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# Canada's Black Carbon Inventory

2016 Edition



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# Canada's Black Carbon Inventory

Environment and Climate Change Canada  
Pollutant Inventories and Reporting Division  
[February 2016]

A decorative graphic consisting of numerous thin, light green wavy lines that originate from the bottom left and fan out towards the right side of the page, creating a sense of movement and depth.

# Acknowledgements

The Pollutant Inventories and Reporting Division (PIRD) of Environment and Climate Change Canada wishes to acknowledge the individuals and organizations that contributed to *Canada's Black Carbon Inventory*. PIRD would like to highlight the contributions of the following inventory developers, authors and/or reviewers, whose work helped to develop the black carbon inventory report and estimates:

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## List of Acronyms, Abbreviations and Units

APEI	Air Pollutant Emission Inventory
API	American Petroleum Institute
BC	Black carbon
CLRTAP	Convention on Long-range Transboundary Air Pollution
CO <sub>2</sub>	Carbon dioxide
ECCC	Environment and Climate Change Canada
EEA	European Environment Agency
EMEP	European Monitoring and Evaluation Programme
H <sub>2</sub> S	Hydrogen sulphide
IE	Included elsewhere
kg/m <sup>3</sup>	Kilograms per cubic metre
kt	Kilotonne
MOVES	Motor Vehicle Emission Simulator
LPS	Large Point Sources
NGL	Natural Gas Liquids
NFR	Nomenclature for Reporting
NPRI	National Pollutant Release Inventory
OC	Organic carbon
PIRD	Pollutant Inventories and Reporting Division
PM	Particulate matter
PM <sub>2.5</sub>	Particulate matter less than or equal to 2.5 micrometres in diameter
UNECE	United Nations Economic Commission for Europe
UNFCCC	United Nations Framework Convention on Climate Change
U.S. EPA	United States Environmental Protection Agency
w/w	Mass fraction (weight by weight)

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## Executive Summary

Black carbon (BC) is a short-lived, small aerosol (or airborne) particle linked to both climate warming and adverse health effects. Black carbon emissions have recently become a focus of attention due to their effects on the near-term warming of the atmosphere and on human health. Reducing black carbon emissions is of particular interest in polar regions, such as the Arctic, which are especially sensitive to the effects of black carbon.

During Canada's chairmanship of the Arctic Council (2013–2015), the Council promoted actions to achieve enhanced reductions of black carbon and methane emissions, and it continues to do so under the United States chairmanship (2015–2017). A framework for action was agreed to in April 2015 that included a commitment from all Arctic states to develop and improve emission inventories for black carbon using, where possible, relevant guidelines from the Convention on Long-range Transboundary Air Pollution (CLRTAP). Environment ministers from Arctic states had previously agreed that these inventories could be voluntarily submitted under the CLRTAP. This report presents the results of Canada's second annual inventory of black carbon emissions. Emissions in this inventory are grouped according to the following sources:<sup>1</sup>

- Mobile sources
- Non-industrial sources
- Industrial sources

In 2014, approximately 43 kilotonnes (kt) of black carbon were emitted in Canada, slightly less than the revised 2013 emissions of 45 kt (Table ES-1). Mobile sources are by far the most important sources of black carbon in Canada, accounting for 27 kt (61.9%) of total emissions in 2014. Among mobile sources, off-road diesel engines account for 14 kt (32% of the total emissions). The other large mobile source is diesel engines used for on-road transport, which account for 7.6 kt (18%) of total emissions.

Non-industrial sources are the second-largest contributor to black carbon emissions in Canada, representing emissions of 13 kt, or 29.6% of total emissions in 2014. Residential wood combustion is the largest source in this category, representing 12 kt of emissions, or 27% of total 2014 emissions. Wood is an abundant fuel in Canada; it is estimated that 14 million tonnes of wood are burned annually in Canadian homes. More information on the estimation methods can be found in Section 2.2.

Black carbon emissions in industrial sectors represent 8.5% (3.7 kt) of total emissions in 2014. The most important industrial source is the upstream petroleum industry, which accounts for 6.3% (2.7 kt) of total emissions. Estimation methods are outlined in Section 2.1.

The sources included in this second annual inventory are estimated to account for at least 90% of anthropogenic black carbon emissions. Work will continue to improve the completeness and accuracy of the inventory, quantifying the industrial and non-industrial emissions that are not captured yet, and refining base data and estimation techniques.

All emissions reported in this inventory are from anthropogenic (human) sources. Natural sources of black carbon, such as wildfires, are not included.

<sup>1</sup> Descriptions of sectors within the source categories can be found in Table A-1.

