	3	1	1	1	1	4	5	6
	Light-Duty Diesel Trucks	0.74	2	1	1	0.92	5	7	8
	Heavy-Duty Diesel Vehicles	191	441	411	389	378	252	295	308
	Propane and Natural Gas Vehicles	0.80	-	-	-	-	-	-	-
	Railways	3	6	10	10	11	18	16	13
	Domestic Navigation	4	-	0.27	-	1	3	1	4
	Other Transportation	170	110	96	80	75	330	470	390
	Off-Road Agriculture & Forestry	0.65	0.44	0.29	0.24	0.22	1	2	1
	Off-Road Commercial & Institutional	11	7	6	5	5	17	24	4
	Off-Road Manufacturing, Mining & Construction	130	87	77	62	59	290	410	350
	Off-Road Residential	2	2	2	2	x	4	5	5
	Off-Road Other Transportation	25	9	9	9	7	20	27	29
	Pipeline Transport	5	3	2	3	x	1	0.79	0.28
c.	**Fugitive Sources**	**14**	**18**	**14**	**24**	**20**	**19**	**14**	**14**
	Coal Mining	-	-	-	-	-	-	-	-
	Oil and Natural Gas	14	18	14	24	20	19	14	14
d.	**CO_2 Transport and Storage**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
INDUSTRIAL PROCESSES AND PRODUCT USE		**10**	**22**	**27**	**29**	**30**	**33**	**34**	**36**
a.	**Mineral Products**	**0.01**	**0.16**	**-**	**-**	**-**	**-**	**-**	**-**
	Cement Production	-	-	-	-	-	-	-	-
	Lime Production	-	-	-	-	-	-	-	-
	Mineral Products Use	0.01	0.16	-	-	-	-	-	-
b.	**Chemical Industry**[2]	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
	Adipic Acid Production	-	-	-	-	-	-	-	-
c.	**Metal Production**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
	Iron and Steel Production	-	-	-	-	-	-	-	-
	Aluminum Production	-	-	-	-	-	-	-	-
	SF_6 Used in Magnesium Smelters and Casters	-	-	-	-	-	-	-	-
d.	**Production and Consumption of Halocarbons, SF_6 and NF_3**[3]	**6**	**14**	**23**	**25**	**25**	**27**	**29**	**32**
e.	**Non-Energy Products from Fuels and Solvent Use**	**x**	**x**	**x**	**x**	**x**	**x**	**x**	**x**
f.	**Other Product Manufacture and Use**	**0.53**	**0.49**	**0.37**	**0.42**	**0.42**	**0.39**	**0.45**	**0.54**
AGRICULTURE		**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
a.	**Enteric Fermentation**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
b.	**Manure Management**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
c.	**Agricultural Soils**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
	Direct Sources	-	-	-	-	-	-	-	-
	Indirect Sources	-	-	-	-	-	-	-	-
d.	**Field Burning of Agricultural Residues**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
e.	**Liming, Urea Application and Other Carbon-containing Fertilizers**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
WASTE		**8**	**9**	**9**	**10**	**10**	**10**	**10**	**10**
a.	**Solid Waste Disposal**	**5**	**6**	**6**	**6**	**6**	**7**	**7**	**7**
b.	**Biological Treatment of Solid Waste**	**-**	**-**	**0.06**	**0.03**	**0.02**	**0.03**	**0.06**	**0.08**
c.	**Wastewater Treatment and Discharge**	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**3**
d.	**Incineration and Open Burning of Waste**	**0.19**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**

Notes:

1. Emissions from ethanol and biodiesel are included in the Transport categories using gasoline and diesel respectively.
2. Emissions from Ammonia Production, Nitric Acid Production and Petrochemical Production and Carbon Black categories are included in Non-Energy Products from Fuels and Solvent Use as CO_2 eq values within provincial/territorial tables.
3. HFC and PFC consumption began in 1995; HFC emissions occurring as a by-product of HCFC production (HCFC-22 exclusively) only occurred in Canada from 1990–1992 and PFC emissions prior to 1995 are the result of by-product CF_4 emissions from the use of NF_3.

- Indicates no emissions

0.00 Indicates emissions truncated due to rounding

x Indicates data has been suppressed to respect confidentiality

Estimates for the latest year (2016) are based on preliminary energy data; these data, though the best available information at the time of publication, are subject to revision in the next submission year.

Provincial/Territorial GHG emissions allocated to Canadian economic sectors are provided in Annex 12 of this report

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Table A11–25 2016 GHG Emission Summary for Northwest Territories

Greenhouse Gas Categories	Greenhouse Gases									
	CO_2	CH_4	CH_4	N_2O	N_2O	HFCs[4]	PFCs[4]	SF_6	NF_3	TOTAL
Global Warming Potential			25		298			22 800	17 200	
Unit	kt	kt	kt CO_2 eq	kt	kt CO_2 eq	kt CO_2 eq	kt CO_2 eq	kt CO_2 eq	kt CO_2 eq	kt CO_2 eq
TOTAL	**1 530**	**0.74**	**18**	**0.10**	**29**	**32**	**0.00**	**-**	**-**	**1 610**
ENERGY	**1 530**	**0.36**	**9**	**0.09**	**30**	**-**	**-**	**-**	**-**	**1 560**
a. Stationary Combustion Sources	**614**	**0.06**	**1**	**0.05**	**10**	**-**	**-**	**-**	**-**	**629**
Public Electricity and Heat Production	68	0.01	0.12	0.01	3	-	-	-	-	71
Petroleum Refining Industries	-	-	-	-	-	-	-	-	-	-
Mining and Upstream Oil and Gas Production	385	0.03	0.62	0.03	10	-	-	-	-	396
Manufacturing Industries	x	x	x	x	x	x	x	x	x	x
Construction	x	x	x	x	x	x	x	x	x	x
Commercial and Institutional	87	0.00	0.04	0.00	0.60	-	-	-	-	88
Residential	72	0.02	0.60	0.00	0.30	-	-	-	-	73
Agriculture and Forestry	-	-	-	-	-	-	-	-	-	-
b. Transport[1]	**906**	**0.06**	**2**	**0.05**	**14**	**-**	**-**	**-**	**-**	**921**
Domestic Aviation	107	0.01	0.20	0.00	1	-	-	-	-	110
Road Transportation	398	0.02	0.50	0.02	7	-	-	-	-	405
Light-Duty Gasoline Vehicles	11	0.00	0.03	0.00	0.12	-	-	-	-	12
Light-Duty Gasoline Trucks	54	0.00	0.11	0.00	0.55	-	-	-	-	54
Heavy-Duty Gasoline Vehicles	18	0.00	0.02	0.00	0.44	-	-	-	-	18
Motorcycles	0.29	0.00	0.00	0.00	0.00	-	-	-	-	0.29
Light-Duty Diesel Vehicles	6	0.00	0.00	0.00	0.10	-	-	-	-	6
Light-Duty Diesel Trucks	7	0.00	0.01	0.00	0.20	-	-	-	-	8
Heavy-Duty Diesel Vehicles	303	0.01	0.30	0.02	5	-	-	-	-	308
Propane and Natural Gas Vehicles	-	-	-	-	-	-	-	-	-	-
Railways	12	0.00	0.02	0.01	1	-	-	-	-	13
Domestic Navigation	4	0.00	0.01	0.00	0.03	-	-	-	-	4
Other Transportation	385	0.03	0.80	0.02	5	-	-	-	-	390
Off-Road Agriculture & Forestry	1	0.00	0.00	0.00	0.02	-	-	-	-	1
Off-Road Commercial & Institutional	4	0.00	0.02	0.00	0.04	-	-	-	-	4
Off-Road Manufacturing, Mining & Construction	346	0.01	0.30	0.01	4	-	-	-	-	350
Off-Road Residential	5	0.00	0.06	0.00	0.05	-	-	-	-	5
Off-Road Other Transportation	29	0.02	0.50	0.00	0.30	-	-	-	-	29
Pipeline Transport	0.27	0.00	0.00	0.00	0.01	-	-	-	-	0.28
c. Fugitive Sources	**8**	**0.24**	**6**	**0.00**	**0.00**	**-**	**-**	**-**	**-**	**14**
Coal Mining	-	-	-	-	-	-	-	-	-	-
Oil and Natural Gas	8	0.24	6	0.00	0.00	-	-	-	-	14
d. CO_2 Transport and Storage	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
INDUSTRIAL PROCESSES AND PRODUCT USE	**4**	**-**	**-**	**0.00**	**0.37**	**32**	**0.00**	**-**	**-**	**36**
a. Mineral Products	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
Cement Production	-	-	-	-	-	-	-	-	-	-
Lime Production	-	-	-	-	-	-	-	-	-	-
Mineral Products Use	-	-	-	-	-	-	-	-	-	-
b. Chemical Industry[2]	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
Adipic Acid Production	-	-	-	-	-	-	-	-	-	-
c. Metal Production	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
Iron and Steel Production	-	-	-	-	-	-	-	-	-	-
Aluminum Production	-	-	-	-	-	-	-	-	-	-
SF_6 Used in Magnesium Smelters and Casters	-	-	-	-	-	-	-	-	-	-
d. Production and Consumption of Halocarbons, SF_6 and NF_3[3]	**-**	**-**	**-**	**-**	**-**	**32**	**0.00**	**-**	**-**	**32**
e. Non-Energy Products from Fuels and Solvent Use	**x**	**x**	**x**	**x**	**x**	**x**	**x**	**x**	**x**	**x**
f. Other Product Manufacture and Use	**0.20**	**-**	**-**	**0.00**	**0.37**	**-**	**-**	**-**	**-**	**0.54**
AGRICULTURE	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
a. Enteric Fermentation	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
b. Manure Management	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
c. Agricultural Soils	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
Direct Sources	-	-	-	-	-	-	-	-	-	-
Indirect Sources	-	-	-	-	-	-	-	-	-	-
d. Field Burning of Agricultural Residues	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
e. Liming, Urea Application and Other Carbon-containing Fertilizers	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
WASTE	**0.00**	**0.38**	**10**	**0.00**	**0.86**	**-**	**-**	**-**	**-**	**10**
a. Solid Waste Disposal	**-**	**0.27**	**7**	**-**	**-**	**-**	**-**	**-**	**-**	**7**
b. Biological Treatment of Solid Waste	**-**	**0.00**	**0.05**	**0.00**	**0.03**	**-**	**-**	**-**	**-**	**0.08**
c. Wastewater Treatment and Discharge	**-**	**0.10**	**3**	**0.00**	**0.80**	**-**	**-**	**-**	**-**	**3**
d. Incineration and Open Burning of Waste	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**-**	**-**	**-**	**-**	**0.00**

Notes:

1. Emissions from ethanol and biodiesel are included in the Transport categories using gasoline and diesel respectively.
2. Emissions from Ammonia Production, Nitric Acid Production and Petrochemical Production and Carbon Black categories are included in Non-Energy Products from Fuels and Solvent Use as CO_2 eq values within provincial/territorial tables.
3. HFC and PFC consumption began in 1995; HFC emissions occurring as a by-product of HCFC production (HCFC-22 exclusively) only occurred in Canada from 1990–1992 and PFC emissions prior to 1995 are the result of by-product CF_4 emissions from the use of NF_3.
4. IPCC's Fourth Assessment Report provides global warming potentials (GWPs) for the various species of HFCs and PFCs. Chapter 1, Table 1-1 of this report provides a list of GWPs used.

\- Indicates no emissions

0.00 Indicates emissions truncated due to rounding

x Indicates data has been suppressed to respect confidentiality

Estimates for the latest year (2016) are based on preliminary energy data; these data, though the best available information at the time of publication, are subject to revision in the next submission year.

Provincial/Territorial GHG emissions allocated to Canadian economic sectors are provided in Annex 12 of this report

Table A11–26 GHG Emission Summary for Nunavut, Selected Years

Greenhouse Gas Categories	1990	2005	2011	2012	2013	2014	2015	2016
	kt CO_2 eq							
TOTAL	**262**	**443**	**509**	**550**	**694**	**688**	**612**	**700**
ENERGY	**254**	**428**	**487**	**527**	**669**	**662**	**583**	**670**
a. Stationary Combustion Sources	**108**	**133**	**76**	**76**	**72**	**123**	**118**	**129**
Public Electricity and Heat Production	18	x	x	x	x	x	x	129
Petroleum Refining Industries	-	-	-	-	-	-	-	-
Mining and Upstream Oil and Gas Production	90	0.26	-	-	-	-	-	-
Manufacturing Industries	-	x	x	x	-	-	-	-
Construction	-	x	x	x	x	x	x	x
Commercial and Institutional	-	8	-	-	-	-	-	-
Residential	-	-	-	-	-	-	-	-
Agriculture and Forestry	-	-	-	-	-	-	-	-
b. Transport[1]	**145**	**296**	**411**	**450**	**597**	**539**	**465**	**540**
Domestic Aviation	110	140	130	140	140	130	120	110
Road Transportation	17	102	205	235	255	113	89	128
Light-Duty Gasoline Vehicles	2	6	8	9	9	9	9	11
Light-Duty Gasoline Trucks	4	8	15	17	18	20	20	26
Heavy-Duty Gasoline Vehicles	2	8	10	12	12	6	6	8
Motorcycles	0.01	0.02	0.04	0.05	0.06	0.06	0.06	0.08
Light-Duty Diesel Vehicles	0.07	0.33	0.78	0.85	0.91	2	2	2
Light-Duty Diesel Trucks	-	0.35	0.72	0.74	0.79	2	2	4
Heavy-Duty Diesel Vehicles	8	79	171	196	214	73	50	77
Propane and Natural Gas Vehicles	0.86	-	-	-	-	-	-	-
Railways	-	x	x	x	x	x	x	x
Domestic Navigation	-	-	-	-	120	130	120	120
Other Transportation	17	x	x	x	x	x	x	x
Off-Road Agriculture & Forestry	-	-	-	-	-	-	-	-
Off-Road Commercial & Institutional	2	6	7	7	8	16	13	3
Off-Road Manufacturing, Mining & Construction	10	37	54	52	53	120	97	140
Off-Road Residential	0.59	x	x	x	x	x	x	x
Off-Road Other Transportation	5	9	14	15	15	25	22	31
Pipeline Transport	-	x	x	x	x	-	-	-
c. Fugitive Sources	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
Coal Mining	-	-	-	-	-	-	-	-
Oil and Natural Gas	-	-	-	-	-	-	-	-
d. CO_2 Transport and Storage	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
INDUSTRIAL PROCESSES AND PRODUCT USE	**3**	**8**	**15**	**16**	**17**	**18**	**20**	**22**
a. Mineral Products	**0.01**	**0.16**	**-**	**-**	**-**	**-**	**-**	**-**
Cement Production	-	-	-	-	-	-	-	-
Lime Production	-	-	-	-	-	-	-	-
Mineral Products Use	0.01	0.16	-	-	-	-	-	-
b. Chemical Industry[2]	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
Adipic Acid Production	-	-	-	-	-	-	-	-
c. Metal Production	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
Iron and Steel Production	-	-	-	-	-	-	-	-
Aluminum Production	-	-	-	-	-	-	-	-
SF_6 Used in Magnesium Smelters and Casters	-	-	-	-	-	-	-	-
d. Production and Consumption of Halocarbons, SF_6 and NF_3[3]	**3**	**8**	**14**	**16**	**17**	**18**	**20**	**22**
e. Non-Energy Products from Fuels and Solvent Use	**x**	**x**	**x**	**x**	**x**	**x**	**x**	**x**
f. Other Product Manufacture and Use	**0.35**	**0.34**	**0.26**	**0.30**	**0.32**	**0.28**	**0.28**	**0.35**
AGRICULTURE	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
a. Enteric Fermentation	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
b. Manure Management	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
c. Agricultural Soils	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
Direct Sources	-	-	-	-	-	-	-	-
Indirect Sources	-	-	-	-	-	-	-	-
d. Field Burning of Agricultural Residues	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
e. Liming, Urea Application and Other Carbon-containing Fertilizers	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
WASTE	**5**	**7**	**8**	**8**	**8**	**8**	**9**	**9**
a. Solid Waste Disposal	**3**	**4**	**5**	**5**	**5**	**5**	**6**	**6**
b. Biological Treatment of Solid Waste	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
c. Wastewater Treatment and Discharge	**2**	**2**	**3**	**3**	**3**	**3**	**3**	**3**
d. Incineration and Open Burning of Waste	**-**	**0.06**	**0.07**	**0.07**	**0.08**	**0.08**	**0.08**	**0.08**

Notes:

1. Emissions from ethanol and biodiesel are included in the Transport categories using gasoline and diesel respectively.
2. Emissions from Ammonia Production, Nitric Acid Production and Petrochemical Production and Carbon Black categories are included in Non-Energy Products from Fuels and Solvent Use as CO_2 eq values within provincial/territorial tables.
3. HFC and PFC consumption began in 1995; HFC emissions occurring as a by-product of HCFC production (HCFC-22 exclusively) only occurred in Canada from 1990–1992 and PFC emissions prior to 1995 are the result of by-product CF_4 emissions from the use of NF_3.

\- Indicates no emissions

0.00 Indicates emissions truncated due to rounding

x Indicates data has been suppressed to respect confidentiality

Estimates for the latest year (2016) are based on preliminary energy data; these data, though the best available information at the time of publication, are subject to revision in the next submission year.

Provincial/Territorial GHG emissions allocated to Canadian economic sectors are provided in Annex 12 of this report

Table A11–27 **2016 GHG Emission Summary for Nunavut**

Greenhouse Gas Categories	Greenhouse Gases									
	CO_2	CH_4	CH_4	N_2O	N_2O	HFCs[4]	PFCs[4]	SF_6	NF_3	TOTAL
Global Warming Potential			25		298			22 800	17 200	
Unit	kt	kt	kt CO_2 eq	kt	kt CO_2 eq	kt CO_2 eq	kt CO_2 eq	kt CO_2 eq	kt CO_2 eq	kt CO_2 eq
TOTAL	**656**	**0.39**	**10**	**0.04**	**12**	**22**	**0.00**	**-**	**-**	**700**
ENERGY	**656**	**0.08**	**2**	**0.04**	**10**	**-**	**-**	**-**	**-**	**670**
a. Stationary Combustion Sources	**124**	**0.01**	**0.20**	**0.02**	**5**	**-**	**-**	**-**	**-**	**129**
Public Electricity and Heat Production	120	0.01	0.15	0.02	6	-	-	-	-	129
Petroleum Refining Industries	-	-	-	-	-	-	-	-	-	-
Mining and Upstream Oil and Gas Production	-	-	-	-	-	-	-	-	-	-
Manufacturing Industries	-	-	-	-	-	-	-	-	-	-
Construction	x	x	x	x	x	x	x	x	x	x
Commercial and Institutional	-	-	-	-	-	-	-	-	-	-
Residential	-	-	-	-	-	-	-	-	-	-
Agriculture and Forestry	-	-	-	-	-	-	-	-	-	-
b. Transport[1]	**533**	**0.07**	**2**	**0.02**	**6**	**-**	**-**	**-**	**-**	**540**
Domestic Aviation	113	0.00	0.05	0.00	0.90	-	-	-	-	110
Road Transportation	126	0.01	0.20	0.01	2	-	-	-	-	128
Light-Duty Gasoline Vehicles	11	0.00	0.02	0.00	0.12	-	-	-	-	11
Light-Duty Gasoline Trucks	26	0.00	0.05	0.00	0.26	-	-	-	-	26
Heavy-Duty Gasoline Vehicles	7	0.00	0.01	0.00	0.19	-	-	-	-	8
Motorcycles	0.08	0.00	0.00	0.00	0.00	-	-	-	-	0.08
Light-Duty Diesel Vehicles	2	0.00	0.00	0.00	0.06	-	-	-	-	2
Light-Duty Diesel Trucks	4	0.00	0.00	0.00	0.09	-	-	-	-	4
Heavy-Duty Diesel Vehicles	76	0.00	0.08	0.00	1	-	-	-	-	77
Propane and Natural Gas Vehicles	-	-	-	-	-	-	-	-	-	-
Railways	x	x	x	x	x	x	x	x	x	x
Domestic Navigation	116	0.01	0.30	0.00	1	-	-	-	-	120
Other Transportation	x	x	x	x	x	x	x	x	x	x
Off-Road Agriculture & Forestry	-	-	-	-	-	-	-	-	-	-
Off-Road Commercial & Institutional	3	0.00	0.04	0.00	0.03	-	-	-	-	3
Off-Road Manufacturing, Mining & Construction	141	0.01	0.10	0.01	2	-	-	-	-	140
Off-Road Residential	x	x	x	x	x	x	x	x	x	x
Off-Road Other Transportation	30	0.04	1	0.00	0.30	-	-	-	-	31
Pipeline Transport	-	-	-	-	-	-	-	-	-	-
c. Fugitive Sources	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
Coal Mining	-	-	-	-	-	-	-	-	-	-
Oil and Natural Gas	-	-	-	-	-	-	-	-	-	-
d. CO_2 Transport and Storage	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
INDUSTRIAL PROCESSES AND PRODUCT USE	**0.04**	**-**	**-**	**0.00**	**0.31**	**22**	**0.00**	**-**	**-**	**22**
a. Mineral Products	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
Cement Production	-	-	-	-	-	-	-	-	-	-
Lime Production	-	-	-	-	-	-	-	-	-	-
Mineral Products Use	-	-	-	-	-	-	-	-	-	-
b. Chemical Industry[2]	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
Adipic Acid Production	-	-	-	-	-	-	-	-	-	-
c. Metal Production	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
Iron and Steel Production	-	-	-	-	-	-	-	-	-	-
Aluminum Production	-	-	-	-	-	-	-	-	-	-
SF_6 Used in Magnesium Smelters and Casters	-	-	-	-	-	-	-	-	-	-
d. Production and Consumption of Halocarbons, SF_6 and NF_3[3]	**-**	**-**	**-**	**-**	**-**	**22**	**0.00**	**-**	**-**	**22**
e. Non-Energy Products from Fuels and Solvent Use	**x**	**x**	**x**	**x**	**x**	**x**	**x**	**x**	**x**	**x**
f. Other Product Manufacture and Use	**0.04**	**-**	**-**	**0.00**	**0.31**	**-**	**-**	**-**	**-**	**0.35**
AGRICULTURE	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
a. Enteric Fermentation	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
b. Manure Management	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
c. Agricultural Soils	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
Direct Sources	-	-	-	-	-	-	-	-	-	-
Indirect Sources	-	-	-	-	-	-	-	-	-	-
d. Field Burning of Agricultural Residues	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
e. Liming, Urea Application and Other Carbon-containing Fertilizers	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
WASTE	**0.08**	**0.32**	**8**	**0.00**	**0.69**	**-**	**-**	**-**	**-**	**9**
a. Solid Waste Disposal	**-**	**0.23**	**6**	**-**	**-**	**-**	**-**	**-**	**-**	**6**
b. Biological Treatment of Solid Waste	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
c. Wastewater Treatment and Discharge	**-**	**0.09**	**2**	**0.00**	**0.70**	**-**	**-**	**-**	**-**	**3**
d. Incineration and Open Burning of Waste	**0.08**	**0.00**	**0.00**	**0.00**	**0.00**	**-**	**-**	**-**	**-**	**0.08**

Notes:

1. Emissions from ethanol and biodiesel are included in the Transport categories using gasoline and diesel respectively.
2. Emissions from Ammonia Production, Nitric Acid Production and Petrochemical Production and Carbon Black categories are included in Non-Energy Products from Fuels and Solvent Use as CO_2 eq values within provincial/territorial tables.
3. HFC and PFC consumption began in 1995; HFC emissions occurring as a by-product of HCFC production (HCFC-22 exclusively) only occurred in Canada from 1990–1992 and PFC emissions prior to 1995 are the result of by-product CF_4 emissions from the use of NF_3.
4. IPCC's Fourth Assessment Report provides global warming potentials (GWPs) for the various species of HFCs and PFCs. Chapter 1, Table 1-1 of this report provides a list of GWPs used.

\- Indicates no emissions

0.00 Indicates emissions truncated due to rounding

x Indicates data has been suppressed to respect confidentiality

Estimates for the latest year (2016) are based on preliminary energy data; these data, though the best available information at the time of publication, are subject to revision in the next submission year.

Provincial/Territorial GHG emissions allocated to Canadian economic sectors are provided in Annex 12 of this report

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Table A11–28 GHG Emission Summary for Northwest Territories & Nunavut, Selected Years

Greenhouse Gas Categories	1990	1991	1992	1993	1994	1995	1996	1997	1998
	kt CO_2 eq								
TOTAL	**1 630**	**1 600**	**1 400**	**1 670**	**1 830**	**1 960**	**1 890**	**1 710**	**1 550**
ENERGY	**1 620**	**1 570**	**1 390**	**1 630**	**1 710**	**1 860**	**1 880**	**1 700**	**1 530**
a. Stationary Combustion Sources	**922**	**992**	**854**	**952**	**1 010**	**1 160**	**1 030**	**981**	**740**
Public Electricity and Heat Production	163	162	131	142	145	161	123	135	180
Petroleum Refining Industries	8	6	7	5	12	11	4	-	-
Mining and Upstream Oil and Gas Production	311	237	129	172	244	357	305	293	262
Manufacturing Industries	26	16	18	8	14	20	-	-	-
Construction	6	5	6	3	4	21	0.68	0.70	0.53
Commercial and Institutional	250	367	357	389	401	474	405	371	207
Residential	156	188	192	230	190	118	196	181	90
Agriculture and Forestry	2	9	12	2	2	0.01	-	0.01	0.02
b. Transport[1]	**601**	**479**	**445**	**588**	**638**	**631**	**782**	**703**	**779**
Domestic Aviation	240	220	220	240	240	220	230	230	230
Road Transportation	166	124	110	162	175	148	228	219	266
Light-Duty Gasoline Vehicles	45	40	40	55	55	46	53	54	43
Light-Duty Gasoline Trucks	21	19	19	26	27	23	29	31	25
Heavy-Duty Gasoline Vehicles	10	9	10	13	13	11	15	17	15
Motorcycles	0.16	0.13	0.12	0.15	0.14	0.11	0.12	0.12	0.08
Light-Duty Diesel Vehicles	2	1	1	1	1	1	2	2	3
Light-Duty Diesel Trucks	0.08	0.07	0.07	0.14	0.18	0.18	0.40	0.39	0.66
Heavy-Duty Diesel Vehicles	86	54	39	65	75	64	127	114	178
Propane and Natural Gas Vehicles	0.80	0.79	2	1	3	2	1	1	1
Railways	3	2	2	2	2	2	1	3	2
Domestic Navigation	0.14	0.21	0.53	0.46	0.10	63	-	-	-
Other Transportation	190	140	110	190	220	190	320	250	280
Off-Road Agriculture & Forestry	0.38	0.26	0.20	0.37	0.44	0.40	0.70	0.56	0.75
Off-Road Commercial & Institutional	12	9	7	12	15	13	23	18	23
Off-Road Manufacturing, Mining & Construction	130	90	69	130	150	140	230	180	210
Off-Road Residential	3	2	1	3	3	3	5	4	5
Off-Road Other Transportation	44	35	32	47	49	42	57	49	46
Pipeline Transport	-	-	-	-	2	0.14	0.09	0.04	-
c. Fugitive Sources	**97**	**100**	**89**	**94**	**65**	**65**	**60**	**12**	**10**
Coal Mining	-	-	-	-	-	-	-	-	-
Oil and Natural Gas	97	100	89	94	65	65	60	12	10
d. CO_2 Transport and Storage	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
INDUSTRIAL PROCESSES AND PRODUCT USE	**5**	**13**	**4**	**26**	**106**	**88**	**4**	**5**	**7**
a. Mineral Products	**-**	**-**	**-**	**-**	**-**	**0.03**	**0.03**	**0.03**	**0.00**
Cement Production	-	-	-	-	-	-	-	-	-
Lime Production	-	-	-	-	-	-	-	-	-
Mineral Products Use	-	-	-	-	-	0.03	0.03	0.03	0.00
b. Chemical Industry[2]	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
Adipic Acid Production	-	-	-	-	-	-	-	-	-
c. Metal Production	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
Iron and Steel Production	-	-	-	-	-	-	-	-	-
Aluminum Production	-	-	-	-	-	-	-	-	-
SF_6 Used in Magnesium Smelters and Casters	-	-	-	-	-	-	-	-	-
d. Production and Consumption of Halocarbons, SF_6 and NF_3[3]	**-**	**-**	**-**	**-**	**-**	**2**	**3**	**4**	**6**
e. Non-Energy Products from Fuels and Solvent Use	**x**	**x**	**x**	**x**	**x**	**x**	**x**	**x**	**x**
f. Other Product Manufacture and Use	**0.37**	**0.36**	**0.3**	**0.34**	**0.38**	**0.46**	**0.47**	**0.50**	**0.86**
AGRICULTURE	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
a. Enteric Fermentation	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
b. Manure Management	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
c. Agricultural Soils	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
Direct Sources	-	-	-	-	-	-	-	-	-
Indirect Sources	-	-	-	-	-	-	-	-	-
d. Field Burning of Agricultural Residues	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
e. Liming, Urea Application and Other Carbon-containing Fertilizers	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
WASTE	**10**	**10**	**11**	**11**	**11**	**12**	**12**	**13**	**13**
a. Solid Waste Disposal	**5**	**6**	**6**	**6**	**6**	**7**	**7**	**7**	**8**
b. Biological Treatment of Solid Waste	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
c. Wastewater Treatment and Discharge	**4**	**5**	**5**	**5**	**5**	**5**	**5**	**5**	**5**
d. Incineration and Open Burning of Waste	**0.18**	**0.18**	**0.18**	**0.19**	**0.19**	**0.19**	**0.20**	**0.20**	**0.19**

Notes:

1. Emissions from ethanol and biodiesel are included in the Transport categories using gasoline and diesel respectively.
2. Emissions from Ammonia Production, Nitric Acid Production and Petrochemical Production and Carbon Black categories are included in Non-Energy Products from Fuels and Solvent Use as CO_2 eq values within provincial/territorial tables.
3. HFC and PFC consumption began in 1995; HFC emissions occurring as a by-product of HCFC production (HCFC-22 exclusively) only occurred in Canada from 1990–1992 and PFC emissions prior to 1995 are the result of by-product CF_4 emissions from the use of NF_3.

\- Indicates no emissions

0.00 Indicates emissions truncated due to rounding

x Indicates data has been suppressed to respect confidentiality

Provincial/Territorial GHG emissions allocated to Canadian economic sectors are provided in Annex 12 of this report

Annex 12

PROVINCIAL/ TERRITORIAL GREENHOUSE GAS EMISSION TABLES BY CANADIAN ECONOMIC SECTOR, 1990–2016

This annex contains summary tables (Table A12–2 to Table A12–15) illustrating GHG emissions by province/territory, allocated to Canadian economic sectors, from 1990–2016. To account for the creation of Nunavut in 1999, a time series from 1999–2016 is provided for both Northwest Territories and Nunavut (Table A12–13 and Table A12–14), and the years 1990–1998 are presented as a combined region in Table A12–15. In addition, Table A12–1 provides a brief description of each economic sector.

Provincial/territorial GHG emissions allocated to IPCC sectors are provided in Annex 11 of this report.

Reallocating provincial/territorial emissions from IPCC sectors into Canadian economic sectors is useful for the purposes of analyzing trends and policies, as most people associate GHG emissions with a particular economic activity (e.g. producing electricity, farming, or driving a car). This re-allocation simply re-categorizes emissions under different headings but does not change the overall magnitude of the provincial/territorial emission estimates. Estimates for each economic sector include emissions from energy-related and non energy related processes.

Although the UNFCCC reporting guidelines require that only national-level detail be reported, provincial- and territorial-level detail is important, owing to the regional differences in emission levels and trends. Note that provincial and territorial emission estimates may not necessarily sum to the national totals due to rounding.

Provincial/territorial greenhouse gas emission tables are also available in electronic file format online at http://open.canada.ca.

Table A12–1 **Canadian Economic Sector Descriptions**

Economic Sector	Description
Oil and Gas	
Upstream Oil and Gas	Stationary combustion, onsite transportation, electricity and steam production, fugitive and process emissions from:
Natural Gas Production and Processing	- natural gas production and processing
Conventional Light Oil Production	- conventional light crude oil production
Conventional Heavy Oil Production	- conventinoal heavy crude oil production
Frontier Oil Production	- offshore and arctic production of crude oil
Oil Sands (Mining, In-situ, Upgrading)	Stationary combustion, onsite transportation, electricity and steam production, fugitive and process emissions from:
Mining and Extraction	- crude bitumen mining and extraction
In-situ	- in-situ extraction of crude bitumen including primary extraction, cyclic steam stimulation (CSS), steam-assisted gravity drainage (SAGD) and other experimental techniques.
Upgrading	- crude bitumen and heavy oil upgrading to synthetic crude oil
Oil and Natural Gas Transmission	Combustion and fugitive emissions from the transport and storage of crude oil and natural gas
Downstream Oil and Gas	Emissions resulting from:
Petroleum Refining	Stationary combustion, onsite transportation, electricity and steam production, fugitive and process emissions from petroleum refining industries
Natural Gas Distribution	Combustion and fugitive emissions from local distribution of natural gas
Electricity	Combustion and process emissions from utility electricity generation, steam production (for sale) and transmission. Excludes utility owned cogeneration at industrial sites.
Transportation	Mobile related emissions including all fossil fuels and non-CO_2 emission from biofuels.
Passenger Transport	Mobile related combustion, process and refrigerant emissions from the vehicles that primarily move people around.
Cars, Light Trucks and Motorcycles	- Light duty cars and trucks up to 4 500 lb. GVWR and motorcycles.
Bus, Rail and Domestic Aviation	- All buses and the passenger component of rail and domestic aviation
Freight Transport	Mobile related combustion, process and refrigerant emissions from the vehicles that primarily move cargo or freight around.
Heavy Duty Trucks, Rail	- Vehicles above 4 500 lb. GVWR and the freight component of rail
Domestic Aviation and Marine	- Cargo/Freight component of domestic aviation and all domestic navigation
Other: Recreational, Commercial and Residential	Combustion emissions from the non-industrial use of off-road engines (e.g., ATVs, snowmobiles, personal watercraft), including portable engines (e.g., generators, lawn mowers, chain saws).
Heavy Industry	Stationary combustion, onsite transportation, electricty and steam production, and process emissions from:
Mining	- metal and non-metal mines, stone quarries, and gravel pits
Smelting and Refining (Non Ferrous Metals)	- Non-ferrous Metals (aluminium, magnesium and other production)
Pulp and Paper	- Pulp and Paper (primarily pulp, paper, and paper product manufacturers)
Iron and Steel	- Iron and Steel (steel foundries, casting, rolling mills and iron making)
Cement	- Cement and other non-metallic mineral production
Lime & Gypsum	- Lime and Gypsum product manufacturing
Chemicals & Fertilizers	- Chemical (fertilizer manufacturing, organic and inorganic chemical manufacturing)
Buildings	Stationary combustion and process (i.e. air conditioning) emissions from:
Service Industry	- Service industries related to mining, communication, wholesale and retail trade, finance and insurance, real estate, education, etc.; offices, health, arts, accommodation, food, information & cultural; Federal, provincial and municipal establishments; National Defence and Canadian Coast Guard; Train stations, airports and warehouses
Residential	- personal residences (homes, apartment hotels, condominiums and farm houses)
Agriculture	Emissions resulting from:
On Farm Fuel Use	- Stationary combustion, onsite transportation and process emissions from the agricultural, hunting and trapping industry (excluding food processing, farm machinery manufacturing, and repair)
Crop Production	- Application of inorganic nitrogen fertilizers, decomposition of crop residues, loss of soil organic carbon, cultivation of organic soils, indirect emissions from leaching and volatilization, field burning of agricultural residues, liming, and urea application
Animal Production	- Animal housing, manure storage, manure deposited by grazing animals, and application of manure to managed soils
Waste	Non-CO_2 Emissions from biomass resulting from:
Solid Waste	- Municipal solid waste management sites (landfills), dedicated wood waste landfills, and composting of municipal solid waste
Waste Water	- Domestic and industrial wastewater treatment
Waste Incineration	- Municipal solid, hazardous and clinical waste, and sewage sludge incineration
Coal Production	Stationary combustion, onsite transportation and fugitive emissions from underground and surface coal mines
Light Manufacturing, Construction & Forest Resources	Stationary combustion, onsite transportation, electricty and steam production, and process emissions from (excluding LULUCF):
Light Manufacturing	- all other manufacturing industries not included in the Heavy Industry category above
Construction	- construction of buildings, highways etc.
Forest Resources	- forestry and logging service industry

Table A12–2 **GHG Emissions for Newfoundland and Labrador by Canadian Economic Sector, Selected Years**

	1990	2005	2011	2012	2013	2014	2015	2016
	Mt CO_2 eq							
NATIONAL GHG TOTAL	9.3	9.9	10.0	9.4	9.4	10.4	10.6	10.8
Oil and Gas	**1.1**	**2.6**	**2.4**	**2.4**	**2.6**	**2.7**	**2.5**	**2.7**
Upstream Oil and Gas	-	1.6	1.5	1.3	1.6	1.7	1.6	1.7
Natural Gas Production and Processing	-	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Conventional Oil Production	-	1.6	1.5	1.3	1.6	1.7	1.6	1.6
Conventional Light Oil Production	-	-	0.0	-	-	0.0	-	-
Conventional Heavy Oil Production	-	-	-	-	-	-	-	-
Frontier Oil Production	-	1.6	1.5	1.3	1.6	1.7	1.6	1.6
Oil Sands (Mining, In-situ, Upgrading)	-	-	-	-	-	-	-	-
Mining and Extraction	-	-	-	-	-	-	-	-
In-situ	-	-	-	-	-	-	-	-
Upgrading	-	-	-	-	-	-	-	-
Oil and Natural Gas Transmission	-	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Downstream Oil and Gas	1.1	1.0	0.9	1.1	1.0	1.0	1.0	1.1
Petroleum Refining	1.1	1.0	0.9	1.1	1.0	1.0	1.0	1.1
Natural Gas Distribution	-	-	-	-	-	-	-	-
Electricity	**1.6**	**0.8**	**0.8**	**0.8**	**0.9**	**1.2**	**1.3**	**1.5**
Transportation	**2.8**	**3.1**	**3.7**	**3.6**	**3.1**	**3.5**	**3.8**	**3.8**
Passenger Transport	1.3	1.4	1.8	2.0	1.8	2.0	2.1	2.0
Cars, Light Trucks and Motorcycles	1.1	1.3	1.7	1.8	1.6	1.8	1.9	1.8
Bus, Rail and Domestic Aviation	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Freight Transport	1.1	1.4	1.7	1.4	1.2	1.3	1.5	1.6
Heavy Duty Trucks, Rail	0.4	0.9	1.1	0.9	0.9	1.1	1.2	1.3
Domestic Aviation and Marine	0.7	0.6	0.6	0.4	0.3	0.2	0.3	0.4
Other: Recreational, Commercial and Residential	0.4	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Heavy Industry	**1.8**	**1.6**	**1.0**	**0.8**	**0.8**	**0.8**	**0.8**	**0.5**
Mining	1.3	1.3	0.9	0.8	0.8	0.8	0.7	0.4
Smelting and Refining (Non Ferrous Metals)	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0
Pulp and Paper	0.4	0.3	0.0	0.0	0.0	0.0	0.0	0.0
Iron and Steel	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Cement	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Lime & Gypsum	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Chemicals & Fertilizers	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Buildings	**1.2**	**0.9**	**1.0**	**0.8**	**1.1**	**1.2**	**1.1**	**1.1**
Service Industry	0.3	0.4	0.4	0.3	0.7	0.7	0.7	0.7
Residential	0.8	0.4	0.6	0.5	0.4	0.5	0.4	0.5
Agriculture	**0.1**	**0.1**	**0.1**	**0.2**	**0.1**	**0.1**	**0.1**	**0.1**
On Farm Fuel Use	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Crop Production	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0
Animal Production	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Waste	**0.6**	**0.6**	**0.6**	**0.6**	**0.6**	**0.6**	**0.6**	**0.6**
Solid Waste	0.5	0.6	0.5	0.6	0.6	0.6	0.6	0.6
Wastewater	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Waste Incineration	-	-	-	-	-	-	-	-
Coal Production	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
Light Manufacturing, Construction & Forest Resources	**0.2**	**0.2**	**0.3**	**0.3**	**0.2**	**0.2**	**0.3**	**0.3**
Light Manufacturing	0.1	0.0	0.2	0.1	0.1	0.1	0.1	0.1
Construction	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.2
Forest Resources	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Notes:

Totals may not add up due to rounding.

National GHG emissions allocated to IPCC sectors are provided in Annex 9 of this report.

Provincial/territorial GHG emissions allocated to IPCC sectors are provided in Annex 11 of this report.

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.

Emission estimates for Solid Waste include emissions from municipal solid waste landfills, wood waste landfills and municipal solid waste composting.

- Indicates no emissions.

0 indicates emissions of less than 0.5 Mt CO_2 eq; truncated due to rounding

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Table A12–3 GHG Emissions for Nova Scotia by Canadian Economic Sector, Selected Years

	1990	2005	2011	2012	2013	2014	2015	2016
	Mt CO_2 eq							
NATIONAL GHG TOTAL	19.6	23.2	20.9	19.2	18.2	16.4	16.6	15.6
Oil and Gas	**0.7**	**1.5**	**1.5**	**1.6**	**1.4**	**0.8**	**0.6**	**0.5**
Upstream Oil and Gas	0.0	0.4	0.7	0.6	0.6	0.8	0.6	0.5
Natural Gas Production and Processing	0.0	0.4	0.7	0.6	0.6	0.8	0.6	0.5
Conventional Oil Production	-	-	-	-	-	-	-	-
Conventional Light Oil Production	-	-	-	-	-	-	-	-
Conventional Heavy Oil Production	-	-	-	-	-	-	-	-
Frontier Oil Production	-	-	-	-	-	-	-	-
Oil Sands (Mining, In-situ, Upgrading)	-	-	-	-	-	-	-	-
Mining and Extraction	-	-	-	-	-	-	-	-
In-situ	-	-	-	-	-	-	-	-
Upgrading	-	-	-	-	-	-	-	-
Oil and Natural Gas Transmission	-	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Downstream Oil and Gas	0.7	1.1	0.9	1.0	0.9	0.0	0.0	0.0
Petroleum Refining	0.7	1.1	0.9	1.0	0.8	0.0	0.0	0.0
Natural Gas Distribution	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Electricity	**6.9**	**10.8**	**8.5**	**7.6**	**7.6**	**7.2**	**7.0**	**6.6**
Transportation	**4.6**	**5.6**	**5.5**	**5.2**	**4.8**	**4.3**	**4.8**	**4.8**
Passenger Transport	2.4	2.8	2.8	2.9	2.5	2.3	2.8	2.9
Cars, Light Trucks and Motorcycles	2.2	2.6	2.6	2.7	2.3	2.1	2.6	2.7
Bus, Rail and Domestic Aviation	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Freight Transport	1.5	2.5	2.4	2.0	2.0	1.8	1.7	1.6
Heavy Duty Trucks, Rail	0.9	1.6	1.8	1.6	1.6	1.5	1.5	1.4
Domestic Aviation and Marine	0.6	0.9	0.5	0.4	0.3	0.3	0.2	0.2
Other: Recreational, Commercial and Residential	0.6	0.3	0.3	0.3	0.3	0.3	0.3	0.3
Heavy Industry	**1.0**	**0.8**	**0.6**	**0.6**	**0.5**	**0.4**	**0.5**	**0.5**
Mining	0.1	0.2	0.2	0.1	0.1	0.1	0.1	0.1
Smelting and Refining (Non Ferrous Metals)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Pulp and Paper	0.4	0.3	0.2	0.1	0.1	0.1	0.1	0.1
Iron and Steel	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Cement	0.3	0.4	0.3	0.3	0.3	0.3	0.3	0.3
Lime & Gypsum	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Chemicals & Fertilizers	0.1	0.0	0.0	0.0	0.1	0.0	0.0	0.0
Buildings	**3.0**	**2.8**	**3.1**	**2.6**	**2.5**	**2.2**	**2.3**	**2.0**
Service Industry	0.8	1.3	1.1	0.8	0.9	0.7	0.8	0.7
Residential	2.2	1.4	2.0	1.8	1.6	1.5	1.5	1.3
Agriculture	**0.6**	**0.6**	**0.6**	**0.5**	**0.5**	**0.5**	**0.5**	**0.5**
On Farm Fuel Use	0.2	0.2	0.2	0.1	0.1	0.1	0.1	0.1
Crop Production	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Animal Production	0.4	0.4	0.3	0.3	0.4	0.4	0.4	0.3
Waste	**0.7**	**0.6**	**0.5**	**0.5**	**0.5**	**0.5**	**0.4**	**0.4**
Solid Waste	0.6	0.5	0.4	0.4	0.4	0.4	0.4	0.4
Wastewater	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0
Waste Incineration	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Coal Production	**1.6**	**0.1**	**0.1**	**0.1**	**0.1**	**0.0**	**0.0**	**0.0**
Light Manufacturing, Construction & Forest Resources	**0.4**	**0.4**	**0.5**	**0.4**	**0.4**	**0.4**	**0.3**	**0.3**
Light Manufacturing	0.2	0.2	0.3	0.3	0.3	0.3	0.2	0.2
Construction	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Forest Resources	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Notes:

Totals may not add up due to rounding.

National GHG emissions allocated to IPCC sectors are provided in Annex 9 of this report.

Provincial/territorial GHG emissions allocated to IPCC sectors are provided in Annex 11 of this report.

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.

Emission estimates for Solid Waste include emissions from municipal solid waste landfills, wood waste landfills and municipal solid waste composting.

- Indicates no emissions.

0 indicates emissions of less than 0.5 Mt CO_2 eq; truncated due to rounding

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Table A12–4 **GHG Emissions for Prince Edward Island by Canadian Economic Sector, Selected Years**

	1990	2005	2011	2012	2013	2014	2015	2016
	Mt CO_2 eq							
NATIONAL GHG TOTAL	1.9	2.0	2.1	2.0	1.7	1.7	1.7	1.8
Oil and Gas	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
Upstream Oil and Gas	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Natural Gas Production and Processing	-	-	-	-	-	-	-	-
Conventional Oil Production	-	-	-	-	-	-	-	-
Conventional Light Oil Production	-	-	-	-	-	-	-	-
Conventional Heavy Oil Production	-	-	-	-	-	-	-	-
Frontier Oil Production	-	-	-	-	-	-	-	-
Oil Sands (Mining, In-situ, Upgrading)	-	-	-	-	-	-	-	-
Mining and Extraction	-	-	-	-	-	-	-	-
In-situ	-	-	-	-	-	-	-	-
Upgrading	-	-	-	-	-	-	-	-
Oil and Natural Gas Transmission	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Downstream Oil and Gas	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Petroleum Refining	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Natural Gas Distribution	-	-	-	-	-	-	-	-
Electricity	**0.1**	**0.0**	**0.0**	**0.0**	**0.0**	**x**	**x**	**x**
Transportation	**0.6**	**0.8**	**0.9**	**0.8**	**0.7**	**0.7**	**0.8**	**0.9**
Passenger Transport	0.4	0.5	0.5	0.5	0.4	0.4	0.4	0.5
Cars, Light Trucks and Motorcycles	0.4	0.5	0.5	0.5	0.4	0.4	0.4	0.5
Bus, Rail and Domestic Aviation	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Freight Transport	0.2	0.2	0.3	0.3	0.2	0.3	0.3	0.3
Heavy Duty Trucks, Rail	0.1	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Domestic Aviation and Marine	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Other: Recreational, Commercial and Residential	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0
Heavy Industry	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
Mining	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Smelting and Refining (Non Ferrous Metals)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Pulp and Paper	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Iron and Steel	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Cement	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Lime & Gypsum	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Chemicals & Fertilizers	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Buildings	**0.6**	**0.4**	**0.6**	**0.5**	**0.4**	**0.4**	**0.3**	**0.3**
Service Industry	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.0
Residential	0.4	0.3	0.5	0.4	0.3	0.3	0.2	0.3
Agriculture	**0.4**	**0.5**	**0.4**	**0.4**	**0.4**	**0.4**	**0.4**	**0.5**
On Farm Fuel Use	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0
Crop Production	0.1	0.2	0.2	0.2	0.1	0.2	0.2	0.2
Animal Production	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Waste	**0.1**	**0.1**	**0.1**	**0.1**	**0.1**	**0.1**	**0.1**	**0.1**
Solid Waste	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Wastewater	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Waste Incineration	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Coal Production	-	-	-	-	-	-	-	-
Light Manufacturing, Construction & Forest Resources	**0.1**	**0.2**	**0.2**	**0.2**	**0.1**	**0.1**	**0.1**	**0.1**
Light Manufacturing	0.1	0.1	0.1	0.2	0.1	x	x	x
Construction	0.0	0.0	0.0	0.0	0.0	x	x	x
Forest Resources	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Notes:

Totals may not add up due to rounding.

National GHG emissions allocated to IPCC sectors are provided in Annex 9 of this report.

Provincial/territorial GHG emissions allocated to IPCC sectors are provided in Annex 11 of this report.

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.

Emission estimates for Solid Waste include emissions from municipal solid waste landfills, wood waste landfills and municipal solid waste composting.

- Indicates no emissions.

0 indicates emissions of less than 0.5 Mt CO_2 eq; truncated due to rounding

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Table A12–5 **GHG Emissions for New Brunswick by Canadian Economic Sector, Selected Years**

	1990	2005	2011	2012	2013	2014	2015	2016
	Mt CO_2 eq							
NATIONAL GHG TOTAL	16.1	20.1	18.7	16.8	14.8	14.4	14.3	15.3
Oil and Gas	**1.2**	**2.5**	**3.3**	**3.3**	**3.2**	**2.9**	**2.7**	**2.6**
Upstream Oil and Gas	-	0.0	0.0	0.0	0.1	0.1	0.1	0.1
Natural Gas Production and Processing	-	0.0	0.0	0.0	0.1	0.1	0.1	0.0
Conventional Oil Production	-	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Conventional Light Oil Production	-	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Conventional Heavy Oil Production	-	-	-	-	-	-	-	-
Frontier Oil Production	-	-	-	-	-	-	-	-
Oil Sands (Mining, In-situ, Upgrading)	-	-	-	-	-	-	-	-
Mining and Extraction	-	-	-	-	-	-	-	-
In-situ	-	-	-	-	-	-	-	-
Upgrading	-	-	-	-	-	-	-	-
Oil and Natural Gas Transmission	-	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Downstream Oil and Gas	1.2	2.5	3.3	3.3	3.1	2.8	2.6	2.5
Petroleum Refining	1.2	2.5	3.3	3.2	3.1	2.8	2.6	2.5
Natural Gas Distribution	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Electricity	**6.0**	**8.1**	**4.9**	**4.1**	**4.2**	**4.4**	**4.0**	**4.9**
Transportation	**3.8**	**4.9**	**5.6**	**4.9**	**4.0**	**3.7**	**3.9**	**4.3**
Passenger Transport	1.6	2.2	2.4	2.4	2.0	1.8	2.1	2.4
Cars, Light Trucks and Motorcycles	1.5	2.1	2.3	2.3	1.9	1.6	2.0	2.3
Bus, Rail and Domestic Aviation	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Freight Transport	1.2	2.2	2.8	2.2	1.7	1.6	1.5	1.5
Heavy Duty Trucks, Rail	0.9	1.8	2.3	1.8	1.4	1.4	1.3	1.3
Domestic Aviation and Marine	0.3	0.4	0.5	0.3	0.3	0.3	0.2	0.2
Other: Recreational, Commercial and Residential	1.1	0.5	0.3	0.3	0.3	0.3	0.3	0.3
Heavy Industry	**1.8**	**1.3**	**1.3**	**1.2**	**0.9**	**0.8**	**1.0**	**0.9**
Mining	0.2	0.3	0.4	0.3	0.1	0.1	0.1	0.1
Smelting and Refining (Non Ferrous Metals)	0.1	0.1	0.2	0.2	0.2	0.2	0.2	0.1
Pulp and Paper	1.3	0.7	0.5	0.5	0.5	0.4	0.5	0.4
Iron and Steel	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Cement	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Lime & Gypsum	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Chemicals & Fertilizers	0.0	0.1	0.1	0.1	0.0	0.0	0.1	0.2
Buildings	**1.8**	**1.5**	**1.9**	**1.9**	**1.1**	**1.2**	**1.3**	**1.2**
Service Industry	0.6	0.7	0.9	1.0	0.5	0.5	0.5	0.5
Residential	1.2	0.8	1.0	0.9	0.6	0.6	0.8	0.7
Agriculture	**0.6**	**0.6**	**0.6**	**0.6**	**0.6**	**0.6**	**0.5**	**0.6**
On Farm Fuel Use	0.1	0.1	0.2	0.1	0.1	0.1	0.1	0.1
Crop Production	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.3
Animal Production	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
Waste	**0.5**	**0.6**	**0.5**	**0.6**	**0.6**	**0.5**	**0.5**	**0.5**
Solid Waste	0.5	0.6	0.5	0.5	0.5	0.5	0.5	0.5
Wastewater	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Waste Incineration	-	0.0	0.0	0.0	0.0	0.0	0.0	-
Coal Production	**0.0**	**0.0**	**-**	**-**	**-**	**-**	**-**	**-**
Light Manufacturing, Construction & Forest Resources	**0.4**	**0.5**	**0.5**	**0.4**	**0.4**	**0.3**	**0.3**	**0.3**
Light Manufacturing	0.2	0.4	0.3	0.2	0.3	0.2	0.2	0.2
Construction	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Forest Resources	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1

Notes:

Totals may not add up due to rounding.

National GHG emissions allocated to IPCC sectors are provided in Annex 9 of this report.

Provincial/territorial GHG emissions allocated to IPCC sectors are provided in Annex 11 of this report.

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.

Emission estimates for Solid Waste include emissions from municipal solid waste landfills, wood waste landfills and municipal solid waste composting.

- Indicates no emissions.

0 indicates emissions of less than 0.5 Mt CO_2 eq; truncated due to rounding

Table A12–6 **GHG Emissions for Quebec by Canadian Economic Sector, Selected Years**

	1990	2005	2011	2012	2013	2014	2015	2016
	Mt CO_2 eq							
NATIONAL GHG TOTAL	86.6	86.5	81.7	79.5	79.9	78.0	78.4	77.3
Oil and Gas	**3.9**	**4.4**	**2.8**	**2.8**	**2.7**	**2.7**	**2.8**	**2.4**
Upstream Oil and Gas	0.2	0.3	0.2	0.2	0.3	0.3	0.3	0.2
Natural Gas Production and Processing	-	-	0.0	-	-	-	-	-
Conventional Oil Production	-	-	-	-	-	-	-	-
Conventional Light Oil Production	-	-	-	-	-	-	-	-
Conventional Heavy Oil Production	-	-	-	-	-	-	-	-
Frontier Oil Production	-	-	-	-	-	-	-	-
Oil Sands (Mining, In-situ, Upgrading)	-	-	-	-	-	-	-	-
Mining and Extraction	-	-	-	-	-	-	-	-
In-situ	-	-	-	-	-	-	-	-
Upgrading	-	-	-	-	-	-	-	-
Oil and Natural Gas Transmission	0.2	0.3	0.1	0.2	0.3	0.3	0.3	0.2
Downstream Oil and Gas	3.7	4.1	2.7	2.6	2.4	2.3	2.5	2.2
Petroleum Refining	3.6	4.0	2.6	2.5	2.4	2.2	2.4	2.2
Natural Gas Distribution	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Electricity	**1.5**	**0.7**	**0.4**	**0.5**	**0.4**	**0.3**	**0.3**	**0.3**
Transportation	**24.8**	**31.3**	**33.0**	**32.9**	**32.5**	**30.7**	**31.1**	**31.7**
Passenger Transport	15.0	18.9	19.1	18.7	18.5	17.7	18.1	18.5
Cars, Light Trucks and Motorcycles	14.2	18.1	18.3	17.8	17.6	16.9	17.3	17.7
Bus, Rail and Domestic Aviation	0.8	0.8	0.8	0.9	0.9	0.8	0.8	0.8
Freight Transport	5.6	10.4	12.0	12.5	12.3	11.3	11.2	11.3
Heavy Duty Trucks, Rail	4.0	9.0	10.9	11.5	11.2	10.4	10.4	10.4
Domestic Aviation and Marine	1.6	1.4	1.0	0.9	1.0	0.8	0.8	0.8
Other: Recreational, Commercial and Residential	4.1	2.0	1.9	1.7	1.7	1.7	1.8	1.9
Heavy Industry	**24.9**	**19.5**	**17.4**	**17.0**	**17.4**	**17.2**	**16.6**	**14.8**
Mining	2.1	1.5	1.4	1.9	1.9	1.7	1.6	1.6
Smelting and Refining (Non Ferrous Metals)	12.9	9.8	8.1	7.6	7.8	7.3	7.4	7.0
Pulp and Paper	4.5	2.8	1.5	1.4	1.6	1.2	1.4	1.4
Iron and Steel	1.2	0.9	1.9	1.5	2.1	2.2	1.2	1.1
Cement	2.5	2.5	2.3	2.5	2.2	2.2	2.3	2.0
Lime & Gypsum	0.5	0.9	0.9	0.9	0.7	0.8	0.8	0.7
Chemicals & Fertilizers	1.2	1.1	1.4	1.2	1.1	1.8	1.8	0.9
Buildings	**12.7**	**13.1**	**11.2**	**9.9**	**10.0**	**10.7**	**10.9**	**10.9**
Service Industry	4.5	6.4	6.3	5.3	5.4	6.0	6.1	5.9
Residential	8.3	6.8	4.9	4.6	4.6	4.8	4.8	5.0
Agriculture	**8.2**	**8.5**	**8.7**	**8.8**	**8.7**	**8.7**	**8.9**	**8.9**
On Farm Fuel Use	1.1	0.9	1.1	1.0	1.0	0.9	1.0	0.9
Crop Production	1.9	1.8	2.1	2.5	2.4	2.4	2.6	2.7
Animal Production	5.2	5.8	5.4	5.3	5.3	5.3	5.3	5.3
Waste	**5.3**	**4.8**	**3.3**	**3.0**	**3.3**	**3.6**	**3.9**	**4.0**
Solid Waste	4.6	4.3	2.8	2.6	2.9	3.2	3.5	3.5
Wastewater	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
Waste Incineration	0.4	0.3	0.3	0.1	0.1	0.1	0.1	0.1
Coal Production	-	-	-	-	-	-	-	-
Light Manufacturing, Construction & Forest Resources	**5.3**	**4.1**	**4.8**	**4.7**	**4.9**	**4.1**	**3.8**	**4.2**
Light Manufacturing	3.7	2.9	3.0	3.2	3.6	2.9	2.5	2.9
Construction	1.4	1.0	1.4	1.2	1.1	1.0	1.0	1.1
Forest Resources	0.2	0.2	0.3	0.3	0.3	0.2	0.3	0.2

Notes:

Totals may not add up due to rounding.

National GHG emissions allocated to IPCC sectors are provided in Annex 9 of this report.

Provincial/territorial GHG emissions allocated to IPCC sectors are provided in Annex 11 of this report.

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.

Emission estimates for Solid Waste include emissions from municipal solid waste landfills, wood waste landfills and municipal solid waste composting.

- Indicates no emissions.

0 indicates emissions of less than 0.5 Mt CO_2 eq; truncated due to rounding

Table A12–7 **GHG Emissions for Ontario by Canadian Economic Sector, Selected Years**

	1990	2005	2011	2012	2013	2014	2015	2016
	Mt CO_2 eq							
NATIONAL GHG TOTAL	179.2	204.7	172.5	169.1	168.4	165.4	162.9	160.6
Oil and Gas	**10.3**	**11.8**	**9.1**	**10.2**	**10.3**	**10.7**	**10.1**	**9.4**
Upstream Oil and Gas	3.3	3.9	1.7	1.7	1.7	2.3	2.3	1.9
Natural Gas Production and Processing	0.3	0.4	0.3	0.4	0.2	0.2	0.2	0.2
Conventional Oil Production	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Conventional Light Oil Production	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Conventional Heavy Oil Production	-	-	-	-	-	-	-	-
Frontier Oil Production	-	-	-	-	-	-	-	-
Oil Sands (Mining, In-situ, Upgrading)	-	-	-	-	-	-	-	-
Mining and Extraction	-	-	-	-	-	-	-	-
In-situ	-	-	-	-	-	-	-	-
Upgrading	-	-	-	-	-	-	-	-
Oil and Natural Gas Transmission	3.0	3.6	1.4	1.3	1.5	2.1	2.1	1.7
Downstream Oil and Gas	7.0	7.9	7.4	8.5	8.5	8.5	7.9	7.5
Petroleum Refining	6.6	7.3	6.9	8.0	8.0	7.9	7.3	7.0
Natural Gas Distribution	0.4	0.6	0.5	0.5	0.5	0.5	0.5	0.5
Electricity	**25.9**	**33.9**	**12.9**	**12.8**	**9.2**	**4.9**	**5.0**	**4.5**
Transportation	**41.6**	**57.1**	**55.8**	**53.8**	**56.4**	**54.5**	**55.5**	**55.8**
Passenger Transport	25.5	35.1	33.3	31.5	33.3	32.4	33.2	33.9
Cars, Light Trucks and Motorcycles	23.5	33.0	31.3	29.2	31.0	30.2	31.0	31.7
Bus, Rail and Domestic Aviation	2.0	2.1	2.0	2.3	2.3	2.2	2.2	2.2
Freight Transport	8.4	17.7	18.8	19.0	19.6	18.6	18.8	18.3
Heavy Duty Trucks, Rail	7.0	16.5	17.7	17.7	18.1	17.0	17.3	16.9
Domestic Aviation and Marine	1.4	1.2	1.1	1.3	1.5	1.5	1.5	1.4
Other: Recreational, Commercial and Residential	7.7	4.2	3.7	3.4	3.5	3.5	3.6	3.6
Heavy Industry	**43.1**	**35.2**	**30.5**	**31.2**	**28.8**	**29.9**	**28.6**	**30.0**
Mining	1.0	0.9	1.2	1.3	1.3	1.3	1.2	1.3
Smelting and Refining (Non Ferrous Metals)	1.5	1.9	1.0	1.0	0.9	0.7	0.7	0.7
Pulp and Paper	3.2	2.1	2.2	1.9	2.0	1.8	1.7	1.9
Iron and Steel	15.0	15.1	14.6	14.8	12.4	13.7	12.4	13.7
Cement	4.5	6.4	4.5	4.8	4.4	4.4	4.2	4.2
Lime & Gypsum	1.7	1.7	1.2	1.2	1.1	1.1	1.1	1.1
Chemicals & Fertilizers	16.2	7.1	5.8	6.4	6.7	6.9	7.3	7.2
Buildings	**27.9**	**36.2**	**35.5**	**32.8**	**35.8**	**38.9**	**37.1**	**34.5**
Service Industry	9.7	15.4	14.7	14.3	15.2	16.6	15.9	15.6
Residential	18.2	20.8	20.8	18.5	20.5	22.3	21.3	18.8
Agriculture	**12.5**	**12.4**	**12.7**	**12.6**	**12.9**	**12.4**	**12.1**	**12.5**
On Farm Fuel Use	2.1	2.3	2.9	2.8	2.7	2.5	2.5	2.5
Crop Production	3.1	2.7	3.6	3.4	3.8	3.6	3.3	3.7
Animal Production	7.3	7.4	6.3	6.3	6.3	6.3	6.3	6.4
Waste	**5.4**	**7.0**	**6.4**	**6.4**	**6.2**	**5.7**	**5.7**	**5.8**
Solid Waste	4.9	6.4	5.8	5.8	5.6	5.0	5.0	5.0
Wastewater	0.2	0.3	0.3	0.3	0.3	0.3	0.3	0.3
Waste Incineration	0.3	0.3	0.3	0.3	0.3	0.3	0.4	0.4
Coal Production	-	-	-	-	-	-	-	-
Light Manufacturing, Construction & Forest Resources	**12.5**	**11.1**	**9.7**	**9.3**	**8.9**	**8.4**	**8.7**	**8.1**
Light Manufacturing	9.9	8.0	6.9	6.8	6.5	6.1	6.1	5.8
Construction	2.5	2.9	2.7	2.4	2.3	2.2	2.5	2.2
Forest Resources	0.1	0.2	0.1	0.1	0.1	0.1	0.1	0.1

Notes:

Totals may not add up due to rounding.

National GHG emissions allocated to IPCC sectors are provided in Annex 9 of this report.

Provincial/territorial GHG emissions allocated to IPCC sectors are provided in Annex 11 of this report.

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.

Emission estimates for Solid Waste include emissions from municipal solid waste landfills, wood waste landfills and municipal solid waste composting.

- Indicates no emissions.

0 indicates emissions of less than 0.5 Mt CO_2 eq; truncated due to rounding

Table A12–8 **GHG Emissions for Manitoba by Canadian Economic Sector, Selected Years**

	1990	2005	2011	2012	2013	2014	2015	2016
	Mt CO_2 eq							
NATIONAL GHG TOTAL	18.3	20.2	19.0	20.2	20.9	20.9	20.8	20.9
Oil and Gas	**1.3**	**0.8**	**0.4**	**0.5**	**0.6**	**0.7**	**0.7**	**0.6**
Upstream Oil and Gas	1.3	0.8	0.4	0.4	0.5	0.7	0.7	0.6
Natural Gas Production and Processing	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.1
Conventional Oil Production	0.1	0.1	0.3	0.3	0.3	0.3	0.3	0.3
Conventional Light Oil Production	0.1	0.1	0.3	0.3	0.3	0.3	0.3	0.3
Conventional Heavy Oil Production	-	-	-	-	-	-	-	-
Frontier Oil Production	-	-	-	-	-	-	-	-
Oil Sands (Mining, In-situ, Upgrading)	-	-	-	-	-	-	-	-
Mining and Extraction	-	-	-	-	-	-	-	-
In-situ	-	-	-	-	-	-	-	-
Upgrading	-	-	-	-	-	-	-	-
Oil and Natural Gas Transmission	1.2	0.6	0.1	0.0	0.1	0.3	0.3	0.3
Downstream Oil and Gas	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Petroleum Refining	0.0	-	-	0.0	0.0	-	-	-
Natural Gas Distribution	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Electricity	**0.5**	**0.4**	**0.1**	**0.1**	**0.1**	**0.1**	**0.1**	**0.1**
Transportation	**5.0**	**5.5**	**6.1**	**7.1**	**6.9**	**7.1**	**6.9**	**7.0**
Passenger Transport	2.9	3.2	3.2	3.8	3.9	3.9	3.7	3.8
Cars, Light Trucks and Motorcycles	2.5	2.7	2.8	3.4	3.4	3.4	3.3	3.4
Bus, Rail and Domestic Aviation	0.4	0.5	0.4	0.5	0.5	0.4	0.4	0.4
Freight Transport	1.4	1.9	2.6	2.9	2.7	2.9	2.8	2.9
Heavy Duty Trucks, Rail	1.3	1.8	2.6	2.9	2.7	2.9	2.7	2.8
Domestic Aviation and Marine	0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.0
Other: Recreational, Commercial and Residential	0.7	0.4	0.3	0.3	0.3	0.4	0.4	0.3
Heavy Industry	**1.3**	**1.5**	**1.3**	**1.2**	**1.4**	**1.2**	**1.3**	**1.3**
Mining	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Smelting and Refining (Non Ferrous Metals)	0.3	0.2	0.1	0.1	0.1	0.1	0.0	0.0
Pulp and Paper	0.2	0.2	0.1	0.0	0.0	0.1	0.1	0.1
Iron and Steel	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1
Cement	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Lime & Gypsum	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Chemicals & Fertilizers	0.3	0.9	0.9	0.8	0.9	0.8	0.9	0.9
Buildings	**3.1**	**2.7**	**2.7**	**2.5**	**2.9**	**3.0**	**2.6**	**2.6**
Service Industry	1.4	1.6	1.6	1.4	1.6	1.7	1.5	1.5
Residential	1.7	1.1	1.1	1.1	1.3	1.3	1.1	1.1
Agriculture	**5.8**	**7.8**	**6.8**	**7.1**	**7.5**	**7.2**	**7.4**	**7.5**
On Farm Fuel Use	1.1	1.4	1.0	1.1	1.0	1.0	0.9	0.9
Crop Production	2.2	2.0	2.2	2.5	3.1	2.7	3.0	3.1
Animal Production	2.5	4.4	3.5	3.4	3.5	3.5	3.5	3.5
Waste	**0.6**	**0.8**	**0.8**	**0.9**	**0.8**	**0.8**	**0.8**	**0.8**
Solid Waste	0.5	0.8	0.8	0.8	0.7	0.7	0.7	0.7
Wastewater	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Waste Incineration	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Coal Production	-	-	-	-	-	-	-	-
Light Manufacturing, Construction & Forest Resources	**0.6**	**0.8**	**0.8**	**1.0**	**0.8**	**0.8**	**1.0**	**1.1**
Light Manufacturing	0.4	0.5	0.6	0.7	0.5	0.6	0.8	0.8
Construction	0.2	0.3	0.2	0.2	0.2	0.2	0.2	0.3
Forest Resources	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Notes:

Totals may not add up due to rounding.

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Provincial/territorial GHG emissions allocated to IPCC sectors are provided in Annex 11 of this report.

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.

Emission estimates for Solid Waste include emissions from municipal solid waste landfills, wood waste landfills and municipal solid waste composting.

\- Indicates no emissions.

0 indicates emissions of less than 0.5 Mt CO_2 eq; truncated due to rounding

Table A12–9 **GHG Emissions for Saskatchewan by Canadian Economic Sector, Selected Years**

	1990	2005	2011	2012	2013	2014	2015	2016
	Mt CO_2 eq							
NATIONAL GHG TOTAL	44.7	68.9	69.0	71.3	74.0	77.4	79.5	76.3
Oil and Gas	**12.1**	**25.1**	**22.1**	**22.5**	**23.7**	**27.4**	**27.9**	**25.0**
Upstream Oil and Gas	10.9	23.5	20.4	20.6	21.8	25.4	25.9	22.8
Natural Gas Production and Processing	2.1	4.1	3.6	3.4	3.4	3.5	3.5	3.4
Conventional Oil Production	6.3	14.9	12.2	12.3	13.6	16.7	17.6	14.8
Conventional Light Oil Production	1.7	2.7	4.3	4.7	6.0	7.9	8.3	7.1
Conventional Heavy Oil Production	4.6	12.2	7.9	7.6	7.6	8.9	9.3	7.7
Frontier Oil Production	-	-	-	-	-	-	-	-
Oil Sands (Mining, In-situ, Upgrading)	0.0	2.1	2.2	2.4	2.3	2.4	2.3	2.4
Mining and Extraction	-	-	-	-	-	-	-	-
In-situ	-	-	-	-	-	-	-	-
Upgrading	0.0	2.1	2.2	2.4	2.3	2.4	2.3	2.4
Oil and Natural Gas Transmission	2.4	2.3	2.4	2.5	2.5	2.8	2.5	2.3
Downstream Oil and Gas	1.2	1.6	1.7	1.9	1.9	2.0	2.1	2.2
Petroleum Refining	0.7	1.4	1.5	1.7	1.7	1.7	1.8	2.0
Natural Gas Distribution	0.5	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Electricity	**11.1**	**14.8**	**14.2**	**14.7**	**14.0**	**14.2**	**15.1**	**15.0**
Transportation	**5.3**	**6.2**	**8.3**	**9.3**	**10.2**	**10.2**	**10.7**	**10.7**
Passenger Transport	2.9	3.3	3.9	4.6	4.8	4.5	4.9	5.1
Cars, Light Trucks and Motorcycles	2.7	3.1	3.7	4.3	4.5	4.3	4.7	4.8
Bus, Rail and Domestic Aviation	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Freight Transport	1.6	2.5	4.0	4.3	4.9	5.2	5.3	5.2
Heavy Duty Trucks, Rail	1.6	2.4	4.0	4.2	4.9	5.2	5.2	5.2
Domestic Aviation and Marine	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Other: Recreational, Commercial and Residential	0.8	0.4	0.4	0.5	0.5	0.5	0.5	0.5
Heavy Industry	**1.6**	**2.2**	**4.2**	**4.0**	**3.6**	**3.3**	**3.4**	**3.1**
Mining	1.0	1.3	3.3	3.0	2.6	2.6	2.6	2.5
Smelting and Refining (Non Ferrous Metals)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Pulp and Paper	0.3	0.2	0.1	0.1	0.1	0.1	0.1	0.1
Iron and Steel	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Cement	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Lime & Gypsum	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Chemicals & Fertilizers	0.2	0.6	0.7	0.7	0.8	0.5	0.6	0.5
Buildings	**3.2**	**3.3**	**3.3**	**3.1**	**3.3**	**3.3**	**3.1**	**3.3**
Service Industry	1.0	1.6	1.5	1.3	1.4	1.4	1.3	1.5
Residential	2.1	1.6	1.8	1.8	1.9	1.9	1.8	1.7
Agriculture	**10.2**	**16.1**	**15.3**	**16.2**	**17.6**	**17.3**	**17.6**	**17.7**
On Farm Fuel Use	2.4	3.5	4.1	4.0	4.5	4.8	4.7	4.6
Crop Production	3.5	4.7	5.0	5.9	6.9	6.3	6.7	6.9
Animal Production	4.3	7.9	6.2	6.3	6.3	6.2	6.2	6.2
Waste	**0.6**	**0.7**	**0.8**	**0.8**	**0.8**	**0.8**	**0.8**	**0.8**
Solid Waste	0.5	0.7	0.8	0.8	0.8	0.7	0.8	0.8
Wastewater	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1
Waste Incineration	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Coal Production	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
Light Manufacturing, Construction & Forest Resources	**0.6**	**0.4**	**0.7**	**0.7**	**0.7**	**0.9**	**0.8**	**0.6**
Light Manufacturing	0.5	0.2	0.5	0.5	0.4	0.6	0.5	0.4
Construction	0.1	0.2	0.2	0.2	0.2	0.2	0.3	0.2
Forest Resources	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Notes:

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Provincial/territorial GHG emissions allocated to IPCC sectors are provided in Annex 11 of this report.

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.

Emission estimates for Solid Waste include emissions from municipal solid waste landfills, wood waste landfills and municipal solid waste composting.

\- Indicates no emissions.

0 indicates emissions of less than 0.5 Mt CO_2 eq; truncated due to rounding

Table A12–10 **GHG Emissions for Alberta by Canadian Economic Sector, Selected Years**

	1990	2005	2011	2012	2013	2014	2015	2016
	Mt CO_2 eq							
NATIONAL GHG TOTAL	174.1	231.0	243.8	256.1	264.9	268.6	266.9	262.9
Oil and Gas	**68.9**	**97.0**	**104.8**	**114.3**	**120.7**	**124.1**	**123.2**	**126.0**
Upstream Oil and Gas	65.2	92.4	100.8	109.9	115.8	118.8	117.7	120.4
Natural Gas Production and Processing	29.2	43.4	32.8	35.1	35.8	33.8	31.5	34.1
Conventional Oil Production	16.8	12.6	12.9	15.2	15.6	16.8	14.7	12.6
Conventional Light Oil Production	9.4	7.9	6.9	7.9	8.6	9.8	8.9	8.0
Conventional Heavy Oil Production	7.4	4.7	6.1	7.2	7.0	7.0	5.8	4.6
Frontier Oil Production	-	-	-	-	-	-	-	-
Oil Sands (Mining, In-situ, Upgrading)	15.3	32.4	52.7	57.1	61.2	65.2	68.2	69.3
Mining and Extraction	4.5	9.5	14.1	14.3	15.5	16.8	17.4	17.5
In-situ	4.8	11.3	21.7	25.2	27.8	30.3	33.9	37.5
Upgrading	6.1	11.7	16.9	17.6	17.9	18.0	16.9	14.3
Oil and Natural Gas Transmission	3.9	4.0	2.3	2.5	3.2	3.1	3.4	4.3
Downstream Oil and Gas	3.6	4.6	4.0	4.4	5.0	5.3	5.4	5.6
Petroleum Refining	3.2	4.3	3.8	4.2	4.8	5.1	5.3	5.5
Natural Gas Distribution	0.4	0.3	0.2	0.2	0.2	0.2	0.2	0.2
Electricity	**39.6**	**48.8**	**46.2**	**43.5**	**44.7**	**45.8**	**47.8**	**45.2**
Transportation	**17.0**	**25.1**	**30.4**	**32.3**	**34.1**	**35.1**	**32.9**	**31.1**
Passenger Transport	8.8	10.3	10.2	11.0	11.7	12.2	11.8	12.1
Cars, Light Trucks and Motorcycles	7.7	9.0	8.9	9.5	10.2	10.7	10.3	10.7
Bus, Rail and Domestic Aviation	1.0	1.3	1.3	1.5	1.6	1.5	1.5	1.4
Freight Transport	5.7	13.4	19.1	20.3	21.2	21.6	19.8	17.9
Heavy Duty Trucks, Rail	5.5	13.2	19.0	20.1	21.0	21.4	19.6	17.7
Domestic Aviation and Marine	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Other: Recreational, Commercial and Residential	2.5	1.4	1.1	1.1	1.2	1.3	1.3	1.2
Heavy Industry	**12.4**	**16.7**	**17.3**	**17.1**	**17.9**	**17.2**	**17.6**	**16.6**
Mining	0.2	0.3	0.3	0.3	0.3	0.3	0.4	0.2
Smelting and Refining (Non Ferrous Metals)	0.4	0.6	0.8	0.0	0.8	0.7	0.7	0.6
Pulp and Paper	0.5	0.8	0.7	0.8	0.8	0.9	0.9	1.0
Iron and Steel	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Cement	1.2	1.8	1.7	1.6	1.5	1.4	1.5	1.3
Lime & Gypsum	0.2	0.3	0.2	0.2	0.2	0.2	0.2	0.2
Chemicals & Fertilizers	9.8	12.8	13.4	14.1	14.1	13.6	13.8	13.3
Buildings	**12.1**	**16.2**	**19.1**	**22.9**	**20.4**	**19.4**	**18.8**	**17.7**
Service Industry	5.3	8.5	10.2	14.1	11.6	10.2	10.3	10.4
Residential	6.9	7.7	8.9	8.8	8.9	9.3	8.4	7.3
Agriculture	**16.7**	**22.8**	**20.9**	**21.1**	**21.6**	**21.4**	**21.3**	**20.9**
On Farm Fuel Use	2.9	3.6	3.6	3.3	3.3	3.2	3.1	2.7
Crop Production	3.7	4.0	5.2	5.6	6.0	5.9	6.0	5.7
Animal Production	10.0	15.2	12.1	12.2	12.3	12.2	12.1	12.4
Waste	**1.2**	**1.7**	**1.6**	**1.7**	**1.8**	**1.9**	**1.9**	**2.0**
Solid Waste	1.1	1.6	1.5	1.6	1.6	1.7	1.7	1.8
Wastewater	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Waste Incineration	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1
Coal Production	**0.6**	**0.5**	**0.6**	**0.5**	**0.6**	**0.4**	**0.6**	**0.5**
Light Manufacturing, Construction & Forest Resources	**5.6**	**2.2**	**2.9**	**2.7**	**3.1**	**3.2**	**2.9**	**2.9**
Light Manufacturing	4.8	1.3	2.2	2.1	2.4	2.4	2.2	2.2
Construction	0.7	0.7	0.5	0.5	0.5	0.6	0.6	0.6
Forest Resources	0.1	0.2	0.2	0.1	0.2	0.2	0.2	0.1

Notes:

Totals may not add up due to rounding.

National GHG emissions allocated to IPCC sectors are provided in Annex 9 of this report.

Provincial/territorial GHG emissions allocated to IPCC sectors are provided in Annex 11 of this report.

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.

Emission estimates for Solid Waste include emissions from municipal solid waste landfills, wood waste landfills and municipal solid waste composting.

- Indicates no emissions.

0 indicates emissions of less than 0.5 Mt CO_2 eq; truncated due to rounding

Table A12–11 **GHG Emissions for British Columbia by Canadian Economic Sector, Selected Years**

	1990	2005	2011	2012	2013	2014	2015	2016
	Mt CO_2 eq							
NATIONAL GHG TOTAL	51.1	63.3	59.3	60.3	60.9	60.4	59.4	60.1
Oil and Gas	**7.5**	**11.9**	**14.4**	**14.2**	**14.5**	**14.5**	**13.5**	**13.3**
Upstream Oil and Gas	6.1	11.3	13.6	13.4	13.8	13.8	12.7	12.4
Natural Gas Production and Processing	3.9	9.2	11.9	11.7	11.8	11.9	10.6	10.2
Conventional Oil Production	0.7	0.7	0.6	0.6	0.6	0.6	0.6	0.6
Conventional Light Oil Production	0.7	0.7	0.6	0.6	0.6	0.6	0.6	0.6
Conventional Heavy Oil Production	-	-	-	-	-	-	-	-
Frontier Oil Production	-	-	-	-	-	-	-	-
Oil Sands (Mining, In-situ, Upgrading)	-	-	-	-	-	-	-	-
Mining and Extraction	-	-	-	-	-	-	-	-
In-situ	-	-	-	-	-	-	-	-
Upgrading	-	-	-	-	-	-	-	-
Oil and Natural Gas Transmission	1.5	1.4	1.1	1.0	1.4	1.2	1.5	1.7
Downstream Oil and Gas	1.5	0.6	0.7	0.8	0.7	0.7	0.8	0.8
Petroleum Refining	1.3	0.5	0.6	0.7	0.6	0.6	0.7	0.7
Natural Gas Distribution	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Electricity	**0.9**	**1.0**	**0.3**	**0.3**	**0.4**	**0.3**	**0.3**	**0.2**
Transportation	**15.8**	**21.5**	**19.9**	**21.3**	**21.7**	**21.6**	**22.1**	**22.0**
Passenger Transport	7.7	10.2	8.9	9.2	9.5	9.6	10.1	11.0
Cars, Light Trucks and Motorcycles	6.5	8.7	7.8	7.9	8.2	8.4	8.8	9.7
Bus, Rail and Domestic Aviation	1.2	1.5	1.1	1.2	1.3	1.3	1.3	1.3
Freight Transport	5.5	9.9	10.0	11.0	11.1	10.8	10.8	9.9
Heavy Duty Trucks, Rail	4.2	7.2	7.6	8.2	8.8	8.7	8.8	8.7
Domestic Aviation and Marine	1.2	2.7	2.4	2.8	2.3	2.1	2.0	1.1
Other: Recreational, Commercial and Residential	2.5	1.5	1.1	1.1	1.1	1.2	1.2	1.2
Heavy Industry	**8.7**	**7.1**	**5.8**	**5.7**	**5.4**	**5.7**	**5.7**	**6.3**
Mining	0.5	0.3	0.2	0.2	0.3	0.3	0.4	0.3
Smelting and Refining (Non Ferrous Metals)	2.0	1.7	1.4	1.4	1.3	1.0	0.9	1.3
Pulp and Paper	4.1	1.9	1.8	1.9	1.8	2.0	1.9	1.9
Iron and Steel	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Cement	1.0	2.0	1.6	1.5	1.5	1.8	2.0	2.1
Lime & Gypsum	0.2	0.3	0.3	0.2	0.2	0.3	0.2	0.2
Chemicals & Fertilizers	0.9	0.9	0.4	0.3	0.3	0.3	0.3	0.4
Buildings	**7.6**	**8.4**	**8.3**	**8.0**	**7.9**	**7.8**	**7.3**	**7.6**
Service Industry	3.0	3.7	3.6	3.6	3.5	3.6	3.2	3.3
Residential	4.6	4.7	4.7	4.4	4.4	4.2	4.2	4.2
Agriculture	**2.8**	**3.0**	**2.6**	**2.7**	**2.8**	**2.7**	**2.8**	**2.9**
On Farm Fuel Use	0.6	0.3	0.5	0.6	0.6	0.6	0.6	0.6
Crop Production	0.4	0.3	0.3	0.3	0.4	0.3	0.3	0.3
Animal Production	1.8	2.4	1.8	1.8	1.8	1.9	1.9	2.0
Waste	**3.6**	**4.2**	**4.1**	**3.9**	**3.8**	**3.7**	**3.7**	**3.7**
Solid Waste	3.4	4.0	3.9	3.7	3.5	3.5	3.5	3.5
Wastewater	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.2
Waste Incineration	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Coal Production	**1.8**	**1.7**	**1.8**	**2.0**	**2.0**	**1.8**	**1.6**	**1.8**
Light Manufacturing, Construction & Forest Resources	**2.6**	**4.3**	**2.2**	**2.3**	**2.5**	**2.2**	**2.3**	**2.4**
Light Manufacturing	1.5	3.1	1.3	1.5	1.6	1.4	1.4	1.5
Construction	0.6	0.5	0.4	0.4	0.4	0.3	0.4	0.5
Forest Resources	0.5	0.7	0.4	0.4	0.5	0.4	0.5	0.4

Notes:

Totals may not add up due to rounding.

National GHG emissions allocated to IPCC sectors are provided in Annex 9 of this report.

Provincial/territorial GHG emissions allocated to IPCC sectors are provided in Annex 11 of this report.

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.

Emission estimates for Solid Waste include emissions from municipal solid waste landfills, wood waste landfills and municipal solid waste composting.

- Indicates no emissions.

0 indicates emissions of less than 0.5 Mt CO_2 eq; truncated due to rounding

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Table A12–12 GHG Emissions for Yukon by Canadian Economic Sector, Selected Years	1990	2005	2011	2012	2013	2014	2015	2016
	Mt CO_2 eq							
NATIONAL GHG TOTAL	0.5	0.5	0.7	0.7	0.6	0.4	0.5	0.4
Oil and Gas	**0.0**	**0.1**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
Upstream Oil and Gas	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0
Natural Gas Production and Processing	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0
Conventional Oil Production	-	-	-	-	-	-	-	-
Conventional Light Oil Production	-	-	-	-	-	-	-	-
Conventional Heavy Oil Production	-	-	-	-	-	-	-	-
Frontier Oil Production	-	-	-	-	-	-	-	-
Oil Sands (Mining, In-situ, Upgrading)	-	-	-	-	-	-	-	-
Mining and Extraction	-	-	-	-	-	-	-	-
In-situ	-	-	-	-	-	-	-	-
Upgrading	-	-	-	-	-	-	-	-
Oil and Natural Gas Transmission	-	-	-	-	-	-	-	-
Downstream Oil and Gas	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Petroleum Refining	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Natural Gas Distribution	-	-	-	-	-	-	-	-
Electricity	**0.1**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
Transportation	**0.3**	**0.3**	**0.5**	**0.5**	**0.4**	**0.3**	**0.3**	**0.3**
Passenger Transport	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Cars, Light Trucks and Motorcycles	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Bus, Rail and Domestic Aviation	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Freight Transport	0.1	0.2	0.3	0.3	0.3	0.2	0.2	0.1
Heavy Duty Trucks, Rail	0.1	0.2	0.3	0.3	0.3	0.2	0.2	0.1
Domestic Aviation and Marine	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Other: Recreational, Commercial and Residential	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Heavy Industry	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
Mining	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Smelting and Refining (Non Ferrous Metals)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Pulp and Paper	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Iron and Steel	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Cement	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Lime & Gypsum	0.0	-	0.0	0.0	-	0.0	0.0	-
Chemicals & Fertilizers	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Buildings	**0.1**	**0.1**	**0.1**	**0.1**	**0.1**	**0.0**	**0.0**	**0.0**
Service Industry	0.1	0.0	0.1	0.1	0.1	0.0	0.0	0.0
Residential	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Agriculture	**0.0**	**0.0**	**-**	**-**	**-**	**-**	**-**	**0.0**
On Farm Fuel Use	0.0	0.0	-	-	-	-	-	0.0
Crop Production	-	-	-	-	-	-	-	-
Animal Production	-	-	-	-	-	-	-	-
Waste	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
Solid Waste	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Wastewater	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Waste Incineration	-	0.0	-	-	-	-	-	-
Coal Production	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
Light Manufacturing, Construction & Forest Resources	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
Light Manufacturing	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Construction	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Forest Resources	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Notes:

Totals may not add up due to rounding.