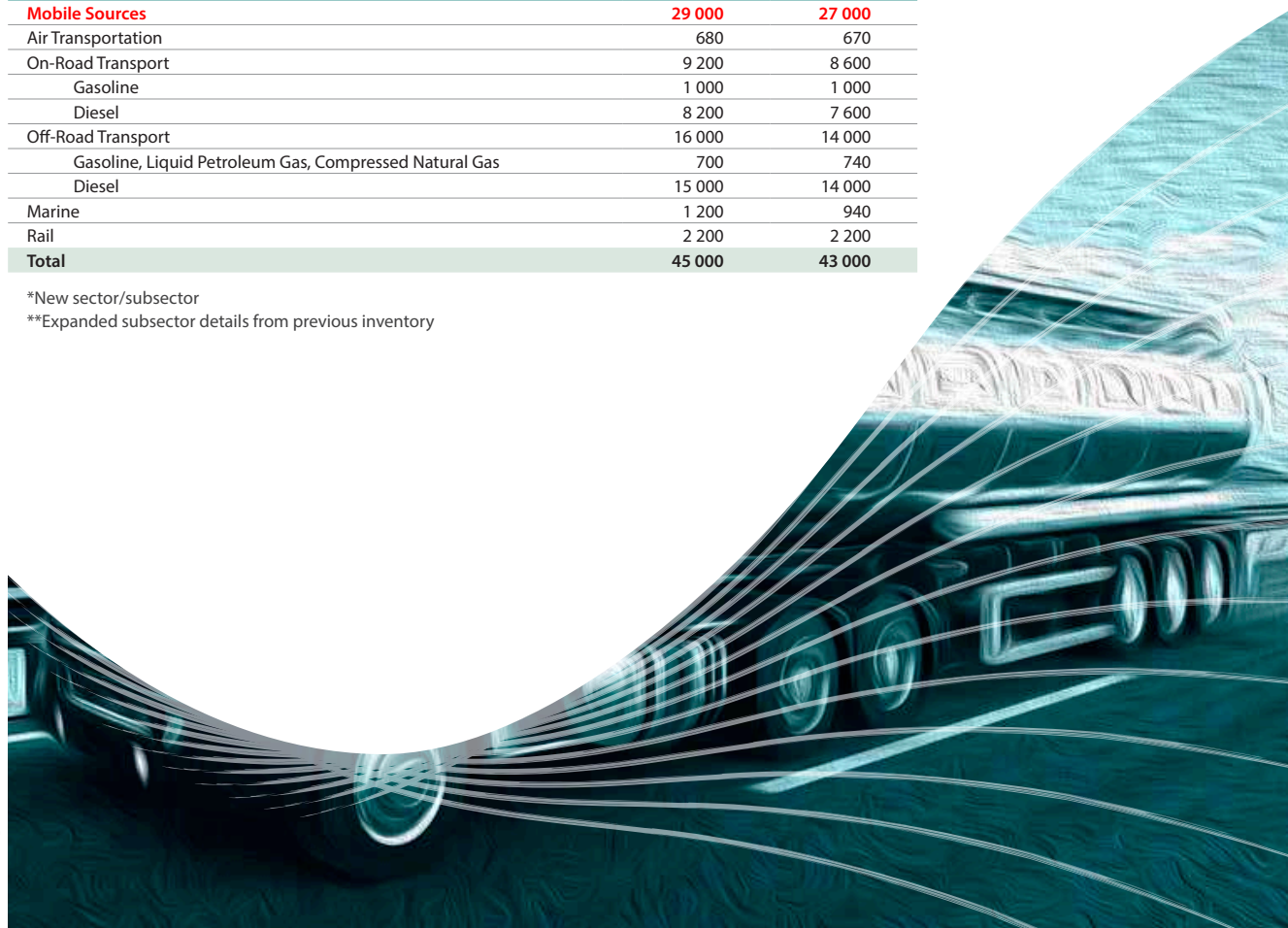


Table ES-1 Canadian Black Carbon Emissions by Sector (2013–2014)

Sector	Black Carbon (tonnes)	
	2013	2014
<b>Industrial Sources</b>	<b>3 200</b>	<b>3 700</b>
Aluminium Industry	56	51
Cement and Concrete Industry	21	17
Foundries	0.058	0.061
Mining and Rock Quarrying	490	450
Pulp and Paper Industry	280	230
Wood Industry*	250	190
Upstream Petroleum Industry**	2 100	2 700
Petroleum Liquids Transportation	2.2	2.3
Petroleum Liquids Storage	0.0067	0.0054
Oil Sands In-Situ Extraction and Processing	150	120
Oil Sands Mining Extraction and Processing	0.22	0.33
Bitumen and Heavy Oil Upgrading	140	730
Light Medium Crude Oil Production	810	880
Well Drilling	6.9	8.2
Well Servicing	0.021	0.02
Well Testing	61	67
Natural Gas Production	450	460
Natural Gas Processing	330	340
Heavy Crude Oil Cold Production	110	120
Disposal and Waste Treatment	5.8	6.3
<b>Non-industrial Sources</b>	<b>13 000</b>	<b>13 000</b>
Commercial Fuel Combustion*	830	830
Electric Power Generation (Utilities)*	190	200
Coal	37	46
Natural Gas	11	8.8
Other	140	150
Residential Fuel Combustion*	170	170
Residential Wood Combustion	12 000	12 000
Wood Stoves	4 100	4 100
Furnaces	4 200	4 200
Fireplaces	3 400	3 300
Agriculture – Fuel Combustion*	9.9	9.9
Construction Fuel Combustion*	36	36
<b>Mobile Sources</b>	<b>29 000</b>	<b>27 000</b>
Air Transportation	680	670
On-Road Transport	9 200	8 600
Gasoline	1 000	1 000
Diesel	8 200	7 600
Off-Road Transport	16 000	14 000
Gasoline, Liquid Petroleum Gas, Compressed Natural Gas	700	740
Diesel	15 000	14 000
Marine	1 200	940
Rail	2 200	2 200
<b>Total</b>	<b>45 000</b>	<b>43 000</b>

\*New sector/subsector

\*\*Expanded subsector details from previous inventory





# 1 Introduction

Black carbon (BC) is a short-lived, small aerosol (or airborne) particle linked to both climate warming and adverse health effects. Black carbon emissions have recently become a focus of attention due to their effects on the near-term warming of the atmosphere and on human health. Reducing black carbon emissions is of particular interest in polar regions, such as the Arctic, which are especially sensitive to the effects of black carbon. When black carbon particles settle on snow and ice, they darken the surface and enhance absorption of solar radiation, thus increasing the rate of melting.

The Arctic Council was one of the first fora to recognize the importance of taking action to address short-lived climate forcers and pollutants, such as black carbon, methane and ground-level ozone. During Canada's chairmanship (2013–2015), the Council promoted actions to achieve enhanced reductions of black carbon and methane emissions, and it continues to do so under the current U.S. chairmanship (2015–2017). A key component of these actions is the voluntary reporting by Arctic states of their black carbon emissions to the United Nations Economic Commission for Europe (UNECE). At the 2015 meeting of Arctic Council ministers, Canada, along with other Arctic states, renewed its commitment to take action to reduce black carbon emissions. As part of this commitment, Canada will continue to improve the quality and transparency of information related to black carbon emissions and to publish national black carbon inventories.

This document describes Canada's second annual inventory of anthropogenic black carbon emissions, covering years 2013 and 2014. All emissions reported in this inventory are from anthropogenic (human) sources. Natural sources of black carbon, such as wildfires, are not included.

## 1.1 Background on Black Carbon Emission Quantification

Black carbon is an aerosol (airborne particle) emitted from combustion processes in the form of very fine particulate matter. Black carbon is not emitted on its own, but as a component of particulate matter less than or equal to 2.5 micrometres in diameter ( $PM_{2.5}$ ), along with other components, such as organic carbon (OC) and inorganic compounds such as sulfates.

Two important assumptions underlie the present inventory: black carbon is predominantly emitted in  $PM_{2.5}$ ; and only  $PM_{2.5}$  emissions resulting from combustion contain significant amounts of black carbon. Therefore, the basis for the black carbon inventory is the  $PM_{2.5}$  emitted from combustion processes, multiplied by

black carbon ratios specific to each type of source. Although important in some cases,  $PM_{2.5}$  emissions from non-combustion sources, such as dust raised by traffic on paved and unpaved roads or by wind and machinery on open fields or mine sites, are not considered sources of black carbon.