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Provincial/territorial GHG emissions allocated to IPCC sectors are provided in Annex 11 of this report.

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.

Emission estimates for Solid Waste include emissions from municipal solid waste landfills, wood waste landfills and municipal solid waste composting.

\- Indicates no emissions.

0 indicates emissions of less than 0.5 Mt CO_2 eq; truncated due to rounding

Table A12–13 **GHG Emissions for Northwest Territories by Canadian Economic Sector, Selected Years**

	1990	2005	2011	2012	2013	2014	2015	2016
	Mt CO_2 eq							
NATIONAL GHG TOTAL	1.2	1.6	1.4	1.5	1.4	1.5	1.7	1.6
Oil and Gas	**0.2**	**0.2**	**0.2**	**0.3**	**0.2**	**0.2**	**0.2**	**0.2**
Upstream Oil and Gas	0.2	0.2	0.2	0.3	0.2	0.2	0.2	0.2
Natural Gas Production and Processing	0.0	0.1	0.1	0.2	0.1	0.1	0.1	0.1
Conventional Oil Production	0.1	0.1	0.0	0.1	0.0	0.0	0.0	0.0
Conventional Light Oil Production	-	-	-	-	-	-	-	-
Conventional Heavy Oil Production	-	-	-	-	-	-	-	-
Frontier Oil Production	0.1	0.1	0.0	0.1	0.0	0.0	0.0	0.0
Oil Sands (Mining, In-situ, Upgrading)	-	-	-	-	-	-	-	-
Mining and Extraction	-	-	-	-	-	-	-	-
In-situ	-	-	-	-	-	-	-	-
Upgrading	-	-	-	-	-	-	-	-
Oil and Natural Gas Transmission	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Downstream Oil and Gas	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Petroleum Refining	0.0	-	0.0	0.0	0.0	0.0	0.0	0.0
Natural Gas Distribution	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Electricity	**0.1**	**0.1**	**0.1**	**0.1**	**0.1**	**x**	**x**	**x**
Transportation	**0.4**	**0.7**	**0.7**	**0.7**	**0.6**	**0.5**	**0.6**	**0.6**
Passenger Transport	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Cars, Light Trucks and Motorcycles	0.1	0.0	0.1	0.1	0.1	0.1	0.1	0.1
Bus, Rail and Domestic Aviation	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Freight Transport	0.2	0.5	0.5	0.5	0.4	0.3	0.3	0.4
Heavy Duty Trucks, Rail	0.2	0.5	0.5	0.4	0.4	0.3	0.3	0.3
Domestic Aviation and Marine	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Other: Recreational, Commercial and Residential	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Heavy Industry	**0.2**	**0.2**	**0.3**	**0.3**	**0.3**	**0.5**	**0.6**	**0.5**
Mining	0.2	0.2	0.3	0.3	0.3	0.5	0.6	0.5
Smelting and Refining (Non Ferrous Metals)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Pulp and Paper	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Iron and Steel	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Cement	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Lime & Gypsum	-	0.0	-	-	-	0.0	0.0	-
Chemicals & Fertilizers	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Buildings	**0.3**	**0.3**	**0.2**	**0.2**	**0.2**	**0.2**	**0.2**	**0.2**
Service Industry	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Residential	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Agriculture	**0.0**	**0.0**	**-**	**-**	**-**	**-**	**-**	**-**
On Farm Fuel Use	0.0	0.0	-	-	-	-	-	-
Crop Production	-	-	-	-	-	-	-	-
Animal Production	-	-	-	-	-	-	-	-
Waste	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
Solid Waste	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Wastewater	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Waste Incineration	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Coal Production	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
Light Manufacturing, Construction & Forest Resources	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**x**	**x**	**x**
Light Manufacturing	0.0	0.0	0.0	0.0	0.0	x	x	x
Construction	0.0	0.0	0.0	0.0	0.0	x	x	x
Forest Resources	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Notes:

Totals may not add up due to rounding.

National GHG emissions allocated to IPCC sectors are provided in Annex 9 of this report.

Provincial/territorial GHG emissions allocated to IPCC sectors are provided in Annex 11 of this report.

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.

Emission estimates for Solid Waste include emissions from municipal solid waste landfills, wood waste landfills and municipal solid waste composting.

- Indicates no emissions.

0 indicates emissions of less than 0.5 Mt CO_2 eq; truncated due to rounding

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Table A12–14 **GHG Emissions for Nunavut by Canadian Economic Sector, Selected Years**

	1990	2005	2011	2012	2013	2014	2015	2016
	Mt CO_2 eq							
NATIONAL GHG TOTAL	0.3	0.4	0.5	0.6	0.7	0.7	0.6	0.7
Oil and Gas	**0.0**	**x**	**x**	**x**	**0.0**	**0.0**	**0.0**	**0.0**
Upstream Oil and Gas	-	-	-	-	-	-	-	-
Natural Gas Production and Processing	-	-	-	-	-	-	-	-
Conventional Oil Production	-	-	-	-	-	-	-	-
Conventional Light Oil Production	-	-	-	-	-	-	-	-
Conventional Heavy Oil Production	-	-	-	-	-	-	-	-
Frontier Oil Production	-	-	-	-	-	-	-	-
Oil Sands (Mining, In-situ, Upgrading)	-	-	-	-	-	-	-	-
Mining and Extraction	-	-	-	-	-	-	-	-
In-situ	-	-	-	-	-	-	-	-
Upgrading	-	-	-	-	-	-	-	-
Oil and Natural Gas Transmission	-	x	x	x	-	-	-	-
Downstream Oil and Gas	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Petroleum Refining	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Natural Gas Distribution	-	-	-	-	-	-	-	-
Electricity	**0.0**	**0.1**	**x**	**x**	**0.1**	**x**	**x**	**x**
Transportation	**0.1**	**0.3**	**0.4**	**0.4**	**0.5**	**0.4**	**0.4**	**0.4**
Passenger Transport	0.1	0.1	0.1	0.1	0.2	0.2	0.1	0.2
Cars, Light Trucks and Motorcycles	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Bus, Rail and Domestic Aviation	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Freight Transport	0.0	0.1	0.2	0.2	0.4	0.2	0.2	0.2
Heavy Duty Trucks, Rail	0.0	0.1	0.2	0.2	0.2	0.1	0.1	0.1
Domestic Aviation and Marine	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1
Other: Recreational, Commercial and Residential	0.0	0.0	x	0.0	0.0	0.0	0.0	0.0
Heavy Industry	**0.1**	**0.0**	**0.0**	**0.0**	**0.0**	**0.1**	**0.1**	**0.1**
Mining	0.1	0.0	0.0	0.0	0.0	0.1	0.1	0.1
Smelting and Refining (Non Ferrous Metals)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Pulp and Paper	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Iron and Steel	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Cement	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Lime & Gypsum	-	-	-	-	-	-	-	-
Chemicals & Fertilizers	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Buildings	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
Service Industry	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Residential	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Agriculture	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
On Farm Fuel Use	-	-	-	-	-	-	-	-
Crop Production	-	-	-	-	-	-	-	-
Animal Production	-	-	-	-	-	-	-	-
Waste	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
Solid Waste	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Wastewater	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Waste Incineration	-	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Coal Production	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
Light Manufacturing, Construction & Forest Resources	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**x**	**x**	**x**
Light Manufacturing	0.0	0.0	0.0	0.0	0.0	x	x	x
Construction	0.0	0.0	0.0	0.0	0.0	x	x	x
Forest Resources	-	-	-	-	-	-	-	-

Notes:

Totals may not add up due to rounding.

National GHG emissions allocated to IPCC sectors are provided in Annex 9 of this report.

Provincial/territorial GHG emissions allocated to IPCC sectors are provided in Annex 11 of this report.

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.

Emission estimates for Solid Waste include emissions from municipal solid waste landfills, wood waste landfills and municipal solid waste composting.

- Indicates no emissions.

0 indicates emissions of less than 0.5 Mt CO_2 eq; truncated due to rounding

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Table A12–15 **GHG Emissions for Northwest Territories & Nunavut by Canadian Economic Sector, 1990–1998**

	1990	1991	1992	1993	1994	1995	1996	1997	1998
	Mt CO_2 eq								
NATIONAL GHG TOTAL	1.6	1.6	1.4	1.7	1.8	1.9	1.9	1.7	1.5
Oil and Gas	**0.4**	**0.3**	**0.2**	**0.2**	**0.2**	**0.2**	**0.2**	**0.1**	**0.1**
Upstream Oil and Gas	0.4	0.3	0.2	0.2	0.2	0.2	0.2	0.1	0.1
Natural Gas Production and Processing	0.1	0.1	0.0	0.1	0.0	0.0	0.0	0.0	0.0
Conventional Oil Production	0.3	0.2	0.2	0.2	0.2	0.2	0.2	0.1	0.1
Conventional Light Oil Production	-	-	-	-	-	-	-	-	-
Conventional Heavy Oil Production	-	-	-	-	-	-	-	-	-
Frontier Oil Production	0.3	0.2	0.2	0.2	0.2	0.2	0.2	0.1	0.1
Oil Sands (Mining, In-situ, Upgrading)	-	-	-	-	-	-	-	-	-
Mining and Extraction	-	-	-	-	-	-	-	-	-
In-situ	-	-	-	-	-	-	-	-	-
Upgrading	-	-	-	-	-	-	-	-	-
Oil and Natural Gas Transmission	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Downstream Oil and Gas	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Petroleum Refining	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Natural Gas Distribution	-	-	-	-	-	-	-	-	-
Electricity	**0.2**	**0.2**	**0.1**	**0.1**	**0.1**	**0.2**	**0.1**	**0.1**	**0.2**
Transportation	**0.5**	**0.4**	**0.4**	**0.5**	**0.5**	**0.5**	**0.5**	**0.5**	**0.6**
Passenger Transport	0.3	0.2	0.2	0.3	0.3	0.3	0.3	0.3	0.3
Cars, Light Trucks and Motorcycles	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Bus, Rail and Domestic Aviation	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Freight Transport	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.2
Heavy Duty Trucks, Rail	0.1	0.1	0.0	0.1	0.1	0.1	0.1	0.1	0.2
Domestic Aviation and Marine	0.1	0.0	0.0	0.1	0.1	0.1	0.0	0.0	0.0
Other: Recreational, Commercial and Residential	0.1	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.1
Heavy Industry	**0.1**	**0.1**	**0.1**	**0.1**	**0.3**	**0.3**	**0.4**	**0.3**	**0.3**
Mining	0.1	0.1	0.1	0.1	0.2	0.3	0.4	0.3	0.3
Smelting and Refining (Non Ferrous Metals)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Pulp and Paper	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Iron and Steel	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Cement	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Lime & Gypsum	0.0	0.0	0.0	0.0	0.0	0.0	-	-	-
Chemicals & Fertilizers	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Buildings	**0.4**	**0.6**	**0.6**	**0.6**	**0.7**	**0.7**	**0.6**	**0.6**	**0.3**
Service Industry	0.3	0.4	0.4	0.4	0.5	0.6	0.4	0.4	0.2
Residential	0.2	0.2	0.2	0.2	0.2	0.1	0.2	0.2	0.1
Agriculture	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**-**	**0.0**	**0.0**
On Farm Fuel Use	0.0	0.0	0.0	0.0	0.0	0.0	-	0.0	0.0
Crop Production	-	-	-	-	-	-	-	-	-
Animal Production	-	-	-	-	-	-	-	-	-
Waste	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
Solid Waste	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Wastewater	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Waste Incineration	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Coal Production	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
Light Manufacturing, Construction & Forest Resources	**0.1**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
Light Manufacturing	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Construction	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Forest Resources	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Notes:

Totals may not add up due to rounding.

National GHG emissions allocated to IPCC sectors are provided in Annex 9 of this report.

Provincial/territorial GHG emissions allocated to IPCC sectors are provided in Annex 11 of this report.

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.

Emission estimates for Solid Waste include emissions from municipal solid waste landfills, wood waste landfills and municipal solid waste composting.

\- Indicates no emissions.

0 indicates emissions of less than 0.5 Mt CO_2 eq; truncated due to rounding

Annex 13

ELECTRICITY IN CANADA: SUMMARY AND INTENSITY TABLES

This annex presents detailed greenhouse gas (GHG) information related to the generation of electricity by the Public Electricity and Heat Production category (IPCC Category 1.A.1.a), on a national and provincial level.

The Canadian electricity generation industry produces electricity by transforming the energy in falling water, coal, natural gas, refined petroleum products (RPPs), other miscellaneous fuels, biomass, nuclear, wind and solar resources. The process of supplying electricity to the public involves not only power generation at the plant, but also distribution through the electricity grid. The efficiency of the transmission system has an impact on the amount of electricity available to consumers. GHG emission estimates and electricity generation values are therefore based on activities that occur at the generating plant, and efforts have been made to include the impact of the transmission and distribution infrastructure (including sulphur hexafluoride (SF_6) emissions associated with switchgear and other electrical equipment, which is accounted for in the Industrial Processes and Product Use Sector).

The electricity generation industry in Canada is composed of entities whose main activity is the production of electricity (main activity producers) and those who generate either partially or wholly for their own use (autoproducers). Main activity producers sell their electricity to the grid, and can be either public or private generators. Autoproducers are generally private companies that are generating electricity either to feed their operations or as a by-product of their operation. They may sell some or all of their electricity to the grid.

The analysis in this section only includes main activity producers. This analysis relies on a variety of data sources; fuel consumption and electricity production data are published by Statistics Canada in the *Report on Energy Supply and Demand in Canada* (RESD) (Statistics Canada 57-003-X), in the publication *Electric Power Generation, Transmission and Distribution* (EPGTD) (Statistics Canada 57-202-X) and online via CANSIM (Tables 127-0006,127-0007 and 127-0008).

A "generation intensity" indicator is derived to reflect the GHG emissions intensity of electricity as it is delivered to the electricity grid. Electricity generation intensity values were derived for each fuel type using GHG emission estimates and electricity generation data. The methodology used to develop the GHG emissions is discussed in Chapter 3 and Annex 3.1 of this report. GHG emissions are based on the total fuel consumed by the public utility sector, as provided in the RESD,[1] while generation data are from CANSIM (2005–2016) and the EPGTD publication (1990–2004).

A "consumption intensity" indicator was also derived to reflect the GHG emissions intensity of electricity as it is delivered to the consumer. Accordingly, electric energy losses in transmission and distribution are subtracted from overall total electricity generation, while SF_6 emissions associated with equipment used in electricity transmission and distribution are added to overall total GHG emissions. The electric energy losses in transmission and distribution are taken to be the utility sector's share of "unallocated energy," as presented in Table A13–1 to Table A13–14 and calculated from data provided by CANSIM 127-0008. Likewise, the SF_6 emission values are based on the electric utility sector's share of total SF_6 emissions from equipment used in electricity transmission and distribution.

Electricity intensity values for Canada, the provinces and the territories are provided in Table A13–1 to Table A13–14.

1 Occasionally, Statistics Canada revises some of its historic data, which can affect the values provided in Table A13–1 to Table A13–14.

Table A13–1 **Electricity Generation and GHG Emission Details for Canada[1]**

	1990	2000	2005	2011	2012	2013	2014	2015	2016[2]
Greenhouse Gas Emissions[3]									
	kt CO_2 equivalent								
Combustion	**94 300**	**132 000**	**125 000**	**94 200**	**91 000**	**87 200**	**84 300**	**87 300**	**84 500**
Coal	80 200	109 000	97 900	68 400	63 100	63 600	60 800	62 700	60 000
Natural Gas	2 720	13 800	15 400	21 700	23 900	19 300	18 600	19 300	19 000
Other Fuels[4]	11 300	9 400	11 300	4 050	3 980	4 280	4 930	5 370	5 600
Other Emissions[5]	**–**	**27.2**	**52**	**61**	**82**	**63**	**73**	**87**	**80**
Overall Total[6,7]	**94 300**	**132 000**	**125 000**	**94 200**	**91 000**	**87 200**	**84 400**	**87 400**	**84 600**
Electricity Generation[8,9]									
	GWh								
Combustion[10]	**101 000**	**146 000**	**140 000**	**119 000**	**107 000**	**104 000**	**110 000**	**111 000**	**108 000**
Coal	82 200	106 000	93 900	70 200	60 200	60 900	61 600	60 900	58 000
Natural Gas	4 140	26 600	29 800	41 000	39 100	35 600	40 000	41 000	41 400
Other Fuels	14 800	13 400	16 700	7 670	7 460	7 900	8 640	8 630	8 670
Refined Petroleum Products	14 700	10 600	10 800	2 310	2 320	2 160	3 170	3 560	3 440
Biomass	14.4	1 830	1 780	2 150	1 990	2 050	2 030	1 980	2 220
Other	91	960	4 100	3 200	3 100	3 700	3 400	3 100	3 000
Nuclear	**68 800**	**68 700**	**86 800**	**88 300**	**89 500**	**97 600**	**101 200**	**96 000**	**95 400**
Hydro	**263 000**	**323 000**	**327 000**	**342 000**	**345 000**	**357 000**	**348 000**	**345 000**	**353 000**
Other Renewables[11]	**26.2**	**264**	**1 580**	**10 370**	**11 500**	**11 400**	**12 900**	**27 500**	**31 100**
Other Generation[12,13]	**–**	**–**	**–**	**9 000**	**10 260**	**9 550**	**2 240**	**140**	**130**
Overall Total[7]	**433 000**	**539 000**	**556 000**	**575 000**	**570 000**	**587 000**	**575 000**	**580 000**	**588 000**
Greenhouse Gas Intensity[14]									
	g GHG / kWh electricity generated								
CO_2 intensity (g CO_2 / kWh)	220	240	220	160	160	150	150	150	140
CH_4 intensity (g CH_4 / kWh)	0.004	0.009	0.01	0.01	0.01	0.01	0.01	0.01	0.01
N_2O intensity (g N_2O / kWh)	0.004	0.005	0.004	0.003	0.003	0.003	0.003	0.003	0.003
Generation Intensity (g CO_2 eq / kWh)[7]	**220**	**240**	**220**	**170**	**160**	**150**	**150**	**150**	**140**
Unallocated Energy (GWh)[17,18]	31 000	42 000	37 000	57 000	46 000	41 000	29 000	19 000*	8 000
SF_6 Emissions (kt CO_2 eq)[17]	200	200	160	140	190	220	130	190	190
Consumption Intensity (g CO_2 eq / kWh)[18]	**240**	**270**	**240**	**180**	**180**	**160**	**150**	**160**	**150**

Notes:

1. Data presented include emissions, generation and intensity for facilities classified under NAICS code 22111 – Electric Power Generation.
2. Preliminary data.
3. Emissions based on data taken from the *Report on Energy Supply-Demand in Canada*, Catalogue No. 57-003-XIB, Statistics Canada.
4. Includes GHG emissions from the combustion of refined petroleum products (light fuel oil, heavy fuel oil, and diesel), petroleum coke, still gas and other fuels not easily categorized.
5. GHG emissions from on-site combustion of fuel not directly related to electricity generation.
6. GHG emissions from the flooding of land for hydro dams are not included.
7. Totals may not add up to overall total due to rounding.
8. Taken from CANSIM Tables 127-0006 and 127-0007 (for 2005–2016).
9. Taken from the *Electric Power Generation, Transmission and Distribution* (EPGTD) publication, Catalogue No. 57-202-XIB, Statistics Canada (for 1990–2004).
10. From 2014 onward, this includes the electricity generated from the by-product steam associated with the fuel combustion. Prior to 2014, it was not possible to break this data into the original fuel source, so it was included in Other Generation.
11. Other Renewables - includes electricity generation by wind, tidal and solar.
12. NAICS category 221119, Other Electric Power Generation.
13. Prior to 2014, this includes electricity generation from steam from waste heat. From 2014 onward, electricity generation from steam from waste heat is reported as part of its original fuel source.
14. Intensity values have been rounded so as to present the estimated level of accuracy.
15. Adapted from Statistics Canada CANSIM Table 127-0008 (2005-2016) or Cat. No. 57-202-XIB (1990–2004).
16. Includes transmission line losses, metering differences and other losses.
17. The electric utility sector's share of emissions from electrical equipment from CRF Category 2.F.viii (Production and Consumption of Halocarbons and SF_6).
18. Consumption intensity values are impacted by unallocated energy and SF_6 transmission emissions.

– Indicates no emissions or no electricity generation

0 Indicates emissions or electricity generation value less than 0.1

* For years where unallocated energy data was not available, values were interpolated

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Table A13–2 **Electricity Generation and GHG Emission Details for Newfoundland and Labrador[1]**

	1990	2000	2005	2011	2012	2013	2014	2015	2016[2]
Greenhouse Gas Emissions[3]									
	kt CO_2 equivalent								
Combustion	**1 640**	**823**	**819**	**790**	**769**	**867**	**1 206**	**1 340**	**1 523**
Coal	–	–	–	–	–	–	–	–	–
Natural Gas	–	–	–	–	–	–	–	–	–
Other Fuels[4]	1 640	823	819	790	769	867	1 206	1 340	1 523
Other Emissions[5]	**–**	**–**	**–**	**–**	**–**	**–**	**–**	**–**	**–**
Overall Total[6,7]	**1 640**	**823**	**819**	**790**	**769**	**867**	**1 206**	**1 340**	**1 523**
Electricity Generation[8,9]									
	GWh								
Combustion[10]	**2 090**	**1 020**	**1 360**	**1 009**	**970**	**1 090**	**1 470**	**1 560**	**1 800**
Coal	–	–	–	–	–	–	–	–	–
Natural Gas	–	–	–	–	–	–	–	–	–
Other Fuels	2 090	1 020	1 360	1 009	970	1 090	1 470	1 560	1 800
Nuclear	**–**	**–**	**–**	**–**	**–**	**–**	**–**	**–**	**–**
Hydro	**34 300**	**41 800**	**38 900**	**39 100**	**41 300**	**40 500**	**38 200**	**38 800**	**38 600**
Other Renewables[11]	**0**	**–**	**–**	**198**	**195**	**192**	**177**	**172**	**190**
Other Generation[12,13]	**–**	**–**	**–**	**–**	**–**	**–**	**–**	**–**	**–**
Overall Total[7]	**36 400**	**42 800**	**40 300**	**40 300**	**42 500**	**41 800**	**39 800**	**40 500**	**40 600**
Greenhouse Gas Intensity[14]									
	g GHG / kWh electricity generated								
CO_2 intensity (g CO_2 / kWh)	45	19	20	19	18	21	30	33	37
CH_4 intensity (g CH_4 / kWh)	0.0006	0.0002	0.0002	0.0003	0.0003	0.0003	0.0004	0.0005	0.0006
N_2O intensity (g N_2O / kWh)	0.001	0.0005	0.0	0.0	0.0	0.0	0.001	0.001	0.001
Generation Intensity (g CO_2 eq / kWh)[7]	**45**	**19**	**20**	**20**	**18**	**21**	**30**	**33**	**37**
Unallocated Energy (GWh)[17,18]	990	1 300	810	1 300	1 300	1 400	1 200	900	2 400
SF_6 Emissions (kt CO_2 eq)[17]	0.94	0.92	0.50	0.83	1.0	1.0	1.3	3.4	3.4
Consumption Intensity (g CO_2 eq / kWh)[18]	**46**	**20**	**21**	**20**	**19**	**21**	**31**	**34**	**40**

Notes:

1. Data presented include emissions, generation and intensity for facilities classified under NAICS code 22111 – Electric Power Generation.
2. Preliminary data.
3. Emissions based on data taken from the *Report on Energy Supply-Demand in Canada*, Catalogue No. 57-003-XIB, Statistics Canada.
4. Includes GHG emissions from the combustion of refined petroleum products (light fuel oil, heavy fuel oil, and diesel), petroleum coke, still gas and other fuels not easily categorized.
5. GHG emissions from on-site combustion of fuel not directly related to electricity generation.
6. GHG emissions from the flooding of land for hydro dams are not included.
7. Totals may not add up to overall total due to rounding.
8. Taken from CANSIM Tables 127-0006 and 127-0007 (for 2005–2016).
9. Taken from the *Electric Power Generation, Transmission and Distribution* (EPGTD) publication, Catalogue No. 57-202-XIB, Statistics Canada (for 1990–2004).
10. From 2014 onward, this includes the electricity generated from the by-product steam associated with the fuel combustion. Prior to 2014, it was not possible to break this data into the original fuel source, so it was included in Other Generation.
11. Other Renewables – includes electricity generation by wind, tidal and solar.
12. NAICS category 221119, Other Electric Power Generation.
13. Prior to 2014, this includes electricity generation from steam from waste heat. From 2014 onward, electricity generation from steam from waste heat is reported as part of its original fuel source.
14. Intensity values have been rounded so as to present the estimated level of accuracy.
15. Adapted from Statistics Canada CANSIM Table 127-0008 (2005–2016) or Cat. No. 57-202-XIB (1990–2004).
16. Includes transmission line losses, metering differences and other losses.
17. The electric utility sector's share of emissions from electrical equipment from CRF Category 2.F.viii (Production and Consumption of Halocarbons and SF_6).
18. Consumption intensity values are impacted by unallocated energy and SF_6 transmission emissions.

– Indicates no emissions or no electricity generation

0 Indicates emissions or electricity generation value less than 0.1

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Table A13–3 **Electricity Generation and GHG Emission Details for Prince Edward Island[1]**

	1990	2000	2005	2011	2012	2013	2014	2015	2016[2]
Greenhouse Gas Emissions[3]									
	kt CO_2 equivalent								
Combustion	**104**	**53.0**	**4.76**	**1.23**	**10.8**	**3.9**	**4.3**	**13.9**	**14.6**
Coal	–	–	–	–	–	–	–	–	–
Natural Gas	–	–	–	–	–	–	–	–	–
Other Fuels[4]	104	53.0	4.76	1.23	10.8	3.9	4.3	13.9	14.6
Other Emissions[5]	**–**	**–**	**–**	**–**	**–**	**–**	**–**	**–**	**–**
Overall Total[6,7]	**104**	**53.0**	**4.76**	**1.23**	**10.8**	**3.9**	**4.3**	**13.9**	**14.6**
Electricity Generation[8,9]									
	GWh								
Combustion[10]	**81.1**	**48.1**	**6.31**	**4.81**	**14.5**	**8.2**	**8.3**	**9.8**	**9.9**
Coal	–	–	–	–	–	–	–	–	–
Natural Gas	–	–	–	–	–	–	–	–	–
Other Fuels	81.1	48.1	6.31	4.81	14.5	8.2	8.3	9.8	9.9
Nuclear	**–**	**–**	**–**	**–**	**–**	**–**	**–**	**–**	**–**
Hydro	**–**	**–**	**–**	**–**	**–**	**–**	**–**	**–**	**–**
Other Renewables[11]	**–**	**–**	**40.1**	**488**	**468**	**499**	**611**	**606**	**565**
Other Generation[12,13]	**–**	**–**	**–**	**–**	**–**	**–**	**–**	**–**	**–**
Overall Total[7]	**81.1**	**48.1**	**46.4**	**492**	**482**	**507**	**620**	**616**	**575**
Greenhouse Gas Intensity[14]									
	g GHG / kWh electricity generated								
CO_2 intensity (g CO_2 / kWh)	1 300	1 100	100	2.5	22	8	7	22	25
CH_4 intensity (g CH_4 / kWh)	0.02	0.01	0.001	0.00006	0.0005	0.0002	0.0001	0.0007	0.0005
N_2O intensity (g N_2O / kWh)	0.03	0.02	0.002	0.0001	0.0004	0.0001	0.0001	0.0004	0.0005
Generation Intensity (g CO_2 eq / kWh)[7]	**1 300**	**1 100**	**100**	**2.5**	**22**	**8**	**7**	**23**	**25**
Unallocated Energy (GWh)[17,18]	unk	unk	unk	21	20	20	33	9.4*	8.9*
SF_6 Emissions (kt CO_2 eq)[17]	0	0	–	0	0	0	0	0	0
Consumption Intensity (g CO_2 eq / kWh)[18]	**	**	**	**	**	**	**	**	**

Notes:

1. Data presented include emissions, generation and intensity for facilities classified under NAICS code 22111 – Electric Power Generation.
2. Preliminary data.
3. Emissions based on data taken from the *Report on Energy Supply-Demand in Canada*, Catalogue No. 57-003-XIB, Statistics Canada.
4. Includes GHG emissions from the combustion of refined petroleum products (light fuel oil, heavy fuel oil, and diesel), petroleum coke, still gas and other fuels not easily categorized.
5. GHG emissions from on-site combustion of fuel not directly related to electricity generation.
6. GHG emissions from the flooding of land for hydro dams are not included.
7. Totals may not add up to overall total due to rounding.
8. Taken from CANSIM Tables 127-0006 and 127-0007 (for 2005–2016).
9. Taken from the *Electric Power Generation, Transmission and Distribution* (EPGTD) publication, Catalogue No. 57-202-XIB, Statistics Canada (for 1990–2004).
10. From 2014 onward, this includes the electricity generated from the by-product steam associated with the fuel combustion. Prior to 2014, it was not possible to break this data into the original fuel source, so it was included in Other Generation.
11. Other Renewables – includes electricity generation by wind, tidal and solar.
12. NAICS category 221119, Other Electric Power Generation.
13. Prior to 2014, this includes electricity generation from steam from waste heat. From 2014 onward, electricity generation from steam from waste heat is reported as part of its original fuel source.
14. Intensity values have been rounded so as to present the estimated level of accuracy.
15. Adapted from Statistics Canada CANSIM Table 127-0008 (2005-2016) or Cat. No. 57-202-XIB (1990–2004).
16. Includes transmission line losses, metering differences and other losses.
17. The electric utility sector's share of emissions from electrical equipment from CRF Category 2.F.viii (Production and Consumption of Halocarbons and SF_6).
18. Consumption intensity values are impacted by unallocated energy and SF_6 transmission emissions.

– Indicates no emissions or no electricity generation

0 Indicates emissions or electricity generation value less than 0.1

unk Indicates unknown as appropriate data were unavailable

* For years where unallocated energy data was not available, values were interpolated

** Due to the high level of imports from New Brunswick, values for New Brunswick are more indicative of GHG consumption intensity.

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Table A13–4 **Electricity Generation and GHG Emission Details for Nova Scotia**[1]

	1990	2000	2005	2011	2012	2013	2014	2015	2016[2]
	Greenhouse Gas Emissions[3]								
	kt CO_2 equivalent								
Combustion	**6 900**	**9 430**	**10 700**	**8 450**	**7 620**	**7 530**	**7 200**	**6 970**	**6 580**
Coal	x	8 150	5 460	6 090	5 110	5 100	4 800	4 400	4 350
Natural Gas	–	–	x	x	x	x	760	690	550
Other Fuels[4]	x	1 280	x	x	x	x	1 640	1 890	1 680
Other Emissions[5]	–	–	–	–	–	–	–	–	–
Overall Total[6,7]	**6 900**	**9 430**	**10 700**	**8 450**	**7 620**	**7 530**	**7 200**	**6 970**	**6 580**
	Electricity Generation[8,9]								
	GWh								
Combustion[10]	**8 440**	**10 500**	**11 100**	**9 500**	**9 210**	**8 770**	**8 560**	**8 220**	**7 820**
Coal	6 020	8 850	6 770	6 020	5 390	5 500	5 250	4 870	4 810
Natural Gas	–	–	181	2 430	2 260	1 370	1 470	1 300	1 240
Other Fuels	2 430	1 610	4 110	1 050	1 560	1 890	1 840	2 050	1 770
Nuclear	–	–	–	–	–	–	–	–	–
Hydro	**1 120**	**887**	**1 040**	**1 070**	**806**	**964**	**1 096**	**1 009**	**862**
Other Renewables[11]	**26.1**	**0**	**113**	**809**	**827**	**780**	**764**	**821**	**1 045**
Other Generation[12,13]	–	–	–	–	–	–	–	–	–
Overall Total[7]	**9 590**	**11 300**	**12 200**	**11 400**	**10 800**	**10 500**	**10 400**	**10 000**	**9 700**
	Greenhouse Gas Intensity[14]								
	g GHG / kWh electricity generated								
CO_2 intensity (g CO_2 / kWh)	720	830	880	740	700	710	690	690	670
CH_4 intensity (g CH_4 / kWh)	0.007	0.009	0.02	0.04	0.04	0.03	0.03	0.03	0.02
N_2O intensity (g N_2O / kWh)	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Generation Intensity (g CO_2 eq / kWh)[7]	**720**	**830**	**880**	**740**	**700**	**720**	**690**	**690**	**680**
Unallocated Energy (GWh)[17,18]	580	830	770	640	1 200	600	400*	200	200*
SF_6 Emissions (kt CO_2 eq)[17]	23	23	29	33	22	39	33	33	33
Consumption Intensity (g CO_2 eq / kWh)[18]	**770**	**900**	**940**	**790**	**790**	**760**	**720**	**710**	**690**

Notes:

1. Data presented include emissions, generation and intensity for facilities classified under NAICS code 22111– Electric Power Generation.
2. Preliminary data.
3. Emissions based on data taken from the *Report on Energy Supply-Demand in Canada*, Catalogue No. 57-003-XIB, Statistics Canada.
4. Includes GHG emissions from the combustion of refined petroleum products (light fuel oil, heavy fuel oil, and diesel), petroleum coke, still gas and other fuels not easily categorized.
5. GHG emissions from on-site combustion of fuel not directly related to electricity generation.
6. GHG emissions from the flooding of land for hydro dams are not included.
7. Totals may not add up to overall total due to rounding.
8. Taken from CANSIM Tables 127-0006 and 127-0007 (for 2005–2016).
9. Taken from the *Electric Power Generation, Transmission and Distribution* (EPGTD) publication, Catalogue No. 57-202-XIB, Statistics Canada (for 1990–2004).
10. From 2014 onward, this includes the electricity generated from the by-product steam associated with the fuel combustion. Prior to 2014, it was not possible to break this data into the original fuel source, so it was included in Other Generation.
11. Other Renewables – includes electricity generation by wind, tidal and solar.
12. NAICS category 221119, Other Electric Power Generation.
13. Prior to 2014, this includes electricity generation from steam from waste heat. From 2014 onward, electricity generation from steam from waste heat is reported as part of its original fuel source.
14. Intensity values have been rounded so as to present the estimated level of accuracy.
15. Adapted from Statistics Canada CANSIM Table 127-0008 (2005-2016) or Cat. No. 57-202-XIB (1990–2004).
16. Includes transmission line losses, metering differences and other losses.
17. The electric utility sector's share of emissions from electrical equipment from CRF Category 2.F.viii (Production and Consumption of Halocarbons and SF_6).
18. Consumption intensity values are impacted by unallocated energy and SF_6 transmission emissions.

– Indicates no emissions or no electricity generation

0 Indicates emissions or electricity generation value less than 0.1

x Indicates data not shown due to statistical limitations

* For years where unallocated energy data was not available, values were interpolated

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Table A13–5 **Electricity Generation and GHG Emission Details for New Brunswick[1]**

	1990	2000	2005	2011	2012	2013	2014	2015	2016[2]
					Greenhouse Gas Emissions[3]				
					kt CO_2 equivalent				
Combustion	**6 020**	**8 970**	**8 060**	**4 920**	**4 060**	**4 190**	**4 390**	**3 950**	**4 920**
Coal	1 180	3 130	2 910	x	x	x	1 930	1 410	2 180
Natural Gas	–	–	x	x	x	x	1 040	1 040	1 000
Other Fuels[4]	4 840	5 840	x	1 620	1 330	1 150	1 410	1 500	1 740
Other Emissions[5]	**–**	**–**	**–**	**–**	**–**	**–**	**–**	**–**	**–**
Overall Total[6,7]	**6 020**	**8 970**	**8 060**	**4 920**	**4 060**	**4 190**	**4 390**	**3 950**	**4 920**
					Electricity Generation[8,9]				
					GWh				
Combustion[10]	**7 630**	**11 000**	**12 100**	**6 040**	**5 160**	**5 310**	**6 980**	**5 630**	**6 100**
Coal	1 270	3 820	2 920	2 340	1 900	2 250	2 560	1 660	2 160
Natural Gas	–	–	1 970	1 960	1 780	1 770	2 570	2 320	2 360
Other Fuels	6 360	7 210	7 210	1 740	1 490	1 290	1 850	1 650	1 580
Nuclear	**5 340**	**3 960**	**4 380**	**–**	**414**	**4 481**	**5 012**	**4 277**	**4 545**
Hydro	**3 460**	**3 220**	**3 820**	**3 840**	**2 860**	**3 400**	**2 960**	**2 620**	**3 130**
Other Renewables[11]	**–**	**–**	**–**	**693**	**733**	**737**	**786**	**792**	**856**
Other Generation[12,13]	**–**	**–**	**–**	**–**	**–**	**–**	**–**	**–**	**–**
Overall Total[7]	**16 400**	**18 200**	**20 300**	**11 900**	**10 300**	**15 100**	**15 700**	**13 300**	**14 600**
					Greenhouse Gas Intensity[14]				
					g GHG / kWh electricity generated				
CO_2 intensity (g CO_2 / kWh)	360	490	390	440	420	290	280	290	330
CH_4 intensity (g CH_4 / kWh)	0.004	0.005	0.01	0.03	0.03	0.02	0.02	0.02	0.02
N_2O intensity (g N_2O / kWh)	0.007	0.009	0.007	0.007	0.007	0.004	0.004	0.005	0.005
Generation Intensity (g CO_2 eq / kWh)[7]	**370**	**490**	**400**	**440**	**420**	**290**	**280**	**300**	**340**
Unallocated Energy (GWh)[17,18]	990	1 300	1 100	160	160*	349*	445*	352	432
SF_6 Emissions (kt CO_2 eq)[17]	0.71	0.70	–	0.61	0.53	0.82	0.58	0.83	0.83
Consumption Intensity (g CO_2 eq / kWh)[18]	**390**	**530**	**420**	**440**	**430**	**300**	**290**	**300**	**350**

Notes:

1. Data presented include emissions, generation and intensity for facilities classified under NAICS code 22111 – Electric Power Generation.
2. Preliminary data.
3. Emissions based on data taken from the *Report on Energy Supply-Demand in Canada*, Catalogue No. 57-003-XIB, Statistics Canada.
4. Includes GHG emissions from the combustion of refined petroleum products (light fuel oil, heavy fuel oil, and diesel), petroleum coke, still gas and other fuels not easily categorized.
5. GHG emissions from on-site combustion of fuel not directly related to electricity generation.
6. GHG emissions from the flooding of land for hydro dams are not included.
7. Totals may not add up to overall total due to rounding.
8. Taken from CANSIM Tables 127-0006 and 127-0007 (for 2005–2016).
9. Taken from the *Electric Power Generation, Transmission and Distribution* (EPGTD) publication, Catalogue No. 57-202-XIB, Statistics Canada (for 1990–2004).
10. From 2014 onward, this includes the electricity generated from the by-product steam associated with the fuel combustion. Prior to 2014, it was not possible to break this data into the original fuel source, so it was included in Other Generation.
11. Other Renewables – includes electricity generation by wind, tidal and solar.
12. NAICS category 221119, Other Electric Power Generation.
13. Prior to 2014, this includes electricity generation from steam from waste heat. From 2014 onward, electricity generation from steam from waste heat is reported as part of its original fuel source.
14. Intensity values have been rounded so as to present the estimated level of accuracy.
15. Adapted from Statistics Canada CANSIM Table 127-0008 (2005–2016) or Cat. No. 57-202-XIB (1990–2004).
16. Includes transmission line losses, metering differences and other losses.
17. The electric utility sector's share of emissions from electrical equipment from CRF Category 2.F.viii (Production and Consumption of Halocarbons and SF_6).
18. Consumption intensity values are impacted by unallocated energy and SF_6 transmission emissions.

– Indicates no emissions or no electricity generation

0 Indicates emissions or electricity generation value less than 0.1

x Indicates data not shown due to statistical limitations

unk Indicates unknown as appropriate data were unavailable

* For years where unallocated energy data was not available, values were interpolated

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Table A13–6 Electricity Generation and GHG Emission Details for Quebec[1]

	1990	2000	2005	2011	2012	2013	2014	2015	2016[2]
Greenhouse Gas Emissions[3]									
	kt CO_2 equivalent								
Combustion	**1 500**	**569**	**617**	**404**	**488**	**371**	**248**	**208**	**237**
Coal	–	–	–	–	–	–	–	–	–
Natural Gas	x	x	x	x	x	x	x	x	x
Other Fuels[4]	x	x	x	x	x	x	x	x	x
Other Emissions[5]	**–**	**2.5**	**4.6**	**–**	**–**	**–**	**–**	**–**	**–**
Overall Total[6,7]	**1 500**	**571**	**622**	**404**	**488**	**371**	**248**	**208**	**237**
Electricity Generation[8,9]									
	GWh								
Combustion[10]	**1 980**	**1 150**	**1 390**	**1 360**	**1 260**	**1 140**	**1 010**	**960**	**1 370**
Coal	–	–	–	–	–	–	–	–	–
Natural Gas	–	191	212	198	191	14	14	0	0
Other Fuels	1 980	961	1 170	1 170	1 070	1 130	1 000	960	1 370
Nuclear	**4 070**	**4 890**	**4 480**	**3 530**	**4 210**	**0**	**0**	**0**	**0**
Hydro	**112 000**	**153 000**	**155 000**	**170 000**	**171 000**	**182 000**	**177 000**	**175 000**	**177 000**
Other Renewables[11]	**–**	**173**	**416**	**1 000**	**1 011**	**1 031**	**1 010**	**6 422**	**6 999**
Other Generation[12,13]	**–**	**–**	**–**	**–**	**–**	**–**	**–**	**–**	**–**
Overall Total[7]	**118 000**	**160 000**	**161 000**	**176 000**	**178 000**	**184 000**	**179 000**	**182 000**	**185 000**
Greenhouse Gas Intensity[14]									
	g GHG / kWh electricity generated								
CO_2 intensity (g CO_2 / kWh)	13	3.5	3.7	2.3	2.7	2.0	1.4	1.1	1.2
CH_4 intensity (g CH_4 / kWh)	0.0004	0.0005	0.0009	0.0002	0.0004	0.0002	0.0001	0.0	0.0
N_2O intensity (g N_2O / kWh)	0.0003	0.0002	0.0005	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
Generation Intensity (g CO_2 eq / kWh)[7]	**13**	**3.6**	**3.9**	**2.3**	**2.7**	**2.0**	**1.4**	**1.1**	**1.3**
Unallocated Energy (GWh)[17,18]	7 300	13 000	9 100	11 000	12 000	12 000	13 000	9 000*	4 000
SF_6 Emissions (kt CO_2 eq)[17]	37	36	30	30	54	67	17	74	74
Consumption Intensity (g CO_2 eq / kWh)[18]	**14**	**4.1**	**4.3**	**2.6**	**3.3**	**2.5**	**1.6**	**1.6**	**1.7**

Notes:

1. Data presented include emissions, generation and intensity for facilities classified under NAICS code 22111 – Electric Power Generation.
2. Preliminary data.
3. Emissions based on data taken from the *Report on Energy Supply-Demand in Canada*, Catalogue No. 57-003-XIB, Statistics Canada.
4. Includes GHG emissions from the combustion of refined petroleum products (light fuel oil, heavy fuel oil, and diesel), petroleum coke, still gas and other fuels not easily categorized.
5. GHG emissions from on-site combustion of fuel not directly related to electricity generation.
6. GHG emissions from the flooding of land for hydro dams are not included.
7. Totals may not add up to overall total due to rounding.
8. Taken from CANSIM Tables 127-0006 and 127-0007 (for 2005–2016).
9. Taken from the *Electric Power Generation, Transmission and Distribution* (EPGTD) publication, Catalogue No. 57-202-XIB, Statistics Canada (for 1990–2004).
10. From 2014 onward, this includes the electricity generated from the by-product steam associated with the fuel combustion. Prior to 2014, it was not possible to break this data into the original fuel source, so it was included in Other Generation.
11. Other Renewables – includes electricity generation by wind, tidal and solar.
12. NAICS category 221119, Other Electric Power Generation.
13. Prior to 2014, this includes electricity generation from steam from waste heat. From 2014 onward, electricity generation from steam from waste heat is reported as part of its original fuel source.
14. Intensity values have been rounded so as to present the estimated level of accuracy.
15. Adapted from Statistics Canada CANSIM Table 127-0008 (2005-2016) or Cat. No. 57-202-XIB (1990–2004).
16. Includes transmission line losses, metering differences and other losses.
17. The electric utility sector's share of emissions from electrical equipment from CRF Category 2.F.viii (Production and Consumption of Halocarbons and SF_6).
18. Consumption intensity values are impacted by unallocated energy and SF_6 transmission emissions.

– Indicates no emissions or no electricity generation

0 Indicates emissions or electricity generation value less than 0.1

x Indicates data not shown due to statistical limitations

* For years where unallocated energy data was not available, values were interpolated

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Table A13–7 **Electricity Generation and GHG Emission Details for Ontario[1]**

	1990	2000	2005	2011	2012	2013	2014	2015	2016[2]
	Greenhouse Gas Emissions[3]								
	kt CO_2 equivalent								
Combustion	**25 800**	**44 200**	**35 400**	**14 400**	**14 300**	**10 300**	**6 030**	**6 250**	**5 500**
Coal	24 700	38 800	29 000	4 400	4 390	3 150	100	0	0
Natural Gas	x	x	x	x	x	7 040	5 810	6 170	5 370
Other Fuels[4]	x	x	x	x	x	60	130	80	120
Other Emissions[5]	–	**0.77**	**1.4**	**0.23**	–	–	–	–	–
Overall Total[6,7]	**25 800**	**44 200**	**35 400**	**14 400**	**14 300**	**10 300**	**6 000**	**6 300**	**5 500**
	Electricity Generation[8,9]								
	GWh								
Combustion[10]	**29 200**	**52 200**	**40 900**	**23 100**	**22 400**	**17 500**	**15 600**	**16 000**	**13 600**
Coal	27 800	40 800	29 400	3 900	4 100	2 850	80	0	0
Natural Gas	3.18	10 200	10 000	18 500	17 600	13 900	14 700	15 300	12 700
Other Fuels	1 430	1 140	1 440	782	703	722	778	699	871
Nuclear	**59 400**	**59 800**	**78 000**	**84 800**	**84 900**	**93 100**	**96 200**	**91 800**	**90 900**
Hydro	**38 700**	**36 600**	**34 600**	**34 600**	**33 000**	**36 900**	**38 200**	**34 800**	**34 800**
Other Renewables[11]	–	**1.22**	**26.0**	**3 420**	**4 320**	**4 240**	**3 660**	**12 240**	**13 380**
Other Generation[12,13]	–	–	–	**3 501**	**4 256**	**3 337**	–	–	–
Overall Total[7]	**127 000**	**149 000**	**153 000**	**153 000**	**153 000**	**158 000**	**154 000**	**155 000**	**153 000**
	Greenhouse Gas Intensity[14]								
	g GHG / kWh electricity generated								
CO_2 intensity (g CO_2 / kWh)	200	300	230	95	95	65	39	40	35
CH_4 intensity (g CH_4 / kWh)	0.002	0.01	0.01	0.02	0.02	0.01	0.01	0.01	0.01
N_2O intensity (g N_2O / kWh)	0.003	0.005	0.004	0.002	0.002	0.002	0.001	0.001	0.001
Generation Intensity (g CO_2 eq / kWh)[7]	**200**	**300**	**230**	**96**	**96**	**66**	**39**	**40**	**36**
Unallocated Energy (GWh)[17,18]	10 000	12 000	12 000	16 000	15 000	22 000	9 000	9 000*	9 000*
SF_6 Emissions (kt CO_2 eq)[17]	76	75	50	38	56	64	43	56	56
Consumption Intensity (g CO_2 eq / kWh)[18]	**220**	**320**	**250**	**110**	**110**	**80**	**40**	**40**	**40**

Notes:

1. Data presented include emissions, generation and intensity for facilities classified under NAICS code 22111 – Electric Power Generation.
2. Preliminary data.
3. Emissions based on data taken from the *Report on Energy Supply-Demand in Canada*, Catalogue No. 57-003-XIB, Statistics Canada.
4. Includes GHG emissions from the combustion of refined petroleum products (light fuel oil, heavy fuel oil, and diesel), petroleum coke, still gas and other fuels not easily categorized.
5. GHG emissions from on-site combustion of fuel not directly related to electricity generation.
6. GHG emissions from the flooding of land for hydro dams are not included.
7. Totals may not add up to overall total due to rounding.
8. Taken from CANSIM Tables 127-0006 and 127-0007 (for 2005–2016).
9. Taken from the *Electric Power Generation, Transmission and Distribution* (EPGTD) publication, Catalogue No. 57-202-XIB, Statistics Canada (for 1990–2004).
10. From 2014 onward, this includes the electricity generated from the by-product steam associated with the fuel combustion. Prior to 2014, it was not possible to break this data into the original fuel source, so it was included in Other Generation.
11. Other Renewables – includes electricity generation by wind, tidal and solar.
12. NAICS category 221119, Other Electric Power Generation.
13. Prior to 2014, this includes electricity generation from steam from waste heat. From 2014 onward, electricity generation from steam from waste heat is reported as part of its original fuel source.
14. Intensity values have been rounded so as to present the estimated level of accuracy.
15. Adapted from Statistics Canada CANSIM Table 127-0008 (2005-2016) or Cat. No. 57-202-XIB (1990–2004).
16. Includes transmission line losses, metering differences and other losses.
17. The electric utility sector's share of emissions from electrical equipment from CRF Category 2.F.viii (Production and Consumption of Halocarbons and SF_6).
18. Consumption intensity values are impacted by unallocated energy and SF_6 transmission emissions.

– Indicates no emissions or no electricity generation

0 Indicates emissions or electricity generation value less than 0.1

x Indicates data not shown due to statistical limitations

* For years where unallocated energy data was not available, values were interpolated

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Table A13–8 **Electricity Generation and GHG Emission Details for Manitoba**[1]

	1990	2000	2005	2011	2012	2013	2014	2015	2016[2]
Greenhouse Gas Emissions[3]									
	kt CO_2 equivalent								
Combustion	**518**	**1 067**	**349**	**110**	**91.9**	**104.4**	**110.1**	**103.0**	**54.6**
Coal	x	x	x	x	x	x	x	x	x
Natural Gas	x	x	x	x	x	x	x	x	x
Other Fuels[4]	50.7	12.1	15.7	12.9	12.9	1.7	1.7	.0	13.7
Other Emissions[5]	–	**4.8**	**8.8**	**12**	**21**	**16**	**16**	**21**	**15**
Overall Total[6,7]	**518**	**1 072**	**358**	**123**	**112**	**120**	**127**	**124**	**70**
Electricity Generation[8,9]									
	GWh								
Combustion[10]	**399**	**881**	**447**	**106**	**94**	**91**	**96**	**107**	**56**
Coal	375	869	421	49.7	51.5	65.4	68.9	63.4	28.5
Natural Gas	0.904	–	10.6	41.1	27.4	24.0	25.2	29.4	11.7
Other Fuels	22.4	12.4	15.1	15.3	15.2	1.5	1.6	14.4	15.5
Nuclear	–	–	–	–	–	–	–	–	–
Hydro	**19 800**	**31 500**	**36 400**	**34 200**	**32 200**	**35 300**	**34 500**	**34 800**	**35 600**
Other Renewables[11]	–	–	**53.4**	**747**	**877**	**868**	**911**	**903**	**863**
Other Generation[12,13]	–	–	–	–	–	–	–	–	–
Overall Total[7]	**20 200**	**32 400**	**36 900**	**35 100**	**33 200**	**36 300**	**35 500**	**35 800**	**36 500**
Greenhouse Gas Intensity[14]									
	g GHG / kWh electricity generated								
CO_2 intensity (g CO_2 / kWh)	25	33	9.6	3.5	3.4	3.3	3.5	3.4	1.9
CH_4 intensity (g CH_4 / kWh)	0.0005	0.0004	0.0002	0.0004	0.0002	0.0003	0.0003	0.0003	0.0001
N_2O intensity (g N_2O / kWh)	0.001	0.001	0.0002	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
Generation Intensity (g CO_2 eq / kWh)[7]	**26**	**33**	**9.7**	**3.5**	**3.4**	**3.3**	**3.6**	**3.5**	**1.9**
Unallocated Energy (GWh)[17,18]	2 100	3 750	1 900	4 600	3 600	3 800	3 900	3 800	4 000
SF_6 Emissions (kt CO_2 eq)[17]	4.3	4.2	4.0	6.0	1.3	1.2	.9	1.0	1.0
Consumption Intensity (g CO_2 eq / kWh)[18]	**29**	**38**	**10.3**	**4.2**	**3.9**	**3.7**	**4.0**	**3.9**	**2.2**

Notes:

1. Data presented include emissions, generation and intensity for facilities classified under NAICS code 22111 – Electric Power Generation.
2. Preliminary data.
3. Emissions based on data taken from the *Report on Energy Supply-Demand in Canada*, Catalogue No. 57-003-XIB, Statistics Canada.
4. Includes GHG emissions from the combustion of refined petroleum products (light fuel oil, heavy fuel oil, and diesel), petroleum coke, still gas and other fuels not easily categorized.
5. GHG emissions from on-site combustion of fuel not directly related to electricity generation.
6. GHG emissions from the flooding of land for hydro dams are not included.
7. Totals may not add up to overall total due to rounding.
8. Taken from CANSIM Tables 127-0006 and 127-0007 (for 2005–2016).
9. Taken from the Electric Power Generation, Transmission and Distribution (EPGTD) publication, Catalogue No. 57-202-XIB, Statistics Canada (for 1990–2004).
10. From 2014 onward, this includes the electricity generated from the by-product steam associated with the fuel combustion. Prior to 2014, it was not possible to break this data into the original fuel source, so it was included in Other Generation.
11. Other Renewables – includes electricity generation by wind, tidal and solar.
12. NAICS category 221119, Other Electric Power Generation.
13. Prior to 2014, this includes electricity generation from steam from waste heat. From 2014 onward, electricity generation from steam from waste heat is reported as part of its original fuel source.
14. Intensity values have been rounded so as to present the estimated level of accuracy.
15. Adapted from Statistics Canada CANSIM Table 127-0008 (2005-2016) or Cat. No. 57-202-XIB (1990–2004).
16. Includes transmission line losses, metering differences and other losses.
17. The electric utility sector's share of emissions from electrical equipment from CRF Category 2.F.viii (Production and Consumption of Halocarbons and SF_6).
18. Consumption intensity values are impacted by unallocated energy and SF_6 transmission emissions.

– Indicates no emissions or no electricity generation

0 Indicates emissions or electricity generation value less than 0.1

x Indicates data not shown due to statistical limitations

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Table A13–9 **Electricity Generation and GHG Emission Details for Saskatchewan[1]**

	1990	2000	2005	2011	2012	2013	2014	2015	2016[2]
	Greenhouse Gas Emissions[3]								
	kt CO_2 equivalent								
Combustion	**11 100**	**14 400**	**15 200**	**15 500**	**16 100**	**15 000**	**15 200**	**16 400**	**16 700**
Coal	x	x	x	x	x	x	x	x	x
Natural Gas	x	x	x	x	x	x	x	x	x
Other Fuels[4]	6.74	10.8	4.48	7.20	6.64	0.28	6.37	9.13	9.41
Other Emissions[5]	**–**	**10**	**18**	**30**	**31**	**35**	**35**	**39**	**42**
Overall Total[6,7]	**11 100**	**14 400**	**15 200**	**15 500**	**16 100**	**15 000**	**15 300**	**16 500**	**16 700**
	Electricity Generation[8,9]								
	GWh								
Combustion[10]	**9 660**	**14 100**	**14 800**	**13 600**	**13 900**	**15 300**	**14 800**	**19 100**	**20 300**
Coal	9 340	11 400	12 200	11 600	11 400	11 800	10 200	12 100	12 000
Natural Gas	308	2 660	2 610	2 000	2 490	3 510	4 530	6 990	8 220
Other Fuels	8.78	12.5	12.0	10.0	9.30	12.42	9.40	13.44	.41
Nuclear	–	–	–	–	–	–	–	–	–
Hydro	**4 210**	**3 050**	**4 570**	**4 640**	**4 240**	**4 450**	**4 710**	**3 430**	**3 280**
Other Renewables[11]	**–**	**–**	**91.9**	**608**	**655**	**640**	**615**	**620**	**730**
Other Generation[12,13]	–	–	–	–	–	–	–	–	–
Overall Total[7]	**13 900**	**17 100**	**19 500**	**19 600**	**19 800**	**22 100**	**20 100**	**23 100**	**24 300**
	Greenhouse Gas Intensity[14]								
	g GHG / kWh electricity generated								
CO_2 intensity (g CO_2 / kWh)	790	840	770	800	830	700	750	690	650
CH_4 intensity (g CH_4 / kWh)	0.02	0.03	0.03	0.04	0.05	0.04	0.04	0.05	0.05
N_2O intensity (g N_2O / kWh)	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
Generation Intensity (g CO_2 eq / kWh)[7]	**800**	**840**	**780**	**810**	**830**	**710**	**750**	**690**	**660**
Unallocated Energy (GWh)[17,18]	1 300	1 700	1 400	1 000	1 100	1 900	3 200	1 600	2 400
SF_6 Emissions (kt CO_2 eq)[17]	1.8	1.7	1.3	1.2	0.75	0.91	0.42	0.73	0.73
Consumption Intensity (g CO_2 eq / kWh)[18]	**880**	**940**	**840**	**850**	**880**	**780**	**900**	**750**	**730**

Notes:

1. Data presented include emissions, generation and intensity for facilities classified under NAICS code 22111 – Electric Power Generation.
2. Preliminary data.
3. Emissions based on data taken from the *Report on Energy Supply-Demand in Canada*, Catalogue No. 57-003-XIB, Statistics Canada.
4. Includes GHG emissions from the combustion of refined petroleum products (light fuel oil, heavy fuel oil, and diesel), petroleum coke, still gas and other fuels not easily categorized.
5. GHG emissions from on-site combustion of fuel not directly related to electricity generation.
6. GHG emissions from the flooding of land for hydro dams are not included.
7. Totals may not add up to overall total due to rounding.
8. Taken from CANSIM Tables 127-0006 and 127-0007 (for 2005–2016).
9. Taken from the *Electric Power Generation, Transmission and Distribution* (EPGTD) publication, Catalogue No. 57-202-XIB, Statistics Canada (for 1990–2004).
10. From 2014 onward, this includes the electricity generated from the by-product steam associated with the fuel combustion. Prior to 2014, it was not possible to break this data into the original fuel source, so it was included in Other Generation.
11. Other Renewables – includes electricity generation by wind, tidal and solar.
12. NAICS category 221119, Other Electric Power Generation.
13. Prior to 2014, this includes electricity generation from steam from waste heat. From 2014 onward, electricity generation from steam from waste heat is reported as part of its original fuel source.
14. Intensity values have been rounded so as to present the estimated level of accuracy.
15. Adapted from Statistics Canada CANSIM Table 127-0008 (2005–2016) or Cat. No. 57-202-XIB (1990–2004).
16. Includes transmission line losses, metering differences and other losses.
17. The electric utility sector's share of emissions from electrical equipment from CRF Category 2.F.viii (Production and Consumption of Halocarbons and SF_6).
18. Consumption intensity values are impacted by unallocated energy and SF_6 transmission emissions.

– Indicates no emissions or no electricity generation

0 Indicates emissions or electricity generation value less than 0.1

x Indicates data not shown due to statistical limitations

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Table A13–10 **Electricity Generation and GHG Emission Details for Alberta**[1]

	1990	2000	2005	2011	2012	2013	2014	2015	2016[2]
	Greenhouse Gas Emissions[3]								
	kt CO_2 equivalent								
Combustion	**39 600**	**50 100**	**51 900**	**48 700**	**46 900**	**48 100**	**49 100**	**51 300**	**48 100**
Coal	x	x	x	x	x	x	x	x	x
Natural Gas	x	x	x	x	x	x	x	x	x
Other Fuels[4]	11.8	301	68.4	20.8	18.7	18.4	17.0	17.5	1.5
Other Emissions[5]	–	**5.7**	**10**	**13**	**23**	**6**	**14**	**19**	**17**
Overall Total[6,7]	**39 600**	**50 100**	**51 900**	**48 700**	**46 900**	**48 100**	**49 100**	**51 300**	**48 200**
	Electricity Generation[8,9]								
	GWh								
Combustion[10]	**39 900**	**51 300**	**54 200**	**62 100**	**52 000**	**53 200**	**59 700**	**57 100**	**55 200**
Coal	37 300	40 700	42 200	46 300	37 300	38 500	43 400	42 200	39 000
Natural Gas	2 510	10 200	11 600	15 200	14 100	14 100	15 700	14 300	15 800
Other Fuels	21.6	443	424	542	630	630	550	517	448
Nuclear	–	–	–	–	–	–	–	–	–
Hydro	**2 060**	**1 760**	**2 240**	**1 970**	**2 570**	**1 990**	**1 820**	**1 980**	**2 280**
Other Renewables[11]	–	**88.9**	**837**	**2 220**	**2 290**	**2 260**	**3 520**	**4 090**	**5 390**
Other Generation[12,13]	–	–	–	–	–	–	–	–	–
Overall Total[7]	**41 900**	**53 200**	**57 300**	**70 100**	**61 300**	**61 900**	**65 300**	**63 400**	**63 200**
	Greenhouse Gas Intensity[14]								
	g GHG / kWh electricity generated								
CO_2 intensity (g CO_2 / kWh)	940	940	900	710	790	800	750	800	760
CH_4 intensity (g CH_4 / kWh)	0.02	0.04	0.03	0.03	0.04	0.04	0.04	0.04	0.04
N_2O intensity (g N_2O / kWh)	0.02	0.02	0.02	0.01	0.02	0.02	0.01	0.02	0.01
Generation Intensity (g CO_2 eq / kWh)[7]	**950**	**940**	**910**	**710**	**790**	**810**	**750**	**810**	**760**
Unallocated Energy (GWh)[17,18]	3 400	4 100	4 900	17 400	8 400	8 800*	9 800*	9 900*	9 900*
SF_6 Emissions (kt CO_2 eq)[17]	1.6	1.6	0.43	1.16	3.1	2.4	3.1	3.2	3.2
Consumption Intensity (g CO_2 eq / kWh)[18]	**1 000**	**1 000**	**990**	**1 000**	**930**	**950**	**890**	**960**	**900**

Notes:

1. Data presented include emissions, generation and intensity for facilities classified under NAICS code 22111 – Electric Power Generation.
2. Preliminary data.
3. Emissions based on data taken from the *Report on Energy Supply-Demand in Canada*, Catalogue No. 57-003-XIB, Statistics Canada.
4. Includes GHG emissions from the combustion of refined petroleum products (light fuel oil, heavy fuel oil, and diesel), petroleum coke, still gas and other fuels not easily categorized.
5. GHG emissions from on-site combustion of fuel not directly related to electricity generation.
6. GHG emissions from the flooding of land for hydro dams are not included.
7. Totals may not add up to overall total due to rounding.
8. Taken from CANSIM Tables 127-0006 and 127-0007 (for 2005–2016).
9. Taken from the *Electric Power Generation, Transmission and Distribution* (EPGTD) publication, Catalogue No. 57-202-XIB, Statistics Canada (for 1990–2004).
10. From 2014 onward, this includes the electricity generated from the by-product steam associated with the fuel combustion. Prior to 2014, it was not possible to break this data into the original fuel source, so it was included in Other Generation.
11. Other Renewables – includes electricity generation by wind, tidal and solar.
12. NAICS category 221119, Other Electric Power Generation.
13. Prior to 2014, this includes electricity generation from steam from waste heat. From 2014 onward, electricity generation from steam from waste heat is reported as part of its original fuel source.
14. Intensity values have been rounded so as to present the estimated level of accuracy.
15. Adapted from Statistics Canada CANSIM Table 127-0008 (2005-2016) or Cat. No. 57-202-XIB (1990–2004).
16. Includes transmission line losses, metering differences and other losses.
17. The electric utility sector's share of emissions from electrical equipment from CRF Category 2.F.viii (Production and Consumption of Halocarbons and SF_6).
18. Consumption intensity values are impacted by unallocated energy and SF_6 transmission emissions.

– Indicates no emissions or no electricity generation

0 Indicates emissions or electricity generation value less than 0.1

x Indicates data not shown due to statistical limitations

* For years where unallocated energy data was not available, values were interpolated

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Table A13–11 **Electricity Generation and GHG Emission Details for British Columbia[1]**

	1990	2000	2005	2011	2012	2013	2014	2015	2016[2]
	Greenhouse Gas Emissions[3]								
	kt CO_2 equivalent								
Combustion	**807**	**1 940**	**1 330**	**775**	**503**	**590**	**571**	**496**	**650**
Coal	–	–	–	–	–	–	–	–	–
Natural Gas	x	x	x	x	x	539	517	447	606
Other Fuels[4]	x	x	x	x	x	51	54	50	44
Other Emissions[5]	**–**	**2.4**	**4.6**	**6.5**	**7.2**	**6.7**	**7.4**	**7.2**	**6.5**
Overall Total[6,7]	**807**	**1 940**	**1 340**	**780**	**510**	**596**	**578**	**504**	**656**
	Electricity Generation[8,9]								
	GWh								
Combustion[10]	**1 390**	**3 930**	**3 820**	**1 760**	**1 510**	**1 820**	**1 780**	**1 610**	**1 560**
Coal	–	–	–	–	–	–	–	–	–
Natural Gas	1 310	3 350	3 140	610	712	892	936	788	1 037
Other Fuels	79.4	585	689	1 150	798	926	846	818	522
Nuclear	**–**	**–**	**–**	**–**	**–**	**–**	**–**	**–**	**–**
Hydro	**46 400**	**50 800**	**50 300**	**51 700**	**55 800**	**50 500**	**49 000**	**52 400**	**56 400**
Other Renewables[11]	**–**	**–**	**–**	**187**	**158**	**152**	**849**	**868**	**1 056**
Other Generation[12,13]	**–**	**–**	**–**	**2 590**	**2 750**	**2 520**	**2 240**	**0**	**0**
Overall Total[7]	**47 800**	**54 700**	**54 100**	**56 400**	**60 300**	**55 000**	**53 900**	**54 900**	**59 000**
	Greenhouse Gas Intensity[14]								
	g GHG / kWh electricity generated								
CO_2 intensity (g CO_2 / kWh)	17	35	24	13	8.2	10.5	10.4	8.9	10.8
CH_4 intensity (g CH_4 / kWh)	0.004	0.009	0.007	0.004	0.003	0.003	0.003	0.003	0.003
N_2O intensity (g N_2O / kWh)	0.0006	0.001	0.0015	0.0011	0.0007	0.0009	0.0008	0.0008	0.0008
Generation Intensity (g CO_2 eq / kWh)[7]	**17**	**35**	**25**	**14**	**8.5**	**10.9**	**10.7**	**9.2**	**11.1**
Unallocated Energy (GWh)[17,18]	2 200	2 300	2 100	810	900	2 400*	3 900	2 900*	1 300
SF_6 Emissions (kt CO_2 eq)[17]	57	56	48	26	47	42	26	20	20
Consumption Intensity (g CO_2 eq / kWh)[18]	**19**	**38**	**27**	**15**	**9.4**	**12.1**	**12.1**	**10.1**	**11.7**

Notes:

1. Data presented include emissions, generation and intensity for facilities classified under NAICS code 22111 – Electric Power Generation.
2. Preliminary data.
3. Emissions based on data taken from the *Report on Energy Supply-Demand in Canada*, Catalogue No. 57-003-XIB, Statistics Canada.
4. Includes GHG emissions from the combustion of refined petroleum products (light fuel oil, heavy fuel oil, and diesel), petroleum coke, still gas and other fuels not easily categorized.
5. GHG emissions from on-site combustion of fuel not directly related to electricity generation.
6. GHG emissions from the flooding of land for hydro dams are not included.
7. Totals may not add up to overall total due to rounding.
8. Taken from CANSIM Tables 127-0006 and 127-0007 (for 2005–2016).
9. Taken from the *Electric Power Generation, Transmission and Distribution* (EPGTD) publication, Catalogue No. 57-202-XIB, Statistics Canada (for 1990–2004).
10. From 2014 onward, this includes the electricity generated from the by-product steam associated with the fuel combustion. Prior to 2014, it was not possible to break this data into the original fuel source, so it was included in Other Generation.
11. Other Renewables – includes electricity generation by wind, tidal and solar.
12. NAICS category 221119, Other Electric Power Generation.
13. Prior to 2014, this includes electricity generation from steam from waste heat. From 2014 onward, electricity generation from steam from waste heat is reported as part of its original fuel source.
14. Intensity values have been rounded so as to present the estimated level of accuracy.
15. Adapted from Statistics Canada CANSIM Table 127-0008 (2005–2016) or Cat. No. 57-202-XIB (1990–2004).
16. Includes transmission line losses, metering differences and other losses.
17. The electric utility sector's share of emissions from electrical equipment from CRF Category 2.F.viii (Production and Consumption of Halocarbons and SF_6).
18. Consumption intensity values are impacted by unallocated energy and SF_6 transmission emissions.

– Indicates no emissions or no electricity generation

0 Indicates emissions or electricity generation value less than 0.1

x Indicates data not shown due to statistical limitations

* For years where unallocated energy data was not available, values were interpolated

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Table A13–12 **Electricity Generation and GHG Emission Details for Yukon**[1]

	1990	2000	2005	2011	2012	2013	2014	2015	2016[2]
	Greenhouse Gas Emissions[3]								
	kt CO_2 equivalent								
Combustion	**94.0**	**22.2**	**23.0**	**27.7**	**18.5**	**17.7**	**17.1**	**19.0**	**20.0**
Coal	–	–	–	–	–	–	–	–	–
Natural Gas	–	–	–	–	–	–	–	–	–
Other Fuels[4]	94.0	22.2	23.0	27.7	18.5	17.7	17.1	18.2	18.2
Other Emissions[5]	–	–	–	–	–	–	–	–	–
Overall Total[6,7]	**94.0**	**22.2**	**23.0**	**27.7**	**18.5**	**17.7**	**17.1**	**19.0**	**20.0**
	Electricity Generation[8,9]								
	GWh								
Combustion[10]	**62.1**	**36.7**	**22.4**	**36.9**	**24.4**	**23.3**	**22.7**	**25.5**	**27.0**
Coal	–	–	–	–	–	–	–	–	–
Natural Gas	–	–	–	–	–	–	–	–	–
Other Fuels	62.1	36.7	22.4	36.9	24.4	23.3	22.7	24.2	23.8
Nuclear	–	–	–	–	–	–	–	–	–
Hydro	**423**	**261**	**320**	**388**	**430**	**425**	**411**	**422**	**419**
Other Renewables[11]	–	**0.388**	**0.890**	**0.402**	**0.445**	**0.277**	**0.334**	**0.650**	**0.509**
Other Generation[12,13]	–	–	–	–	–	–	–	–	–
Overall Total[7]	**485**	**298**	**344**	**425**	**455**	**449**	**434**	**448**	**447**
	Greenhouse Gas Intensity[14]								
	g GHG / kWh electricity generated								
CO_2 intensity (g CO_2 / kWh)	190	71	64	62	39	38	38	41	43
CH_4 intensity (g CH_4 / kWh)	0.009	0.004	0.003	0.003	0.002	0.002	0.002	0.002	0.003
N_2O intensity (g N_2O / kWh)	0.03	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Generation Intensity (g CO_2 eq / kWh)[7]	**190**	**75**	**67**	**65**	**41**	**39**	**39**	**42**	**45**
Unallocated Energy (GWh)[17,18]	47	24	45	51	58	55	17	54	48
SF_6 Emissions (kt CO_2 eq)[17]	–	–	–	–	–	–	–	–	–
Consumption Intensity (g CO_2 eq / kWh)[18]	**210**	**81**	**77**	**74**	**47**	**45**	**41**	**48**	**50**

Notes:

1. Data presented include emissions, generation and intensity for facilities classified under NAICS code 22111 – Electric Power Generation.
2. Preliminary data.
3. Emissions based on data taken from the *Report on Energy Supply-Demand in Canada*, Catalogue No. 57-003-XIB, Statistics Canada.
4. Includes GHG emissions from the combustion of refined petroleum products (light fuel oil, heavy fuel oil, and diesel), petroleum coke, still gas and other fuels not easily categorized.
5. GHG emissions from on-site combustion of fuel not directly related to electricity generation.
6. GHG emissions from the flooding of land for hydro dams are not included.
7. Totals may not add up to overall total due to rounding.
8. Taken from CANSIM Tables 127-0006 and 127-0007 (for 2005–2016).
9. Taken from the *Electric Power Generation, Transmission and Distribution* (EPGTD) publication, Catalogue No. 57-202-XIB, Statistics Canada (for 1990–2004).
10. From 2014 onward, this includes the electricity generated from the by-product steam associated with the fuel combustion. Prior to 2014, it was not possible to break this data into the original fuel source, so it was included in Other Generation.
11. Other Renewables – includes electricity generation by wind, tidal and solar.
12. NAICS category 221119, Other Electric Power Generation.
13. Prior to 2014, this includes electricity generation from steam from waste heat. From 2014 onward, electricity generation from steam from waste heat is reported as part of its original fuel source.
14. Intensity values have been rounded so as to present the estimated level of accuracy.
15. Adapted from Statistics Canada CANSIM Table 127-0008 (2005-2016) or Cat. No. 57-202-XIB (1990–2004).
16. Includes transmission line losses, metering differences and other losses.
17. The electric utility sector's share of emissions from electrical equipment from CRF Category 2.F.viii (Production and Consumption of Halocarbons and SF_6).
18. Consumption intensity values are impacted by unallocated energy and SF_6 transmission emissions.

– Indicates no emissions or no electricity generation

0 Indicates emissions or electricity generation value less than 0.1

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Table A13–13 Electricity Generation and GHG Emission Details for the Northwest Territories[1]

	1990	2000	2005	2011	2012	2013	2014	2015	2016[2]
	Greenhouse Gas Emissions[3]								
	kt CO_2 equivalent								
Combustion	**163**	**109**	**94**	**65**	**65**	**67**	**86**	**123**	**71**
Coal	x	x	x	x	x	–	–	–	–
Natural Gas	x	x	x	x	x	3.66	4.82	6.17	7.71
Other Fuels[4]	x	x	x	x	x	63	82	117	63
Other Emissions[5]	**x**	**x**	**x**	**x**	**x**	**–**	**–**	**–**	**–**
Overall Total[6,7]	**163**	**110**	**98**	**65**	**65**	**67**	**86**	**123**	**71**
	Electricity Generation[8,9]								
	GWh								
Combustion[10]	**227**	**195**	**78**	**83**	**83**	**84**	**109**	**161**	**96**
Coal	–	–	–	–	–	–	–	–	–
Natural Gas	–	15.8	23.3	23.7	5.63	5.77	7.53	10.70	14.21
Other Fuels	227	179	54	59	77	79	102	150	82
Nuclear	**–**	**–**	**–**	**–**	**–**	**–**	**–**	**–**	**–**
Hydro	**226**	**247**	**259**	**260**	**253**	**263**	**234**	**164**	**255**
Other Renewables[11]	**–**	**–**	**–**	**–**	**–**	**–**	**–**	**–**	**–**
Other Generation[12,13]	**–**	**–**	**–**	**–**	**–**	**–**	**–**	**–**	**–**
Overall Total[7]	**453**	**442**	**337**	**343**	**336**	**347**	**343**	**325**	**351**
	Greenhouse Gas Intensity[14]								
	g GHG / kWh electricity generated								
CO_2 intensity (g CO_2 / kWh)	340	240	280	180	190	180	240	360	190
CH_4 intensity (g CH_4 / kWh)	0.02	0.01	0.03	0.02	0.01	0.01	0.01	0.02	0.01
N_2O intensity (g N_2O / kWh)	0.05	0.03	0.03	0.02	0.03	0.03	0.03	0.05	0.03
Generation Intensity (g CO_2 eq / kWh)[7]	**360**	**250**	**290**	**190**	**190**	**190**	**250**	**380**	**200**
Unallocated Energy (GWh)[17,18]	21	21	19	23	10	17	58	6	27
SF_6 Emissions (kt CO_2 eq)[17]	–	–	–	–	–	–	–	–	–
Consumption Intensity (g CO_2 eq / kWh)[18]	**380**	**260**	**310**	**200**	**200**	**200**	**300**	**390**	**220**

Notes:

1. Data presented include emissions, generation and intensity for facilities classified under NAICS code 22111 – Electric Power Generation.
2. Preliminary data.
3. Emissions based on data taken from the *Report on Energy Supply-Demand in Canada*, Catalogue No. 57-003-XIB, Statistics Canada.
4. Includes GHG emissions from the combustion of refined petroleum products (light fuel oil, heavy fuel oil, and diesel), petroleum coke, still gas and other fuels not easily categorized.
5. GHG emissions from on-site combustion of fuel not directly related to electricity generation.
6. GHG emissions from the flooding of land for hydro dams are not included.
7. Totals may not add up to overall total due to rounding.
8. Taken from CANSIM Tables 127-0006 and 127-0007 (for 2005–2016).
9. Taken from the *Electric Power Generation, Transmission and Distribution* (EPGTD) publication, Catalogue No. 57-202-XIB, Statistics Canada (for 1990–2004).
10. From 2014 onward, this includes the electricity generated from the by-product steam associated with the fuel combustion. Prior to 2014, it was not possible to break this data into the original fuel source, so it was included in Other Generation.
11. Other Renewables – includes electricity generation by wind, tidal and solar.
12. NAICS category 221119, Other Electric Power Generation.
13. Prior to 2014, this includes electricity generation from steam from waste heat. From 2014 onward, electricity generation from steam from waste heat is reported as part of its original fuel source.
14. Intensity values have been rounded so as to present the estimated level of accuracy.
15. Adapted from Statistics Canada CANSIM Table 127-0008 (2005–2016) or Cat. No. 57-202-XIB (1990–2004).
16. Includes transmission line losses, metering differences and other losses.
17. The electric utility sector's share of emissions from electrical equipment from CRF Category 2.F.viii (Production and Consumption of Halocarbons and SF_6).
18. Consumption intensity values are impacted by unallocated energy and SF_6 transmission emissions.

– Indicates no emissions or no electricity generation

0 Indicates emissions or electricity generation value less than 0.1

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Table A13–14 **Electricity Generation and GHG Emission Details for the Nunavut[1]**

	1990	2000	2005	2011	2012	2013	2014	2015	2016[2]
					Greenhouse Gas Emissions[3]				
					kt CO_2 equivalent				
Combustion	**	**	**x**	**x**	**x**	**71**	**123**	**118**	**129**
Coal	**	**	x	x	x	–	–	–	–
Natural Gas	**	**	x	x	x	–	–	–	–
Other Fuels[4]	**	**	x	x	x	71	123	118	129
Other Emissions[5]	**	**	**x**	**x**	**x**	**–**	**–**	**–**	**–**
Overall Total[6,7]	**	**	**x**	**x**	**x**	**71**	**123**	**118**	**129**
					Electricity Generation[8,9]				
					GWh				
Combustion[10]	**	**	**142**	**98**	**98**	**98**	**158**	**157**	**173**
Coal	**	**	–	–	–	–	–	–	–
Natural Gas	**	**	–	–	–	–	–	–	–
Other Fuels	**	**	142	98	98	98	158	157	173
Nuclear	**	**	**–**	**–**	**–**	**–**	**–**	**–**	**–**
Hydro	**	**	**–**	**–**	**–**	**–**	**–**	**–**	**–**
Other Renewables[11]	**	**	**–**	**–**	**–**	**–**	**–**	**–**	**–**
Other Generation[12,13]	**	**	**–**	**–**	**–**	**–**	**–**	**–**	**–**
Overall Total[7]	**	**	**142**	**98**	**98**	**98**	**158**	**157**	**173**
					Greenhouse Gas Intensity[14]				
					g GHG / kWh electricity generated				
CO_2 intensity (g CO_2 / kWh)	**	**	x	x	x	700	740	720	710
CH_4 intensity (g CH_4 / kWh)	**	**	x	x	x	0.0	0.0	0.0	0.0
N_2O intensity (g N_2O / kWh)	**	**	x	x	x	0.0	0.0	0.0	0.0
Generation Intensity (g CO_2 eq / kWh)[7]	**	**	**x**	**x**	**x**	**730**	**780**	**750**	**750**
Unallocated Energy (GWh)[17,18]	**	**	7	2	2	2	3*	3*	3*
SF_6 Emissions (kt CO_2 eq)[17]	**	**	–	–	–	–	–	–	–
Consumption Intensity (g CO_2 eq / kWh)[18]	**	**	**920**	**790**	**790**	**740**	**790**	**770**	**760**

Notes:

1. Data presented include emissions, generation and intensity for facilities classified under NAICS code 22111 – Electric Power Generation.
2. Preliminary data.
3. Emissions based on data taken from the *Report on Energy Supply-Demand in Canada*, Catalogue No. 57-003-XIB, Statistics Canada.
4. Includes GHG emissions from the combustion of refined petroleum products (light fuel oil, heavy fuel oil, and diesel), petroleum coke, still gas and other fuels not easily categorized.
5. GHG emissions from on-site combustion of fuel not directly related to electricity generation.
6. GHG emissions from the flooding of land for hydro dams are not included.
7. Totals may not add up to overall total due to rounding.
8. Taken from CANSIM Tables 127-0006 and 127-0007 (for 2005–2016).
9. Taken from the *Electric Power Generation, Transmission and Distribution* (EPGTD) publication, Catalogue No. 57-202-XIB, Statistics Canada (for 1990–2004).
10. From 2014 onward, this includes the electricity generated from the by-product steam associated with the fuel combustion. Prior to 2014, it was not possible to break this data into the original fuel source, so it was included in Other Generation.
11. Other Renewables – includes electricity generation by wind, tidal and solar.
12. NAICS category 221119, Other Electric Power Generation.
13. Prior to 2014, this includes electricity generation from steam from waste heat. From 2014 onward, electricity generation from steam from waste heat is reported as part of its original fuel source.
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17. The electric utility sector's share of emissions from electrical equipment from CRF Category 2.F.viii (Production and Consumption of Halocarbons and SF_6).
18. Consumption intensity values are impacted by unallocated energy and SF_6 transmission emissions.

– Indicates no emissions or no electricity generation

0 Indicates emissions or electricity generation value less than 0.1

* For years where unallocated energy data was not available, values were interpolated

** Data is only available aggregated with Northwest Territories. Please refer to Table A13–13 for values.

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REFERENCES

Annex 8, Rounding Protocol

ICF Consulting. 2004. *Quantitative Assessment of Uncertainty in Canada's National GHG Inventory Estimates for 2001*. Unpublished report. Contract No.: K-2362-3-0060. Submitted to Environment Canada.

ICF Consulting 2005. *Quantitative Assessment of Uncertainty in Canada's National GHG Inventory Estimates for 2001–Supplementary Analysis.* Unpublished report. Contract No.: K2362-04-0121. Submitted to Environment Canada.

[IPCC] Intergovernmental Panel on Climate Change. 2001. *Climate Change 2001: The Scientific Basis. Contribution of Working Group 1 to the Third Assessment Report of the Intergovernmental Panel on Climate Change*. Cambridge (UK): Cambridge University Press.

[IPCC] Intergovernmental Panel on Climate Change. 2006. *2006 IPCC Guidelines for National Greenhouse Gas Inventories*. Prepared by the National Greenhouse Gas Inventories Programme. Eggleston HS, Buendia L, Miwa K, Ngara T, Tanabe K, editors. Kanagawa (JP): Institute for Global Environmental Studies. Available online at www.ipcc-nggip.iges.or.jp/public/2006gl/index.html.

[IPCC/OECD/IEA] Intergovernmental Panel on Climate Change, Organisation for Economic Co-operation and Development, and International Energy Agency. 1997. *Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories*. Available online at http://www.ipcc-nggip.iges.or.jp/public/gl/invs1.htm.

Annex 10, Canada's Greenhouse Gas Emission Tables by Canadian Economic Sector, 1990–2016

Cheminfo Services Inc., and Clearstone Engineering Ltd. 2014. *Compilation of a National Inventory of Greenhouse Gas and Fugitive VOC Emissions by the Canadian Coal Mining Industry.* Final report submitted to the Energy Group, PIRD, Environment Canada.

[CIEEDAC] Canadian Industrial Energy End-use Data Analysis Centre. 2016. Database on Energy, Production and Intensity Indicators for Canadian Industry. [cited 2017 January 16]. Available online at: http://cieedacdb.rem.sfu.ca/.

Environment Canada. 2014. *Technical Report on Canada's Upstream Oil and Gas Industry.* Vols. 1 – 4. Prepared for Environment Canada. Calgary (AB): Clearstone Engineering Ltd.

Statistics Canada. 2003– . *Report on Energy Supply and Demand in Canada*. Catalogue No. 57-003-X. Available online at: http://www5.statcan.gc.ca/olc-cel/olc.action?objId=57-003-X&objType=2&lang=en&limit=0.

Statistics Canada. 2016. Electric Power Thermal Generating Station Fuel Consumption Survey. CANSIM: tables 127-0004 to 127-0006. Available online at: http://www5.statcan.gc.ca/cansim/home-accueil?lang=eng.

Annex 13, Electricity in Canada: Summary and Intensity Tables

Statistics Canada. *Electric Power Generation, Transmission and Distribution* (annual). Catalogue No. 57-202-X.

Statistics Canada. *Report on Energy Supply and Demand in Canada* (annual). Catalogue No. 57-003-X.

Statistics Canada. No date. Table 127-0006: Electricity generated from fuels, by electric utility thermal plants (annual). CANSIM 2005-2015 [accessed 2017 November 30].

Statistics Canada. No date. Table 127-0007: Electric power generation, by class of electricity producer (annual). CANSIM 2005-2015 [accessed 2017 November 30].

Statistics Canada. No date. Table 127-0008: Supply and disposition of electric power, electric utilities and industry (annual). CANSIM 2005-2015 [accessed 2017 November 30].

Statistics Canada. No date. Table 127-0004: Fuel Consumed for Electric Power Generation, by electric utility thermal plants (annual) CANSIM 2015 [accessed 2017 November 30]

Government of Canada Gouvernement du Canada

Actions to reduce emissions

Buildings

Making Canada's building sector more energy efficient is a cost-effective way to reduce greenhouse gas emissions and save households and businesses money.

- Sustainable and efficient homes and buildings

Electricity

Building a smart, integrated clean electricity system will deliver reliable and affordable power, where it is needed.

- Powering our future with clean electricity
- Reducing reliance on diesel
- Just Transition for Canadian coal power workers and communities

Forestry, agriculture and waste

Canada's forests, wetlands, and croplands can absorb and store atmospheric carbon. Repurposing wastes as fuel, where possible, can also reduce emissions.