Black carbon emissions are grouped in the same categories as those used in Canada's Air Pollutant Emission Inventory (APEI); these categories are described in Annex A to the present document.

The dataset that breaks down the  $PM_{2.5}$  emitted from a particular source (e.g. diesel engine emissions) into its different components, including black carbon and organic carbon, is known as a speciation profile. Most speciation profiles contain a fraction for elemental carbon; these fractions are commonly used as a surrogate to quantify black carbon emissions. The current inventory primarily relies on the United States Environmental Protection Agency's (U.S. EPA) SPECIATE database (EPA 2014) to calculate black carbon emissions from compiled combustion  $PM_{2.5}$  emissions. Several BC/ $PM_{2.5}$  ratios are specific to the combustion processes or technologies (e.g. appliance types for residential wood combustion), to the fuel type (e.g. diesel, gasoline, natural gas) or to the application (e.g. natural gas use for electrical power generation). Annex C lists all ratios used in this inventory.

In this edition of the black carbon inventory, priority has been given to improving the accuracy and completeness of both industrial and non-industrial estimates. Within industrial sources, methodology upgrades were implemented in upstream oil and gas sources to improve the accuracy of emissions; the application of BC/ $PM_{2.5}$  ratios was refined; and black carbon emissions from the wood product industry were added. Non-industrial sources were expanded to include emissions from the combustion of fuels other than wood in residential and commercial settings and from electric power generation. Methodological improvements were also made to mobile sources to improve accuracy of estimates.

Improvements were applied to the quantification of emissions for both 2013 and 2014 in order to maintain a consistent time series.

The estimates in this inventory are based on the best available information at the time of compilation. Estimates of  $PM_{2.5}$  emissions are consistent with those reported in the 2016 APEI. Please refer to the APEI Report (Environment and Climate Change Canada 2016) for a description of estimation methods for  $PM_{2.5}$ . The present document will describe how black carbon emissions were estimated from  $PM_{2.5}$  emissions.

## 2 Black Carbon Emissions in Canada

Approximately 43 kilotonnes (kt) of black carbon were emitted in Canada in 2014 (Table 1). Emissions have been grouped according to the following sources:

- Industrial
- Non-industrial
- Mobile

Black carbon emissions in industrial sectors represent 8.5% (3.7 kt) of total emissions. An important industrial sector is the upstream petroleum industry, which accounts for 6.3% (2.7 kt) of total emissions. Estimation methods are outlined in Section 2.1.

Non-industrial sources are the second-largest contributor to black carbon emissions in Canada, representing emissions of 13 kt, or 29.6% of total emissions. Residential wood combustion is the largest source in this category, representing 12 kt of emissions, or 27% of total emissions. Wood is an abundant fuel in Canada; it is estimated that 14 million tonnes of wood are burned annually in Canadian homes. More information on the estimation methods can be found in Section 2.2.

**Table 1 Black Carbon Emissions in Canada (2014)**

Sector	Black Carbon (tonnes)	Percentage of Total
<b>Industrial Sources</b>	<b>3 700</b>	<b>8.5%</b>
Aluminium Industry	51	0.1%
Cement and Concrete Industry	17	<0.1%
Foundries	0.061	<0.01%
Mining and Rock Quarrying	450	1.0%
Pulp and Paper Industry	230	0.5%
Wood Industry*	190	0.4%
Upstream Petroleum Industry**	2 700	6.3%
Petroleum Liquids Transportation	2.3	<0.01%
Petroleum Liquids Storage	0.0054	<0.01%
Oil Sands In-Situ Extraction and Processing	120	0.3%
Oil Sands Mining Extraction and Processing	0.33	<0.01%
Bitumen and Heavy Oil Upgrading	730	1.7%
Light Medium Crude Oil Production	880	2.0%
Well Drilling	8.2	<0.1%
Well Servicing	0.02	<0.01%
Well Testing	67	0.2%
Natural Gas Production	460	1.1%
Natural Gas Processing	340	0.8%
Heavy Crude Oil Cold Production	120	0.3%
Disposal and Waste Treatment	6.3	<0.1%
<b>Non-Industrial Sources</b>	<b>13 000</b>	<b>29.6%</b>
Commercial Fuel Combustion*	830	1.9%
Electric Power Generation (Utilities)*	200	0.5%
Coal	46	0.1%
Natural Gas	8.8	<0.1%
Other	150	0.3%
Residential Fuel Combustion*	170	0.4%
Residential Wood Combustion	12 000	27%
Wood Stoves	4 100	9.4%
Furnaces	4 200	9.6%
Fireplaces	3 300	7.7%
Agriculture – Fuel Combustion*	9.9	<0.1%
Construction Fuel Combustion*	36	0.1%
<b>Mobile Sources</b>	<b>27 000</b>	<b>61.9%</b>
Air Transportation	670	1.5%
On-Road Transport	8 600	20%
Gasoline	1 000	2.3%
Diesel	7 600	18%
Off-Road Transport	14 000	33%
Gasoline, Liquid Petroleum Gas, Compressed Natural Gas	740	1.7%
Diesel	14 000	32%
Marine	940	2.2%
Rail	2 200	5.1%
<b>Total</b>	<b>43 000</b>	<b>100%</b>

\*New sector/subsector

\*\*Expanded subsector details from previous inventory

Mobile sources are by far the most important sources of black carbon in Canada, accounting for 27 kt (61.9%) of total emissions in 2014. Off-road use of diesel engines accounts for just under one third (32% or 14 kt) of total emissions. The other major mobile source is on-road transport, again primarily diesel engines, which account for 20% (8.6 kt) of total emissions. More information on estimation methodologies is provided in Section 2.3.

Emissions from the following sources that were missing in the first inventory have now been included: wood product industry emissions; electricity generation; stationary fuel combustion in commercial, agriculture and construction industries; and residential fuel combustion (other than wood). These improvements are described in Section 2.5, while future refinements are discussed in Section 3.

Generally, black carbon emissions are calculated using  $PM_{2.5}$  emissions from combustion processes and the fraction of black carbon in the  $PM_{2.5}$ . For example, diesel engines have relatively high emission rates of  $PM_{2.5}$  per unit energy, and the fraction of black carbon in these  $PM_{2.5}$  emissions is also relatively high. The majority of diesel fuel in Canada is used for mobile sources, particularly in off-road applications. Other combustion sources with high  $PM_{2.5}$  emissions include solid fuel combustion units, such as coal- and wood-fired boilers. Industrial sources are generally equipped with highly effective  $PM_{2.5}$  controls on boiler emissions, with PM-control efficiencies often in the 90% range. This is reflected in the lower  $PM_{2.5}$  emissions compared to other sources. In contrast, the smaller and markedly different equipment used for residential wood combustion (fireplaces, wood stoves or furnaces) have poorer  $PM_{2.5}$ -control efficiencies than larger units, notwithstanding the different types of fuel and firing practices used for burning firewood. Given the lack of treatment of stack gases, residential wood-burning devices are by far the largest source of combustion-related  $PM_{2.5}$  emissions in Canada, but black carbon emissions from residential wood burning are only one third that of mobile sources due to a lower BC/ $PM_{2.5}$  fraction for wood devices than for diesel engines.

## 2.1 Industrial Sources

Industrial sources include primary resource extraction and processing, and manufacturing industries. For the purpose of this inventory, black carbon emissions were considered for the following industries:

- Aluminium industry
- Cement and concrete industry
- Foundries
- Mining and rock quarrying
- Pulp and paper industry

- Upstream petroleum industry
- Wood product industry (new in the 2016 inventory edition)

Greater sectoral coverage and further refinement of emissions are expected in future inventories.

Industrial  $PM_{2.5}$  emissions originate from both combustion and non-combustion sources; however, only  $PM_{2.5}$  emissions resulting from combustion contain significant amounts of black carbon. Where readily available, the  $PM_{2.5}$  emissions data from combustion were used in conjunction with BC/ $PM_{2.5}$  fractions to estimate black carbon emissions (Table 2). For example, the information to distinguish between combustion (i.e. flaring) and non-combustion sources of  $PM_{2.5}$  in the upstream petroleum industry currently exists (Clearstone 2014). Separating combustion from non-combustion sources of  $PM_{2.5}$  remains a challenge in some cases due to a lack of data on activities (i.e. quantity of fuel burned) and on non-combustion sources (e.g. rock dust at a mine). In those cases, combustion and non-combustion  $PM_{2.5}$  are separated based on the judgement of experts with knowledge of industrial processes.

Among all industrial activities included in this inventory, the upstream petroleum industry accounts for the largest proportion (6.3% or 2.7 kt) of black carbon emissions in 2014 (Figure 1). Emissions are grouped according to the following categories:

- Petroleum liquids transportation
- Light medium crude oil production
- Well drilling
- Well servicing
- Well testing
- Natural gas production
- Natural gas processing
- Heavy crude oil cold production
- Disposal and waste treatment

Although the 2014 combustion emissions of  $PM_{2.5}$  from industrial sources (25 kt; see Table 2) are approximately half those from mobile sources (47 kt; see Table 4), black carbon emissions from industrial sources (3.7 kt) are much lower than those from mobile sources (27 kt). The relatively lower importance of black carbon emissions from industrial sources is due to the lower BC to  $PM_{2.5}$  ratio specific to a several industrial sources of  $PM_{2.5}$ , compared to the BC to  $PM_{2.5}$  ratio for diesel engines. Black carbon emissions from the mining and rock quarrying sector are larger due to the emissions from remote mines that generate electricity for sites using diesel.

Off-road diesel engines are used in many industrial sectors, such as mining, rock quarrying, and well drilling, serving and testing. Emissions from these engines are included in the mobile source estimates under off-road transport (diesel).

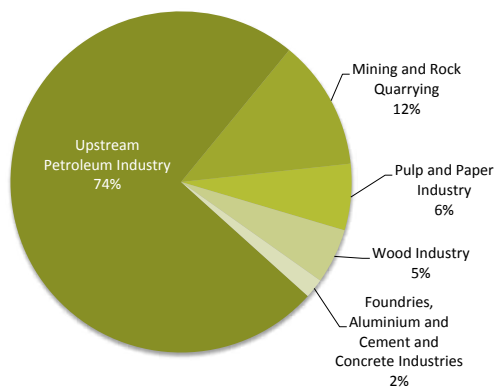
**Table 2 Industrial Sources Components of Black Carbon Estimation (2013–2014)**

Sector	PM <sub>2.5</sub> (tonnes)		Black Carbon (tonnes)	
	2013	2014	2013	2014
Aluminium Industry	2 600	2 300	56	51
Cement and Concrete Industry	960	870	21	17
Foundries	6.4	6.7	0.058	0.061
Mining and Rock Quarrying	1 700	1 900	490	450
Pulp and Paper Industry	8 400	8 000	280	230
Wood Industry*	3 600	2 900	250	190
Upstream Petroleum Industry**	7 900	8 900	2 100	2 700
Petroleum Liquids Transportation	5.9	6.3	2.2	2.3
Petroleum Liquids Storage	2.8	2.3	0.0067	0.0054
Oil Sands In-Situ Extraction and Processing	640	490	150	120
Oil Sands Mining Extraction and Processing	90	140	0.22	0.33
Bitumen and Heavy Oil Upgrading	1 400	2 300	140	730
Light Medium Crude Oil Production	2 800	3 000	810	880
Well Drilling	29	34	6.9	8.2
Well Servicing	0.087	0.085	0.021	0.02
Well Testing	250	270	61	67
Natural Gas Production	1 300	1 300	450	460
Natural Gas Processing	1 100	1 100	330	340
Heavy Crude Oil Cold Production	280	280	110	120
Disposal and Waste Treatment	24	26	5.8	6.3
<b>Total</b>	<b>25 000</b>	<b>25 000</b>	<b>3 200</b>	<b>3 700</b>

\*New sector/subsector

\*\*Expanded subsector details from previous inventory

**Figure 1 Black Carbon Emissions from Industrial Sources (2014)**



Note: Totals may not add up due to rounding.

The APEI Report (Environment and Climate Change Canada 2016) provides more information on the development of PM<sub>2.5</sub> emission estimates from industrial sources.

## 2.2 Non-Industrial Sources

Non-industrial sources include commercial fuel combustion, residential fuel and wood combustion, stationary combustion in agriculture, heat generation in construction industries, and electricity generation from utilities. The majority of emissions from these sources are due to combustion in large, efficient commercial boilers, or in small, less-efficient residential fireplaces and woodstoves. The following sources are included in this year's report:

- Commercial fuel combustion (new to the 2016 inventory)
- Electric power generation (utilities) (new to the 2016 inventory)
- Residential fuel combustion other than wood (new to the 2016 inventory)
- Residential wood combustion
- Agriculture fuel combustion (new to the 2016 inventory)
- Construction fuel combustion (new to the 2016 inventory)

Large sources of black carbon are those where either large quantities of PM<sub>2.5</sub> are emitted or where the BC/PM<sub>2.5</sub> fraction is large.