- Forestry, agriculture and waste

Industry

Canada's industries are the backbone of our economy, but are also a major source of greenhouse gas emissions. The right investments today can make dramatic changes to reduce emissions and increase sustainability.

- Competitive, clean Canadian industries
- Technical backgrounder: proposed federal methane regulations for the oil and gas sector

Short-lived climate pollutants (SLCPs)

676 Canada's plan for addressing short-lived climate pollutants (SLCPs) will help meet climate goals and improve air quality.

- Canada's SLCP Strategy
- An overview of SLCPs

Transportation

With smart and strategic investments in transportation, we will not only grow a cleaner economy and create good jobs, we will improve our quality of life.

- Our low carbon transportation future

Climate action map

- Explore the climate action map

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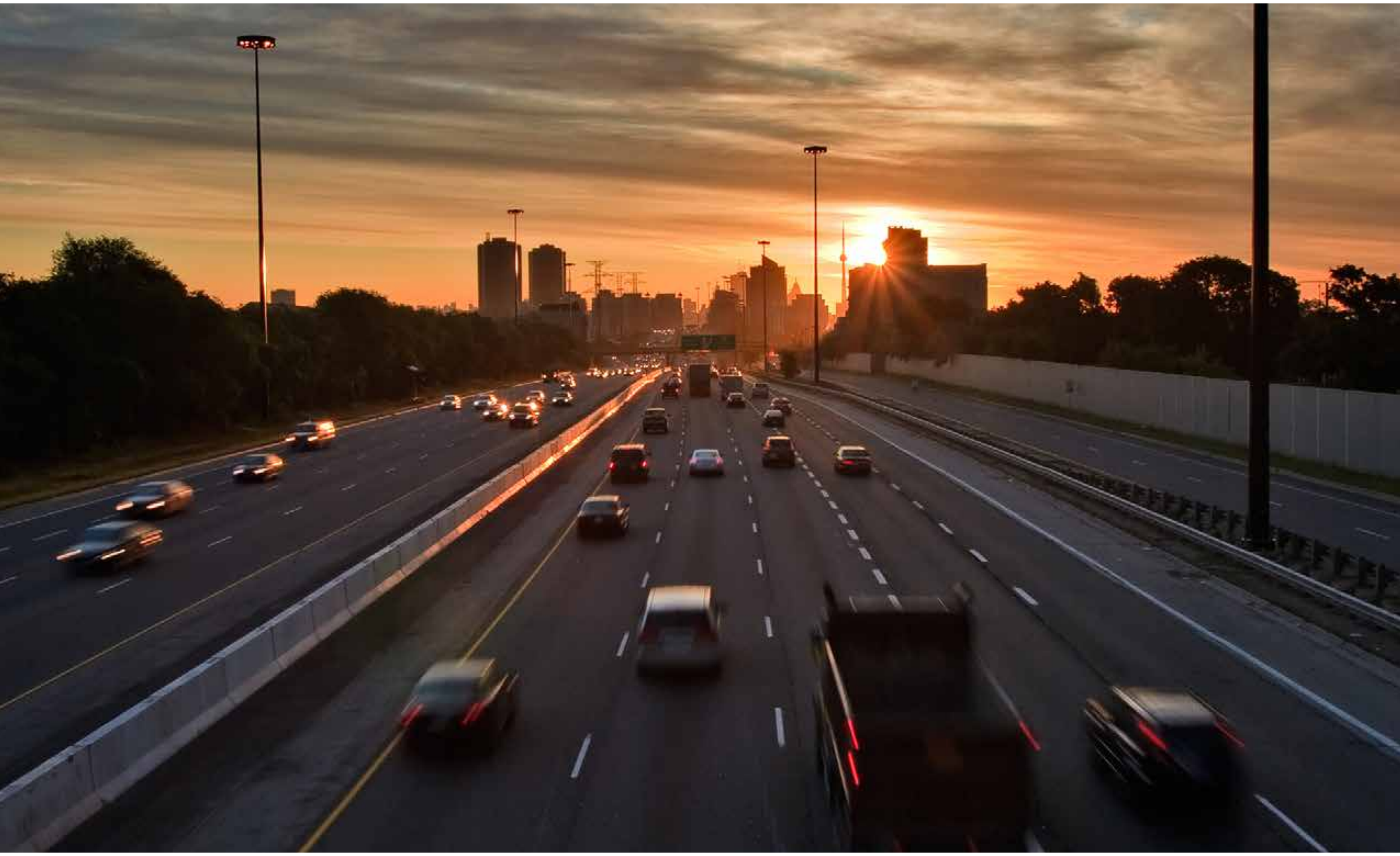
2018-10-23



SPECIFIC MITIGATION OPPORTUNITIES WORKING GROUP

FINAL REPORT

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SPECIFIC MITIGATION OPPORTUNITIES WORKING GROUP

FINAL REPORT

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1 EXECUTIVE SUMMARY

1.1 Introduction

In response to the urgent global challenge of climate change, Canada's First Ministers came together in March 2016 and issued the Vancouver Declaration on Clean Growth and Climate Change (Vancouver Declaration). First Ministers affirmed Canada's commitment to act on climate change and support a transition to a sustainable, low-carbon economy. The Vancouver Declaration launched four federal, provincial, and territorial (FPT) working groups mandated to identify specific actions to grow Canada's economy while reducing greenhouse gas (GHG) emissions and adapting to climate change.

This report presents the work of the Working Group on Specific Mitigation Opportunities ('Mitigation Working Group' or MWG), which was tasked with developing a broad menu of policy options to reduce emissions across all sectors of Canada's economy. This reflects Canada's commitment to the international community that it will reduce emissions to at least 30% below 2005 levels by 2030. Meeting this goal will require new and ambitious policy measures. This report is intended to support the Canadian Council of Ministers of the Environment, who will review this report and provide their recommendations to First Ministers by October 2016.

The MWG, supported by technical sub-groups, has developed 46 illustrative policy options designed to meet multiple objectives. In developing options, the goal of each sub-group was to:

- Cover all of the principal opportunities for emissions reductions;
- Include highly ambitious policy options to ensure deep reductions;
- Present options from a jurisdictionally-neutral, national perspective;
- Reflect options proposed by Indigenous peoples, the public and stakeholders; and
- Provide enough detail where possible to be considered as practical, implementable options.

These policy options are intended as a broad menu or toolbox, from which Ministers can choose and adapt the most relevant options for future plans. To ensure broad consideration of possible opportunities, the MWG has included many ambitious policy options that may not be relevant or feasible for all jurisdictions, and that could have significant economic impacts in some cases. Therefore, importantly, the report includes policy options that not all jurisdictions endorse or would be prepared to implement. In many cases, these policies are examples of the types of approaches that could be taken, with the understanding that they would be adjusted and refined before being implemented.

This report is the result of a collective effort by officials from across Canada, based on input from expert and stakeholder groups and the general public who contributed a wealth of thoughtful policy solutions, and National Indigenous Organizations who consulted broadly with Indigenous communities and communicated their perspectives and priorities. All of these groups played an important role in informing the development of the policy options presented in this report.

The Mitigation Working Group received input from the Assembly of First Nations (AFN) and the Métis National Council (MNC). The Inuit Tapiriit Kanatami (ITK) opted to provide their input directly to Ministers. The submission from the Assembly of First Nations emphasizes human and Indigenous rights should be central to shaping further climate action, and advocates for energy democracy and security, food sovereignty and water purity for Indigenous peoples as key outcomes for Canada's climate action. The AFN proposes several policy options, including targeted funds to promote cleaner and more efficient energy, technology, infrastructure, and capacity in First Nations communities, and measures to improve the efficiency of buildings in First Nations communities, which would have important co-benefits. The submission from the Métis National Council outlines overarching rights-based principles to inform Canada's action on climate change, with an emphasis on the need for ongoing dialogue, engagement, and partnership with the Métis Nation as policies are developed and implemented. The MNC provides general support for mitigation measures that complement carbon pricing, while identifying some potential opportunities in Métis communities, such as energy efficient buildings, electricity generation, forestry, and government operations.

Key Findings

Large Industrial Emitters: The industrial sector, including oil and gas, is the largest source of Canada's emissions and offers the most significant opportunities for emissions reductions. Mitigation options for the industrial sector include transitioning to lower carbon fuels, like electricity, natural gas, or renewable fuels; capturing emissions from industrial processes; and improving energy efficiency. There are a broad range of costs and potential emissions reductions across this diverse sector. In some cases, there are remaining opportunities to reduce emissions at a low cost. For instance, the cost savings generated by some energy efficiency measures could completely offset their upfront costs in relatively short timeframes. Recently announced federal regulations to reduce methane emissions from the oil and gas sector are expected to achieve up to 20Mt of reductions at a cost of under $50 per tonne. However, many mitigation options remain costly and further development of new and transformative technologies will be needed to achieve deep reductions from industrial emissions over the longer term. As a major driver of Canada's economy, the impacts of climate change policies on the competitiveness of the industrial sector are a central consideration. It will be important to ensure that policies in this sector contribute to future innovation, job creation, and better outcomes for environmental and human health.

Transportation: Canada is a large country; people and goods move across it using a variety of transportation – including passenger cars and trucks, airplanes, freight vehicles like heavy-duty trucks, trains, and marine vessels, public transit, walking and biking, and off-road vehicles such as those used in mining, construction and agriculture. In general, options to reduce emissions from transportation include improving the energy efficiency of vehicles and systems; shifting to lower carbon fuels, either with zero-emission vehicles or by using renewable fuels in conventional vehicles; reducing vehicle use (e.g., by driving less) and choosing lower emitting modes (e.g., moving freight by rail rather than trucks). Energy efficiency standards could be applied across modes of transportation to reduce fuel use, which generally offsets upfront costs. A low-carbon fuel standard could be used to scale up the renewable content of fuels and achieve significant (10-20 Mt by 2030) reductions at a relatively low cost (under $50 per tonne). Investments in infrastructure are key to reducing emissions in the transportation sector. For example, infrastructure investments can support better access to public transportation, safe spaces to walk and bike, and charging or fueling stations for alternative vehicles. Investments to ensure adequate access to low-carbon fuels, refueling infrastructure for low-carbon freight vehicles and other measures to support freight efficiency and modal shifts could also be considered. In some areas, such as the electrification of freight transportation, further research, development, and demonstration may be needed.

Built Environment: The majority of emissions from Canada's residential, commercial and institutional buildings are from space and water heating. Reducing emissions will mean moving towards highly-insulated buildings, improved building operations, better-performing equipment, and in the long-term, transitioning from fossil fuels to low-emissions electricity and other lower-carbon fuels. Ambitious equipment standards and 'net-zero-ready' building codes can achieve significant reductions in 2030 (about 10-15Mt) and lay the foundation for deeper reductions in the longer-term. Retrofit and fuel-switching programs can also achieve substantial reductions, and policies to help consumers use energy more efficiently show potential as well. Costs for these measures vary widely because of the impact of fuel savings on net costs. Policies for this sector have the potential to stimulate the economy via construction-related jobs, making training and technical assistance particularly important.

This sector also includes analysis of urban form and spatial planning policies, which can reduce emissions by helping to reduce building energy use, encouraging district heating, and helping shift transportation patterns towards public transit and active transportation. These policies are driven by multiple objectives, with emissions reductions only one of many goals. However, reductions could be significant, particularly in the longer term post-2030.

Electricity Generation and Transmission: To reduce emissions in the electricity sector, Canada will need to continue to strengthen its capacity for clean electricity leadership and accelerate the shift away from fossil fuels. There are a number of options that could support scaled-up clean electricity generation, including emissions performance standards or regulations, a non-emitting portfolio standard, or financial incentives. Investment in grid infrastructure could also help to connect existing and new clean electricity generation resources with electricity demand. Most of these options as presented in this report have significant potential for reductions (up to about 20 Mt), but there are important regional differences in access to clean electricity across Canada that will need to be accommodated. There are also important considerations around the economic impacts of shutting down electricity generation assets before the end of their useful life, and infrastructure investments that would be needed to ensure clean electricity is available at a reasonable cost to consumers across Canada. Of equal importance is the potential for major health and environmental benefits from reduced air pollution associated with decreased reliance on fossil fuels like coal. There are also specific areas where additional, targeted investments could be warranted, such as to help Northern and remote communities to reduce their reliance on diesel for energy generation.

Clean electricity is fundamental to the transition to a low-carbon economy; a number of electrification options for reducing emissions in other sectors, like transportation, industry and the built environment, depend on access to increasing amounts of clean, reliable electricity. Electricity sector policies will need to account for the probability that policies to promote electrification in other sectors could substantially increase overall electricity demand.

Agriculture: Opportunities for emissions reductions in the agricultural sector using current technologies are generally small. Market forces and past government programs have already encouraged farmers to adopt management practices such as no-till farming that substantially reduce emissions. Remaining opportunities focus primarily on managing methane emissions from livestock and manure storage, using fertilizers more efficiently, and increasing planting of cover crops or nitrogen-fixing crops and forages. The options presented in this report primarily propose incentive programs to help expand or accelerate environmentally-beneficial practices, taking into account the need to manage impacts on food prices for consumers and international competitiveness. Further research and development in areas like reduction and treatment of methane from livestock could contribute to lower costs and increase the potential for future emissions reductions.

Forestry: Building on current best practices by planting more trees and adjusting forest management, Canada could achieve significant emissions reductions (potentially beyond 15 Mt by 2030) at a relatively low cost (under $50 per tonne). Furthermore, trees continue to store carbon dioxide and remove it from the atmosphere over their lifetime, meaning that the impact of measures in the forestry sector will grow and become even more significant beyond 2030. In the long-term – for instance, by 2050 - carbon sequestration in forests and wood products could represent one of the largest mitigation opportunities for Canada. In addition, forestry measures can also have other environmental benefits, and contribute to climate change adaptation objectives as well as economic development in remote communities. Increasing the use of wood as a building material could also help to lower the environmental impact of construction materials.

Other Areas for Action: The Mitigation Working Group also identified options to reduce emissions from the waste sector, such as increasing the capture and use of landfill gas; increasing diversion of recyclables and organics from landfills; and reducing food waste. As these measures would reduce demand for raw materials, emissions from transporting and processing these inputs, as well as emissions from landfills, they could have significant impacts across multiple sectors, both within and outside Canada, at relatively low costs.

Individuals and governments have an important leadership role to play in driving forward ambitious action on climate change. Small changes in behaviour by individual Canadians - like using less energy at home, reducing the use of personal vehicles, and purchasing more environmentally-friendly products – can have huge aggregate impact when multiplied millions of times. A successful national approach to climate change will need the active participation and support of Canadians. Efforts to promote education and awareness would have an important role in supporting many of the policy options included in this report.

Governments have a role in leading by example, by adopting ambitious measures to reduce emissions from their facilities, fleets, and other assets, as well as by using procurement to drive market demand for low-carbon goods and services. A carbon-neutral government policy is one example of a tool that can be used to enable this type of change.

Finally, Canada could also consider acquiring credits for emissions reductions in other parts of the world where costs are lower. Known as "internationally transferred mitigation outcomes," emissions reductions from outside of Canada's borders may have lower costs and contribute to investment in sustainable development abroad. Canada is actively participating in ongoing international discussions on this issue, and exploring which types of tools may be beneficial to Canada.

Considerations

While this report does not rank or prioritize options, it provides information and analysis about relevant considerations for policy makers, including:

Emissions reductions: Estimated emissions reductions are provided for each individual measure, based on either economic modelling or analysis by technical experts. Note that estimated emissions reductions for each individual policy cannot be added together; this would greatly overestimate total reductions, as there are significant overlaps and interactions between many of these policies. These estimates are most useful as an indication of the relative contribution of each policy.

Costs: The estimated ranges of the cost per tonne of emissions reductions in this report are intended to give a general indication of which measures have low, modest, or high costs. Costs are presented as high-level, national averages and therefore do not fully capture important regional variations. Costs also do not include related infrastructure investments or stranded assets for most options, nor do they take into consideration the indirect public expenditure savings that may result from the options (e.g., improved public health). Finally, as they rely on existing estimates in the available literature and/or calculations by technical experts, cost estimates may not be fully comparable.

Economic and consumer impacts: The report includes a qualitative assessment of potential positive and negative impacts on job creation, competitiveness, and economic growth. The report also considers which policy measures have the potential to contribute to longer-term, structural shifts towards a low-carbon economy.

Interactions with carbon pricing: As one of the principal policy tools for reducing GHG emissions, carbon pricing was studied by the Working Group on Carbon Pricing Mechanisms. Carbon pricing options are therefore not included in this report. However, the report includes some analysis of how the mitigation options presented could interact with carbon pricing.

Regional impacts, including on Northern and remote communities: The presentation of policy options in this report aims to be 'jurisdictionally neutral,' meaning that the policies are national in scope and do not specify which order of government would potentially implement them. Some considerations around the regional impacts of each policy option are included. In addition, this report highlights considerations specific to Northern and remote communities, as the policy solutions that are appropriate to these regions may be different from the rest of Canada.

Other types of benefits: Many of the policies in this report would also help to improve health; contribute to other environmental goods like biodiversity, clean water, or soil health; or reduce short-lived climate pollutants such as black carbon, which also have an important warming effect. In addition, some mitigation policies can reinforce climate change adaptation objectives.

Technology and infrastructure requirements: The feasibility of many of the measures in this report would depend on investments in infrastructure (the costs of which are not included in the estimated cost per tonne of each policy) as well as future improvements in the availability and affordability of innovative new technologies. Specific policies related to research, development and demonstration (RD&D) are included in the report by the Working Group on Clean Technology, Innovation, and Jobs.

A number of other considerations, such as linkages to the Canadian Energy Strategy and to other working group reports, are also incorporated throughout this report.

Structure

The report is organized into seven chapters and three annexes, as described below:

- *Chapter 2* contextualizes the work of the Mitigation Working Group, and describes its mandate, process, and approach
- *Chapter 3* summarizes key findings
- *Chapter 4* highlights the input that was received from National Indigenous Organizations
- *Chapter 5* summarizes input received from the general public and key stakeholders, and explains how their solutions were integrated into the development of policy options.
- *Chapter 6* provides profiles of each major economic sector, which briefly describe economic and emissions trends, policies currently in place, and key opportunities for further emissions reductions.
- *Chapter 7* provides concluding thoughts
- *Annex 1* provides a summary table of all policy options
- *Annex 2* presents short profiles of each policy option
- *Annex 3* provides more detail on key methodological choices and the economic modeling approach used to assess emissions reductions from each policy option.

The core content of this report references and builds on the policy options that are summarized in Annex 1 and explored more fully in Annex 2. Each policy option is identified by a letter, corresponding to the economic sector with which it is associated (e.g., B for Built Environment) and a number. Specific policy options are referred to throughout this report by a letter and number (e.g., option B1 is Net-Zero Ready Codes for New Housing). A summary list of all policy options and the corresponding letter/ number by which they are identified in this report follows below.

1.2 List of Policy Options

The following is a list of the policy options presented in this report. These options are referenced in Chapter 3, Key Findings and Considerations, are summarized in Annex 1 and are explored in greater detail in Annex 2.

Large Industrial Emitters
I1. Use Incentives to Promote Cogeneration
I2. Transitioning to Electrification
I3. Mandate or Use Incentives to Promote Energy Efficiency
I4. Zero Routine Flaring
I5. Fuel Switching to Lower Carbon Alternatives
I6. Methane Reductions
I7. Limiting Carbon Emissions through Abatement and Sequestration (CCS and other) Technology
I8. Emission intensity regulations to drive transformative changes in technology throughout the industrial sectors

Transportation
T1: Passenger Vehicle Emission Regulations and Incentives
T2: Increased Availability and Use of low-carbon Fuel for On-road and Off-road Vehicles
T3: Energy Efficiency in the Aviation, Rail, Marine and Off-road Industrial Sectors
T4: Heavy Duty Vehicle and Engine Emission Regulations and Incentives
T5: Vehicle and Engine Fuel Efficiency in the Aviation, Marine, Rail and Off-road Sectors
T6: Fuel Efficiency of On-road Vehicles
T7. Freight Efficiency
T8: Changing Transportation Usage Patterns
T9: Reducing Congestion and Vehicle-kilometers Travelled
T10. Increased Availability and Use of Low Carbon Fuels in the Domestic Marine, Rail and Aviation Sectors

Built Environment
B1. Net- Zero Ready Codes for New Housing
B2. Existing Housing
B3. Net-Zero Ready Codes for New Commercial-Institutional Buildings
B4. Existing Commercial-Institutional Buildings
B5. Equipment Efficiency
B6. Renewable Power and Fuel Switching
B7. Demand Response Opportunities and Behaviour Change
B8. Urban Form & Spatial Planning

Electricity
E1. Emissions Intensity Performance Standard for Fossil Fuel-fired Electricity Generation
E2. Accelerated Phase-out of Coal-Fired Electricity
E3. Non-Emitting Portfolio Standard for Electricity Generation
E4. Provide Financial Support to New Non Emitting Electricity Generating Facilities
E5. Financial Support to Reduce Reliance on Diesel Energy in Northern and Remote Communities
E6. Increase Interjurisdictional Transfers of Non-Emitting Electricity

Agriculture

A1. Reduction of Methane Emissions from Cattle
A2. Convert Marginal Land from Annual Crop Land to Permanent Cover
A3. Increase Acres of Nitrogen Fixing Crops, Pulses/Forages in Rotation
A4. Increase Adoption of Zero Till
A5. Enhance Adoption of Available Technologies That Capture and Destroy/ Treat Methane from Manure Storage Systems on Large Farms
A6. Increase the Total Crop Area on Which Precision Application Methods for Nitrogen Fertilizers Are Used

Forestry

F1. Increase Domestic Wood Use as a Substitute Material for More Emissions-Intensive Building Products
F2. The New Forest Program
F3. Increased Forest Rehabilitation
F4. Change in Forest Management Practices

Waste

W1. Landfill Gas Capture and Utilization
W2. Reduce Avoidable Food Waste
W3. Diversion of Organics
W4. Diversion of Recyclable Materials

Government Operations and Leadership

G1. Carbon Neutral Government

2 OVERVIEW

2.1 Introduction

In Canada and abroad, the impacts of climate change are already becoming evident. The science is clear that human activities are driving unprecedented changes in the Earth's climate, which pose significant risks to human health and economic growth. Ambitious global action is needed to avoid severe negative impacts of climate change, some of which are already being felt in Canada, such as rising sea levels, coastal erosion, melting permafrost, thinning sea ice, shifting precipitation patterns, increases in heat waves, droughts and flooding, risks to critical infrastructure and food security, and the spread of invasive species and diseases.

The international community has broadly agreed that tackling climate change is an urgent priority, and also a historic opportunity to shift towards a low-carbon economy. The adoption of the Paris Agreement in December 2015 was the culmination of years of negotiations under the United Nations Framework Convention on Climate Change (UNFCCC). The Paris Agreement is a commitment to accelerate and intensify the actions and investments needed for a sustainable low carbon future. In order to limit global average temperature rise to well below 2°C and pursue efforts to limit the increase to 1.5°C, all Parties to the agreement are required to put forward their best efforts through "nationally determined contributions" (NDCs) and to strengthen these efforts in the years ahead.

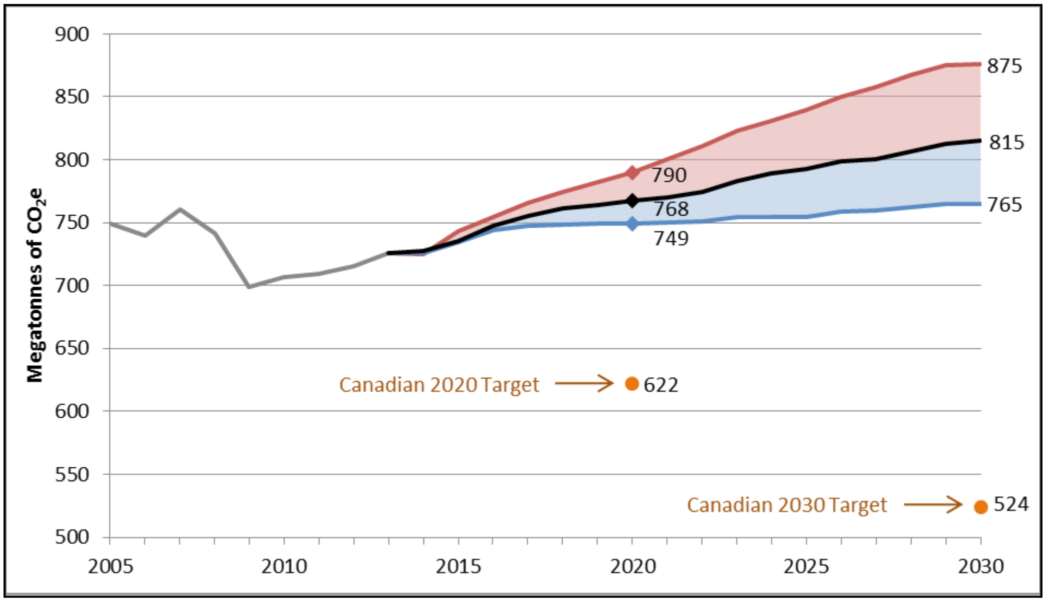
Provincial, territorial, federal, municipal, and Indigenous leaders all contributed constructively to the development of the Paris Agreement. Canada's collective task is now to ensure that domestic action on climate change is consistent with the long-term low-carbon development objectives set out in the Paris Agreement. Canada has submitted an NDC that sets a target of a 30% reduction below 2005 levels of emissions by 2030. The current federal government has stated that this will be Canada's minimum contribution and has committed to working with provinces and territories to achieve this target. Commitments and actions already taken by provinces and territories provide a strong foundation for Canada's climate action. However, there is still a significant gap between business-as-usual emissions projections to 2030 and Canada's 2030 target. Based on Canada's most recent emissions projections which were published in *Canada's Second Biennial Report on Climate Change* (in February 2016) and which take into account measures in place as of September 2015, Canada's emissions in 2030 will exceed the target of 30% below 2005 levels by 291 megatonnes (Mt) unless further action is taken.

There are a number of recently announced policies that are not included in these emissions projections that will help to reduce the gap to Canada's 2030 target.[1] These include, for instance, proposed federal regulations for hydrofluorocarbons (HFCs), heavy-duty vehicles, and methane emissions from the oil and gas sector; Ontario's (ON) cap-and-trade system and Climate Change Action Plan; Alberta's (AB) Climate Leadership Plan; Saskatchewan's (SK) renewable energy target; Newfoundland and Labrador's (NL) Management of Greenhouse Gases Act; and British Columbia's (BC) Climate Leadership Plan; as well as the federal government's endorsement of the World Bank's Zero Routine Flaring by 2050 initiative. Nevertheless, concerted, collaborative, and coordinated action by all orders of government will be needed to fulfill Canada's climate change commitments.

While the scale of Canada's emissions reduction challenge is significant, and compounded by factors such as a cold climate and a population that is dispersed over a large geographic area, Canada also benefits from a highly educated population and rich endowments of natural resources. With careful, forward-looking planning and strategic investments, Canada can position itself to be a leader in the global transition to a low-carbon economy.

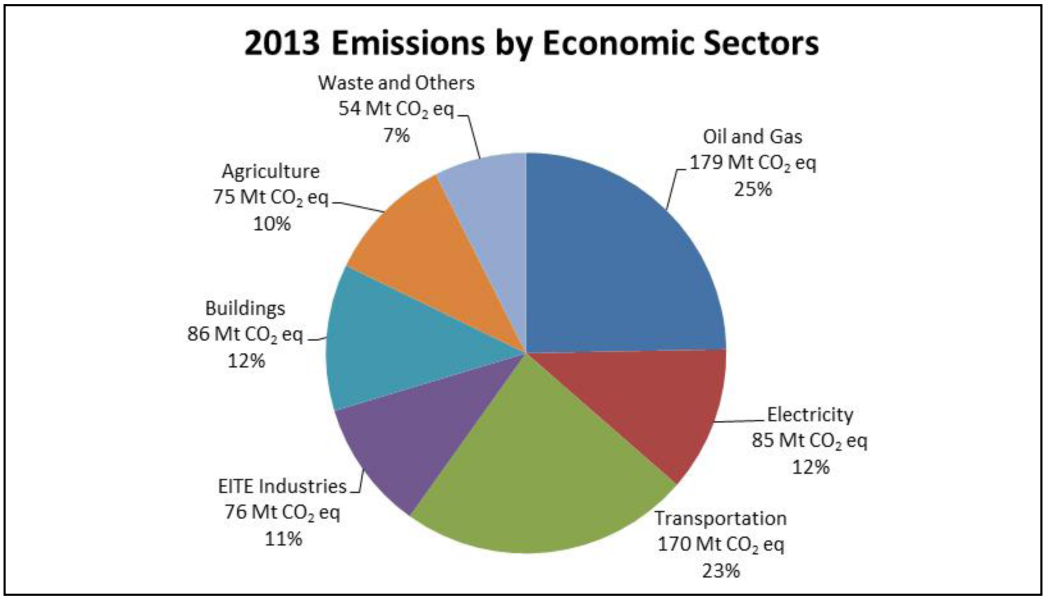
1 Time constraints and lack of detail for some announced policies meant it was not possible to update the baseline or business as usual scenario for this report. An updated business as usual scenario will be available later in 2016/17.

Figure 1: Canada's Emissions Projections in 2020 and 2030 (Mt CO_2e)[2]



Meeting Canada's climate change mitigation target will require action across all economic sectors. Historical emissions by major economic sector in Canada, as presented in Canada's Second Biennial Report, are shown in the graph below.

Figure 2: 2013 Emissions by Economic Sector



An important aspect of Canada's GHG emissions that is not fully captured in the trends and emissions described above is the impact of Short Lived Climate Pollutants (SLCPs). SLCPs are GHGs and/or air pollutants with short atmospheric lifetimes compared to longer-lived GHGs that have a warming impact

2 The range of projected emissions in this graph is based on a range of different scenarios that reflect the impact of key drivers of GHG emissions in Canada, notably oil and gas prices and economic growth. Projections exclude emissions and removals from the Land Use, Land-use Change and Forestry Sector (LULUCF). Please see Canada's Second Biennial Report for a complete discussion of these scenarios.

on climate. Because of their short atmospheric lifetimes, reducing SLCPs is particularly relevant for slowing the rate of climate change in the short term. While some SLCPs, such as methane, are included in emissions trends, an important air pollutant that is not is black carbon, a component of fine particulate matter released by the incomplete combustion of fossil fuels and biomass. The biggest sources of black carbon in Canada are on- and off-road diesel vehicles and engines, followed by residential wood burning. Stationary diesel engines are another regionally significant source in the North.

The Vancouver Declaration

Building on the commitments and actions already taken by provinces and territories and the momentum of the Paris Agreement, Canada's First Ministers met on March 3, 2016 and issued the Vancouver Declaration on Clean Growth and Climate Change (Vancouver Declaration). Under the Declaration, First Ministers affirmed Canada's commitment to taking action to address climate change while supporting a transition to a sustainable, low-carbon economy, and launched four federal, provincial, and territorial (FPT) working groups mandated to identify specific actions to grow Canada's economy while reducing greenhouse gas emissions and adapting to climate change. These working groups were tasked with developing reports identifying options for action in the following areas: clean technology, innovation and jobs; carbon pricing mechanisms; specific mitigation opportunities; and adaptation and climate resilience.

2.2 The Mitigation Working Group: Mandate and Process

The Vancouver Declaration sets out the following mandate for the Mitigation Working Group (MWG):

The Working Group on Specific Mitigation Opportunities will provide a report with options on how to promote clean growth and achieve a range of ambitious reductions in key sectors, including large industrial emitters, transportation, electricity generation and transmission, built environment, agriculture and forestry, and government operations as well as individual energy conservation actions. The working group will also look at approaches to internationally transferred mitigation outcomes, in the context of the Paris Agreement. The working group, supported by technical subgroups, will consider various emissions reduction opportunities, taking into consideration existing and planned policies.

The core deliverable of the MWG was a report with a broad range of practical, implementable policy options for each key sector to achieve ambitious GHG emissions reductions by 2030. As per the Vancouver Declaration, this report was delivered to the Canadian Council of Ministers of the Environment in September 2016.

The report does not rank or prioritize policy options, as the development of recommendations falls under the purview of Ministers. However, it provides relevant analysis and considerations to support Ministerial discussions on policy options.

The MWG was co-chaired by the Government of Canada and the Provinces of British Columbia (BC) and Alberta (AB). It established six technical subgroups in mid-April 2016, comprised of FPT government experts. The subgroups conducted their work from mid-April to mid-July 2016. The subgroups were:

- Large Industrial Emitters (including oil and gas)
- Transportation
- Built Environment
- Electricity Generation and Transmission
- Agriculture and Forestry
- Government Operations and Leadership[3]

3 These subgroups follow direction from the Vancouver Declaration and the breakdown of emissions in these sectors varies somewhat from the way they are presented in the Biennial Report (as in Figure 2). For instance, the Large Industrial Emitter subgroup includes emissions from the oil and gas sector, Emissions-Intensive and Trade-Exposed (EITE) industries sector, and light manufacturing, which

- The Mitigation Working Group provided guidance to subgroups, and examined specific policy options related to internationally transferred mitigation outcomes (ITMOs) and the waste sector. Individual energy conservation actions were considered across all subgroups.

Sub-groups developed a wide range of policy options that met multiple objectives.

Policy options for each sector needed to:

- Cover all of the principal opportunities for emissions reductions;
- Include highly ambitious policy options to ensure deep reductions;
- Be presented from a jurisdictionally-neutral, national perspective;
- Reflect options proposed by Indigenous peoples, the public and stakeholders; and
- Provide enough detail where possible to be considered as practical, implementable options.

This report is intended as a broad menu or toolbox, from which Ministers can choose and adapt the most relevant options for future plans. Sub-groups were asked to develop a comprehensive set of illustrative policy options, rather than an exhaustive description of all possible policy design variations. To ensure broad consideration of possible opportunities, the MWG has included many ambitious policy options that may not be relevant or feasible for all jurisdictions, and that could have significant economic impacts in some cases. Therefore, importantly, the report includes policy options that not all jurisdictions endorse or would be prepared to implement. In many cases, these policies are examples of the types of approaches that could be taken, with the understanding that these policies would be adjusted and refined before being implemented.

As this was a joint FPT initiative, the MWG considered policy options that can be implemented by one or more orders of government, either independently or in collaboration with other jurisdictions. Wherever possible, this report is neutral regarding which order of government is best placed to implement each option and presents potential emissions reductions and costs from a national perspective.

Options in this report focus on GHG emissions reductions in the 2030 timeframe, to support efforts to meet Canada's international commitment under the Paris Agreement. Options do not include specific measures aimed at reducing black carbon emissions, which could have an important role in reaching temperature goals. However, potential black carbon reductions from measures are identified for each measure as a co-benefit, and measures for future consideration are discussed under key findings and considerations.

Annex 3: Report Scope and Limitations provides more detail on key methodological choices in developing policy options for this report.

2.2.1 Estimating emissions reductions

Greenhouse gas (GHG) reductions in 2030 were estimated wherever possible using modeling from Environment and Climate Change Canada using its Energy, Emissions and Economy Model for Canada (E3MC). Where it was not possible to model the impacts of a given policy, subgroups estimated reductions using the best available information from existing studies and policies in other jurisdictions.

Emissions reductions were estimated separately for each policy option against a baseline or business-as-usual scenario of emissions projections to 2030 that included all existing policies as of September 2015. Estimated reductions do not account for overlaps or interactions between policy options and any of the many new policies announced by all orders of government since September 2015. Consequently, reductions from proposed policies need to be considered separately – they cannot be added together without greatly overestimating total reductions.

in the Biennial Report is found in the 'Waste and Others' category. The sector profiles in this report reflect emissions profiles that align with subgroup areas identified in the Vancouver Declaration.

While most options consider only emissions reductions that would be directly associated with the policy, a few options have taken a broad 'lifecycle' approach that also considered the indirect emissions reductions that would occur across multiple sectors as a result of changes to inputs and processes associated with the policy measure.

2.2.2 Estimating costs per tonne

Climate change mitigation policies are often compared based on how much it costs society to avoid a tonne of carbon dioxide equivalent (CO_2e), known as the cost per tonne of the policy.

Policy options in this report generally include estimates of the costs of proposed policies presented in terms of the "economic cost per tonne" of the policy. Where possible, this is estimated to be the total lifetime incremental economic costs generated by the policy, including all costs to businesses, consumers, and government, net of easily quantifiable benefits (principally fuel savings), divided by the amount of tonnes of CO_2e reduced over the lifetime of the implemented measure. Costs were incremental to a business-as-usual scenario. Costs can be negative if the savings realized over time (e.g., reduced fuel use from an energy efficiency policy) are greater than the costs associated with implementing the policy.

For example, a proposed policy to improve building codes included the additional cost of building a new home to a more stringent code, instead of the current code (e.g. additional insulation). Fuel savings from reduced heating and cooling costs over the lifetime of the home were subtracted from these costs. This net cost was divided by the total tonnes of CO_2e avoided due to reduced energy use over the lifetime of the home.

Where costs included capital expenditures, net present value costs applied discount rates to any fuel savings over the lifetime of equipment. However, no discounting was applied to GHG reductions achieved over the same duration.

The cost estimates in this report are intended to give a general indication of which measures have low, modest, or high costs. As they rely on existing estimates in the available literature and/or calculations by technical experts, cost estimates may not be fully comparable because of differing assumptions on key variables such as future fuel costs, building costs, technology costs, capital turnover rates, discount rates and exchange rates. As such, they are subject to considerable uncertainty. There are additional—and potentially significant—costs and benefits that were not calculated in this report, such as infrastructure needs, financial impacts of retiring carbon-intensive assets before the end of their useful life (i.e. stranded assets), or benefits from reduced health costs. More specific details on the calculation of cost per tonne estimates for each policy can be found in the policy option profiles in Annex 2.

- Economic cost per tonne estimates are generally expressed as broad ranges:
  - < $0/t (negative cost, i.e., savings are greater than cost)
  - $0-50/t
  - $50-100/t
  - $100-250/t
  - > $250/t

2.2.3 Integration with Other Working Groups

The three other working groups established by the Vancouver Declaration – on Carbon Pricing Mechanisms; Innovation, Clean Technology and Jobs; and Adaptation and Resilience – address other important elements of a national climate change plan.

A number of the mitigation policies in this report would also help to advance climate change adaptation objectives, or could be implemented alongside adaptation measures. A detailed discussion of options for climate change adaptation can be found in the report of the Working Group on Adaptation and Resilience, but linkages between adaptation and mitigation options have been highlighted in this report where relevant.

Carbon pricing is another type of mitigation measure, which has been addressed by the Working Group on Carbon Pricing Mechanisms. The MWG report includes measures that can complement carbon pricing, measures that can be used as an alternative to carbon pricing, and measures that drive long-term change or achieve other benefits alongside carbon pricing. Interactions between pricing and other policies are discussed in Chapter 3.

There are practical limits to regulations and other mitigation measures (e.g. high compliance costs, infrastructure needs) that can be addressed by support for research, development, and demonstration (RD&D) and investments in key infrastructure. Such actions can help bring down the cost of mitigation opportunities. This provides an important feedback loop between these measures, enabling more ambitious pricing and mitigation measures as more low and non-emitting technologies become available. Options for investment in RD&D and innovation are addressed in the report produced by the Working Group on Clean Technology, Innovation, and Jobs. Some of the options developed by the Mitigation Working Group identify key technological gaps that could benefit from the options to support clean technology and innovation proposed by the Working Group on Clean Technology, Innovation, and Jobs.

In important ways, the mandates of these working groups reflect three essential elements of a comprehensive approach to mitigating GHG emissions: broad, economy-wide carbon pricing; specific and targeted regulations and other policy instruments; and support for research, development and demonstration (RD&D) for new technologies.[4] Each plays a particular role when implemented together.

2.2.4 Inclusion of Indigenous Peoples

Working group membership was limited to FPT officials; however, the co-chairs of the working groups held regular teleconference calls or face-to-face meetings with the Assembly of First Nations (AFN), the Métis National Council (MNC), and Inuit Tapiriit Kanatami (ITK) to provide updates on their work. These National Indigenous Organizations were also invited to discussion sessions with the full working group at face-to-face meetings.

In parallel to the working group process, the AFN, MNC, and ITK engaged with their respective memberships to develop input on climate change solutions that meet the needs and priorities of Indigenous peoples. However, the timelines and structure of the working group process posed significant challenges. An ongoing process of meaningful engagement with Indigenous peoples will be needed in order to ensure that the priorities of Indigenous communities are reflected in a pan-Canadian framework on clean growth and climate change.

Input received from the AFN and MNC is reflected in Chapter 4, as well as incorporated into the section on Indigenous Perspectives in Chapter 3 and in various policy options throughout this report. The ITK chose to provide their input directly to Ministers.

4 See also OECD/IEA/NEA/ITF (2015), Aligning Policies for a Low-carbon Economy, OECD Publishing, Paris. http://dx.doi.org/10.1787/9789264233294-en.

2.2.5 Public and stakeholder engagement

The MWG and other working groups engaged the public and key experts and stakeholders via two approaches:

- **Public engagement**, through an interactive website, email, regular mail, and publically organized town halls, and
- **Consultation with key experts and stakeholders**, through a series of three full-day roundtable events.

In April, the Government of Canada launched an interactive website where Canadians could share their ideas on how to address climate change and promote clean growth. This platform allowed Canadians to share their ideas, comment on the ideas of others, and be part of a national conversation on climate change. The website also gave Canadians the tools to hold town halls and discuss these issues within their communities. The public was further encouraged to submit comments by email and mailed correspondence.

All four working groups incorporated public input received through the interactive website and by email into their work. Chapter 5 outlines key themes and presents statistics describing the input received from the public and stakeholders.

3 KEY FINDINGS AND CONSIDERATIONS

The process of selecting and designing climate policies is complex. Climate policies can have direct and indirect impacts on a broad range of economic activities and social outcomes, as well as varying impacts across regions and populations. These impacts need to be carefully weighed and managed.

When considering whether to implement a specific mitigation policy, key questions for policymakers to ask include:

- What are the potential emissions reductions, and at what cost?
- What are the potential positive and negative impacts on economic growth, jobs, and competitiveness?
- Is this policy still necessary if other policies, such as a carbon price, are in place?
- Is this policy needed to enable foundational, transformative changes that will facilitate the transition to a low-carbon future in the long term?
- Are there other benefits from this policy, like improved health outcomes?
- Does this policy contribute to other key policy objectives beyond climate policy?

Once a policy has been selected, the details of how it ought to be designed are crucial to ensure it achieves its objectives while minimizing negative impacts. Some of the key questions to ask related to policy design include:

- Which type of policy tool(s) are best suited to implement this policy?
- How does this policy need to be tailored to address different regional circumstances?
- Does this policy address the unique considerations and priorities of Indigenous peoples?
- Is it appropriate to the needs of Northern and remote communities?
- What types of infrastructure or technology would be needed to support this policy?
- Can this policy contribute to or reinforce climate change adaptation objectives?

The ranking and weighting of all of the above factors depend on the priorities of each decision-maker. While this report does not attempt to prioritize options, the sections that follow provide more detailed information on the relationship between the options in this report and the considerations listed above.

3.1 Estimated Emissions Reductions and Costs

Two important issues to consider in weighing the policies presented in this report are the amount of emissions reductions each policy will achieve, and the relative cost of the policy in terms of costs per tonne of emissions reduced.

There are important limitations to keep in mind when looking at these two factors. Many of these policies overlap and interact with each other or represent alternative approaches. As such, reductions cannot be summed together. Policies in this report may also interact with some of the new provincial, federal and territorial measures announced since September 2015. As an illustration, when added up, estimated reductions from these policies are a minimum of 400 Mt - far more than the 291 Mt gap to Canada's 2030 emissions. This vastly overestimates the combined impact of these policies if they were all implemented together. Understanding the real impact of these policies will require choosing packages of mitigation policies to model together. However, reduction estimates do give a sense of the relative impact of each policy and where the biggest opportunities lie.

Similarly, the costs per tonne discussed below are most useful as a tool for comparing policies at a national level and identifying relatively low-cost measures. These estimates used broad, indicative ranges and are net of any direct cost savings, such as reduced fuel use. They do not, however, reflect regional differences or costs related to enabling infrastructure, which could be very high for some policies in some jurisdictions.

For example, moving away from coal-fired electricity may require new natural gas pipelines in some regions, or new electricity transmission infrastructure in others. More indirect benefits, such as reduced health costs due to lower air pollution levels, are also not reflected. The costs presented in this report also do not reflect who would bear the cost – e.g., industry, individuals, and/or government. This will depend on the chosen policy tool as well as the competitiveness of the sector, with some sectors more able to pass costs on to consumers.

With these caveats in mind, policy options are discussed below in order of estimated cost per tonne.[5] Some Built Environment policies, which broke costs out by fuel type, are discussed separately, as are policies that estimated emissions reductions on a lifecycle basis.

Policies with negative costs ($<0/t)

Significant opportunities (5-10 Mt): A handful of policy options have estimated negative costs – i.e., savings will outweigh the costs over time. Recently announced federal regulations for heavy-duty vehicles (T4) could achieve 3-6 Mt, and ambitious retrofit and recommissioning policies for commercial and institutional buildings (B4) could achieve up to 6 Mt.

Other policies with negative costs that achieve small (<5 Mt) reductions include transportation measures such as improving freight logistics (T7a) and allowing for heavier and longer trucks on roads (T4e) as well as measures that target behavioural changes of building users (B7) and commuters (T8, T9).

Policies with costs in the range of $0-$50 per tonne

Major opportunities (>10Mt): Major reductions in this cost range could be achieved by policies aimed at increasing the availability and use of low carbon fuels, including a low carbon fuel standard (T2). Industrial energy efficiency measures (I3) could achieve reductions of 10 Mt or more in this cost range, as could announced federal and provincial methane reduction measures (I6). Changes in forest management practices (F4) could also reduce emissions by up to 10 Mt.

Significant opportunities (5-10 Mt): Ambitious tree-planting programs (F2a) could achieve over 5 Mt of reductions, as could changes in forest management practices to focus on climate change mitigation (F4). Requiring domestic flights to compensate for most or all of their emissions by purchasing emissions offset credits (T3a) could also achieve substantial reductions, although costs could be higher if offset credit prices increase. Eliminating heavy oil use in industrial combustion equipment (I5a) could also achieve up to 6 Mt of reductions.

Other opportunities: Policies that could achieve smaller amounts of reductions include incentives to enhance the use of cogeneration (combined production of heating/cooling and electrical power) in the industrial and electricity sectors (I1); efforts to reduce speeding (T6); policies to increase the use of wood in construction (F1); and regulations or incentives to reduce methane emissions from landfills (W1). Various agricultural measures (A1, A2, A3, A4, A6) could achieve modest reductions (<1-1Mt each) at low cost.

Policies with costs in the range of $50-$100 per tonne

Major opportunities (>10Mt): Most policy options for reducing electricity generation emissions fall into this cost range and produce substantial reductions (E1, E2, E3, E4, E6).[6]

5 Some policies options only include very wide ranges for costs (e.g., $0-250/t) – they are presented here in terms of the high end of their cost ranges.

6 However, Nova Scotia estimates that the cost of some of these measures in their jurisdiction would be over $250/t.

Significant opportunities (5-10 Mt): Ambitious standards for light-duty vehicle and/or policies to increase the market share of zero-emissions vehicles (T1) could achieve significant reductions, a portion of which may be available to a cost below $50/ tonne. Policies to reduce emissions from off-road vehicles could potentially also reduce emission by over 5 Mt.

Other opportunities: Smaller reductions (<5 Mt) are available from policies that encourage purchasing low-emission vehicles (T9), increase the use of carbon capture and sequestration in industrial sectors (I7), rehabilitation of crown land affected by natural disturbances (F3), and better road pricing and measures for in-use heavy-duty vehicles (T7c and T4). Limiting carbon emissions through abatement and sequestration (CCS and other) technology (I7) could also achieve reductions of up to 5 Mt.

Policies with costs in the range of $100-$250 per tonne

Major opportunities (>10Mt): Industrial policies to encourage the use of lower carbon alternatives to fossil fuels such as renewable natural gas (I5), accelerate electrification (I2), and adopt transformative technologies (I8) could achieve more than 10 Mt of reductions each. More ambitious methane reduction targets for industrial sectors could also produce significant incremental reductions (I6b), in a wide cost range ($0-$250/t).

Significant opportunities (5-10 Mt): Policies to scrap older passenger vehicles (T1b) could achieve more than 5 Mt of reductions.

Other opportunities: More modest reductions could be driven by various transportation policies aimed at fuel efficiency (T6), measures targeting the marine, rail and aviation sectors (T3, T10, T5), changing transportation usage patterns (T8), and providing financial incentives to purchase zero emission vehicles (T1); targeted financial incentives for non-emitting generation in northern and remote communities (E5); and some agricultural policies (A1, A3, A6).

Policies with costs greater than $250 per tonne

Policies with costs of over $250 per tonne that were included in this report generally achieved small reductions (i.e., in the range of <1 – 3 Mt). Examples of these policies include efforts to eliminate routine flaring in the oil and gas and other sectors; a few specific transportation options to change transportation usage patterns (T8d, g), support modal shift (T7b), scrap older heavy-duty vehicles (T4d) and regulate in-use vehicles in the off-road, aviation, marine or rail sectors (T5d); programs targeting solar photovoltaic installations for residential buildings (B6); and agricultural manure management programs (A5).

Some policies have broad cost ranges that stretch above $250, suggesting a portion of emissions may require significant expenditures. These include industrial electrification (I2), heavy-duty vehicle retrofits (T4), energy efficiency measures in the aviation, marine, rail and off-road sectors (T5), and targeted financial incentives for non-emitting generation in northern and remote communities (E5).

Other policies:

Built Environment policies with variable costs based on fuel type

Costs for many built environment policies vary substantially by fuel type, because differences in fuel prices affect the potential cost savings from these policies. In particular, current natural gas prices are roughly one third those for electricity. Where buildings use natural gas, building codes, retrofit programs, and fuel switching to electricity have relatively high costs per tonne, reaching over $250/t in some cases. Where these measures target electrically heated buildings, on the other hand, costs are negative. Costs for oil-heated buildings are also relatively low. Estimated costs for retrofit programs are also likely conservative, since they don't reflect the fact that the older, more inefficient buildings can be retrofitted at low or negative costs per tonne in some cases, even when fueled by natural gas.[7]

Ambitious, 'net-zero-ready' residential (B1) and commercial (B3) building codes could produce roughly 5 Mt of reductions in 2030 each, as could the most ambitious residential retrofit programs (B2) and residential fuel-switching programs (B6). More stringent standards for equipment and appliances (B5) could achieve up to 8 Mt of reductions, with costs also varying by equipment and fuel type and potentially low for some equipment.

As discussed below in the section on Foundational and Transformative Change, the longer-term transition to a low carbon economy will likely require moving away from natural gas heating towards low-emissions electricity and/or other low-emissions fuels. This is an important factor to keep in mind when considering the relative costs of built environment policies.

Lifecycle emissions reductions
Several policies in this report estimate 'lifecycle' emissions reductions – reductions caused across the economy, and in some cases at a global rather than national level. Notably, an ambitious policy to reduce food waste by 50% (W2) could achieve 10-15 Mt of lifecycle reductions at a negative cost, and policies to divert recyclable materials (W4) from the waste stream could achieve similar reductions at low cost (under $50/t). Many of these reductions would occur outside of Canada. Policies to divert organics from the waste stream (W3) and encourage more use of wood in buildings (F1) would achieve more modest reductions (<5 Mt), all within Canada.

While the emissions reductions and costs are central considerations in determining which mix of policy options is most appropriate, there are many other factors that should also be carefully weighed by decision-makers. The sections that follow highlight a number of these considerations.

3.2 Economic and Employment Impacts

There are likely to be opportunities for significant economic and employment growth in the development and provision of materials, technologies and fuels needed to transition to a low-carbon economy. However, this transition will also be costly; most sectors will face new costs, largely in proportion to their emissions intensity. Consumers could see the prices of goods and services rise, in particular carbon-intensive activities such as transportation and home heating. It is, however, important to consider these costs in relation to global direct and indirect economic benefits, which could be considerable, as well as the long-term costs of not taking action on climate change, which some have argued could have severe negative impacts on the global economy.

A number of sectors will likely experience positive economic spinoffs due to mitigation policies. In jurisdictions that have already taken action, some of these trends are already underway. For example, the construction sector would likely expand to meet demand for building retrofits, and may also have to reorient some of its work practices to incorporate new techniques for net-zero ready energy construction on a large scale (B1-B5). Studies have shown that investments in energy efficiency for buildings can lead to increases in GDP (B2). Another domestic industry that has the potential for considerable growth is the renewable and low-carbon fuels sector. Policies requiring increased use of low-carbon fuels would create strong demand, although policy design can impact whether the fuels are produced domestically or imported (T10, T2, I5). Building new, clean electricity generation such as wind turbines, hydroelectric facilities and solar panels,

7 Differences in costs per tonne between the energy efficiency policy option in the Large Industrial Emitters sector (I3) and those in the Built Environment sector (B2, B4) are due to the emissions-intensive nature of industry. Buildings—in particular low-rise residential housing—are not emissions-intensive, and thus reduction potential is lower and costs per tonne are higher.

as well as power lines to transmit the electricity would also generate jobs and growth through construction and, potentially, domestic technology development (E1, E3, E4 , E6). Another key opportunity is in the development of carbon capture and storage (CCS) technology. This is an area where Canadian industry has an opportunity not just to deploy their technology at home, but to become a global market leader (I7). Domestic natural gas production may also experience growth in the short-to-medium term as industries switch away from heavier fuels (I5).

There may be opportunities for Indigenous leadership and economic development across a number of sectors, in particular in buildings, electricity and forestry. Indigenous communities have an urgent need for housing solutions that are safe, sustainable, culturally appropriate, and also energy efficient. Construction to meet these needs may represent an opportunity for Indigenous-owned businesses. Electricity and energy solutions for Indigenous communities, such as reducing reliance on diesel (E5) and increasing use of renewable and distributed generation, could support local economic growth. The AFN has proposed designing policies to allow for home or community renewable energy solutions or community ownership and operation of renewable energy projects. The AFN has also noted that Indigenous communities face significant barriers to economic development due to the high cost of doing business in their communities, and that improved access to capital as well as partnership and training programs could help overcome some of these barriers. The AFN also advocates that resource sharing and co-management agreements as well as impact benefit agreements should be designed to guarantee that First Nations are agents and drivers in the new economy. The MNC also identified housing and energy solutions, including reduced reliance on diesel, as two priority areas for Métis communities. The submission from the MNC also recommended the creation of Métis -specific contract capacity set asides for Métis businesses in government procurement strategies, including those businesses that have a clean technology focus. In addition, the MNC proposes establishing regional collaboration/ impact benefit agreements in Métis Nation Traditional Territories that include effective procurement provisions, particularly in the purchase of clean technologies, training, employment, community investment and equity participation benefits

The up-front costs associated with cutting emissions could be substantial. Near-term capital investments may be significant across a number of sectors, in particular those that have to install new equipment to reduce their emissions. Where financial incentives are provided to help accelerate these investments and reduce the economic burden on businesses, it is important to note that these incentives also represent costs to governments and taxpayers. In many cases, investments to cut emissions can pay off over the medium- to long-term through fuel and other operational savings. Examples include energy efficiency measures in the industrial (I3), transportation (T6, T3, T5) and buildings (B1-B5) sectors, capturing marketable products like methane that are currently being wasted (I4, I6, A6, W1), and broader structural changes to buildings, cities and transportation networks (B1, B3, B8, T3, T8, T7).

This general finding about upfront costs that pay back over time applies to consumers, businesses, industries, and governments, and points to the need for policies to consider the distributional impacts of the costs they impose. Care must be taken to minimize the burden on low income, rural and northern Canadians.

Impacts on consumers could be variable. There are opportunities for considerable savings due to greater efficiencies and lowered fuel costs (T6). At the same time, many costs will likely increase. Electricity prices would likely rise in provinces currently reliant on fossil fuels for their power generation (E1-E4). The costs of emission-intensive activities would also rise, such as driving large or inefficient vehicles and flying. The costs of consumer goods may be affected by changes to the freight sector, but it is difficult to project net impacts – increased fossil fuel prices could push the price of goods higher, but investments in efficiency and logistical coordination could bring prices down, making definitive conclusions difficult to reach (T4).

The policies identified in this report vary widely in terms of cost and feasibility. Some are easy to implement measures that will realize quick cost savings. Others are ambitious ideas that could require aggressive action with considerable associated costs. In the latter cases in particular, further analysis is needed to better understand regional and national economic impacts and policies would have to be carefully designed to limit impacts and distribute the burden equitably.

3.3 Competitiveness

A large part of Canada's economy is driven by international trade. Canada has a wealth of natural resources – from forests to oil deposits to hydro-electric resources – and industries whose products are sold to other countries in international markets. These trade-based industries that sell commodities to buyers outside of Canada face a particular set of economic and political challenges. They are generally "price takers," meaning they have less control over the prices they can charge. The oil and gas sector is a prime example where price is determined through international markets. Producers can make decisions that affect their costs – but these costs are also in part influenced by government policy. Similarly, some manufacturing industries, such as the automotive sector, operate in integrated, competitive markets. For instance, policies to improve the energy efficiency of vehicles or increase the share of electric vehicles (T1) should be designed to enable Canadian manufacturers to maintain their competitiveness.

There are a number of considerations in designing mitigation policies that will impact these "trade-exposed" industries. Harmonizing policies across jurisdictions wherever possible helps set a level playing field for all actors. It also helps minimize "leakage" – that is, the movement of firms away from jurisdictions with ambitious policies toward those with weaker policies. Harmonization also simplifies regulatory compliance. Where harmonization is not possible, domestic policies can be designed to allow all businesses to comply without overly harming the competitive position of trade-exposed industries. This can be accomplished through tools such as exemptions or financial support.

There are also beneficial opportunities for some trade-exposed industries. In some energy-intensive sectors, developing new industrial technologies has the potential to actually provide Canadian firms with a competitive advantage over their international rivals by improving the efficiency of their processes (I8). Improvements to electrical grid infrastructure to facilitate inter-jurisdictional transfers could expand export markets for some provinces and allow them to sell excess supply of clean electricity (E6).

It is worth noting that industrial policy options presented in this report estimate costs across a variety of industries. The impact on each industry will vary depending on their profit margins or ability to pass these costs on to consumers. Even within trade-exposed sectors, some sectors may have the profit margin to absorb a certain level of costs, while other would be more challenged to do so.

Finally, the transition to a low-carbon economy could open new market opportunities for Canada and help to increase export markets for Canadian firms that offer innovative, low-carbon goods and services.

3.4 Interactions with Carbon Pricing

As detailed in the report by the Working Group on Carbon Pricing, a broad, economy-wide carbon price implemented via policies such as a carbon tax or a cap-and-trade system is widely regarded as one of the most efficient policy tools for reducing GHG emissions, as it provides flexibility to industry and consumers to identify the least-cost way to reduce their own emissions, and spur innovation to find new opportunities for emissions reduction.

However, carbon pricing alone cannot address Canada's GHG emissions. There are four reasons why other policy tools should be considered:

A. To complement pricing by overcoming barriers that carbon pricing cannot address
B. As an alternative to pricing – in particular, where pricing levels are not sufficiently stringent on their own to achieve emissions reduction targets
C. To drive long-term change aimed at facilitating the transition to a low-carbon economy
D. To achieve other benefits not reflected in carbon pricing

Complementary Policies

Targeted complementary policies address specific barriers and could be implemented regardless of the level of pricing in place. Key barriers include:

- *Emissions cannot be covered by a carbon price:* It can be impractical to price emissions that are hard to quantify (e.g., fugitive methane emissions) or where both emissions and removals are associated with the same activity (e.g., forestry). Targeted policies are needed to address these emissions – for example, methane regulations (I6), waste stream diversion policies (W2-4), or targeted agriculture and forestry programs.

- *Lack of information:* Consumers and emitters may not have enough information about their own carbon emissions or low-carbon alternatives to take action. Policies such as labeling programs (B2, B4, B5) and technical assistance programs can close these gaps.

- *Lack of alternatives:* Without access to reasonably-priced alternatives, behaviour will not change as quickly or as much in response to a carbon price. Policies that increase the supply of alternatives can complement carbon pricing. Some examples include support for renewable energy in the north (E5), equipment and appliance standards (B5) or low carbon fuel standards (T2). More broadly, technological innovation is an important means to develop alternatives and to lower costs.

- *Pricing does not fully support public goods:* Carbon pricing does not fully drive investments in public goods such as transit (T8, B8), some electricity infrastructure (E6) and research and development (R&D). Technological advances spurred by R&D will be vital to achieve low cost reductions in the long term.[8] These public goods continue to need to be delivered and/or funded by government.

- *"Split incentives" between actors:* Carbon pricing is not effective where the actor making an investment does not receive the benefits of that investment. For example, increased energy prices may not lead a landlord to invest in energy efficiency improvements in a rental property if the tenant pays the heating and power bills. Similarly, tenants may not reduce energy use where landlords pay energy bills. Building codes (B1, B3) and retrofit programs (B2, B4) can overcome this issue.

- *Delayed response:* Some activities do not respond to a carbon price quickly. For example, drivers may not buy more efficient vehicles in the near term to respond to a carbon price, making demand for gasoline relatively steady in the short term even with a carbon price. Targeted policies like codes and standards (B5) and low carbon fuel standards (T2) can help drive short term change.

- *Lack of access to capital or structure of financial instruments:* Some consumers or businesses may not have access to sufficient capital to make changes in response to a carbon price, for example low-income families, small businesses, and small/remote communities. Even where financing exists, people may not want to invest if payback periods are long and they do not expect to own the investment long enough to see future cost savings. These barriers can be addressed by targeted support such as building retrofit programs (B2, B4) or support for remote communities (E5). New financing instruments can also help to overcome these issues (see 'Policy Tools').

8 More broadly, research and development is hindered by persistent market failures (e.g. knowledge spillovers) and barriers (e.g. capital and time intensity).

Alternative policies

Other policies act as potential alternatives to a carbon price – they are aimed at emissions or activities that would be addressed by a sufficiently stringent carbon price. The importance of these policies will depend on whether there is a price on carbon and how high it is.

For example, regulations for electricity generation (E1, E2) and industry (I1, I2, I3, I5, I7, I8) might not be needed if sufficiently stringent pricing is in place. However, without a price on carbon, or where such a price is relatively low, these measures can be designed to achieve similar outcomes as a carbon price.

Longer-term policies

Finally, even with relatively stringent pricing in place, specific and targeted mitigation policies will be needed to avoid investments and 'lock-in' of carbon-intensive equipment and infrastructure, drive transformative changes, and help ensure a consistent transition for all key economic sectors towards a low-carbon economy. For example, building codes and equipment standards (B1, B3, B5) ensure new equipment and buildings are highly efficient.

Realizing other benefits

Governments may want to pursue specific policies that provide additional benefits beyond those associated with pricing. For example, transit investments provide mobility benefits for various populations and reduce congestion (B8, T8).

3.5 Foundational and Transformative Change

This report focuses on developing policies to reduce GHG emissions in order to help meet Canada's 2030 emission reduction target.[9] As challenging as it is, getting to 2030 is only the beginning of the battle. Ultimately Canada and the world will need to transition to a low-carbon economy by 2050; along with its G7 partners, Canada has recognized the need to reduce emissions by 40-70% or beyond by 2050, and many stakeholders have called for reductions of 80% or more. Some provinces and territories have set 80-95% reduction targets for 2050. Achieving this longer-term mid-century transition will not be possible without fundamental changes in the technologies and systems that power our society. Consequently, some policies that are important for reaching Canada's 2030 goal may be less important for the longer-term transition, in particular those that target incremental changes such as some energy efficiency measures, or those that rely on a transition to lower-emitting fossil fuels such as natural gas. In these cases, careful planning will be needed to minimize the risk of stranded assets in the long term. Other policies may have limited impact in 2030 but will need to be put in place now in order to realize larger impacts in 2050. The latter category includes RD&D to continue developing cleaner technologies and stringent 'net-zero ready' building codes (B1, B3).

There are a few key large-scale transitions that will likely be central to building a low-carbon economy by 2050. There is broad agreement that electrification across multiple sectors, including industry, transportation and buildings, coupled with dramatic decarbonization of electricity generation is a promising pathway toward a low carbon economy. Canada's electric grid is already about 80% non-emitting, and provinces and territories are taking further action to increase that percentage. This report identifies a number of policies to help accelerate the push to decarbonize electricity production, as well as policies to help other sectors to convert their operations to run off electricity.

9 Many provinces and territories have their own 2030 emission reduction targets, some have 2020 targets and some have 2050 targets. Some provinces also have targets by sector.

Electrification may not be the solution in all sectors. For example, significant electrification may not be practical in Canada's oil and gas sector, the country's largest and fastest growing source of GHG emissions. In this sector, new transformative technologies hold great potential to reduce emissions. In some cases these technologies have already moved from the research lab to real-world trials. Continued investments today, together with forward-looking and aggressive expectations for efficiency improvements, can help scale up these next-generation technologies to commercial competitiveness in time for 2050. Transformative technologies can play a similar role in decarbonizing other sectors as well; a prime example is the potential for zero-emission vehicles to cut emissions from transportation. This report includes policy options that will indirectly support and incent the development and deployment of new technologies. Policies focused on technology development are explored in greater detail in the report of the Working Group on Clean Technology, Innovation and Jobs.

Another central consideration in transitioning to a low carbon economy is how to plan and design cities in order to support low-emission technologies and lifestyles. This kind of structural change will take time to realize, but governments can start building momentum in the short-term by deciding to take a holistic approach to development through integrating land use, transportation, energy production and community planning (B8, T8).

Another sector that will require time to realize its mitigation potential is the forestry sector. Trees take time to grow, and by 2050 Canada's forests could be sequestering very significant amounts of CO_2. This report identifies a number of policies (e.g., F2, F3, F4) that, if enacted in the near-term, could help the forest sector contribute in a major way
to achieve Canada's climate goals.

3.6 Co-benefits and Other Impacts

By reducing GHGs, climate change policies can help to minimize or avoid the future risks of climate change. However, climate policies may also positively and substantively contribute to other types of benefits, such as reduced air pollution and improved health, energy security, better quality of life, or reduced noise pollution. Climate policies can also help to maintain or improve other types of environmental goods like clean water, soil health, biodiversity, and ecosystem services. These multiple benefits from climate change policies are referred to as 'co-benefits.' Typically, the primary goal of climate change policies is to reduce GHGs, and other types of benefits are secondary effects. In some cases, however, the primary objective of a policy could be to reduce air pollution or achieve another type of benefit, and GHG reductions could be a secondary benefit. For example, investments in public transportation may not generate large GHG reductions in the near term, but would contribute to improved health and quality of life, as well as facilitate longer-term shifts between transportation modes.

It can be complex to compare the costs of climate change policies with these types of co-benefits, which are often non-monetary goods. The balance of costs and benefit vary by policy, but in some cases the total benefits of the climate policies may significantly outweigh the costs. For example, recently published Multi-Sector Air Pollutants Regulations (MSAPR) have an expected benefit to cost ratio of 5:1 for boilers and heaters equipment used to generate heat and steam for various purposes in many industrial facilities, and 16:1 for stationary engines equipment used for compression, electric power generation and pumping in many industrial facilities.[10]

10 www.ec.gc.ca/lcpe-cepa/default.asp?lang=En&n=FEA2BB78-1&printfullpage=true

Climate change policies can also contribute to job creation and advances in clean technology and innovation. In some cases, climate change policies can generate direct cost savings and have negative costs. Some policies can have multiple benefits or objectives that are mutually reinforcing, such as reducing GHGs while contributing to innovation or adaptation objectives, creating jobs, or advancing priorities identified by Indigenous communities.

Burning fossil fuels generates air pollutants that have very serious negative implications for human health, such as particulate matter, black carbon, and others. Reducing air pollutants is a major co-benefit of climate policies, given their profound impact on health, the environment, and the economy. These benefits could be realized by policies that reduce the use of fossil fuels by improving efficiency and using less fuel (e.g.,I3, T6, T3, T7, T1, T4, T5, B1, B2, B3, B4, B5), by transitioning to lower-carbon fuels (e.g., I1, I2, I5,T2, E1, E2, E3, E4, B6), or by implementing management practices to capture and manage emissions that contribute to air pollution (e.g., I4, I6, I7, A6, W1).

Climate policies can also contribute to social goods, like livable cities, improved productivity, and quality of life. For instance, measures to reduce the use of personal vehicles and increase the use of public and active transportation (e.g., T9, T8) can help to alleviate traffic congestion, improve road safety, and promote active lifestyles, which can in turn reduce health care costs. A number of studies have indicated that highly efficient buildings (e.g., B1, B4) can help to enhance productivity and comfort.

There may also be other environmental benefits associated with climate change policies. For example, afforestation and forest rehabilitation policies (F2, F3) could contribute to enhanced habitat for wildlife and biodiversity. Soil health could be improved by cover crops on marginal land (A2) and nitrogen-fixing crops (A3), as well as increasing the diversion of organic matter from waste (W3), which would contribute to soil nutrient structure and improved water retention. Reducing fossil fuel use (e.g., coal) in the electricity sector could decrease water intake and discharge used for cooling as well as reductions in solid waste disposal.

Unless appropriately designed, however, climate policies can also have unintended negative impacts. For example, changes to industrial processes to achieve GHG reduction could produce additional air pollutants (e.g., increased temperature in cement kilns could lead to a significant increase in NOx emissions under I5). Rapidly increasing demand for building retrofits and/or imposing new building codes (B1-4) without sufficient time for training could raise construction costs and create potential health, safety, and building durability issues for homeowners. In the transportation sector, some operational efficiency measures (e.g., T3) could have negative impacts, such as increased noise. In some cases, the benefits would still outweigh the potential negative impacts, but these types of risks nevertheless need to be identified and managed.

3.7 Short-Lived Climate Pollutants

Short-lived climate pollutants (SLCPs) are GHGs and/or air pollutants with short atmospheric lifetimes compared to longer-lived GHGs, such as carbon dioxide, that have a warming impact on the climate. SLCPs include methane, hydrofluorocarbons (HFCs), black carbon, and tropospheric ozone. Methane, HFCs and ozone are GHGs. Black carbon and ozone are air pollutants. Methane is a precursor to ozone. As such action on SLCPs provides an opportunity to concurrently advance climate and air quality priorities.

The Intergovernmental Panel on Climate Change estimates that methane and black carbon are the second and third largest contributors to current warming, following CO_2. Due to their short atmospheric lifetimes, reducing emissions of SLCPs will quite quickly lead to reduced atmospheric levels, and will help to slow the rate of warming. In fact, recent scientific studies indicate that the only way to meet temperature commitments in the Paris Agreement is to take early global action on CO_2 and SLCPs. These expected benefits are particularly relevant for Canada as an Arctic nation. In Canada, the Arctic warmed by 2.2°C between 1948 and 2013 resulting in significant impacts to local populations and sensitive ecosystems. Black carbon is of particular significance in the Arctic due to its additional warming effect when deposited onto snow or ice, which accelerates melting.

The biggest opportunities to reduce methane emissions come from industrial sector (e.g., I4 and I6) and policies aimed at reducing landfill emissions and/or diverting organics from landfills (W1, W4). Some agricultural measures may also reduce methane emissions slightly (A1, A4). Multiple measures will reduce black carbon emissions as a cobenefit, either by reducing the use of fossil fuels by improving efficiency (e.g.,I3, T6, T3, T7, T1, T4, T5, B1, B2, B5), by transitioning to cleaner fuels (e.g.I1, I2, I5,T2, E1, E2, E3, E4, B6), or by implementing management practices to capture and manage emissions that contribute to air pollution (e.g., I4, I6, I7, A6, W1). Measures that target on and off-road diesel emissions (T6, T7, T2, T4,T5) are particularly relevant.

Potential areas for future consideration and action include:
- Retrofitting or early retirement of equipment or engines
- Regulations for new stationary diesel engines
- Regulations, funding support, or awareness campaigns targeted wood-burning appliances

3.8 Policy Tools

Multiple policy tools could be used to implement many of the options presented in this report. The best policy tool is often dependent on the specific circumstances and priorities of the jurisdiction implementing the policy. In Canada, federal, provincial and territorial governments, along with municipal and Indigenous governments, all use multiple policy tools to achieve a variety of environmental goals.

The options in this report focus primarily on various types of regulatory, incentive and other non-pricing tools, since pricing instruments are considered under the Working Group on Carbon Pricing Mechanisms. Regulations can be used to require or prohibit particular work practices, processes or equipment, or can specify a level of performance that must be met (e.g., an acceptable level of emissions and/or an ambient environmental threshold) and allow regulatees to determine the best means of compliance.

Incentives are subsidies, generally financial, provided to encourage desirable action. Incentives should be designed carefully in order to minimize unintended consequences, ‘free ridership’ and potentially high government costs. Incentives, including environmental tax subsidies generally privilege one or a few avenues for emissions reduction over others, meaning they are less flexible than broad market instruments like carbon pricing.

Beyond direct incentives, there are a range of other fiscal tools that governments can use to support mitigation. These include measures to help fund mitigation actions and technology development such as green bonds and green banks, as well as measures to impose costs on emitters, such as royalties and rules around corporate disclosure of climate change-related risks. Reviewing existing subsidies is another important tool. Canada, along with the United States and other G20 countries, has committed to rationalize and phase out inefficient fossil fuel subsidies that encourage wasteful consumption over the medium term.[11]

Other important tools are targeted education programs and public awareness campaigns. These can support and complement other policy actions by, for example, providing people eligible for an incentive program with the information they need to take advantage of the incentive program. Training and technical assistance

11 This commitment was most recently affirmed in that G20 Leaders’ Communique Hangzhou Summit www.g20.org/English/Dynamic/201609/t20160906_3396.html

programs are particularly important to facilitate the adoption of new technologies or techniques, e.g., in the building industry. In other cases, education and awareness alone can help drive behavioural changes. Some key educational and awareness-focused policy tools include:

- Informational tools such as labelling that allow consumers and businesses to include emissions intensity and energy efficiency in their decision-making;
- Training and technical assistance programs that help individuals and industries gain the skills needed to implement mitigation measures and/or shift industries when programmatic measures to sequester carbon or reduce emissions are not feasible for their industry;
- Awareness activities aimed at encouraging individual action.

Many GHG mitigation opportunities identified in this report could potentially be incented by carbon offset programs. A carbon offset represents one tonne of GHG reductions that can be used by another emitter to compensate for one tonne of GHG emissions. Generally programs are voluntary. Offset programs already exist within some emissions trading programs, for example in Quebec and Alberta, where entities can purchase offsets as one compliance option to meet regulatory requirements (e.g., instead of reducing emissions or using emission allowances or emission performance credits). Some sector-specific regulations, such as BC's low carbon fuel standard, also allow for the use of reductions outside the regulated scope for compliance, similar to an offset program.The private sector has also created various offset programs for consumers and businesses interested in voluntarily compensating for their emissions. Input from the MNC suggests that Métis-driven offset programs could be considered as a means of involving Métis communities and ensuring that they benefit from climate change policies.

Offsets have a similar impact to incentive programs, but tend to have a high administrative burden which may prevent smaller proponents from moving ahead with valid projects. To be effective, offsets need to meet various environmental integrity criteria. For example, offsets must be 'additional' –i.e. they are not reductions that would have happened anyway. Offsets awarded for carbon sequestration projects need to be accompanied by rigorous rules to monitor and ensure the permanence of GHG emissions reductions. Offset programs are particularly relevant for activities that are more difficult to directly regulate, such as some of the agriculture and forestry measures identified in this report, when programmatic measures to sequester carbon or reduce emissions are not feasible. However, in practice they are limited by the need to develop and apply rigorous quantification protocols at a scale to justify the administrative costs

Considering distributional impacts is important in policy development – in particular, policies should be designed to limit negative consequences on specific groups. There are a variety of ways to achieve this. Regulations can include exemptions or other provisions that limit their application. Incentives and funding programs can include targeted carve-outs for specific populations; for example, an infrastructure funding program could include a portion that is earmarked specifically for infrastructure in Indigenous communities and/or for Indigenous-owned businesses. For instance, the MNC recommends providing financial support for growth of both Métis capital corporations and equity capital funds in each of the Métis Nation Traditional Territories, including flexible terms for use of capital funds to allow investment and loans to Métis Nation corporations that have a clean technology focus.

Table 1 below provides a high-level summary of the policy tools included in the options outlined in this report. In many cases, options include references to multiple types of policy tools, either as alternative approaches or levels of ambition, or as complementary measures. Therefore the number of policy tools included in the table is larger than the number of options.

Table 1: Policy Tools

Sector	Policy Tool				
	Regulation	*Financial Incentive (e.g., grant, tax, etc.)*	*Other fiscal instrument (e.g., loan)*	*Action Plan/ Management Practices*	*Education/ awareness*
Agriculture		5		1	2
Built Environment	13	10	4	3	13
Electricity	4	3	3		1
Forestry		3		2	2
Large Industrial Emitters	9	8	1	1	
Transportation	19	14	15	5	3
Waste	3	3	2	1	2
Total	**48**	**46**	**25**	**13**	**23**

3.9 Regional Diversity

Not all options included in this report are appropriate for all jurisdictions. The majority of options presented could be national in scope, but would need to be tailored to take into account the economic structure and resource endowments of Canada's diverse regions, as well as provincial and territorial policies that are currently in place or have been recently announced. This report does not analyze whether specific policy options are feasible or practical in individual jurisdictions.

Electricity generation is a prime example of the important variation that can exist between Canada's provinces and territories. While some provinces and territories have abundant sources of clean energy, like hydroelectricity, others will require significant capital and infrastructure investments to shift towards cleaner generation sources. This means that policies to reduce emissions in the electricity sector would have very different costs in some regions relative to others. Furthermore, policies that aim to reduce emissions through electrification (e.g., I2, T1, B6) will have limited impacts unless the electricity is primarily supplied by non-emitting sources.

Differences in industries and resources across provinces and territories would also affect many of the proposed policy options. For example, differences in forest characteristics and farming conditions and activities across Canada make it difficult to define 'one size fits all' approaches for the forestry and agricultural sectors, although flexible policies can be designed around broad common objectives. Policy options targeting large industrial emitters could have widely variable costs and impacts across jurisdictions, depending on factors such as the type of industrial activity, available infrastructure, and policies already in place.

Different provinces and territories have various mixes of transportation systems. Some modes of transport are more concentrated in certain regions, such as domestic marine transportation, freight rail, and passenger rail. Policies targeting these modes of transportation would thus affect some provinces and territories more than others (T5).

The importance and design of policies for the built environment also varies widely by region. Building codes and retrofit programs (B1, B2, B3, B4) need to be adapted to local climates and construction industries. Differences in fuel availability and fuel cost also affect these programs. Urban planning policies must also reflect regional differences in population density and the needs of rural versus urban populations.

In general, these differences mean that more detailed analysis and tailored design will be important in implementing the majority of options included in this report.

Finally, responsibility for environmental policy is shared between provinces and territories and the federal government. Municipalities also have an important role in many areas related to climate policy, like urban planning and transportation. Provinces and territories have significant authority over environmental policies in their jurisdiction, leading to a variety of different types of policy regimes in place across Canada. While there are many advantages to this diversity, challenges related to regulatory duplication or overlap and competitiveness must also be managed.

3.10 Indigenous Perspectives and Opportunities for Leadership and Partnership

Both domestically and internationally, Canada has made significant commitments to work in collaboration with Indigenous peoples on climate action. More specifically, the Paris Agreement commits to, "*strengthen knowledge, technologies, practices and efforts of local communities and indigenous peoples related to addressing and responding to climate change*," and the Vancouver Declaration agrees to strengthen collaboration with Indigenous peoples "*based on recognition of rights, respect, cooperation and partnership*." Additional commitments to collaboration with Indigenous and local communities and leaders were included in the Leader's Statement on a North American Climate, Clean Energy, and Environment Partnership issued in June 2016, including to "*respectfully include traditional knowledge in decision making, including in natural resource management, where appropriate*" and to "*promote universal energy access and integration in the Americas, and to mobilize finance for the development of sustainable energy projects with a particular focus on indigenous communities, marginalized groups, and more vulnerable regions*." In May 2016, the Government of Canada officially announced its full support, without qualification, of the United Nations Declaration on Rights of Indigenous Peoples, which describes both individual and collective rights of Indigenous peoples around the world. It offers guidance on cooperative relationships with Indigenous peoples to states, the United Nations, and other international organizations based on the principles of equality, partnership, good faith and mutual respect. It addresses the rights of Indigenous peoples on issues such as governance, culture, environment, and health.

There are a number of factors that contribute to the particular vulnerability of Indigenous peoples to climate change; however, Indigenous peoples are also uniquely positioned to be leaders and agents of climate change action.

Many Indigenous communities are in northern or remote geographic locations; rely heavily on the natural environment for livelihoods; and face social and economic disadvantages, including a legacy of colonialism, sub-standard infrastructure and limited access to services, and lower quality of overall well-being (e.g., income, education) compared to the Canadian national average.

These conditions contribute to the exposure of Indigenous peoples to the negative impacts of climate change. For instance, sub-standard infrastructure increases the risks to Indigenous communities from extreme weather events, and exposure to vector-borne diseases (e.g., due to lack of access to clean water). The shortened winter road season is preventing critical shipments of necessary infrastructure, medical supplies, equipment, and fuel. A decline in access to traditional food, medicine, and other materials has economic and health impacts on Indigenous communities. The impacts of climate change may also damage social and cultural well-being and diversity, including diminished ability to pass on Traditional Knowledge and other knowledge to youth.

In the face of these challenges, Indigenous peoples are taking adaptive measures both formally and informally, to respond to the impacts of a changing climate and taking tangible steps to become active drivers of change. Indigenous peoples have been strong advocates for ambitious climate change action and have an important stewardship role over lands and resources. In addition, Traditional Knowledge can support managing complex ecosystems and addressing climate challenges.

However, adequate support will be required to enable the full and meaningful involvement of Indigenous peoples on climate action. Current economic realities in many Indigenous communities include inadequate access to capital, low rates of investment in Indigenous communities, and low employment rates. All of these factors impede the ability of Indigenous communities to diversify economies or invest in new infrastructure, which makes it harder for Indigenous peoples to address the increased resource needs associated with mitigating the impacts of climate change. Some potential solutions to overcome some of these barriers and challenges could include improving access to capital for Indigenous communities, designing resource sharing and co-management agreements to help Indigenous peoples be agents and drivers of change, and partnership with all levels of government and other institutions in order to strengthen Indigenous voices in climate change decision making. While further consultation with Indigenous peoples will be required to develop specific policy solutions, a number of options in this report point to areas where targeted programs or policies could respond to priorities identified by Indigenous peoples and enable opportunities for Indigenous leadership (e.g., B1, B2, B3, B6, B8, E3, E4, E5, E6, F3, F4, W4).

3.11 Northern and Remote Communities

Northern and remote communities account for a small portion of Canada's total emissions, and each of these communities faces specific challenges that affect the feasibility and cost of mitigation initiatives, and their capacity to implement and sustain these initiatives. Each community's circumstances vary by its climate, size, distance from other communities, access to transportation networks, access to energy and electricity, local industries and economic activity, the availability of skilled labour, and a variety of other factors. Climate solutions that benefit urban centers may not be equally relevant to Northern and remote communities. Regionally-appropriate policies are needed to respond to the needs and priorities of these jurisdictions.

One important area for further action is to reduce the reliance of off-grid communities on the use of diesel to generate heat and power. An estimated 200,000 Canadians live in remote communities that continue to rely primarily on diesel. In addition to its association with significant environmental and health risks, diesel fuel is expensive, vulnerable to risks associated with winter road delivery, and generates black carbon emissions. Limits to energy supply can also impede economic growth and have important social consequences.

Connecting to the electric grid or transitioning to natural gas may be a viable option for some Northern and remote communities. For others, scaling up use of on-site low-carbon energy generation from sources such as wind, solar, biomass, or hydroelectric development may be preferable. High upfront capital costs are a central challenge associated with deploying renewable energy technologies, developing or expanding hydro capacity, and grid extension projects. While savings from reduced diesel use could help to recover costs over time, near-term support would be required. Trained personnel would also be needed to install and maintain more complex systems.

This report presents some preliminary analysis of options to reduce diesel use for energy generation in off-grid communities (E5, E6). Biomass or combined heat and power may be an alternative option to diesel or heating oil in homes, buildings, and some industrial operations in Northern and remote communities. Since remote communities often have higher electricity prices and many of their grids are already at maximum load, this may be an alternative to some of the options for electrification presented in this report.

The governments of Manitoba, Quebec, Newfoundland and Labrador, the Northwest Territories, Yukon, British Columbia, and Ontario recently established a Pan-Canadian Task Force to reduce the use of diesel fuel to generate electricity in remote communities, which will develop and publish a report by the spring of 2017. In Budget 2016, the Federal Government also committed funds to implement renewable energy projects in off-grid Indigenous and northern communities that rely on diesel and other fossil fuels to generate heat and power.

Technological mitigation solutions must be appropriate to the weather, climate, and infrastructure of Northern and remote communities. Harsh northern climates can affect durability and reliability of some greenhouse gas mitigation technologies, rendering them inoperable or ineffective. For example, electric heat pumps experience reduced efficiency in cold temperatures. Some Northern and remote communities may not have ready access to the materials or skills required for servicing some technologies, and geographic distance and limited transportation options may affect the feasibility and costs of maintenance and repair.

Energy efficiency standards (I3, B5) and building codes (B1,B3) will need to continue to take account of the unique energy challenges of the North. Options to improve energy efficiency or transition to lower carbon fuels for buildings and industry (e.g., I1, I5, I3, B2, B4, B6) may also require incremental incentives or other types of accommodation to make them economically feasible in Northern and remote communities. Some options to reduce emissions from the transportation sector, such as electrification of passenger vehicles or increasing use of public transit, are less applicable to Northern and remote communities. Northern and remote communities rely on air and marine transportation and winter roads due to the great distances that must be traversed. Long-distance medical travel is also necessary for residents living in small, remote communities with limited health care services, as well as for hospital patients requiring medical procedures that are not available locally. Measures to limit aviation emissions (e.g.,T5, T10) could have a notable impact, particularly on smaller operators servicing the North and remote communities. While emissions from marine shipping are relatively low, they are predicted to grow as the open water season extends due to climate change, which could increase the importance of implementing measures to limit GHG and black carbon emissions from shipping (T10,T5).

In addition, options to reduce shipping costs could be explored. For instance, as suggested in option W4, a case could be made for processing paper along with organic waste locally (e.g. via composting), which would reduce the need to ship these waste products out of communities.

The Northern economy is less diversified than Canada's national economy and the industries that are prevalent are fuel-intensive. For example, mining, quarrying and oil and gas extraction, along with public administration, accounted for over 40 per cent of the North's GDP in 2011. Oil and gas reserves, as well as mining and forestry operations, represent potential sources of future emissions growth in some Northern and remote communities. It will be important to continue to develop these resources responsibly, for instance by limiting venting, flaring, and fugitive emissions from oil and gas operations (I4, 16), addressing emissions from off-road vehicles (T5), and improving industrial efficiency (I3), while balancing impacts on operating costs for these industries. In forest-based remote communities, options that increase the use of biomass and/or wood production (e.g. F1, E1, E2, B6), or contribute to afforestation or forest rehabilitation (F2, F3, F4) could potentially contribute to economic development.