Overall, residential wood stoves, furnaces and fireplaces collectively account for the largest portion of black carbon emissions from non-industrial sources (Figure 2), with approximately 12 kt or 27% of overall black carbon emissions. A key determinant of total emissions is the relative quantity of wood burned in each type of wood-burning device. Wood furnaces, even though they emitted less PM<sub>2.5</sub> than other wood-burning devices in 2014, account for the largest proportion of black carbon emissions from residential wood combustion because the proportion of BC to PM<sub>2.5</sub> is more than twice that of other wood-burning devices (Table 3). Conventional wood stoves emitted more PM<sub>2.5</sub> in 2014, but come second for black carbon emissions for this source because the BC/PM<sub>2.5</sub> fraction is lower.

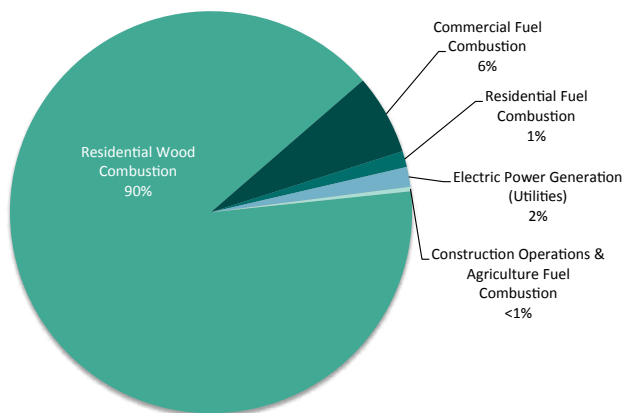
The next largest source of black carbon emissions in this category is commercial fuel combustion, which accounts for 0.83 kt of emissions and 1.9% of overall black carbon emissions.

The combustion of fuels other than wood (commercial, residential, construction and agricultural) accounts for 2.4% (1.0 kt) of

**Table 3 Non-Industrial Sources Components of Black Carbon Estimation (2013–2014)**

Sector	PM <sub>2.5</sub> (tonnes)		Black Carbon (tonnes)	
	2013	2014	2013	2014
Commercial Fuel Combustion*	2 200	2 200	830	830
Electric Power Generation (Utilities)*	3 100	3 600	190	200
Coal	2 200	2 700	37	46
Natural Gas	450	350	11	8.8
Other	430	520	140	150
Residential Fuel Combustion*	2 400	2 400	170	170
Residential Wood Combustion	160 000	160 000	12 000	12 000
Wood Stoves	74 000	73 000	4 100	4 100
Furnaces	30 000	30 000	4 200	4 200
Fireplaces	61 000	60 000	3 400	3 300
Agriculture – Fuel Combustion*	140	140	9.9	9.9
Construction Fuel Combustion*	95	95	36	36
<b>Total</b>	<b>170 000</b>	<b>170 000</b>	<b>13 000</b>	<b>13 000</b>

\*New sector/subsector

**Figure 2 Black Carbon Emissions from Non-Industrial Fuel Combustion (2014)**

Note: Totals may not add up due to rounding.

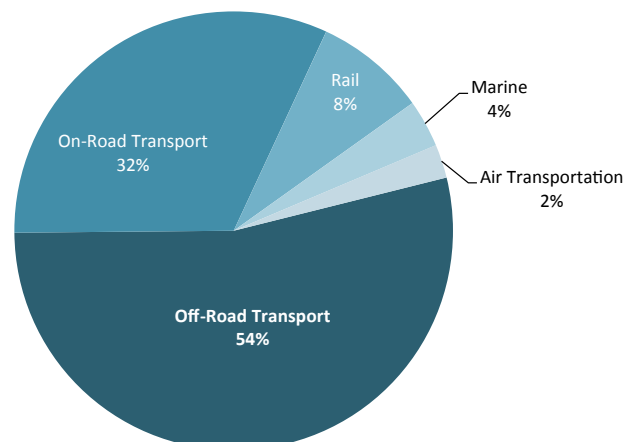
the total black carbon emissions in 2014 from this non-industrial category. Estimations for these sources are based on the fuel type and quantity consumed in Canada and the corresponding BC/PM<sub>2.5</sub> fraction for each sector.

Black carbon emissions from electric power generation are low because large facilities using solid fuels are equipped with particulate controls. Emissions of PM<sub>2.5</sub> from liquid and gaseous fuels from boilers and heaters are low. There is relatively little diesel fuel used in large stationary electricity generation applications. Coverage for this sector is nearly complete; the remaining small sources (smaller facilities including those in remote communities that do not report their emissions to the National Pollutant Release Inventory) will be addressed in future inventories. Emissions from these sources, though small nationally, can have important regional impacts in such areas as Canada's North.

## 2.3 Mobile Sources

Mobile sources include air transportation, marine transportation, on-road vehicles, off-road transport and rail transportation (Figure 3). Off-road transport is a highly diverse source that includes lawn and garden equipment, recreational vehicles such as pleasure craft and snowmobiles, farm equipment, construction and mining equipment, and portable generators and pumps. Both on-road and off-road diesel engines are subject to emission standards for particulate matter and are equipped with sophisticated emission controls to reduce particulate matter. As more new engines equipped with this technology replace older more polluting engines, it is expected that emissions of particulate matter will decrease.

To estimate emissions from mobile sources, bottom-up approaches were adopted, i.e. obtaining emission factors and applying

**Figure 3 Black Carbon Emissions from Mobile Sources (2014)**

Note: Totals may not add up due to rounding.

them to disaggregated activity data. Generally, emission factors (by application class, age, load and fuel type), activity data (i.e. vehicle-kilometres travelled or number of applications, their hours-of-use and load factor) and BC/PM<sub>2.5</sub> fractions were taken from the most recent models and sources. In all cases other than on-road vehicles, PM<sub>2.5</sub> was estimated first and, from these results, black carbon was estimated. For on-road vehicles, the Motor Vehicle Emission Simulator (MOVES) model (EPA 2014-2) directly outputs black carbon estimates, which therefore means only one step was required to estimate emissions of both PM<sub>2.5</sub> and black carbon. The methods for estimating PM<sub>2.5</sub> emissions from mobile sources are described in the APEI Report (Environment and Climate Change Canada 2016).