Islands and island communities, which are not necessarily considered to be northern or remote, may face similar challenges depending on their isolation relative to the mainland. For example, there may be limited access to alternative fuels or other electrical grids. These communities may face higher transportation costs, which could have an impact on the cost of all goods and services in those communities.

3.12 Accelerating Technological Development

Developing, optimizing and deploying new technologies will be crucial to help reduce emissions across most sectors. In some sectors, such as buildings and electricity generation, low-carbon technologies are already quite mature, and research, development and demonstration (RD&D) requirements focus on optimizing existing technologies or filling key gaps. In other sectors such as large industry, more significant technological advances are required and so the need for R&D is greater. In some cases these technologies have reached the pilot deployment stage but considerable work remains to prove them at scale before they can be rolled out in commercial applications.

RD&D-focused policies were assessed by the Working Group on Clean Technology, Innovation and Jobs, and are beyond the scope of this report. However, many of the policies identified here will create a strong market 'pull' for RD&D efforts, either through direct financial incentives that scale up technologies or indirectly through regulations that set ambitious performance targets that require technological advances to achieve (e.g., I8). Governments can also play a direct role through procurement and showcasing new technologies in their own operations.

Specific enabling technology requirements in the industrial sector include R&D to support codes, standards and guidelines for biomass used in cogeneration cogeneration (the combined production of heat and power) (I1); process optimization for industrial energy efficiency (I3); and research on improving the efficiency and lowering the cost of carbon capture and storage technology (I7). As mentioned above, industry also needs substantial RD&D to accelerate the development and adoption of next-generation technologies and to bring down costs. Specific technologies and research needs vary by sub-sector and technical challenge.

In the transportation sector, technological requirements include R&D to reduce production costs and facilitate expanded supply for low-carbon fuels, as well as to support codes and standards and improve process reliability (T2); deployment of pilot intelligent transportation systems (T6); R&D on converting marine vessels and locomotives to accept low-carbon fuels (T10); and demonstrations of novel charging technologies and hydrogen fuel cell vehicle applications as well as R&D on specific components (T1).

In the buildings sector, key technology needs include demonstrations of net-zero ready energy communities (B1) and targeted RD&D for specific equipment such as heat pumps for cold climates (B5). In the electricity sector, RD&D of grid integration technologies such as energy storage could help lower the cost of integrating renewable energy (E3, E6). In agriculture, research on optimizing planting, fertilizer placement and harvesting could help increase the potential from nitrogen fixation (A3) and carbon sequestration (by increasing levels of soil organic carbon), and research to optimize catalytic oxidation could help reduce methane emissions from manure (A6). In forestry, research to improve forest monitoring and reporting could help better track the effects of mitigation actions (F4).

3.13 Infrastructure Investments

Many policies rely on access to various types of infrastructure. Some key areas in which infrastructure investments may be needed include improvements to the electricity grid; transmission capacity (e.g., pipelines) for natural gas, renewable natural gas, and carbon capture and geological storage; and transportation infrastructure, including public transit and active transportation, infrastructure to support intermodal transfers, and zero emissions vehicle charging infrastructure. It should be noted that the costs associated with building new infrastructure are not included in the cost-per-tonne estimates in this report.

Careful planning and significant investment will be required in order to ensure that Canada's electricity grid can incorporate additional clean energy capacity to displace fossil fuel generation (e.g., E1, E2, E3), and respond to potential growth in demand from increased electrification in transportation, industry, and buildings (e.g., T1, I2, B6). As outlined in option E6, investments to increase cross-border trade in non-emitting electricity could help reduce emissions, while also supporting intermittent renewable power (e.g., wind and solar) and improving reliability and flexibility. Advance planning will be important, as new electricity projects and transmission lines often take a long time to build and are costly. To support electrification policies, some industrial facilities may require additional infrastructure (capital investment) to support new electrical equipment (I2). Scaling up use of zero-emissions vehicles would require policies such as incentives, building codes and standards, and government investments for charging and fueling infrastructure (T1, T2). Some provinces are already heavily investing in public fast-charging infrastructure and offering incentives for home and work charging infrastructure.

Infrastructure to support a transition to lower-carbon fuels may also require significant investment. For example, reduced flaring from oil and gas facilities, petroleum refineries, and chemical plants (I4) may require new gas-gathering infrastructure (e.g., pipelines). The availability of lower carbon fuels is critical to options for industrial fuel switching (I5). Infrastructure investments for natural gas distribution, electric grid expansion, or renewable energy production may be necessary in some regions that currently lack access to alternatives to carbon-intensive fuels. Similarly, options to convert waste to power (e.g., W1, W3) or enhance industrial cogeneration (I1) would require access to the electricity grid and/or natural gas distribution pipelines. More generally, additional infrastructure may be required to scale up capacity for processing and producing renewable fuels. Limiting carbon emissions through abatement and sequestration (CCS and other) technology (I7) would require pipeline infrastructure to transport captured carbon dioxide to underground storage sites for facilities in locations without local storage opportunities.

Investments in active transportation networks (e.g. cycling and walking paths) and public transportation, and investments in inter-city rail can help to encourage people to shift away from emissions-intensive transportation modes such as personal vehicles (T8, B8). Urban planning policies that support higher-density communities can also significantly reduce the life-cycle costs of hard infrastructure. Strategic investments could also be made to encourage modal shifts for freight transportation (T7), including infrastructure improvements for rail terminals and ports. Over the longer term, infrastructure investments in electrified truck highways or other alternative transportation fuelling infrastructure could also help to reduce emissions from freight transportation (T4, T2). In the North, investment in basic infrastructure is needed before investment in such things as electric vehicle charging stations and large-scale active transportation networks. For example, highways are needed to replace winter roads and bridges to replace ferries.

Indigenous communities have a variety of infrastructure needs, from renewable energy and transmission infrastructure to help reduce reliance on diesel to improvements to housing. In order to improve the ability of First Nations to invest in needed infrastructure, the AFN has proposed improving access to capital and other financing mechanisms, mentorship, partnership and skills training, as well as ensuring these tools are designed to accommodate the fiscal realities of remote communities.

3.14 Access and Supply of Clean, Renewable Energy

Ensuring an adequate supply of clean electricity and other low-carbon and renewable fuels will be essential to powering a low-carbon economy. Renewable energy sources such as geothermal, wind and solar have an opportunity to replace a significant portion of emitting generation including coal and natural gas, and to meet additional demand of a low-carbon economy. Measures to improve energy efficiency (e.g., I3, T6, T3, T4, T5, B1, B2, B3, B4, B8) play a crucial role in lowering demand for electricity and other fuels. Maximizing efficiency and reducing demand will be an important first step towards an economy run by renewable and alternative fuels, and can help to counterbalance potentially significant increased demand from measures to promote electrification and fuel switching (e.g., I1,I2, I5, T2, T10, T1, B6). In some cases, however, efficiency measures could result in lower than expected fuel savings, to the extent decreased fuel costs contribute to increased use (i.e., the 'rebound effect').

Although electrification is a central element of a low-carbon economy, shifting to electricity is not always the most practical or cost-effective choice. Low-carbon and renewable fuels, in particular those produced from wastes, including ethanol, biodiesel, biomass, and renewable natural gas, as well as transition fuels such as natural gas will also be important sources of energy.

For example, industrial co-generation of heat and power (I1) could be fueled by waste wood biomass, renewable natural gas, or biogas. In the electricity sector, biomass could be co-fired with or replace coal (E1, E2). Biomass fuel sources, such as wood pellets, may also help move Northern and remote communities off heating oil (B6). Alternative fuels for various industrial operations (I5) could include renewable natural gas, biogas, biomass, pyrolysis oil, biodiesel, or renewable diesel. In the transportation sector, a low-carbon fuel standard could help increase the use of a range of low-carbon and renewable fuels across all modes of transportation, including on-road light and heavy-duty vehicles (T2) and marine, aviation, and rail transportation (T10).

However, there could be significant barriers to scaling up renewable fuels that would require policy support to overcome. Feedstock supply could present a major challenge. Supporting domestic production and distribution of low carbon fuels may be done through financial incentives (e.g., grants, tax preferences, low interest loans) as well as continued support for research, development and demonstrations (e.g. RD&D to support codes and standards, optimization of production pathways and to bring down costs). Otherwise there is a risk that requirements to use low-carbon fuels could result in significant and potentially costly imports. It will also be important to demonstrate that renewable fuels achieve lifecycle emissions reductions. Further research and development may be required to reduce the price premium of renewable fuels relative to fossil fuels, in particular if a strong carbon pricing regime is not in place. Finally, compatibility with engines and equipment may also be a consideration when blending higher levels of some renewable fuels with fossil fuel.

Canada has existing sources of feedstock (e.g. forest and agricultural residues, canola and other crops) but supply chains need further development and the supply of these crops would have to be significantly increased. Recycled oils and animal fats could be another source of feedstock if quality specifications could be met. Captured methane emissions from the agricultural sector (A6) and landfill gas (W1, W3) could provide some supply of renewable natural gas. In the forestry sector, forest management and rehabilitation policies (F3. F4) could support increased extraction of harvest residues for bioenergy.

Additional study of requisite infrastructure associated with other low-carbon or renewable fuels will be an essential part of implementing ambitious policies. Utilities and electric systems operators will also need to take into account new electrification policies when designing their systems.

Indigenous groups and some stakeholders have raised the concept of energy equity as foundational in order to ensure a just transition to a low carbon economy. Energy equity means that all Canadians should have access to modern energy services delivered safely and from clean sources. In particular, vulnerable populations or those who currently have poor energy access could be prioritized, including Indigenous peoples, people living in Northern and remote communities, and low-income Canadians. Input from the AFN has highlighted the importance of allowing for decentralized and distributed community-owned energy generation as a way of improving equity and access to clean energy for First Nations.

Renewable energy can play a role in helping Indigenous communities reduce reliance on diesel for heating and electricity (E5). The AFN proposes a number of measures to support deployment of renewable energy technologies in Indigenous communities, such as creating a central institution to streamline processes, introducing incentives for small-scale renewable energy and strengthening the grid to absorb more renewable generation.

3.15 Links to Adaptation

Many mitigation and adaptation policies can be designed to be complementary. For example, adaptation-focused ecosystem management and land-use-based activities used to manage climate risks associated with extreme weather, such as natural and wetlands conservation to reduce flood risks and protect biodiversity, can also reduce GHG through carbon sequestration and storage. Similarly, the use of urban canopies and other measures (e.g., green roofs, lighter pavement, reflective surfaces, etc.) to reduce the urban heat island effect can also lead to reductions in energy demands for cooling (B8).

In the same vein, mitigation policies in this report should be implemented with adaptation goals in mind wherever relevant. In some cases, policies can be designed to have adaptation benefits. For example, forestry policies aimed at rehabilitating crown land or increased afforestation (F2, F3) could be designed to protect biodiversity or reduce flood risks. Agriculture policies can also be designed to enhance food security.

Best practices from adaptation policies can help to inform the design of mitigation policies. For example, many of the policy options within this report require infrastructure investments, such as in public transit (T8) or electricity transmission (E6). These investments would need to incorporate adaptation considerations – e.g., be built to reflect changing weather patterns and flood risks. Similarly, mitigation policies should consider current and predicted climate impacts in their design and implementation, so as not to lead to maladaptation, jeopardize the permanence of emission reductions, or miss potential opportunities (e.g., increased potential for hydro power as a result of increase precipitation in some areas).

Lastly, some mitigation and adaptation policies could be implemented together. For example, efforts to accelerate building code improvements (B1, B3) and to support tree plantings, green roofs and permeable surfaces (B8) for mitigation could be implemented at the same time as improvements focused on adaptation.

3.16 Linkages with the Canadian Energy Strategy

In summer 2015, Provincial and Territorial Premiers finalized the *Canadian Energy Strategy (CES)*, a demonstration of their commitment to strengthening the economy, creating jobs, ensuring a secure supply of energy for all Canadians, supporting energy innovation and addressing climate change. In conjunction with provincial and territorial Energy Ministers, Premiers identified three themes to inform the future of energy in Canada: sustainability and conservation, technology and innovation, and delivering energy to people. The CES outlines ten main goals related to these themes.

Under the CES, Premiers agreed to form committees focused on energy efficiency, delivering energy to people; the transition to a lower carbon economy; and technology and innovation. At their summer 2016 meeting in Whitehorse, Premiers reaffirmed their commitment to the CES and welcomed the participation of the federal government in certain areas, including reducing diesel use in remote communities, supporting clean energy technology and innovation, and enhancing energy efficiency policies and mechanisms.

Table 2 below provides some examples of linkages between goals articulated by the CES and options presented in the Mitigation Working Group report.

Table 2: Linkages between the Canadian Energy Strategy and Mitigation Working Group Options

Canadian Energy Strategy Goal	Examples of Linkages with Mitigation Working Group Policy Options
1.2 Maximize access to energy savings by all energy consumers.	• B2. Existing Housing • B4. Existing Commercial-Institutional Buildings • B5. Equipment Efficiency
1.3 Encourage market transformation through targeted energy efficiency and conservation policies, including regulations and building retrofit codes	• B1: Net-Zero Ready Codes for New Housing • B3. Net-Zero Ready Codes For New Commercial-Institutional Buildings • B4. Existing Commercial-Institutional Buildings • B5. Equipment Efficiency • I3. Improve Energy Efficiency of Industrial Facilities
2.2 Foster an understanding by governments on the use of market-oriented policies to reduce greenhousegas emissions across Canada	• E1. Emissions Intensity Performance Standard for Fossil Fuel-fired Electricity Generation • E3. Non-Emitting Portfolio Standard for Electricity Generation
2.3 Actively pursue greenhouse gas emissions reductions with targets based on sound science.	• E1. Emissions Intensity Performance Standard for Fossil Fuel-fired Electricity Generation • E3. Non-Emitting Portfolio Standard for Electricity Generation
3.2 Increase awareness and understanding of energy in Canada.	• B7. Demand Response Opportunities and Behaviour Change
6.1 Support the efficient deployment of clean and renewable energy sources across Canada.	• B6. Renewable Power And Fuel Switching • E4. Financial Support for New Non-Emitting Electricity Generating Facilities
6.2 Support greater access to affordable, clean, and reliable supplies of energy for all Canadians.	• E5. Targeted Financial Incentives for Non-Emitting Generation in Northern and Remote Communities • E6. Increase Interjurisdictional Transfers of Non-Emitting Electricity
7.3 Facilitate greater exchanges and transfers of energy between or across the provinces and territories	• E6. Increase Interjurisdictional Transfers of Non-Emitting Electricity

4 INPUT FROM NATIONAL INDIGENOUS ORGANIZATIONS

The section below highlights key messages from the submissions that the Mitigation Working Group received from the Assembly of First Nations (AFN) and the Métis National Council (MNC), and discusses how this input was incorporated into the report. As noted above, the Inuit Tapiriit Kanatami (ITK) intends to provide input directly to Ministers.

4.1 Assembly of First Nations

The Assembly of First Nations (AFN) is a national advocacy organization representing First Nation citizens in Canada, which includes more than 900,000 people living in 634 First Nation communities and in cities and towns across the country. Every Chief in Canada is entitled to be a member of the Assembly, and the National Chief is elected by the Chiefs in Canada, who in turn are elected by their citizens. The AFN National Executive is made up of the National Chief, 10 Regional Chiefs and the chairs of the Elders, Women's and Youth councils.

The AFN's submission to the Mitigation Working Group emphasizes that any discussion pertaining to climate change needs to be based on full respect for the constitutional, treaty and internationally recognized rights of Indigenous peoples, and advocates for energy democracy and security, food sovereignty and water purity for Indigenous peoples as key outcomes for Canada's climate action. Indigenous or Traditional Knowledge has a critical role in managing and addressing climate-related challenges, but also in developing climate policies and related programs.

> *"When we talk about climate change we need to keep our language very real. When we say climate change, people tend to gloss over, even though we are in a crisis – it's just a word now. For me, climate change is going to change my way of life, it is changing my way of life, it has changed my way of life and it is very real today."*
>
> Lorraine Netro, AFN Women's Council Representative (2016)

The AFN advises that Indigenous communities must be directly involved in policy development, decision-making, and implementation going forward , and recommends that this engagement be delivered primarily by First Nations communities, tribal councils and organizations to ensure the widest possible support and maximum absorption of information and decision making. The model of shared decision making recommended by the AFN would require a more inclusive process for more meaningful engagement on climate action, supported by adequate resources.

The AFN's submission proposes three funds to reduce emissions, build capacity, and contribute to sustainable economic development in First Nations communities:

Fund A: Reducing Diesel in Northern & Remote Off-Grid Communities Fund: 50% reduction of diesel used for heating and electricity in Canada's ~140 remote and northern First Nations and other Indigenous communities by 2022 through energy efficiency/conservation, renewable energy, local smart grids, transport electrification, transmission connection, housing/facility design, and community energy planning. Funding: $900 million - $1.7 billion over 10 years

Fund B: Indigenous Clean Energy Technologies & Infrastructure Fund: 2,500 MW in renewable energy generating electricity technologies and large-scale infrastructure projects replacing existing coal and natural gas generation, or offsetting fossil fuel reliant electricity growth by 2024. Funding: $400-500 million over 10 years

Fund C: First Nations Clean Energy Community Capacity & Entrepreneurs Fund: Building community clean energy capacity through a national-wide cadre of First Nations clean energy entrepreneurs, through initiatives which build clean energy capacity and networks, in communities and through partnerships with clean energy and Cleantech companies and electric utilities. Funding: $50 million over 10 years

In addition to the proposed funds above, input from the AFN presents a range of general principles and specific recommendations across various economic sectors. For the large industrial emitters sector, including oil and gas, the AFN points to the need to work together on a process to address specific issues around engaging and partnering with First Nations in energy and extractive industries. Fundamental principles for this interaction outlined by the AFN include acknowledgement of ownership over traditional territories and associated rights; Supreme Court of Canada's Decisions on the Duty to Consult; and the importance of Free Prior and Informed Consent. The AFN also proposes some possible uses of carbon pricing revenue, including reinvestment in clean technology and reinvestment in the agricultural sector to ensure food security for low-income Canadians and those at risk of food insecurity.

Key themes from the AFN's submission have been incorporated in the policy options throughout this report, notably in the built environment, electricity and forestry sectors. The section below outlines some of the key ideas included in the AFN's submission, and suggests ways in which they could be addressed by the policy options in this report.

- **Support for culturally sensitive and energy efficient housing, including net-zero housing and communities**
  - Could be enabled: by net zero ready building codes that are sufficiently flexible to reflect Indigenous culture in building design (B1, B3); programs or incentives targeted to Indigenous communities for energy efficiency retrofits (B2), switching to less carbon-intensive energy systems and solar solutions (B6)
- **Stable and transparent clean energy policies that support renewable energy,** including First Nations home-based or community owned and operated systems. The AFN notes that scaled up deployment of renewable and distributed energy technologies will require action to address grid integration risks, favourable pricing policies, and incentives such as feed in tariffs and stable net metering that are accessible to First Nations Communities.
  - Could be enabled by: set-asides for renewable energy generation by Indigenous communities as part of broader strategies to scale up the use of renewable energy technologies (E3, E4), investments in electricity grid infrastructure (E6)
- **Incorporation of Indigenous knowledge and stewardship practices in the forestry sector**
  - Could be incorporated into forest rehabilitation policies (F3) and changes in forestry management practices (F4).

4.2 Métis National Council

The Métis National Council (MNC) is the Métis-specific national representative body, which receives its mandate and direction from the democratically elected leadership of the Métis Nation's governments from Ontario westward. The Métis National Council is represented by the Governing Members, namely the Métis Nation – British Columbia, Métis Nation of Alberta, Métis Nation – Saskatchewan, Manitoba Métis Federation, and the Métis Nation of Ontario through representative democratic governments.

Based on the national definition of Métis for citizenship within the Métis Nation adopted in September 2002, it is estimated that there are 350,000 to 400,000 Métis Nation citizens in Canada.

The MNC's submission emphasizes that climate change actions must be based on full respect for human rights and the rights of Indigenous peoples. Their support for effective action on climate change is contingent on permanent engagement with Métis during implementation, efforts to counter disproportionate impacts of policies on lower income households and remote communities, and assistance to strengthen Métis capacity for mitigation and adaptation. The MNC advises that efforts to address climate change must not be overshadowed or displaced by economy specific discussions, and seeks the implementation of the United Nations Declaration on the Rights of Indigenous Peoples within this and every process in relation to climate change.

The MNC suggests that the Low-Carbon Economy Fund, a $2 billion fund to support emissions reductions that the federal government announced in Budget 2016, could include set-asides for the Métis Nation. They also recommend establishing a fund for Métis communities to complete climate risk assessments and planning (similar to funding available to the Federation of Canadian Municipalities) and a new engagement process with the Métis Nation on an incentive and support program specifically targeting initiatives in Métis communities, such as the greening of Métis governance and institutional operations and retrofitting buildings, identifying opportunities for more local food, water, and energy conservation. The MNC also recommends creating Métis specific contract capacity set asides for Métis businesses in government procurement strategies, including those businesses that have a clean technology focus.

The MNC provided a submission to all four working groups, which noted that providing input to the Mitigation Working Group was particularly challenging given the broad scope and complexity of its mandate. The MNC notes that greater sector-specific engagement will be needed moving forward, including Métis specific dialogue at the regional and national levels as mitigation policies are developed and implemented. The MNC's submission points to some potential measures for further development, specifically related to the built environment, electricity, forestry, and government operations sectors. The section below provides a brief overview of how these areas could be addressed under options included in this report.

- **Support for energy efficient houses, businesses, and government buildings**. The MNC notes that Governing Members have housing authorities, some of which are significant property owners and managers. Energy efficiency initiatives could help to lower emissions and energy costs for Métis homes and businesses
    - » Could be enabled by programs or incentives targeted to Indigenous communities for energy efficiency retrofits (B2), switching to less carbon-intensive energy systems and solar solutions (B6), and policies to support efficient government operations (G1)
- **Clean energy generation initiatives,** including Métis delivery of new energy options (e.g., biomass, solar, geothermal) and identification of pilot projects to move communities away from diesel and towards alternative means of electricity and heat generation, identified in cooperation with Governing Members. The MNC'S submission notes that some Governing Members are engaged with the management of Métis consumers within their areas and coordinate spending as part of an incentive and support program
    - » Could be enabled by set-asides for renewable energy generation by Indigenous communities as part of broader strategies to scale up the use of renewable energy technologies (E3, E4), targeted support to reduce reliance on diesel energy in Northern and remote communities (E5)
- **Métis-driven carbon offset programs**, which could, for instance, support northern communities that rely on existing old growth forests for maintenance of traditional livelihoods, manage forest fires on a regular basis, and have a direct interest in forest land management, in some cases through land use agreements or licenses
    - » Could be enabled by measures to expand new forest areas (F2), forest rehabilitation policies (F3), and changes in forestry management practices (F4).

5 PUBLIC AND STAKEHOLDER INPUT

The Mitigation Working Group received significant and substantive input from the general public and stakeholder groups, such as non-profit organizations, think tanks, and industry associations, which has been carefully considered and integrated to the greatest extent possible throughout this report. Some ideas that were ultimately outside the scope of this analysis or could not be fully explored in the options presented due to time constraints are flagged in the areas for further consideration in the sector profiles found in Chapter 6.

Public Engagement: Interactive Website and Town Halls

In April, an interactive website was launched to seek input from Canadians on how to address climate change and promote clean growth. This engagement tool allowed Canadians to share their ideas, comment on others, and be part of a national conversation on climate change. The website also gave Canadians the tools to hold town halls and discuss these issues within their communities, and many such groups submitted the results of their town halls to the interactive website. The public was also encouraged to submit comments by email and mailed correspondence.

Inclusion of submissions in working group reports

All four working groups have incorporated public input received through the interactive website and by email into their work. Weekly summaries of public input were circulated to representatives from the Mitigation Working Group, including subgroup co-chairs, and sub-groups systematically reviewed all submissions related to their respective sectors. The suggestions, views, and constructive comments in the submissions received have been included through this report.

5.1 Submissions Received

As of late August, 2016, almost 5000 submissions, of which about 3300 are related to mitigation, have been received by mail, email and through Canada's interactive website, letstalkclimateaction.ca/. Based on an analysis of the ideas in each submission related to mitigation, almost 5000 unique ideas were identified.

Submissions were received from Canadians and organizations across all provinces and territories, with 88% coming from individuals, while organizations account for 12% of submissions. The outcomes of over 50 town hall events, which took place in communities across Canada, have been submitted to the interactive website or by email.

The majority of comments submitted by Canadians were supportive of the Pan Canadian Framework process and provided constructive input that was helpful for assessing options in this report. Some views submitted by Canadians were more broadly critical of the pan-Canadian Framework process and/or the consultation process. These comments have been useful feedback on the development and implementation of the process. A small minority of comments were skeptical of climate change science, and of the need to mitigate climate change.

A significant number of submissions expressed general support for ambitious climate action by individuals, businesses, and governments, or provided general policy ideas such as setting new greenhouse gas reduction targets. Other submissions focused on a number of key themes; these themes are summarized below, along with a brief discussion of how this input was incorporated into the policy options included in this report.

5.2 Key Themes from Submissions

- **Clean energy investment and incentives**
  - *Number of submissions:* 1131
  - Reflected in various options in the electricity, large industrial emissions, and built environment sectors. Examples include: financial support for new non-emitting electricity generating facilities (E4); transitioning to electrification (I2); renewable power and fuel switching (B6)

- **Reducing dependence on fossil fuels and promoting the transition to a low carbon economy (e.g., phasing out fossil fuel subsidies, and support to train workers in clean energy industries)**;
  - *Number of submissions:* 1136
  - Options across multiple sectors (e.g., large industrial emitters, built environment, transportation, electricity, etc.) include measures that would reduce reliance on fossil fuels and promote the transition to a low-carbon economy

- **Promoting and improving public transportation**
  - *Number of submissions:* 315
  - Public transportation investments are included in option T8, changing transportation usage patterns
  - Option B8, urban form and spatial planning, also includes a discussion of measures to promote public transportation

- **Incentivizing energy efficient improvements in homes and commercial buildings**;
  - *Number of submissions:* 287
  - Options in the built environment sector that would improve the efficiency of new and existing residential and commercial buildings include net-zero ready building codes (B1, B3); retrofit policies (B2, B4); and policies to improve the efficiency of equipment and appliances (B5)

- **Supporting the transition towards electric cars, and building electric vehicle infrastructure;**
  - *Number of submissions:* 279
  - Policies to promote electric vehicles are addressed in option T1, passenger vehicle emission regulation and incentives, which discusses consumer incentives, education initiatives, and mandates or standards (voluntary or regulatory) to promote zero emissions vehicles.
  - Option T9, reducing congestion and vehicle-kilometers travelled, also includes measures that would help to promote zero-emissions vehicles, such as registration and excise taxes based on vehicle emissions ratings, and financial incentives
  - Option B8, urban form and spatial planning, discusses support for electric vehicles including EV parking and charging equipment in new buildings

- **Reducing emissions from electricity production**;
  - *Number of submissions:* 272
  - Could be addressed by various options included for the electricity sector, including emissions intensity performance standards for fossil fuel-fired electricity generation (E1); an accelerated phase-out for coal-fired electricity (E2); a non-emitting portfolio standard (E3); financial support for non-emitting electricity generating facilities (E4), support to reduce reliance on diesel energy in Northern and remote communities; or increasing interjurisdictional transfers of non-emitting electricity (E6)

- **Other means to reduce emissions from transportation (e.g. promoting changes in personal behaviour, incentivizing the development of cleaner means of transportation, reducing emissions from shipping, aviation, and commercial transportation)**
  - *Number of submissions:* 268
  - Various options in the transportation sector could help to facilitate access to low-carbon transportation options

- » Various options in the transportation sector could help to promote shifts in personal transportation choices. For example, option T8 (changing transportation usage patterns) includes investments in public and active transportation as well as measures to promote car sharing, carpooling and ride sharing, while option T9 (reducing congestion and vehicle-kilometers travelled) proposes a range of economic instruments that would target shifts in driving behaviour
- » Measures to improve energy efficiency and reduce the carbon intensity of fuels from shipping, aviation, and commercial transportation are included in options T3 (energy efficiency in the aviation, rail, marine and off-road industrial sectors, T4 (heavy duty vehicle and engine emissions regulations and incentives), T5 (vehicle and engine fuel efficiency in the aviation, marine, rail and off-road sectors), and T10 (increased availability and use of low-carbon fuels in the domestic marine, rail, and aviation sectors)

- **Promoting and incentivizing cycling and walking, and building infrastructure to support active transportation**;
  - » *Number of submissions:* 239
  - » Infrastructure to promote active transportation is addressed in option T8, changing transportation usage patterns
  - » Option B8, urban form and spatial planning, also discusses measures to promote active transportation

- **Develop and implementing building codes that promote the use of cleaner technologies and higher energy efficiency;**
  - » *Number of submissions:* 171
  - » Options for net zero-ready building codes for new residential and commercial buildings (B1, B3) are included in the report, as are options that would include the development of retrofit codes and energy use disclosure standards for existing buildings (B2, B4)

- **Reducing meat production and consumption**; and
  - » *Number of submissions:* 113
  - » This idea is discussed in the section on individual actions
  - » Other key themes found in submissions that have been incorporated into policy options include:

- **Providing education on climate change**
  - » Various options include an education and awareness component
  - » For example, T1 (passenger vehicle regulations and incentives) includes an option on funding for consumer awareness programs for zero emissions vehicles. T6 (fuel Efficiency of on-road vehicles) includes an option for outreach and education programs to improve the efficiency of driver behaviour. Options in the waste sector – such as a strategy to reduce avoidable food waste (W2) – include consumer education initiatives.

- **Supporting local farms and food growing**
  - » This idea is discussed in the section on individual actions

- **Creating clean energy infrastructure**
  - » Infrastructure needs, including for clean energy infrastructure, are noted in a number of options, as discussed in greater detail in the section on infrastructure in Chapter 3
  - » Some examples of options related to clean energy infrastructure include electricity grid investments (E6) and investments in charging and fueling infrastructure for low or zero emissions vehicles (T1, T2)

- **Reducing waste and improving recycling**
  - » Options for the waste sector include increasing the diversion of organic materials and recyclables from landfills (W3, W4), and reducing avoidable food waste (W2)

- **Incentivizing the greening of cities and communities**
  - » Options B8 (urban form and spatial planning) and T9 (reducing congestion and vehicle-kilometers travelled) include a variety of measures that are primarily targeted to reducing emissions in urban areas

- **Incentivizing and investing in technology and development of new and more sustainable practices in agriculture**
  - » Options in the agricultural sector include incentives to adopt practices and technologies to reduce or capture methane emissions (A1, A4), use fertilizers more efficiently (A5), convert marginal land to permanent cover (A2), and increase acres of nitrogen-fixing crops (A3)
- **Promoting afforestation, protection, and sustainable development of forests**
  - » The forestry sector includes options to substantially increase the area of newly forested land (F2), increase forest rehabilitation (F3), and implement changes to forestry management practices (F4).
- **Promoting the greening of federal buildings**
  - » Options to reduce emission from government buildings are discussed in the government operations sector profile, and would also be covered by a carbon neutral government policy (G1)

5.3 Consultation with Key Experts and Stakeholders

Three roundtables were held with invited stakeholders and National Indigenous Organizations on June 7 (Montreal), June 8 (Ottawa) and June 21 (Vancouver), 2016. These sessions were jointly hosted by the Mitigation Working Group and the Working Group on Carbon Pricing Mechanisms. Participants at the roundtable sessions were highly engaged, and brought forward a wide variety of issues, considerations, and ideas. There was broad agreement on the need for ambitious climate change action, with a range of perspectives on priorities and next steps. Participants also generally agreed on the need for a carbon price high enough to change behavior without decreasing public support; the importance of price certainty for business; and the value of learning from international experiences with different carbon pricing approaches.

Some of the other key messages that emerged from these sessions are summarized below.

- Participants identified opportunities for emissions reductions across all sectors of the economy, and pointed to several cross-cutting enabling conditions – such as investment in clean electricity, inter-jurisdictional transmission grids and vehicle charging infrastructure to prepare for more electric vehicles, updated building codes and adequate access to capital to allow businesses to invest in new technologies.
- There are a number of emerging trends that could be accelerated to drive deeper emissions reductions. These include urban densification; social innovation and the sharing economy; consideration of financial liabilities and investment risks related to climate change; and changing business models, such as the move towards a circular economy.
- Individual Canadians can be agents of change. Public outreach and educations efforts are needed to make people aware of the impacts of their choices and to build broad support and understanding of the action being taken. Policies should avoid hidden costs in order to send clear signals to consumers; however, there is also a need to make low-carbon choices convenient and attractive. Governments have a responsibility to lead by example.
- Environmental, economic, and social criteria need to be balanced when evaluating policies. In addition to metrics such as total costs and emissions reductions (e.g., cost per tonne), other considerations include potential for transformative change, competitiveness impacts, potential for job creation and skills development, social acceptability, and impacts on vulnerable populations. High-quality data and consistent reporting on progress is needed to develop and evaluate policies effectively and to inform data-driven decisions.
- Some key areas of potential partnership with Indigenous people include enhancing carbon sinks, electricity and distributed energy production, particularly in Northern and remote communities.

- Some participants suggested that Canada could consider purchasing ITMOs to help meets its climate change targets, provided that sufficient investments are also made in achieving domestic emissions reductions. Some participants suggested that there may also be potential for Canada to receive credit for exporting low-carbon technologies, products, or resources.
- Effective climate change policy requires a full suite of tools, including regulations, incentives, outreach and education, and investment in research and development. Carbon pricing is a key tool, but complementary measures are also needed to reach emissions that are not effectively addressed through pricing. Governments should focus on achieving emissions reduction outcomes rather than being prescriptive.
- When designing climate policies, governments can either choose to use carbon pricing as the main driver for GHG reduction (high carbon price, few complementary measures) or decide to rely on a wider array of measures (low carbon price, multiple complementary measures).
- Competitiveness needs to be carefully considered, both in terms of impacts of new costs on industry, as well as steps industry can take to enhance its competitiveness in a carbon-constrained world. Emissions-Intensive and Trade-Exposed (EITE) sectors should be clearly defined and regularly reviewed.
- There is a need for policy coherence, including between carbon pricing and other mitigation policies, and between policies developed by different orders of government (federal, provincial, territorial). A patchwork of systems across the country can be difficult for business. Identifying and addressing unintended barriers or areas of overlap between policies is a key challenge.
- A collection of approaches, including infrastructure spending, regulations, and carbon pricing are needed to achieve step changes, such as a transition to low-carbon fuels.

Beyond the engagement specifically led by the MWG, several provinces and territories have conducted significant climate action engagement exercises over the past several months to inform their respective climate change policy plans. The input gathered through those sessions has also been considered as the MWG prepares its report.

6 SECTOR PROFILES

6.1 Introduction

This chapter of the report provides an overview of Canada's major economic sectors and the policy options developed by technical sub-groups for each sector. The sectors profiled are: large industrial emitters, transportation, the built environment, electricity generation and transmission, agriculture, forestry, waste, and government operations and leadership. The chapter also includes sections on individual actions and Internationally Transferred Mitigation Outcomes.

6.2 Large Industrial Emitters

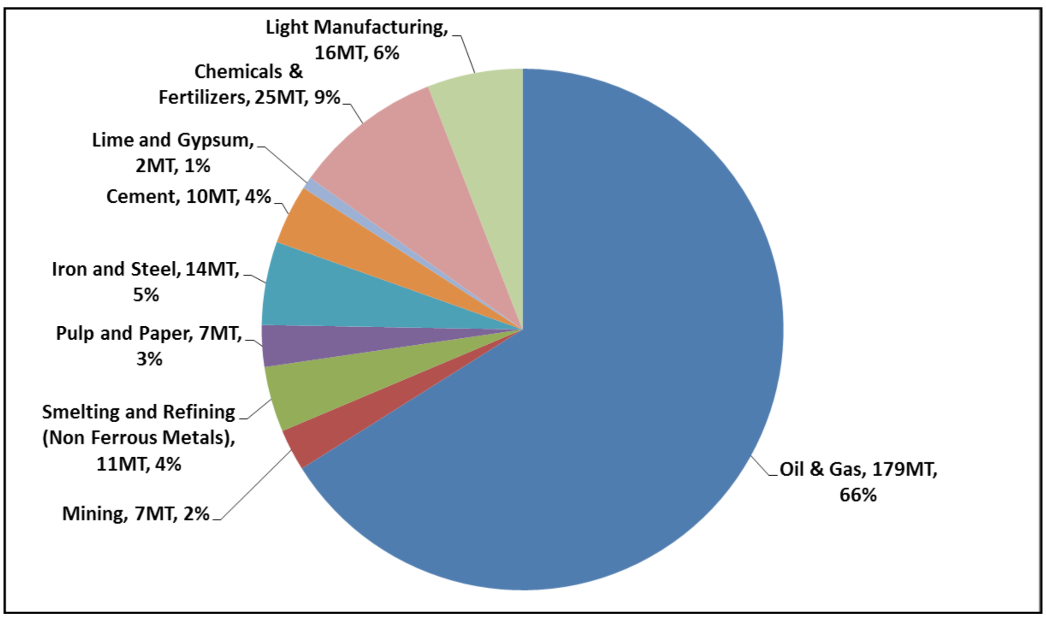
6.2.1 Sector Portrait

The large industrial emitters sector covers a range of industries that help drive the economy and create jobs, and generate a significant portion of Canada's GHG emissions. Industries in this sector include oil and gas; mining; smelting and refining; pulp and paper; iron and steel; cement; lime and gypsum; chemicals and fertilizers; and light manufacturing. This sector includes facilities of varying sizes that perform a wide range of different activities.

Sector Emissions

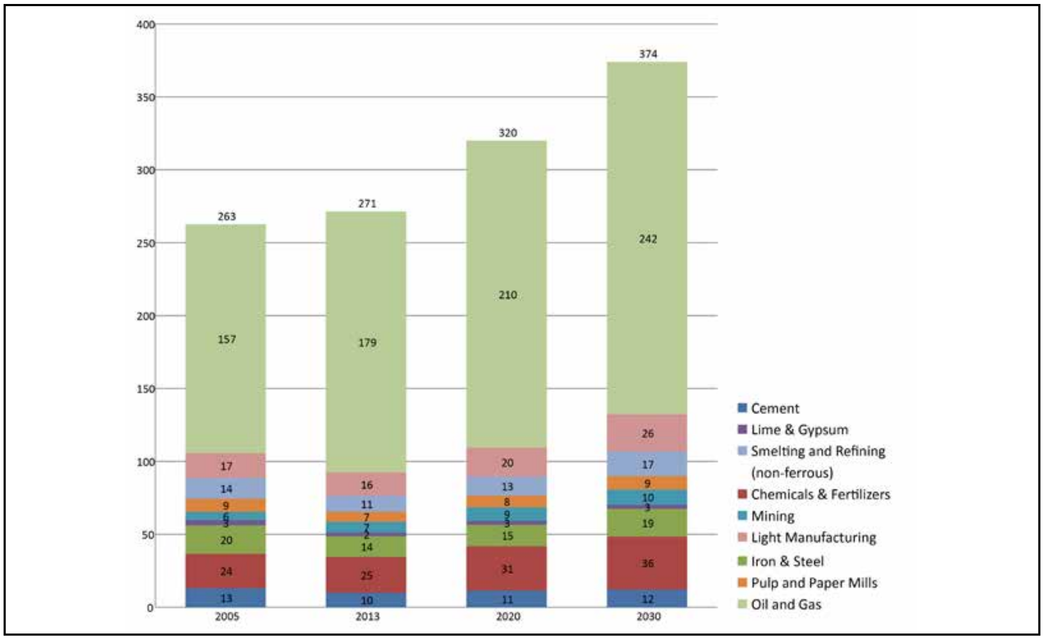
In 2013, this sector was responsible for approximately 271 Mt CO_2e or 35% of Canada's GHG emissions.

Figure 3: Emissions from Large Industrial Emitters from 2013 data in Mt CO_2e



Emissions from this sector are projected to grow due to increased production across these industries as demand for Canadian-produced goods grows domestically and internationally.

Figure 4: Emission Trends for Industrial Subsectors (Mt CO_2e)[12]



While emissions across the industries in this sector are expected to increase, some will likely grow more than others. According to Environment and Climate Change Canada's "business as usual" projections, oil and gas emissions are projected to increase about 35% by 2030, largely due to growth in oil sands production. Oil sands emissions are projected to grow 82% by 2030, in part due to the energy intensive nature of in-situ production.[13]

The light manufacturing industry — composed of non-emissions-intensive industrial production, such as the food and beverage industry — produced 6% of the sector's emissions in 2013, but is projected to more than double by 2030. Other areas where significant emissions growth is anticipated by 2030 include chemicals and fertilizers (44% growth) and iron and steel (36%). Not all industrial sectors will see their emissions grow. The forest products industry may actually contribute to significant emission reductions through production of new bio-products and bioenergy. If these products replace carbon-intensive fuels and materials in other sectors, they could offset substantial GHG emissions.

Economic Impact

In 2013, the large industrial emitters sector generated about $160 billion or 11% of national GDP, and employed two million Canadians in direct jobs and another two million in supporting industries. Many of the large industrial emitters are export-oriented and vulnerable to international competition. Increases in production costs can make it harder to compete in international markets. For example, in the oil and gas sector, any new production costs cut into profits since prices are set internationally. Given that oil and gas prices are currently at historic lows, the industry's ability to bear new costs may be limited.

The oil and gas industry has the largest economic impact, generating $120 billion or 8% of national GDP in 2013. Crude oil production has grown steadily over the past two decades and is expected to continue growing, primarily driven by the oil sands. While natural gas production has fallen since 2005, it is expected

12 Canada's Second Biennial Report on Climate Change, ECCC 2016.

13 This projection is consistent with Alberta's 100 Mt/year cap on emissions from the oil sands, a recently announced policy which excludes emissions from upgraders and cogeneration.

to increase 15% by 2030, and there is potential for significant growth in the export of liquefied natural gas if a number of proposed projects go forward. In 2014, Canada exported 76% of its annual crude oil production and 52% of its annual natural gas production, with the vast majority going to the U.S.

The chemicals and fertilizers industry is anticipated to grow due to new and expanded facilities in areas such as ethylene and polyethylene manufacturing. Ammonia manufacturing for fertilization is expected to increase due to the agricultural needs of a growing North American population. There are also other expected plant expansions.

The iron and steel industry exports around 50% of its annual production, primarily to the U.S., and is expected to increase its production so it is operating at 80% of its full capacity by 2030.

The forest products industry, with approximately 95 pulp and paper mills, and over 1000 wood products mills, is operating below capacity and limited growth is expected. In 2014, it generated $16.6 billion. In many rural communities, this industry is the primary or sole economic driver, and is also a major employer for Indigenous communities, providing jobs for approximately 9,000 Indigenous people across Canada.

Canadian Context

Canada's oil and gas production is located primarily in AB, SK, and BC, with offshore production in NL and NS. Bitumen production is concentrated in AB, with some production in SK. Gas production in BC and AB currently consists of a mix of conventional and unconventional gas (i.e. shale and tight gas); unconventional production is expected to dominate in BC in the future. Refining crude oil into various petroleum fuels occurs in most provinces, with the largest facilities and greatest capacity in AB, ON, QC and NB.

The chemicals and fertilizers industry is primarily located in AB, ON and QC. However, 75% of its reported GHG emissions come from the ethylene, ammonia and hydrogen manufacturing facilities located in AB and ON. AB has also announced that two or three new petrochemical plants could be built under its economic diversification strategy.

ON is the largest base for steel production, with three facilities. QC has a major iron and steel company and one ilmenite smelter that produces steel as a by-product. Together, these facilities account for about 68% of national steel production and 90% of the industry's emissions. Aluminum production is the largest source of emissions in the non-ferrous smelting and refining of metals industry, with about 60% coming from nine aluminum smelters in QC and one in BC.

The other industries — namely cement, lime, pulp and paper, and mining — together generated about 10% of the sector's emissions. All are currently operating under capacity, from 55% for lime and gypsum, to 85% for pulp and paper.

Key Policies in Place

The federal government has established programs to improve energy efficiency across industries within this sector, such as the Energy Efficiency for Industry program. Other funding programs have targeted the pulp and paper industry, and numerous research and development initiatives specific to the manufacturing and oil and gas industries have been launched to improve environmental performance. The federal government in recent years has phased out a number of tax incentives supporting fossil fuel (coal, oil and gas) exploration or development.

The federal government has committed to introduce regulations to reduce venting and fugitive methane emissions from the oil and gas sector by 40-45% below 2012 levels by 2025. The federal government has also endorsed the World Bank's Zero Routine Flaring by 2030 Initiative.

Provincial and territorial governments across the country have proposed or implemented various measures to target emissions in this sector. BC has a $30/tonne carbon tax on fossil fuels. BC has also set an emissions intensity benchmark on facilities in its emerging liquefied natural gas sector (0.16 tonnes CO_2e/tonne of LNG). BC is also working with its cement sector to set a combustion emissions intensity benchmark for 2019. BC's August 2016 Climate Leadership Plan includes a goal of a 45 per cent reduction for fugitive and vented methane from the natural gas sector by 2025. AB has announced it will bring a new $30/tonne carbon levy on transportation and heating fuel into effect in 2017. AB also has the *Specified Gas Emitters Regulation* that requires facilities with over 100 kt CO_2e of annual emissions to meet emission intensity reduction targets and reinvest revenues in reduction opportunities. AB will bring a new carbon pricing approach into effect in 2018 that will include emission performance standards for large industry, and has committed to a 45% reduction in methane emissions from the oil and gas industry by 2025. AB has also set a 100 Mt CO_2e cap on emissions from the oil sands.

NL recently announced requirements for facilities generating over 25 kt CO_2e of annual emissions. QC has implemented a cap and trade approach that covers facilities emitting over 25 ktCO_2e of annual emissions,[14] and ON is scheduled to implement a similar system in 2017. A number of programs from QC's Climate Change Action Plan target large industrial emitters, working to improve energy efficiency and support the transition to lower-carbon fuels. MB provides research and development funding arrangements to support efforts on emission efficiencies.

Federal, provincial and territorial governments have also worked together to reduce industrial emissions, notably by jointly developing the Air Quality Management System. This system creates a framework for working together to set ambient air quality standards and introduce base-level industrial emission requirements, known as BLIERs.

6.2.2 Summary of Key Options to Reduce Emissions in 2030

Analysis to date has shown that policies directed at reducing fossil fuel use, reducing emissions of short lived climate pollutants, and enhancing capture and use of industrial process gases will all serve to mitigate GHG emissions in the short to medium term. Such policy options include provision of direct financial incentives (e.g., grants, tax preferences, low-interest loans), as well as requirements on industrial facilities. Support from governments may be required to ensure necessary infrastructure is available to access reduction opportunities. Over longer timescales, research and development will be required to bring on-line new, less-carbon-intensive technologies.

Consequently, low carbon electrification, carbon capture and storage/use, reducing methane emissions, energy efficiency and increasing the use of zero/low-emitting and renewable fuels and feedstocks are some of the key technical reduction opportunities. These opportunities will require specific and targeted measures coupled with investment in technology and infrastructure development in order to drive reductions to 2030 and beyond. It will be important to realize near-term operational improvements together with a clear longer-term path to implement transformative technologies.

14 QC's cap and trade system also covers electricity production and imports, fugitive emissions from electricity and natural gas transportation and distribution as well as companies distributing over 200 liters of fuel (automotive gasoline, diesel fuels, propane, natural gas and heating fuel).

Table 3: Policy Options for Large Industrial Emitters

	Policy Tool	Estimated Range of Emissions Reductions in 2030	Estimated Cost per Tonne
I1	Use incentives to promote cogeneration	1-2 Mt	<$0-$50
I2	Apply equipment regulations and/or rate based incentives to increase use of electricity throughout the industrial sectors	3-15 Mt	$100->$250
I3	Mandate or use incentives to promote energy efficiency	6-41 Mt	Varies by policy option, from $0 to $0-$50
I4	Ban on routine flaring from oil and gas facilities, petroleum refineries and chemical plants	<1-2 Mt	N/A
I5	Switch fuels with lower carbon alternatives	1-27 Mt	Varies by policy option, from $0-$50 to $100-$250
I6	Require methane emissions reductions from upstream oil and gas facilities	18-20 Mt	$0 to $50
I7	Additional carbon emissions reductions through abatement and sequestration (CCS and other) technology	3-5 Mt	$50-$100
I8	Limit carbon emissions through transformative changes in technology	11-29 Mt	$100-$250*

* Costs are presented in standardized ranges. Costs for this policy are based on estimates in the range of $100-$150 per tonne.

Areas for further consideration

- The federal government has committed to phase out its inefficient fossil fuel subsidies.[15] Ongoing review of relevant taxes and programs could support this objective.

- Another area to explore is the use of captured carbon in products, as a fuel or feedstock, or alternative storage methods. Capturing carbon emissions is a practical technology in some industrial sectors but the proximity to suitable underground geologic storage sites can be a limiting factor. Technologies and processes that use or store captured carbon are being developed and demonstrated but need to be scaled up in order to make any meaningful impact on industrial emissions.

- The field of industrial ecology holds potential for helping to reduce emissions. This is similar to the concept of the “circular economy,” in which industrial wastes can be used as inputs to other industries and processes. In some cases, this can be achieved through the creation of industrial parks where co-location allows for technologies such as district heating using waste heat or large-scale cogeneration of heat and power for multiple facilities. Some of these individual ideas are already explored in the report but the potential for industrial ecology in the Canadian context could benefit from further analysis.

- There are a number of policy options identified in this report that cut across sectors. Before implementing such policies, careful cross-sectoral analysis would be required to coordinate policies. For instance, the supply for renewable fuels such as biogas, biofuels, biomass or agricultural wastes would require coordination with the waste, transportation, agriculture and forestry sectors. Options to increase electrification could also increase electricity demand and would need to be coordinated with efforts

15 Recent iterations of this commitment by the federal government include the Leaders’ Statement on a North American Climate, Clean Energy, and Environment Partnership (June 2016) http://pm.gc.ca/eng/news/2016/06/29/leaders-statement-north-american-climate-clean-energy-and-environment-partnership and the G7 Ise-Shima Leaders’ Declaration (May 2016)

to scale up clean electricity generation and transmission. Optimization of new cogeneration potential would require the development of specific scenarios together with the electricity subgroup accounting for availability of waste gases, geography and local non-industrial demand.

6.3 Transportation

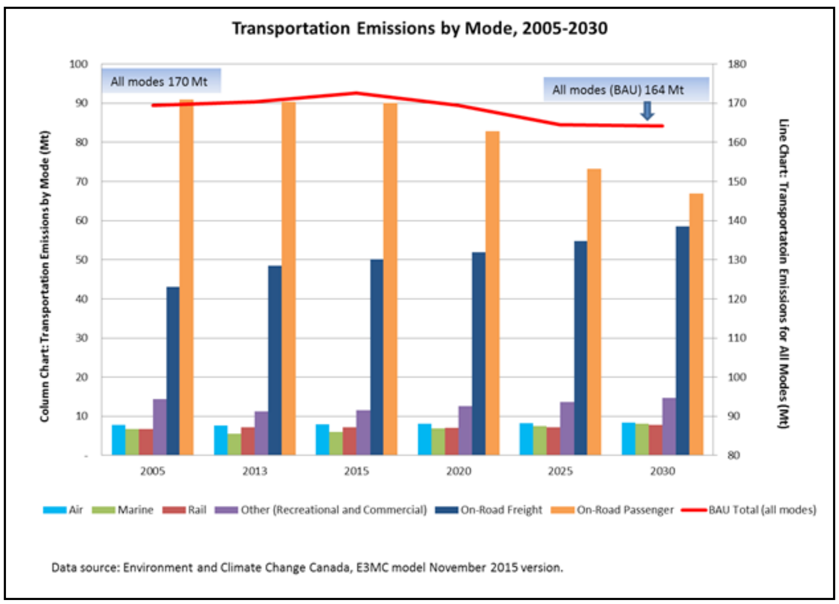
6.3.1 Sector Portrait

Transportation plays a vital role in the lives of Canadians and our economy. It links people to jobs, products to consumers, and communities to each other, while connecting Canada with global value chains that serve as the backbone for domestic and international trade.

Sector Emissions

Transportation GHG emissions growth slowed between 2005 and 2013, increasing only 1%. With no further mitigation actions, this sector's emissions are projected to be 3% lower than 2005 levels by 2030, largely as a result of existing federal regulations limiting GHG emissions from new on-road vehicles. Passenger vehicle emissions have tended to track population growth, although there has been a gradual decoupling since the early 2000s. Freight emissions are linked to economic activity and thus follow GDP.

Figure 5: Transportation Emissions by Mode, 2005-2030



Emissions in this sector can be divided by mode of transportation:

On-road emissions include those from vehicles such as cars, buses and trucks, and made up approximately 81% of total transportation emissions in 2013. Light-duty vehicles, which include vehicles such as passenger automobiles, minivans, and SUVs, currently make up the majority of the sector's emissions. Under the Business as Usual scenario, these emissions are expected to decline to 40% of the sector's emissions by 2030. However, Canadian consumers increasingly prefer higher GHG-emitting vehicles, such as Sport Utility Vehicles, which may slow this decline. On-road freight accounted for 28% of the sector's emissions in 2013, and is anticipated to grow to 36% by 2030, largely due to growth in freight activity and the predominance of carbon-intensive fuels.

Domestic aviation emissions accounted for 4% of the sector's emissions in 2013, a slight decrease from 2005 despite increased passenger traffic. This decline is due to engine and operational efficiencies. Emissions are expected to increase by 2030 due to increased traffic.

Rail emissions increased slightly between 2005 and 2013, accounting for 4% of the sector total, and are anticipated to grow to 5% by 2030. Freight operations accounted for 97% of these emissions. Rail is more efficient than on-road freight transportation per tonne-kilometre.

Domestic marine emissions decreased nearly 20% between 2005 and 2013, representing 3% of the sector's emissions, with growth to 5% anticipated by 2030. This mode is largely used for freight and is more efficient per tonne-kilometre than heavy-duty vehicles.

Off-road emissions, which include residential equipment as well as recreational and commercial vehicles, accounted for 7% of the sector's emissions in 2013. This mode is expected to account for 9% of the sector's emissions by 2030. Industrial vehicles (primarily agricultural, construction and mining vehicles) are generally accounted for outside the transportation sector, but generated nearly 30Mt in 2013, about 4% of total national emissions. For the purposes of this report, these industrial vehicles are considered within the transportation sector.

Economic Impact

In 2014, Canada's transportation system generated 3.7% of national GDP, moved over $1 trillion worth of goods through international trade, and directly provided jobs for 896,000 Canadians, representing 5% of employment across the country.

Canadian Context

The majority of emissions from transportation are concentrated in southern Canada in urban centres, which are key hubs for passenger and freight transportation. ON accounted for 32% of total transportation emissions in 2013, and together with QC and the Prairie provinces, generated 80% of Canada's total transportation emissions. The majority of these emissions are from on-road vehicles. As a result of economic and population growth, transportation emissions increased in AB, SK and MB from 2005 to 2013. The Territories accounted for less than 1% of transportation emissions in 2013. Emissions are generally spread proportionally by population across the country, with the exception of rail, where the largest share of emissions comes from AB (42%), and domestic marine emissions, which are concentrated in B.C. (40%) and the Eastern provinces (60%).

Key Policies in Place

The federal government has aligned regulations with the U.S. that establish progressively stricter GHG emissions standards for new passenger automobiles (2011-2025 model years), as well as new on-road heavy-duty vehicles and engines (2014-2018 model years). It has also announced its intent to develop a second phase of regulations with more stringent standards for post-2018 model years to further reduce GHG emissions from new heavy-duty vehicles, engines and trailers, which will also be aligned with the U.S. The federal *Renewable Fuels Regulation* sets minimum volumetric requirements for renewable content of gasoline (5%) and diesel (2%). Existing transportation programs that facilitate improvements in fuel efficiency across this sector include the SmartWay Transport Partnership; driver training; a "green levy" on inefficient vehicles; and funding to advance the deployment of shore power technology at some Canadian ports. Most recently, Canada announced $62.5 million for the demonstration and deployment of electric vehicle charging and alternative fueling stations.

Canada is a member of the International Civil Aviation Organization, which has launched a framework for alternative fuels, developed a standard for CO_2 emissions from new airplanes that comes into effect in 2020, and is developing a market-based approach to carbon neutral growth from 2020 onwards. Domestically, the sector has been improving fuel efficiency through voluntary agreements with the Government of Canada since 2005. In 2013, a memorandum of understanding was renewed with the Railway Association of Canada to encourage voluntary emission reductions between 2011 and 2015. In partnership with the International Maritime Organization, the federal government has also adopted a number of measures to reduce GHG emissions from Canadian-flagged ships navigating in international waters, which includes requiring newly built vessels to meet progressively stricter minimum energy efficiency standards from 2015 onwards.

Transportation and the environment are both areas of shared federal and provincial-territorial jurisdiction. These orders of government, as well as municipal governments, have put in place many initiatives to limit GHG emissions and air pollution across transportation modes. Given that almost 82% of Canadians live in urban areas, efforts have been made by all levels of government to promote alternate modes of transportation such as transit, walking, and cycling. Many municipalities also integrate land-use and transportation planning, as land use decisions have a long-term influence on how people travel.

Several provinces have implemented carbon-pricing measures or taken steps to increase the use of lower carbon fuels[16] via renewable fuel regulations that exceed the federal renewable fuel requirements. BC has also implemented a low-carbon fuel standard. Some provinces have implemented initiatives to test emissions from in-use on-road vehicles (e.g. Drive Clean in ON), or to accelerate the replacement of on-road vehicles (e.g. BC SCRAP-IT).

Provinces have also enacted measures to reduce emissions from the on-road sector, including: consumer rebates for electric vehicles (QC, ON and BC); funding for electric vehicle charging stations; and incentives for fuel-efficient retrofits for heavy-duty vehicles. BC has a program allowing natural gas utilities to spend up to $149 million over 5 years on incentives for ferries, heavy-duty vehicles and infrastructure. BC has also announced a doubling of the incentives for renewable natural gas in the transportation sector and fuelling ocean-going marine vessels with LNG. Governments are studying and supporting the trend towards greater connectivity and automation in the transportation network, which is expected to lead to a number of benefits including emissions reductions. Recently, ON became the first province to allow on-road testing of automated vehicles. Both QC and BC are members of the International Zero Emission Vehicle Alliance, a collaboration of national and subnational governments working together to accelerate the adoption of zero emission vehicles. Finally, it is important to note that reductions in GHG emissions from transportation could reduce air pollutant emissions, resulting in overall public health benefits.

6.3.2 Summary of Key Options to Reduce Emissions in 2030

Opportunities exist to reduce emissions across all modes of transportation, from light-duty passenger and commercial vehicles to heavy-duty trucks, marine vessels, rail, aviation, and off-road transportation, including in the mining, agricultural and industrial sectors. The fleet of vehicles currently in use across all sectors represent a significant opportunity given their long life but can be costly to retrofit or replace. Some modes and sectors represent larger opportunities than others. For example, tightening fuel efficiency standards can lead to emission reductions when fleets are renewed; however, turnover rates – and the potential for achieving emission reductions before 2030 – differs from mode to mode. The potential to reduce emissions also varies by region, with limited opportunities in sparsely populated areas such as northern Canada and rural parts of many provinces and territories.

16 LCF: Lower carbon fuels refers to fuels that emit fewer GHGs relative to fossil gasoline or diesel.

For passenger vehicles, key opportunities include technological changes such as improving fuel efficiencies and expanding the number of Zero Emission Vehicles (ZEVs) on the road. This report includes a suite of policy options aimed at reducing passenger vehicle emissions, including regulatory action on fuel efficiency and measures to increase the share of ZEVs in automakers's fleets.

Beyond driving cleaner cars and trucks, there are significant opportunities in designing our cities and building public infrastructure to help people drive less by sharing vehicles, walking, cycling and taking transit. There are also opportunities for efficient inter-city transportation. This kind of behavioural shift is best accomplished with integrated and complementary policies that both push people away from polluting activities – such as driving alone – and concurrently pull them toward cleaner modes of transport.

For heavy duty freight vehicles, there are a range of promising technological opportunities, from aerodynamic retrofits to improve efficiencies to new engine technologies powered by alternative fuels to advanced computers to optimize, automate and connect vehicles so they are better coordinated and more efficient. Some of these technologies could be applied to both on-road and off-road heavy duty vehicles and equipment. This report includes a variety of policy tools aimed at supporting deployment of these technologies.

Another major opportunity that cuts across all transportation modes and sectors is the use of low carbon fuels. Light and heavy duty vehicles in Canada mostly run on petroleum-based fuels, with a small amount of biofuels blended in. There is potential to use more biofuels, and also to use a greater variety of alternative fuels which are less polluting than gasoline and diesel, such as compressed or liquefied natural gas, renewable natural gas, and hydrogen produced with clean power.

Table 4 below provides a high-level overview of policy options to target these opportunities, with further detail in Annexes 1 and 2. It should be noted that the cost per tonne ranges below are based on national averages, and therefore do not fully capture important regional differences.

The above policies are intended as a comprehensive set of potential options. Some policies focus on near term improvements while others are meant to drive deeper reductions over the longer term. Some are complementary while others overlap or interact; as a result, the emission reduction estimates shown above should not be added together but rather must be considered separately.

As discussed in Chapter 3, the programs above are largely complementary to carbon pricing: many of them focus on overcoming barriers that pricing cannot fully target. Some, however, might be duplicative of an aggressive price on carbon, such as various targeted pricing policies and some elements of low carbon fuel policies. In most cases, a strong carbon price would strengthen the cost-effectiveness of the above policies

Table 4: Policy Options for Transportation

Policy Tool		Estimated Reductions in 2030	Estimated Cost per Tonne
T1	Passenger vehicle regulations and incentives, including for Zero Emission Vehicles	2-12 Mt	Varies by policy tool, from $0-$100 to $100-$250
T2	Regulations and complementary measures to increase the use of low carbon fuels for on-road vehicles and off-road industrial vehicles	10-20 Mt	Varies by policy tools, from $0-$50 to $100-$200
T3	Regulations, incentives and other measures to improve energy efficiency in the marine, aviation, rail and off-road industrial sectors	3-17 Mt	Varies by policy tool, from $0-$50 to $0-$250
T4	Regulations and incentives for heavy duty vehicles and engines	6-13 Mt	Varies by policy tool, from <$0 to >$250
T5	Regulations, incentives and other tools to improve vehicle and engine fuel efficiency in the aviation, marine, rail and off-road sectors	2-6 Mt	$0->$250
T6	Regulations, funding and incentives to improve fuel efficiency of the current fleet of on-road vehicles	2-6 Mt	Varies by policy tool, from $0-$50 to >$250
T7	Incentives, investments and other mechanisms to improve freight efficiency	1-5 Mt	Varies by policy tool, from <$0 to >$250
T8	Transportation demand management plans to change transportation usage patterns	1-4 Mt	Varies by policy tool, from <$0 to >$250
T9	Reducing congestion and vehicle-kilometres travelled using prices, taxes and other economic instruments	1-3 Mt	Varies by policy tool, from >$0-$100
T10	Regulations and other measures to increase low carbon fuels for marine, rail and aviation	1-2 Mt	$100-$250

Areas for further consideration

There are number of additional areas that could be explored further for future policy action to target the transportation sector:

- The integration of transportation network design into urban planning is an issue that cuts across multiple sectors, including transportation, buildings, electricity. This could include integrating public and active transportation into urban design and infrastructure projects, basing urban design decisions on analysis and optimization of transportation patterns.
- Further study is needed on opportunities for integrating electric vehicles into the electric grid. This is an issue that cuts across the transportation and electricity sectors. With sufficient numbers of vehicles on the road, electric vehicles can act as a large distributed battery and provide grid storage, which can help allow more renewable energy to come online. Options could also be explored for supporting systems that integrate electric vehicle charging infrastructure with renewable energy on a small scale.
- Further development of alternative fuel options for heavy-duty vehicles (e.g., renewable natural gas, fuel cells, electricity).

- This report explores options for zero-emission vehicles for passenger use (T1) and compatibility of vehicles with low-carbon fuels (T2) but an area for further study could be policies to drive replacement of urban fleets (e.g. taxis, delivery and service vehicles, municipal government vehicles) and off-road vehicles with alternative fuel or zero emission vehicles.
- Targeted policy support for domestic production of zero-emission and alternative fuel vehicles could be further explored, and potentially supported by options identified by the Working Group on Clean Technology, Innovation and Jobs.

6.4 Built Environment

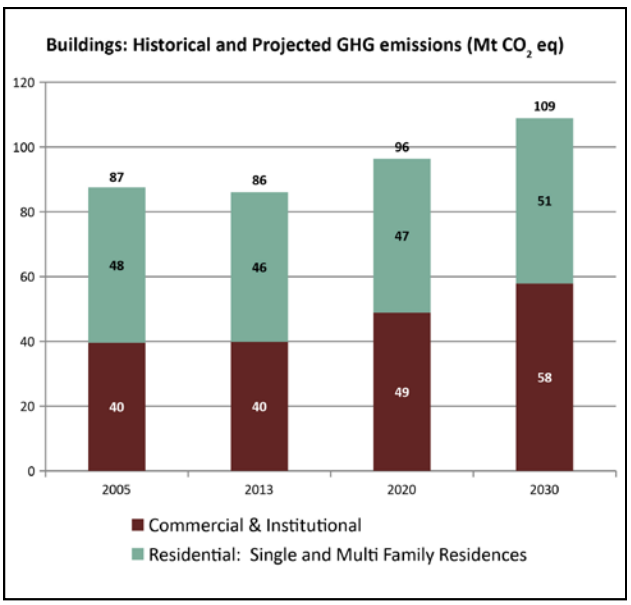
6.4.1 Sector Portrait

Canada's built environment includes residential, commercial and institutional buildings, as well as the equipment used within them to power functions like space heating and ventilation.

Sector Emissions

Canada's built environment produces about 12% of our total GHG emissions. Nearly 85% of emissions from residential buildings and almost 70% of emissions from commercial buildings are a result of fossil fuel combustion for space and water heating. Figure 6 shows past and forecasted direct emissions for the sector, which have been relatively flat between 2005 and 2013. However, direct GHGs in this sector — created by fossil fuel use and fugitive emissions from refrigerants — are anticipated to grow by almost 27% between 2013 and 2030.

Figure 6: Buildings – Historical and Projected Direct GHG emissions (excluding electricity generation)



Although electricity accounted for 38% of the energy used in the built environment in 2013, the emissions associated with electricity generation are not included in the above numbers. If these indirect emissions were included, the sector's overall share of 2013 national emissions would increase from 12% to 17%. Even though there has been a decoupling of energy use and GHG emissions over the past 10 years due to efficiency improvements and a greener electricity grid, population and economic growth will push emissions up.

Economic Impact

Since 1990, economic growth in the residential and commercial sectors has been rapid, and is expected to continue — for example, GDP associated with the commercial sector has increased by over 75%. Commercial and institutional floor space is projected to increase by close to 50% between 2005 and 2030, and the number of households will increase by 40%. These projections are influenced by broader macroeconomic trends including population growth (expected to be 1% per year) and overall economic growth (expected to be 2.2% per year).

From a consumer perspective, in 2013 Canadians spent almost $49.1 billion – the equivalent of about 3% of GDP – on energy to heat and cool their homes and offices, and to operate appliances. However, in 2013, Canadians saved over $17 billion in energy costs and avoided over 38 Mt of GHG emissions, as a result of energy efficiency improvements between 1990 and 2013 in the built environment[17].

Canadian Context

The built environment's emissions vary across provinces, largely driven by different supply mixes for electricity generation and energy use. Regionally, electricity use is most prominent in QC and some Atlantic provinces, while natural gas is the primary fuel used in AB, SK and ON. Gas and electricity use have more equal shares of the total in MB, BC and the North; there is very little gas in NWT. Housing conditions are of particular concern for many Indigenous communities facing shortages, chronic overcrowding and sub-standard housing conditions.

Key Policies in Place

Over the last 20 years, energy efficiency programs and measures have been the predominant tool at all levels of government used to reduce GHG emissions from the built environment, while also achieving other policy goals such as: conserving energy; improving energy delivery to reduce generation, transmission and distribution costs; and reducing the impact of energy price increases and volatility. Energy efficiency also provides the benefit of healthier indoor environments by improving heating and ventilation systems. Energy efficiency investments and re-investing energy savings can also provide stimulus to the economy[18]. Research has found that $1 of energy efficiency programs spent by utilities and provincial governments resulted in $4 to $8 of GDP[19].

Energy efficiency programs from all levels of government have significantly affected both historical and forecasted emissions. The federal government develops and implements regulations for appliances and equipment that are applied nationally. It also typically provides national standards, codes, and benchmarking systems for use by the provinces, territories and municipalities. In turn, these tools are used to develop local regulations, and to deliver incentives to meet their local circumstances and climate change polices. A 2015 study reviewed 268 programs offered across Canadian jurisdictions by large utilities and government agencies, with spending totalling $613 million.[20] Based on input submitted by provinces and territories, and a voluntary listing of energy efficiency programs[21], the study found that most of the energy efficiency programs in Canada provide a financial subsidy to incentivize investments in energy efficiency.

17 http://oee.nrcan.gc.ca/corporate/statistics/neud/dpa/data_e/publications.cfm?attr=0#a

18 Capturing the Multiple Benefits of Energy Efficiency, International Energy Agency, 2014

19 Energy Efficiency, Engine of Economic Growth in Canada, Environment Northeast, 2013

20 Leverage Office of Energy Efficiency Spending, Indeco Strategic Consulting., December 2015

21 http://oee.nrcan.gc.ca/corporate/statistics/neud/dpa/policy_e/programs.cfm

6.4.2 Summary of Key Options to Reduce Emissions in 2030

Opportunities exist to reduce GHG emissions across the built environment, and for the most part, the path to reductions is well understood. Realizing the technical potential will require integration of this knowledge across the sector and reducing costs to ensure affordability. They can be broken out into several key opportunities:

- Increasing building efficiency (insulation, air tightness, design and siting)
- Increasing building heating, cooling and mechanical (e.g., ventilation, controls) equipment efficiency
- Transitioning space and water heating fuels towards low-carbon alternatives
- Increasing the efficiency of appliances, lighting, electronics and other non-heating and cooling equipment
- Improving management of commercial buildings and regular recommissioning to optimize performance
- Behavioural and operational changes by building users to reduce energy use and shift the timing of energy use to reduce peak demands on energy systems
- Moving towards more compact, higher density, mixed-use community development patterns that support accelerated shifts to transit and active transportation modes, as well as sustainable energy use

Table 5 below provides a high-level overview of policy options to target these opportunities, with further detail in Annexes 1 and 2. It should be noted that the cost per tonne ranges below are based on national averages, and therefore do not fully capture important regional differences. Costs per tonne also vary by heating fuel because of significant variations in fuel costs.

A key enabling measure across these policies is training and education for consumers and the construction and building operation industries. In many cases improvements can be achieved at low cost but are not implemented due to lack of knowledge or expertise.

While aspects of policies B1 to B5 would interact with one another upon implementation, they have been modelled as targeting separate market segments (e.g. new vs existing buildings; equipment efficiency vs building envelope improvements) to limit overlap between them. The other policies would also interact, but any potential overlap has not been taken into account. For example, residential fuel-switching measures under policy B6 would both interact with and complement B2, Existing Housing and B5, Equipment Efficiency. Implementation of building based solar photovoltaic systems under B6 would interact strongly with electricity sector measures. Urban form and spatial planning measures will largely drive transportation emissions reductions but may also facilitate improvements to new building efficiency by driving more compact design. Demand response opportunities and behavioural change will interact with all other building-related policies. More broadly, policies in the electricity and industry sector aimed at reducing the emissions intensity of fuels will interact strongly with building policies.

As discussed in Chapter 3, the programs above are complementary to carbon pricing: they are focused on overcoming barriers that pricing can't fully target. However, a strong carbon price would strengthen the cost-effectiveness of many of the above measures, increasing market uptake on voluntary programs such as home retrofits. This is particularly true for policies reducing natural gas consumption.

Table 5: Policy Options for the Built Environment

	Policy Tool	Estimated Reductions in 2030	Estimated Cost per Tonne*
B1	Net- Zero Ready Codes For New Housing by 2030 or 2025 *(~40% improvement from 2012 model code)*	4-5 Mt	Electricity: <$0 Natural Gas: >$250 Oil: $0-50/t to $50-100
B2	Existing Housing *(retrofits to achieve 1.5%-10% reduction in energy use via incentives, building labeling, regulations, financial instruments)*	1-6 Mt	Electricity/Oil: < $0 to $0-50 Natural Gas: $50-100 to >250
B3	Net-Zero Ready Codes For New Commercial-Institutional Building by 2035, 2030 or 2025 *(~65% improvement from 2015 model energy code)*	4-5 Mt	Gas/Elec.: $100-250 Oil/Elec.: $0-50 Elec.: <$0
B4	Existing Commercial-Institutional Buildings *(energy management and retrofits to achieve 2-17% reduction in energy use via incentives, regulations and information programming)*	<1-6 Mt	<$0
B5	Equipment Efficiency *(more stringent standards; incentives for high efficiency equipment)*	6-8 Mt	Varies by category: < $0 to >$250 in 2016, <$0 for all by implementation**
B6	Renewable Power And Fuel Switching *(1 million residential solar PV systems; incentives or loans for residential fuel switching to electricity)*	<1-6 Mt	Solar PV: >$250 Oil to Electricity: <$0 Natural Gas to Electricity: >$250
B7	Demand Response Opportunities and Behaviour Change *(enhanced billing, time of use billing, demand response incentives, adaptive thermostats)*	<1-2 Mt	<$0
B8	Urban Form & Spatial Planning *(densification, transit supportive planning, transportation demand management, community energy planning, tree planting, green roofs, permeable surfaces)*	N/A	N/A

* Costs per tonne for retrofit programs may overstate actual costs as costs are lower for older and inefficient buildings, which are among those most likely to take advantage of these programs. In some cases costs are negative (<$0/t) even for natural gas-fuelled buildings.

** Cost by implementation date for all measures anticipated to be <$0/t due to long ramp-up period, market transformation initiatives and technological improvements

Areas for further consideration

- Demand-side management (DSM) programs are widely used in Canada by utilities and provincial governments as a low-cost alternative to building new electricity generation and transmission capacity or new natural gas distribution capacity. The most successful North American programs have reduced demand by 1-2.5% of total demand per year. Standalone DSM utilities such as Efficiency One (Nova Scotia) are an effective approach to harnessing this potential. Some aspects of the policies identified in this report are similar to DSM programs but have been adapted to focus on GHG mitigation. Further integrating GHG mitigation goals into provincial and utility DSM programs and broader DSM policy work (e.g., regarding changes to the regulatory framework for utilities to align profit incentives with DSM goals) could lead to significant emission reductions and warrants further investigation.
-

- Building codes and retrofit measures could also further explore how to reduce the embedded carbon in building materials by prioritizing low carbon materials (e.g., wood rather than concrete or steel, where appropriate). Policy option F1 under the Forestry sector proposes specific work on this which could be expanded.
- Programs targeting primary agriculture buildings could offer further possibilities as energy for heating and cooling is a major source of GHG emissions from greenhouses, fruit and livestock production.
- As detailed in Annex 2, this report does not estimate GHG reductions from changes to urban form. These areas warrant further analysis. Substantial reductions are possible through integrated land use, transportation and community energy approaches. Annual urban GHG emissions could be further reduced if population and job growth occurs primarily within existing developed areas; infill areas are prioritized around transit networks; more travel happens by transit, bike and by foot; and more communities are powered by district energy systems and renewable energy.

6.5 Electricity Generation and Transmission

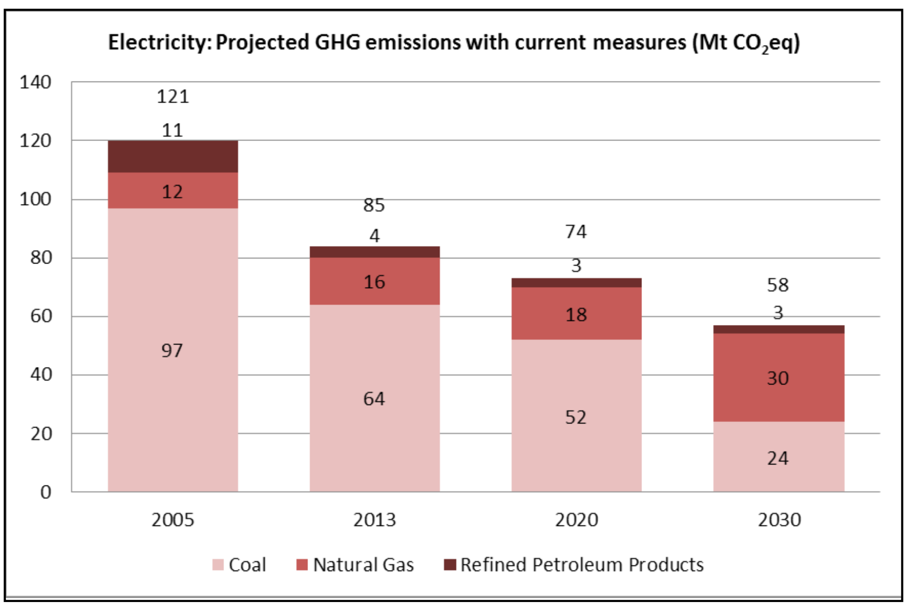
6.5.1 Sector Portrait

Canada is one of the world's largest and cleanest producers of electricity, ranking second globally in hydroelectricity[22] and first in the G7 on the share of renewables in our supply mix[23].

Sector Emissions

Electricity generation is Canada's fourth-largest source of GHG emissions, representing 12% of national emissions in 2013. Emissions in this sector are projected to decline 52% by 2030 from 2005 levels, as a result of policies currently in place.[24]

Figure 7: Projected Electricity GHG Emissions (Mt CO_2e) *Numbers may not add up due to rounding*[25]



22 *"Canada – Canada Statistics,"* International Hydropower Association, 2014, www.hydropower.org/country-profiles/canada.

23 *IEA's Electricity Information 2015 with 2013 data, Table 1.2, page III.8.*

24 Based on policies in place as of September 2015, as per emissions projections included in Canada's Second Biennial Report on Climate Change.

25 Canada's Second Biennial Report on Climate Change www.ec.gc.ca/GES-GHG/default.asp?lang=En&n=02D095CB-1

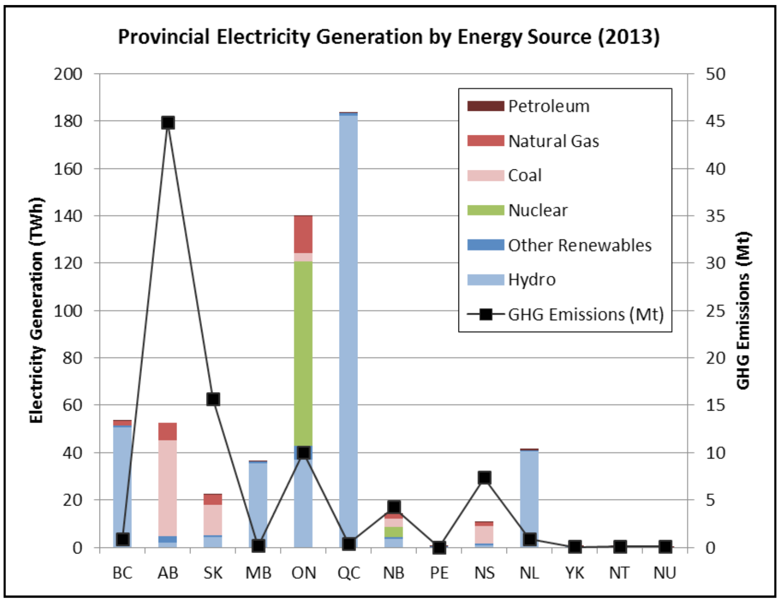
Economic Impact

Electricity generation and transmission is a major driver of our economy, contributing $37 billion per year or 2% of direct GDP, while creating an average of 87,250 direct jobs. [26] In 2014, capital and repair expenditure totaled $25.6 billion.[27] Canada also has some of the lowest electricity prices in the Organisation for Economic Co-operation and Development countries,[28] which makes our industries more competitive.

Canadian Context

Canada's electricity supply was about 80% non-emitting in 2014[29], with a supply mix that included 59% hydroelectricity, 16% nuclear and about 5% non-hydro renewables[30]. However, between 2008 and 2014, wind and solar energy represented the fastest-growing generation sources. [31] There is also substantial coal-, natural gas- and oil-fired generation in Canada, accounting for about 21% of Canada's generation mix. Much of Canada's hydroelectric generation happens in remote areas that require high voltage transmission lines to bring power to urban and industrial centers.

Figure 8: Provincial/ Territorial Electricity Generation by Energy Source and total GHG Emissions (2013)[32]



Sector emissions vary widely by province, as some jurisdictions are already more than 90% emissions-free and/or renewable[33], while others are more reliant on GHG-intensive sources.

26 Energy Markets Fact book, 2014-2015, NR Can (2013 figures).

27 Statistics Canada. Table 029-0046 - Capital and repair expenditures by North American Industry Classification System

28 IEA, *Energy Prices and Statistics: Quarterly Statistics.* www.iea.org/media/statistics/surveys/electricity/mes.pdf

29 *Ibid.*

30 *Ibid.*

31 *Ibid.*

32 *Ibid.*

33 Statistics Canada CANSIM tables 127-0007 and NRCan internal data for wind/solar. www5.statcan.gc.ca/cansim/a26?lang=eng&id=1270007

Key Policies in Place

Efforts by the federal government to reduce emissions in this sector include: regulations for coal-fired electricity; significant incentives for renewable energy programs; funding for research, development and demonstration projects; loan guarantees for major projects; and accelerated capital cost allowances for renewable energy equipment.

Provincial and territorial governments are taking action to reduce reliance on GHG-intensive electricity generation. AB has committed to eliminating GHG emissions from coal-fired electricity by 2030, replacing the coal-fired generating capacity with two-thirds renewable energy, along with implementing a planned carbon levy. ON has eliminated coal-fired electricity, and approximately 90% of its power in 2015 came from non-emitting sources. BC's carbon tax applies to fossil fuel-fired generation. MB's last remaining coal facility operates under a standby provision and can only generate electricity under emergency circumstances. This unit will cease all operations in 2019 once new hydro resources come on-line. NWT is targeting renewable energy of up to 20% of the average load in their diesel communities and ranks second in Canada per capita for installed solar capacity. The NWT is proposing to reduce its diesel fuel use for electricity generation by 25% by 2025.

Many jurisdictions are setting requirements or targets to reduce emissions and drive expansions in hydroelectric and other renewable electricity generation. SK has announced plans for a 50% renewables capacity target for 2030. Its Boundary Dam project is the world's first commercial-scale, coal-fired carbon, capture and storage electricity project, and is able to capture and sequester up to 90% of its GHG emissions. YK has established and met a target to increase renewable energy by 20% by 2020, is implementing energy conservation initiatives at the government and utility levels, and continues to plan for additional renewable energy capacity. NWT is targeting a solar supply of up to 20% of the average load in their diesel communities.

BC, MB, QC, and NS have also announced plans to expand hydroelectric capacity, while NB and PEI have both established targets to expand renewable energy use. BC requires a minimum of 93% of electricity to be clean or renewable and recently announced it intends to make BC's electricity 100% clean or renewable. ON plans to significantly expand renewables and is refurbishing nuclear stations. QC has established a cap-and-trade program for GHGs and is targeting a 25% increase in renewable energy output by 2030. Once NL's Lower Churchill hydroelectricity project's first phase (Muskrat Falls) is completed, 98% of the province's electricity generation will be renewable. NS has legislated hard caps on GHG emissions in the sector, driving a more than 50% reduction by 2030, with plans to reach at least 40% renewable generation in the grid supply by 2020. These policies are also supported by an equivalency agreement between NS and current federal regulations to phase-out coal-fired electricity.

Provinces are also increasing trade of electricity to expand access to cleaner electricity, including: MB and SK; NL and NS; and ON and QC. Some jurisdictions have also made investments in demand-side management measures. For example, NS requires their electricity utility to invest in energy efficiency when it is the most cost-effective option for ratepayers. ON recently announced a new entity will be created as a low-carbon service provider and financing entity. Efficiency NB and NB Power have merged, allowing NB Power to provide energy efficiency programs. Similarly, BC has legislated requirements that require 66% of all new power demand to be met through conservation by 2020.

6.5.2 Summary of Key Options to Reduce Emissions in 2030

There are two basic ways to reduce emissions from the electricity sector: reduce demand for electricity from fossil fuel-fired electricity or replace fossil-fuel fired electricity with non- or low-emitting sources. Both types of approaches are needed, and should work together to achieve reductions. Demand-side management measures are considered in the Built Environment section of this report. A more thorough and comprehensive analysis of the emissions reduction potential of demand-side measures is an area for future work. Policy tools to reduce emissions from electricity generation include performance standards and regulations; non-emitting portfolio standards; financial incentives; and trade between provinces and territories with abundant low-emitting resources and those currently dependent upon fossil fuel combustion.

Additional, targeted policies may be needed to address diesel fuel use in off-grid communities. Estimated total current GHG emissions are small at 1.4 Mt CO_2e /year, but reductions would have significant co-benefits for the many remote communities in Canada that rely on diesel fuel combustion for energy generation.

Table 6 below provides a high-level overview of policy options to reduce emissions from electricity generation and transmission. Further detail about these policy options can be found in Annexes 1 and 2. It should be noted that the cost per tonne ranges below are based on national averages, and therefore do not fully capture important regional differences. The impact that these policies would have on consumer electricity prices could vary significantly across jurisdictions. In addition, these costs do not include investments in enabling infrastructure that would be needed or account for stranded assets, both of which could be significant in some jurisdictions. For example, Nova Scotia estimates that the costs of policy options E1 and E2 are much higher than presented. This is due to: limited natural gas accessibility; existing natural gas supplies are far more expensive in Nova Scotia; and the high cost of building new gas pipeline extensions needed for reliability from the rest of Canada into Nova Scotia.

Table 6: Policy Options for Electricity Generation and Transmission

	Policy Tool	Estimated Range of Emissions Reductions in 2030	Estimated Cost per Tonne*
E1	Emissions Intensity Performance Standards	9-21 Mt	$0-50 or $50-100, depending on policy design**
E2	Accelerated Coal Phase-out By 2030, with regulatory flexibility to enable use of CCS technology	15 Mt	$50-100**
E3	Non-Emitting Portfolio Standard	8 – 15 Mt	$50-100
E4	Financial support for non-emitting electricity generation (30-45 TWh)	13-19Mt	$50-100
E5	Financial support to reduce diesel use in Northern/ remote communities	<1 Mt	$100->$250
E6	Electricity grid investments	1-17 Mt	Site specific $0-100

*Note that cost estimates in the electricity sector are based on conservative assumptions, and may decline as renewable energy technologies continue to improve and the challenges to ensure electric reliability in a changing resource mix are identified and addressed.

**Nova Scotia has estimated the cost of this option at $>250/t for their jurisdiction.

Broadly speaking, the above policies are different tools that target the same sources of emissions and overlap significantly with each other. However, these options could also be complementary under a well-designed and coordinated approach. For example, improving interconnectedness and providing financial support for the construction of new non-emitting forms of electricity generation can facilitate the implementation of a non-emitting portfolio standard or the setting of an emissions intensity performance standard for fossil fuel-fired electricity generation. A price on carbon could also be used to drive reductions in the electricity sector, with appropriate complementary measures that would depend on the level of the carbon price.

Areas for further consideration

There are numerous other costs and considerations that should inform any future policy approach. These include the potential costs of stranded assets; the cost of associated infrastructure; potential impacts on the stability and reliability of the electricity grid; the pace of technological improvement in renewable energy and storage technologies; and the impact of health and air quality co-benefits.

In addition, there are several areas that were not fully explored while developing options for this report but could merit further consideration:

- Other financial incentives (e.g., grants, tax preferences, low interest loans) to support the deployment of renewable energy technologies
- Options to increase decentralized generation, including community-based energy strategies. Further development of possible approaches in areas such as microgeneration, district energy, and combined heat and power, and others could be explored in coordination with the built environment and industrial sectors (Options in included in this report include some preliminary analysis – e.g., B6)
- Best practices for utility legislation and regulation in a low-carbon world. Model guides for energy regulators could be developed, for instance to encourage performance-based rate setting in support of increased investments in energy efficiency, storage, and grid reliability
- Further analysis on how different market structures might interact with various policy options
- Future demand for cross-border clean energy trade with the United States
- Further study of the potential to increase grid interconnectedness, flexibility, and stability, including solutions to address barriers to scaled up East-West linkages, and options for grid modernization to optimize new transmission assets
- The impact on electricity demand associated with policies to reduce emissions by transitioning from fossil fuels to clean electricity in key sectors such as transportation, the built environment, and industrial sectors

6.6 Agriculture

6.6.1 Sector Portrait

Agriculture is a foundational industry in Canada that drives employment, creates trade opportunities and sustains our communities. This portrait largely focuses on primary agricultural production.

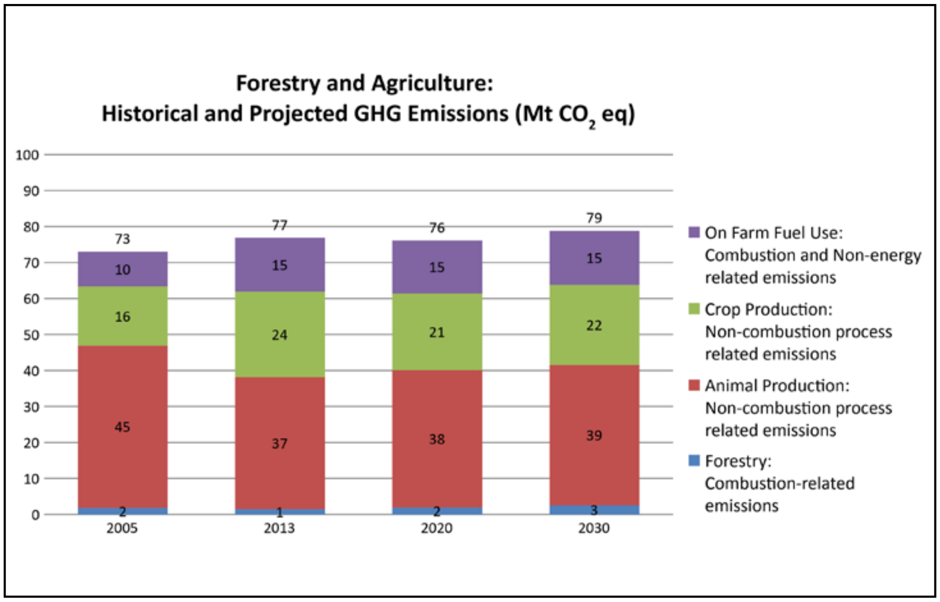
Sector Emissions

Emissions in this sector are largely produced by the biological processes inherent to animal and crop production. While agriculture contributes to GHG emissions, agricultural soils have the capacity to sequester carbon, which offsets the sector's overall impact.

Total emissions from this sector have been relatively stable since 2000, despite agricultural productivity increasing. This is due to advances in efficient farm management practices, which has resulted in a reduction in the aggregate emission intensity of the sector by about 20% since 2000. Aggregate emissions include GHG emissions from crop production, livestock production and energy use on farms, as well as emissions and removals from agricultural land use.

Non-energy GHG emissions directly related to animal and crop production accounted for 59 Mt CO_2e in 2014 — approximately 8% of Canada's total GHG emissions. Agriculture contributed 27% of national methane and 70% of national nitrous oxide emissions. The two main sources of agricultural emissions are ruminant animals and fertilizer application. In addition to non-energy GHG emissions, on-farm fuel use generated 14 Mt CO_2e in 2014.

Figure 9: Agriculture and Forestry: Historical and Projected GHG Emissions



The CO_2 storage in agricultural soils resulting from changes in land management practices has been significant and offers a case study of an effective policy continuum for this sector combining research/development/demonstration and, education/incentives to ease practice change. For over twenty years, Canadian farmers have increasingly substituted conventional tillage with no-till or conservation tillage seeding techniques, particularly in the prairies, where no-till is suited to the growing conditions. Extensive changes to tillage, combined with a major reduction in summerfallow (i.e. cropland purposefully kept out of production) and an increase in perennial forage crops, has resulted in 11 Mt CO_2e being sequestered in agricultural soils nationally. Land converted to cropland emitted 3 Mt CO_2e in 2014, for a net carbon removal of 8 Mt CO_2e. Some existing government policies continue to encourage these trends, and there may be potential to accelerate modest additional reductions in jurisdictions where producers are less familiar with these techniques, such as Quebec and Ontario.

Economic Impact

While primary agriculture accounted for 1.1% of Canada's GDP in 2014, it is at the heart of a larger agri-food industry that created one in eight jobs and contributed 6.6% to national GDP. Economic impacts to primary agriculture are transferred throughout the value chain, including: farm input production; food processing; food retail/wholesale; and food services. Agriculture's contribution to provincial GDP varies significantly, and is highest in PEI and SK, where primary agriculture and food processing accounted for 10.1% and 7.4% of their respective GDPs in 2014.

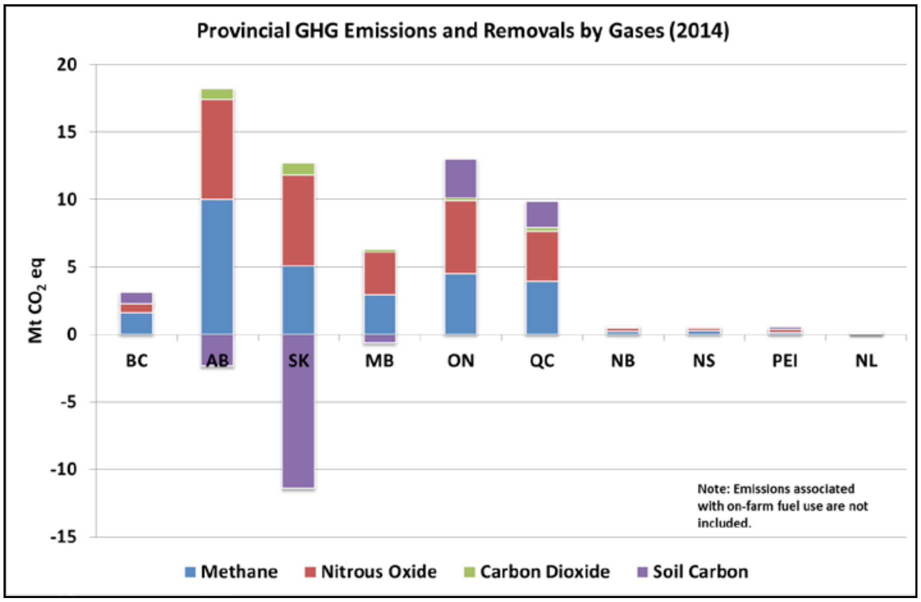
Canadian Context

Canadian agriculture is highly regionalized: 75% of beef and over 90% of wheat, barley and canola is produced in the prairies; while 75% of dairy cattle, 60% of swine and poultry, and over 90% of corn and soybean is produced in central and eastern Canada. Only 7% of Canada's land mass is suitable for agricultural production, and productive farmland is being lost to urbanization and rural settlements. In 2011, approximately 205,000 farms were managing a total area of 65 million hectares. Cropland has been increasing over time and now represents 55% of total farmland, followed by pastures at 31%.

Canada is a major exporter of agriculture and agri-food products, with approximately 58% of the value of primary agricultural production in Canada exported in 2014. While the level of export dependence varies by agricultural commodity, Canada has to compete in international markets and accept prevailing prices for its products. The U.S. is the most important trade partner, although growing Asian and European markets are also very important.

The sector's emissions profile is highly asymmetric across Canada, reflecting regional production systems. AB, SK and MB were the only provinces achieving a net soil carbon removal rate in 2014. This reflects the suitability of no-till to prairie conditions, and the financial and environmental benefits of low impact one-pass seeding in the prairies, where large farms are coupled with soils prone to erosion.

Figure 10: Provincial GHG Emissions and Removals by Gases (2014)



Key Policies in Place

Sustainability is a key component of the principal federal-provincial-territorial agriculture policy framework, which is renegotiated every 5 years. The current framework, Growing Forward 2 (2013-18), includes programs that provide environmental education and cost-shared funding for producers to implement on-farm beneficial management practices (BMPs). BMPs have multiple outcomes, such as improved soil and water health, and GHG reductions. Some provinces also include a focus on programs specific to on-farm energy use, such as improved efficiency, increased use of renewables, and capture of methane from on-farm waste.

Outside of the agriculture policy framework, many provincial or federal-provincial policies and programs contribute to on-farm GHG reductions, including: feed-in-tariffs; nutrient management regulations; intensive livestock operations regulations; manure management regulations; and land management policies. AB, QC and ON have agricultural offsets as part of their emissions trading programs.

Investments in GHG-specific research, innovation and technology transfer are a key policy focus (e.g. the federal Agriculture Greenhouse Gas Program). Additional research, extension, and technology transfer efforts geared towards improvement of production efficiencies are contributing to reducing GHG emissions per unit of production.

6.6.2 Summary of Key Options to Reduce Emissions in 2030

Opportunities for further absolute emissions reductions are regionally variable and generally small under current technologies. Remaining opportunities focus primarily on managing methane emissions from livestock and manure, using fertilizers more efficiently, and increasing planting of cover crops or nitrogen-fixing crops and forages. Given that farmers are price takers and manage their operations to remain competitive on world markets, policy options focus on voluntary incentive programs.

There may be potential for additional reductions of emissions resulting from on-farm fuel use, for instance by improving the energy efficiency of farm equipment and buildings, or increasing on-site energy generation (e.g., T5, B6).

Table 7: Policy Options for Agriculture

	Policy Tool	Estimated Range of Emissions Reductions in 2030	Estimated Cost per Tonne*
A1	Reduced methane from cattle *(dietary changes/ reduced age at harvest)*	<1-2 Mt	$0-$50 or $50-$100, depending on policy option
A2	Conversion of marginal land from annual crops to permanent cover	<1 Mt	$0-$50
A3	Increase planting of nitrogen-fixing crops, pulses and forages	<1 Mt	$0-$100
A4	Increase adoption of zero-till	<1 – 1 Mt	$0-$50
A5	Manure management technologies	<1 Mt	>$250
A6	Precision fertilizer application	Up to 1 Mt	$0-$50 or $50-$100, depending on policy design and level of ambition

*With the exception of A5, the estimated cost per tonne only reflects government costs.

Options to reduce summerfallow were also considered, and show some promise as mitigation measures. However, summerfallow requires no government intervention to achieve reductions of up to 1 MT of CO_2e. in 2030.

Offset credits for emissions reductions generated by sustainable agricultural practices could be considered as a compliance option under a carbon pricing system. Some of the options considered in this report are similar to offset protocols in place under current carbon pricing regimes and/or offset systems. Any use of offsets to incent emissions reduction would require rigorous, long-term monitoring methods to ensure the permanence of reductions.

<u>Areas for Further Consideration</u>

Some key areas that are important to the agricultural sector but not fully reflected in the above options include:

- *Research, Development and Demonstration (RD&D):* Innovation and information will be a key component of further major reductions from the sector. Research developments suggest significant potential to reduce emissions in the medium term, but substantial additional work remains to be done, in particular in feed and nutrition improvements for livestock, innovation in genetics and breeding, and enhanced efficiency fertilizers and measurement of carbon reduction potential in grasslands.

- *Bioenergy/Bioproducts:* The sector can play an important role in the development of bioenergy sources. There is potential to expand the conversion of agricultural wastes into energy, and increase the use of dedicated crops as feedstock for plastics, composites, fibre and fuel. Enabling conditions include policies to drive market demand, increase feedstock supply, and encourage investment into processing facilities.
- *Policy research:* Additional analysis could determine which policy tools would be best suited to support the acquisition of equipment and technology for precision agriculture management, bio-digesters and other on-farm changes requiring significant capital investments.
- *Data collection:* Most recommended actions are not captured in the National Inventory Report. Improved data collection and measurement techniques are required to fully capture the effects of action taken by farmers to reduce emissions. For instance, investments are needed in the accuracy and detail of the data used to inform Canada's GHG inventories and reporting. There is significant diversity in Canada's agricultural sector that may be missed by methodologies that adopt a normalized national baseline or a broad business as usual approach.

6.7 Forestry

6.7.1 Sector Portrait

Forestry is one of Canada's foundational industries and still drives the economy of many communities. Canada's forests are of global significance as a stock of carbon. Forests offer significant potential for long-term mitigation through both reductions in emissions and increasing the carbon removed from the atmosphere. Considering how Canada's forests will adapt to climate change is also important – for instance, adjusting forest management to account for increased frequency and intensity of forest fires.

Sector Emissions

GHG emissions and carbon removals in this sector are included in the Land Use, Land-Use Change and Forestry Sector in Canada's GHG inventory. This inventory only includes so-called "managed" forests – i.e., those under active human intervention – which make up about two-thirds of Canada's total forests. The GHG balance of Canada's managed forest fluctuates from year to year, largely due to the impacts of natural disturbances such as wildfires and insects. These disturbances vary in severity, extent, and frequency, making future disturbances difficult to predict. Including natural disturbances in GHG inventory estimates obscures the impacts of human activity on emissions and removals trends; new approaches are being explored to remove the impact of natural disturbances from the inventory estimates[34]. Natural disturbances can have significant emissions impacts.

Commercial harvesting results in a substantial amount of stored carbon being taken out of Canada's forests each year, averaging 158 Mt CO_2 annually between 1990 and 2014[35]. Once harvested, the carbon in the wood may not immediately be released into the atmosphere, as the timing of release depends on the end use of the wood. Reducing harvesting may not reduce overall emissions if the wood products get replaced by more emissions-intensive products such as concrete and steel. Bioenergy produced using residues from harvesting or manufacturing can reduce carbon emissions in other sectors by replacing fossil fuel use. In this report, options for the use of bioenergy are considered in the Large Industrial Emitters, Built Environment and Electricity sectors.

34 National Inventory Report 1990-2014, Part 1, page 151 and Part 2, page 112

35 Based on estimates for the National Inventory Report 1990-2014.

Table 8: Forest-related GHG emissions and removals, Mt CO_2e. Negative numbers are removals or a "sink"; positive numbers are emissions or a "source".

	1990	2000	2005	2010	2013	2014	2030[1]
Managed forest[2]	-250	-250	-150	-82	-170	-63	NA
Harvested wood products	140	160	150	140	140	140	NA
Deforestation[3]	19	14	14	13	12	12	NA
Afforestation[4]	-1	-1	-0.9	-0.7	-0.6	-0.6	NA

1. No projections are provided in keeping with Canada's approach in its 2016 second Biennial Report to the UNFCCC, pending development of estimates that exclude the impacts of natural disturbances.
2. GHG inventory category of forest land remaining forest land (includes emissions from natural disturbances).
3. GHG inventory categories of forest land converted to other land categories.
4. GHG inventory category of land converted to forest land.
Source: National Inventory Report 1990-2014: GHG Sources and Sinks in Canada, Part 1, page 142.

There is very little land-use change in Canada's forests[36]. Less than 0.02% of the country's forest land is affected by deforestation each year and this rate is declining. Deforestation emissions have averaged 14 Mt CO_2e per year since 1990. They are not primarily driven by the forestry sector, but rather by a complex mix of economic factors and impacts from sectors such as agriculture, resource development, and municipal development. Afforestation rates (e.g. planting trees on unused land) are relatively low and not closely monitored. Afforestation has removed about 1 Mt CO_2e per year since 1990.

Economic Impact

About 904 thousand hectares of Canada's forests are harvested every year[37]. Canada is the world's leading exporter of softwood lumber, newsprint and chemical wood pulp based on the value of those products[38]. This focus on international exports makes the forest industry particularly sensitive to economic and policy differences between jurisdictions. Overall, the industry contributed $21 billion or 1.1%[39] of Canada's nominal GDP in 2014, and directly employed over 195,000 Canadians across the country[40], many in rural communities. The forest sector is also important for Indigenous people, with 70% of Indigenous communities located in forested regions and 9,000 Indigenous Canadians employed in the sector.

Canadian Context

Canada has the third largest forest in the world, covering some 348 million hectares. Approximately two-thirds of this (232 million hectares) is managed forest.[41] Close to 90% of the forest is under provincial or territorial jurisdiction, about 2% is under federal jurisdiction, 2% is under Indigenous jurisdiction, and the remaining 6% is privately owned[42]. This breakdown differs by region; for example, in the Maritime Provinces, most forested land is privately owned. Engagement and consultation with Indigenous peoples will be critical when considering mitigation activities in many areas.

36 Statistics on land-use change are based on estimates used in the National Inventory Report 1990-2014.

37 National Forestry Database (http://nfdp.ccfm.org/). 2014 data.

38 The State of Canada's Forests 2015, page 45.

39 Ibid, page 51.

40 Ibid, page 12.

41 National Inventory Report 1990-2014, Part 1, page 147.

42 The State of Canada's Forests 2015, page 50.

Harvesting and the industries it supports — such as producing lumber or paper products — occurs in all provinces and territories except NU. Some provinces have larger forest industries than others, and the economic differences between them reflect regional differences in harvest rates and the types of products produced. For example, BC accounts for the largest share of Canada's harvest and generates the most revenue from wood product manufacturing, while QC, with the second largest harvest, generates the most revenue from pulp and paper manufacturing[43].

Key Policies in Place

Few policies with the direct goal of forest-related mitigation have been implemented, but other policies often have a mitigation benefit. For example, the federal government indirectly addresses mitigation through collaborative wood market development programs that promote the use of wood as a renewable building material. Some provinces have "wood first" policies which similarly encourage the use of wood in construction, such as "Atlantic WoodWORKS!" and British Columbia's "Wood First" Act.

Provincial standards and regulations require that all forests harvested on public land be regenerated. Sustainable forest management is supported by a framework of extensive laws, regulations and policies, and forest certification. At the end of 2015, Canada had 166 million hectares of independently certified forest land, the largest area of third-party-certified forests in the world[44].

Provincial and territorial governments have a number of initiatives that directly seek to achieve mitigation related to forests, such as the Ontario 50 Million Tree Program and the BC Forest Carbon Partnership Program. A number of provinces support or are considering forest carbon quantification protocols for use in offset programs that allow emitters to balance their environmental impact by investing in efforts to protect, restore or plant forests. BC was the first jurisdiction in Canada to establish a government standardized and accredited forest carbon offset protocol (FCOP) in 2011. BC also developed a policy that enables sharing of carbon benefits between the province and First Nations groups.

6.7.2 Summary of Key Options to Reduce Emissions in 2030

Canada's forests have considerable potential to increase their role in helping mitigate climate change, in particular over the long term. Realizing this potential will require a focus on actions that help reduce emissions and increase the carbon stored in trees, soils, and forest products. The Intergovernmental Panel on Climate Change has emphasized the importance of lifecycle analysis and considering the total GHG impacts across the forest and forest products system, taking into account emissions and removals in the forest, storage of carbon in harvested wood products, and avoided emissions in other sectors.[45] It is important to note that due to this report's focus on mitigation by 2030, the contribution of the forest sector appears lower than it would over a long time period. For most policies, GHG reductions will be quite a bit greater by 2050.

For example, harvested wood products can contribute to mitigation when they are used in ways that avoid immediate emissions through decomposition and replace more emissions-intensive products in other sectors. One of the options in this report proposes increasing the use of harvested wood in the construction of tall and mid- rise buildings, timber bridges, industrial buildings and commercial box-type construction projects, thereby increasing the long-term storage of carbon in our building stock and helping reduce the use of carbon-intensive building products such as concrete and steel.

43 Ibid, pages 52 and 54.

44 www.sfmcanada.org/en/sustainable-forest-management/embracing-third-party-certification.

45 See Nabuurs et al. 2007. Forestry. In Climate Change 2007: Mitigation. Contribution of Working Group III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Edited by B. Metz, O.R. Davidson, P.R. Bosch, R. Dave, and L.A. Meyer. Cambridge University Press, Cambridge, UK.

Another opportunity is to increase the amount of carbon sequestered in living forests. This can be achieved through planting more trees to expand forest cover and changing forest management practices, both of which are included as options in this report. There are a range of practices that can help increase carbon storage and reduce or avoid emissions, such as reduced burning of harvest residues, changes in harvesting practices and rehabilitating forest lands affected by natural disturbances. These practices tend to be regionally-specific; certain approaches make more sense in certain parts of Canada and in particular forests than others. One of the options presented in this report is to increase regional forest rehabilitation activities, and another is to develop regional forest action plans that reflect how GHG mitigation can be achieved through adjustments in forest management practices.

Using forest biomass (e.g. wastewood, organic residues from industry, etc.) for renewable bioenergy can also contribute to mitigation. This opportunity is included in fuel switching options in other sectors: Large Industrial Emitters (I1, I5), Built Environment (B6), Transportation (T2, T10) and Electricity Generation and Transmission (E1, E2).

Table 9 below provides a high-level overview of policy options to target these opportunities, with further detail in Annexes 1 and 2. It should be noted that the cost per tonne ranges below are based on national averages, and therefore do not fully capture important regional differences. As well, mitigation will be higher when considered over a longer period such as to 2050. Costs have been estimated based on longer-term GHG mitigation (i.e. beyond 2030) and so already reflect the long term benefits of near-term investments.

Table 9: Policy Options for Forestry

	Policy Tool	Estimated Reductions in 2030*	Estimated Cost per Tonne
F1	Increase domestic wood use for building construction	<1-2 Mt	$0-$50
F2	A new forest program to increase the area of newly forested land	1-7 Mt	$0-$50
F3	Increased forest rehabilitation after natural disturbances like fire and insect infestation where such efforts are not currently required	<1-1 Mt	$50-$100
F4	Change in forest management practices	8-10 Mt	$0-$50

*Mitigation benefits continue to grow after 2030 as a result of initial investments (for example, because trees continue to grow).

As discussed in Chapter 3, the programs above are complementary to carbon pricing. Since they mostly focus on increasing carbon sequestration rather than reducing emissions, pricing carbon would not provide a strong incentive to pursue these forestry actions.

Areas for further consideration

There are a number of important areas in which the forestry sector could contribute to mitigation outcomes which are not fully addressed in the detailed options presented in this report. Some of these areas for further consideration include:

- Avoiding deforestation – policy options to explore could include incorporating reducing deforestation as a goal in land use planning or environmental impact assessments. Deforestation policies would focus on many sectors, not just the forest sector, since most deforestation is due to actions in other sectors.
- Improving forest inventories, in particular using new technologies to help take stock of Canada's forests on a national scale, as well as the capacity for monitoring and modeling carbon changes at the regional scale.

- Establishing integrated policies and guidance on criteria to conserve non-commercial forest elements such as wetlands and forest soils.
- Research – priority areas include improving our understanding of fire and pest dynamics and suppression, carbon-rich ecosystem components like deep soils, wetlands/peatlands, how albedo is affected by mitigation actions, and non-tree forest plants such as mosses and lichens. Research could also explore improvements to carbon modeling and enhanced management practices.
- Developing policies or strategies for unmanaged forest lands.

6.8 Waste

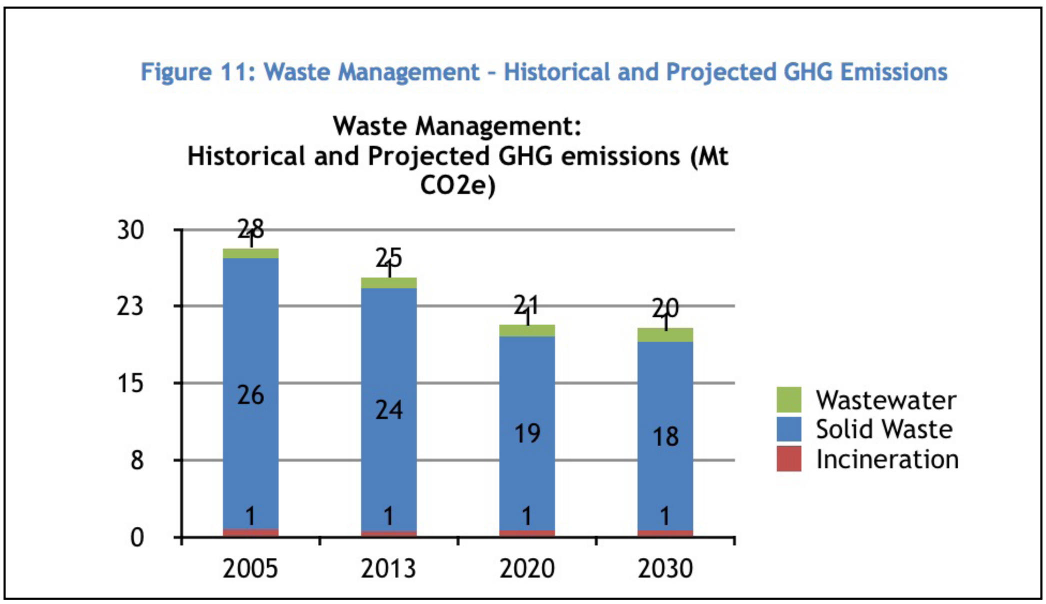
6.8.1 Sector Portrait

The waste sector handles the by-products of human life, from the food waste of communities, to the wastewater of industry. However, innovative strategies and clean technologies are helping us close the loop as we work to become a zero-waste society.

Sector Emissions

Waste accounts for about 3% of Canada's total GHG emissions and includes emissions from landfills, wastewater treatment and incineration. Emissions in this sector are anticipated to decrease by almost 29% below the 2005 level by 2030. Around 82% of these emissions are associated with municipal solid waste landfill gas. This trend of emissions reductions is largely due to increases in landfill gas capture.

Figure 11: Waste Management – Historical and Projected GHG Emissions (Mt CO_2e)



While landfills are an important source of emissions, there is a growing body of evidence that identifies waste prevention, reuse and recycling as the largest source of untapped potential for GHG reductions in this sector.[46,47] These activities produce indirect GHG reductions that, on a life cycle basis, appear in other sectors of the economy or even outside of Canada and are not directly attributed to the waste sector in national emissions inventory reporting.

Economic Impact

In 2015, the waste management industry employed about 43,000 people[48] and contributed about $9 billion (or 0.6%) to the national GDP[49].

Canadian Context

Canada's municipal solid waste generation per capita continues to be closely linked to growth in GDP, and is among the highest in the Organisation for Economic Co-operation and Development (OECD) countries.[50] The vast majority of municipal solid waste is landfilled in 88 large landfills across the country, as well as in numerous smaller facilities in rural and northern areas. Canadians generate about 33 million tonnes of waste per year, of which about 73% is disposed in landfills and less than 2% is incinerated. [51] Only about 25% is diverted, whereas leading OECD countries divert 50% to 60%.

Jurisdictions that are leading in waste diversion provide insight on what realistic diversion and recycling targets could be for Canada as a whole. For example, in 2013, NS led with the highest diversion at 42% of total waste generated and the highest organics diversion at 23.5% of total waste generated, compared to only a 6.7% national diversion rate for organics. For recyclables, QC and BC had the best performance, diverting 23% and 21.4% of total waste generated respectively,[52] compared to a 15.7% national diversion rate

Key Policies in Place

Policies to address the emissions produced by municipal solid waste landfills have been implemented at the provincial and municipal government levels. Several PTs have existing regulations or other instruments to mandate or encourage landfill gas capture and flaring or utilization However, regulations are not equivalent in all jurisdictions and further opportunities are available.

For organics diversion, NS and PEI have regulations banning organic waste from disposal and requiring collection of organics from the non-residential sector. QC also has announced its intention to ban organics by 2020. In the provinces and territories without regulations, many municipalities have implemented green bin programs to collect organics from residences and/or bans on landfilling organics[53]. The non-residential sub-sectors — which include institutional, commercial and industrial waste — represent a significant opportunity to improve organics diversion rates across Canada.[54]

46 Waste Management, In Climate Change 2007: Mitigation. Contribution of Working Group III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. www.ipcc.ch/pdf/assessment-report/ar4/wg3/ar4-wg3-chapter10.pdf

47 Greenhouse Gas Emissions and Potential for Mitigation from Materials Management within OECD Countries. OECD, 2012. www.oecd.org/env/waste/50035102.pdf.

48 Statistics Canada, 2016. CANSIM Table 281-0023. www5.statcan.gc.ca/cansim/a47

49 Statistics Canada, 2016. CANSIM Table 379-0031. www5.statcan.gc.ca/cansim/a26

50 Conference Board of Canada, 2013. www.conferenceboard.ca/hcp/details/environment/municipal-waste-generation.aspx

51 Statistics Canada, 2013. www.statcan.gc.ca/tables-tableaux/sum-som/l01/cst01/envir32a-eng.htm

52 Statistics Canada, 2013.

53 Giroux Environmental Consulting, 2014. State of Waste Management in Canada.

54 Ibid.

For recyclable materials, all provinces and territories have programs in place, particularly for materials that are the most pressing from a GHG reduction perspective, such as paper products and metals. The territories have limited programs in place due to unique challenges in northern/remote areas, but efforts are under way to expand the range of materials covered. BC has achieved its diversion rate using mandatory and voluntary Extended Producer Responsibility (EPR) programs, while QC employs a mix of shared responsibility programs, Product Stewardship programs and EPR. For institutional, commercial and industrial waste, there are gaps in recycling program coverage in most jurisdictions, which represent a significant opportunity for further reductions.[55]

Federal, provincial and territorial jurisdictions collaborate on waste policy priorities through the Canadian Council of Ministers of the Environment.

6.8.2 Summary of Key Options to Reduce Emissions in 2030

There are three basic ways to reduce emissions from waste: 1) waste prevention; 2) diversion of organics or recyclable material; and 3) capture and reuse emissions from waste such as landfill gas. The policy tools with greatest potential to reduce GHG emissions in the waste sector in Canada are: increasing landfill gas capture and flaring or utilization; reducing avoidable food waste; increasing organics diversion; and increasing recyclable materials diversion.

The IPCC fourth assessment report identifies waste prevention, re-use and recycling as key GHG mitigation actions and indicates that life cycle analysis is required to quantify GHG-reductions from these actions. For example, waste prevention and recycling conserve raw materials and reduce energy consumption, while diversion of organics and paper products reduces landfill methane generation, and organics can be processed to produce renewable natural gas. As such, a life-cycle approach has been taken to estimate potential emission reductions for waste reduction and diversion policy options presented in this report. These are the only policy options in this report using this approach and as such have relatively large reductions attributed to them. Note that some estimated lifecycle reductions would occur outside of Canada.

Table 10 below presents a brief summary of the proposed policies, estimated emission reductions and estimated costs for the waste sector.

Table 10: Policy Options for Waste

Policy Tools		Estimated Range of Emissions Reductions in 2030	Estimated Cost per Tonne
Direct Emissions Reductions			
W1	Landfill gas capture and use *(increase to 60%, with regulations/incentives)*	2-3 Mt	$0-50
Indirect Emissions Reductions (based on life-cycle approach)			
W2	Reduce avoidable food waste *(by 50%)*	10 to 15 Mt*	$<0
W3	Diversion of organics *(increase to 20-25% by 2030)*	1 to 4 Mt*	$0-50
W4	Diversion of recyclable materials *(increase to 13-35%)*	2-16 Mt*	$0-50

* These indirect emissions reductions estimates were calculated using a life-cycle approach and as such also include reductions in other sectors of the economy.

55 Ibid.

Some of the options presented above are overlapping. For example, reducing the quantity of organics that is landfilled will also reduce landfill gas to be captured in the future, and waste prevention activities will reduce the quantity of material and organics available for diversion. However, if combined into a coordinated approach, these options could enable Canada to move toward a low-waste, 'circular' economy over the longer term. Ideally, waste would be reduced to the maximum extent possible, inevitable waste would be reintegrated into the production chain, and emissions from legacy landfill waste would be captured and used to generate energy.

Areas for further consideration

Some of the options would require significant investments in infrastructure and enforcement such as municipal organic processing and recycling facilities. Also, a carbon pricing scheme could support emission reductions in the waste sector, for example by making the price of landfill gas more competitive with fossil fuels and/or by using the proceeds from carbon pricing to fund improvements in recycling and organics diversion. Further work is required to identify specific infrastructure costs or potential impacts of a carbon price on the policies proposed above. Additional analysis is also needed to refine methodologies for estimating reductions (e.g. emissions factors) from lifecycle measures.

In addition, two other policy options that were not fully explored while developing options for this report could merit further consideration:

- Options to reduce packaging and use of disposable products (e.g. plastic bags and foam cups), clothing/textile reuse and other waste prevention activities could be examined to determine which policy tools could be adopted and estimate potential emission reductions and costs.
- Energy-from-waste (EFW) - recovering energy from waste via combustion in the form of electricity, heat or steam (this is distinct from any methane capture and combustion). Currently, less than two percent of Canada's total waste is processed in less than five EFW facilities. EFW could be considered in Canada as a complementary policy tool when high levels of waste reduction, recycling and diversion will have been achieved, with consideration for negative impacts (e.g. air quality) and place-specific costs.

6.9 Government Operations and Leadership

The government operations sector is large and diverse, providing a wide variety of services to Canadians. This sector includes federal, provincial, and territorial government operations, and can be scoped more broadly to include the operations of municipalities, universities, schools, and hospitals.

As an influential sector, government can show leadership by reducing its own emissions. Governments are responsible for a significant stock of public assets, providing an opportunity to lead by example by implementing ambitious policies to reduce emissions from fleet, buildings, and other assets. They are also major purchasers and providers of goods and services, which can help to build demand for low-carbon goods and services and provide a testing ground for new and emerging technologies.

Sector Emissions

The core operations of the federal and provincial government accounted for about 0.6% of Canada's total emissions in 2013 (about 5 Mt)[56]. The biggest emitter by far is the federal government, which has diverse operations in every jurisdiction. The biggest single source of emissions in the federal government is the Department of National Defence.

56 Statistics Canada. Table 153-0114 - Physical flow account for greenhouse gas emissions, annual (kilotonnes), CANSIM (database). (accessed: 2016/09/08) www5.statcan.gc.ca/cansim/a26?lang=eng&retrLang=eng&id=1530114 The 0.6% includes the following two sectors of the Statistics Canada table: "Other provincial and territorial government services", and "Other federal government services and defence services".

When hospitals, universities, government residential care facilities, education services and other municipal services are included, they accounted for a total share of about 2.4% of Canada's emissions in 2013 (about 18 Mt).

Canadian Context

The public sector has significant purchasing power and is an important source of employment. For instance, the Government of Canada purchases approximately $16.05 billion worth of goods and services every year on behalf of federal departments and agencies.[57] Provincial, territorial, and local governments are also major purchasers of goods and services. In 2011, federal, provincial, and territorial governments employed about 780,000 people.[58] Approximate estimates of federal, provincial, and territorial government assets indicate that these governments control fleets of at least 64,000 vehicles and 39,000 buildings across the country, with a total of at least 45 million square metres of floor space.

While this section focuses primarily on the operations of federal, provincial, and territorial governments, many of the options proposed could also be applied to the public sector operations more broadly (e.g., local governments, universities, schools, and hospitals) to achieve significant emissions reductions.

Key Policies in Place

The federal government and most provinces and territories have put key policies in place to reduce GHG emissions from their operations. The federal government's Federal Sustainable Development Strategy includes a government-wide target to reduce emissions by 17% below 2005 levels by 2020. Some provincial and territorial governments have also set targets to reduce emissions from their operations. For example, BC's Carbon Neutral Government Regulation requires public sector organizations to achieve net-zero emissions. It includes requirements to measure and reduce emissions, and to purchase offsets to achieve carbon neutrality. Similarly, ON, MB and YK have also committed to introducing carbon neutral programs.

To support their GHG reduction targets, the federal government and most provinces also have specific policies in place to reduce emissions from their buildings, such as meeting green building standards and targets for improving energy efficiency and using renewable fuel sources for new government-funded buildings or major renovations. Governments have also established funding programs to support investments in these areas. For example, QC has provided $20 million for public building retrofits to convert existing heating systems to use cleaner sources of energy.

A number of governments also have initiatives to reduce emissions from their fleets, such as targets for switching to low- or zero-emission vehicles. Additionally, some governments have implemented policies to encourage the use of public transit and telework to reduce emissions from employee commuting.

Local governments across Canada are also taking action to reduce their emissions, and share jurisdiction over many of the sectors that are important potential sources of emissions reductions.

6.9.1 Summary of Key Options to Reduce Emissions in 2030

Many of the policies included in other sectors of this report could be applied to the government operations sectors (built environment, transportation, electricity generation and transmission). In general, governments can lead by example by adopting ambitious policies, potentially on accelerated timelines, in order to demonstrate that these policies are feasible and beneficial.

57 https://buyandsell.gc.ca/for-businesses/selling-to-the-government-of-canada/the-procurement-process

58 Total employment in the public sector, including schools, hospitals, universities and municipalities was approximately 3.6 million people in 2011. Statistics Canada, "Public sector employment, wages and salaries (employees)" www.statcan.gc.ca/tables-tableaux/sum-som/l01/cst01/govt54a-eng.htm, 2011 data.

Options to enhance Canada's procurement of clean technologies are discussed in greater detail in the report by the Working Group on Clean Technology, Innovation and Jobs.

Actions

The list below provides some examples of actions that can be taken to reduce emissions in the government operations sector.

Facilities:

- Transition to renewable power
- Improve building energy efficiency through retrofits
- Ensure new construction is highly efficient (e.g., net zero)
- Develop internal energy efficiency performance standards for buildings
- Benchmark building energy performance
- Include performance clauses in real property management contracts
- Change IT services delivery models, including use of cloud computing, and rationalize IT infrastructure to reduce power demands
- Improve efficiency of central heating plants

Fleet:

- Transition to electric vehicles and install charging station infrastructure
- Improve fleet fuel economy
- Switch to less carbon intensive fuels
- Optimize fleet size
- Establish coordinated vehicle retro-fit/maintenance programs
- Implement vehicle telemetrics
- Reduce the number of kilometers travelled

Commodity Products and Services:

- Procure goods and services with known (defined) environmental certifications
- Include energy efficiency and GHG emissions criteria in procurement decisions
- Publish "scorecards" for largest Government suppliers , highlighting their environmental practices
- Use only certified, recycled, or renewable paper
- Mandate green procurement training for all procurement staff
- Enable demonstration projects for new and emerging clean technologies

Employment Policies:

- Enable flexible work arrangements, such as teleworking, hoteling/ hot desking, desk sharing and optimize space allocation
- Subsidize the use of shared or public transportation and reduce business related travel
- Mobilize the public service, through 'green teams' and linkages between emissions reductions and performance pay

Tools

A variety of tools can be used to drive the types of emissions reductions actions listed above. In many cases, these tools could be used in combination with each other and be mutually reinforcing. All of these tools would require careful tracking and measurement of emissions reductions, and investments in data collection. Some of these tools include:

Targets

High-level targets for emissions reductions across government operations can provide an overarching objective and framework for the development of more specific policies to achieve these reductions. Targets for specific types of actions (e.g., use of 100% renewable power, 50% improvement in light-duty vehicle fleet fuel economy, etc.) can also guide action by setting a clear level of ambition. Targets should be complemented by mechanisms to collect data and report regularly on progress.

Carbon Neutral Government Policy

Under a carbon neutral government policy, governments would commit to having no net impact on emissions. Governments would reduce their emissions as much as possible, and then invest in emissions reductions projects to offset any remaining remissions. This would require access to an offset system, with eligible projects to produce verified emissions reductions, as well as registries and tracking systems. An illustrative example of a carbon-neutral government policy is included in Annex 2.

Shadow Price/ Internal Carbon Price

Shadow pricing is a method of investment or decision analysis that adds a hypothetical surcharge to market prices for goods or services that involve significant carbon emissions in their supply chain. Many companies in Canada in a variety of sectors are using a shadow carbon price. Shadow carbon pricing is typically used at the project level – as part of evaluating options for large projects and for specific greenhouse gas reduction projects, but can apply in all sorts of analyses of investments, procurements, and other strategic decisions to give an edge to options that are less emissions-intensive.

Another possibility could be for the government to adopt an internal carbon price that is higher than any other economy-wide pricing regime in place, in order to drive deeper reductions.

Financial Tools

Investments in emissions reductions may require the use of innovative financing tools in order to facilitate access to capital. For example, one option could be to establish an energy revolving fund to provide funding in the form of loans for investments in energy conservation or efficiency. The financial savings from the investments are used to repay the loan, so that over time the principal of the revolving fund is replenished.

Options to scale up the use of energy performance contracting in government operations could be explored. An energy performance contract is an agreement between an organization and energy services company, which guarantees energy savings and can provide financing for departments that have little or no access to capital funding.

6.10 Individual actions

Over the past few months, thousands of Canadians have submitted ideas on ways that they can help Canada to combat climate change. While each individual action may have a small impact, multiplied millions of times, the aggregate impact on emissions is large. There is a range of actions that Canadians can take at home, at work, and on the go to reduce their environmental footprint. Some of these actions are small shifts in behaviour; others involve more substantive investments and behavioural changes. Particularly to enable these bigger shifts, government has an important role in putting in place policies that make it easy, attractive, and convenient for Canadians to act on climate change.

For instance, some examples of actions that Canadians can take include:

- Using active transportation (e.g. walking or cycling to work)
- Taking public transit
- Participating in carpooling and car-sharing services
- Reducing and avoiding idling (e.g. turn the car off when it is parked, reduce "warm-up" time in winter before driving, walk in to restaurants rather than using drive-thrus)
- Avoiding food waste (e.g. grocery shopping based on meals planned for the week)
- Reducing meat consumption
- Using multi-use containers, like reusable water bottles, bags, and containers
- Adjusting thermostats by a few degrees to reduce heating and air conditioning needs

Some of the policy options in this report that could help to enable these actions include:

- A national strategy and campaign to reduce avoidable food waste (W2);
- Investments in active transportation networks, such as increased cycling and walking infrastructure (B8, T7);
- Investments in public transit expansion and frequency (T7)
- Education and outreach programs to promote ecoDriving (T6);
- Home energy use information programs (B7);

Purchasing decisions by individual Canadians also play a very significant role in shifting economic activity towards lower carbon goods and services. Some examples of small spending decisions by Canadians that can have an impact over time include:

- Buying locally-sourced food in season
- Choosing items with minimal, compostable and/or recycled packaging
- Purchasing environmentally certified products
- Purchasing carbon offsets for air travel.

Less frequent, major purchases like appliances and vehicles and investments in home improvements are also key opportunities for Canadians to make choices that have larger and longer term impacts. Some examples of actions include:

- Purchasing appliances and electronic accessories that are more energy efficient (e.g. appliances with high energy efficiency rated by the EnerGuide system);
- Undertaking home energy audits, and considering appropriate retrofits to improve energy efficiency;
- Installing small-scale sources of renewable energy (e.g. solar panels on roofs);
- Purchasing low or zero emission vehicles (e.g. hybrids and electric cars);

Options in this report that can help Canadians to make these types of purchases and investments include:

- Financial incentives (grants, tax preferences, low interest loans) and regulations to increase home energy efficiency of existing residential housing stock (B2)
- Incentives for residential fuel switching and small-scale renewable energy sources (B6);
- Zero Emission Vehicle (ZEV) consumer incentives, incentives to accelerate the turn-over of pre-2006 passenger vehicles, and consumer awareness programs for ZEVs (T1);

6.11 Internationally Transferred Mitigation Outcomes

Article 6 of the Paris Agreement recognizes that Parties may choose to cooperate in implementing their Nationally Determined Contributions (NDCs) through the voluntary use of internationally transferred mitigation outcomes (ITMOs). ITMOs are mitigation outcomes (or emissions reductions) that occur outside of a country's borders.

The use of ITMOs for compliance with NDCs is based on the fact that a reduction in GHG emissions has the same impact on the atmosphere regardless of where it takes place. Access to ITMOs could ultimately provide the foundation for allowing climate ambition to be raised over time, as per the Vancouver Declaration and the Paris Agreement, while driving down costs.

ITMOs are not specifically defined. They could encompass any mitigation outcomes in other jurisdictions and could take various forms, including: GHG reductions resulting from centralized UNFCCC mechanisms, investments in emission reduction projects or technology transfers; allowances from capped emissions trading systems; and credits from reducing emissions from deforestation and forest degradation in developing countries. The Paris Agreement also created a new centralized mechanism to contribute to GHG mitigation and support sustainable development.

Rules, modalities and procedures for using ITMOs have not yet been developed. With the exception of the use of the new centralized UNFCCC mechanism, which will have specific rules, it is likely to be left largely to Parties to decide which ITMOs they will 'count' as reductions toward meeting their NDCs and to demonstrate how they promote sustainable development, ensure environmental integrity, and are consistent with the accounting guidance to be developed to ensure they avoid double counting (i.e., the situation where two countries claim the same emissions reduction toward an NDC).

ITMOs can be acquired through various avenues, including:

- Investment in multilateral initiatives through the World Bank, Multilateral Development Banks, or other multilateral funds;
- Trading systems either at the national or sub-national level;
- Bilateral investment in reductions outside of Canada; and
- Use of the centralized UNFCCC mechanism.

If ITMOs are being transferred between Parties, the Parties will need to make mutual adjustments to their NDCs, which will require agreement between them, including if necessary, on how/whether they will account for the ITMOs.

Toward a Canadian strategy for acquiring and using ITMOs

Meeting Canada's NDC will require significant reductions by 2030 and reaching it through domestic action alone is likely to include some options that are relatively expensive. While it is important for Canada to put in place strategies that will result in significant domestic emissions reductions and contribute to clean economic growth that supports the transition to a low-carbon economy, some of these higher-cost opportunities may not contribute to this transition, or may be prohibitive in cost.

Given that the price of reductions tends to increase over time as lower-cost reduction opportunities are exhausted, and that the mitigation opportunities considered feasible and readily implementable may not be enough to close the 2030 emissions reduction gap, acquiring ITMOs to meet a portion of Canada's 2030 gap bears consideration.

Careful consideration will need to be given to the balance between investing in domestic mitigation actions in Canada that may have multiple benefits, and in lower-cost reductions abroad to close the gap.

Acquiring ITMOs could also contribute to Canada's sustainable development goals, and Canada's support for the achievement of the United Nations Sustainable Development Goals. Exports of Canadian technology or cleaner energy whose end-use results in emissions being lower than they otherwise would have been in another country could also be considered ITMOs. Without agreement from the importing country that Canada could use the ITMOs created, this would not help Canada to meet its NDC, but it could have other benefits to Canadian jurisdictions. ITMOs could also be directly transferred in or out of the country under the Quebec-California cap-and-trade system or through other bilateral mechanisms. In addition, Canadian and international airlines with obligations under ICAO's market based measure may want to acquire Canadian-based ITMOs if they exist and are available to them.

A strategy for acquiring ITMOs (i.e., outside of those that already exist under the Western Climate Initiative cap-and-trade system) would need to consider the quantity of ITMOs to be acquired, the timing of acquisition, funding source and vehicle, potential infrastructure requirements, and the criteria that Canada would use both to determine ITMOs it deems acceptable to use towards our NDC and to demonstrate environmental integrity. It will also need to consider whether to allow ITMOs to flow out of Canada for use by others.

Decisions on the quantity of ITMOs to be acquired could be informed by a variety of approaches:

- A cost/tonne threshold: Mitigation that surpasses a pre-determined level would be undertaken through ITMOs;
- Gap filling: ITMOs could be used to completely cover any gap left by selected domestic mitigation policies;
- A fixed percentage of the gap is covered by ITMOs (based on some criteria);
- A fixed amount of money dedicated to the purchase of/investment in ITMOs.

In terms of timing, some avenues for acquiring ITMOs may require lead time for negotiation, capacity building or project implementation. Early investment and planning could help enable the production of ITMOs, and work to mitigate the risk that there will not be an adequate supply if and when Canada decides to acquire them. Canada could consider acquiring ITMOs early enough to ensure a constant and sufficient supply until 2030 and possibly beyond, and should consider early investments that enable the production of ITMOs, given future uncertainties related to supply and price.

Canada as well as some provinces and territories have already committed significant funding to climate financing to help support the low-carbon transition in developing countries. Opportunities to convert part of such climate financing to investment in ITMOs that would benefit both Canada and provinces and territories could be identified. In addition, a fund dedicated to the purchase of ITMOs could be developed. Consideration could be given to the possibility of sharing the cost of ITMOs between the federal, provincial and territorial governments considering that certain provinces and territories may also be interested in ITMOs to meet their commitments.

Infrastructure such as a registry, to track and report on transfers to and from the federal government may need to be developed.

Canada will need to demonstrate the environmental integrity of any ITMOs it uses. This is generally done using an established set of criteria to show that the reductions are real, additional, permanent, properly owned, quantified, monitored and reported, and verified.

Canada will also need to work within the UNFCCC to ensure its interests related to ITMOs, including the outcome of a strategy developed to acquire ITMOs, are advanced and that any rules developed under the UNFCCC do not hinder its implementation.

Further considerations related to ITMOs can be found in Annex 2.

7 CONCLUSION

This report has identified a broad range of possible options for ambitious emissions reductions across all economic sectors. These options build on efforts that are already underway by all orders of government across Canada. The task before Ministers is now to weigh these options against each jurisdictions' priorities and identify which measures could potentially work together to form part of a national plan on climate change and clean growth. As highlighted in this report, some of the key considerations that could inform these deliberations include:

- Potential emissions reductions
- Economic costs
- Impacts on economic growth, jobs and competitiveness
- Contribution towards longer-term, transformative change
- Other benefits, like improved health
- Alignment with the priorities and perspectives of Indigenous peoples
- Regional differences and impacts
- Applicability to the needs of Northern and remote communities
- Enabling infrastructure and technology needs
- Capacity to reinforce or contribute to adaptation objectives
- The choice of policy tools

The options in this report are illustrative examples of possible actions that could be taken to help Canada to reach its 2030 emissions reductions target. Not all options may be feasible or appropriate to every jurisdiction, and a more fulsome assessment of the advantages and disadvantages of each policy option will need to be undertaken before making concrete decisions on policy implementation. Additional modelling and analysis will also be needed to account for interactions between measures, as many of the options in this report overlap with each other. Additional, complementary measures, such as investments in emissions inventories to better account for the impacts of mitigation actions, may also be needed.

Close coordination between a range of partners will be required to determine a path forward on mitigation action. For instance, appropriate mitigation actions depend in part on decisions about carbon pricing options; both Ministers of Environment and Ministers of Finance will consider options presented in the report by the Working Group on Carbon Pricing Mechanisms. Ministers of Innovation will consider options in the report from the Working Group on Clean Technology, Innovation and Jobs. A national approach to climate change and clean growth will need to bring together a coherent vision and set of measures for mitigation (including carbon pricing), adaptation, and clean growth.

In addition, many provinces and territories are currently in the process of updating their climate change plans and strategies, or have recently announced new measures. It will be important to ensure that a national approach to climate change and clean growth reinforces and complements these actions.

Furthermore, Indigenous leaders, municipalities, international partners, and other stakeholders will also have an important role going forward in shaping and implementing ambitious new climate change policies. Collective and coordinated efforts will be critical to implementing climate policies as efficiently as possible, in order to maximize benefits and mitigate potential negative impacts.

As a next step, Ministers of the Environment, in cooperation with their colleagues, will provide an analysis of these options to First Ministers, who will meet again in the fall of 2016. While the magnitude of the climate change challenge is large, so is Canada's capacity for innovative solutions and its commitment to progress. Collectively, the reports from the Working Groups on Carbon Pricing Mechanisms, Adaptation and Resilience, and Clean Technology, Innovation and Jobs, and this report from the Working Group on Specific Mitigation Opportunities offer a large spectrum of potential options on multiple pathways for action on climate change that would benefit both Canadians and the global community.

ANNEX 1: SUMMARY TABLE OF POLICY OPTIONS

Large Industrial Emitters

	Policy Description	Estimated Reductions in 2030 (Mt CO_2e)	Estimated Cost per Tonne (tCO_2e) (approximate range)
I1	*Use Incentives to Promote Cogeneration*		
a.	Enhance cogeneration by 10% nationally *(where lower carbon fuels than existing grids available)*	1-2 Mt	$0-$50
b.	Use biomass instead of natural gas as fuel *(in up to 10 facilities)*	<1 Mt	<$0-$50
I2	*Transitioning to Electrification*		
a.	Require all new mechanical drive systems to be electric + 20% rate based incentives	3-7 Mt	$100->$250
b.	I2a + replace 10% of existing fuel use by electricity by 2030	11-15 Mt	$100->$250
I3	*Mandate or Use Incentives to Promote Energy Efficiency*		
a.	Financial incentives *(grants, tax preferences, low interest loans)* to accelerate the use of energy management systems	6-9 Mt	$0
b.	Regulations to set emissions standards for new and/or existing facilities *(5-15% improvement)*	14-41 Mt	$0-$50
I4	*Zero Routine Flaring*		
a.	Zero routine flaring for oil production	<1 Mt	N/A
b.	Expand zero routine flaring to other sectors	<1 Mt	
c.	Increase stringency of economic tests or thresholds	1-2 Mt	
I5	*Fuel Switching to Lower Carbon Alternatives*		
a.	Eliminate heavy oils in combustion equipment where there is access to natural gas or alternatives	1-6 Mt	$0-$50
b.	Replace 5-10% of natural gas used in combustion with renewable alternatives by 2030	5-11 Mt	$100-$250
c.	Replace 5-10% of natural gas used as feedstock and in combustion with renewable alternatives	6-12 Mt	$100-$250
d.	Requirement for natural gas producers to include 5-10% renewable content in natural gas supplied to all sectors	13-26 Mt	$100-$250
I6	*Methane Reductions*		
a.	40-45% reduction from 2012 levels by 2030 *(announced federal policy for 2025)*	18-20 Mt	$0-50

	Policy Description	Estimated Reductions in 2030 ($Mt\ CO_2e$)	Estimated Cost per Tonne (tCO_2e) (approximate range)
I7	*Additional carbon emissions reductions through abatement and sequestration (CCS and other) technology*		
a.	Increase sequestration of carbon by 20% in industrial sectors where applicable	3-5 Mt	$50-$100
I8	*Limit carbon emissions through transformative changes in technology throughout the industrial sectors*		
a.	Regulations or incentives to limit emissions to a benchmark and bring forward ambitious technologies earlier than BAU	11-29 Mt	$100-$250*

* Costs are presented in standardized ranges. Costs for this policy are based on estimates in the range of $100-$150 per tonne.

Transportation

	Policy Description	Estimated Reductions in 2030 (Mt CO_2e)	Estimated Cost per Tonne (tCO_2e) (approximate range)
T1	*Passenger vehicle emission regulations and incentives*		
a.	Zero Emission Vehicle consumer incentives	1-3 Mt	$100-$250*
b.	Scrappage program		
c.	Consumer awareness program	-	
d.	Light duty vehicle GHG regulations for model years 2026-2030		
i.	Modest emissions standard of 172 g/mile in 2026 and increasing in stringency to 158 g/mile by 2030	1-2 Mt	$0-$100
ii.	Moderately ambitious emissions standard of 163 g/mile in 2026 and increasing in stringency to 131 g/mile by 2030	4-5 Mt	
iii.	Ambitious emissions standard of 158 gCO_2/mile in 2026 and increasing in stringency to 105 g/mile by 2030	6-7 Mt	
e.	Zero Emission Vehicle Standard		
i.	Beginning with 2% of the fleet in 2022 to 30% of the fleet by 2030	2-4 Mt	$0-$100
ii.	Beginning with 10.5% of the fleet in 2022 to 50% of the fleet by 2030	6-9 Mt	
T2	*Increased availability and use of low-carbon fuel for on-road and off-road vehicles*		
a.	Increase renewable fuel requirements	10-20 Mt	$0-$50
b.	Low Carbon Fuel Standard		$0-$50
c.	Truck engine compatibility with low carbon fuels	N/A	N/A
d.	Truck engine rebate		
e.	Transit vehicle compatibility with low carbon fuels		
f.	Transit electrification		
g.	Fuelling infrastructure		
h.	Domestic production of low carbon fuels		
T3	*Energy efficiency in the aviation, rail, marine and off-road industrial sectors*		
a.	Aviation offsets:		
i.	30% of domestic aviation emissions	2-3 Mt	$0-$50
ii.	70% of domestic aviation emissions	6 Mt	$0-$50
iii.	100% of domestic aviation emissions	8 Mt	$0-$50
b.	Regulations, programs and incentives for the following sectors:		
i.	Off road	1-7 Mt	$0-$100

Policy Description		Estimated Reductions in 2030 ($Mt\ CO_2e$)	Estimated Cost per Tonne (tCO_2e) (approximate range)
ii.	Marine and rail	0-2 Mt	$0-$250
T4	*Heavy duty vehicle and engine emission regulations and incentives*		
a.	Post-2018 HDV GHG regulations	3-6 Mt	< $0
b.	Incentives for retrofits on in-use HDVs	1-3 Mt	$100->$250*
c.	Regulations requiring GHG-reducing technologies for in-use HDVs		$50-$100
d.	Scrappage of older HDVs		> $250
e.	Revise weight and dimension regulations	2-3 Mt	<$0
f.	Require truck stop electrification		$0-$100
g.	Funding for electrified truck highway pilot projects	<1 Mt	>$250
T5	*Vehicle and engine fuel efficiency in the aviation, marine, rail and off-road sectors*		
a.	Regulations for new vehicles/equipment	1-3 Mt	$0-$250
b.	Voluntary aviation commitment		N/A
c.	Funding/incentives for retrofits	1-2 Mt	$0-$250
d.	Regulations for in-use vehicles/equipment	2-3 Mt	$0->$250
T6	*Fuel Efficiency of on-road vehicles*		
a.	Increased speed enforcement	2-4 Mt	$0-$50
b.	Regulation requiring truck speed limiters	0-1 Mt	$0-$50
c.	Outreach and education programs	<1 Mt	$0-$50
d.	Funding program for ITS deployment	<1 Mt	>$250
e.	Funding program to increase paved roadways	0-1 Mt	$100-$250
T7	*Freight efficiency*		
a.	Incentives for freight logistics and supply chain efficiencies	0-2 Mt	<$0
b.	Funding to support modal shift	1-2 Mt	>$250
c.	Pricing - heavy goods vehicle per kilometre charge	0-1 Mt	$0-$100
T8	*Changing transportation usage patterns*		
a.	Shift vehicle passengers to public transit and active transportation:		
i.	Funding for public transit	0-1 Mt	$100-$250
ii.	Funding for active transportation	<1 Mt	
iii.	Urban planning strategies	N/A	
b.	Reduce vehicle-kilometres travelled:		

Policy Description		Estimated Reductions in 2030 (Mt CO_2e)	Estimated Cost per Tonne (tCO_2e) (approximate range)
i.	HOV and HOT lanes	1-2 Mt	>$250
ii.	Incentives for car sharing		<$0
iii.	Employer TDM		<$0
c.	Funding for high frequency/performance rail	<1 Mt	>$250
T9	*Reducing congestion and vehicle-kilometres travelled*		
a.	Road use pricing based on vehicle kilometres travelled	1-2 Mt	<$0
b.	Pay-as-you-drive (PAYD) insurance policies		<$0
c.	Congestion pricing in 3-6 of Canada's largest cities	<1 Mt	<$0
d.	Variable vehicle registration pricing	<1 Mt	$0-$100
e.	Variable vehicle excise taxation based on vehicles emissions rating		$0-$100
f.	Financial incentives to accelerate fleet turnover		$50-$100**
T10	*Increased availability and use of low-carbon fuel in the domestic marine, rail and aviation sectors*		
a.	Low Carbon Fuel Standard for marine and rail	1-2 Mt	$100-$250
b.	Low Carbon Fuel Framework for aviation	<1 Mt	$100-$250

* Costs are presented in standardized ranges. Costs for this policy are based on estimates in the range of $150-$250 per tonne.

** Costs are presented in standardized ranges. Costs for this policy are based on estimates in the range of $50-$150 per tonne.

Built Environment

	Policy Description	Estimated Reductions in 2030 ($Mt\ CO_2e$)	Estimated Cost per Tonne (tCO_2e) (approximate range)*
B1	*Net- Zero Ready Codes For New Housing*		
a.	Net-zero ready implemented by 2030 *(~40% lower than 2012 model code on average; varies by climate zone)*	4 Mt	Elect: <$0 Natural Gas: >$250 Oil: $0-50
b.	Net-zero ready implemented by 2025	5 Mt (includes B1a)	Elect: <$0 Natural Gas: >$250 Oil: $50-$100
B2	*Existing Housing*		
a.	Financial incentive to reduce low rise housing energy use 1.5% via voluntary **shallow retrofits** to 1 million homes	1 Mt	Elec/Oil: < $0 Nat Gas: $50-100
b.	Regulation/financial incentive to reduce energy use by 4% via voluntary **deep retrofit** of 1 million homes	2 Mt	Elec: $0 Oil: $0-$50 Nat. Gas: > $250
c.	Regulation/loan program to reduce energy use by 10% by requiring **moderate retrofits** at time of home sale or permit application	6 Mt	Elec/Oil: < $0 Nat. Gas: $100-250
B3	*Net-Zero Ready Codes For New Commercial-Institutional Buildings*		
a.	Building codes reach net-zero ready by 2035 *(65% average improvement from 2015 energy code, exact percentage varies by climate zone)*	4 Mt	Gas/Elec.: $100-250 Oil/Elec.: $0-50 Elec.: <$0/t
b.	Building codes reach net-zero ready by 2030	5 Mt (includes B3a)	
c.	Building codes reach net-zero ready by 2025	5 Mt (includes B3b)	
B4	*Existing Commercial-Institutional Buildings*		
a.	Financial Incentives/Information Programs to reduce energy use by 2%	<1 Mt	< $0
b.	Reduce energy use by 3% through measures in Ambition A and energy disclosure regulations	<1 Mt (includes B4a)	< $0
c.	Reduce energy use by 17% through measures in Ambition B, $750M in financial incentives and regulations requiring retrofits	6 Mt (includes B4b)	< $0
B5	*Equipment Efficiency*		
a.	Increase minimum standards and labelling (EnerGuide and ENERGY STAR®) for up to 10 categories of space and water heating equipment beyond U.S. levels,, supported by 8 years of market transformation initiatives (e.g. incentives)	6 Mt (includes 4 Mt from announced federal action)	Varies by category **In 2016:** < $0 to $100-250 **By implementation:** <$0***

Policy Description		Estimated Reductions in 2030 (Mt CO_2e)	Estimated Cost per Tonne (tCO_2e) (approximate range)*
b.	Increase minimum standards for additional product categories, such as home appliances, consumer electronics and lighting beyond U.S. levels; and set standards for product categories that are not yet regulated in Canada or the U.S. at the national level, supported by 8 years of market transformation initiatives (e.g. incentives).	1 Mt	Varies by category **In 2016:** < $0 to $100-250 **By implementation:** <$0***
c.	Regulations to phase-out residential space and water heating equipment (such as high efficiency furnaces) that is less efficient than heat pump technology, supported by 8 years of market transformation initiatives (e.g. incentives).	<1 Mt**	**In 2016:** Oil to HP: < $0, Nat Gas to HP: >$250 **By implementation:** <$0***
B6	*Renewable Power and Fuel Switching*		
a.	Incentive or loan programs for 1 million 5 kW solar photovoltaic systems	<1 Mt	> $250
b.	Incentive or loan programs to reduce 5 Mt of GHG emissions by fuel switching space and water heating from oil/natural gas to less GHG intensive alternatives.	5 Mt	Oil to Elec: < $0 Nat Gas to Elec: >$250
B7	*Demand Response Opportunities and Behaviour Change*		
a.	Regulations requiring utilities to offer enhanced billing, to reduce energy use in the residential sector by 2%	1 Mt	<$0
b.	Regulations and incentives to reduce peak electricity demand by 1-2% through time of use rates or by providing utilities control over household thermostat settings	1 Mt	<$0
c.	Financial incentive/rebate to reduce overall energy use of the residential sector by 0.75% - 1% by installing adaptive thermostats in 1 million existing households	<1 Mt	<$0
B8	*Urban Form and Spatial Planning*		
a.	Reduce transportation-related and heating-related GHG emissions in municipalities through smart growth oriented development patterns	N/A	N/A
b.	Reduce overall urban emissions through tree planting, green roofs and permeable surfaces	N/A	N/A

* Costs per tonne for retrofit programs may overstate actual costs as costs are lower for older and inefficient buildings. In some cases costs are negative (<$0/t) even for natural gas-fuelled buildings.

** Note that reductions for B5/Option C are relatively low in 2030 because implementation begins in 2028, but will become much more significant in the longer term, e.g., 2050

*** Cost by implementation date for all measures anticipated to be <$0/t due to long ramp-up period, market transformation initiatives and technological improvements

Electricity Generation and Transmission

	Policy Description	Estimated Reductions in 2030 (Mt CO_2e)	Estimated Cost per Tonne (tCO_2e) (approximate range)*
E1	*Emissions intensity performance standard*		
a.	For all large fossil fuel-fired electricity generating units, set at level of highly efficient combined cycle natural gas *(365 tCO2e/GWh, with compliance flexibilities)*	Compliance credits: $25/ tonne: 9 Mt	$0-$50
		$50/ tonne: 14 Mt	$0-$50
		$75/ tonne: 20 Mt	$50-$100
b.	For all large fossil fuel-fired electricity generating units, set at a level of 300 tCO_2e/GWh in 2020, increasing in stringency to 250 tCO_2e/GWh in 2025 with compliance flexibilities	Compliance credits: $25/ tonne: 11 Mt	$0-$50
		$50/ tonne: 15 Mt	$0-$50
		$75/ tonne: 21 Mt	$50-$100
c.	For all large coal- and for natural gas (NG)-fired units that operate as baseload starting in 2030, set at a level of 250 tCO_2e / GWh for coal-fired units and 375 tCO_2e /GWh for natural gas-fired units. No flexibilities.	15-20 Mt	$50-$100**
E2	*Accelerated phase-out of unabated coal-fired electricity*		
	Phase-out of unabated coal-fired units by 2030	15 Mt	$50-$100**
E3	*Non-Emitting Portfolio Standard*		
a.	The lesser of 90% non-emitting supply in 2030 or a 20 percentage point increase from the 2014 portion of non-emitting supply by 2030.	8 Mt	$50-$100
b.	The lesser of 97% non-emitting supply in 2030 or a 30 percentage point increase from the 2014 portion of non-emitting supply by 2030.	15 Mt	$50-$100
E4	*Financial Support for New NonEmitting Electricity Generating Facilities*		
a.	Construction of 30 TWh of new, non-emitting generation	13 Mt	$50-$100
b.	Construction of 45TWh of new, non-emitting generation	19 Mt	$50-$100
E5	*Targeted Financial Incentives for Non-Emitting Generation in Northern and Remote Communities*		
a.	Support the construction of new non-emitting electricity generating capacity in remote communities in order to generate about 0.3 TWh to displace diesel-fueled electricity (20% reduction in total remote community electricity related emissions)	<1 Mt	$100-$>250
b.	Support the construction of new non-emitting electricity generating capacity in remote communities in order to achieve a 50% reduction in diesel used for heating and electricity in about 140 remote and northern, First Nations and other Indigenous communities	<1 Mt	$100-$>250

	Policy Description	Estimated Reductions in 2030 (Mt CO_2e)	Estimated Cost per Tonne (tCO_2e) (approximate range)*
E6	*Increase interjurisdictional transfers of non-emitting electricity*		
a.	Increase use of existing capacity	Up to 6 Mt	\$0-50 *(site-specific example)*
b.	Increase existing relevant intertie capacities by the greater of 500 MW or 25%	Up to 10 Mt *(incremental to A)*	\$50-\$100 *(site-specific example)*
c.	Add new transmission capacities (up to 500 MW, as appropriate) where none currently exist	<1 Mt	\$50-\$100 *(site-specific example)*

* Note that cost estimates in the electricity sector are based on conservative assumptions, and may decline as renewable energy technologies continue to improve and the challenges to ensure electric reliability in a changing resource mix are identified and addressed.

** Nova Scotia has estimated the costs of options E1c and E2 at $>250/t for their jurisdiction.

Agriculture

Policy Description		Estimated Reductions in 2030 ($Mt\ CO_2e$)	Estimated Cost per Tonne (tCO_2e) (approximate range)
A1	*Reduction of Methane Emissions from Cattle*		
a.	10% adoption of feeding oils/ oilseeds *(6-7% of dry matter intake)*	<1 Mt	$50-$100
b.	30% adoption of feeding oils/ oilseeds *(6-7% of dry matter intake)*	<1 Mt	$50-$100
c.	10% adoption of reduced age at harvest by 60 days	<1 Mt	$0-$50
d.	30% adoption of reduced age at harvest by 60 days	1-2 Mt	$0-$50
A2	*Convert Marginal Land From Annual Crop Land to Permanent Cover*		
a.	Increase percentage of annually cropped marginal land (class 5 and 6) converted to permanent cover crops by 5% between 2017-2021	<1 Mt	$0-$50
b.	Increase percentage of annually cropped marginal land (class 4, 5 and 6) converted to permanent cover crops by 5% between 2017-2021	<1 Mt	$0-$50
A3	*Increase Acres of Nitrogen Fixing Crops, Pulses/Forages in Rotation*		
a.	Increase soybean acres in Canada from 5.3 M acres (est.)in 2016 to 8 M acres in 2030	<1 Mt	$0-$50
b.	Increase pulse acres in Canada from 9.7 M acres (est.) in 2016 to 11.3 M acres in 2030	<1 Mt	$0-$50
c.	Increase perennial legume forage acres in Canada by 3% from 2016 to 2030	<1 Mt	$0-$100
d.	Increase legume cover crops from low levels in 2016 to 10% of land growing crops by 2030	<1 Mt	$50-$100
e.	Increase legume intercrops from non-significant in 2016 to 5% of canola acres in 2030	<1 Mt	$50-$100
A4	*Increase Adoption of Zero Till*		
a	By 20-26% *(jurisdiction-specific)*	<1 – 1 Mt	$0-$50
b	By 10-16 % *(jurisdiction-specific)*	<1 Mt	$0-$50
A5	*Capture and Destroy/ Treat Methane from Manure Storage Systems*		
a.	Biofilter/catalytic oxidation, covering up to 2 % of manure storage systems in Canada by 2030	<1 Mt	>$250
b.	Anaerobic digestion, covering up to 2 % of manure storage systems in Canada by 2030	<1 Mt	>$250
c.	Biofilter/catalytic oxidation, covering up to 5 % of manure storage systems in Canada by 2030	<1 Mt	>$250

Policy Description		Estimated Reductions in 2030 (Mt CO_2e)	Estimated Cost per Tonne (tCO_2e) (approximate range)
d.	Anaerobic digestion, covering up to 5 % of manure storage systems in Canada by 2030	<1 Mt	>$250
A6	*Increase Total Crop Area using Precision Application Methods for Nitrogen Fertilizers*		
a.	Financial incentive of $20/tonne of CO_2e	<1 Mt	$0-$50
b.	Financial incentive of $40/tonne of CO_2e	<1 Mt	$0-$50
c.	Financial incentive of $100/tonne of CO_2e	1 Mt	$50-$100

Forestry

	Policy Description	Estimated Reductions in 2030 (Mt CO_2e)	Estimated Cost per Tonne (tCO_2e) (approximate range)
F1	*Increase Domestic Wood Use in Building Products*		
a.	High-uptake of wood-intensive building designs and proposed building code changes	2 Mt	\$0-\$50
b.	Low-uptake of wood-intensive building designs and proposed building code changes	<1 Mt	\$0-\$50
F2	*New Forest Program**		
a.	One billion tree planting program focused on mitigation in 2030 with a mix of tree species including a large proportion of fast-growing species	4-7 Mt	\$0-\$50
b.	One billion tree planting program that serves a range of goals including long-term mitigation and ecological co-benefits by using traditional slower-growing species	1-2 Mt	\$0-\$50
c.	250 million tree planting focused on mitigation in 2030 with a mix of tree species including a large proportion of fast-growing species	1-2 Mt	\$0-\$50
F3	*Increased Forest Rehabilitation**		
a.	Support rehabilitation of about 4 million hectares of Crown lands affected by natural disturbances where such efforts are not currently required	<1 Mt	\$50-100
b.	Support rehabilitation of about 1.1 million hectares of Crown lands affected by natural disturbance where such efforts are not currently required	<1 Mt	\$50-100
F4	*Change in Forest Management Practices**		
a.	Regionally-appropriate changes to forest management	8-10 Mt	\$0-50

* Mitigation benefits continue to grow after 2030 as a result of initial investments (for example, because trees continue to grow).

Waste

Policy Description		Estimated Reductions in 2030 ($Mt\ CO_2e$)	Estimated Cost per Tonne (tCO_2e) (approximate range)
W1	*Landfill Gas Capture and Utilization*		
a.	Mandate capture: 57% of all LFG is captured and flared or utilized by 2030	2-3 Mt	$0-$50
b.	Incentives for utilization: 57% of all LFG is captured and 33% is utilized by 2030	2-3 Mt	$0-$50
W2	*Reduce Avoidable Food Waste*		
a.	50% by 2030	10 to 15 Mt (life cycle)	<$0
W3	*Diversion of Organics*		
a.	To >20% by 2030	1 to 3 Mt (life cycle)	$0-$50
b.	To >25% by 2030	1 to 4 Mt (life cycle)	$0-$50
W4	*Diversion of Recyclable Materials*		
a.	To 13% by 2030	2 to 4 Mt (life cycle)	$0-$50
b.	To 20% by 2030	2 to 4 Mt (life cycle)	$0-$50
c.	To 35% by 2030	14 to 16 Mt (life cycle)	$0-$50

Government Operations

Policy Description		Estimated Reductions in 2030 ($Mt\ CO_2e$)	Estimated Cost per Tonne (tCO_2e) (approximate range)
G1	*Carbon neutral government*		
a.	"Low carbon" government with targeted GHG reductions	1-2 Mt	$0-$50
b.	Carbon neutral with targeted GHG reductions	4-5 Mt	$0-$50
c.	Carbon neutral with best efforts reductions	4-5 Mt	$0-$50

ANNEX 2: POLICY OPTION PROFILES

Large Industrial Emitters

I1. Use Incentives to Promote Cogeneration

POLICY GOAL: Use cogeneration (combined production of heating/cooling and electrical power) to reduce GHG emissions in the industrial and electricity sectors using the lowest carbon fuel sources available in an economically achievable manner.

POLICY TOOL: Direct incentives and/or enhanced tax incentives for industrial facilities.

Policy Details

- A direct incentive and/or enhanced tax support would be available to industrial facilities to partially offset start-up and capital costs related to the installation of cogeneration units and transmission infrastructure. To be eligible, a proposed project would need to meet criteria demonstrating GHG reductions as compared to the use of grid electricity and facility process steam. These demonstrated reductions could include reductions in the industrial and electricity sectors as compared to a base case.
- Incentives to offset operating costs would be available to promote the use of biomass and lower carbon fuels (as compared to natural gas). Project proponents would be required to demonstrate GHG reductions as compared to the use of natural gas (NG).
- These incentives would be available immediately for a specified 10 year period (2018-2028) to allow for investment planning.

Options		Est. reductions in 2030	Est. cost/tonne
A.	Enhance the use of cogeneration in industrial sectors by 10% nationally (where lower carbon fuels than existing grids are available)	1-2 Mt*	\$0-\$50
B.	Use biomass instead of NG in up to 10 facilities	< 1 Mt	<\$0-\$50

* Note that these estimates depend heavily on assumptions regarding the future composition and structure of the electric grid. The upper end of this estimate includes reductions from the electric grid, assuming a "business as usual" grid composition, i.e., only considering policies currently in place. This means that some of the existing grid would be displaced. Note that reductions are due not only to efficiency gains, but also lower carbon-intensive fuels (i.e., moving from coal to natural gas and biomass).

Note: options A and B are separate policies; GHG reductions from one would be incremental to the other.

ECONOMIC AND CONSUMER IMPACTS

- Saving on operating costs related to electricity purchase could be achieved if the cogeneration project replaces a less efficient system and fuel savings are also achieved.

CONSIDERATIONS

Stakeholder perspectives: The development of government incentives to promote cogeneration using biomass and biomass-driven fuels, from waste streams, would provide a predictable environment for investments and deliver GHG reductions.

Co-benefits/negative impacts:

- Supports the electricity sector by providing local generation source that enhances the grid reliability. This is because cogeneration assists the electrical grid by providing distributed power and more stability in system voltage and frequency. These factors provide more resilience to electrical outages for electrical consumers.

- With modern technology, combining the production of heat and power in one process is 40%[59] more fuel-efficient than providing that heat and power separately.
- Depending on the technology and fuel used, reduction of air pollutants, such as NO_x and SO_x through the reduction in combustion overall and of higher hydrocarbon fuels.
- Control of air pollutant on larger heat and power unit is more efficient and cost effective than control of air pollutant of many small separate heat and power units.

Linkages with other working group areas and other proposed policies:
- This policy would benefit from the fuel switching policy (I5) in that NG fueled facilities would see reductions as a result of use of renewable natural gas content required.
- Cogeneration also exists in the electricity sector. This policy should ensure that it does not favor cogeneration in any particular sector. Alignment with policies developed for the utility sector should be considered as utility rates may incent/de-incent cogeneration.
- Carbon pricing could also incent the use of cogeneration if fossil fuel prices increase and facilities are able to achieve cost savings through use of cogeneration.

Regional impacts including northern and remote communities:
- This initiative could be regionally focused to reflect the relative benefit or dis-benefit of cogenerated electricity relative to grid alternatives.
- This policy would apply best to jurisdictions with a carbon-intensive grid. It may be less useful to jurisdictions that wish to further electrify using clean hydro-electricity instead of cogeneration, such as BC or QC.

Implementation, feasibility, technological and enabling infrastructure issues:
- Cogeneration facilities, given the right financial incentives, can be attractive as investments to both the manufacturing and utility companies. This policy does not cover incentives for utility companies, but could be expanded to address this.
- Waste wood biomass, RNG, biogas are examples of renewable fuels that can be used to power cogeneration units furthering the carbon reductions.
- Some sectors like the Forest Products or O&G sectors already operate with significant cogeneration thermal capacity, so the opportunities for growth are limited.
- Barriers to implementation of cogeneration, which is already commercially available include:

  » grid access and transmission tariffs
  » price differential between low-cost electricity and incentive to produce power with cogeneration
  » lack of integrated heating/cooling infrastructure
  » lack of information, skilled personnel and financial incentives
  » purchase agreements
  » administrative burden to get permits
  » competition for capital
  » lack of feed-in tariff arrangements

- The decision to implement cogeneration is also defined by the facility needs. Even without the listed barriers, cogeneration may not always be the right choice for every facility. Additional incentives such as feed-in tariffs or financial incentives (grants, tax preferences, low interest loans) may tip the investment decision towards cogeneration.
- R&D is needed to support the development of codes, standards and guidelines for the biomass fuel supply, to optimize technologies and procedures for the storage, handling and pre-treatment of biomass, and to optimize biomass conversion technologies.

59 www.cogeneurope.eu/what-is-cogeneration_19.html

- There is a need for demonstrations of an integrated feedstock supply with advanced biofuel production for cogeneration by large industry.
- Siting is important for cogeneration as heat is useful only over short distance. Siting is further constrained if solid biomass is desired as fuel as transport of this fuel is expensive.
- Advanced forms of cogeneration such as fuel cells which allow for water recovery or technologies more aligned with carbon capture could be considered. There are a few projects under the Climate Change and Emissions Management Corporation in development.
- This policy should be coordinated with electricity sector policies to ensure overall emission reductions. For example, the requirement that cogeneration demonstrate emission reductions compared to grid-delivered power should incorporate electricity sector policies that will reduce emissions from the grid.

I2. Transitioning to Electrification

POLICY GOAL: Within large industrial facilities, replace fuel with electricity use where technologically practical

POLICY TOOLS:

i. Regulations requiring the use of electrical drive systems for new equipment only or for new and existing equipment.

ii. Rate based incentives for industrial facilities to access grid electricity.

Policy Details

i. Regulations on large industrial facilities requiring that new or new and existing drives be powered by electricity rather than fossil fuels. Equipment such as steam engines, steam turbines, reciprocating engines, and gas turbines that use fossil fuels would be subject to the regulations.
   » Heating and steam making equipment would be excluded
   » Other exemptions would require careful design to avoid developing requirements for regions or facilities where technology is unproven or electricity supply is unavailable or not cost effective to access or has greater emission intensity than direct fossil fuel use.

ii. Electrical rate rebates for industrial users would be available nationally to partially offset costs to industry.

Options		Est. reductions in 2030	Est. cost/tonne
A.	i. Require all new drives be electrical instead of fossil fuel powered. Heating and steam making equipment would be excluded. ii. Achieved through implementation of a rate-based incentive program to offset electrical costs for large industry.	3-7 Mt[1]	\$100->\$250[2]
B.	i. Replace a portion of existing mechanical drives with electric drives. Modelling assumes that 10% of existing fuel use would be displaced. Reductions are scalable with % of fuel displacement. ii. Costs would be partially offset through reduced electricity rates.	11-15 Mt	\$100->\$250[3]

1. The reduction calculations are based on the assumption made by CIEEDAC (Canadian Industrial End-use Energy Data and Analysis Centre) regarding use of natural gas within the Canadian industrial sector (ref: www2.cieedac.sfu.ca/mwg-internal/de5fs23hu73ds/progress?id=NynAvN7JW8UbUzEpOg7F32bJ30UP71fGfW3rw7vTN7g)

2. Costs vary considerably across jurisdictions due to differences in emissions from electricity production. In jurisdictions with higher percentages of non-emitting generation, costs are estimated to be in the range of $100-$150/tonne; in jurisdictions with higher intensity electricity generation emissions, costs could be greater than $250/tonne. Costs per tonne are higher in jurisdictions with higher intensity electricity generation emissions due to lower greenhouse gas reductions. This is because fuel use reductions within the industrial facility are offset by fuel used in the generation of grid electricity.

3. Ibid.

CONSIDERATIONS

- For level of Ambition A - Modelling does not include capital stock turnover, only new facilities, therefore reductions modelled are conservative.
- It is assumed that for new builds 15% of fossil fuel use would be displaced by electrical drive use. The 15% displacement is based on CIEDAAC documentation and expertise that consider consumption of direct drives, using turbines or internal combustion engines, to move, compress or liquefy natural gas and other process liquids and gases.
- Also, 75% of emissions from projected LNG export production in BC, which is approximately one large facility, would be displaced. Without the addition of the LNG facility the reductions would be the lower bound of the estimates – 3MT. Should additional LNG facilities come online reductions could exceed the upper bound of 7MT.
- For level of Ambition B, it is assumed that 10% of fossil fuel used for existing growth would be displaced by electricity.
- Emissions from the grid consistent with the Canada's 2nd Biennial Report were included in the emissions reduction modelling.

ECONOMIC AND CONSUMER IMPACTS

- Stimulate demand for electricity as well as construction of electrical transmission and delivery systems to supply the additional electricity demand
- Additional generation capacity in the utility systems, in the form of hydro and renewables or nuclear, over and above the regular plans, may be required, resulting in higher electricity costs for all ratepayers.

REGIONAL CONSIDERATIONS/IMPACTS

- BC's experience has shown that in the upstream oil and gas industry a rate based incentive of at least 25% is required to enable electrification as a viable approach.
- Except for cases where facilities may generate their own low carbon electricity for use in their facilities, the GHG reductions are dependent on the GHG intensity of the grid, including imports from other jurisdictions (other provinces, US). Sufficient generation of low carbon electricity across all provincial/territorial grids combined with increased grid access to some locations would be required.

For some provinces, this policy option will only realize benefits over the long term as regional electricity generation is decarbonized.

Implementation, feasibility, technological and enabling infrastructure issues:

- 15% of fuel used within large industry supports the operation of mechanical drives and could potentially be replaced with electricity. In some instances electrical drives have a higher efficiency than steam driven drives.
- Utility level transmission and delivery system extensions in the form of upgraded power lines and newer electrical substations to feed the electrified loads in the industry will likely be required. These technologies are readily available. The scope and cost of the build out will be far greater in remote oil and gas fields where the electrical system may not be present
- New electricity projects and transmission lines often have long lead times and high costs.
- Enhanced electrification promotes standard and unified automation and optimization of facilities. This provides an improved platform for energy efficiency programs further improving competitiveness of large industry.
- Some facilities may require additional infrastructure (capital investment) to support new electrical equipment.
- This policy option could be implemented incrementally to the fuel switching policy option (I5). This is because this policy is limited to drive systems and 15% of fuel used within large industry.
- To provide flexibility to the industry allowance may be made for the industry to electrify load equipment at the time of capital turnover (end of life) rather than a specified time.

- Further investigation will be required to determine the degree of electrification possible for each industrial sector and availability of clean or lower carbon electricity from the grid.
- This policy option presently includes electrification of new natural gas-fueled compressors used in natural gas pipelines. While this presents a significant potential greenhouse gas emission reduction, the remoteness and isolated nature of these compressors may constrain their electrification. Where sources of electricity are reasonably close to the compressors, electrification may be an attractive option.
- Existing electrical distribution equipment in the industry may require upgrades to higher power handling capacity in order to meet the feed to large electrical drives

I3. Mandate or Use Incentives to Promote Energy Efficiency

POLICY GOAL: Enhance energy efficiency of large industry beyond a BAU 1% per year improvement

POLICY TOOLS:

A. Accelerate use of recognized energy management systems, such as ISO 50001, Superior Energy Performance and ENERGY STAR for Industry through targeted direct incentives or tax measures
B. Regulations to set emission and energy standards for new only or new and existing facilities through facility specific greenhouse gas emission and energy baselining approaches tied to energy management

Policy details

- Energy management systems would include the setting of facility-specific emission and energy standards either through voluntary or regulatory means. Implementation may require that each facility:
  - » Conduct a review (analyze energy data, identify areas of significant energy use and identify areas for energy performance improvement)
  - » Establish emissions and energy baseline, to set objectives and targets that are measurable and have timelines for achievement
  - » Establish and implement an action plan to achieve the objectives and targets
  - » Monitor and assess energy and GHG performance
  - » Third party verification of assessment

Options		Estimated reductions in 2030	Estimated cost/tonne
A.	Voluntary measures (financial incentives such as grants, tax preferences, low interest loans)	6-9 Mt*	$0
B.	Regulations to set emissions standards for new and/or existing facilities (5-15% improvement)	14-41 Mt	$0-$50

Note: emission reductions are additional to a business-as-usual improvement of 1% per year.