Larger sources of black carbon are those that either emit large quantities of PM<sub>2.5</sub>, or those for which the BC/PM<sub>2.5</sub> fraction is large, such as off-road transport. Off-road transport is the largest (33%) source of total black carbon emissions in Canada, with 14 kt emitted in 2014. Off-road engines emit significant quantities of PM<sub>2.5</sub>, and diesel engines have the highest BC/PM<sub>2.5</sub> fractions of all black carbon sources (Table 4). As a result, off-road diesel engines account for nearly all emissions from off-road transport, or about half (51%) of black carbon emissions from mobile sources. On-road mobile sources account for 8.6 kt of emissions, which represent 32% of all black carbon emissions from mobile sources in Canada.

## 2.4 Use of Facility-Reported Emissions

Only emissions of PM<sub>2.5</sub> resulting from combustion contain significant amounts of black carbon. In the APEI, PM<sub>2.5</sub> emission estimates are calculated using a variety of data sources, notably emission estimates reported by Canadian facilities to the National Pollutant Release Inventory (NPRI). For sources that are incompletely covered by PM<sub>2.5</sub> estimates reported to the NPRI due to reporting thresholds, PM<sub>2.5</sub> emissions are quantified using activity data, statistics and emission factors. For this inventory, all industrial source emissions are estimated using facility data, except

in the upstream oil and gas industry, where facility-reported data are used in combination with the results of an independent study. Within non-industrial sources, electric power generation is estimated using facility data, while emissions due to agricultural, construction and residential (wood and other) fuel combustion are estimated from data on fuel consumption and combustion technologies. Commercial fuel combustion is estimated using a combination of facility-reported and other data sources. Mobile source emissions are entirely calculated using non-facility data sources.

Stack emissions of PM<sub>2.5</sub> reported by facilities form the basis of the black carbon estimation. For each individual stack, the appropriate black carbon speciation factor (or factors) was applied to the combustion-related PM<sub>2.5</sub> (Annex C). The emissions are then summed at the facility level and aggregated to form the sectoral emission estimate.

## 2.5 Recalculations and Completeness

As new data and methodologies become available, emission estimates from previous inventory editions are recalculated. Several methodological changes have occurred since the first annual black carbon inventory, resulting in the recalculation of 2013 emissions. Tables 5 through 7 outline the changes that have been implemented in the black carbon inventory.

A quantitative assessment of completeness is challenging, because detailed analyses have not been completed for all sources. The sources included in this inventory are estimated to account for at least 90% of anthropogenic black carbon emissions in Canada, since the largest combustion sources as well as those with little PM<sub>2.5</sub> control measures are accounted for. An estimate of the sectoral coverage is included in the following tables, and efforts will be made in coming inventories to expand the sectoral coverage.

**Table 4 Mobile Sources Components of Black Carbon Estimation (2013–2014)**

Sector	PM <sub>2.5</sub> (tonnes)		Black Carbon (tonnes)	
	2013	2014	2013	2014
Air Transportation	880	870	680	670
On-Road Transport	16 000	15 000	9 200	8 600
Gasoline	5 300	5 300	1 000	1 000
Diesel	10 000	9 500	8 200	7 600
Off-Road Transport	24 000	23 000	16 000	14 000
Gasoline, Liquid Petroleum Gas, Compressed Natural Gas	5 200	5 500	700	740
Diesel	19 000	17 000	15 000	14 000
Marine	7 800	6 100	1 200	940
Rail	2 800	2 900	2 200	2 200
<b>Total</b>	<b>51 000</b>	<b>47 000</b>	<b>29 000</b>	<b>27 000</b>

**Table 5 Summary of Methodological Changes or Refinement for Industrial Source Emissions**

Sector/Subsector	Description	Impact on Emissions	Sectoral Coverage
Aluminium Industry	Industry-specific emissions were estimated using the facility reported PM <sub>2.5</sub> emissions	Emissions attributed to the sector represent 0.1% of Canada's 2014 black carbon emissions	Complete
Cement and Concrete Industry	Industry-specific emissions were estimated using the facility reported PM <sub>2.5</sub> emissions	Emissions attributed to the sector represent <0.01% of Canada's 2014 black carbon emissions	Complete
Foundries	Industry-specific emissions were estimated using the facility reported PM <sub>2.5</sub> emissions	Emissions attributed to the sector represent <0.01% of Canada's 2014 black carbon emissions	Complete
Mining and Rock Quarrying	Industry-specific emissions were estimated using the facility reported PM <sub>2.5</sub> emissions	Emissions attributed to the sector represent 1% of Canada's 2014 black carbon emissions	Complete
Pulp and Paper Industry	Industry-specific emissions were estimated using the facility reported PM <sub>2.5</sub> emissions	Emissions are attributed to the sector representing 0.5% of Canada's 2014 black carbon emissions	Complete
Wood Products Industry	Industry-specific emissions were estimated using the facility reported PM <sub>2.5</sub> emissions	New sector for the Black Carbon Inventory representing 0.4% of Canada's 2014 black carbon emissions	>70% coverage due to smaller facilities not included (below NPRI reporting thresholds)
Upstream Petroleum Industry	Reallocation of emissions and the inclusion of Oil Sands In-Situ emissions. Removed diesel emissions from mobile equipment (i.e. drilling rigs), as they are covered in the mobile source emissions. Expanded sectoral coverage by adding Oil Sands Mining.	Compared to the previous inventory, 2013 BC emissions decreased by 49% or 1.8 kt	Complete

**Table 6 Summary of Methodological Changes or Refinement for Non-Industrial Sources**

Sector/Subsector	Description	Impact on Emissions	Sectoral Coverage
Commercial Fuel Combustion	Emissions were estimated using facility reported PM <sub>2.5</sub> emissions as well as statistical data on fuel use	New sector for the Black Carbon Inventory representing 1.9% of Canada's 2014 black carbon emissions	Complete
Electric Power Generation (Utilities)	Emissions were estimated using the facility reported PM <sub>2.5</sub> emissions	New sector for the Black Carbon Inventory representing 0.5% of Canada's 2014 black carbon emissions	>95% coverage due to smaller facilities not being included (below NPRI reporting thresholds)
Residential Fuel Combustion	Emissions were estimated using statistical data on fuel use and combustion technologies	New sector for the Black Carbon Inventory representing 0.4% of Canada's 2014 black carbon emissions	Complete
Agriculture Fuel Combustion	Emissions were estimated using statistical data on fuel use and combustion technologies	New sector for the Black Carbon Inventory representing <0.01% of Canada's 2014 black carbon emissions	Complete
Construction Fuel Combustion	Emissions were estimated using statistical data on fuel use	New sector for the Black Carbon Inventory representing 0.1% of Canada's 2014 black carbon emissions	Complete