* NRCan estimates and report "Process Integration Incentive Program: Results and Impacts 2004-2013"

ECONOMIC AND CONSUMER IMPACTS

- Energy management systems can generate financial savings. Case studies demonstrate that facilities can save up to 20% in energy costs in the first four years after implementing ISO 50001.
- Energy and fuel savings will reduce operational costs and pay for capital investments over time, leading to increased profits for businesses and/or savings for consumers.
- Implementation costs are expected to rise for individual businesses once the low or no-cost actions are taken. Early actors may face higher costs. There is evidence that overall implementation costs drop as the number of implementations rises.
- Energy efficiency measures could contribute to increased GDP and increased employment due to the need for private sector services to implement energy efficiency projects.
- If facilities need to increase their costs in order to meet the energy efficiency standards, there might be additional costs carried forward to the consumer.

- Flexibility mechanisms may be needed to manage impacts of equipment replacement. This should include consideration for early actors to limit the risk of having requirements to replace new equipment/capital stock. Preferential tax treatment currently exists (Accelerated Capital Cost Allowance) to help offset this, but consideration could be given to providing further relief.

CONSIDERATIONS

Co-Benefits:

- With less energy consumed, it is expected that air pollutant emissions would be reduced.
- Potential for increased energy security
- Potential for competitive advantage locally / internationally

Regional Impacts, including in Northern and remote communities:

- Some jurisdictions already have carbon price policies. The new policy tools would need to be integrated with current regulations to avoid duplication or increased administrative burden.
- The cost to deliver the program would be higher in remote/small communities.
- Additional considerations in northern jurisdictions include the higher energy demands due to climate.

Interaction with other working group areas and other proposed policies:

- A carbon price could incent some efficiency at industrial facilities (e.g. a low carbon price could incent project with low overall cost). This could also be an opportunity to integrate with district heat/power and encourage heat and steam exchange between facilities for an overall energy reduction. Cogeneration and industry parks could facilitate this. Regulation and Energy management results are not cumulative; these are two methods that can lead to reduced energy consumption.
- This policy GHG reduction could overlap with other policies such as fuel switching, electrification, transformative technologies.
- Jurisdictions with a carbon price are already incenting energy efficiency, incrementally, with expected improvements of 5 – 15% over the next 10 years. Improvement may vary by jurisdictions, because of infrastructure needs, no easy access to NG, higher capital cost (remote location), early actors, etc.

Implementation, feasibility, technological and enabling infrastructure issues:

- Recognized energy management systems, such as ISO 50001, Superior Energy Performance and ENERGY STAR for Industry are available:
  - » ENERGY STAR provides a fundamental approach for developing a systematic energy management program based upon industry best practices and benchmarking tools.
  - » ISO 50001 is an internationally-recognized energy management systems standard that provides a rigorous framework for an organization to develop its energy management system and commitment to continuous improvement.
  - » Superior Energy Performance (SEP) builds on the requirements of the ISO 50001 standard by setting energy performance improvement targets and requiring third-party verification of results
- It is expected that energy management systems can drive incremental GHG reduction:
  - » EnMS (1% - 2% energy savings/yr)
  - » ISO 50001 (2% - 4% energy savings/yr)
  - » Superior Energy Performance (4% - 8% energy savings/yr)
- Consider exclusion and/or adjustment in the intensity of reduction accordingly to the potential of reducing emission years after years
- Best Available Technology (BAT) equipment may be more expensive than current equipment
- R&D support should be considered to provide more opportunities of improvement. R&D can help inform codes, standards and regulations.
- Complementary programs could support capacity and knowledge building, international standards development and improved collaboration between federal, provincial, territorial and municipal governments, industry associations, and utilities.

I4. Zero Routine Flaring

POLICY GOAL: Limit on routine flaring from oil and gas facilities, petroleum refineries and chemical plants

POLICY TOOL: Regulation

Policy Details

Implement and build on the federal government's recent endorsement of the World Bank's *Zero Routine Flaring by 2030 Initiative* for oil production facilities, for reductions relative to BAU in 2030 in routine flaring at new and existing oil and gas facilities, petroleum refineries and chemical and fertilizer plants.

- The policy would be enacted through regulations that ban routine flaring, except in prescribed circumstances (e.g., safety or emergency reasons or where the quality or quantity of gas is inconsistent and extraordinary efforts are required to make it marketable and could include an economic test). An exempted facility would be allowed to continue to routinely flare waste gases, subject to other regulations and requirements.
- For new facilities, the regulation would start two years after the policy is approved (to allow for changes in design and the project application process), while for existing facilities it would start five years later (to allow for the design and installation of new equipment).
- A key design consideration would be the definition of an isolated or remote facility; this definition would be tightened in stages.
- At least three provinces include an economic test (based on net present value) when determining whether gas must be conserved at oil production facilities (i.e., costs less than $50,000 in B.C. and Saskatchewan, or $55,000 in Alberta to conserve gas).
- Incentives could also be considered for the development of new technology, the purchase of capital equipment, and the development of infrastructure (e.g., gas-gathering pipelines to collect and transport the gas).
- Regulations limiting flaring would have to be carefully coordinated with policies on venting, such as the methane option in this report (I6) since regulating venting can result in increased flaring and vice versa.

A. Option A would implement zero routine flaring at new and existing oil production facilities.
B. Option B would expand the ban on routine flaring to new and existing natural gas facilities, petroleum refineries and chemical and fertilizer plants.
C. Option C would increase the stringency of these economic tests or reduce the volume threshold above which facilities would be required to conserve their produced gas. This could be done in stages from 2020 to 2030.

Options		Est. reductions in 2030	Est. cost/tonne
A.	Implement Zero Routine Flaring for oil production	<1 Mt	N/A*
B.	Expand Zero Routine Flaring to other sectors	<1 Mt	
C.	Further reduce flaring through more stringent measures	1-2 Mt	

Note: Reductions estimated for levels of ambition A-C are cumulative (i.e., B includes A, and C includes B).

* A study on costs is needed. Cost will depend on which facilities are excluded from the requirements due to their isolation, gas consistency or other factors. Definitions of what is an "isolated facility" and what is "non-routine" flaring will also be important, and could significantly affect final costs. Alberta estimates that costs could range from $100-250 per tonne for policy option (a); $250-500 per tonne for policy option (b), and $500-1000 per tonne for policy option (c). BC estimates that lowering the economic threshold or expanding the definition of routine flaring would likely result in significant cost increases. Newfoundland noted that in a 2010 report, the preliminary costs for its offshore facilities were estimated to be in excess of $300 per tonne.

ECONOMIC AND CONSUMER IMPACTS

- More captured natural gas available for sale in situations where the natural gas can be sold, and for use on-site (displacing other energy use or for use in enhanced oil recovery).
- More royalties for provinces in situations where the captured natural gas can be sold.
- It is likely very costly to totally eliminate routine flaring at isolated facilities, and as a consequence there could be stranded resources if the regulation applies to such facilities and the operator decides not to develop further reserves at the isolated site.

CONSIDERATIONS

Co-benefits/negative impacts:

- Limiting or banning routine flaring would reduce air pollution and hence improve the health of people in nearby communities
- Reducing flaring will reduce emissions of black carbon and other air pollutants.
- Additional network of gathering and transport pipelines could fragment wildlife habitat.

Linkages with other working group areas and other proposed policies:

- There are international efforts to achieve zero routine flaring from oil production operations under the World Bank's **Zero Routine Flaring by 2030 Initiative**. The federal government formally endorsed this initiative in April 2016.
- A price on carbon could help to reduce flaring emissions if applied to these emissions, but if there is a desire to ensure zero routine flaring and to reduce black carbon from flaring, targeted regulations would ensure the desired outcome. Increases in the stringency of the economic tests that are currently being applied would reduce routine flaring.

Regional impacts including northern and remote communities:

- Alberta will apply a carbon price to emissions from flaring starting in 2023, as announced in its climate plan.

Implementation, feasibility, technological and enabling infrastructure issues:

- The policy to further reduce flaring from oil production facilities by 2030 could be enacted by increasing the stringency of the provincial economic tests in stages from 2020 to 2030.
- The GHG reduction benefits from a total elimination of routine flaring would be reversed and possibly result in a GHG increase if operators choose to vent even a small portion of the otherwise flared gas, so policy and regulatory development that integrates flaring and venting is necessary. In order for the policy to have a net GHG reduction, capture and then use, sale or sequestration of the waste gas must be required and neither flaring nor venting can be permitted. Currently, in most cases, where flaring is practiced in Canada, it is the only cost-effective way to mitigate venting and thereby reduce methane emissions. Technology and gas gathering infrastructure can provide alternatives in most cases.
- The application of a flaring regulation in an offshore setting could only be enacted after industry safety regulations are amended, and its application to existing facilities after such amendments could result in stranded assets.
- Landfill sites and biogas facilities also flare gases, and limitations on flaring could be considered.
- Options to reduce flaring without venting include: capturing the gas and using it on-site or transporting it in a gas gathering system (either via pipelines or trucks); cogeneration using the waste gas; using incineration technologies; re-injecting to enhance oil recovery; and geological sequestration. One facility in southwest Saskatchewan has recently used captured gas to create electricity, and more such projects are anticipated.
- R&D and policy and regulatory development that integrate flaring and venting may be needed.
- At refineries and chemical facilities, there is an economic incentive to utilize the heating value of waste gas, and not to engage in routing flaring or non-routine flaring. In addition, there may be opportunities to capture and store waste gas instead of flaring; however, such storage might not be consistent with safety considerations.

- New gas-gathering infrastructure (e.g., pipelines) will be needed to connect the isolated facilities where feasible. Financial support could be considered for regions that have no gas-gathering infrastructure.

I5. Fuel Switching to Lower Carbon Alternatives

POLICY GOAL: *Switch fuels at large industrial facilities to lower carbon alternatives*

POLICY TOOL: Regulation, including trading of credits, and/or financial incentives

Policy Details

Policy option A:
- A regulation on large industrial facilities requiring the use of lower carbon alternatives with emissions equivalent to, or lower than, natural gas. Combustion of heavy fuels (e.g., heavy fuel oil, bunker oil, petroleum coke, bitumen) would not be permitted.
- The requirement would be phased in starting c. 2020 and reach full implementation by 2025.
- Various lower carbon alternative fuels could be used, including biogas, biomass, pyrolysis oil, biodiesel, and renewable diesel.
- Certain industrial uses of heavy oils that cannot readily be replaced (e.g., iron-ore pellet sector) would be exempt for a prolonged but not indefinite period.
- Facilities in regions where lower carbon electricity, natural gas, LNG, biomass-derived or other lower carbon alternatives are not currently available (Newfoundland, northern Quebec, PEI, and the Territories) could be exempt until lower carbon alternatives become available. Exemptions would require careful design to avoid penalizing facilities requiring infrastructure to comply.
- Facilities could be incentivized to use even lower carbon alternatives if switching to such alternatives earns them performance credits or avoids a carbon cost.

Policy options B and C:
- A regulation to require suppliers of natural gas to large industrial facilities to replace 10% of their natural gas with lower carbon alternatives equivalent to, or better than, renewable natural gas (e.g., from landfills, etc.). If fuel quality is less of an issue (e.g., in certain industrial application), biogas could be used instead of renewable natural gas.
- Other renewable fuels (biogas, biomass, pyrolysis oil, biodiesel, renewable diesel), could be permitted as alternatives to renewable natural gas.
- The requirement would be phased in, starting at 5% in 2025 and increasing in stages to reach 10% by 2030.
- The focus of the requirement would be on the suppliers of natural gas to large industrial facilities, not the large industrial facilities themselves (since they would not likely know if the natural gas they obtain has renewable natural gas in it).
- These policies could be expanded to include the replacement of other lower carbon petroleum fuels (such as light fuel oil and diesel fuel) used by industrial facilities with renewable alternatives.

Policy option D
- This option would extend the regulation described above for options B and C beyond the industrial sectors to include all uses of natural gas as part of a broader policy of natural gas replacement.

An additional option would be to provide incentives only; GHG reductions and costs for such an option have not been estimated.

Options		Est. reductions in 2030	Est. cost/tonne
A.	Eliminate heavy oils in combustion equipment where there is access to lower carbon alternatives.	1-6 Mt	0-$50
B.	Replace 5-10%[1] of natural gas used in combustion equipment at large industrial facilities[2] with renewable natural gas, biogas, renewable fuel or renewable energy by 2030.	5-11 Mt	$100-250
C.	Same as option B with the addition of replacement of 5-10% [1] of natural gas used as feedstock (in addition to combustion) at large industrial facilities by biogas or renewable natural gas.	6-12 Mt (includes B)	$100-250
D.	Place a requirement on natural gas producers or suppliers to supply all natural gas to all sectors[3] with 5-10% [1] renewable content.	13-26 Mt (includes C)	$100-250

1. Final percentage would be set after a review of supply of renewable gas, biogas and renewable fuels.

2. Does not include light manufacturing or cogeneration.

3. Includes combustion, feedstock and cogeneration in industry, electricity generation and buildings but excludes transportation.

Note: policy option A is a separate policy approach from options B through D, which describe different levels of ambition of a similar policy approach. The GHG reductions associated with A are independent of reductions associated with B – D.

Also note: options B – D are scalable.

Also note: the above estimates do not include emissions from upstream production of renewable fuels and do not account for any impacts on production of fossil natural gas.

ECONOMIC AND CONSUMER IMPACTS

Policy option A: Low economic impact.

- Analysis would be required to determine the feasibility of eliminating heavy fuels combustion in the back-up systems of facilities. The possibility of adding an exception for these systems could be considered.
- Heavy fuels, particularly petroleum coke, are used in a number of refineries and upgraders. These facilities use the heavy fuels as complements to natural gas within a complex mix of fuels. Heavy oils are also used in the mining, pulp and paper, chemicals and base metals sectors.
- This switch has already taken place extensively in the large industrial sector due to the low cost of natural gas. There are only a few large industrial facilities that continue to use heavy (high-carbon) oils, due to a variety of economic and equipment related reasons (e.g., reluctance to change out older equipment). This policy may encourage further development of lower carbon alternatives and could drive associated employment growth.
- The fuel efficiency of new natural gas combustion equipment is better than older heavy fuels combustion equipment, thus leading to fuel savings for the facility.

Policy options B through D: Moderate to high economic impact, due to the higher cost of fuel.

- Infrastructure to transport the renewable natural gas, biogas or other renewable fuels would be required.
- Employment would be increased in companies making renewable natural gas, and could decrease in companies extracting petroleum-based natural gas if there were no additional export market opportunities.

CONSIDERATIONS

Co-benefits/negative impacts:

- Policy option A: The switch from heavy fuels to lower-carbon alternatives would also significantly reduce secondary pollutants. In the case of a switch to natural gas, reductions of emissions of SO_2, NO_x, PM, VOCs and heavy metals would be significant. However, in cement kilns, a significant increase in NO_x could be expected due to increased temperature.
- Policy options B – D: It is not expected that the replacement of petroleum natural gas with renewable natural gas would result in reduction of air pollutants during combustion, but it would likely reduce emissions of air pollutants from the production of petroleum-based natural gas.
- High percentages of renewable natural gas would increase fuel costs for the industrial customers, impacting competitiveness.

Linkages with other working group areas and other proposed policies:

- Any of these options could be implemented as part of a broader approach to low-carbon fuels, such as the low-carbon fuel standard option proposed for the transportation sector (T2).
- A price on carbon would help drive fuel switching, but may not provide the necessary price signal for all companies to switch fuels or for investment in facilities to make renewable fuels.

Regional impacts including northern and remote communities:

- Some possible increase in rural employment for increasing production of biofuels, although such production is unlikely in the Arctic.

Implementation, feasibility, technological and enabling infrastructure issues:

- An incentives only option could be considered but has not been modelled. Some fuel switching has been realized through an incentive only approach.

Policy option A:

- The availability of lower carbon alternatives is critical to this policy option. For instance, availability of natural gas is limited or non-existent in Newfoundland, northern Quebec, and the Territories. Liquefied natural gas is an alternative, but is more expensive. However, biomass-derived fuels may be available in these regions in the future. Criteria will have to be developed to assess whether a region has access to natural gas, including considerations around transporting liquefied natural gas.
- Incentives could be considered to encourage growth in the natural gas network and the liquefied natural gas distribution system. Financial support could be considered for regions that have at present no access to natural gas. The availability of lower-carbon electricity in the future resulting from technological advances could broaden the range of lower-carbon fuel switching options.
- The switch from heavy fuels to natural-gas-equivalent alternatives would also significantly reduce emissions of SO_2, NO_x, PM, VOCs and heavy metals in most applications. However, in cement kilns, a significant increase in NOx could be expected due to increased temperature.
- The affected facilities would have to install new combustion equipment, which would take 2 to 4 years.
- In some industries, heavy fuels (coke breeze, petroleum coke etc.) are used for process purposes not for typical fuel combustion purposes; e.g., as a reductant in aluminium smelters, additives for the iron ore pellet sector and for ore separation in mining.
- A verification or detailed survey of which facilities are still using heavy fuels, and in what quantities and for what purposes, should be undertaken before policy A is adopted.

Policy options B – D:

- Renewable natural gas is effectively chemically indistinguishable from petroleum-based natural gas (both are almost entirely methane), so existing combustion equipment can be used. The consumers of the 5%-10% renewable natural gas would not notice any difference.
- A study of the regional supply and infrastructure needed for capturing and producing RNG or equivalent alternatives from biogas, tie-ins to the natural gas network and delivery to industrial facilities should be undertaken before policies B – D are adopted. The study should include the recovery of biogas from point sources that would have to be further equipped to produce RNG, or might be too costly to connect to the natural gas network. These sources could produce renewable electricity and heat.
- A study of the availability of renewable natural gas, biogas and other renewable fuels suitable for industrial combustion should be undertaken before policies B – D are adopted. If the policy is broadened, the availability of renewable electricity and heat should be included. A common evaluation methodology for each type of fuel or energy source should be used (e.g., the GHGenius model).

I6. Methane Reductions

POLICY GOAL: Reduce venting and fugitive emissions of methane from upstream oil and gas facilities

POLICY TOOL: Regulation

Policy Details

- This option is a recently announced federal policy and is already under development, with regulations expected to be published in 2017[60]

Options	Est. reductions in 2030	Est. cost/tonne
40-45% reduction from 2012 by 2025 (announced federal policy)	18-20 Mt below BAU by 2025	$0-$50

Further reductions may be possible post-2025, building on the experience of implementing the announced regulations.

ECONOMIC AND CONSUMER IMPACTS

- There are low-cost options (<$20/t) to reduce methane emissions.
- Provincial royalties could be increased through the sale of captured natural gas.

CONSIDERATIONS

Co-benefits/negative impacts:

- Reductions in emissions of VOCs, H_2S and odours.
- Health benefits from improved air quality.

Linkages with other working group areas and other proposed policies:

- In March 2016, the federal government announced a policy of reducing methane emissions from oil and gas facilities by 40-45% from 2012 levels by 2025. It also announced that it would regulate various equipment and operating practices at both new and existing facilities starting in 2018 with full implementation by 2020. The federal government plans to phase-in requirements: starting with leak detection and repair and well completions in 2018 for new and existing facilities; and then adding other requirements through 2020.

60 This policy is included here since it was not modeled in the reference case used in Canada's 2016 Biennial Report – see Annex 3, "Key Methodological Choices" for more details

- The federal government has led a number of international research, development and demonstration projects under the Climate and Clean Air Coalition and the Global Methane Initiative. Canada has provided financial support ($3 million) to facilitate strategic, inclusive and country-specific capacity building dialogue that will enable accurate, credible and verifiable quantification of emissions reduction opportunities across the upstream, midstream and downstream oil and gas sector.
- Carbon pricing on non-combustion emissions could help to incent reductions of venting and fugitive methane; however, careful consideration would be needed to determine how to accurately account for emissions from sources that are difficult to quantify, including fugitive equipment leaks. Alberta has announced a $30/t carbon price on produced fuels used on site starting 2023.

Regional impacts including northern and remote communities:

- Positive impact on people in rural communities as there would be significantly less exposure to methane, VOCs, H_2S and odours for people living in the producing regions.
- Costs are likely to be higher in B.C. which is dominated by gas production, not oil production, so opportunities for capturing additional gas would be limited.
- The NWT could be affected in regards to a facility in Norman Wells.

Implementation, feasibility, technological and enabling infrastructure issues:

- Federal regulations are expected to be published in 2017
- Gas-gathering infrastructure would be required in some locations in order to capture and use gas off-site. This would likely be subject to the usual federal and provincial permitting processes.
- Depending on the methane reduction technology required, access to grid electricity may be required.
- In the future, there may be some potential to address methane emissions from landfills, wastewater, coal mining, agricultural sources, and transportation (natural gas-powered vehicles).
- There may also be potential to consider deeper emissions reductions post-2025, e.g., by increasing the stringency of leak detection and repair; additional requirements for compressors, venting, flaring, well completions; coverage of other sources. Further action could require strategies to contain costs, targeted exemptions, investments in technological development, and/or major expansions to the gas-gathering infrastructure.

I7. Additional carbon emissions reductions through abatement and sequestration (CCS and other) technology

POLICY GOAL: Limiting carbon emissions through abatement and sequestration (CCS and other) technology

POLICY TOOLS:

- Require or incent large industrial facilities to use sequestration to a sector-specific benchmark or by a mandated work practice.
- Facilities in regions where sequestration is not practical and/or pipelines are not accessible could be exempt for a period of time.
- Implement a credit trading system as part of the policy to allow some facilities to trade their over-compliance with other facilities.
- Offset protocol as part of a larger carbon pricing/trading approach.

Options	Est. reductions in 2030	Est. cost/tonne
Increase sequestration of carbon by 20% in industrial sectors where it is applicable. This could include capture of: a) Formation CO_2 at oil and gas wells b) Combustion emissions c) A portion of process emissions d) Capture in long-lived products e) CO_2 conversion into fuel and chemicals	3 – 5 Mt*	$50 - $100**

* This would consider formation gas sequestration, CO_2 emissions produced during production of hydrogen at upgraders and refineries (including H2 production in oil sands) and chemicals and fertilizer sectors using CCS to mitigate 20% of the emissions in 2013. For Large Industrial Emitters, capturing these process emissions present the lowest cost opportunity.

** CCS costs are deemed to be quite high in general, and their estimates fluctuate widely. One study from Global CCS Institute, which "covers more than 80 percent of the world's CO_2 emissions from energy and industrial sources", offered a cost range of $38 to $107 per tonne of captured CO_2. A more recent cost data from the US congressional budget office indicates that the average capital cost of a CCS-equipped coal plant would average 76% higher than a conventional plant and the levelized cost of energy (LCOE) of a new plant would also be 76% more than for a conventional plant. While some institutes estimate that coal-fired CCS power plants would become commercially viable at $46 per tonne of CO_2, other non-industry views estimate that it would be above $110/tonne.

Example of a technology: Capture CO_2 from hydrogen production processes and send the CO_2 to oil fields for aiding in oil recovery or for long-term sequestration.

ECONOMIC AND CONSUMER IMPACTS

- CCS project equipment needs will stimulate domestic manufacturing and result in global market opportunities for technology companies and engineering firms; CCS construction project needs will stimulate construction industry
- Significant research needed for capture technology to improve efficiency and bring down costs, since at current costs it would represent a significant burden to industry.

CONSIDERATIONS

Linkages with other working group areas and other proposed policies:

- Could be included as an offset protocol as part of a larger carbon pricing/trading approach
- Carbon pricing could drive CO_2 sequestration. However, carbon pricing would need to carefully consider how to account for CO_2 emissions stored, in particular off-site, in order to ensure that the reduction is accurately accounted for and reflected in the cost of carbon paid. Consideration should be given to linking long term monitoring with annual carbon price paid/reduction accounted for.
- Fertilizer industry in particular is amenable to CCS as CO_2 separation is a part of its process. Other opportunities include acid gas capture at natural gas processing facilities, enhanced oil recovery and hydrogen production at petroleum refineries, upgraders, and chemicals facilities as these are more concentrated sources of CO_2 and therefore lower cost for capture. Technologies other than CCS are potentially available for carbon sequestration: capture in long-lived products and CO_2 conversion into chemicals. Reduction impact and cost would need to be assessed.

Implementation, feasibility, technological and enabling infrastructure issues:

- Accesses to geological storage and long term monitoring and reliability for storage are key considerations. Pipeline infrastructure is needed to facilitate storage for facilities in locations without local storage opportunities.
- Substantial R&D is required to bring down cost and move CCS technologies towards commercialization.
- Additional demonstration projects are also required to adapt CCS technologies to other subsectors.
- Announced CO_2 sources for the Alberta Carbon Trunk Line (fertilizer and refinery sectors) are to be connected in early 2017.
- CO_2 capture from hydrogen manufacturing units, with amine, is relatively common and found at Scotford, Agrium, Air Products and some chemical manufacturing facilities.
- If the cost per tonne does not come down with the demonstration projects, then it will be more economic to pay the compliance obligation than invest in new technology.
- Leakage concerns must be addressed.

I8. Limiting carbon emissions through transformative changes in technology throughout the industrial sectors

POLICY GOAL: Bringing forward next known transformative technologies.

POLICY TOOL:

- Regulations that set emission-intensity benchmarks for facilities, or possibly specific processes.
- Direct Incentives and/or tax measures to promote adoption of transformative technologies

<u>Policy Details</u>

- The regulations would include schedules for deferred application should facilities instead implement CCS or technologies which are more ambitious than best available technologies (BAT; note: BAT is implicitly considered in a number of the other policy options for large industrial sector).
- The technological options would be included as schedules to the regulation and updated regularly.
- Exemptions, or other cost containment strategies would require careful design to ensure that the regulation would drive significant reductions in the industrial sectors where possible.

Sectors could include: Oil and Gas; Chemicals; Nitrogen and Potash Fertilizer; Lime and gypsum; Mining; Cement; Iron and Steel; Base Metal Smelting; Food sector; Aluminum

In addition to carbon capture and storage and electrification (which have their own policy options), there are several transformative technologies which could be included in regulatory schedules and/or incentivize uptake directly or through tax measures:

- Aluminum sector:
  - » Non-emitting anodes
- Pulp and paper sector:
  - » Methanization of effluent waste
  - » Biomass steam reforming to replace natural gas to the lime kiln burner
  - » Black liquor gasification
- Chemical sector:
  - » Hydrogen production through electrolysis
  - » Increased use of renewable feedstocks for the production of chemical and fertilizer products
- Cement:
  - » Use of limestone and supplementary cementing materials to replace clinker in cement
- Steel:
  - » Substitute coke and carbon with bio-carbon in integrated mills (all in Ontario):

- Oil and gas:
  - » For oil and gas facilities that could be possible in the next 5-15 years:
    - Down-hole steam generation, warm-water extraction, increased heat integration, in-fill or wedge wells, improved electrical submersible pumps, and advanced reservoir modelling and optimization of reservoir management.
  - » Combined, the above oil and gas technologies have the potential to reduce GHG emissions per barrel of oil extracted by 15-40% (on a well-to-tank basis).
  - » In addition, hybrid solvent-steam technologies could reduce GHG emissions per barrel by up to 25% for specific sites.
- Electrification of heaters or boilers

Options		Est. reductions in 2030	Est. cost/tonne
A.	Limiting carbon emissions by setting regulations or providing direct or tax incentives to limit emissions from industrial sectors to a benchmark and bring forward ambitious technologies earlier than BAU	11-29 Mt[1]	\$100-\$250[2,3]

1. based upon sector benchmarks and adoption of solvent use (6-22 Mt) and improvement of bitumen extraction technologies (1-3 Mt), plus actions in other sectors (~4 Mt).

2. Pathways to a Low Carbon Economy Version 2 of the Global Greenhouse Gas Abatement Cost Curve, McKinsey and Company 2009.

3. Costs are presented in standardized ranges. Costs for this policy are based on estimates in the range of \$100-\$150 per tonne.

ECONOMIC AND CONSUMER IMPACTS

- Competitive advantage locally / internationally, with a reduction of energy need/production cost
- Energy / fuel savings for the facilities
- Stimulate growth in electricity grid and manufacturing of equipment related to the grid.
- Stimulate the development of the bio-carbon supply chain, which can provide jobs in remote areas.
- Selling Canadian expertise /technologies

CONSIDERATIONS

Co-benefits/negative impacts:

- Reduced air pollutants such as SOx, PM, PAH, NOx, HFCs
- Stimulate research by Canadian companies.
- Develop Canadian expertise with these high tech processes.

Linkages with other working group areas and other proposed policies:

- Carbon price could help support the deployment of transformative technologies (for example by reducing the difference in cost between NG and biomass)
- This policy could overlap with energy efficiency and with policies aimed at deploying specific technologies, such as CCS and electrification.

Regional impacts including northern and remote communities:

- Development, manufacturing and implementation of these technologies may not be possible in all jurisdictions.

Implementation, feasibility, technological and enabling infrastructure issues:

- Research, development and demonstrations will be required to accelerate innovation of next generation technologies and reduce costs. Specifics depend on target sectors and their challenges.
- Complementary measures to enhance and support RD&D can support a more rapid development and deployment of transformative technologies and reduce risk to first movers.

• Transportation

T1: Passenger Vehicle Emission Regulations and Incentives

POLICY GOAL: Reduce GHG emissions from passenger vehicles

POLICY TOOLS: Regulations and incentive programs to increase market penetration of advanced GHG-reducing passenger vehicle technologies, including Zero Emission Vehicles (ZEVs)[61], and overall improvements to the fleet, including encouraging accelerated fleet turn-over of older passenger vehicles.

Policy Details

A. Zero Emission Vehicle (ZEV) Consumer Incentives
   - Provide rebate of $7,000 to $12,000[62] on the purchase of a new ZEV, varying based on battery size. Hydrogen fuel cell vehicles would receive the maximum amount.
   - Beginning in 2017 and reducing over time until cost parity with conventional vehicles (projected by 2022)
   - Implement free access to tolls and HOV lanes for ZEVs through the use of green plates
   - $1000 rebate could also be offered for installation of charging infrastructure

B. Scrappage Incentive Program
   - A consumer incentive program intended to accelerate the fleet turn-over of pre-2006 passenger vehicles, targeted at 8%-9% annual turnover.
   - Modest incentives for scrapping older vehicles and replacing with a new gasoline vehicle (e.g. up to $1500 per vehicle based on a carbon calculation of the GHG reduction)
   - More substantial incentives for replacing the scrapped vehicle with a ZEV (e.g. up to $3000; could be tied in with above ZEV Consumer Incentive program).
   - Could be implemented as soon as a program is developed.

C. Funding for Consumer Awareness Programs for ZEVs
   - Program would partner with vehicle manufacturers, ENGOs, and other levels of government to educate and promote ZEVs to Canadians
   - Could begin immediately and leverage existing provincial and not-for-profit ZEV information programs.

D. Light-Duty Vehicle GHG Regulations for 2026-2030 model years
   - Various scenarios for future amendments to the *Passenger Automobile and Light Truck Greenhouse Gas Emission Regulations* (which apply increasingly stringent standards to model years 2017-2025) to establish increasingly stringent fleet-average GHG emission standards for model years 2026 to 2030.
   - The standards could be numerically "fixed" performance-based standards that would apply to all technologies (including ZEV) and a company's entire fleet of passenger automobiles and light trucks

E. Zero Emission Vehicle (ZEV) standard
   - Regulatory or voluntary standard requiring or encouraging manufacturers to supply a certain percentage of ZEVs in their fleet every year, starting in 2022 (see levels of ambition in the table below).
   - Preceded from 2017-2022 by Option A and B, and possibly C
   - A regulatory approach could include compliance flexibility through credit banking and trading – credits could be earned for over-compliance in a given year
   - Voluntary sales targets could be implemented in combination with consumer education and incentive programs

61 ZEVs include full electric vehicles, plug-in hybrids, and hydrogen fuel cell vehicles.

62 This is the current price premium of most ZEVs compared to conventional vehicles.

Options		Est. reductions in 2030	Est. cost/tonne
A.	ZEV consumer incentives	1-3 Mt	$100-$250*
B.	Scrappage program		
C.	Consumer awareness program	-	
D.	Light duty vehicle GHG regulations for model years 2026-2030		
i.	Modest emissions standard of 172 g/mile in 2026 and increasing in stringency to 158 g/mile by 2030	1-2 Mt	$0-$100
ii.	Moderately ambitious emissions standard of 163 g/mile in 2026 and increasing in stringency to 131 g/mile by 2030	4-5 Mt	
iii.	Ambitious emissions standard of 158 gCO_2/mile in 2026 and increasing in stringency to 105 g/mile by 2030	6-7 Mt	
E.	*ZEV Standard*		
i.	Beginning with 2% of the fleet in 2022 to 30% of the fleet by 2030	2-4 Mt	$0-$100
ii.	Beginning with 10.5% of the fleet in 2022 to 50% of the fleet by 2030**	6-9 Mt	

Note: emission reduction estimates are not cumulative. Also, options D and E are alternatives, i.e. they would not both be implemented since they target the same emissions. Consequently, the GHG reductions cannot be added together; this is reflected in the summary table on page 56. Options A, B and C are additional to D and E.

* Costs are presented in standardized ranges. Costs for this policy are based on estimates in the range of $150-$250 per tonne.

** Percentages are examples based on existing legislation in California and analysis in Quebec.

ECONOMIC AND CONSUMER IMPACTS:

- ZEV owners would benefit from significant fuel savings. According to Electric Mobility Canada, plug-in EVs are 4-6 times cheaper to operate than conventional vehicles
- While current ZEVs carry a purchase cost-premium of $7k to $12k compared to conventional vehicles, this is expected to lower over time. By 2022, it is projected that production costs will be cost-competitive with conventional vehicles. The above policy options are outlined to help bridge the gap for consumers until ZEVs become cost competitive.
- A regulatory ZEV standard or voluntary sales targets could spur automaker investment in ZEV technology and industrial development in Canada.
- Mandatory ZEV sales requirements could result in competitiveness impacts, particularly in Ontario, and could result in carbon leakage (i.e., shifts in production to jurisdictions with less stringent requirements). A voluntary standard may provide less certainty with respect to emissions reductions, but could help to manage competitiveness impacts.

CONSIDERATIONS

Stakeholder perspectives:

- Vehicle manufacturers are against a ZEV standard, citing unachievable and costly targets; adoption of this type of approach may lead to manufacturers choosing to invest outside Canada.

Linkages to other policy options

- Modifications to building codes can also support vehicle charging infrastructure (see B1, B3)

Co-benefits/negative impacts:
- Increased reliance on clean electricity to realize full GHG reduction potential of increased deployment of electric vehicles.
- Air pollutant co-benefits including improved health outcomes

Regional impacts including northern and remote communities:
- Some provinces currently have a ZEV consumer incentive program (QC, Ontario and BC).
- The automotive sector is an important manufacturing industry in Ontario; the economic and competitiveness impacts of policies affecting vehicle manufacturers would need to be carefully considered

Implementation, feasibility, technological and enabling infrastructure issues:
- Moving ahead of the U.S on vehicle emission regulations could be challenging as it would bring Canada and the U.S. out of regulatory alignment for a sector that is fully integrated – the passenger car and light truck manufacturing sector. Experience in other jurisdictions with ZEV standards suggests that models would be brought to Canada first so manufacturers can fulfill their obligations.
- In the absence of demand side measures (e.g., consumer incentives), supply side measures (e.g., ZEV standard) alone would be insufficient to make significant progress.
- Incentives, building codes and standards, and government investments around charging infrastructure must complement this policy option (specifically level 3 fast charging). Some provinces are already heavily investing in public fast-charging infrastructure and offering incentives for home and work charging infrastructure.
- As more electric vehicles take up market share and charging demands increase at home, issues could arise with local electrical transformers.
- Demonstrations of novel charging technologies to lower costs, improve performance and ease grid integration, as well as R&D on specific components, can help address the difficulties of integrating charging technologies into distribution grids or new end-use applications. Likewise, demonstrations of hydrogen fuel cell vehicle applications and funding for fuelling infrastructure can help increase automaker fuel cell vehicle supply to Canada and create opportunities for Canadian companies active in this sector.
- R&D related to lightweighting vehicles can reduce energy consumption and increase vehicle range.
- More stringent GHG emission standards for 2026-2030 model years could have an impact on the ability of consumers to purchase vehicles with larger power requirements, such as pick-up trucks.
- If a high gas guzzler tax was added to the cost of less efficient vehicles (e.g, pickup trucks), then the added revenue generated could be used to offset the costs of the ZEV rebate.

T2: Increased availability and use of low-carbon fuel for on-road and off-road vehicles

POLICY GOAL: To reduce the carbon intensity of transportation fuels used in Canada and support fuel switching to lower carbon fuels for cars, trucks, mining and construction equipment, commuter rail and public transit,[63] while stimulating the domestic production of low carbon fuels.

POLICY TOOLS: Regulations, including a Low-Carbon Fuel Standard and increased renewable fuel requirements; and financial measures, including direct funding and incentives for enabling infrastructure for fuel switching

63 Annex T10 addresses low carbon fuels for the marine, rail and aviation sectors.

Regulatory measures:

A. Renewable fuels

- Increase renewable content requirement up to 10% for gasoline and up to 5% for diesel, beginning in 2020, including requiring renewable fuels to have lower carbon intensity than gasoline and diesel.

B. Low Carbon Fuel Standard (LCFS)

- Would apply to all producers or importers of transportation fuels (gasoline, diesel, natural gas, propane, electricity, hydrogen, etc.), requiring a 1% reduction in fuel lifecycle carbon intensity each year, beginning in 2020.
- Modeled off B.C.'s existing LCFS, including compliance flexibility through credit trading
- For example, transit authorities could earn compliance credits through the use of low carbon fuels, and engage in credit trading to offset low carbon fuel costs.
- Fuelling infrastructure investments could be eligible for credits
- Could be expanded beyond the transportation sector – see industrial fuel switching option I5

C. Truck engine compatibility with low-carbon fuels

- Regulations requiring all new medium- and heavy-duty truck engines sold or imported into a jurisdiction to be compatible with a fuel other than gasoline containing less than 10% ethanol or diesel containing less than 5% biodiesel by 2030[64].

Complementary measures:

D. Truck engine rebate

- New medium- and heavy-duty truck engine rebate offered to purchasers of new truck engines between 2020 and 2025
- Three rebate levels would be offered based on the lifecycle carbon intensity of the typical fuel mix of the new engine relative to 100% fossil-based gasoline or diesel:
  - » 10% rebate for 10% reduction
  - » 30% rebate for 30% reduction
  - » 50% rebate for 50% reduction

E. Transit vehicle compatibility with low-carbon fuels

- Funding for transit authorities purchasing public transit vehicles (including commuter rail) with engines compatible with a fuel other than fossil-based gasoline or diesel
- Based on same lifecycle carbon intensity scheme as truck engine rebate above:
  - » 10% rebate for 10% reduction
  - » 30% rebate for 30% reduction
  - » 50% rebate for 50% reduction

F. Transit electrification

- Funding for infrastructure, including trolleys, street cars and commuter rail.
  - » Funding for feasibility studies.
  - » Infrastructure costs vary.
  - » Feasibility studies could be initiated immediately

64 This could be achieved through a number of existing technologies: alternative fuel engines (electric, propane, natural gas, or hydrogen); hybrid gasoline-electric or diesel-electric engines; flex-fuel gasoline engines (ethanol blends up to E85); use of renewable diesel - HDRD or biodiesel (FAME) in diesel engines; and bi-fuel or dual-fuel engines (gasoline or diesel and an alternative fuel such as propane, natural gas or hydrogen). Measures ensuring proper alternative fuel use would also need to be developed.

G. Fuelling infrastructure

- Funding for transit and retail fuelling infrastructure for fuels other than fossil-based gasoline or diesel.
  - » A blender fuel pump with tank is estimated to cost about $200,000.
  - » A five-year assistance program with declining incentive level, e.g., starting at 75% and declining to 25%.
  - » Infrastructure investments could begin immediately
- Credits for fuelling infrastructure could be awarded through the LCFS credit system

H. Incentives for domestic low carbon fuel production

- Tiered based on lifecycle carbon intensity reductions relative to fossil-based gasoline or diesel, and augmented if the fuel makes use of domestic feedstocks:
  - » 2 to 5 cents/liter for 30% reduction
  - » 5 to 10 cents/liter for 60% reduction
  - » 10 to 20 cents/liter for 90% reduction
- Incentives could begin immediately

Options		Est. reductions in 2030	Est. cost/tonne*
A.	Increase renewable fuel requirements	10 to 20 Mt	$0-$50
B.	Low Carbon Fuel Standard		
C-H	Additional complementary measures to enable A, B	N/A (supportive)	Not directly tied to emission reductions but could raise overall cost somewhat

* Based on preliminary industry estimates and experience, these costs assume a scenario where complementary measures to enable options A and B are adopted to some extent.

ECONOMIC AND CONSUMER IMPACTS

- Options A-G will reduce demand for fossil fuels currently used and increase demand for low carbon fuels. These polices do not differentiate between domestic and foreign sources.
- In the near term, imports of renewable fuels would likely increase but regulatory design and complementary measures could help boost domestic production in the longer term. Option H is included to promote the production and use of domestic low carbon fuels.
- In other jurisdictions that have implemented similar measures, impacts on prices affecting consumers have been shown to be minimal. The efficiency of combustion, the blend levels of low carbon fuels, and the price and energy content of low carbon fuels, may result in some incremental costs for finished gasoline and diesel fuel blends at the pump.
- Demand-push policies targeting low carbon fuels and fuel alternatives that help increase the availability and reduce the cost of these alternatives to consumers could also help to reduce compliance costs for industry.
- The transformation of fuel retail infrastructure and truck engine requirements will favour fuel retailers, truck manufacturers and truck operators who adapt, and disfavour those who do not.
- The use of electricity and alternative fuels in transit could support clean jobs, innovation and clean-tech development.

CONSIDERATIONS

Co-benefits:

- Increased demand for domestic feedstocks would benefit the forestry and agricultural sectors, and increased demand for tallow and yellow grease would support commercial recycling initiatives.
- Moderate to significant air pollution reductions (e.g., electric vehicles using renewable electricity).

Linkages with other working group areas and other proposed policies:

- A separate annex (T10) addresses the use of low carbon fuels in the marine, rail (except commuter rail) and aviation sectors. The electricity subgroup is considering options for reducing reliance on diesel generators in remote communities. Also note that provinces have different renewable content requirements for gasoline and diesel, in addition to the federal requirement.
- Low carbon transit investments will not be effective without Transportation Demand Management (TDM) measures (see policy option T8) to incent the use of public transit, and reduce incentives for driving (e.g. parking supply and cost, road cost, congestion charging).

Regional impacts including northern and remote communities:

- Domestic fossil crude oil production is currently focused primarily in Alberta, Saskatchewan, and Newfoundland, with refineries located in most provinces. Domestic renewable fuel production is currently occurring in each province west of the Maritimes.
- The proposed incentives will result in new opportunities for low carbon fuel production across Canada. For example, medium- and large-scale renewable diesel (such as HDRD) production can be located in regions with access to a sufficient supply of biomass feedstocks, including oil seeds, animal fats, waste cooking oil, organic content of municipal solid waste, forestry and agricultural residues.

Implementation, feasibility, technological and enabling infrastructure issues:

- Customer protection measures similar to the U.S. Magnuson-Moss Warranty Act may be required to ensure that vehicle manufacturers honour their warranty obligations with respect to fuel use.
- The fuel industry will need to update its fuel tracking systems to include carbon intensity information, and train staff to respond to new regulatory requirements.
- Truck engine requirements will need to be co-ordinated with U.S. partners.
- Fuel “shuffling” can occur between provinces when fuel suppliers redirect lower carbon intensity fuels to jurisdictions with LCFS policies, and redirect higher carbon intensity fuels to other jurisdictions, with no change in overall GHG emissions associated with these fuels. A federal or national LCFS would minimize this effect.
- Transit electrification requires specific investments in overhead electrical connectivity (pantographs and catenary wire).
- It is assumed that the price and capability/performance of natural gas, hydrogen fuel cell and electric vehicles will continue to improve so that by 2022 there could be no price differential with conventional internal combustion engine vehicles.
- Important infrastructure requirements are needed for some alternative fuel pathways (e.g. hydrogen infrastructure for fuel cell vehicles).
- Research and development may be required to support codes and standards, improve process reliability, reduce costs, promote consumer confidence and increase the availability of fuels.
- These options will require complementary science-based communication and education on fuel options and their impact on GHG emissions.
- Continued investment and support from the Government of Canada for science-based fuel lifecycle assessment tools, including GHGenius, is another important complementary measure.

T3: Energy Efficiency in the aviation, rail, marine and off-road industrial sectors

POLICY GOAL: Reducing emissions in the aviation, rail, marine, and off-road (agriculture, construction, mining) sectors through efficiency improvements to the overall system (e.g. reduced network congestion) and specific operations (e.g. reduced weight and idling)

POLICY TOOLS: Regulations; voluntary agreements; financial incentives, education and awareness, market-based measures

Policy Details

Aviation

A. Require operators to offset their domestic aviation emissions starting as early as 2021:
   - » Obligation could be met by reducing emissions through operational or technological improvements or compensating for emissions by purchasing certified offsets
   - » Different levels of stringency (see table below)
   - » Approach would be designed to align with the international market-based measure approach under development through the International Civil Aviation Organization (ICAO)
   - » Would drive efficiency measures such as shutdown of auxiliary power units, (10 minutes less APU usage)single engine taxi(10 minutes single engine tax – 80kg saved on A330 flight of 2500nm)ing, and improved air traffic management
   - » Timing would depend on the progress of the ICAO market-based measure development, likely in 2021

Off road

B. Regulations to require anti-idling technologies:
   - » Requirement for owners/operators of specified vehicles to install technologies that automatically shut down the engines of off-road agriculture, construction and mining equipment during the idle portions of their duty cycle. These devices may restart the engines when required
   - » Shorter-term complementary measures could include incentives to install anti-idling technology and promoting awareness and training operators to reduce idling
   - » Incentive, awareness and training programs could be initiated immediately to achieve emission reductions and inform the development of regulations

Cross-sectoral measures

C. Introduce benchmarking and reporting requirements for operational energy efficiency:
   - » Introduce requirement for all operators in each sector to report annually on their operational efficiency (where requirement does not currently exist)
   - » Establish benchmarking and reporting mechanisms for transportation hubs to improve year-over-year operational efficiency in-line or above benchmarks for each sector
   - » Voluntary benchmarking and reporting could be implemented immediately. Timing for a regulatory option would depend on the development process and design of the regulation

D. Regulations requiring annual operational efficiency improvements in all sectors:
   - » Sector-specific targets for annual operational efficiency improvements
   - » Complementary measures could include requiring energy management plans for specific sectors/ operators, e.g. rail (would include locomotive and network operations)
   - » This measure would complement fleet average energy efficiency improvements achieved through retrofits of existing in-use aviation, marine, rail and off-road vehicles described in policy option T5.
   - » Timing would depend on the regulatory development process and design of the regulation

E. Introduce funding/incentive programs for the deployment of lower GHG emitting vehicles and engines at transportation hubs (e.g. airport ground support equipment, cargo-handling equipment, shore power technology, Genset switchers, etc.).
   - » Could improve operational energy efficiency by 5% year-over-year for those hubs
   - » Could be implemented immediately following development of a funding/incentive program.

Options		Est. reductions in 2030	Est. cost / tonne
A.	*Aviation offsets:*		
i.	30% of domestic aviation emissions	2-3 Mt	$0-50*
ii.	70% of domestic aviation emissions	6 Mt	$0-50*
iii.	100% of domestic aviation emissions	8 Mt	$0-50*
B-E	*Regulations, programs and incentives above (B-E) for the following sectors:*		
	Off road	1-7 Mt	$0-$100
	Marine and rail	0-2 Mt	$0-$250

Note: emission reduction estimates for Ai., ii. And iii. are cumulative. Remaining estimates are not cumulative

*Estimated market cost of carbon offsets (may rise if demand increases).

ECONOMIC AND CONSUMER IMPACTS

- High upfront costs associated with certain solutions (e.g. technological changes, training, certification) could result in longer payback periods
- Over time, operational efficiency could lead to reduced costs and/or time savings for passengers and shippers, as well as improved competitiveness
- If there is a national carbon price, the rail and marine sectors would not have independent offset programs. Emissions from these modes would be priced in accordance with a national carbon price in order to ensure emission cost competitiveness with light and heavy duty vehicles.
- Requirements to offset aviation emissions would have an impact on the cost of domestic air travel and would likely need to be limited to medium and larger companies to avoid burden on very small operators.
- If there were an offset requirement for aviation, consideration would need to be given to reducing or eliminating other economic instruments applied to aviation emissions (e.g. carbon or fuel taxes).
- If the eligible offsets were restricted to Canada it could help drive reductions in other sectors of the economy, however as domestic offsets are likely to be comparatively expensive such a restriction could further increase the cost of aviation and reduce demand.

CONSIDERATIONS

Indigenous perspectives:

- Companies owned and operated by Indigenous groups (logging companies that have off road equipment, shortline and regional railways) may be impacted by this policy.

Co-benefits / negative impacts:

- Air pollutant and black carbon reductions could be anticipated, which is particularly important around hubs, ports and urban populations, thereby improving public health.
- Some operational efficiency measures could have negative impacts, such as increased noise.

Linkages with other working group areas and other proposed policies:

- The policies presented here should not duplicate carbon or fuel taxation policies. For example, including the aviation sector in pricing systems as well as an offset requirement could cause the economic burden on aviation to be unbalanced relative to other modes and sectors.
- There is also a link to measures that aim to improve fleet efficiency, utilize ground infrastructure to reduce emissions (e.g. shore power), improve logistics, and exploit the increased efficiency potential of intelligent transportation systems.
- Rail, marine and off-road emissions would be priced in accordance with a national carbon price.

Regional impacts, including northern and remote communities:

- Increased costs associated with new/existing off-road equipment, locomotives, airplanes and marine vessels, could be passed on by transportation operators and may be disproportionately felt in northern and remote communities, although this could be limited/off-set by lower operating costs and competitive interests.

Implementation, feasibility, technological and enabling infrastructure issues:

- Proposed measures should be compatible with international (air, marine) and/or North American approaches (marine, rail)
- If offsets are implemented for aviation, there may be a need to develop a strategy to accommodate smaller carriers and operators that may be sensitive to additional economic strain.
- Some improvements may be slower to implement (e.g. airspace and rail infrastructure changes require extensive consultations)
- High capital costs associated with technological improvements could hinder pace of implementation (e.g. rail network planning systems are known to be expensive)
- Behavioural changes within industry can take time to become mainstream
- Safety considerations, existing regulations, and infrastructure capacity could act as a barrier to implementation
- Achieving efficiencies often entails close collaboration among operators (e.g. airlines), infrastructure authorities (e.g. airport operators), and network managers (e.g. air navigation services providers)

T4: Heavy Duty Vehicle and Engine Emission Regulations and Incentives

POLICY GOAL: Reduce greenhouse gas emissions from new and in-use heavy-duty vehicles and engines (HDVs) through greater market penetration of advanced GHG-reducing technologies, and overall improvements to the fleet, including encouraging accelerated fleet turn-over of older HDVs.

POLICY TOOLS: Regulations and Incentives

Policy Details

A. Continue with on-going work to introduce more stringent HDV GHG regulations for new vehicles post-2018
   » Develop a second phase of the *Heavy-Duty Vehicle and Engine Greenhouse Gas Emission Regulations* to further reduce GHG emissions from new on-road heavy-duty vehicles and engines for 2021 and later model years.
   » Would introduce emissions standards for trailers pulled by on-road tractors, setting new GHG emission standards for 2018 and later model years.

B. Provide incentives for the retrofit of GHG reducing technologies on in-use HDVs
   » Direct rebates to owners/operators covering a percentage of the cost of retrofits (varying by technology)
   » Incentives could begin to be delivered as soon as a program is developed

C. Regulate GHG technologies for in-use heavy-duty vehicles.
   » Require operators to install a combination of technologies, including low-rolling resistant tires, aerodynamic add-ons, auxiliary power units to reduce idling
   » Timing would depend on the regulatory development process and design of the regulation

D. Scrappage program for older in-use HDVs
   » Would provide $25k-$35k rebate toward the purchase of a newer, cleaner HDV, based on a calculation of the GHG emissions reduced by the replacement
   » Target 5%-15% increase in annual fleet turnover
   » Could be initiated as soon as a program is developed

» Revise provincial weight and dimension regulations to eliminate barriers to the deployment of GHG-reducing advanced technology vehicles.
» Expand the use of turnpike double long combination vehicles in order to double the volume of goods moved
» Allow for heavier weight limits where appropriate
» Timing would depend on the regulatory development process

E. Regulate or provide incentives for truck stop electrification
» Requirement that major truck stops across Canada install infrastructure to provide electrical connections for trucks in order to reduce idling during rest periods
» Regulation could be supported/replaced by incentives
» Incentives could be implemented immediately following the development of a program.
» A regulatory strategy would need to allow sufficient lead time for truck stops to install the required infrastructure.

F. Funding for electrified truck highways
» Demonstration or pilot projects would be eligible for funding
» Pilot projects could be initiated immediately following the development of a program

Options		Est. reductions in 2030	Est. cost/tonne
A.	Post-2018 HDV GHG regulations	3-6 Mt	< $0-$50
B.	Incentives for retrofits on in-use HDVs	1-3 Mt	$100->$250*
C.	Regulations requiring GHG-reducing technologies for in-use HDVs		$50-$100
D.	Scrappage of older HDVs		>$250
E.	Revise weight and dimension regulations	2-3 Mt	<$0
F.	Require truck stop electrification		$0-100
G.	Funding for electrified truck highway pilot projects	<1 Mt	>$250

Note: emission reduction estimates are not cumulative

* Costs are presented in standardized ranges. However, costs for this option are likely in the range of $150-$250+.

ECONOMIC AND CONSUMER IMPACTS:

- Many of the options outlined above are currently available in the U.S. If implemented this would help to support overall competiveness of the Canadian market, as well as being supported by industry.
- There are some differences between Canadian and U.S vehicles, in regards to weight and dimensions (some jurisdictions have different restrictions on length and weight of trucks), which may impact the implementation of some technologies. Significant fuels savings are possible by encouraging the uptake of *'off-the-shelf'* aerodynamic technologies -- up to 8,600 litres annually per truck (resulting in GHG savings of up to 22,700 kg CO_2 annually per truck). Additionally, improved fuel efficiency associated with the adoption of these technologies can yield cost savings of up to $7,200 annually per truck.
- Cost savings to industry could, in some cases, be passed on to consumers of freight products.
- Past examples have shown that companies often expand their investment once they have gained experience and clear economic benefits from them, thus creating a multiplier effect on technology uptake and promoting technology and innovation within the transportation industry.
- Potential manufacturing possibilities within Canada for some of the technologies.

CONSIDERATIONS:

Stakeholder perspectives:

- Industry associations such as the Canadian Trucking Alliance have been advocating for HDV aerodynamic incentive programs to assist Canada's trucking industry for many years*.*

Co-benefits/negative impacts:

- Criteria air pollutant emission reductions, with associated health benefits.
- With carefully controlled operating conditions and routes specified by special permits, long combination vehicles have been shown to be safer than individual tractor semi-trailers. However, in some cases such as mountainous areas and severe weather conditions, these vehicles can pose safety concerns.

Reduction of congestion on highways.

Linkages with other working group areas and other proposed policies:

- Carbon pricing would increase the cost of fuel, thus improving the business case for truck retrofits with fuel saving technologies (e.g., aerodynamic devices).
- Work on national harmonization on some of the above measures is currently being looked at under the Council of Deputy Ministers Responsible for Transportation and Highway Safety's Task Force on Weights and Dimensions.

Regional impacts including northern and remote communities:

- Regional harmonization of technologies such as long-combination vehicles and weights and dimensions can help facilitate inter-provincial and cross-border trade. However there are limitations to implementing such standards nationally due to varying geography and highway infrastructure capacities in provinces and territories. Such technologies can have adverse impacts on road infrastructure.

Implementation, feasibility, technological and enabling infrastructure issues:

- The Government of Canada is currently consulting on a second phase of the *Heavy-Duty Vehicle and Engine Greenhouse Gas Emission Regulations,* to further reduce GHG emissions from new on-road heavy-duty vehicles and engines of the 2021 and later model years, and trailers of 2018 and later model years. (option A)
- Aerodynamic technologies are readily available and proven. Any technology that would be incented or regulated would need to be vetted by a certification authority (e.g. U.S EPA's Verified Technologies for SmartWay and Clean Diesel Campaign).
- There have been previous national and provincial programs offering HDV retrofit incentives, as well as scrappage incentives.
- Road infrastructure is critical in harmonizing trucking standards for LCVs/weights and dimensions (e.g. lane width, capacity of highway infrastructure, pavement strength, bridge capacity, etc.), such technologies can have adverse impacts on road infrastructure.
- Some of the measures outlined above are complimentary (e.g. if trucks are equipped with APUs to address vehicle idling, there may not be significant further reduction in emissions through the use of truck stop electrification).
- The proposed options could complement Natural Resources Canada's SmartWay Transport Partnership Program, which encourages owners and operators to improve fuel efficiency through the adoption of low carbon technologies and practices, and by measuring the performance improvements.

- R&D related to lightweighting vehicles can reduce energy consumption and allow for increased cargo weights.
- Due to the high cost of installation and maintenance of infrastructure for electrified truck highways this currently presents a significant implementation issue, and may only be feasible in small focused deployments (e.g. regular movements between port and distribution centre on dedicated truck lanes). Fuel cell technologies (allowing for wireless electric propulsion) may be a better alternative for wide-scale deployment over the long term. Such a policy option may be considered for emissions reductions from the transportation sector over the longer-term (to 2050).
- Any type of scrappage program should need to ensure proof that the vehicle is taken out of service and that emissions don't get displaced elsewhere.

T5: Vehicle and Engine Fuel Efficiency in the Aviation, Marine, Rail and Off-road Sectors

POLICY GOAL: Reduce greenhouse gas emissions from new and in-use airplanes, marine vessels, locomotives and off-road equipment through greater adoption of fuel saving devices and overall improvements to the fleet, including promoting accelerated fleet turn-over of older equipment.

POLICY TOOLS: Regulations, operating requirements, voluntary agreements, financial incentives (grants, tax preferences, low interest loans)

Policy Details

A. Regulations to establish GHG performance and fuel efficiency standards (up to 15% overall reduction in emissions performance of new engines and equipment in 2030 relative to established baselines) for new locomotives, off-road (i.e., construction, agriculture, mining, and forestry) engines and equipment, and domestic marine vessels
   - For domestic marine, 15% energy efficiency improvements for new vessels in 2030 compared to vessels in the 2005-2015 baseline.
   - For off-road, 10% GHG emissions improvements for new engines by 2030 compared to 2017 model year engines.
   - For domestic rail, 10-15% GHG emission reductions for new locomotives in 2030 compared to 2016 model year locomotives.

B. Continue to work with domestic aviation industry commitments under the Aviation Action Plan with potential to update commitments and accelerate where feasible the adoption in Canada of highly efficient airplanes.
   - International aviation CO_2 standards for new commercial and business airplanes are expected to be adopted internationally in 2016, and could inform new commitments.
   - The Action Plan could be updated upon agreement to do so with the membership.

C. Introduce funding/incentive programs for fuel saving retrofits or technologies for in-use equipment across all modes with benefits expected as follows:
   - For aviation, given the relatively modern fleet in operation, the overall fleet wide fuel reduction from retrofits in 2030 is estimated to be minimal, in the range of up to 0.04% annually between 2016 and 2030 (~0.5% by 2030).
   - For domestic rail, a fleet average improvement of up to 0.75-1.75% annually for locomotives between 2016-2030.
   - For domestic marine, fleet average improvement of up to 1% annually between 2020 and 2030.
   - A variety of technological retrofits that can reduce GHG emission reductions could be eligible for financial incentives (grants, tax preferences, low interest loans) to support owners and operators with improving in-use fleet performance.
   - Funding/incentive programs could be initiated immediately

» Introduce mandatory energy efficiency standards or retrofit requirements targeting equipment of a certain age/efficiency with the objective of driving upgrades and accelerating the phase-out of the oldest, highest emitting equipment. Equipment with retrofits already installed could be exempt.

» 30% energy efficiency improvements for new domestic marine vessels in 2030 compared to vessels in the 2005-2015 baseline.
» For domestic marine, mandatory energy efficiency standards for existing domestic vessels are implemented, in which the existing fleet is required to achieve 10-30% efficiency improvement by 2030.
» For domestic rail, fleet average annual energy efficiency improvements of 1.75-2.25% for locomotives between 2016-2030.
» For off-road, up to 20% GHG emissions improvements for new engines by 2030 compared to 2017 model year engines.

Options		Est. reductions in 2030	Est. cost/tonne
A.	Regulations for new vehicles/equipment	1-3 MT	\$0-\$250
B.	Voluntary aviation commitment		N/A
C.	Funding/incentives for retrofits	1-2 MT	\$0-\$250
D.	Regulations for in-use vehicles/equipment	2-3 MT	\$0-\$>250

Note: emission reduction estimates are not cumulative. Options C and D are alternatives, i.e. they target the same emissions and so GHG reduction estimates cannot be added; this is reflected in the table on page 57.

ECONOMIC AND CONSUMER IMPACTS

- Fuel accounts for a large share of operators' operating costs (e.g., 18% for rail[65]) and fuel savings will increase competiveness of companies.
- Significant capital investments will be required, with payback periods varying and affecting adoption rates. Consumers may face increased costs from companies passing through their capital investment costs.
- The domestic industry that supplies vehicles or engines and technologies to these transportation sectors may benefit from increased uptake of their products to meet energy efficiency standards.

CONSIDERATIONS

Indigenous perspectives:

- Companies owned and operated by Indigenous groups (logging companies that have off road equipment, shortline and regional railways) may be affected by this policy.
- Indigenous people living in the North may also be affected by any increased costs associated with new/existing off-road equipment, locomotives, airplanes and marine vessels, passed on by transportation operators.

Stakeholder perspectives:

- Stakeholders have an interest in improving fuel economy, as fuel is one their largest operating costs. Reductions in aviation, marine and rail modes are challenging as equipment is more capital intensive and fleet turnover is much slower.
- Stakeholders will want assurances that any proposed measures are compatible with international (air, marine) and/or North American approaches (marine, rail).
- Canada has worked collaboratively with aviation and rail industry stakeholders to reduce GHG emissions through voluntary agreements, establishing a solid base for further collaborative action.

65 RAC (2015), Railway Association of Canada, Rail Trends 2015.

Co-benefits/negative impacts:

- Would lead to reductions in air pollutant and black carbon emissions, in particular around hubs, ports and urban populations, thereby improving public health.
- GHG performance requirements in these areas may also generate technological spillovers to other industries and private investment in research and development.
- Fuel efficiency improvements can be associated with a rebound effect (greater use) although this is likely to be small for these sectors.

Linkages with other working group areas and other proposed policies:

- Improved operational efficiencies (T3), along with carbon pricing and reducing the carbon intensity of fuels (e.g., deployment of biojet for aviation – see T10), are important complementary policies.
- Equipment efficiency improvements will depend on technology development. Policy measures that support research, development and deployment of emissions reduction solutions would be complementary. For instance, near term opportunities may exist to support pilot demonstrations of low-carbon advanced technology solutions where systems are being built (e.g., hydrogen powered "wireless electric" commuter rail).
- Development of a global market based measure (i.e. offsetting) for international aviation emissions could be expanded to domestic operations, with alternative ambitions, and drive GHG performance improvements in the domestic fleet across vehicles and engines and operational measures. Policy options to this effect are identified in policy option T3 – Energy efficiency in the aviation, rail, marine and off-road industrial sectors.

Regional impacts including northern and remote communities:

- For the marine sector, Ontario, Quebec and British Columbia, account for the greatest share of domestic marine emissions, and would be most impacted.
- For the aviation sector, new airplanes would have the greatest potential impacts with smaller operators servicing the North and remote communities where the average airplane in operation is over 30 years.
- For the freight rail sector, Ontario, BC and the three prairies provinces would be primarily affected. Canada's passenger rail is dominated by the provinces of Ontario and Quebec thus impacts would be greater in those two regions.
- Northern and remote communities may also be impacted by any increased costs associated with new/existing off-road equipment (mining, forestry equipment).

Implementation, feasibility, technological and enabling infrastructure issues:

- Companies are already actively retrofitting and renewing their fleet with efficient new equipment, limiting the impact of new equipment requirements/commitments. Larger companies are generally earlier adopters than their small/medium counterparts.
- Most proven technologies are currently available to retrofit existing aircrafts, vessels, or locomotives. Financial support programs (e.g., grants, low interest loans) could support smaller transportation operators who may have less capital/experience/knowledge to undertake retrofits or adopt technologies as high capital costs associated with technological improvements hindered pace of implementation.
- For off-road sector, regulating new equipment based solely on the availability of engine optimization technologies is possible, but would take Canada out of regulatory alignment with the United States (and as a result, the cost efficiencies of a joint approach would not be realized).

T6: Fuel Efficiency of On-road Vehicles

POLICY GOAL: Improve on-road fuel efficiency of the current vehicle fleet.

POLICY TOOLS: Regulations and enforcement to reduce driving speeds; funding for vehicle connectivity and automation; funding and incentives to improve driver behaviour; funding for road paving and maintenance.

Policy Details

A. Increased enforcement of speed limits
   - Could apply to heavy duty vehicles and/or passenger vehicles
   - For passenger vehicles, could be preceded by pilot projects in certain regions/corridors and/or at certain times of day/year
   - Could leverage/incorporate ITS/GPS technologies and data from electronic toll collection
   - Could be implemented quickly to achieve reductions in the short term as soon as resources are made available

B. Regulation requiring all trucks to install and activate speed limiting devices
   - Would apply to trucks travelling into or within Canada
   - Devices would be set at no more than 105 km/h.
   - Accompanied by increased enforcement on major highways
   - Timing would depend on the regulatory development process and design of the regulation
   - ON and QC already require speed limiters; could be expanded to other provinces to achieve reductions in the short term.

C. Outreach and education programs to improve the efficiency of driver behaviour
   - Requiring eco-driving as a core curriculum for drivers' education and licensing programs through policy tools such as amendments to licensing requirement regulations
   - Incentives/rewards for increased usage of on-board monitoring technologies, e.g., rebate programs, tax exemptions, reduced insurance rates
   - ecoDriving outreach campaigns targeted at experienced drivers
   - Could be implemented as soon as programs are developed;[66] some existing programs should be leveraged for faster implementation

D. Demand-based funding program to accelerate connectivity and automation in the Canadian transportation system.
   - To be eligible, a proponent would require government partnership
   - Eligible projects would include Intelligent Transportation Systems (ITS) such as smart roadway infrastructure, and connected/-automated vehicle pilot deployments; capacity and skills building; and ITS/big data approaches to improve system efficiency
   - Could start with pilot projects, followed by actual deployments in 3-5 urban centres
   - Pilot projects could be initiated as soon as a funding program is developed. Pilot projects have been run in the US for a number of years in anticipation of expected requirement for new vehicles to include connectivity technology starting in 2018.

E. Demand-based funding program to expand the paved road network and increase maintenance of existing paved roads
   - To be eligible, a project would have to meet criteria linked to expected GHG reductions
   - Eligible projects would also include those that test the effects of pavement characteristics such as roughness and macrotexture on vehicle fuel consumption
   - Projects could be initiated as soon as a funding program is developed

66 Typical program development is between 6 and 12 months depending on the complexity of the program. This would apply to all policy options where the timing is depending on program development.

Options		Est. Reduction in 2030	Est. cost/tonne
A.	Increased speed enforcement	2-4 Mt[1]	$0-$50
B.	Regulation requiring truck speed limiters	0-1 Mt[2]	$0-$50
C.	Outreach and education programs	<1 Mt[3]	$0-$50[4]
D.	Funding program for ITS deployment	<1 Mt[5,6]	>$250
E.	Funding program to increase paved roadways[7]	0-1 Mt	$100-$250

Note: emission reduction estimates are not cumulative. There is some overlap between the above options, e.g., option C driver education may help reduce speeds and so could target some of the same emissions as option A. The potential for overlap has been taken into account in the GHG range in the summary table on page 57

1. U.S. Federal Highway Administration, GHG Handbook www.fhwa.dot.gov/environment/climate_change/mitigation/publications/ghg_handbook/ghghandbook.pdf

2. Transport Canada "Assessment of a Heavy Truck Speed Limiter Requirement in Canada" www.tc.gc.ca/media/documents/roadsafety/tp14808e.pdf

3. http://innovativemobility.org/wp-content/uploads/2015/07/Public-Education-on-Ecodriving.pdf

4. http://innovativemobility.org/wp-content/uploads/2015/07/Public-Education-on-Ecodriving.pdf

5. Barth, Matthew J., G. Wu and K. Borbiboonsomsin,"Intelligent Transportation Systems and Greenhouse Gas Reductions", Current Sustainable/Renewable Energy Reports 2.3 (2015), 90-97, http://link.springer.com/article/10.1007%2Fs40518-015-0032-y

6. Pandazis, Jean-Charles and Andrew Winder. Study of Intelligent Transport Systems for reducing CO2 emissions for passenger cars. 10 September 2015. ERTICO-ITS Europe. http://erticonetwork.com/wp-content/uploads/2015/09/ITS4rCO2-Report-Final-2015-09-10-submitted.pdf

7. U.S. Federal Highway Administration, "Towards Sustainable Pavement Systems" Chapter 6 Use-Phase Considerations www.fhwa.dot.gov/pavement/sustainability/hif15002/chapters/hif15002_06.pdf

ECONOMIC AND CONSUMER IMPACTS: *Economic impacts would mainly be related to reduced costs as well as potential clean sector opportunities:*

- On road efficiency measures are associated with reduced fuel costs as well as reduced operating and maintenance costs for vehicles.
- All of these measures are linked to improvements in congestion, productivity, and efficiency which can have significant positive economic impacts.
- For ITS and connected/automated vehicles there is potential for Canada to build on its expertise in the automotive and ITS sectors and take a leadership role given a supportive environment.
- Small fleet operators and owner-operators may avoid truck speed limit jurisdictions

CONSIDERATIONS:

Stakeholder perspectives:

- The Canadian Trucking Alliance supports mandating activation of truck speed limiters

Co-benefits/negative impacts:

- Improved road safety by increasing scope of defensive/anticipatory driving techniques, reduced speeds, reduced collisions due to automated and connected vehicles,
- All of the measures can be linked to improved air quality and associated population health impacts.
- ITS and connected-automated vehicles can improve security by integrating wireless connectivity in freight transportation (e.g. data-enhanced inspections, tracking of dangerous goods)

Implementation, feasibility, technological and enabling infrastructure issues:

- For outreach and education programs, provinces/territories would lead integration of eco-driving into driver certifications and licensing. Support for installation of monitoring/feedback technology in vehicles will also be required
- For enforcement and regulations to limit speeds:
  - » Speed limit enforcement challenges include limitations on uniformly reading and obtaining an accurate assessment of the speed limiter settings
  - » A pan-Canadian speed limit mandate would require a harmonized regulatory approach across jurisdictions
  - » Cost and practicability are both key considerations (e.g., photo radar would likely be the most cost effective method but may not be supported in some jurisdictions)
  - » Using ITS/GPS technologies or electronic toll collection data for enforcement may require complex administrative and legislative changes, and may raise privacy concerns.
  - » Need to examine implication that fuel savings costs could be offset by time costs.
  - » There is potential to introduce a greater variance in vehicle speeds which could reduce safety.
  - » There would likely be significant driver resistance.

- For ITS and connected-automated vehicles:
  - » Would enable other complementary approaches, including road-tolling and enhanced intermodal freight logistics
  - » Would require development of codes, standards, and regulations for safety, communications, and information security and privacy
  - » Would require strong federal-provincial-territorial coordination and capacity-building, as well as coordination with U.S. introduction timelines

- For increasing paved roadways:
  - » Local impacts of increased congestion/traffic as traffic volume increases.
  - » Should balance with modal shift to transit, active transportation, etc.
  - » Differences between pavement types are not significant; more important for the fuel efficiency are pavements in good condition with good surface characteristics[67]

T7. Freight Efficiency

POLICY GOAL: Reduce greenhouse gas emissions (GHG) from all modes of freight transportation (air, marine, rail and on-road and associated off-road vehicles and engines) by improving efficiency at hubs (ports, airports, rail yards, and transfer points) and across supply chains.

POLICY TOOL: Information sharing, financial incentives, investment in infrastructure, and pricing schemes

Policy Details

A. Incentives to adopt best practices related to freight logistics and supply chain efficiencies
  - » Grants, tax incentives, municipal measures (e.g. parking/bylaws) that support private sector adoption of best practices
  - » Best practices would include off-peak delivery, load matching, loading procedures, packaging re-design, distribution centre relocation, improved network connections
  - » Complementary measures: establish an information exchange portal and network
  - » Incentives could be provided immediately

67 Beuving et al., *"Fuel Efficiency of Road Pavements"*, Proceedings of the 3rd Eurasphalt and Eurobitume Congress Held Vienna, May 2004, p. 983-992, available online at: https://trid.trb.org/view.aspx?id=743829.

» $100M+ in funding for infrastructure, equipment and logistics that facilitate intermodal transfers
» Eligible projects could include improvements and modifications to infrastructure at intermodal rail terminals and ports to facilitate faster, more efficient transfers of freight to less-carbon intensive modes (e.g. improved road access to intermodal terminals, barge facilities).
» Target 1%-2.5% shift of total freight truck tonne kilometers[68]
» Projects could be initiated as soon as funding programs are developed

B. Introduce a per-kilometre charge for on-road vehicles carrying heavy goods
» Funds could be used towards repairing road damage and/or clean vehicle technologies[69]
» Would help encourage a shift to lower-emitting modes
» Investments to install tracking technology (e.g., telematics) required to implement pricing
» Pilot projects could be implemented quickly; wider deployment would not be feasible before 2020

These measures help reduce emissions by:
» Improving logistics/supply chain efficiency (including improved network connections, load matching, off-peak delivery, packaging and packing efficiencies), and
» Facilitating the shift of freight transportation to more GHG efficient modes (i.e., marine and rail) through investments in infrastructure, equipment and logistics.
» Facilitating the shift of freight transportation to more GHG efficient modes through pricing mechanisms that achieve more competitive equality across modes.

Options		Est. reductions in 2030	Est. cost/tonne
A.	Incentives for freight logistics and supply chain efficiencies	0-2 MT	<$0
B.	Funding to support modal shift	1-2 MT	>$250*
C.	Pricing - heavy goods vehicle per kilometre charge	0-1 MT	$0-$100

Note: emission reduction estimates are not cumulative

* Extrapolated from the European Commission's Marco Polo II program which ran from 2007 to 2013 with a budget of €450M (addition of private funding would bring investment to an estimated €900M) , achieving a reduction of 2.86Mt. The total freight tonne truck kilometers shifted through this program is estimated to be less than 0.7%. However, care should be taken in adapting assumptions based on European experience due to differences in infrastructure networks, policies, geography, and consumer/shipper preferences.

ECONOMIC AND CONSUMER IMPACTS

- The freight industry is likely to achieve cost savings through logistics improvements; these savings may be used to expand operations and/or could contribute to reducing the rate of growth of prices for consumer goods.
- The freight sector would also reduce fuel costs through shifts to lower emitting modes; however, these savings would likely be offset by increased cargo handling costs as the first and last kilometer of freight hauls will need to continue to be delivered by truck.
- Reduced traffic on roads avoids congestion and accidents and reduces travel time and pavement maintenance costs.

68 Opportunities for shifts would occur over medium- and long-distances. Other modes can begin to offer competitive alternatives at distances of over 500km.

69 For example, Germany introduced a toll on heavy goods vehicles to help achieve more competitive equality. Another 10 European countries (including Switzerland, Austria, and Poland) have also implemented heavy goods vehicle per-km charging to account for the damage that these vehicles cause to roads, reduce emissions, and raise revenues.

- Encouraging a shift from truck to rail or marine will have an impact on labour needs in affected modes; the trucking industry is currently struggling to attract/retain drivers.
- Infrastructure projects create jobs and encourage growth in the local economy.

CONSIDERATIONS

Stakeholder perspectives:

- The introduction of a heavy goods vehicle per kilometre charge would increase costs for on-road freight transportation and is unlikely to be supported by the trucking industry, particularly if it is in addition to the existing International Registration Plan and a price on carbon. This fee would need to be established in consideration of the existing International Registration Plan.

Co-benefits:

- Reduced air pollution and black carbon in major urban areas could contribute to important air quality and human health benefits.

Linkages with other working group areas and other proposed policies:

- Greater deployment and use of freight innovations including intelligent transportation systems and smart corridors will provide better information to further improve the efficiency of freight logistics.
- Carbon pricing, depending on the level and scope, could increase the incentive for companies to improve their freight logistics and further reduce fuel consumption.

Regional impacts including northern and remote communities:

- The majority of investments and improvements are expected to occur in urban centres; impacts on Northern, rural and remote communities are expected to be minimal.
- Depending on the location of the investments, the impact on regions would be different:
  - » Support for short-sea shipping could see investment in ON, QC, BC, and in the Atlantic provinces;
  - » Choice of location for investments in small centre intermodal terminals could benefit the regions where they are located.

Implementation, feasibility, technological and enabling infrastructure issues:

- Infrastructure investments to induce mode shift would involve improvements at intermodal connection points that would allow for freight to be transferred from one mode to another, as well as improvements to address choke points in existing infrastructure networks.
- A high level of coordination between the many players involved in a supply chain will be necessary to achieve reductions.
- Price is one of many factors that influence a shipper's mode choice. A government policy package that successfully induces modal shift would need to address shipper considerations such as:
  - » Modal characteristics (e.g., capacity, trip time, reliability, equipment availability, seasonal availability)
  - » Commodity characteristics (e.g., shipment size, package characteristics, shipment value, shelf life)
  - » Shipper and receiver characteristics (e.g., access to modes)
  - » Logistics costs (e.g., order and handling costs, inventory costs, service reliability costs, fuel costs)
  - » Other (e.g., length of haul, shipment frequency, environmental/sustainability)
- Because of the considerations listed above, the fraction of total freight truck tonne kilometers that can be shifted to more efficient modes is limited.

- The potential for mode shift initiatives to reduce emissions depends heavily on the capacity utilization of the lower-emitting modes. Trains and ships would need to be significantly filled in order to realize reductions; consolidating such a shipment would be logistically complex and could increase the transport times, making multi-modal shipping options less attractive.
- Supply chains are highly fluid. The use of investments and market signals to support modal shift could instead result in a realignment of supply chains, making estimating emission reductions challenging.
- A heavy goods vehicle kilometre charge would require investment in electronic technology/sensors to identify and bill vehicles and companies. Information privacy concerns would need to be identified and addressed.

T8: Changing transportation usage patterns

POLICY GOAL: Reduce on-road GHG emissions through Transportation Demand Management (TDM) programs that reduce single passenger vehicle travel demand and provide more sustainable public transportation options.

POLICY TOOL: Require that municipalities or provinces develop and implement urban TDM plans which include policies and programs to encourage low-carbon transportation options or reduce transportation demand.

Policy Details

- TDM is most effective when implemented through an integrated policy package that includes both pull strategies (“carrots”) and push strategies (“sticks”) coupled with effective social marketing[70]. These policies have synergistic effects. For example, two individual policies –improving public transit and increasing parking prices – may each reduce vehicle trips by 5% if implemented separately, but combined they may reduce trips by 25%[71].
- The following policies would be central components of any urban TDM plan. Most of these policy options could begin implementation as soon as resources are made available

A. Shift vehicle passengers to public transit and active transportation through:
   i. Investments in public transit
      - Eligible projects would include expansion and frequency (e.g. bus rapid transit), access and system improvements (e.g. transit priority lanes, transit signal priority systems, optimizing bus routes, control systems, queue jumps, etc.), and enhanced services (e.g., electronic payment systems, amenities at stations, real-time schedules)
      - Target increase in public transit modal share by 15%-50% by 2030
   ii. Investments in active transportation networks
      - Eligible projects would include cycling and walking infrastructure
      - Target increase in active transit modal share by 15%-50% by 2030
   iii. Complementary measure: urban planning strategies
      - Help reduce average trip distance and promote mode shift for residents

B. Reduce overall urban on-road vehicle kilometres travelled (by 2-5% in 2030[72]) by encouraging increased vehicle occupancy and trip avoidance through, for example:
   i. Conversion of highway lanes to high occupancy vehicle (HOV) and high occupancy toll (HOT) lanes (e.g., Ontario plans for HOV and HOT lanes on provincial highways in urban centres)

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70 Habibian, et al. Exploring the role of transportation demand management policies’ interactions, 2011

71 Engel-Yan and Hollingworth, Putting Transportation Emission Reduction Strategies in Perspective: Why Incremental Improvements Will Not Do, 2008

72 Range consistent with similar bundle of measures analyzed in Urban Land Institute’s 2009 Moving Cooler report, and Hickman and Banister’s 2006 report for UK Department of Transport.

ii. Incentives for carsharing, carpooling and ride sharing, including:
- Preferential parking spaces and rates for carpool (high occupancy) vehicles
- Free, dedicated on-street parking for carshare vehicles
- Promoting/requiring employer TDM programs/initiatives (teleworking, compressed work week). For example, increase employer-based TDM programs by 25 – 50%[73] or requiring large urban service-sector employers to have TDM strategies[74].

C. Funding for the infrastructure and/or equipment to develop high frequency/performance rail in key strategic corridors to reduce emissions from inter-city personal vehicle trips and short domestic flights through, for example, Toronto-Ottawa-Montreal, and Calgary-Edmonton[75]. Infrastructure investments could begin immediately; emissions reductions would be realized upon completion of the rail corridors.

Options		Est. reductions in 2030	Est. cost/tonne*
A.	*Shift vehicle passengers to public transit and active transportation*		
i.	Funding for public transit	0-1 MT	\$100-\$250
ii.	Funding for active transportation	<1 MT	
iii.	Urban planning strategies	N/A	
B.	*Reduce vehicle-kilometres travelled:*		
i.	HOV and HOT lanes	1-2 MT	>\$250
ii.	Incentives for car sharing		<\$0
iii.	Employer TDM		<\$0
C.	*Funding for high frequency/performance rail*	<1 MT	>\$250

Note: emission reduction estimates are not cumulative

* Based on studies or literature : "Moving Cooler: An Analysis of Transportation Strategies for Reducing Greenhouse Gas Emissions" report", Urban Land Institute (2009)

ECONOMIC AND CONSUMER IMPACTS

- Inefficient urban transport systems lead to many costs, including excessive traffic congestion, road and parking facility costs, traffic accidents, consumer costs, and inadequate mobility for non-drivers. TDM can help solve these problems by increasing overall transport system efficiency.
- TDM strategies can reduce the need for new or widened roads, diminish the social costs of car use, and increase the return on investments in transit (bus and rail), walking, cycling and carpooling.
- Increased active transportation would have a spin-off benefit of increasing physical activity levels, and reducing chronic disease costs. Direct health care costs from physical inactivity were estimated to be \$2.4 billion in 2009[76]

73 http://scholarcommons.usf.edu/cgi/viewcontent.cgi?article=1580&context=etd

74 Urban Land Institute, Moving Cooler, 2009

75 www.apta.com/resources/reportsandpublications/Documents/HPPR-Cost-of-Inaction.pdf

76 Janssen, I. Health care costs of physical inactivity in Canadian adults (2012) Applied Physiology, Nutrition and Metabolism, 37 (4), pp. 803-806.

CONSIDERATIONS

Co-benefits/negative impacts:

- Implementing TDM takes time and resources but can contribute to the creation of healthy built environments by incorporating the principles of appropriate land use density, diversity and network connectedness.
- Communities will experience a number of benefits, including greater return on investments in transit, walking, cycling and carpooling facilities; cleaner air and associated health benefits; less noise and traffic congestion; improved road safety, improved quality of life with more walkable and age friendly communities
- Employers will experience benefits such as easier employee recruitment, better employee retention, less need for parking spots, improved productivity
- Individuals will experience greater transportation choice and convenience, time and cost savings, better health and fitness,

Linkages with other working group areas and other proposed policies:

- The Government of Canada announced in Budget 2016 $3.4 billion in public transit investments over three years, starting in 2016–17, to be provided through a new Public Transit Infrastructure Fund.
- The Government of Canada offers a non-refundable tax credit at the lowest personal income tax rate for the cost of monthly public transit passes or passes of longer duration.
- This policy package is linked to a number of other policies, including B8 - Urban form and spatial planning and carbon pricing, which would increase the cost of carbon-intensive travel. It is also linked to T9 Reducing congestion and vehicle-kilometres travelled since reducing road vehicle travel is integral to achieving optimal emission reductions through a TDM policy.
- Other measures such as the imposition of market-based parking fees (e.g., San Francisco), differential rates or discounts for carpool or vanpool parking (green lanes), or transit pricing management can function to reduce the number of single occupant trips by increasing the travel cost of driving alone or decreasing the travel cost of alternative modes.

Regional impacts including northern and remote communities:

- These policies are significantly less effective in small and remote communities. However, individual components of a comprehensive urban TDM strategy could still have a place in such communities – particularly car/ride sharing and teleworking.

Implementation, feasibility, technological and enabling infrastructure issues:

- Transport Canada, Canadian Institute of Planners (CIP), Federation of Canadian Municipalities, public health agencies, and many cities and communities have developed guidance documents and materials to support development of community-specific TDM strategies.
- Requiring the preparation/implementation of TDM plans as a condition of various federal and provincial infrastructure and capital funding (gas tax etc.) is a feasible and reasonable expectation. Measuring the effectiveness of such plans is important to ensure additional and sustained GHG reductions.
- Federal funding for public transit could incorporate climate criteria such as: achieve the greatest GHG reductions and at the lowest cost, encourage high-density development, ensure adequate operation and maintenance funding to maintain quality of public transit and support the electrification of transit.
- Funding required to develop a high-frequency passenger rail corridor is not determined but could be significant, given a total estimated cost of $4B including infrastructure (dedicated track), and rolling stock, and electrification elements.

T9: Reducing congestion and vehicle-kilometres travelled

POLICY GOAL: Reduce the total on-road kilometers traveled and/or avoid the use of higher GHG emitting travel

POLICY TOOLS: Economic instruments: pricing mechanisms, fees, taxes and other financial tools

Policy Details

A. Road use pricing based on vehicle-kilometres travelled (VKT)
   - » Would apply to passenger and commercial vehicles, with exemptions (e.g. emergency vehicles, waste services, zero-emission vehicles)
   - » Rates could start at $0.01/km in 2020, and increase over time
   - » Would require funding and/or incentives for installation of tracking technologies

B. Strategy to increase pay-as-you-drive (PAYD) insurance policies to 30% of all policies by 2030
   - » Require all insurance companies to offer and promote PAYD policies
   - » Timing would depend on the regulatory development process; pilot projects could start immediately on voluntary agreement with insurance companies

C. Urban congestion pricing
   - » Fees charged for entering certain areas, with higher rates during peak traffic periods (e.g. 6-9am, 3-6pm) and lower off-peak rates
   - » Different fees depending on approach, e.g. fee for entering Toronto city centre could range depending on time of day (e.g., flat rate of $20.92 in London, UK, during peak rush hours)
   - » Would apply to passenger and commercial vehicles, with exemptions similar to road use pricing
   - » Pilot projects could be initiated immediately.