**Table 7 Summary of Methodological Changes or Refinement for Mobile Source Emissions**

Sector/Subsector	Description	Impact on Emissions	Sectoral Coverage
Air Transportation	Emissions were refined based on revised fuel availability provided by Statistics Canada for 2013	Compared to the previous inventory, 2013 BC decreased by 2.4% or 25 t.	Complete
Marine	Emissions were refined based on removal of the double counting of marine emissions in the Arctic	Compared to the previous inventory 2013 BC decreased by 25% or 410 t.	Complete
Rail	Emissions were refined based on revised fuel availability provided by Statistics Canada for 2013	Compared to the previous inventory BC decreased by 4% or 89 t.	Complete

## 2.6 Sources of Uncertainty

One source of uncertainty with black carbon inventories is the inconsistencies between definitions and measurements of black carbon (Bond et al. 2013). Scientists use different methods to measure black carbon particle emissions at the source and in the

atmosphere, and therefore measured quantities are not strictly comparable.

Although not quantified, uncertainty about black carbon estimates in this inventory is primarily driven by the uncertainty with the BC/PM<sub>2.5</sub> ratios. There is large variability in the size of

measurement samples used to derive these ratios; the same ratios can be by default applied to several different technologies. An example of the limitation in available BC/PM<sub>2.5</sub> ratios is demonstrated with the application of the diesel BC/PM<sub>2.5</sub> ratio for aviation turbo fuel in jet aircrafts, as there is no available ratio specific to aviation turbo fuel. Similarly, a single BC/PM<sub>2.5</sub> ratio is applied to all residential wood combustion appliances except wood furnaces (Annex C, Table C-2). The refinement of BC/PM<sub>2.5</sub> ratios is expected to improve when new measurements become available.

The uncertainty is high in determining the proportion of PM<sub>2.5</sub> emissions that arise from combustion emissions for industrial sources. The primary data source for estimating PM<sub>2.5</sub> emissions from many industrial sources is the NPRI, in which emissions are reported by facilities by stack or as one aggregate value for the facility as a whole and are not broken down between combustion and non-combustion emissions. Engineering knowledge was necessary to attribute a ratio to each sector, with varying degrees of accuracy.

### 3 Considerations for Future Editions of This Inventory

This inventory is estimated to provide 90% coverage of Canadian black carbon emissions. Future improvements will focus on expanding the coverage of industrial sectors as well as improving the accuracy of emission estimates. Work will also be carried out to allow for expansion of coverage of the non-industrial sectors, specifically the use of diesel engines for electricity generation in remote locations not currently reporting emissions to the NPRI.

Another source not currently estimated is prescribed burning, which is the controlled and intentional burning of biomass as a land management practice. Although it is not expected to be a large source of emissions for Canada, it will be included in future inventories.



# Annex A: Sector Description

Table A-1 Sector Description

Industrial Sources	
Aluminium Industry	Emissions from alumina production through bauxite refining, and the production of primary aluminium through smelting and refining.
Cement and Concrete Industry	Emissions from the entire process of cement production in rotary kilns, and the preparation of ready-mix concrete.
Foundries	Emissions from facilities for the production of castings of various types of ferro-alloys and small iron and steel foundries not associated with integrated iron and steel facilities.
Mining and Rock Quarrying	Emissions from overburden removal, drilling in rock, blasting, loading of materials, transporting raw materials by conveyors or haulage trucks, scraping, bulldozing, grading, open storage pile losses and wind erosion from exposed areas.
Pulp and Paper Industry	Emissions from chemical, mechanical, recycling and semi-chemical mills, including the production of energy through the combustion of spent pulping liquor, biomass and fossil-fuel combustion. Also includes fugitive emissions from wood refining, screening and drying, and various steps in chemical recovery systems.
Upstream Petroleum Industry	
Petroleum Liquids Transportation	Emissions from the transportation by pipeline, truck, rail and ship of liquid hydrocarbons, but does not include emissions from the vehicles themselves.
Petroleum Liquids Storage	Emissions from the storage of liquid hydrocarbons (i.e. crude oil, diluted bitumen, natural gas liquids, condensate, etc.) including storage tank losses, loading/unloading and handling losses.
Oil Sands In-Situ Extraction and Processing	Emissions from the recovery of bitumen from a reservoir using a series of wells and thermal techniques.
Oil Sands Mining Extraction and Processing	Emissions from the recovery of bituminous sands using open pit mining techniques and the extraction of bitumen from the mined ore through hot water and hydrocarbon solvent extraction.
Bitumen and Heavy Oil Upgrading	Emissions from the process of upgrading heavy oil and/or bitumen into a lighter synthetic crude oil using either a carbon rejection or hydrogen addition process with some hydro-treating and distillation.
Light Medium Crude Oil Production	Emissions from the production of crude oil characterized by relatively low viscosity, a lower carbon-to-hydrogen ratio, and a relatively lower density—typically less than 900 kg/m <sup>3</sup> (greater than 25° API).
Well Drilling	Emissions from the process of drilling wells. Emissions from diesel engines used to power the rigs are included in the off-road use of diesel.
Well Servicing	Emissions from work performed on a well after its initial completion for repair or to increase production rates. Emissions from diesel engines used to power the rigs are included in the off-road use of diesel.
Well Testing	Emissions from flow testing conducted to determine the deliverability of a well. (Sometimes the test may be conducted into a flow or gathering line; however, more often the liquids are produced into temporary tankage brought on site for the test, and the gas phase is either vented or flared.)
Natural Gas Production	Emissions from the production of a naturally occurring mixture of hydrocarbon and non-hydrocarbon compounds existing in the gaseous phase or in solution with hydrocarbon liquids in geologic formations beneath the earth's surface. The principal hydrocarbon constituent is methane.
Natural Gas Processing	Emissions from the removal of undesired constituents of raw natural gas such as helium, ethane, natural gas liquids (NGLs), water, H <sub>2</sub> S and CO <sub>2</sub> to upgrade the quality of the natural gas to meet contract specifications. May also include the fractionation of mixed NGLs to natural gas products and possibly adjusting the heating value by the addition or removal of nitrogen.
Heavy Crude Oil Cold Production	Emissions from the production of crude oil which does not involve the use of any thermal techniques. Heavy crude oil is a category of crude oil characterized by relatively high viscosity, a higher carbon-to-hydrogen ratio, and a relatively higher density - typically 900 kg/m <sup>3</sup> or more (25° or less API). Heavy crude oil typically is more difficult to extract with conventional recovery techniques and is more costly to refine.
Disposal and Waste Treatment	Emissions from the treatment and disposal of any oilfield or processing waste fluids or produced water. Typically injected into a disposal well.
Wood Products	Emissions from Sawmills, Panel board mills (including veneer, plywood, waferboard, particle board and medium-density fiberboard mills), and Other wood products (including furniture and cabinet makers, wood treating plants, wood pellet mills and Masonite manufacturers)
Non-Industrial Sources	
Commercial Fuel Combustion	Emissions resulting primarily from external combustion sources used for space/water heating in commercial establishments, health and educational institutions and government/public administration facilities
Electric Power Generation (Utilities)	Emissions from electrical power produced by utilities and by industry for commercial sale and/or private use
Coal	Emissions from electrical power produced by coal-fired utilities
Natural Gas	Emissions from electrical power produced by utilities and by industry for commercial sale and/or private use
Other	Emissions from electrical power produced by oil combustion, wood-fired boilers, and diesel power generation
Residential Fuel Combustion	Emissions resulting primarily from combustion of fossil fuels used for space/water heating in residences
Residential Wood Combustion	
Wood Stoves	Emissions from residential woodstoves burning both firewood and wood pellets
Furnaces	Emissions from wood furnaces, particularly from larger, exterior units
Fireplaces	Emissions from residential fireplaces, both sealed and open units
Agriculture—Fuel Combustion	Emissions from stationary combustion sources in agricultural facilities such as space and water heating and crop drying
Construction Fuel Combustion	Emissions from stationary combustion sources at construction sites such as power generators, heaters, and boilers
Mobile Sources	
Air Transportation	Emissions from piston and turbine military, commercial and general aviation (landing and take-off only), and in-flight (cruise) emissions for turbine aircraft
On-Road Transport—Gasoline	Emissions from gasoline road vehicles, including light- and heavy-duty trucks, automobiles and motorcycles
On-Road Transport—Diesel	Emissions from diesel road vehicles, including light- and heavy-duty trucks, and automobiles
Off-Road Transport—Gasoline, Liquid Petroleum Gas, Compressed Natural Gas	Emissions from off-road vehicles using gasoline, liquid petroleum gas and compressed natural gas, including 2- and 4-stroke mining, construction, recreational, agricultural, commercial, logging, railway maintenance, airport ground support, and lawn and garden equipment
Off-Road Transport—Diesel	Emissions from off-road vehicles using diesel oil as a fuel source, including mining, construction, recreational, agricultural, commercial, logging, railway maintenance, airport ground support, and lawn and garden equipment
Marine	Emissions from marine craft in anchored, berth and underway phase
Rail	Emissions from freight and passenger trains, including yard-switching activities