D. Variable vehicle registration pricing based on vehicle emissions rating
   - » Levied annually or at time of sale, based on standard vehicle class ratings
   - » For example, variable charges could be applied to annual vehicle licence plate sticker renewals (current price for all passenger vehicles in Southern Ontario is $108), with lower rates for ZEVs and higher rates for high emitting vehicles.
   - » Timing would depend on the regulatory development process.

E. Variable vehicle excise taxation based on vehicle emissions rating
   - » Modifications (scope or rate) to existing vehicle excise taxes (e.g., the Federal Tax on Fuel Inefficient Vehicles, also known as the Green Levy) according to vehicle emissions rating
   - » One-time tax rates could range from $0 for ZEVs to $4,000 or more for the highest emitting vehicles.
   - » Timing would depend on the regulatory development process and design of the regulation; existing excise taxation could be leveraged for faster implementation.

F. Financial incentives (e.g., grants, tax preferences, low interest loans) to accelerate fleet turnover
   - » Focus on increasing ZEVs and other fuel efficient vehicles and engines.
   - » Applicable to business/commercial vehicles only, likely small costs.

Options		Est. reductions in 2030	Est. cost / tonne*
A.	Road use pricing based on VKT	1-2 MT	<$0
B.	Pay-as-you-drive (PAYD) insurance policies		<$0
C.	Congestion pricing Canada's largest, most congested cities**	<1 MT	<$0
D.	Variable vehicle registration pricing	<1 MT	$0-100
E.	Variable vehicle excise taxation based on vehicle emissions rating		$0-100
F.	Financial incentives to accelerate fleet turnover		$50-100***

Note: emission reduction estimates are not cumulative

* Moving Cooler, 2009 by Cambridge Systematics, https://uli.bookstore.ipgbook.com/moving-cooler-products-9780874201185.php?page_id=21 ; US Congress by US DOT: http://ntl.bts.gov/lib/32000/32700/32779/DOT_Climate_Change_Report_-_April_2010_-_Volume_1_and_2.pdf

** Based on empirical data from charging systems in London, Singapore and Stockholm congestion, reductions of 13-30%, GHG reductions of 15-20% and significant reductions of air pollutants. Could reduce VKT by 10-16% in charging zones based on empirical evidence from existing systems

*** Costs are reported in standardized increments. However, costs associated with this option may be somewhat higher, e.g., in the range of $50-$150 per tonne.

ECONOMIC AND CONSUMER IMPACTS

- Fees and taxes allow government to collect revenues to offset costs for transportation GHG related improvements (e.g. investments in transit, active transportation infrastructure, etc.) but modifications should be done with consideration of overall tax system efficiencies, trade agreements.
- Increased costs to consumers on the purchase of new, fuel inefficient vehicles (i.e. increased excise tax, registration costs) provides a price signal at time of purchase to incent fuel efficiency considerations; may also create a perverse incentive to keep older vehicles longer (this could be addressed in a well-designed scrappage program).
- With increased turnover of commercial vehicles and engines (all modes), increased deployment of more fuel efficient, lower emitting technologies.
- Increase the efficient movement of freight and passengers.
- Significant positive impact due to reduced congestion – it is estimated that vehicle congestion typically erodes a country's GDP by 1-3%.
- Higher passenger and freight transportation costs could be passed on to consumers/taxpayers, resulting in higher cost of living.
- Municipalities may consider use of 'toll roads' which would increase transportation costs to on-road drivers
- Potential for reduced costs on vehicle ownership and road maintenance/expansion.
- Distance based fees more accurately reflect the insurance, road and pollution costs imposed by individual vehicles.

CONSIDERATIONS

Co-benefits / negative impacts:

- Accelerate the penetration of low- and zero-emission vehicles, and encourage carpooling/car sharing. However, additional fees can increase the operational costs of the HDV trucking sector and weaken its competitiveness if the charges are not harmonized across jurisdictions. Consideration would be needed around the applicability of new charges on U.S. trucks and possible negative economic impacts.
- Reduce air pollution and associated population health impacts, accidents, and congestion in urban areas.
- Directly influence travel behaviour by increasing public transit ridership, active transportation; associated health benefits.

- Road pricing options can have higher financial burdens for low-income households and those without alternatives; possible need for mitigating these impacts through policy design.
- Lower total fuel consumption resulting from higher transportation cost could negatively affect employment in petroleum refining, distribution and retailing sector but support Canadian businesses in fields focused on advanced transportation technologies and telematics, alternative modes and public transit, cleaner vehicles and transportation demand management.

Linkages with other working group areas and other proposed policies:

- Carbon Pricing: Congestion pricing affects the choice of time and location of driving, while carbon pricing affects the choice of the amount and type of fuel used.
- With a high enough carbon price, road use pricing may not be required
- Adjustments to vehicle taxes based on emissions performance can complement other vehicle incentives (e.g., manufacturer regulations, electric vehicle rebates, low carbon/renewable fuel standards, and vehicle replacement/scrappage programs).
- PAYD insurance policies are complementary with connected vehicles (CV being an enabling technology for road-toll/usage-based insurance schemes).

Regional impacts including northern and remote communities:

- Congestion pricing is designed for large cities, while VKT taxes can be implemented in virtually all areas. These tools can contribute to urban densification and modal shifts. In order to encourage such modal shift it is imperative alternative options are in place such as public transit.
- For VKT taxes consideration would be needed to ensure rural/remote community drivers (larger distances where alternatives to driving are limited) are not adversely impacted.
- Reduced private vehicle traffic can help improve urban land use and dedicate more road space to sustainable transportation infrastructure (e.g. cycling lanes).
- Emission performance based vehicle taxes tend to have relatively higher impacts on remote or northern communities as light-trucks account for a higher share due in part to climate and road conditions.

Implementation, feasibility, technological and enabling infrastructure issues:

- Care should be taken to design these measures, and where possible, build upon existing policies, regulations and fees, to reduce the administrative complexity.
- Congestion pricing would require investment in electronic technology/sensors to identify and bill vehicles and drivers. VKT charging and PAYD insurance can require installation of telematics devices to record driving time, distance, and location. On-board technologies used for distance-based charging systems have potential cyber-security implications that may need to be addressed. Privacy and public acceptability concerns will need to be addressed. Public acceptability and political leadership to pilot such systems may be more significant barrier than technology readiness.
- The existing “green levy” imposes an excise tax on vehicles that consume more than 13L/100 KM but does not apply to pickup trucks or vans with ten or more seats. Modifying the existing system for vehicle excise taxes based on emissions performance would involve some administrative cost (and potentially mandating vehicle labelling for all new and existing on road vehicles).
- Such policies have the potential to encourage people to use alternatives to driving (e.g., public transit and active transportation), and/or generate significant revenues that could be used for highway maintenance, reconstruction and upgrading the technologies (e.g. electronic charging systems). Their impact would be optimized through parallel improvements to public transit and active transportation systems.
- While fees and taxes can be phased-in gradually to avoid unnecessary shocks to the economy, new charges to road users (who currently have free access to the roads) would be expected to face public acceptance challenges.

- Congestion pricing has seen notable success in European cities (e.g. London and Stockholm[77]), while VKT charging pilots are underway in Oregon[78] and California. Experience in the U.S. shows that establishing a national VKT requires further study and analysis.
- Enabling legislation may be required to implement congestion/road pricing.
- Multiple technologies have been proven for such mechanism, creating flexibility in implementation.

T10. Increased Availability and Use of Low Carbon Fuels in the Domestic Marine, Rail and Aviation Sectors

POLICY GOAL: Accelerate low carbon fuels uptake in the domestic marine, rail and aviation sectors. For marine and rail, the most promising fuels are drop-in renewable diesel, liquefied natural gas and potentially biodiesel. For aviation, biojet fuel is the only opportunity, although it can be produced in different ways.[79]

POLICY TOOL: Regulations and Incentives

Marine and Rail

A. Adopt a low carbon fuel standard for the domestic marine and rail sectors
   » Require 10% life cycle carbon intensity reduction of the fuel used in vessels and locomotives in 2030 relative to 2020 (starting year).
   » This would be done through regulatory fuel demand measures (e.g., B.C. Low Carbon Fuel Requirement Regulation) coupled with specific fiscal incentives (e.g., producer incentives, infrastructure programs, LCFS credit banking and trading, etc.) to address the cost of low carbon fuel production and distribution infrastructure deployment.

Aviation

B. Develop a low carbon fuel framework specifically for the domestic aviation sector
   » Implement measures to increase the blend of biojet to 1% of the domestic jet fuel demand in 2020 and to 5% of the domestic jet fuel demand in 2030.
   » This would be done through regulatory fuel demand measures coupled with specific fiscal incentives to address the capacity to develop and produce low carbon fuel, cost of production, and distribution infrastructure deployment.

Options		Est. reductions in 2030	Est. cost/tonne**
A.	Low Carbon Fuel Standard for marine and rail	1-2 Mt	$100-$250
B.	Low Carbon Fuel Framework for aviation	<1 Mt	$100-$250

* Based on preliminary industry estimates and experience. Though higher longer term benefits – with domestic fuel/energy production – may reduce cost to below zero.

ECONOMIC AND CONSUMER IMPACTS:

- The impacts will depend on future fuel prices, and the price differential between fossil fuels and the low carbon fuels under consideration.
- The impacts on the broader economy (including manufacturing and agriculture sectors) will depend on whether the feedstocks used to produce the low carbon fuels will be Canadian and where the low carbon fuels will be produced (domestically or imported).

77 International Council on Clean Transportation, April 2010 *"Congestion Charging: Challenge and Opportunities"*

78 www.myoregо.org/

79 Biojet from hydro-processed esters and fatty acids (HEFA) and HDRD processes are the most likely candidates on a short/medium term basis with drop-in biojet fuel (Hydrotreated Depolymerized Cellulosic Jet – HDCJ) being actively pursued as a medium/long term objective. Other technology pathways are also in the process of receiving ASTM approval and could also become competitive with adequate RD&D funding.

- The type of feedstock-technology platform selected will greatly influence this decision and the size of the economic impact and employment benefits.
- Important economic benefits could be expected with domestic fiscal support for low-carbon fuel production. Fiscal incentives would need to be used judiciously in order to promote Canadian production rather than subsidizing the importation of biofuels, especially with a 2020 start.
- When considering GHG reductions, a life-cycle analysis of fuel production should be considered to ensure all emissions are taken into account.

CONSIDERATIONS:

Regional impacts including northern and remote communities:
- In the absence of an adequate fiscal environment to level the playing field between low carbon fuels and their fossil counterparts, increased costs of fuels could be expected overall that could have an impact on Indigenous people and remote communities; however, this can be overcome via targeted fiscal measures for these communities.
- Domestic low carbon fuel production could provide a much needed economic growth for these communities if plants are built in those regions.
- Feedstock supply, access to hydrogen and other inputs, and market access for co-products are important variables that can greatly influence the location of new biofuel production plants. In addition, potential land use impacts associated with an increased use of crop-based or forest feedstock would need to be performed for different biofuel volume scenarios.

Implementation, feasibility, technological and enabling infrastructure issues:
- Policy options could be integrated into a much larger LCFS framework covering all modes of transportation, including on and off-road.
- Because locomotives, ships and airplanes operate across national boundaries, international cooperation and harmonization on LCFS should be pursued.
- For rail and marine, the structure of shared trade and operating areas with the U.S. means that at minimum a bilateral framework is needed to avoid leakage in face of regulation.
- For the international maritime and in particular for the international aviation sector separate treatment may be needed as international initiatives led by the International Maritime Organization (IMO) and the International Civil Aviation Organization (ICAO) may have a significant impact on the ultimate policy option chosen for these sectors.
- In order to enable domestic low carbon fuel production and distribution infrastructure deployment, a strong enabling fiscal environment is needed (e.g. adequate carbon pricing, financial incentives such as grants, tax preferences, low interest loans, etc.) as well as continued support for research, development and demonstrations (e.g. to support codes and standards, optimization of production pathways and cost reductions). Without domestic support, significant volumes of low carbon fuels would likely be imported.
- A progressive fuel tax based on carbon content could be put in place (e.g. a higher tax rate on diesel) to address the price differential.

Issues specific to marine and rail:
- HDRD use in the rail and marine sectors can be implemented now and do not necessitate any infrastructure changes as it is a drop-in fuel; biodiesel may have some operability/engine warranty issues at higher blends (more than T5) and in extreme cold weather conditions.
- For liquefied natural gas (LNG, including renewable LNG), R&D funding or financial incentive programs could support local rail and marine industries to convert existing vessels and locomotives to accept low-carbon fuels or to purchase new low-carbon fuel vessels or locomotives. Infrastructure funding/programs that can improve low-carbon fuel (LNG and RLNG) infrastructure and supply chain (such as delivery system and bunkering facilities, shore power) are also needed.

- There would be air quality co-benefits associated with the use of all low carbon fuels (e.g. use of LNG in engines will produce much lower levels of NOx and particulate matter compared to diesel locomotives-even considering Tier 4 locomotives).

Marine stakeholder perspectives:

- The International Maritime Organization (IMO) is currently considering measures to improve energy efficiency and reduce greenhouse gas emissions from international maritime shipping. Stakeholders are concerned that regional GHG measures could generate market distortions. Therefore, industry may be concerned if Canada unilaterally pursued GHG measures if those efforts were perceived as creating market distortions.
- Canadian-flagged vessels operating on international routes would need to comply with international agreements implemented by IMO. Canada has, in the past, applied IMO requirements to certain Canadian vessels that do not operate internationally, including Great Lakes ships that visit U.S. and/or Canadian East Coast ports. Regulatory exceptions are made where appropriate.

Issues specific to aviation:

- There is no existing biojet production in Canada, and a number of different biojet pathways are under development.
- Canada has existing sources of feedstock (e.g. forest and agricultural residues, canola, camelina, B. carinata, etc.) and potential to produce HDRD, HEFA and, in the medium/longer term HDCJ biojet. Note that for camelina and B. carinata, supply chains need further development and the supply of these crops would have to be significantly increased. Recycled oils and animal fats could be another source of feedstock if quality specifications could be met.
- With the appropriate policies, market signals, and investments, domestic production could be established to produce the volumes of biojet (~350 ML) targeted for 2030. A financial assessment of biojet fuel import versus domestic biofuel fuel production as well as implications for the agriculture and forestry sectors need to be completed for the different feedstock-technology pathways.
- Work is currently underway in the international aviation community to develop a harmonized approach to feedstock sustainability. To ensure public acceptance and eligibility of Canadian produced biojet in greenhouse gas reduction schemes internationally, Canada's forestry and agricultural practices must be reflected in these sustainability definitions and criteria.

Aviation stakeholder perspectives:

- The International Civil Aviation Organization (ICAO) is currently developing a market-based measure for international civil aviation. Under the system Canada's airlines operating internationally would need to comply starting in 2021. As each litre of biojet fuel would only be able to comply with one of the systems, if the international costs for compliance are higher, available fuel would be used by airlines to meet their international obligations.
- The National Airlines Council of Canada submitted detailed recommendations to the Minster of Environment and Climate Change. Their recommendations focus on continuing to pursue the actions laid out in Canada's Action Plan to Reduce Greenhouse Gases from Aviation, the introduction of "smart" carbon pricing mechanisms, and support for the development of renewable aviation fuel industry in Canada.

Built Environment

B1 Net- Zero Ready Codes for New Housing

POLICY GOAL: Reduce emissions from the new home sector

POLICY TOOL: Regulations

Policy Details

- Reduce emissions from new homes through more energy efficient buildings.
- 'Net-zero ready' homes only use as much energy as they could produce from renewable energy.
- The policy would require authorities having jurisdictions (e.g. provinces/ territories/ municipalities) to adopt "net zero ready codes" supported by a model National Building Code. Roof top orientation, tree cover, and regional sun exposure may not allow all 'net-zero ready' homes to produce sufficient energy to reach 'net-zero' performance level.

Ambition A: Increase the energy requirements in building codes and the National Building code to reach 'net zero ready' by 2030

- Coverage: All new low-rise residential housing starts.
- Roll-out: Adoption of new building codes by authorities having jurisdiction that increase the energy performance of new home construction to net-zero ready by 2030, representing an average energy use reduction of approximately 40% relative to the 2012 model national code (exact percentage varies by climate zone). Model National Building Codes would provide a three-stepped roadmap to net-zero ready.
- Enabling Measures:
  - » Mandatory labelling of new homes to communicate benefits of high performance code, using a robust national energy rating system such as EnerGuide.
  - » Training and capacity building of industry professionals and compliance officials.
  - » RD&D (research, development, demonstration) to lower incremental costs and improve cost per tonne.
  - » Accelerated national adoption by authorities having jurisdiction through a common roadmap that includes Model National Building codes.

Ambition B: Increase the energy requirements in building codes and the National Building code to reach 'net zero ready' by 2025

- Coverage: All new low-rise residential housing starts
- Roll-out: As per Ambition A, but with adoption accelerated to 2025. Model National Building Codes would provide a two-stepped roadmap.
- Additional Enabling Measures beyond Ambition A:
  - » De-coupling energy performance from other building code elements to facilitate accelerated adoption.
  - » Exploration of incentive programs to accelerate market acceptance in advance of code adoption (not costed in this option).

Options		Est. reductions in 2030	Est. cost/tonne*
A.	Increase energy efficiency requirements in building codes and the National Building code to reach **'net zero ready' by 2030**	4 Mt	Elect: <$0 Natural Gas: >$250 Oil: $0-50
B.	Increase the energy efficiency requirements in building codes and the National Building code to reach **'net zero ready' by 2025**	5 Mt	Elect: <$0 Natural Gas: >$250 Oil: $50-100

*Note: cost/tonne will vary widely by region; estimates do not consider the potentially significant value of avoided generation/transmission investments to electricity utilities and natural gas distributors.

ECONOMIC AND CONSUMER IMPACTS

- This option would drive transformational change – gradually moving the building stock to the high levels of efficiency needed for greater emissions reductions in the longer term (e.g., 2050)
- Incremental cost for net-zero ready homes is up to $20,000, increasing a 25 year mortgage by $90/month. Improved performance will decrease operating costs by $20 to $60 per month depending on the heating fuel and regional energy rates.
- Compliance and enforcement will lead to new code-related jobs across the country.
- Unique needs of northern regions will need to be reflected in northern-specific building code considerations. These include both higher construction costs but also additional energy savings from practices such as super-insulation.
- Ambition B (2025) would require substantial support and training for PTs, municipalities and the construction industry to achieve. Code development can be time consuming and it can sometimes take jurisdictions several years to adopt model codes. Limiting time for training will risk raising construction costs and create quality assurance issues without substantial support.

CONSIDERATIONS

Indigenous Perspectives

- Input from the AFN recommends building codes should allow for housing solutions for Indigenous communities that reflect Indigenous culture in design (e.g., circular, modular, portable, even if uninsurable) and allow for tiny homes that are energy efficient, as well as for constellations of tiny homes for extended families.

Linkages with other working group areas and other proposed policies:

- Aligns with Canadian Energy Strategy (CES) 1.3.1 (codes)
- New building codes could include provisions to facilitate future installation of an electric vehicle charging system.
- In regions that use clean electricity for space and water heating, policy will help moderate demand on the grid, but won't achieve GHG savings.
- CMHC Equilibrium Housing research showed that net-zero ready homes still use considerable energy based on occupant behaviour (e.g. number of televisions and hot water usage). Demand management and behavioural change are necessary complementary measures.(B7)

Implementation, feasibility, technological and enabling infrastructure issues:

- Proposed performance levels are feasible using existing technology and are the current building code requirements in jurisdictions such as Brussels, Belgium.
- Developing all model building code steps at the same time would provide better regulatory certainty and allow early adopters to use them as stretch codes.
- Home labelling programs such as ENERGY STAR® or a Canadian version of Passive House would help builders prepare for future increases to building code requirements.

- New codes would need to be accompanied by significant training programs for builders as well as strong performance-based compliance verification. It is more effective for code compliance to be verified through a performance path (such as an EnerGuide energy evaluation) to confirm performance rather than a prescriptive checklist.
- Lessons learned in new home construction will spill-over into the existing renovation market.
- Carbon intensity targets could be included to promote low carbon materials and construction alternatives, giving greater consideration to embodied energy in construction.
- Funding demonstration communities would showcase technology, tools, and solutions.
- Adoption of new construction practices can be accelerated through capacity building mechanisms such as Local Energy Efficiency Partnerships (LEEP).
- Scalability: emission reduction potential limited to the number of national housing starts.

B2 Existing Housing

POLICY GOAL: Increase energy efficiency of existing residential housing stock

POLICY TOOL: Financial incentives (e.g., grants, tax preferences, low interest loans) and regulations

Policy Details

Ambition A: Financial incentive (e.g., grant, tax preference, low interest loan) to reduce energy use of existing low-rise housing sector by 1.5% (22 PJ) though voluntary shallow retrofits to 1 million homes

- $750 - $1,000 incentive to leverage $5,000 investment (e.g., total incentive cost $750M to $1B) Incentives would need to be substantially adjusted for low-income homes and social housing (80%-100% of costs in most existing programs). The financial incentive is scaled down from the $1,400 average grant of the 2007-2012 ecoENERGY Retrofit-Homes program, given that the policy option targets lower average energy savings and a smaller homeowner investment.
- Measures would focus on most affordable envelope retrofits. Heating systems would be excluded as many will reach the end of their service life and be replaced before 2030. Replacement equipment performance could be regulated separately (B5).
- Roll-out: Program would target 50,000 homes in year 1, ramping up to 200,000 per year.
- Enabling Measures:
  - A robust national rating system such as EnerGuide.
  - Training and quality assurance for building professionals.
  - Exploration of a turnkey renovation program that provides retrofit advice, helps with product selection, and pre-qualifies contractors, to overcome obstacles to homeowner participation such as lack of knowledge and time needed for project coordination.

Ambition B: Financial incentive (e.g., grant, tax preference, low interest loan) to reduce energy use of existing low-rise housing sector by 4% (58 PJ) through the voluntary deep retrofit of 1 million homes.

- Financial incentives: $4,000 - $5,000 incentive to leverage $30,000 homeowner investment. Total cost of incentives $4-5 Billion. Incentives would need to be substantially adjusted for low-income homes and social housing (80%-100% of costs in most existing programs). The financial incentive is scaled up from the $1,400 average grant of the 2007-2012 ecoENERGY Retrofit-Homes program. The policy option targets higher average energy savings and greater homeowner investment.
- Roll-out: Incentive program(s) could run for 10 years at average of 100,000 total participants per year.

- Enabling Measures:
  - » A robust national rating system such as EnerGuide.
  - » Authorities with jurisdiction would require mandatory energy labelling at time of sale and inclusion in real estate listings to inform home buyers of energy performance. Mandatory labelling of all houses highlights weak and strong performers and encourages retrofits.
  - » Regional legislation that allow authorities with jurisdiction to require mandatory home labelling.

Ambition C: Regulation/Loan Program to reduce energy use of existing low-rise housing sector by 10% by requiring moderate retrofits at time of home sale or building permit application

- Regulation:
  - » Authorities with jurisdiction would require moderate energy retrofit at time of home purchase or building permit issuance (total 400k homes per year) if the home did not meet minimum performance standards. On average this would require the homeowner to invest $10,000+. Requirements would focus on envelope retrofits.
  - » Relating to home sales, regulation could require completion of retrofits by the buyer within a specified period of time after taking possession of a home (e.g. 1-2 years). This could allow buyers to account for retrofit costs when seeking financing, and would avoid creating delays in housing sales or quality issues due to rushed renovations.
  - » Relating to building permits, regulation could require owners to conduct retrofits to meet a minimum energy performance requirement as a condition of building permit issuance. Requirements could be tied to the type of renovation. Estimated reductions below assume only ~50% of permit applications would trigger retrofits.

- Residential loan program: Options include on-bill financing, local improvement charges, or government guarantees. Loans should be low-interest and tied to property to maximize uptake. Expanded financial support – possibly in the form of grants – might be needed to support low-income homes and social housing (80%-100% of costs in most existing programs).
- Coverage: All purchasers of existing homes and owners applying for building permit. Homes meeting specified performance level may be excluded.
  - » Enabling Measures:
  - » Regional legislation that allow authorities with jurisdiction to adopt retrofit codes.
  - » Development of effective code compliance mechanisms.

Options		Est. reductions in 2030	Est. cost/tonne*
A	Financial incentive to reduce low rise housing energy use 1.5% via voluntary **shallow retrofits** to 1 million homes	1 Mt	Elec/Oil: < $0 Nat Gas: $50-100
B	Financial incentive to reduce energy use by 4% via voluntary **deep retrofit** of 1 million homes	2 Mt	Elec: $0 Oil: $0-$50 Nat. Gas: > $250
C	Regulation/loan program to reduce energy use by 10% by requiring **moderate retrofits** at time of home sale or permit application	6 Mt	Elec/Oil: < $0 Nat. Gas: $100-250

* Note: costs are national averages. Costs per tonne will vary widely by region; estimates do not consider the potentially significant value of avoided generation/transmission investments to electricity utilities and natural gas distributors. Costs may also overstate actual costs as costs are lower for older and inefficient buildings; for instance, over half of retrofits of natural gas-heated homes built prior to 1983 could be achieved for less than $50/tonne. In some cases costs are negative (<$0/t) even for natural gas-fuelled buildings.

ECONOMIC AND CONSUMER IMPACTS

Ambition A and B: Financial Incentives (e.g., grants, tax preferences, low interest loans)

- Retrofit incentives generate economic activity and strong demand for Canadian products such as insulation, windows, and doors.
- Receipt-based financial incentives (e.g., audited grant and tax preferences) diminish the underground retrofit economy.
- Strong consumer support for incentives, but care is needed to avoid free ridership, e.g., by focusing incentives on retrofits with low market share. Products such as gas furnaces and windows can have very high free ridership rates as consumers already tend to choose high efficiency options.
- Research indicates energy efficiency program spending leads to net GDP increases -, e.g., Energy North East found $1 spent on energy efficiency programs let to $4 to $8 dollars of GDP[80].

Ambition C: Regulation/Loan Program

- Mandatory retrofit regulations would need to be carefully designed to minimize negative impacts on consumers, e.g. increasing home purchase or non-efficiency renovation costs, driving delays in home purchasing, etc.
- A retrofit regulation could also cause expansion of underground economy as consumers seek to avoid mandatory retrofits and service taxes by not getting a building permit.
- Could affect the financial security of some homeowners who require renovations but are on fixed incomes, although access to funds could be facilitated by well-designed loan programs.
- Significant job creation in retrofitting, compliance, and energy evaluations.
- Real estate activity could slow considerably while the market adjusts to requirements.

CONSIDERATIONS

Indigenous Perspectives

- Input from the AFN recommends that consideration should be given to the impacts of climate change and more extreme weather conditions on buildings in Indigenous communities when designing incentives and regulations for retrofits.
- Input from the MNC notes that each of the Governing Members has a housing authority, which would have an interest in areas such as energy-efficiency investments, infrastructure, and other opportunities to transition to a low-carbon economy. Energy efficiency initiatives could help Métis homes and businesses to lower emission and energy costs.

Co-benefits/negative impacts:

- Incentives are an effective way to pull demand for energy efficiency, and prepare renovators and manufacturers for longer term regulations (push).
- Deep retrofits will be unaffordable for many low-income households and will require targeted programs.
- Rapidly increasing the demand for retrofits risks introducing poorly qualified contractors, and creating potential health, safety, and building durability issues for homeowners. Should be preceded/accompanied by contractor training and/or accreditation programs.

Linkages with other working group areas and other proposed policies:

- Aligns with Canadian Energy Strategy (CES) 1.2.1 (financing EE)

80 Malone, Howland et al. 2014. Energy Efficiency: Engine of Economic Growth in Canada. Environment Northeast. Ottawa, ON.

Regional impacts including northern and remote communities:

- Targeting incentives based on housing vintage, climate zone and fuel mix would maximize GHG savings, but result in regional bias of the distribution of program funds.
- Access to energy advisors to label homes may be difficult in rural and northern regions.
- Rural and remote areas have limited access to qualified renovators, a greater prevalence of lower household incomes, and higher percentage of old homes – may warrant targeted programs with more contractor support, higher incentive levels.

Implementation, feasibility, technological and enabling infrastructure issues:

- Incentives are a well-established, widespread approach to retrofits. Main challenges are minimizing free ridership and overcoming transaction costs – can be addressed via 'turnkey' programs with accredited contractors
- Incentives could be expanded to include equipment to accelerate equipment upgrades.
- Older homes more likely to be able to reach target and receive grant for deep retrofits.
- Scalability: measures can be scaled up/down.
- Additional considerations required for heritage buildings due to increased complexity/costs
- Time-of-sale labelling allows purchasers to assess and value energy efficiency, encouraging retrofits. European Union experience suggests stringent compliance and coverage of all building types leads to more success with consumer acceptance.
- Renovator certification programs could be developed through industry organizations such as the Canadian Home Builders Association.
- Deep retrofit systems need to be defined, costed and de-risked by the renovation industry working together through capacity-building mechanisms such as Local Energy Efficiency Partnerships (LEEP).
- Continuing RD&D efforts can enable more affordable deep energy retrofits of existing homes and buildings (e.g. developing novel affordable construction practices)
- Proposed policy measures could be applicable to social housing. However, targeted programs, including no-cost retrofits may be required to reach low income and social housing segments. Uptake in low income and social housing is expected to require an incentive model that pays for 80-100% of retrofit costs leading to much higher program delivery costs. For example, the shallow retrofit of 50,000 homes at a cost of $5,000 each would cost $250 million.

B3 Net-Zero Ready Codes for New Commercial-Institutional Buildings

POLICY GOAL: Reduce emissions from new commercial/ institutional/ high rise multi-unit residential buildings

POLICY TOOL: Regulations

Policy Details

- Reduce emissions from new commercial/institutional/multi-unit residential buildings through more energy efficient buildings
- 'Net-zero ready' buildings leverage high efficiency equipment and building envelopes so that they only use as much energy as they could potentially produce from renewable energy.
- The policy would require authorities having jurisdictions (e.g. provinces/ territories/ municipalities) to adopt "net zero ready codes" supported by a model National Energy Code of Canada for Buildings.

Ambition A: Increase the energy requirements in building codes and in the National Energy Code of Canada for Buildings to reach net-zero ready by 2035

- Coverage: New commercial, institutional and high rise multi-unit residential buildings.
- Roll-out: Adoption of new energy codes by authorities having jurisdiction that increase the energy performance of new building construction to net-zero ready by 2035, representing an average improvement in building energy efficiency of 65% relative to 2015 model energy code (exact percentage varies by climate zone and building type). Model National Energy Codes for Buildings would provide a stepped roadmap to net zero ready.
- Enabling Measures:
  - » Substantial capacity building of industry professionals and compliance officials (training and tools).
  - » Accelerated national adoption by authorities having jurisdiction through a common roadmap that includes model national energy codes.

Ambition B: As per Ambition A but accelerated by 5 years to 2030.

Ambition C: As per Ambition A but accelerated by 10 years to 2025.

Options		Est. reductions in 2030	Est. cost/tonne*
A	Building codes reach **net-zero ready by 2035**	4 Mt	Gas/Elec.: $100-250 Oil/Elec.: $0-50 Elec.: <$0
B	Building codes reach **net-zero ready by 2030**	5 Mt	
C	Building codes reach **net-zero ready by 2025**	5 Mt	

*Note: cost/tonne will vary widely by region and building type; estimates do not consider the potentially significant value of avoided generation/transmission investments to electricity utilities and natural gas distributors.

ECONOMIC AND CONSUMER IMPACTS

- Significant incremental cost to achieve net-zero ready could slow new construction and be cost prohibitive. An initial 20% increase over average commercial construction costs is assumed, although modeling in other jurisdictions with different climate zones or other characteristics (e.g., California, Europe) suggests an increase of 1-12% with design improvements
- High performance buildings have lower operating costs that help overcome construction costs.
- Compliance and enforcement will create thousands of new jobs across the country.
- Studies show employee performance improves with building performance.
- 2025 and 2030 scenarios are very ambitious and would require substantial support and training for PTs, municipalities and the construction industry to achieve. Code development can be time consuming and jurisdictions often require several years before adopting and implementing model codes. Limiting time for code development, stated intention to adopt by jurisdictions, the necessary administrative infrastructure, and training will impact the buy-in from jurisdictions and industry stakeholders including developers, owners, facility managers, building officials and service providers.

CONSIDERATIONS

Indigenous Perspectives

- Input from the AFN recommends building codes should allow for housing solutions for Indigenous communities that reflect Indigenous culture in design (e.g., circular, modular, portable, even if uninsurable) and allow for tiny homes that are energy efficient, as well as for constellations of tiny homes for extended families.

Linkages with other working group areas and other proposed policies:

- Carbon intensity targets could be included to promote low carbon materials and construction alternatives, giving greater consideration to embodied energy in construction, such as through increased wood use in tall buildings. (See F1).
- R&D demonstration projects could showcase tools and solutions that demonstrate building code compliance pathways.
- Aligns with Canadian Energy Strategy (CES) 1.3.1 (codes).

Regional impacts including northern and remote communities:

- In regions that use clean electricity for space and water heating, policy will help moderate demand on the grid, but won't achieve GHG savings.

Implementation, feasibility, technological and enabling infrastructure issues:

- California and European jurisdictions have implemented similar targets for 2016-2030
- Developing all proposed model building code tiers at the same time would provide better regulatory certainty and allow early adopters to use them as stretch codes.
- Successful roll-out by 2030 would require immediate work on technical development and training programs
- It is not always possible to install sufficient renewable energy to make commercial buildings fully 'net-zero' - access to solar, wind, and geothermal energy sources can be diminished by the proximity of other buildings (e.g. shade, block wind, depleting energy from the ground etc.).
- Opportunity exists to introduce a requirement for green roofs on select building types. A National Research Council study found that the soil and plants on roofs can reduce energy demand. However, there are conflicting reports regarding the impact of green roofs on energy reduction and further study may be needed.

B4 Existing Commercial-Institutional Buildings

POLICY GOAL: Increase building energy efficiency from existing commercial/ institutional/ high rise multi-unit residential buildings

POLICY TOOL: Incentives, Information Programs, and Regulations

Policy Details

Ambition A: Financial Incentives/Information Programs to reduce energy use in the Commercial, Institutional and high rise Multi-Unit Residential Buildings sector by 2%

- Incentives and voluntary information programs.
- Financial incentives: Performance based financial incentives of $15 /GJ saved. Total cost of subsidy estimated at $125 million. All Commercial, Institutional and high rise Multi-Unit Residential Buildings, excluding government owned (see Government Operations options).
- Information programs:
  - » Expand the ENERGY STAR Portfolio Manager energy performance benchmarking tool to include ENERGY STAR Score rating system for 21 building types. (U.S. experience with voluntary consistent benchmarking suggests 5% average reduction in energy use after three years of regular benchmarking).
  - » Thermographic/solar maps of 30 cities to inform owners on the energy performance of their roofs and potential for roof-top PV.
- Roll-out: Incentive programs supported by an expanded benchmarking tool and solar thermographic maps (available for 12 years), would issue more than 200 incentive payments per year for five years.
- Enabling Measures: Significant training and quality assurance for building professionals.

Ambition B: Reduce energy use in the Commercial, Institutional and high rise Multi-Unit Residential Buildings sector by 3% through measures in Ambition A and energy disclosure regulations

- Regulation to require mandatory energy disclosure of all commercial, institutional and high rise multi-unit residential buildings, excluding government owned.
- Roll-out: National framework for energy disclosure implemented in 2020.

Ambition C: Reduce energy use by 17% in the Commercial, Institutional and high rise Multi-Unit Residential Buildings sector through measures in Ambition B, regulations and $750M in financial incentives

- Regulation:
  » Authorities with jurisdiction would adopt a retrofit building code coupled with regulations that require energy retrofits at time of renovation.[81] This would improve the energy efficiency of 10% of buildings annually. Under a retrofit code, whole-building renovations are expected to achieve 25% energy savings on average (significantly less for smaller renovations). Excludes government owned buildings.
  » Authorities with jurisdiction would regulate mandatory recommissioning every 5 years, supported by a national framework. Recommissioning focuses on low or no-cost operational improvements from ensuring equipment and systems operate optimally.
- Financial incentives: Performance based financial incentives/tax credits of $15 /GJ saved. Total cost of subsidy estimated at $750 million.
- Roll-out: Retrofit Code developed by 2020, adopted 2022. Framework for mandatory recommissioning developed by 2018, implemented 2020. Incentive program launched 2018.
- Enabling Measures:
  » Regional legislation that allows provinces and territories to enact an energy retrofit code that would be actioned at the time of renovations, and to mandate regular recommissioning.
  » Development of effective code compliance mechanisms through capacity building and training measures.

Options		Est. reductions in 2030	Est. cost/tonne
A.	**Financial Incentives/Information Programs** to reduce energy use by 2%	<1 Mt	< $0
B.	Reduce energy use by 3% through measures in Ambition A and **energy disclosure regulations**	<1 Mt	< $0
C.	Reduce energy use by 17% through measures in Ambition B and **$750M in financial incentives**	6 Mt	< $0

Note: cost/tonne will vary by region and building type; estimates do not consider the potentially significant value of avoided generation/transmission investments to electricity utilities and natural gas distributors.

ECONOMIC AND CONSUMER IMPACTS

- This option is particularly cost-effective compared to residential retrofit policies because of low-cost opportunities from recommissioning , and greater energy savings resulting from more comprehensive retrofits and higher energy loads (e.g., more occupants, greater plug loads, energy use in peak times, higher lighting loads, etc.) as compared to housing.
- Financial incentives generate strong retrofit activity and related professional activity.
- Total cost of a tax preference can be difficult to estimate and is outside of the government's direct control.

81 Note that regulations and code would not compel standalone retrofits. Retrofits would only be required when owner is undertaking certain renovations.

- Studies show employee productivity directly correlated to building performance.
- Significant job creation in building retrofitting, compliance, and energy professionals.

Implementation, feasibility, technological and enabling infrastructure issues:

- Opportunities could be sought to apply retrofit and recommissioning initiatives to existing primary covered agricultural buildings which collectively emit approximately 4.8Mt of GHGs.
- To avoid free riders, incentives should target deep retrofits with longer term simple paybacks with positive economic value.
- Capacity building of professionals on ENERGY STAR Portfolio Manager could be done by third party representatives such as community colleges.
- Voluntary information programs such as thermographic and solar mapping have demonstrated a significant increase in the adoption of solar technology and retrofits by building owners.
- Mandatory energy disclosure would increase awareness of energy efficiency, encourage retrofits, and increase value of energy efficient buildings. In the European Union mandatory labelling has had mixed results, but countries that were more stringent on compliance, and targeted all building types, had more success.
- Retrofit code would be applied at time of building renovation; jurisdictions currently considering retrofit codes could serve as models. In England and Wales, all rental properties are required to have a minimum energy rating in order to be lawful to rent as of April 2018. City of Vancouver requires energy upgrading of existing buildings.
- Regulation: Mandatory Recommissioning
  - » Short payback (2-24 months) on small investment in recommissioning.
  - » Supports mandatory energy disclosure.
  - » Would sharply increase demand for recommissioning experts; may warrant training programs

B5 Equipment Efficiency

POLICY GOAL: Increase energy efficiency of equipment used in homes and buildings

POLICY TOOL: Regulations and labelling

Policy Details

Option A: Increase minimum standards and labelling (EnerGuide and ENERGY STAR®) for up to 10 categories of space and water heating equipment beyond U.S. minimum energy performance levels

- Regulations: Increase regulated energy performance for up to 10 categories of space and water heating equipment beyond U.S. levels.
- Labelling: Use EnerGuide and ENERGY STAR® labelling programs to promote higher efficiency equipment and encourage innovation, thereby preparing the market for higher energy performance regulations. ENERGY STAR® levels for up to 10 categories of space and water heating equipment would exceed U.S. ENERGY STAR® levels.
- Roll-out: Implement more stringent regulations for space and water heating equipment by 2025, preceded by 8 years of market transformation initiatives (e.g., incentives) at an estimated cost of $40 million per year targeted at those products with a positive cost per tonne in 2016 to encourage market acceptance and make them less than zero by 2025. Incentives to encourage retrofits, such as those presented in B2, could be used to support the market transformation of space and water heating equipment.

Option B: Increase minimum standards for additional product categories, such as home appliances, consumer electronics and lighting beyond U.S. levels; and set standards for product categories that are not yet regulated in Canada or the U.S. at the national level

- Regulations: Increase regulated energy performance for up to 5 categories of lighting, home appliances, and consumer electronics beyond U.S. levels, and explore opportunities to regulate additional equipment and products not regulated at the national level.
- Labelling: Use EnerGuide and ENERGY STAR® labelling programs to promote higher efficiency equipment and encourage innovation, thereby preparing the market for higher energy performance regulations. ENERGY STAR® levels for selected categories would exceed U.S. ENERGY STAR® levels.
- Roll-out: Higher energy efficiency standards for selected categories, such as lighting, home appliances, and consumer electronics implemented in 2025, preceded by 8 years of market transformation initiatives at an estimated cost of $20 million per year to overcome barriers to consumer acceptance associated with changes to product form and function (e.g. heat pump clothes dryers). Incentives to encourage home retrofits, such as those presented in B2, could be used to support the market transformation of these equipment categories.

Option C: Regulations to phase-out residential space and water heating equipment (such as high efficiency furnaces) that is less efficient than heat pump technology

- Regulations: New regulations requiring all space and water heating equipment to be at least as efficient as heat pump technology. (Heat pump technologies can operate at greater than 100% efficiency.)
- Labelling: Use EnerGuide and ENERGY STAR® labelling programs to promote higher efficiency equipment and encourage innovation, thereby preparing the market for higher energy performance regulations. ENERGY STAR® levels for selected categories would exceed U.S. ENERGY STAR® levels.
- Roll-out: Regulations would begin phase-out of technologies in 2028 (to allow time for RD&D to reduce costs of newer technologies), with full market turnover by 2048 preceded by 11 years of market transformation initiatives at an estimated cost of $90 million per year targeted at those products with a positive cost per tonne in 2016 to encourage market acceptance and make them less than zero by 2028. Fuel switching policies, such as those presented in B6, could also be used to support the market transformation of space and water heating equipment.

Options		Est. reductions in 2030	Est. cost/tonne
A.	Increase minimum standards and labelling (EnerGuide and ENERGY STAR®) for up to 10 categories of **space and water heating equipment beyond U.S. levels**. (Emission reduction estimates include 4Mt from announced federal actions baseline)	6 Mt	Varies by category **In 2016:** < $0 to $100-250 **By implementation:** <$0*
B.	Increase minimum standards for additional product categories, such as **home appliances, consumer electronics and lighting beyond U.S. levels**; and set standards for product categories that are not yet regulated in Canada or the U.S. at the national level. (incremental to Ambition A)	1 Mt	Varies by category In 2016: < $0 to $100-250 By implementation: <$0**
C.	Regulations to **phase-out residential space and water heating equipment** (such as high efficiency furnaces) that is less efficient than heat pump technology. (incremental to Option A)	<1 Mt*	**In 2016:** Oil to HP: < $0, Nat Gas to HP: >$250 **By implementation:** <$0**

*Note that reductions for Option C are relatively low in 2030 because implementation begins in 2028, but will become much more significant in the longer term, e.g., 2050.

**Cost by implementation date for all measures anticipated to be <$0/t due to long ramp-up period, market transformation initiatives and technological improvements

ECONOMIC AND CONSUMER IMPACTS

- Regulations will increase price of equipment, but improved performance will lower operating costs.
- Manufacturers could incur additional regulatory burden (e.g. reporting) with Canada-specific regulations.
- In 2030, consumers and businesses would save the following amounts on their energy bills:
  - » Announced federal measures (Budget 2016): $4.0 billion
  - » Option A + Budget 2016: $5.2 billion
  - » Option A + B + Budget 2016: $6.2 billion

CONSIDERATIONS

- Proposed policies build off of Federal Budget 2016 under which Canada plans to align energy efficiency regulations and labelling program with those of the U.S. for over 50 product categories by 2020. Alignment reduces regulatory burden on industry. The province of Ontario has already aligned some of their energy efficiency regulations with those of the U.S.

Linkages with other working group areas and other proposed policies:

- Use of natural gas heat pumps, rather than electric could help mitigate increased electricity load.

Regional impacts including northern and remote communities:

- In regions that use clean electricity, more stringent electricity consumption regulations will help moderate demand on the grid, but won't achieve GHG savings.

Implementation, feasibility, technological and enabling infrastructure issues:

- Energy efficiency standards and labelling programs are among the most cost effective approaches to improving energy efficiency and reducing greenhouse gas emissions.
- Canada's Energy Efficiency Regulations currently establish standards for over 40 product categories; the ENERGY STAR® labelling program currently sets voluntary specifications for 70 product categories.
- Federal government can set standards for products that are imported or shipped inter-provincially for the purposes of lease or sale.
- Provinces can set standards for products manufactured or sold within their borders.
- Coordinated research, development and deployment will be needed in advance of regulatory implementation.
- Collaboration and engagement with domestic and international partners will help leverage expertise in emerging technology development and deployment.
- Prior to regulations, consumer incentives could be used to accelerate market adoption of products.
- Increased levels of investment in market transformation can accelerate implementation of regulations and improve cost per tonne.
- There is considerable historical evidence that production costs and consumer prices of equipment decrease with time as a result of increased production efficiency and cumulative experience on the part of manufacturers. Market transformation would accelerate the rate of decrease.
- Emerging heat pump technologies that operate on electricity or natural gas work effectively at lower outdoor temperatures, expanding their application to colder climates.
- At current energy prices, moving from natural gas to electricity for space and water heating would not prove cost effective, despite the improvement in equipment efficiency.
- Time frame for implementation reflects need for additional research and development to develop cost effective technological solutions.

B6 Renewable Power and Fuel Switching

POLICY GOAL: Incentivize distributed renewable power generation and low carbon fuel source changes in buildings.

POLICY TOOL: Financial incentives (grants, tax preferences, low interest loans)

Policy Details

Option A: Financial incentives (e.g., grants, tax preferences, low interest loans) to achieve installation of 1 million 5 kW solar photo voltaic systems to help reduce demand for fossil fuel based electricity generation (2 models)

Incentive model:

- 30% subsidy to encourage $20,000 investment in 5kW system. Follows US DOE model. Total value of subsidies estimated at $6 Billion. Subsidy levels would drop with reduced system costs.
- Eligibility: Certified residential or commercial/institutional (CI) roof top or building mounted systems, or agricultural buildings. Owners can have more than one 5kW system, but utility scale generation is excluded.
- Roll-out: Would run for 10 years or until 1 million 5kW installations completed.

OR

Loan programs model:

- Financing to give homeowners access to $20,000 to purchase eligible system. Financing could be via utility bills, local improvement charges, bank loans, or government guarantees. Low-interest financing that is transferable with building ownership will increase attractiveness (e.g., tied to the property)
- Electricity rate guarantees above market value may be needed to reduce payback period and enhance uptake although significant reductions in PV panel costs make this less necessary. Impacts on electricity rates also need to be considered.
- Eligibility: Certified residential or CI systems.
- Roll-out: Would run for 10 years or until 1 million 5kW installations completed.

Option B: Financial incentive (grant, tax preference, low interest loan) to reduce GHG emissions by 5Mt by fuel switching space and water heating from oil/natural gas to less GHG intensive alternatives (2 models). Equivalent to conversion of ~10% of existing residential floor space in 2013 (~1.4 million homes) and 14% of commercial floor space, in both cases largely from natural gas as it is the dominant heating fuel.

Financial incentives model:

- Grant of $300/tonne of annual net GHG reduction to convert diesel/oil/ natural gas to less GHG intensive alternatives for heating, e.g., low emitting electricity, bioenergy or other alternatives. Level of subsidy is aligned with existing provincial programs including conversions from oil heating to heat pump and other conversion types. For some types of conversions, energy cost reductions can offset the initial cost, over and above the subsidy.
- Size of incentive will vary based on the existing fuel type (diesel, oil or natural gas), size of building (residential vs commercial) and the GHG intensity of new energy source (e.g., local electric grid). Total cost of subsidy estimated at $1.5B. Residential homeowners would receive an average of $1,500 for a $10,000 investment.

- Eligibility:
  - » Homes and buildings (including agricultural buildings) that can reduce GHGs by converting from oil/natural gas to less GHG intensive alternatives such as carbon-beneficial biomass and cleaner electricity.
  - » Including carbon beneficial biomass such as wood pellets may help move Northern and remote communities off heating oil and/or diesel.
- Roll-out: Would run for 10 years or until targeted GHGs saved, whichever occurs first.

OR

Residential loan program model:
- Facilitate consumer access to financing through measures such as on-bill financing, local improvement charges, bank loans, or government guarantees.
- Eligibility and roll-out: As per incentive option

Options		Est. reductions in 2030*	Est. cost/tonne
A.	Incentive or loan programs for **1 million 5 kW solar photovoltaic systems**	<1 Mt	> $250
B.	Incentive or loan programs to reduce 5 Mt of GHG emissions by **fuel switching space and water heating** from oil/diesel/natural gas to less GHG intensive alternatives.	5 Mt	Oil to Elec: < $0 Nat Gas to Elec: >$250

* Reductions for Option B assume electricity grid emissions intensity follows business as usual projections. Reductions will change to the extent electricity emissions intensity decreases or increases.

ECONOMIC AND CONSUMER IMPACTS

Option A: Solar photovoltaic power generation
- Job creation – e.g., ON program created 12,000 jobs in 2015 for solar installation.
- Can be more expensive in smaller isolated communities.
- Use of above-market value rates for PV electricity can create rate pressure for all electric customers. However, the size of such incentives has decreased as PV becomes more cost competitive with conventional generation sources.
- Total cost of a tax preference can be difficult to estimate and is outside of the government's direct control.

Option B: Fuel Switching
- Electrification could substantially increase electricity heating demand – modeling suggests by ~150 PJ in 2030 relative to baseline, increasing need for grid investments and/or energy efficiency policies.
- Price-differential between natural gas and electricity will make it difficult to achieve uptake by gas-heating consumers as natural gas costs are ~3.5 times lower. Varies by jurisdiction and heating technology.
- Oil conversion to electricity offers energy efficiency improvements and lower operating costs and therefore has the most attractive payback.
- Reduced revenues for gas utilities and fuel oil distributors and potential for stranded assets. Modeling suggests a ~20-30% reduction in sector demand for these heating fuels in 2030 relative to business as usual, although demand for natural gas increases to supply increased electricity demand.
- Use of waste wood could provide direct and indirect benefits for rural forest-based communities, e.g., energy autonomy, regional investment, employment, forest sector growth.

CONSIDERATIONS

Indigenous perspectives:

- Input from the AFN recommends that Indigenous communities may need additional and targeted support to adopt and switch to less carbon intensive energy (heating and power) systems and solar solutions.
- Input from the MNC notes that each of the Governing Members has a housing authority, which would have an interest in areas such as energy-efficiency investments, infrastructure, and other opportunities to transition to a low-carbon economy.

Option A: Solar photovoltaic power generation

- PV can help reduce dependence on diesel in Indigenous and remote communities, but requires targeted solutions due to increased costs from the need for storage to make the hybrid renewable/diesel systems effective.

Linkages with other working group areas and other proposed policies:

Option A: Solar photovoltaic power generation

- Grid upgrades may be needed to handle intermittent generation.
- Surplus solar PV generation can potentially be exported to the US due to support recent North American clean power goals (50% continent-wide by 2025) and US Clean Power Plan compliance options for states.
- Aligns with Canadian Energy Strategy 4.1.2 (renewables deployment), 6.1.1 and 6.1.2 (clean electricity).

Option B: Fuel Switching

- Given Canada's cold climate and significant heating load, grid upgrades are first needed in some jurisdictions to build capacity for electrification of heating. (Electricity sub-group)
- Fuel switching incentives support longer term strategies to phase-out less efficient space and water heating alternatives. (See B5). If the performance of space and water heating equipment was regulated per B5, incentives would have to end before implementation of the regulation
- Aligns with Canadian Energy Strategy (CES) 4.1.2 (energy system innovation), 6.1.1 (clean electricity/heat).

Regional impacts including northern and remote communities:

Option A: Solar photovoltaic power generation

- Greater GHG impact in regions with high emitting grid supply. Less GHG intensive grids (e.g. BC, MB, QC, ON) may not need more supply from solar PV which may lead to excess low-carbon supply in the absence of export capacity and/or increased demand.

Option B: Fuel Switching

- Remote communities often have higher electricity prices and many of their grids are already at maximum load. Electrification risks exceeding local capacity and further increasing costs for heating and other electrical uses. Higher financial incentives may be needed.
- Most remote communities are forest-based; biomass may be a readily available and opportunistic renewable fuel for baseload heat and power in these communities.
- In some jurisdictions, when heating is shifted from natural gas to electric, increased heating load on the grid will likely be met with natural gas generation unless other policies constrain this choice. Incentive programs should be designed to minimize this outcome since it effectively results in little to no net GHG reduction.

Implementation, feasibility, technological and enabling infrastructure issues:

Option A: Solar photovoltaic power generation
- Scalability: measures can be scaled up/down.
- Carbon pricing on emitting fuels will shorten payback on renewables.
- Would create approximately 5600 GWh of additional generation/year once fully implemented

Option B: Fuel Switching
- To fuel switch to electricity, the grid must be able to accommodate additional heating load.
- Greatest GHG impacts and incentives will occur where switching to low/zero emissions electricity, particularly from oil.
- In jurisdictions with a large spread between electricity and natural gas prices consumers are less likely to convert from natural gas to electricity. Will likely need much higher incentives or a significant carbon tax to reduce the price differential between gas and cleaner electricity.
- Use of biomass such as wood pellets as a fuel source may help move Northern and remote communities off heating oil. Sustainable biomass from harvest residues or other sources has lower emissions on a life-cycle basis when compared to use of fossil fuels. The most cost- and mitigation-effective projects may use local waste wood.

B7 Demand Response Opportunities and Behaviour Change

POLICY GOAL: Reduce emissions through the adoption of behavioural programs to lower consumers' energy bills

POLICY TOOL: Regulations, incentives/rebates and targeted information campaigns

Policy Details

Option A: Regulations requiring utilities to offer enhanced billing, to reduce energy use in the residential sector by 2%
- Regulation: Require utilities to offer enhanced billing (providing more user friendly information on utility bills that includes comparing energy use with other households).
- Coverage: All utilities that service residential households.
- Roll-out: Implement requirement for enhanced billing by 2025. Roll-out preceded by a voluntary phase from 2017-2025. Timeline could be accelerated if required but would vary by jurisdiction.

Option B: Regulations and incentives to reduce peak electricity demand by 1-2% through time of use rates or by providing utilities control over household thermostat settings
- Time of use rates Regulation: Mandate utilities to adopt rate structures that are price-based to limit energy use during specific peak times.
- Coverage: All electrical utilities
- Roll-out: Adoption of rate structures by most jurisdictions by 2025. Could potentially be accelerated but timelines would vary by jurisdiction.
- Financial Incentives / Suasion for utility controlled thermostats: Electrical utilities to install programmable communicating thermostats (either free or with a small incentive) giving them the ability to mitigate peak summer energy use.
- Roll-out: Program would begin in 2020.

- *Option C: Financial incentive/rebate to reduce overall energy use of the residential sector by 0.75% - 1% by installing adaptive thermostats in 1 million existing households*
- Financial Incentives/rebate: 1 million homeowner incentives of $100 to install adaptive/Wi-Fi thermostats by 2030. Total incentive amount $100M. All residential households. Incentive levels based on existing programs.
- Roll-out: Program would target 10,000 homes in year 1, ramping up to 200,000 per year.

Options		Est. reductions in 2030	Est. cost/tonne*
A.	Regulations requiring utilities to offer enhanced billing, to reduce energy use in the residential sector by 2%	1 Mt	<$0
B.	Regulations and incentives to reduce peak electricity demand by 1-2% through time of use rates or by providing utilities control over household thermostat settings	1 Mt	<$0
C.	Financial incentive/rebate to reduce overall energy use of the residential sector by 0.75% - 1% by installing adaptive thermostats in 1 million existing households	<1 Mt	<$0

*Note: cost/tonne will vary widely by region; estimates do not consider the potentially significant value of avoided generation/transmission investments to electricity utilities and natural gas distributors.

ECONOMIC AND CONSUMER IMPACTS

Option A: Enhanced Billing
- Can be implemented without major investments in electricity and gas metering systems in most jurisdictions.

Option B: Time of Use Rates or Utility Controlled Thermostats
- Jobs created to support installation of millions of smart meters
- Customer bill reductions in principle.
- Avoided cost of new generation and transmission in principle
- Time of use rates have a negative impact on those who cannot shift energy use e.g. work from home.
- Costs will be incurred to implement smart meters – e.g., Ontario Auditor-General found roll-out of 5M smart meters in ON costs $1.9B.
- *Option C:* Wi-Fi Thermostats
- The cost of an adaptive/Wi-Fi thermostat is approximately $250

CONSIDERATIONS

Linkages with other working group areas and other proposed policies:
- Potential savings from behavioural policies are impacted by other behavioral or retrofit measures undertaken.

Regional impacts including northern and remote communities:
- Regions with clean electricity will moderate demand on the grid, but won't achieve GHG savings.
- Option B: Time of Use Rates or Utility Controlled Thermostats: provinces and territories may need to enact new or amend existing legislation to allow utilities to establish such price-based demand response options.
- Smart meters are fully implemented across Ontario and British Columbia. The remaining provinces are at various stages of investigating or implementing smart meters[82].

82 Ma, Lily (2014). A Big Data Pilot Project with Smart Meter Data (abridged version). Proceedings of Statistics Canada Symposium 2014.

Implementation, feasibility, technological and enabling infrastructure issues:

Option A: Enhanced Billing

- Some provinces have in place – e.g. Nova Scotia.
- US research has found that indirect billing programs can result in a 2% reduction in energy consumption and that energy savings persist[83].
- Regulatory reform is required to establish separate utilities dedicated to energy efficiency, which would avoid the conflict of interest between revenue generation and demand management, and would motivate utilities to reduce demand.
- Challenges exist in measuring and verifying energy savings/GHG reductions due to potential double-counting with other programs (e.g., retrofits, equipment standards.
- Behavioural options should be accompanied by targeted educational programs and/or marketing campaigns.

Option B: Time of Use Rates or Utility Controlled Thermostats

- Time of Use rates: In place in some PTs, e.g., ON and BC. For example, Ontario's time of use pricing has resulted in 1-2% reduction in electricity consumption during summer peak periods.
- Savings are contingent on the aggressiveness of the price difference between peak and off-peak times.

Option C: Wi-Fi Thermostats

- Research by the American Council for an Energy-Efficient Economy found that the average savings from Wi-Fi thermostats were 10-12% based on U.S. pilot programs.

B8 Urban Form & Spatial Planning

POLICY GOAL: Support the transition to a low-carbon economy by reducing GHG emissions in municipalities through smart growth oriented development patterns, and through tree plantings, green roofs and permeable spaces.

POLICY TOOL: Provincial, territorial or municipal planning directives and financial incentives.

Policy Details

Option A: Reduce transportation-related and heating-related GHG emissions in municipalities through smart growth oriented development patterns.

- Includes a suite of policies for integrated land use, transportation, and community energy planning that promote compact, higher density, mixed-use community development patterns supporting accelerated shifts to transit and active transportation modes, as well as sustainable energy use. Specific smart growth oriented policies include:
    - » Establish minimum density and minimum intensification targets in all cities (defined as population of 100,000 or greater), and increase existing targets by 25-50% in municipalities that have already established them.
    - » Require large municipalities to delineate major transit station areas in their official plans and to establish minimum gross density targets to provide transit supportive densities in those hubs or corridors.
    - » A requirement for municipalities to develop Transportation Demand Management (TDM) policies and integrate them into their official planning processes to encourage modal shifts and prioritize active/public transit in urban planning decisions. (See Transportation sector annex T7 for detailed examples of TDM policy options, some of which could be delivered at the municipal level, with appropriate support from senior governments).

83 Frey, E. and Rogers, R. (2014). Persistence: How Treatment Effects Persists After Interventions Stop. Policy Insights from Behavioural and Brain Sciences. Vol 1(1)172-179

» Increased community energy planning (energy efficiency, renewable energy systems and district energy) via requirements, technical support and/or incentives for municipalities and developers.
» Support for electric vehicles including EV parking and charging equipment in new buildings.

- Financial Incentives: Direct funding to capacity building projects that pilot and mainstream actions that result in more compact, mixed-use, higher density, transit- and pedestrian- oriented communities.
- Coverage: Emissions from buildings, transportation and private vehicles

Option B: Reduce overall urban emissions through tree planting, green roofs and permeable surfaces.

- Regulations: Include tree plantings, green roofs and permeable spaces in provincial-level environmental reviews of development projects. Require municipalities to recover full operating and/or capital costs of sewage works as development occurs to incent increased use of permeable surfaces
- Financial incentives: Direct capital funds for green roofs, urban forests and permeable surfaces
- Information programs: Develop design guidelines/ standards to promote green roofs, urban forests and permeable surfaces
- Enabling Measures: Provincial legislation is required in some cases to provide authority to municipalities toenact some of these policies.
- Coverage: Commercial, institutional and residential development with a minimum Gross Floor Area of 5,000ft^2

EMISSIONS REDUCTIONS AND COST/TONNE

- Emissions reduction estimates for 2030 were not developed for these policy options. However, previous Canadian research[84] estimates that an ambitious integrated land use, transportation and community energy policy package could reduce Canada's urban GHG emissions by 8-15 Mt per year in 2030 and 13-35 Mt per year by 2050, assuming a 2010 start date. These reductions came largely from changes in building energy use, followed by energy supply and transportation-related changes (reduced auto ownership and trip length, increased use of transit and active transport, and reduced travel demand). Similarly, research by CMHC found that compact, mixed-use, walkable and cyclist-oriented urban design can decrease transportation emissions per household by 24 to 50% compared to conventional suburban neighbourhoods.
- Urban tree planting can also provide emissions reductions – for example, planting 200 million urban trees could reduce 0.5 Mt in 2030[85.] Field trials have found green roofs can reduce daily average demand by 75 percent for cooling requirements in the spring and summer months[86].

ECONOMIC AND CONSUMER IMPACTS

Option A: Smart Growth Oriented Development

- Studies focused on 2050 have suggested that smart growth policies can increase GDP by 0.3 to 0.9% due to reduced capital, labour and energy requirements within the transportation, building and domestic energy supply sectors and that life-cycle costs of hard infrastructure are reduced by up to 25% in denser communities.[87]
- Similarly, per-lot capital costs are 33% lower with compact design vs. conventional design.
- Above-average neighbourhood walkability can add $4,000 to $34,000 to home value.
- Increases to active transportation can help address rising health sector costs due to inactivity.

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84 Bataille, C. 2010. *The Capacity for Integrated Community Energy Solutions Policies to Reduce Urban Greenhouse Gas Emissions – Final Technical Report.* MK Jaccard and Associates Inc. Prepared for Quality Urban Energy Systems of Tomorrow (QUEST). Vancouver, B.C.

85 Roulet, N.T and Freedman, B. What trees can do to reduce atmospheric CO_2. Tree Canada, Ottawa, ON. 2008.

86 Liu, K.K.Y. (2002). Energy efficiency and environmental benefits of rooftop gardens. National Research Council Canada.

87 Bataille, C. 2010. The Capacity for Integrated Community Energy Solutions Policies to Reduce Urban Greenhouse Gas Emissions – Final Technical Report. MK Jaccard and Associates Inc. Prepared for Quality Urban Energy Systems of Tomorrow (QUEST). Vancouver, B.C

Option B: Plantings/Green Roofs/Permeable surfaces

- Green roof programs can provide net savings – for example, an assessment of a Toronto-wide green roof installation program found it would provide $313 million in initial net cost savings, with an additional operating cost savings of $37 million annually. Similarly, the 10 million trees in Toronto's urban forest provide $80M in annual benefits from stormwater retention.
- Research by the National Research Council found that green roofs can assist with stormwater management strategies by reducing peak flow and retaining run-off for later use by plants[88]
- Urban trees provide a cooling effect on urban climate mainly through shade provision, reduction of air temperature and the mitigation heat island effects[89].

CONSIDERATIONS

Indigenous Perspectives

- Input from the AFN recommends policies be designed to support the development/piloting of sustainable net-zero infrastructure Indigenous communities.

Co-benefits/negative impacts:

- Policies that encourage active transportation (e.g. bike paths, well-designed sidewalks, benches, and mixed use development) also have important mental and physical health benefits and lead to additional savings in the health sectors, which offset some of the costs from policy and infrastructure changes.
- Co-benefits from green roofs, urban forests and permeable surfaces include reduced storm water runoff and improvement of the health of surrounding waterways, preservation of and protection of fish and wildlife habitat, improved air quality, social and health benefits (increased urban green spaces and recreation opportunities), reduced electricity or natural gas used to operate municipal water and wastewater systems, and greater adaptation to climate change.

Linkages with other working group areas and other proposed policies:

- Smart growth oriented development patterns are complementary to transportation emission reduction initiatives, such as TDM, that focus on reducing personal vehicle use and shifting demand to transit and active transportation modes, since a more compact mixed use urban form reduces average trip distances and makes transit and active transportation more convenient and attractive.
- Urban forests, green roofs and permeable surfaces approaches are closely aligned with integrated land use, transportation, and community energy approaches and also supports climate change adaptation goals.

Regional impacts including northern and remote communities:

Ambition A: Smart Growth Oriented Development

- Several Northern communities have prepared community energy plans, but require capacity and funds to assist with implementation.
- Implementing smart growth oriented development in smaller communities facing population declines can be challenging due to lack of resources and decreasing housing needs.

Implementation, feasibility, technological and enabling infrastructure issues:

- Planting/green roofs/permeable surfaces policies could be difficult for some municipalities to implement. Capacity (staffing, resources) must be considered for smaller municipalities. Requirements must be clearly defined if specific to urban development only. The technology is however currently available.

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88 Liu, K.K.Y. (2002). Energy efficiency and environmental benefits of rooftop gardens. National Research Council Canada.

89 Zupancic, Tara, Westmacott, Claire, and Bulthuis, Mike. (2015). The Impact Of Green Space On Heat And Air Pollution In Urban Communities: A Meta-Narrative Systematic Review. David Suzuki Foundation.

Electricity Transmission and Generation

E1. Emissions Intensity Performance Standard for Fossil Fuel-fired Electricity Generation

POLICY GOAL: Shift from emitting to low- or non-emitting sources of electricity generation

POLICY TOOL: Regulated approach, under which new and existing large fossil fuel-fired electricity generating units would be individually required to meet emissions-intensity performance standards

Policy Details

- Performance standards would apply to units over 25 MW
- Flexible compliance mechanisms (credits) are included under options A and B

	Options	Est. reductions in 2030	Est. cost/tonne*
A.	*An emission intensity (EI) performance standard (PS) of 365 tCO_2e /GWh for all large fossil fuel-fired units, beginning in 2020.*		
	Compliance credits at $25/ tonne	9 Mt	$0-$50
	Compliance credits at $50/ tonne	14 Mt	$50-$100
	Compliance credits at $75/ tonne	20 Mt	$50-$100
B.	*An EI PS for all large fossil fuel-fired units starting at 300 tCO_2e /GWh in 2020 and increasing in stringency to 250 tCO_2e /GWh in 2025.*		
	Compliance credits at $25/ tonne	11 Mt	$0-$50
	Compliance credits at $50/ tonne	15 Mt	$50-$100
	Compliance credits at $75/ tonne	21 Mt	$50-$100
C.	*EI PS for all large coal- and for natural gas (NG)-fired units that operate as baseload starting in 2030. EI PS for coal-fired units is 250 tCO_2e /GWh and for NG-fired units is 375 tCO_2e /GWh. No flexibilities.*	15-20 Mt	$50-$100**

*Note that cost estimates in the electricity sector are based on conservative assumptions, and may decline as renewable energy technologies continue to improve and the challenges to ensure electric reliability in a changing resource mix are identified and addressed.

**Nova Scotia has estimated the cost of this option at $>250/t for their jurisdiction

ECONOMIC AND CONSUMER IMPACTS

- Cost per tonne estimates above represent the difference in overall costs of supplying electricity in the policy scenario relative to the reference case. Cost of supplying electricity include: changes in capital costs, O&M costs, import costs, and fuel costs or savings. Compliance payments were not included in the cost calculation since they do not represent money spent to actually reduce emissions.[90]

90 Compliance payments made by facility owners do not represent money spent to actually reduce emissions. Although from the utility's standpoint the compliance payments would represent costs incurred, from a global standpoint these payments represent a transfer of funds from the facility owner to another entity (a government, for example) and should not (and are not) included in the cost per tonne estimated range provided.

- Beyond the costs included in calculating cost per tonne, this policy option will result in costs in some jurisdictions due to stranded assets and new infrastructure. Therefore, the cost per tonne estimates above do not represent the full cost of these measures, as they do not account for these costs, and they also underestimate the price of natural gas in Nova Scotia.[91]
- In all cases, electricity prices are expected to increase in provinces reliant on fossil fuels for electricity generation.
- The closure of coal-fired units would result in job losses at those units and depending on the economic life of the plant, may also result in investment losses in the facility itself if it cannot be used or sold for other purposes. Job losses could also occur in coal mining operations.
- The construction of new replacement generation and infrastructure could have positive economic impacts in terms of job creation.
- Electricity price increases could impact the competitiveness of affected provinces in terms of both the electricity export market and in manufacturing and industrial sectors on the global market.
- For levels A and B, compliance costs could be reinvested in clean electricity technologies or used to mitigate electricity price increases to customers and stimulate the economy.

CONSIDERATIONS

Co-benefits/negative impacts:

- In addition to health benefits from improved air quality, environmental co-benefits include improved air quality, reductions in air pollutants, water intake and discharge as well as reductions in solid waste disposal.

Linkages with other working group areas and other proposed policies:

- Supports the Canadian Energy Strategy goal to "Foster an understanding by governments on the use of market-oriented policies to reduce greenhouse gas emissions across Canada" and to "Actively pursue greenhouse gas emissions reductions with targets based on sound science".

Regional impacts including northern and remote communities:

- Impacts in Nova Scotia are expected to be considerably higher due to limited access to natural gas; existing natural gas supplies are far more expensive in Nova Scotia; and the high cost of building new gas pipeline extensions needed for reliability from the rest of Canada into Nova Scotia. Based on its record of GHG reductions, in 2014 Nova Scotia established an equivalency agreement with the Federal Government which committed to GHG reductions equivalent to those defined in new Federal regulations. The agreement defines firm GHG reductions commitments while allowing the policy flexibility required to operate coal-fired electricity plants to their end-of-life dates. Through this approach, investments are being made in new, clean electricity resources versus investments in carbon-emitting assets. Similar flexibility would be required for any further acceleration of the phase-out of coal-fired electricity generation in Nova Scotia or increased stringency of performance standards on these plants.
- Estimated emissions reductions do not include Alberta's Climate Leadership plan. Alberta's coal phase out policy, along with their other policies including the renewable energy target and the carbon levy, could achieve similar results to this policy (i.e., reductions under this policy would not be incremental to policies recently announced in Alberta)
- New Brunswick is also reliant on coal and would be highly impacted.
- Further analysis would be needed to provide recognition for Ontario's recently announced cap and trade, and avoid the duplication of incremental costs to ratepayers.
- The size threshold of 25 MW would exclude coverage of diesel-fired units operating in remote communities.

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91 The model used to estimate emissions reductions and costs (E3MC) considers all federal, provincial and territorial measures in place as of September 2015. Alberta's Climate Leadership Plan and Saskatchewan's renewable energy target are not considered in the modeling and therefore not reflected in the results.

Implementation, feasibility, technological and enabling infrastructure issues:
- For levels A and B, further work would be required to define flexibility mechanisms
- Costs of this policy would be reflected in electricity prices, which could impact the competitiveness of jurisdictions that are more reliant on fossil fuels, have carbon pricing in place, and/or adopted already considerable renewable energy and associated ongoing costs.
- New NG generation that has come online recently or will to come online imminently would still need to adhere to their contract or procurement agreements, which may make it difficult to meet the level of stringency if flexibilities are not available.
- Woody biomass can be used to help comply with requirements when co-fired with fossil fuels like coal. Carbon capture and storage can also be used to comply with emission intensity requirements for units, including those burning coal.

E2. Accelerated Phase-out of Unabated Coal-Fired Electricity Generation

POLICY GOAL: Shift from emitting to low- or non-emitting sources of electricity generation

POLICY TOOL: A regulatory requirement to close all unabated coal-fired units by December 31, 2029.

Policy Details
- Policy would provide regulatory flexibility for units that incorporate technology for carbon capture and storage (CCS)

Options		Est. reductions in 2030	Est. cost/tonne*
A.	Phase-out of unabated coal-fired units by 2030	15 Mt	$50-100**

*Note that cost estimates in the electricity sector are based on conservative assumptions, and may decline as renewable energy technologies continue to improve and the challenges to ensure electric reliability in a changing resource mix are identified and addressed.

**Nova Scotia has estimated the cost of this option at $>250/t for their jurisdiction

ECONOMIC AND CONSUMER IMPACTS
- This policy option will result in costs due to the construction of new clean electricity capacity, stranded assets, and new infrastructure.
- The cost per tonne estimates above do not represent the full cost of these measures, as they do not account for stranded assets or associated new infrastructure, and also underestimate the price of natural gas in Nova Scotia.[92]
- Electricity prices are expected to increase in provinces reliant on coal for electricity generation.
- The closure of coal-fired units would result in job losses at those units and depending on the economic life of the plant, may also result in investment losses in the facility itself if it cannot be used or sold for other purposes. Job losses could also occur in coal mining operations.
- The construction of new replacement generation and infrastructure could have positive economic impacts in terms of job creation.

CONSIDERATIONS

Co-benefits/negative impacts:
- In addition to health benefits from improved air quality, environmental co-benefits include improved air quality, reductions in air pollutants, water intake and discharge as well as reductions in solid waste disposal.

92 The model used to estimate emissions reductions and costs (E3MC) considers all federal, provincial and territorial measures in place as of September 2015. Alberta's Climate Leadership Plan and Saskatchewan's renewable energy target are not considered in the modeling and therefore not reflected in the results.

Linkages with other working group areas and other proposed policies:

- The emissions intensity performance standard options under E1 would also affect coal-fired electricity generation. This option would apply only to coal-fired power plants, with no requirements applied to other forms of fossil fuel-burning electricity generation, such as natural gas or fuel oil-fired generation.

Regional impacts including northern and remote communities:

- Across Canada, up to 16 coal-fired units would be required to close sooner than under current Federal regulations (7 in Nova Scotia, 6 in Alberta, 1 in New Brunswick and 1 in Saskatchewan),
- The 2030 coal phase out policy recently announced by Alberta represents an example of this policy option. Alberta's coal phase out policy, along with other policies including their renewable energy target and carbon levy, could achieve similar results in AB to this policy.
- Saskatchewan is reliant on coal and recently invested over $1.4 billion to implement carbon capture and storage (CCS) on one of its coal units and in the past has indicated CCS could be an option to continue running at least two other units.
- Impacts in Nova Scotia are expected to be considerably higher due to limited access to natural gas; existing natural gas supplies are far more expensive in Nova Scotia; and the high cost of building new gas pipeline extensions needed for reliability from the rest of Canada into Nova Scotia. Based on its record of GHG reductions, in 2014 Nova Scotia established an equivalency agreement with the Federal Government which committed to GHG reductions equivalent to those defined in new Federal regulations. The agreement defines firm GHG reductions commitments while allowing the policy flexibility required to operate coal-fired electricity plants to their end-of-life dates. Through this approach, investments are being made in new, clean electricity resources versus investments in carbon-emitting assets. Similar flexibility would be required for any further acceleration of the phase-out of coal-fired electricity generation in Nova Scotia.
- New Brunswick is also reliant on coal power generation from a relatively new unit with a useful life that extends past 2030 and would be impacted.

Implementation, feasibility, technological and enabling infrastructure issues:

- Careful planning and significant investment would be required to ensure that firm capacity and infrastructure is available to make-up for retiring coal-fired capacity in 2030.
- Nova Scotia in particular faces a number of technical challenges with accelerating the phase out of coal-fired electricity, specifically the lack of infrastructure from the rest of Canada required to provide the additional natural gas needed for replacement power generation. In terms of electricity transmission, there is also limited ability to bring in additional firm electricity capacity without substantial network expansion.
- Replacement of coal with biomass can also satisfy the requirements of this policy while permitting rapid conversion of existing generating assets to use renewable energy.
- At this time, it is not expected that there would be a strong business case for additional use of CCS. Emissions reductions results could vary if the cost of CCS declines and this technology is used more broadly.
- Variable renewables such as wind and solar have an opportunity to replace a significant portion of the coal generation displaced if they can be reliably integrated. Demonstrating and deploying smart grid technologies to support increased wind and solar generation could increase the impact of this policy by ensuring that renewables replace a significant portion of coal-fired electricity generation.

E3. Non-Emitting Portfolio Standard for Electricity Generation

POLICY GOAL: Apply a non-emitting portfolio standard for electricity supply

POLICY TOOL: Regulated approach, under which each province and territory would be individually required to meet target levels.

Policy Details

- The target levels can be met using electricity supplied from non-emitting generation sources either generated within a given province or territory or through interprovincial imports of non-emitting electricity. Exports cannot be counted towards the generating province's targets.
- Includes renewable (e.g., hydro, wind, solar, geothermal, tidal, biomass) and nuclear generation.
- Does not include low-emitting technologies, such as cogeneration or fossil fuel-fired generation with carbon capture and storage (CCS).

Options		Est. reductions in 2030	Est. cost/tonne*
A.	The lesser of 90% non-emitting supply in 2030 or a 20 percentage point increase from the 2014 portion of non-emitting supply by 2030.	8 Mt	$50-$100
B.	The lesser of 97% non-emitting supply in 2030 or a 30 percentage point increase from the 2014 portion of non-emitting supply by 2030.	15 Mt	$50-$100

* Note that cost estimates in the electricity sector are based on conservative assumptions, and may decline as renewable energy technologies continue to improve and the challenges to ensure electric reliability in a changing resource mix are identified and addressed.

ECONOMIC AND CONSUMER IMPACTS

- Electricity prices are generally expected to rise as a result of the need to build new generating capacity and infrastructure.
- The construction of new replacement generation and infrastructure could have positive economic impacts in terms of job creation.
- This policy could impact the competitiveness of some provinces in terms of both the electricity export market and manufacturing and industrial sectors on the global market

CONSIDERATIONS

Co-benefits/negative impacts:

- In addition to health benefits from improved air quality, environmental co-benefits include improved air quality, reductions in air pollutants, water intake and discharge as well as reductions in solid waste disposal.

Linkages with other working group areas and other proposed policies

- This option supports a number of Canadian Energy Strategy (CES) goals, specifically the goal to "Foster an understanding by governments on the use of market-oriented policies to reduce greenhouse gas emissions across Canada" and to "Actively pursue greenhouse gas emissions reductions with targets based on sound science".

Indigenous Perspectives:

- Input from the AFN recommends that targeted funding be provided for Indigenous clean energy technologies and infrastructure and for clean energy community capacity and entrepreneurs, and emphasizes that energy systems should be First Nation community-owned or that home systems should be subsidized or otherwise accessible.
- The submission from the MNC also suggested that options should be developed to enable Métis delivery of new energy options, including biomass, solar, and geothermal.

Regional impacts including northern and remote communities:

- Provinces with high levels of non-emitting electricity supply (Newfoundland and Labrador, Quebec, Manitoba and British Columbia) would not need to take action, but could increase exports to help other provinces and territories meet their targets.

- Nova Scotia, New Brunswick, Alberta and Saskatchewan have renewable targets that are in place or that have been announced. In these jurisdictions, the impacts of this policy cannot necessarily be considered incremental.
- These estimates do not account for recently announced policies including Saskatchewan's renewable targets and Alberta's coal phase out policy. Modeled results indicate that the target is met for Alberta and Saskatchewan through construction of wind generation and purchases of clean power from neighbouring provinces, generally displacing natural gas generation.
- The high capital cost associated with replacing diesel generation in northern and remote communities is a significant challenge given the small rate-payer base. There may also be issues accessing trained personnel to install and maintain more complicated systems. This policy would, therefore, heavily impact Nunavut and the Northwest Territories, which would have to displace at least some diesel power generation in remote communities in order to meet their targets. Modeling results indicate the Northwest Territories and Nunavut see an uptake in wind generation to meet the target.
- Ontario already has a high projected level of non-emitting generation but would likely still need to take some action to get to the 90/97% non-emitting supply in 2030 target. Modeling results indicate Ontario could meet the target through increased imports from neighbouring jurisdictions (Manitoba and Quebec) to replace natural gas for peaking.
- Prince Edward Island, which relies heavily on imported generation from emitting sources, would also be impacted.
- Depending on the stringency, Yukon may also need to take action.

Implementation, feasibility, technological and enabling infrastructure issues:

- Compliance with this policy would require capital investment in new non-emitting generation and/or new or upgraded transmission and distribution systems which will increase electricity prices.
- Natural gas generation that has come online in recent years or is expected to come online imminently would still need to satisfy contract or procurement agreements. In addition, return on capital investment is important for long-term planned projects.
- Renewable electricity generation, such as wind and solar, is variable, which means that it is non-dispatchable due to its fluctuating nature. To manage variability and the balance between supply and demand, generation forecasting, demand management, interconnectivity, storage and backup capacity should be considered. There will be system costs to address variability in the case of high penetration levels of wind and solar. RD&D support to bring innovative smart grid and storage technologies to commercial readiness would lower those costs. The percentage of feasible penetration level is location specific and depends on a number of factors.
- There are potentially high upfront capital costs to build new non-emitting supply to displace diesel generation in northern and remote communities; however, these costs might be partially offset by lower operating/fuel costs of non-emitting sources relative to diesel.
- A tracking system would be needed to ensure proper accounting of inter-jurisdictional trading for credits. Tracking systems have been implemented elsewhere but can be complex and require resources to manage.

E4. Financial Support for New NonEmitting Electricity Generating Facilities

POLICY GOAL: Displace emitting forms of generation with non-emitting[93] forms of generation

POLICY TOOL: Standalone financial support for new non-emitting electricity generating facilities can take many forms including price-based incentive programs; capital incentives; open, competitive utility procurement programs; loan guarantees; and tax measures.

93 For the purposes of this document, non-emitting electricity refers to electricity generation that does not emit greenhouse gases. It does not refer to other pollutants.

Policy Details

- All non-emitting sources of electricity generation (e.g., wind, solar, biomass, geothermal, hydro, tidal, wave, nuclear) would be eligible. Some consideration could be given to providing a lower incentive level to fossil fuel-based electricity generation that captures and permanently stores the great majority of its greenhouse gas emissions.
- The incentive level assumed for this analysis is based on a production incentive to make the lowest cost non-emitting electricity generation option (assumed to be wind) competitive with the overall lowest cost option (assumed to be natural gas combined cycle), using conservative assumptions about costs. Alternative approaches could also be considered.
- Further assessment of the most effective policy mechanism(s) to provide financial support would be required.

Options		Est. reductions*in 2030	Est. cost/tonne**
A.	Support the construction of new non-emitting electricity generating capacity, in order to generate 30 terawatt-hours (TWh) to displace emitting electricity generation	13 Mt	$50-100
B.	Support the construction of new non-emitting electricity generating capacity, in order to generate 45 TWh to displace emitting electricity generation	19 Mt	$50-100

* These reductions may not necessarily be incremental to the emission reductions projected in ECCC's biennial report. In some cases, the policy would support non-emitting generation projected to come online under the business as usual scenario modelled by ECCC.

** Note that cost estimates in the electricity sector are based on conservative assumptions, and may decline as renewable energy technologies continue to improve and the challenges to ensure electric reliability in a changing resource mix are identified and addressed.

ECONOMIC AND CONSUMER IMPACTS

- Financial support for new electricity generating projects would result in new economic activity, including investment and jobs during construction and operation. There would also be some negative impacts due to the reduction in use of existing emitting facilities and decisions to not build new emitting facilities that would have otherwise been built.
- The financial support provided to new non-emitting facilities would ultimately be borne by either taxpayers or electricity consumers, depending on the policy mechanism. Increases in electricity prices can have a number of impacts, including affecting competitiveness in other industries.

CONSIDERATIONS

Co-benefits/negative impacts:

- Potential co-benefits from the displacement of fossil fuel-fired electricity generation include reductions in various air pollutant emissions.

Linkages with other working group areas and other proposed policies

- This policy is in alignment with the Council of the Federation's Canadian Energy Strategy, in particular with Goals 6.1 (Support the efficient deployment of clean and renewable energy sources across Canada) and 6.2 (Support greater access to affordable, clean, and reliable supplies of energy for all Canadians).
- This policy may interact with other policies designed to increase non-emitting electricity generation and/or decrease emitting electricity generation, such as carbon pricing, the non-emitting portfolio standard policy, the performance standard policy, and the policy to increase interprovincial electricity trade.

Indigenous Perspectives:
- Could include set asides for First Nation family or community owned and operated systems, as recommended by the AFN.
- Input from the AFN recommends that targeted funding be provided for Indigenous clean energy technologies and infrastructure and for clean energy community capacity and entrepreneurs
- The submission from the MNC also suggested that options should be developed to enable Métis delivery of new energy options, including biomass, solar, and geothermal.

Regional impacts including northern and remote communities:
- This policy would be more effective in reducing greenhouse gas emissions in jurisdictions that are more reliant on emitting sources of electricity generation. Financial support may not be needed in regions where the lowest cost option for electricity generation is a non-emitting source, though support could be considered to add capacity to meet increased demand (e.g., from electric vehicles) or to increase electricity exports to neighboring provinces and/or territories.

Implementation, feasibility, technological and enabling infrastructure issues:
- As greater penetration of variable renewable energy occurs, actions to integrate variability may be required, such as dispatchable backup electricity generating sources (hydro, natural gas, electricity storage). Some consideration could be given to paying a premium for non-emitting sources that can be used as baseload or that are dispatchable.
- The required incentive level may decrease over time with technological advancements in the manufacturing and efficiency of non- and low-emitting electricity generation technologies. Furthermore, research, development and demonstration of grid integration technologies such as energy storage could result in lower costs of integration of variable renewable energy.
- Further analysis is needed to determine the appropriate incentive level, with some consideration given to regional and intertemporal variation.

E5. Targeted Financial Support to Reduce Reliance on Diesel Energy in Northern and Remote Communities

POLICY GOAL: Reduce reliance on diesel energy in off-grid Northern and remote communities

POLICY TOOL: A targeted program to support the development of non-emitting sources of electricity in remote communities (including Indigenous communities), which could include financial tools such as direct contributions, low interest loans or loan guarantees.

Policy Details
- Enabling measures could include capacity building, development of knowledge base and demonstration projects.
- Some consideration could also be given to expanding this policy to include grid connection projects if they have the net effect of displacing emitting forms of local generation with cleaner electricity from the grid.
- Note that these options are scalable, and could be applied to a larger number of communities.

Options		Est. reductions in 2030	Est. cost/tonne*
A.	Support the construction of new non-emitting electricity generating capacity in remote communities in order to generate about 0.3 TWh to displace diesel-fueled electricity (20% reduction in total remote community electricity related emissions)	<1 Mt	$100-$>250
B.	Support the construction of new non-emitting electricity generating capacity in remote communities in order to achieve a 50% reduction in diesel used for heating and electricity in about 140 remote and northern, First Nations and other Indigenous communities	<1 Mt	$100-$>250

* Cost/tonne estimates encompass the use of wind or solar, with or without storage and at diesel costs ranging from $0.75 to 1.0/L. Calculations are based on data from very few operating projects and expertise in renewable energy and systems in remote communities. Further, the results are sensitive to diesel pricing.

ECONOMIC AND CONSUMER IMPACTS

- Upfront capital costs to build new non-emitting supply to displace diesel generation in northern and remote communities are high; however, these costs might be partially offset by lower operating/fuel costs of non-emitting sources relative to diesel.
- About 0.3 TWh of new annual electricity supply by 2030 in remote communities would require about 100 megawatts (MW) new non-emitting capacity installed by 2030. Total funds for new generation coming online in the first 8 years could be in the range of about $280 million, including funds for supporting/enabling activities such as capacity building, development of knowledge base and demonstration projects.
- Input from the AFN suggests that a 50% reduction of diesel used for heating and electricity approximately 140 remote and northern First Nations and other Indigenous communities by 2022 through energy efficiency/conservation, renewable energy, local smart grids, transport electrification, transmission connection, housing/facility design, and community energy planning would require funding in the range of $900 million to $1.7 billion over 10 years.

CONSIDERATION

Co-benefits/negative impacts:

- Could support economic development goals, as well as improved air quality and overall reduced reliance of remote communities on fossil fuels.
- Would reduce risks associated with winter road delivery of diesel, fuel spills and volatile diesel fuel costs.
- With appropriate support, could provide employment opportunities in northern and remote communities

Indigenous Perspectives

- The AFN recommends that a targeted fund be developed to support reduced diesel use in northern and remote off-grid communities, with the objective of achieving a 50% reduction in diesel use by 2022 in 140 remote and northern First Nations and other Indigenous communities.
- Input from the AFN emphasizes that clean electricity energy systems should be owned by families and communities.
- The submission from the MNC includes a recommendation to identify projects and communities through negotiation with Governing Members on a regional basis, where pilot projects can be implemented to move the community away from diesel and towards alternative means of electricity and heat generation.

Regional impacts including northern and remote communities:

- According to the Natural Resources Canada Remote Communities Database, there are roughly 284 remote communities in Canada. These include communities, settlements, villages or cities, as well as long-term commercial outposts and camps for mining, fishing and forestry activities. Approximately 60 per cent are considered to be Indigenous communities (First Nations, Innu, Inuit, Métis).
- All northern and remote communities in Nunavut (25), Quebec (22), and Newfoundland and Labrador (33) rely exclusively on diesel generation
- Several communities in other provinces/territories also rely primarily on diesel for electricity generation: British Columbia (59), Ontario (25), the Northwest Territories (24), Manitoba (4), Yukon (5), Alberta (1), and Saskatchewan (1).

Linkages with other working group areas and other proposed policies

- Diesel energy is widely used for heating as well as electricity generation. Options to reduce reliance on diesel will need to address use in multiple sectors, including electricity, the built environment, and industry.
- This option is in alignment with Action 6.2.1 under the Canadian Energy Strategy, "Work with aboriginal and rural and remote communities and other partners to increase the use of cleaner renewable energy projects to reduce off-grid dependency on diesel"

Implementation, feasibility, technological and enabling infrastructure issues:

- Circumstances of specific Northern and remote communities vary in terms of their climate, size, distance from other communities, access to transportation networks, access to energy and electricity, local industries and economic activity, the availability of skilled labour, and a variety of other factors. This will impact costs and the viability of specific options to increase the share of non-emitting electricity generation.
- Where small populations and long distances from existing grid infrastructure do not make grid connection economically feasible for remote communities, it is technically possible that hybrid wind/solar-diesel generation systems can be deployed to lower the amount of diesel fuel needed for off-grid electricity generation. Diesel generators usually continue to be required to supplement non-emitting electricity in northern and remote communities.
- However, for many communities electricity consumption is too small to integrate wind energy cost effectively and the technical maximum solar penetration may only displace 2-10 per cent of the annual diesel use.
- Technology development can help remote communities deploy micro-grids integrating new non-emitting technologies.
- Some Northern and remote communities may not have ready access to the materials or skills required for servicing some technologies. Geographic distance and limited transportation options affect the feasibility and costs of maintenance and repair.
- Input from the AFN notes that additional action could build on current programing such as REACH, economic development and other INAC programs
- The AFN recommends that action to reduce reliance on diesel could include streams of investment focused on greatest need and readiness. Mapping the intensity and cost of diesel-dependence (including both the fuel consumed and the distance it must travel) could help to identify priority communities/projects. Capacity building and readiness activities would likely be required.

E6. Increase Interjurisdictional Transfers of Non-Emitting Electricity

POLICY GOAL: Improve interconnectedness, efficiency and flexibility of the electricity grid, and, where possible, connect remote communities to the grid

POLICY TOOL: Standalone legislative approach, whereby governments, through their applicable legislative authority, encourage the planning of grid interconnections and electricity generation on a regional basis, and establish incentives for infrastructure upgrades.

Policy Details

- This policy would aim to increase use of existing transmission capacities from jurisdictions with non-emitting electricity sources to jurisdictions where higher-emitting electricity sources can be displaced.
- This policy would facilitate the potential for some remote communities to become connected to the North American electricity grid, thereby displacing diesel-fired electricity generation.
- Applicability, potential GHG reductions and costs must be assessed at a regional and site specific level. The estimated cost/tonne ranges are provided based on site specific examples. These examples considered levelized costs of generation and transmission and may not be representative of applications elsewhere.
- Relevant legislation, regulations and standards for electric reliability would continue to apply.
- This policy may be supported through: facilitated discussions; MOUs, applicable rules, practices, and dispute mechanisms; and streamlined approval processes. Other policies/standards with defined GHG-emission reduction targets may also provide impetus to improve interconnectedness among certain provinces and territories.

Options		Est. reductions in 2030[1]	Est. cost/tonne[2]
A.	Increase use of existing relevant intertie capacity between jurisdictions to transfer/access non-emitting sources of electricity and displace high-emitting sources.	Up to 6.0 Mt annually by mid 2020s and continuing to 2030[3]	Site specific example provides range of $0-50
B.	Increase existing relevant intertie capacities by the greater of 500 MW or 25%, where appropriate.	Up to 10.0 Mt[4] annually (incremental to those described in "A")	Site specific example provides range of $50-100
C.	Add new transmission capacities (up to 500 MW, as appropriate) where none currently exist, between and within jurisdictions.	>1 Mt annually	Site specific example provides range of $50-100

1. Reductions were estimated based on a displacement analysis. The analysis focused on neighbouring jurisdictions where one jurisdiction has significant hydroelectric resources and the other jurisdiction relies significantly on emitting sources of generation. For the purposes of the analysis, hydroelectric jurisdictions are BC, MB, QC, NL, YT, NT. Jurisdictions relying significantly on emitting sources are AB, SK, ON, NB, NS, and NU. This resulted in the following pairs: BC-AB, MB-SK, MB-ON, QC-ON, QC-NB, and NL-NS for Levels A and B, and NT-AB, NT-SK, and MB-NU for Level C. The emissions reductions are calculated by assuming that, on average, 1 MW of capacity will provide 4.8 GWh of electricity (based on a capacity factor of 60% and line losses of 9%) and based on the emission intensity of the energy source (diesel, coal or natural gas) to be displaced by large hydro.

2. A January 2016 study conducted by the Canadian Energy Research Institute looked at options to satisfy oil sands electricity demands, relative to a base case of natural gas-fired cogeneration plants, the Alberta grid average, or coal-fired generation. It found the cost per tonne for a range of options, covering the 3 levels of ambition, to be in the $0 100/t CO_2e range for coal displacement as per Table 3.2 of the report. Costs of both generation and transmission were considered. Taking only transmission costs into account, the range would be $0-50/t CO_2e.

3. Potential emissions reductions may decrease over the period should the displaced fuel mix change.

4. Given that the analysis is based on the projections in the Biennial Report, and the Biennial Report did not take into account the recently announced coal phase out in Alberta, the analysis assumes that coal is displaced in Alberta. If the displaced fuel in Alberta is assumed to be natural gas, the total potential emissions reductions would be 8.7 Mt CO_2e.

Further considerations:

- For Level A, existing transfer capability was compared with the transfers projected in Canada's 2016 Biennial Report. If the latter was less than the former, the analysis assumed that additional hydroelectric generation was built in the exporting province to allow for the full use[94] of the existing transfer capability, to displace the highest available emitting source in the importing province.
- For Level B, rated transfer capacity was increased by the greater of 500 MW or 25% at the six relevant borders[95], and new hydroelectric supply was again assumed to be built in the exporting province to displace the highest available emitting source in the importing province.

94 For reasons relating to electric reliability, maintenance, market factors and transmission line losses, the maximum transfer capability was assumed to be 55% of the rated capacity of the line.

95 A total of 3,200 MW of new transfer capability is added under this scenario.

- Level C looked at establishing 200 MW transfer capability between NT and AB and between NT and SK, and 100 MW transfer capability between MB and NU.
- Estimated capital costs in the CERI report for possible 1,100 MW transmission links to the Alberta oil sands from BC, MB and NT range from $2-$3 billion or $2.6 - $4.5 million/km.
- The 500 MW Maritime Link under construction between NL and NS has an estimated cost of $1.5 billion or $3.6 million/km. The purpose of the analysis is to provide a general sense of magnitude of the potential emissions reductions that could be achieved through increased interconnectedness. The analysis used a general set of rules and did not consider factors specific to each pair of neighbouring jurisdictions. It is possible that some of the increased line usage (in Level A) and increased transfer capability (in Level B and C) are not economically feasible. A more sophisticated and thorough analysis (that is informed by utility data and that considers the great complexities in designing and managing electrical grids and markets) would identify specific projects that have economic merit, taking into account environmental benefits.

ECONOMIC AND CONSUMER IMPACTS

- In all three levels of ambition, relevant costs to be considered include the costs of transmission infrastructure (line and substation) upgrades, and the difference in the cost of new non-emitting electricity generation in exporting provinces and the cost of displaced emitting generation in the importing provinces.
- The cost of required infrastructure upgrades would be borne by tax payers and/or electricity consumers. National/jurisdictional competitiveness could be affected by increased electricity prices.
- Developing non-emitting electricity facilities in-province may be more cost effective than increasing non-emitting imports from neighbouring jurisdictions where the costs are borne by electricity consumers. Importing non-emitting supply from a neighbouring jurisdiction to meet reducing emission targets may limit the development of renewables and the ability to meet provincial renewable energy development targets in the importing jurisdiction. The potential for expanded intertie capacity between provinces should also consider the impact on independent power producers, particularly within the provinces of Alberta and Ontario given their unique market designs.
- Impacts would depend on how and where the increased transfer capability is achieved, and the source of the non-emitting electricity to displace high-emitting electricity sources.
- Positive impacts would include: expanded export markets; increased access to non-emitting energy imports; increased opportunity to sell surplus supply; and economic activity and direct/ indirect jobs to construct/ operate new generation and transmission projects.
- Additionally, increasing flows of non-emitting electricity within and between Canadian jurisdictions may impact export capacity/flexibility to the US.

CONSIDERATIONS

Co-benefits/negative impacts:

- Co-benefits include improved air quality and reductions in air pollutants, particularly in remote communities currently serviced by diesel.
- An expanded electric grid would provide increased electric reliability for Canadians – interties provide flexibility to meet changing supply-demand conditions, e.g. manage peak load.
- Increased interconnectedness enables management of variability of solar/wind over larger geographic area and time zones, which could facilitate an increased penetration of renewables onto the grid.
- Increased interconnectedness may also enable or extend the reach of other applicable greenhouse gas emission reduction policies.

Linkages to other working group areas and other proposed policies

- This option supports the Canadian Energy Strategy goals to “Support greater access to affordable, clean, and reliable supplies of energy for all Canadians” and to “Facilitate greater exchanges and transfers of energy between or across the provinces and territories”.

Indigenous Perspectives:

- Input from the AFN notes that increased grid efficiency and flexibility will be important to accept large quantities of distributed renewable energy generation, including solutions for rural and remote electrification.

Regional impacts including northern and remote communities:

- Could provide enhanced opportunity for some remote communities, including Indigenous communities, to access non-emitting sources of electricity, thereby replacing diesel. Also provides future access to remote commercial opportunities – e.g. mining, oil and gas operations.
- To increase intertie benefits, may need to reassess transmission agreements and market rules, open access and tariffs related to import/export considerations on broader, regional basis.
- To maximize the benefits that could be realized by this policy, it would be essential for the policy approach to take into consideration existing planning processes and regional policies with the goal of harmonizing the policy with provincial and/or territorial plans.

Implementation, feasibility, technological and enabling infrastructure issues:

- Level A would require 8 terawatt-hours of new non-emitting electricity supply to be built in the exporting provinces. Level B would require a further 15 terawatt-hours of new non-emitting electricity supply. Level C would require 2 terawatt-hours of new non-emitting electricity supply.
- Upgrades to transmission and distribution systems would require up front capital outlay as well as regulatory and environmental approvals. Regulatory approvals typically require demonstration that the upgrades are needed and in the public/ratepayer interest of the particular province or territory, and that alternatives are thoroughly assessed as well.
- Establishing new interties will require consultation/access agreements with affected landowners and Indigenous communities.
- Transmission infrastructure could be overbuilt leading to a less efficient use of the system.

Agriculture

A1. Reduction of Methane Emissions from Cattle

POLICY GOAL: Reduce methane emissions from beef and dairy cattle in Canada.

POLICY TOOL: Incentive and educational tools

Policy Details

- Adding oil/oilseed to diets can decrease the methane emissions by up to 20%. Incentives and extension programs would be needed to overcome differential pricing between canola or other alternatives and traditional, lower cost feed grains.
- Shorter duration times of all phases for beef cattle (cow-calf, background, finishing) brings the animals to market weight more quickly, avoiding additional days of methane emissions.
- Incentives would need to be flexible to respond to seasonal/annual fluctuations in market drivers (pricing).
- Options for feeding oils/ oilseeds apply to both beef (pasture, background and feedlot) and dairy cattle. Reduced age of harvest applies to beef cattle.
- All options start in 2018 and assume 2014 populations.

Options		Est. reductions in 2030*	Est. cost/t**
A.	10% adoption of feeding oils/ oilseeds (6-7% of dry matter intake) for beef and dairy cattle	<1 Mt	$50-$100
B.	30% adoption of feeding oils/ oilseeds (6-7% of dry matter intake) for beef and dairy cattle	<1 Mt	$50-$100
C.	10% adoption of reduced age at harvest by 60 days for beef cattle	<1 Mt	$0-$50
D.	30% adoption of reduced age at harvest by 60 days for beef cattle	1-2 Mt	$0-$50

* +/- 20-50% uncertainties should be applied to individual estimates. Emission factors are based on IPCC 2006 estimates used in Canada's National Inventory Report, which are 17% higher than compiled research from Canadian studies.

** Includes only government costs.

ECONOMIC AND CONSUMER IMPACTS

- Since producers are responding to market signals, policies directed at changes to grading system standards and educating consumers are needed to support market demand.
- Incentives would be needed to address costs to producers of edible oils/ seeds relative to lower priced feed grain alternatives (including increased management effort and time for logistics of storing, feeding, and mixing). However, there could also be some benefits of feed savings since canola seed provides a high energy diet relative to extra storage and handling of crushed canola seed.
- Reduced age of harvest will have co-benefits of lower feed costs, shorter feedlot residence times, less yardage costs per animal, although animal numbers may increase to utilize these resources (potential for leakage).

CONSIDERATIONS

Co-benefits/negative impacts:

- Some potential for minimal co-benefits (e.g., dust control) associated with feeding oils
- Knowledge gained concerning management of supplements in pasture feeding contexts may support use of emerging technologies (e.g. 3NOP – methane inhibitor)

Linkages with other working group areas and other proposed policies:

- Changing feeding strategies on pasture and encouraging calves to be put into feedlots earlier may have impacts on needs and availability of forage stocks. Could influence adoption rates of perennial crop initiatives.

Regional impacts including northern and remote communities:

- This is a cattle program area. Alberta has many of the beef cattle in Canada (46 %) and thus would be the most impacted (both policy options).
- Canadian dairy cattle are dominantly located in Quebec and Ontario (70 % of dairy cows - feeding oils option).

Implementation, feasibility, technological and enabling infrastructure issues:

- Additional record keeping would be needed to capture emission reductions in national inventory.
- Co-benefits to producers would likely be minimal. Incentives and extension would therefore be required to encourage adoption.
- Canada could be seen as a global leader if these voluntary policies could be implemented. Methane emissions from ruminants is a concern in many countries. Canada already has many advantages of utilizing natural grasslands to produce protein.

A2. Convert Marginal Land from Annual Crop Land to Permanent Cover

POLICY GOAL: Increase conversion of marginal land from annual crop to permanent cover

POLICY TOOL: Financial incentives

Policy Details
- Eligibility requirements should be included in the policy to include a minimum land conversion amount, agreement to follow specific management practices and a commitment to develop a long term monitoring and management plan.

Options		Est. reductions in 2030	Est. cost/tonne*
A.	Increase percentage of annually cropped marginal land (class 5 and 6) converted to permanent cover crops by 5% between 2017-2021 (1%/ year).	<1 Mt	$0-$50
B.	Increase percentage of annually cropped marginal land (class 4, 5 and 6) converted to permanent cover crops by 5% between 2017-2021 (1%/ year).	<1 Mt	$0-$50

* Includes only government costs.

ECONOMIC AND CONSUMER IMPACTS
- Converting annual cropping to permanent cover crops might increase net farm income in the long term. However, as this measure is costly in the shorter term, a financial incentive will be required.
- More land in permanent cover could lead to an increase in the cattle herd which has an economic impact.
- Eligibility requirements that restrict land use over a given time period may impact land prices. Producers may be reluctant to enter into long term contracts.

CONSIDERATIONS

Co-benefits/negative impacts:
- Less soil erosion
- Increase in organic matter and soil microbial diversity
- Improved water infiltration, which reduces run-off and helps adapt to extreme precipitation events
- Improved soil structure and nutrient cycling
- Enhanced wildlife habitat and increased biodiversity
- Reduction in GHG emissions associated with a decrease use in fertilizer and on farm machinery may occur
- An increase of land in forages as a result of this policy could increase livestock numbers, which could increase GHG emissions from the livestock sector. Assessment at whole farm basis and by stage in production cycle would be needed to determine trade-offs

Linkages with other working group areas and other proposed policies:
- Afforestation (F2) is an alternative option for use of marginal agricultural land.
- Under a carbon pricing system, there is potential for carbon offsets to be generated from permanent cover crop conversion

Regional impacts including northern and remote communities:
- This option would apply differentially to regions that have a significant amount of annual crop production on marginal land.

Implementation, feasibility, technological and enabling infrastructure issues:

- Implementation would require demonstration of additionality (that the practice is above and beyond business as usual), and address issues related to permanence, carbon stock equilibrium and carbon leakage. For instance, permanence risk issues could be addressed by establishing a buffer pool based on a likelihood of the rate of reversal by region. Discounted amounts in the pool could be used as insurance against possible future reversals and may be increased or decreased according to rates of use
- There may be technological challenges in the ability to measure outcomes for reporting purposes
- Under the 2005 baseline policy, if in 2030 the carbon sink in a province (including any measures that increases the sink from 2015 to 2030) is below the 2005 sink level, this province will not be able claim this measure. This affects the estimated reductions in 2030 outlined in the table above.
- There is potential for biomass produced from permanent cover/perennial crops to supply biofuels/ bioproducts markets.
- Growing annual crops generates higher returns than perennial crops; a sufficient incentive would be required to encourage adoption.

A3. Increase Acres of Nitrogen Fixing Crops, Pulses/Forages in Rotation

POLICY GOAL: Increase acres of nitrogen fixing crops, pulses/forages in rotation

POLICY TOOL: Extension, research and incentives

Policy Details

- Increasing the percentage of acres under pulses and soybeans, where agronomically sustainable:
  - » No financial incentives to producers required.
  - » Ongoing extension and research efforts (especially cultivar development).

- Increasing acres of perennial legumes, cover crops and intercrops:
  - » Likely to require some form of producer incentives (at least in the short term).
  - » Ongoing extension, technology transfer and research efforts
  - » Perennial forages have generally not been competitive with annual crops on non-marginal lands and often there is not a prominent livestock sector in crop-dominated areas to utilize the forage resource to any great extent requiring expensive transport of the forage. However, there are potential biofuel/bioproduct markets for perennials.
  - » Cover crops are not yet widely adopted in Canada and will likely require incentives for increased uptake in the short term, even though there are soil and yield benefits to growing cover crops.

- Intercropping with legumes will also likely require incentives to be adopted in significant numbers, at least in the short term, as this practice is not widely adopted and may require equipment and crop rotation modifications.

Options		Est. reductions in 2030	Est. cost/tonne*
A.	Increase soybean acres in Canada from 5.3 M acres (est.)in 2016 to 8 M acres in 2030	<1 Mt	$0-$50
B.	Increase pulse acres in Canada from 9.7 M acres (est.) in 2016 to 11.3 M acres in 2030	<1 Mt	$0-$50
C.	Increase perennial legume forage acres in Canada by 3% from 2016 to 2030	<1 Mt	$0-$100
D.	Increase legume cover crops from low levels in 2016 to 10% of land growing crops by 2030	<1 Mt	$50-$100
E.	Increase legume intercrops from non-significant in 2016 to 5% of canola acres in 2030	<1 Mt	$50-$100

* Includes only government costs.

ECONOMIC AND CONSUMER IMPACTS

- There is opportunity to decrease farm fertilizer input costs with incorporation of N- fixing crops in crop rotations; however there could be negative impacts on rotations if grown too frequently.
- Research on inclusion of pulses and perennial legumes in crop rotations has identified non-N benefits to be just as important as residual soil N to the increased yield of subsequent crops.
- Consumer impacts are expected to be negligible to low.

CONSIDERATIONS

Stakeholder perspectives:

- Pulse and soy industry associations are supportive of increasing acres of their commodities; however, other commodity associations (e.g., grains and oilseeds groups) would not favour this initiative. Increased Canadian domestic consumption is being promoted by Pulse Canada and provincial pulse grower associations in 2016 as a way to increase the market for Canadian grown pulses. Forage commodity groups (e.g. Canadian Grasslands and Forage Association) support increasing forages in rotations, as do conservation groups such as Ducks Unlimited Canada.

Co-benefits/negative impacts:

- *Nitrogen-fixing crops:* benefits to subsequent crops, including increased water availability and pest suppression or interruption. Resilience against market fluctuations as diversity increases in crop rotations.
- *Cover crops and perennial legumes:* increased soil organic matter; increased nutrient cycling; increased water infiltration; reduced soil erosion; increased soil microbial diversity
- *Potential negative impacts:* Increasing soybean's share within a crop rotation under certain circumstances can be undesirable from a soil health perspective and have a negative impact on soil carbon. Cover cropping may be challenging to implement in regions that are prone to water shortages and drought. Increasing legumes in rotations is also potentially at odds with nutrient management objectives or other mitigation activities in some regions, i.e., might reduce acres suitable for manure applications. Not all pulse crops are equally effective for GHG mitigation

Regional impacts including northern and remote communities:

- Not all regions of Canada grow the same types of legume or forage crops. Pulse crops are strongly concentrated in Saskatchewan compared to other provinces. Soybeans are mainly grown in eastern and central Canada, but their range is expanding westward and northward as a result of new cultivars and climate change.
- The opportunity to reduce GHG emissions from increased soybean acreage will vary by region and in some regions further expansion may not be desirable from a soil health perspective.

- Cover cropping is more common in eastern Canada, but should increase in the west as growing seasons continue to lengthen. Cover cropping may also be challenging to implement in regions (e.g., BC interior) that are prone to water shortages and drought.

Implementation, feasibility, technological and enabling infrastructure issues:

- Some potential for minor technical issues related to intercropping (e.g., harvesting, seed separating, herbicides, etc.) and perhaps cover cropping (e.g., seed sourcing).
- Continued applied research on the practical aspects of intercropping with legumes will help solve some technical barriers for widespread adoption of this practice.
- The technology needed is available for the most part, but could be improved/developed in the area of intercropping, e.g., innovations in planting, fertilizer placement and harvesting.
- Market signals will dictate which crops farmers will grow. Domestic consumption of pulses will have little influence on global prices, since Canada is a relatively small market and will remain a 'price taker' for these commodities.

A4. Increase Adoption of Zero Till

POLICY GOAL: Increase percent of land in zero and minimum till

POLICY TOOL: In some circumstances there is no need for policy action from government. However, in other circumstances there may be a need for policy action such as incentives.

Policy Details

- Where no policy action is required farmers will increase zero till acres for reasons other than for soil sequestration.
- There may be a need for incentives and extension in some jurisdictions to move producers away from tillage.
- This proposal is aimed at land seeded to annual crops. Rather than working up perennial forage prior to seeded annual crops, there may be opportunities for zero till in seeding annual crops into a perennial unbroken forage stands.

Options		Est. reductions in 2030	Est. cost/tonne*
A.	Increase percentage of land under no-till from 2011 baseline: • In Alberta from 65 percent in 2011 percent to 85 percent in 2030; • In Saskatchewan from 70 percent in 2011 to 90 percent in 2030. • In Manitoba from 24 percent in 2011 to 50 percent in 2030. • In Peace River region of BC from 30 percent in 2011 to 50 percent in 2030.	<1 – 1 Mt	$0-$50
B.	Increase percentage of land under no-till from 2011 baseline: • In Alberta from 65 percent in 2011 percent to 75 percent in 2030; • In Saskatchewan from 70 percent in 2011 to 80 percent in 2030. • In Manitoba from 24 percent in 2011 to 40 percent in 2030. • In Peace River region of BC from 30 percent in 2011 to 40 percent in 2030.	<1 Mt	$0-$50

* Includes only government costs.

ECONOMIC AND CONSUMER IMPACTS

- No significant economic impact

CONSIDERATIONS

Co-benefits/negative impacts:

- Less soil erosion
- Increase in organic matter and soil microbial diversity
- Improved water infiltration which reduces run-off and helps adapt to extreme precipitation events
- Improved soil structure and nutrient cycling
- More adaptability to drought conditions, better seed emergence
- In wet and cold conditions, and where soils are heavier with more clay in them, soils take longer to dry and warm up compared to conventional tilled soils. Not tilling can delay the growing season.

Regional impacts including northern and remote communities:

- This affects the three Prairie Provinces and the Peace River Region of BC.
- Producers in the Prairie provinces are very familiar with the technology and have been doing this for years. It is assumed that producers who use intensive tillage, for example row crops in Manitoba would not be moving to zero till. It is assumed that a portion of producers practicing minimum till in 2011 would be moving their acres to zero till under this proposal.
- In areas outside these jurisdictions, producers are not as familiar with no-till and do not have the necessary equipment or may need to modify their equipment. This would hinder adoption of this practice.

Implementation, feasibility, technological and enabling infrastructure issues:

- Under the 2005 baseline policy, if in 2030 the carbon sink in a province (including any measures that increases the sink from 2015 to 2030) is below the 2005 sink level, this province will not be able claim this measure. This affects the estimated reductions in 2030 outlined in the table above.
- Carbon sequestration in agricultural soils can be non-permanent if the soil is disrupted or if the reduced tillage practices are abandoned.
- Permanence risk issues could be addressed by establishing a buffer pool based on a likelihood of the rate of reversal by region. Discounted amounts in the pool could be used as insurance against possible future reversals and may be increased or decreased according to rates of use
- There is some evidence that farmers in the prairies are moving away from zero till due to disease pressures and other agronomic reasons such as the need to warm and dry out the soil. This may due to the wetter conditions in recent years.
- Weed resistance to the glyphosate herbicide, a low cost herbicide critical to the economics of zero till, could have a significant impact on the practice. Without a low-cost chemical to control weeds in the spring, farmers would likely revert to a tillage operation for weed control. Glyphosate resistant weeds have become a major problem in Australia and the Southern United States. Governments will need to work with producers and industry to minimize the spread of Glyphosate resistant weeds and look at developing cost effective alternatives.
- The no-till technology is off the shelf and has been around for years, it is assumed that farmers will continue to use the same technology with on-going improvements as they become available.

A5. Enhance Adoption of Available Technologies that Capture and Destroy/ Treat Methane from Manure Storage Systems

POLICY GOAL: Capturing and destroying/treating methane from manure storage systems

POLICY TOOL: Financial incentives

Policy Details

- Government subsidies to support adoption of available technologies that capture and destroy/treat methane from manure storage systems on large farms (e.g., public investment, for example covering 70% of establishment costs).
- Cost-share support towards design and construction of biogas systems and digestate storage equipment.
- Producers must have a manure storage system in place to adopt methane management technologies. This option assumes all manure storage systems are in place and ready to be covered
- Would include biofilter/catalytic oxidation on dairy and non-dairy cattle, swine and poultry farms and anaerobic digestion on dairy and swine farms

Options		Est. reductions in 2030	Est. cost/tonne
A.	Biofilter/catalytic oxidation on dairy and non-dairy cattle, swine and poultry farms, covering up to 2 % of manure storage systems in Canada by 2030	<1 Mt	>$250
B.	Anaerobic digestion on dairy and swine farms, covering up to 2 % of manure storage systems in Canada by 2030	<1 Mt	>$250
C.	Biofilter/catalytic oxidation on dairy and non-dairy cattle, swine and poultry farms, covering up to 5 % of manure storage systems in Canada by 2030	<1 Mt	>$250
D.	Aerobic digestion on dairy and swine farms, covering up to 5 % of manure storage systems in Canada by 2030	<1 Mt	>$250

ECONOMIC AND CONSUMER IMPACTS

- This option requires significant investments for limited estimated reductions, and is therefore not very cost effective. Projects are unlikely to be completed without government support.
- Biogas can generate cost savings if used to produce energy on farms. Using a centralized digester and aggregated projects to share costs might be more economically attractive to farmers, though it depends on regional context.
- The distribution between public and private benefits should be reflected in the level of government support.
- Reduced N loss from NH3 volatilization could be significant for producer as they will not need to compensate by fertilizers.
- The life span of poly covers is not very long (those installed in Quebec are guaranteed for 10 years) so this represents a significant capital investment which would possibly only yield medium-term returns.
- **CONSIDERATIONS**

Co-benefits/negative impacts:

- Improved air quality, and odour reduction in rural areas, potentially improving neighborhood relations.
- Potential GHG avoidance in landfills by facilitating food waste reutilization.
- Potential reduction of mineral N requirements (replaced by organic N from reduced NH3 losses) by approximately 75 kilotons for Canada represent significant savings to farmers

Linkages with other working group areas and other proposed policies:

- Landfill ban on organics (W3) is a lever for this option as it could increase the use of digesters. (The reduction in emissions from this option does not include associated avoided landfill emissions).
- This option could be included as an offset protocol under a carbon pricing system. (E.g., Quebec's cap-and-trade system includes an offset protocol for covered manure storage facilities). A sufficient price signal would be needed to support uptake. Participation in offset projects would require support for farmers to participate, including feasibility studies, monitoring, reporting, and verification.

Regional impacts including northern and remote communities:

- Level of uptake is likely to be significantly different depending on the region due to differing renewable energy and organic waste reduction/reutilization policies.

Implementation, feasibility, technological and enabling infrastructure issues:

- Although this option could in theory be scaled up to target a larger percentage of manure storage systems, there are multiple barriers to implementation in practice. These include lack of access and competition for inputs such as food wastes, variation in manure storage systems, and high operations and maintenance costs that act as a disincentive to farmers.
- Anaerobic digestion in dairy and swine farms can include up to 50% food wastes to make on-farm digesters economically viable. This implies the need to be located close to large urban centers or food processing facilities, which may not always be the case in some parts of Canada. Energy crops are alternative inputs.
- Very cold winters in parts of the country may reduce the efficiency of anaerobic digestion.
- Anaerobic digestion is intended to be for energy production systems, whether thermal, combined heat and power or cogeneration, renewable natural gas (RNG). It is not intended that anaerobic digestion be a passive manure treatment where little to no energy is produced. Anaerobic digestion in winter producing electricity has ample surplus heat. RNG will require partial utilization of the biogas for system heating.
- Use of biogas as an energy source would require policy and regulatory development for energy utilization either through energy purchase contracts, net metering program, or feed-in tariff program and/or program alignment with organic waste reduction and reutilization goals.
- Further research is needed to improve the efficiency of biofilters and optimize catalytic oxidation
- Poly covers are much less expensive but are less practical for farmers to use, unless technological improvements include reinforcements to cover when manure is mixed and emptied. There are also concerns with fugitive emissions from both purpose built and polycovers.

A6. Increase the Total Crop Area on which Precision Application Methods for Nitrogen Fertilizers are used

POLICY GOAL: Reduce Nitrous Oxide (N_2O) Emissions through Improved Nitrogen (N) Fertilizer Use

POLICY TOOL: Financial incentives

Policy Details

- Targeted or varied nutrient application rates are still an emerging practice. Revenue from hypothetical offset credits was modelled where earnings are generated if there is a reduction in N fertilizer use from improved application methods. The scenario covers crop producers in all provinces. It is assumed, based on expert opinion, that adoption of improved management practices and application methods could reduce N fertilizer use by 12% at a cost of between $5 and $12 per hectare.
- The baseline is 2020. N fertilizer prices in 2020 were estimated at $1.46/kg in the west and $1.60/kg in the east. GHG coefficients from nitrogen fertilizer application come from the National Inventory Report. The revenue streams represent these GHG coefficients multiplied by different carbon prices ranging from $20 to $100 per tonne of CO_2e.
- In some cases, support in the form of education may be sufficient to overcome barriers to adoption (e.g., risk aversion, lack of information), as reduced fertilizer use could generate cost savings.

Options		Est. reductions in 2030	Est. cost/tonne*
A.	Financial incentive of $20/tonne of CO_2e	<1 Mt	$0-$50
B.	Financial incentive of $40/tonne of CO_2e	<1 Mt	$0-$50
C.	Financial incentive of $100/tonne of CO_2e	1 Mt	$50-$100

* Includes only government costs.

ECONOMIC AND CONSUMER IMPACTS

- Cost of implementation to farmers could possibly higher depending on application method (e.g. split application) or the need for equipment retrofitting, related services or software or additional fuel consumption.
- The implementation cost would be offset to varying degrees by the reduced cost of using less fertilizer. The cost-benefit ratio will vary regionally depending on agricultural production systems.
- The goal of these practices is enhancement of fertilizer use efficiency, i.e. less fertilizer used per amount of crop produced so no yield reduction or impact on food price is anticipated

CONSIDERATIONS

Co-benefits/negative impacts:

- Improved nitrogen application methods help to reduce the risk of water and air pollution.

Linkages with other working group areas and other proposed policies:

- This option could be included as an offset protocol under a carbon pricing system. (E.g., a protocol for Agricultural Nitrous Oxide Emission Reductions is available under Alberta's offset market). A sufficient price signal would be needed to support uptake.

Regional impacts including northern and remote communities:

- Regions producing a large amount of annual crops and where N fertilizer use represents a significant proportion of their total costs per hectare, such as Central and Eastern Canada, will benefit more from the adoption of improved fertilizer application methods.
- The adoption costs in these regions can be negative (i.e. a net benefit through cost savings) while adoption costs in Western provinces will be higher.

Implementation, feasibility, technological and enabling infrastructure issues:

- Determining nutrient requirement is challenging due to the interactive effects of environmental conditions, such as rainfall, temperature, and pests, with soil. Strategies such as split fertilizer application may be needed to manage potential risks of unforeseen crop responses to nutrient additions.
- Innovative fertilizers are being developed that could greatly improve the efficiency of fertilizer uptake by plants and reduce applied quantities; support for innovation and research are key to advancing these technologies to market and making them affordable.
- Limited data on fertilizer application rates and methods means that the baseline is not well known, making estimates of additionality challenging. Also, the assumption around the percentage reduction in N fertilizer use is based on expert opinion and should be validated scientifically.
- To date, the reduction in N application cost has not been high enough to offset revenue losses from yield reductions resulting from insufficient N application.

Forestry

F1. Increase Domestic Wood Use as a Substitute Material for More Emissions-Intensive Building Products

POLICY GOAL: Achieve increased use of wood-intensive construction including tall wood buildings as a long-term mitigation contribution.

POLICY TOOLS: Investments in demonstration wood-intensive construction projects and in the education, training and changes to codes and standards necessary for wood-intensive construction to become commonplace.

Policy Details

- Funding for activities to support adoption of tall wood buildings into the National Building Code of Canada (NBCC).
- Funding for the development and provision of training/education programs, design software, and life-cycle assessment tools for architects, engineers, code officials and builders interested in building with wood, including engineered wood product (i.e., products manufactured by binding wood particles, fibres, or pieces together with adhesives or other methods to form composite materials with specific characteristics).
- Financial support for wood-intensive structures as demonstration projects to catalyze increased interest in and use of wood in tall and mid- rise buildings, timber bridges, industrial buildings and commercial box-type construction projects.

The mitigation benefits of this option result from making more use of long-lived wood products in domestic construction. Increased domestic use of wood products will provide long-term carbon storage and can contribute substantially less GHG emissions than concrete or steel on a life-cycle basis, when used in comparable construction projects. Success in catalyzing interest in wood-intensive construction could increase mitigation above that estimated for 2030, and continuing beyond 2030.

Options		Est. reductions in 2030*	Est. cost/tonne
A.	High-uptake of wood-intensive building designs and proposed building code changes. Projects maximize wood-use and achieve an average of 4000 t CO_2e avoided per building.	2 Mt	$0-50
B.	Low-uptake of wood-intensive building designs and proposed building code changes. Projects focus on hybrid rather than wood-intensive designs and achieve an average of 1000 t CO_2e avoided per building. Assumes the same number of structures as alternative A.	<1 Mt	$0-$50

* Note: Storage of carbon in wood and recycling of wood are not included in the estimate of emissions reductions. However, at the end-of-life of wood intensive structures, additional mitigation benefits can be realized by using the wood for bioenergy or re-using /re-fabricating it into new structures or other products

ECONOMIC AND CONSUMER IMPACTS

- Building with engineered wood products could be cheaper than traditional non-wood intensive alternatives.
- Increased production and use of engineered wood products would create more jobs, and add value compared to commodity wood products such as lumber. There would be indirect economic benefits and job creation for rural forest-based communities.
- Companies currently manufacturing emissions-intensive building materials that are replaced by wood could experience lost revenue.

CONSIDERATIONS

Co-benefits:

- This option would drive further clean-tech building innovation, building on collaborative efforts of the federal government and various stakeholders (i.e. FPInnovations, Sustainable Development Technology Canada, Canada Wood Council, etc.). It is explicitly aimed at fostering innovation in Canada's construction industry through development of demonstration projects and wood design and construction tools.

Linkages with other working group areas and other proposed policies:

- There are potential long-term linkages to afforestation and forest management policy options as they can influence availability of wood for use in engineered wood products.
- Carbon pricing mechanisms cannot directly encourage actions that take advantage of life-cycle mitigation benefits, as is the case with this option.

Implementation, feasibility, technological and enabling infrastructure issues:

- This option leverages past and current efforts to promote wood use in construction by focusing on domestic uses in a broader range of construction projects.
- A target of 450 wood-intensive structures is considered appropriate to achieve the mitigation amount and the goal of catalyzing greater use of wood, but uptake would need to be monitored over time. Projects could be a mix of building designs ranging from current hybrid wood building designs to first-of-kind mass timber wood-intensive designs. The project mix would determine the overall mitigation benefits.
- Many of the technologies for more intensive construction uses of wood are already demonstrated, commercialized and used in other countries.
- The National Building Code of Canada currently limits tall wood building construction. Thus a key aspect of this option is contributing to future changes in the Code, and in provincial/territorial building codes – specifically changes towards a performance-based (material-neutral) code that will treat all construction materials in the same way.
- Fire risks are minimal when wood buildings are designed properly and appropriate fire protection strategies are implemented, especially during construction. Tests funded by NRCan, provinces and industry have demonstrated excellent fire performance that meets the intent of the building code.
- Currently there is a gap in education in Canada about wood's potential as an advanced and sustainable building material. Academia, architects, engineers and builders focus largely on concrete and steel construction. This option would supplement existing training with education in advanced modern techniques in wood construction, and support creation of tools to assist professionals in incorporating wood into their building or infrastructure construction.
- The investments in wood intensive structures, training, tools and changing building codes are meant to foster broad acceptance and adoption of wood-intensive building practices – a change in mind-set – that will would result in even higher mitigation in the future.
- Growth in the supply chain of engineered wood products would be needed to help support the increased demand for wood-intensive structures.

F2. The New Forest Program

POLICY GOAL: Substantially increase the area of newly forested land (afforestation).

POLICY TOOLS: Cost sharing agreements with landowners, and technical support.

Policy Details

- Cost sharing agreements with landowners to significantly reduce high up-front costs that pose a significant barrier to creation of new forests (i.e., site preparation, seedling and planting costs, but not land purchase costs). A large portion (e.g., 50-95%) of establishment costs could be covered with incentives tailored to the type of land and landowner objectives. Eligibility requirements could include planting of at least

one hectare in size, choice of tree species resilient to climate change, agreement to follow sustainable forest management practices including replanting if harvesting occurs in the future, and implementation of long term monitoring and forest management plans.
- Provision of information and technical support for landowners to raise awareness of afforestation, encourage participation and facilitate new forest establishment and management.

This option would support substantial additions to the forest landscape by encouraging a variety of landowners (e.g., private, municipal) to create new forests. Most planting likely would occur on privately-owned marginal agricultural land, of which there is a very substantial area in Canada. Native grasslands and prime agricultural land are not the focus although farmers could plant trees as part of agroforestry. Also, this option does not cover planting of individual trees or small groups of trees. The alternatives reflect different choices about species to use: while slower-growing species (option B) provide relatively little mitigation in 2030, as they continue to grow they provide much more in 2050 (6 to 8 Mt).

Options		Est. reductions in 2030*	Est. cost/tonne**
A.	One billion tree planting program between 2017 and 2030 focused on mitigation in 2030 with a mix of tree species including almost 60% short rotation, fast growing species. Planting rates would ramp up to the full level of 50,000 ha per year by 2021 (about 600,000 ha planted in total).	4 - 7 Mt	$0-50
B.	One billion tree planting program between 2017 and 2030 that serves a range of goals including long-term mitigation and ecological co-benefits by using traditional slower-growing species. Planting rates would ramp up to the full level of 50,000 ha per year by 2021 (about 600,000 ha planted in total).	1 - 2 Mt*	$0-50
C.	250 million tree planting program between 2017 and 2030 focused on mitigation in 2030 with a mix of tree species including almost 60% short rotation, fast growing species. Planting rates would ramp up to the full level of 12,500 ha per year by 2021 (about 150,000 ha planted in total). This is a scaled-down version of option A.	1 - 2 Mt	$0-50

* Mitigation would be substantially higher in 2050, because trees will continue to grow and sequester more carbon.

** These costs are based on estimates of GHG reductions beyond 2030, and so reflect the fact that trees will continue to grow and provide climate benefits for longer time periods.

ECONOMIC AND CONSUMER IMPACTS

- Landowners will be provided with an additional land use option that could increase diversification of rural economies. Some landowners may be interested in harvesting trees in the future (this would occur after 2030) to generate revenue, although re-planting of trees would be required.
- The option could include a sub-component directed at tree planting on reserve land and could act as a source of economic development for Indigenous peoples.

CONSIDERATIONS

Co-benefits:

- Depending on tree species used, planting locations and landowner objectives for their forests, co-benefits could include enhanced habitat for wildlife, increased biodiversity, improved soil quality due to reduced erosion, watershed protection, and promotion of greener communities. This option would provide a highly visible way to address climate change.

Linkages with other working group areas and other proposed policies:

- Landholders may harvest trees in the future for wood products and/or bioenergy. In the long-term, this option has potential linkages to options that encourage greater use of bioenergy and wood.
- While offset systems can be designed to stimulate afforestation, this option would likely yield more mitigation than would be possible through afforestation offset projects.

Implementation, feasibility, technological and enabling infrastructure issues:

- Afforestation refers to creating forests on land that has never been forest or has not been forest for a long time. This activity has historically been very limited (average of 2,750 hectares per year in 2000 to 2008, the latest year for which data are available from Canada's greenhouse gas inventory).
- Program implementation could be coordinated with or undertaken by existing tree planting agencies (e.g. Tree Canada, Forests Ontario, conservation authorities, and other entities) to take advantage of their practical experience, organizational infrastructure and access to potentially interested landowners. It would make sense to harmonize eligibility criteria with existing efforts.
- The potential for increased afforestation to generate mitigation varies by region due to differences in land availability, tree growth rates, and costs as well as the lack of certainty about future markets for biomass from fast-growing trees. Variable incentives could be designed to reflect these differences so as to cost-effectively achieve mitigation. Most of the afforestation is expected to occur in the Prairie Provinces due to the relatively large area of marginal agricultural land there.
- It will be important to choose tree species that could survive and grow well under expected future climate conditions.
- Alternatives A and C include planting of almost 60% fast-growing short-lived trees that can produce substantial mitigation by 2030. It is assumed that these areas will be harvested, but the emissions that result will be offset trees that are still growing.
- The range shown for mitigation reflects uncertainties in growth rates as well as risks, including the possibility that tree growth or survival will be affected by drought, insects, disease or fire. While using only short-lived fast-growing species would produce even more mitigation than in Alternative A, the risks are also higher. Participating landowners would be required to take actions to reduce risks and commit to long-term maintenance of afforested areas as forest, including after harvesting.
- An assessment would be required of existing tree seed inventories and nursery infrastructure, and the cost of cone/seed collection. Sufficient, appropriate cone/seed and tree seedling stock would need to be developed.

F3. Increased Forest Rehabilitation

POLICY GOAL: Increased rehabilitation of naturally disturbed Crown forest lands for long-term mitigation benefits.

POLICY TOOL: Funding of increased forest rehabilitation activities.

Policy Details

- *Support for substantially increased rehabilitation of naturally disturbed Crown forests to 2030 (for example, forests disturbed by insect outbreaks, wildfire, disease or windstorms).* Actions would include fibre recovery to facilitate regeneration and reduce fire risk, stopping burning of dead biomass in the forest and instead remove it for bioenergy or products, planting of trees to accelerate and improve forest regeneration, and monitoring and follow-up to ensure regeneration success. Species used would be locally appropriate, consistent with government policies. Lands planted would be within the managed forest but not covered by existing obligations or plans for rehabilitation. Criteria for choosing sites to rehabilitate might include cost efficiency, sites with a lot of dead biomass as a result of the natural disturbance, sites where the forest has not regenerated well or is not expected to, perhaps because of a changing climate, and potential adaptation benefits.

Provinces and territories already have programs to rehabilitate forest lands affected by natural disturbances. This policy option would increase rehabilitation above these levels. The estimated mitigation benefits result from faster and better forest growth but these benefits occur over the long term because the species planted will typically be slow-growing. As a result, this option provides relatively little mitigation in 2030, but offers substantial mitigation in the longer term. In 2050, it would provide between 3 and 11 Mt CO_2e depending on the alternative. When considered over an even longer period the cost would fall well below $50/t because mitigation benefits continue to accrue as result of the initial rehabilitation investments.

Options		Est. reductions in 2030*	Est. cost/tonne**
A.	*Support rehabilitation of about 4 million hectares of Crown lands affected by natural disturbances by 2030* to accelerate and improve forest regeneration, where such efforts are not currently required.	<1 Mt	$50-100
B.	*Support rehabilitation of about 1.1 million hectares of Crown lands affected by natural disturbance by 2030* to accelerate and improve forest regeneration, where such efforts are not currently required.	<1 Mt	$50-100

* Mitigation would be substantially higher in 2050, because trees will continue to grow and sequester more carbon.

** These costs are based on estimates of GHG reductions beyond 2030, and so reflect the fact that trees will continue to grow and provide climate benefits for longer time periods.

ECONOMIC AND CONSUMER IMPACTS

- Forestry-dependent and Indigenous communities will be the first to feel the impacts of any timber supply disruptions or losses of other forest values as a result of changing climate conditions and increases in natural disturbances. Jobs in the forest sector would be created in activities that are required for successful regeneration of forests (e.g., fibre recovery, tree planting).
- In the long term this option would contribute to increasing or sustaining the future timber supply, with corresponding long-term economic benefits.

CONSIDERATIONS

Indigenous Perspectives

- The AFN has proposes that Indigenous knowledge and stewardship practices be incorporated into existing rehabilitation programs.
- Input from the MNC also notes that northern communities rely on existing old growth forests for maintenance of traditional livelihoods, manage forest fires on a regular basis, and have a direct interest in forest land management, in some cases through land use agreements or licenses

Co-benefits:

- The rehabilitation activities supported by this option could be designed to help increase the long-term resilience of forests to a changing climate through choice of the tree species planted, and by reducing fire risk. Improved regeneration of forests after natural disturbance could contribute to improved habitat for wildlife, better watershed protection, and increased biodiversity.
- Using dead biomass from natural disturbance for bioenergy instead of burning it in the forest provides air quality benefits through reduced emissions of particulate matter and black carbon.

Linkages with other working group areas and other proposed policies:

- Adaptation to climate change by Canada's forest and forest sector would be assisted by this option.
- Fibre recovery would create an additional source of biomass that could support options which encourage bioenergy or greater use of wood.
- Offset systems can be used to stimulate mitigation involving forests at the project level, and examples exist in Canada, but it is not expected that substantial areas of new forest rehabilitation will be stimulated under offset systems given that the benefits mainly occur in the longer term.

Regional impacts including northern and remote communities:

- Provinces/territories have jurisdiction over 90% of Canada's forests. The greatest mitigation activity would occur in regions with significant natural disturbances, such as the mountain pine beetle infestation in central British Columbia and regions with high occurrence of forest fires.

Implementation, feasibility, technological and enabling infrastructure issues:

- The ranges for mitigation shown reflect uncertainties about factors such as incremental growth due to rehabilitation activities, as well as the diverse range of baseline activities across the country. In some parts of the country dead biomass left after natural disturbance is burned to reduce fire risk and help forest regeneration. The mitigation estimates have not captured reductions in non-CO_2 GHG emissions that would result from stopping open burning.
- Implementation would ramp up over several years and would need to begin as soon as possible as there is a substantial lag between initiation of rehabilitation activities and when mitigation benefits occur, reflecting the long timescales of forest growth in Canada.
- An assessment would be required of existing tree seed inventories and nursery infrastructure, and the cost of cone/seed collection. Sufficient, appropriate cone/seed and tree seedling stock would need to be developed. As well, effort might be needed to develop the supply of private sector contractors qualified to implement rehabilitation activities (i.e. fibre recovery, replanting).
- Consideration would need to be given to how best to make use of existing road networks as some naturally disturbed areas of interest may not be easily accessible. There might be a need to amend forest management plans and shift harvest plans to cover areas closer to naturally disturbed areas to reduce road building requirements.

F4. Change in Forest Management Practices

POLICY GOAL: Achieve 8-10 Mt CO_2e of mitigation in 2030 through changes in forest management.

POLICY TOOL: Commitments to forest Mitigation Action Plans involving changes in forest management.

Policy Details

- *Jurisdictions would develop forest Mitigation Action Plans or regional forest management plans that consider mitigation and identify changes to forest management practices to achieve mitigation. Nationally, the aim would be to achieve 8-10 Mt CO2e of mitigation in 2030.* Plans would vary by jurisdiction and be incremental to existing practices. Plans could include support for research and opportunity identification to increase mitigation outcomes. Changes in practices might be selected based on consistency with the jurisdiction's sustainable forest management goals, mitigation potential in 2030 and beyond, ability

to quantify mitigation outcomes, cost efficiency, impacts on employment and growth of the forest sector, contribution to climate change adaptation, and inclusion of Indigenous stewardship practices.
- *Implementation mechanisms and timing would be determined by jurisdictions consistent with their own sustainable forest management systems, objectives, policy development processes and policy directions.* Mechanisms might include strategic regulatory changes or broadly-applicable approaches (e.g., a "Forest Fund") that provide incentives to forest managers and private land owners to change management practices. Provinces and territories have jurisdiction over 90% of Canada's forests.

It is expected that choices about changes in practices will take into account net GHG impacts including impacts in the forest as well as impacts related to the use of harvested wood and substitution of wood for more emissions-intensive products and fossil fuels. They would also take into account other sustainability objectives. Examples of changes in practices that might be considered include increased silvicultural intensity to improve growth, changes in harvesting practices to extract more biomass per hectare, reduced burning of harvest residues in the forest, increased extraction of harvest residues for wood products or bioenergy, and forest conservation. Mitigation impacts would continue to grow after 2030, reaching 16 to 18 Mt CO_2e in 2050.

Options		Est. reductions in 2030*	Est. cost/tonne**
A.	*Regionally-appropriate changes to forest management aimed at achieving 8-10 Mt of national mitigation in 2030.* In any region, multiple actions might be undertaken as a package to provide a mix of short- and long-term mitigation.	8 - 10 Mt	$0-50

* Mitigation would be substantially higher in 2050, because trees will continue to grow and sequester more carbon.

** These costs are based on estimates of GHG reductions beyond 2030, and so reflect the fact that trees will continue to grow and provide climate benefits for longer time periods.

ECONOMIC AND CONSUMER IMPACTS

- Changes to forest management practices could affect employment or harvesting and other costs, or mean that that the wood made available for forest products has different characteristics.

CONSIDERATIONS

Indigenous Perspectives

- Input from the AFN recommends that Indigenous knowledge inform and guide forest management practices in order to consider forest ecology and fire ecology as components of a holistic approach.
- Input from the AFN recommends that changes in forest management practices should help facilitate Indigenous stewardship practices across landscapes.
- Input from the MNC also notes that northern communities rely on existing old growth forests for maintenance of traditional livelihoods, manage forest fires on a regular basis, and have a direct interest in forest land management, in some cases through land use agreements or licenses

Co-benefits/negative impacts:

- Co-benefits or negative impacts will depend on specific changes in management practices.
- For example, reducing burning of harvest slash in the forest would reduce black carbon emissions but could increase wildfire risk, unless a portion is removed and used for bioenergy or products.

Linkages with other working group areas and other proposed policies:

- A separate option addresses increased rehabilitation of forests following natural disturbances, as a specific forest management action. The impacts of that option are not included in the analysis here.
- While this option focuses on increased sequestration and emission reductions in forests, changes in forest management practices could affect the supply of sustainably harvested wood needed to support options involving increased domestic use of wood in construction or for bioenergy.
- Offset systems can be used to stimulate mitigation involving forests at the project level, and examples exist in Canada. Very substantial demand for forest management offsets would be needed to achieve the levels of mitigation targeted with this option, and it is unlikely that offset systems alone would be enough to stimulate the targeted levels of mitigation.

Regional impacts including northern and remote communities:

- 75% of the managed forest is located in British Columbia, Ontario, Quebec and Alberta. Generally speaking, the greatest mitigation activity would occur in regions with the largest forest sectors.

Implementation, feasibility, technological and enabling infrastructure issues:

- Developing and implementing Mitigation Action Plans could take several years but some changes could happen relatively quickly. The targeted national level of mitigation would need to be re-visited once plans are developed.
- In general, to date, there have been few changes in forest management specifically for GHG mitigation purposes in Canada. This reflects the complexity of forest management and the need for governments to balance mitigation objectives within the broader context of the diverse values and objectives of their sustainable forest management regimes. Care would be needed to ensure changes in practices do not jeopardize meeting forest certification requirements.
- Variations across Canada in the characteristics of forests, forest management and the jurisdictional policy context make it difficult to specify changes in practices that make sense everywhere. Thus, this option would flexibly accommodate differences in order to optimize mitigation. Changes to forest management would be consistent with jurisdictional sustainable forest management objectives and would depend upon their choices about preferred approaches for mitigation.
- All changes in forest management practices in Mitigation Action Plans would be over and above current policy and requirements. The intent is not to relieve holders of forest tenure agreements of any obligations they currently have, and any incentives provided would not be intended to support fulfillment of existing tenure agreement obligations.
- To maximize mitigation, implementation would need to begin soon because there can be a substantial lag between forest management activities and when mitigation benefits occur, reflecting the long timescales of forest growth in Canada.
- Future natural disturbances such as increased forest fires due to climate change could reduce the long-term mitigation. At the same time, changes in forest management practices could combine mitigation and climate change adaptation goals in an effort to reduce the impacts of natural disturbances and increase forest resilience to climate change.
- Improvements in forest monitoring and reporting would help in tracking the effects of mitigation actions, as well as support other objectives such as on-going assessment of how forests are being impacted by a changing climate.

Waste

W1. Landfill Gas Capture and Utilization

POLICY GOAL: Increase municipal solid waste (MSW) landfill gas (LFG) capture and utilization

POLICY TOOLS:
A. Mandatory requirements for MSW LFG capture and flaring or utilization (e.g. regulation); and/or
B. Incentives to encourage MSW LFG utilization (e.g. feed-in-tariff for LFG-to-electricity); could be coupled with policy tool A.

Policy Details

Option A:
- Increased LFG capture would come from about 26 MSW landfills in provinces with no or less stringent regulations, by installing new or expanding existing capture systems.
- Focus on MSW landfills with greater than 1M tonnes of waste in place, and/or accepting greater than 40K tonnes of waste per year, and either active or closed less than 15 to 30 years (depending on size).
- 80% of the LFG capture would come from large landfills with greater than 5M tonnes of waste in place, and more than 75% would be from active landfills.
- Estimated average cost for LFG capture is about $4/t CO_2e.

Option B:
- Increased capture and utilization would come from about 41 MSW landfills across Canada, by installing new or expanding existing capture and utilization systems.
- Emission and cost estimates based on a $0.12 per kWh feed-in tariff for electricity generation (comparable to rates paid in ON and QC), which is the most common use for LFG.
- Would generate about 1 million MWh of electricity (using about 52,000 cfm of LFG).
- LFG must be processed / cleaned prior to electricity generation.
- Producing renewable natural gas from LFG requires more processing, so the financial incentives would likely need to be higher and yields may be lower.

Options		Est. reductions in 2030	Est. cost/tonne
A.	Mandate capture: 57% of all LFG is captured and flared or utilized by 2030 (up from 36% captured in 2013, and 50% currently projected for 2030).	2-3 Mt	$0-50
B.	Incentives for utilization: 57% of all LFG is captured and 33% is utilized by 2030 (up from 18% utilized in 2013).	2-3 Mt	$0-50

Note: The estimated reductions are based largely on conservative estimates completed in 2011-12. Further assessment with more recent information is required to determine if higher levels of landfill gas capture and utilization are technically and economically feasible.

ECONOMIC AND CONSUMER IMPACTS
- Increased employment for design, construction and operation, particularly with LFG utilization.
- Source of renewable electricity and/or renewable natural gas.
- Utilization allows for cost recovery, helping to reduce regulatory compliance costs associated with LFG capture systems.

CONSIDERATIONS

Co-benefits/negative impacts:

- Reduced emissions of volatile organic compounds, odors, and other local air pollutants.
- Potential air pollutant co-benefits from displacement of fossil fuel-fired electricity generation.
- Increased utilization could generate about 1 million MWh of electricity (using about 52,000 cfm of LFG).

Regional impacts including northern and remote communities:

- Existing regulations in BC, AB, MB, ON, QC and PEI; stringency & performance standards vary.
- Further LFG capture opportunities exist at a total of 26 MSW landfills in AB, SK, MB, NB, NS and NL.
- Further LFG utilization opportunities exist at 41 MSW landfills in BC, AB, SK, MB, ON, QC, NB and NL.
- Renewable natural gas option may only be possible in regions of Canada where it is possible to connect a natural gas pipeline.
- Most northern and remote landfills would not be implicated; typically small, do not generate sufficient quantities of LFG to justify the capital investments.

Implementation, feasibility, technological and enabling infrastructure issues:

- Infrastructure investments required to connect LFG utilization systems to electricity grid or natural gas distribution pipelines.
- Existing and commercially available technologies.

W2. Reduce Avoidable Food Waste

POLICY GOAL: Reduce avoidable food waste in Canada by 50%

POLICY TOOL: National Strategy and Campaign to reduce Avoidable Food Waste

Policy Details

- Strategy should include a diverse range of tools and actions, such as: best practices for producers, retailers and consumers; measurement and reporting; packaging standards; market-based incentives; improving donation channels; food grading and labelling; consumer education; and, industry outreach and training.
- A mix of regulatory and non-regulatory tools has been successful in leading countries.
- Examples of specific actions that have been implemented in leading countries include:
    - » Regulations to standardize date labelling (expiry, best before, etc.) to reduce consumer confusion (which accounts for 20% of consumer food waste).
    - » Government and industry could adopt consistent performance indicators, and measurement and reporting approaches to evaluate performance and facilitate meaningful comparisons of food waste reduction, recovery and diversion achievements.
    - » Best practices and training programs could be developed for food sectors to bolster food loss and waste prevention and recovery throughout the supply chain.
    - » Changes in consumer habits could be stimulated through awareness-raising, education and improved food labeling.
    - » Improvements to food donation channels, such as standardized donation regulations, donation liability education, and best practices for donation storage, handling and transport.
- Aligns with Canada's international commitments (e.g. United Nation's High-level Political Forum on Sustainable Development).
- Would complement national food policy being developed by Agriculture and Agri-Food Canada (estimated 2018).

Options	Est. reductions in 2030	Est. cost/tonne
Reduce avoidable food waste in Canada by 50% by 2030, focusing on the retail and consumer levels and reducing food losses along production and supply chains, including post-harvest losses.	10 -15 Mt (life-cycle)	<$0

Note: The IPCC fourth assessment report identifies waste prevention, re-use and recycling as key GHG mitigation actions and indicates that life cycle analysis is required to quantify GHG reductions. Further work would be required to estimate the distribution of reductions between the sectors included in the food production and supply chains. Note that a substantial portion of potential emissions reductions would occur outside of Canada.

ECONOMIC AND CONSUMER IMPACTS

- Economic savings throughout all stages of the food supply chain.
- In Canada, $31 billion/year are lost due to avoidable food waste, which mostly goes to landfill or composting.
- Estimates for US indicate that the net economic value of avoiding food waste is about $3,800/tonne throughout the food supply chain, or about $1,100 of net economic value/t CO_2e.
- Residential consumers represent up to 47% of the economic losses associated with food waste in Canada. Similar food waste reduction initiatives in leading countries have generated up to $240 in savings for consumers for every dollar invested.
- Reduces productivity losses and (potentially) food prices.

CONSIDERATIONS

Co-benefits/negative impacts:

- Reduces quantity of organic waste requiring disposal (generating methane in landfills) or diversion.
- Combats hunger and food insecurity.
- Minimizes resource loss and consumption (e.g., water, pesticide, fertilizer, labour, fuel, deforestation, biodiversity, overfishing, etc.).

Regional impacts including northern and remote communities:

- National issue that impacts all Canadians.
- Likely that largest impact will be in urban centers (population density).
- Impacts will vary depending on options pursued.

Implementation, feasibility, technological and enabling infrastructure issues:

- Collaboration will be required between a broad range of stakeholder organizations including governments (federal, provincial, municipal), food producers and food industries, food retailers and service providers, food transporters, consumers, charities and other NGOs.
- Could involve many technologies, including:
  - » Food waste measurement/inventory management/donation matching: inventory/waste tracking software.
  - » Food packaging: innovative food packaging approaches.
  - » Cold chain management: improved refrigerated transport and storage.
  - » Manufacturing line optimization: improved manufacturing/processing technologies.
  - » Specialized food packaging to optimize food life.

W3. Diversion of Organics

POLICY GOAL: Increase diversion of organics from disposal

POLICY TOOLS:

- Ban organics (i.e. food waste, leaf and yard waste, etc.) from disposal, and mandate collection of those materials from all sources (residential and non-residential) for processing.
- Bans should be supported by education campaigns, guidance and enforcement.
- Additional tools that can support organics diversion include:
  - » Incentives to produce biogas from organics using anaerobic digestion (e.g. feed-in-tariff).
  - » Grants and loans for organics treatment facilities (composting, anaerobic digesters, etc.).

Policy Details

- Requires modifications and increases to organics collection, hauling and processing infrastructure, with largest opportunity likely in institutional, commercial and industrial sectors.
- To ensure compliance, regular and random inspections would be needed to enforce the ban, as well as fines and/or other sanctions for violations.
- Education programs required to shift public attitudes and encourage organics diversion.
- For level of ambition A, focus would likely be on large urban centers.
- To achieve the more ambitious diversion target (level B), increased incentives, education and enforcement would be required, and the focus could be expanded to include smaller population centers (including rural and remote).

Options		Est. reductions in 2030	Est. cost/tonne
A.	Increase organics diversion rate in Canada from 6.7% of total waste generated (or 65 kg/capita) in reference year 2010 to >20% (or >195 kg/capita) by 2030, in line with best performer in Canada (NS).	1 -3 Mt (life cycle)	$0-50
B.	Increase organics diversion rate in Canada from 6.7% of total waste generated (or 65 kg/capita) in reference year 2010 to >25% (or >240 kg/capita) by 2030, in line with best performers in EU.	1- 4 Mt (life cycle)	$0-50

Notes:
The IPCC fourth assessment report identifies waste prevention, re-use and recycling as key GHG mitigation actions and indicates that life cycle analysis is required to quantify GHG reductions. Further work would be required to estimate the distribution of reductions between sectors implicated in organics diversion.

For each level of ambition, the lower end of the range of emission estimates is based on emission factor published by OECD[96] and the upper end of the range is based on estimates using emission factors from ECCC's GHG Calculator for Waste Management[97] and US EPA's Waste Reduction Model (WARM)[98].

ECONOMIC AND CONSUMER IMPACTS

- Achieving ambition level B would result in an additional 6.1 Mt of recyclable materials diverted
- ON study from 2009 indicates 7 jobs are created for every 1,000 tonnes of waste diverted with an economic benefit to society four times greater than the net cost of taking action [99] – on this basis, achieving ambition level B could produce up to 43,000 new jobs.

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96 OECD, 2012. Greenhouse Gas Emissions and Potential for Mitigation from Materials Management within OECD Countries. www.oecd.org/env/waste/50035102.pdf.

97 www.ec.gc.ca/gdd-mw/default.asp?lang=En&n=D6A8B05A-1

98 www.epa.gov/warm

99 AECOM, 2009. The Economic Benefits of Recycling in Ontario. https://archive.org/details/theeconomicbenef00snsn21841

CONSIDERATIONS

Co-benefits/negative impacts:
- Waste diversion contributes to resource efficiency and moves Canada toward a circular economy.
- Organic material is highest proportion of waste landfilled and contributes most to landfill methane emissions.
- Anaerobic digestion produces renewable natural gas.
- Composting and anaerobic digestion produce a valuable soil amendment that: decreases soil erosion by enhancing soil structure; returns a diverse number of nutrients to soil; reduces watering needs by improving water retention in the soil; suppresses plant disease.
- Reduced landfill usage improves quality of life in adjacent communities.
- Fewer landfill sites needed, saving the cost of creating new landfills or transporting waste to more distant landfills.

Regional impacts including northern and remote communities:
- In regions where transporting waste to USA for disposal is cost effective, an organics disposal ban may cause increased exports (i.e. if organics diversion is more costly).
- For northern and remote communities, there is a case to be made for composting paper along with organics, as the paper provides a needed source of carbon for the composting process and the costs for shipping paper out of the community are avoided.

Implementation, feasibility, technological and enabling infrastructure issues:
- Existing and commercially available technologies.
- Infrastructure investments for municipalities and non-residential sectors to collect and process organics.

W4. Diversion of Recyclable Materials

POLICY GOAL: Increase diversion of recyclable materials from disposal

POLICY TOOLS:
- Ban recyclable materials from disposal and mandate collection from all sources (residential and non-residential) for recycling.
- Bans should be supported by education campaigns, guidance and enforcement.
- Additional tools that can support diversion of recyclable materials include grants and loans for recycling programs and facilities.

Policy Details
- Requires modifications and increases to recyclable material collection, hauling and processing infrastructure, including new facilities.
- To ensure compliance, regular and random inspections would be needed to enforce the ban, as well as fines and/or other sanctions for violations.
- Education programs to shift public attitudes and encourage diversion of recyclable materials.
- For level of ambition A, focus would likely be on larger urban centers.
- To achieve the more ambitious diversion target (level B), increased incentives, education and enforcement would be required, and the focus could be expanded to include smaller population centers (including rural and remote).

Options		Est. reductions in 2030	Est. cost/tonne
A.	Increase diversion rate for all paper types from 9.8% of total waste generated (or 98 kg/capita) in reference year 2010 to 13% (or 130 kg/capita) by 2030, in line with best performers in Canada (QC and BC).	2-4 Mt (life cycle)	$0-50
B.	Increase diversion rate for all recyclable materials from 15.7% of total waste generated (or 152 kg/capita) in reference year 2010 to 20% (or 195 kg/capita) by 2030, in line with best performers in Canada (QC and BC).	3-4 Mt (life cycle)	$0-50
C.	Increase diversion rate for all recyclable materials from 15.7% of total waste generated (or 152 kg/capita) in reference year 2010 to 35% (or 335 kg/capita) by 2030, in line with best performers in EU.	14-16 Mt (life cycle)	$0-50

Notes:
The IPCC fourth assessment report identifies waste prevention, re-use and recycling as key GHG mitigation actions and indicates that life cycle analysis is required to quantify GHG reductions. Further work would be required to estimate the distribution of reductions between sectors implicated in recycling.

For each level of ambition, the lower end of the range of emission estimates is based on emission factor published by OECD[100] and the upper end of the range is based on estimates using emission factors from ECCC's GHG Calculator for Waste Management[101] and US EPA's Waste Reduction Model (WARM)[102].

ECONOMIC AND CONSUMER IMPACTS

- Achieving ambition level C would result in an additional 6.3 Mt of recyclable materials diverted
- ON study from 2009 indicates 7 jobs are created for every 1,000 tonnes of waste diverted with an economic benefit to society four times greater than the net cost of taking action [103] – on this basis, achieving ambition level C could produce up to 44,000 new jobs.

CONSIDERATIONS

Indigenous Perspectives

- Input from the AFN recommends developing off-grid recycling and product stewardship solutions, which could help reduce burning or accumulation of trash.

Co-benefits/negative impacts:

- Waste diversion contributes to resource efficiency and moves Canada toward a circular economy.
- Reduces the amount of waste sent to landfills and incinerators.
- Conserves natural resources such as timber, water, and minerals.
- Saves energy and prevents pollution by reducing the need to collect and process new raw materials.
- Fewer landfill sites needed; saves the cost of creating new landfills or transporting waste to more distant landfills.

100 OECD, 2012. Greenhouse Gas Emissions and Potential for Mitigation from Materials Management within OECD Countries. www.oecd.org/env/waste/50035102.pdf.

101 ECCC. www.ec.gc.ca/gdd-mw/default.asp?lang=En&n=D6A8B05A-1

102 US EPA. www.epa.gov/warm

103 AECOM, 2009. The Economic Benefits of Recycling in Ontario. https://archive.org/details/theeconomicbenef00snsn21841

Regional impacts including northern and remote communities:
- In regions where transporting waste to USA for disposal is cost effective, a recyclable materials disposal ban may cause increased exports (i.e. if recycling is more costly).
- For northern and remote communities, costs will be higher due to distances covered and methods used to transport recyclable materials to processors and end-markets. There is a case to be made for processing paper along with organic waste in the community (e.g. via composting), as the paper provides a needed source of carbon for the composting process and the costs for shipping paper out of the community are avoided.

Implementation, feasibility, technological and enabling infrastructure issues:
- Existing and commercially available technologies.
- Infrastructure investments for municipalities and non-residential sectors to collect and process recyclable materials.
- Disposal bans in some jurisdictions have led to increased illegal dumping and associated increases in cost and environments risks. Therefore bans should only be enacted following the establishment of recycling programs (e.g. Extended Producer Responsibility, material / product stewardship programs, etc.) for the banned material.
- Cost implications vary by jurisdiction.

Government Operations and Leadership

G1. Carbon neutral government

POLICY GOAL: Canadian governments can lead by example through a commitment to a carbon neutral public sector. This can be achieved by taking full responsibility for the emissions their operations release to the atmosphere and realizing net-zero greenhouse gas (GHG) emissions from federal, provincial, territorial and even local government public sector operations, including ministries and broader public sector organizations.

POLICY TOOL: Establish Carbon Neutral Government policy through legislation/regulation enacted either federally or by each government, augmented by additional incentives such as funding for investments in emissions reduction projects within the public sector. Legislation could include targets for emission reduction.

Policy Details
- The policy framework consists of five program pillars:
  - » Measure - quantify the greenhouse gas emissions from Canadian public sector operations.
  - » Reduce - plan and take action to reduce emissions as much as possible annually.
  - » Offset - invest in emission reduction projects to offset the remaining emissions.
  - » Report - demonstrate leadership through public reporting on achievements.
  - » Verify - assure the integrity of public sector reporting and offset investments.

- Standards and GHG quantification protocols should be aligned with internationally-recognized standards (e.g., General Reporting Protocol, GHG Protocol)
- Centralized governance, program administration and offsets procurement functions would support efficiency and lower administrative costs
- Carbon neutral government could be administered on a national level, or within each provincial, territorial and local government jurisdiction, or a combination thereof
- A public-facing offsets registry supports accountability, credibility and transparency

- Implementation of CNG could follow a phased approach:
  - » Phase 1: Governments begin to measure, reduce and report their emissions. Begin offset project origination and building an offsets portfolio. (2-4 years)
  - » Phase 2: Governments begin offsetting any emissions not reduced.

- Phase 2 would begin once there has been sufficient time to establish and refine measurement and reporting and to identify and develop a sufficient portfolio pool of offsets.

Level of Ambition A

"Low Carbon" government: 25-40% reduction in emissions from government operations

Level of Ambition B

Carbon neutral with targeted GHG reductions: 25-40% reduction in emissions from government operations, with offsets at a cost of $15-$25 per tonne

Level of Ambition C

Carbon Neutral with best efforts reductions: 0-25% reduction in emissions from government operations, with offsets at a cost of $15-$25 per tonne

Options		Est. reductions in 2030*	Est. cost/tonne
A.	**"Low carbon" government with targeted GHG reductions:** Government organizations reduce operational GHGs by a targeted amount by 2030 relative to a baseline year:	1-2 Mt	$0-50
B.	**Carbon neutral with targeted GHG reductions:** Government organizations achieve carbon neutrality by reducing operational GHGs by a targeted amount by 2030 relative to a baseline year. The remaining emissions are offset.	4-5 Mt	$-0-50
C.	**Carbon neutral with best efforts reductions:** Government organizations achieve carbon neutrality by taking reasonable action to reduce operational GHGs, but with a greater reliance on annually offsetting remaining emissions	4-5 Mt	$0-50

* Note: estimated emissions reductions are based on core operations of federal, provincial, and territorial governments. Greater reductions could potentially be achieved if a carbon neutral government policy was scoped more broadly to include other public sector operations

ECONOMIC AND CONSUMER IMPACTS

From public sector emission reduction activities:

- The Canadian public sector will increase capacity, support proof-of-concept projects, spur the development and adaption of clean technology and turn energy savings into cost savings that can be reinvested in public services such as health care and education.
- Economic benefits include stimulation of the clean technology sector and more effective use of public funds.
- Reduced operational costs through energy savings.

From offsets:

- Offsets investments span all regions and sectors including agriculture, industrial, forestry, oil & gas, waste management and transportation.
- Through offset purchases, governments can leverage these dollars to generate even greater private sector investments in clean technologies and jobs.
- Direct, indirect and induced economic benefits from investment in offset projects include contribution to GDP; federal, provincial, territorial and municipal tax revenue generation; and job creation.

CONSIDERATIONS

Indigenous perspectives:

- Offset purchases by public sector could facilitate low-carbon projects in remote or First Nations communities and enhance regional economic development.
- Input from the MNC suggests that set-asides for Métis communities be developed under the Low-Carbon Economy Fund, which could include funding for greening of Metis government and institutional operations.
- The MNC also recommends creating Métis-specific contract capacity set asides for Metis businesses in government procurement strategies, including those businesses that have a clean technology focus

Co-benefits/negative impacts:

- Reductions in energy consumption within government can have associated environmental benefits such as improved air quality.
- Carbon offset projects can have associated environmental benefits (e.g., habitat conservation).

Linkages with other working group areas and other proposed policies:

- May supplement/complement other carbon price instruments; emission reductions can be augmented by incremental funding or energy budget models, such as revolving energy funds, which allow public sector organizations to use operational energy savings to fund capital investments in emission reduction.

Regional impacts including northern and remote communities:

- Offset purchases by public sector could facilitate low-carbon projects in remote or First Nations communities and enhance regional economic development.

Implementation, feasibility, technological and enabling infrastructure issues:

Implementation considerations:

- Full implementation unlikely before 2022: min. 3 years needed to establish and improve accuracy of energy and emissions reporting.
- Energy & emission measurement and reporting may be burden for some governments.
- Significant emission reduction will require staff and financial resources.
- Will likely be important to ensure that offset projects and their benefits occur in the provinces that purchase them, but there may not be sufficient low cost offset opportunities in some provinces
- The scope of CNG coverage across jurisdictions should be similar, and at least meet the minimum requirements of international protocols.

Required infrastructure:

- Protocols/methodology for energy and emission measurement
- Mechanisms for energy and emissions reporting
- Mechanism(s) to track and record offsets, such as a registry platform.
- Third-party verification expertise
- Staff who are able to assist participating agencies with program requirements and facilitate emission reduction initiatives
- Centralized agency for purchasing offsets on behalf of participating agencies.

Internationally Transferred Mitigation Outcomes

POLICY GOAL: Ensure that Canada can meet its target and lower the overall cost of doing so through the use of Internationally Transferred Mitigation Outcomes (ITMOs).

POLICY TOOL: ITMOs could be produced through numerous avenues, including the use of the new centralized UNFCCC mechanism, investments in multilateral initiatives and funds, use of allowances from capped emissions trading systems, investments in emissions reductions from technology transfers, or credits from reducing emissions from deforestation and forest degradation in developing countries (REDD) or REDD+ (includes additional forest-related activities such as forest management).

Policy Details

- ITMOs can be acquired by national governments, sub-national governments, and the private sector, but their use towards participating Parties' NDCs, including whether and how they are shared, will need to be negotiated and agreed.

Approach	Description
Investment in multilateral initiatives through the World Bank, Multilateral Development Banks, or other multilateral funds	For example, the Transformative Carbon Asset Facility from the World Bank will help developing countries create and monetize the next generation of carbon credits, including those achieved through policy actions. The $500 million initiative will measure and pay for emission cuts in large scale programs in areas like renewable energy, transport, energy efficiency, solid waste management, and low carbon cities. Providing a contribution to the World Bank's results-based forest funds would help ensure that REDD+ carbon credits are available to Canada post-2020, secured at an estimated value of $CAD 6/tonne.
Emissions trading systems either at the national or sub-national level	For example, Quebec and California are participating in a linked cap-and-trade system under the Western Climate Initiative (WCI), and Ontario will soon join the WCI carbon market. Under this linked system, allowances representing reductions in other jurisdictions are being used by participating sub-national jurisdictions for compliance. If agreed by Canada and the United States, the net flow of allowances could be applied against each country's NDC. WCI partners are also looking for other potential partners in North America, and eventually, in other continents to broaden the market.
Bilateral investment in reductions outside of Canada	ITMOs can be produced by bilateral activities such as investment in projects in other countries or transfer of goods or technology. An example of the latter is Japan's Joint Crediting Mechanism (JCM) which provides financial and technological support to help developing countries achieve low-carbon growth. Carbon credits issued from emissions reductions resulting from the implementation of projects are used to meet Japan's national emission reduction targets. Other bilateral emissions-reduction projects could be undertaken in developed or developing countries, either directly or through established (centralized) mechanisms.
Use of centralized UNFCCC mechanism	Article 6 of the Paris Agreement establishes a new centralized mechanism to contribute to mitigation and promote sustainable development, which will be supervised by a body under the UNFCCC. Rules and modalities for the mechanism have not yet been developed. The mechanism will include project-based activities, but may also encompass sectoral approaches. It could also be used to "approve" ITMOs created outside of the UNFCCC, using UNFCCC rules that will be developed.

ECONOMIC AND CONSUMER IMPACTS

- Many ITMOs are expected to be lower-cost relative to available reductions in Canada, indicative of the fact that many of the low-cost mitigation opportunities have not yet been exhausted in other countries (e.g., fuel switching). Acquiring ITMOs could lower the overall cost of meeting Canada's 2030 target.
- The current cost of mitigation outcomes transferred internationally ranges from around CAD$ 6 to above CAD$ 16 per tonne[104]. However, the future supply of ITMOs is uncertain and there could be competition for the available supply.

Co-benefits/negative impacts

- To the extent that ITMO purchases support development in less developed countries, ITMO purchases could contribute to Canada's international development goals and Canada's support for the achievement of the United Nations Sustainable Development goals.[105]
- Could support exports of Canadian technology or cleaner energy whose end-use results in emissions being lower than they otherwise would have been in another country. However, this would require agreement with the other country that Canada could use any ITMOs created, which could be difficult to secure without additional investment or provision of assistance to that country. Otherwise, it would not help Canada meet its NDC.
- Agreeing to account for the flow of ITMOs that occur under the WCI or any other two-way trading system could result in making Canada's NDC more difficult to achieve if the overall flow of ITMOs is out of Canada. In addition, allowing the international aviation sector to access Canadian sourced ITMOs, while providing income to project proponents and a source of units for Canadian airlines operating internationally, could also make Canada's NDC harder to achieve.

Implementation, feasibility, technological and enabling infrastructure issues

- In order to meet the transparency requirements of the Paris Agreement, it could be useful to create infrastructure such as a registry, to track and report on transfers to and from the federal government. Such a system could also potentially support Canada's implementation of the market-based measure under development under International ICAO.
- The transparency framework under the Paris Agreement calls for Parties to report on how they have assessed environmental integrity. One way to ensure Canada can demonstrate environmental integrity would be to ensure that measuring, reporting and verification standards are consistent with international best practices. Ensuring reductions are real, additional, permanent, properly owned, monitored quantified, and reported, and verified would also facilitate the demonstration of environmental integrity.
- Accounting guidance developed under the UNFCCC is expected to address three key areas: avoidance of double-counting; single-year targets; and carry-over of previous units (e.g. under the Kyoto such as Clean Development mechanism or Joint Implementation units).
- Discussion has already begun with Quebec and California as well as the U.S. to determine how the WCI's net flows of ITMOs could be accounted for towards the NDC.
- The creation of a Canadian fund to purchase and invest in ITMOs (i.e., outside those that already exist under the WCI cap-and-trade system) may require new legislation.
- Investments in ITMOs (excluding those stemming from the WCI system) may need to begin well before 2030 in order to mitigate the risks of limited supply or rising costs.
- The federal government, in collaboration with provinces and territories, will continue to assess options for acquiring ITMOs under different mitigation and carbon pricing scenarios and as specific cost and emissions reduction potential estimates become available and/or more refined.

104 The lower end of the range is based on the value of REDD credit on the international market and the upper range on the current cost of allowances under Quebec's cap-and-trade system.

105 https://sustainabledevelopment.un.org/?menu=1300

ANNEX 3: KEY METHODOLOGICAL CHOICES

The MWG and technical subgroups developed a very broad set of policy options in a short time period, and therefore relied on existing, available analysis and expertise. Although the combined expertise of federal, provincial, and territorial experts has facilitated the development of a comprehensive report, some methodological choices have been made and their analytical implications are worth keeping in mind. Many of these are challenges that apply to climate policy analysis more generally.

NATIONAL, JURISDICTIONALLY-NEUTRAL APPROACH

Policy options are presented from a national perspective, and are designed so that in many cases they could be implemented by various orders of government across Canadian jurisdictions. This means that not all policy options are relevant to every jurisdiction, and most options would need to be adjusted before being implemented by a specific jurisdiction. Costs are also presented at the national level, and could vary substantially by jurisdiction due to difference in areas like energy costs, infrastructure, and industrial base. Similarly, emissions reductions from a given policy would not be spread evenly across the country.

DIFFERENT LEVELS OF DETAIL

Some policies are very specific and include design details such as incentive levels and eligibility criteria for assistance programs. Other policy options are higher level and describe the overall goal and type of policy tools available without specifying design details. This is often a function of the type of policy. Policies that address more complex emissions reduction opportunities with a variety of tools are less detailed than policies aimed at specific opportunities. For example, urban planning policies (B8) are broadly described, while building code policies (B1 and B3) are more specific.

EMISSIONS REDUCTIONS MODELLING APPROACH

1. *Baseline emissions projections:* The baseline used for calculating emissions reductions for each policy is the most recent federal emissions projection, published in *Canada's Second Biennial Report on Climate Change* (February 2016)**.** It includes federal, provincial, and territorial measures in place as of September 2015. A number of recent announcements are not reflected in this baseline, including: proposed federal regulations for HFCs, heavy-duty vehicles, and to reduce methane emissions from the oil and gas sector; Ontario's (ON) cap-and-trade system and Climate Change Action Plan; AB's Climate Leadership Plan; SK's renewable energy target; NL's Management of Greenhouse Gases Act; BC's Climate Leadership Plan, as well as the federal government's endorsement of the World Bank's Zero Routine Flaring by 2050 initiative. Since these new policies will represent emission reductions beyond the baseline, this report presents them as policy options in cases where they are discrete sectoral policies. Where such policies are already under development, this is noted to clarify they are being included primarily for accounting purposes.

2. *Interactive effects:* This report presents estimated reductions from each individual policy option, not accounting for potential interactive effects between them. As such, estimates of individual measures cannot be added together to obtain total reductions. Policies were not modelled together because this would require decisions about how policies should be packaged together, which was outside of the working group's mandate to provide options rather than recommendations, and due to time constraints.

3. *The E3MC Model.* Greenhouse gas (GHG) reductions in 2030 were estimated wherever possible using modeling from Environment and Climate Change Canada (ECCC) using its Energy, Emissions and Economy Model for Canada (E3MC). Where it was not possible to model the impacts of a given policy (e.g., in the case of several industrial sector policies), subgroups estimated reductions using the best available information from existing studies and policies in other jurisdictions.

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

Energy 2020 is an integrated, multi-region, multi-sector North American model that simulates the supply of, price of, and demand for all fuels. The model can determine energy output and prices for each sector, both in regulated and unregulated markets. It simulates how such factors as energy prices and government measures affect the choices that consumers and businesses make when they buy and use energy. The model's outputs include changes in energy use, energy prices, GHG emissions, investment costs and possible cost savings from measures, in order to identify the direct effects stemming from each GHG reduction measure considered.

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.

While the macroeconomic model can project the direct impacts on the economy's final demand, output, employment, price formation and sectoral income that result from various policy choices to estimate the effect of climate change policy s on the national economy; this analysis was not conducted for this report due to time constraints.

Court of Appeal File No.: **C65807**

IN THE MATTER OF A REFERENCE to the Court of Appeal pursuant to section 8 of the *Courts of Justice Act*, RSO 1990, c. C.34, by Order-in-Council 1014/2018 respecting the constitutionality of the *Greenhouse Gas Pollution Pricing Act*, Part 5 of the *Budget Implementation Act, 2018, No. 1*, SC 2018, c. 12

COURT OF APPEAL FOR ONTARIO

Proceedings commenced at Toronto

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