## Annex B: Rounding Protocol

The rounding protocol for this report is taken from Annex 9 of Environment Canada's *National Inventory Report 1990–2012: Greenhouse Gas Sources and Sinks in Canada* (Environment Canada 2014), submitted to the United Nations Framework Convention on Climate Change (UNFCCC) in April 2014 ([http://unfccc.int/files/national\\_reports/annex\\_i\\_ghg\\_inventories/national\\_inventories\\_submissions/application/zip/can-2014-nir-11apr.zip](http://unfccc.int/files/national_reports/annex_i_ghg_inventories/national_inventories_submissions/application/zip/can-2014-nir-11apr.zip)). The protocol is based on an estimated uncertainty of 10–50% for all sectors, for which the protocol indicates rounding to two significant digits. Although the rounding protocol was applied to all data in tables and charts in this report, all subtotals and totals were calculated prior to its application.

## Annex C: Black Carbon/PM<sub>2.5</sub> Ratios

The ratios used to convert PM<sub>2.5</sub> emissions to black carbon emissions are listed in Table 2, Table 3 and Table 4.

**Table C-1 Black Carbon/PM<sub>2.5</sub> Ratios for Industrial Source Emission Calculations**

Sector	Subsector	BC/PM <sub>2.5</sub> Fractions		Profile	Reference
		Description	Value (w/w)		
Aluminium	Alumina (Bauxite Refining)	Aluminium Processing, baghouse (avg)	0.02083	2910110	U.S. EPA (2014), Speciate 4.4
		Lime Kiln	0.00576	2320230	U.S. EPA (2014), Speciate 4.4
	Primary Aluminium Smelting & Refining	Aluminium Processing, baghouse (avg)	0.02083	2910110	U.S. EPA (2014), Speciate 4.4
		Aluminium Reduction Potline	0.0268	2910210	U.S. EPA (2014), Speciate 4.4
		Coal Combustion	0.01384	4373	U.S. EPA (2014), Speciate 4.4
		Average of large stack BC/PM <sub>2.5</sub> fractions	0.02043		Weighted average (excluding Coal Combustion)
	Secondary Aluminium (Includes Recycling)	Secondary Aluminium–Dross Recovery Furnace	0.01426	2010310 201032.5 2010330 20103C	U.S. EPA (2014), Speciate 4.4
Cement and Concrete	Cement Manufacture	Cement Kiln (Coal-Fired)	0.002	2720310	U.S. EPA (2014), Speciate 4.4
		Cement Kiln	0.01756	4331	U.S. EPA (2014), Speciate 4.4
		Average of large stack BC/PM <sub>2.5</sub> fractions	0.02778		Weighted average
	Lime Manufacture	Lime Kiln	0.00464	23202C	U.S. EPA (2014), Speciate 4.4
		Cement Kiln	0.01756	4331	U.S. EPA (2014), Speciate 4.4
		Average of large stack BC/PM <sub>2.5</sub> fractions	0.00511		Weighted average
	Concrete Batching & Products	Cement industry	0.0017	3677	U.S. EPA (2014), Speciate 4.4
Gypsum Product Manufacturing	Mineral Products - Avg - Composite	0.01467	91120	U.S. EPA (2014), Speciate 4.4	
Foundries	Ferrous Foundries	Cast Iron Cupola - Composite	0.0091	91157	U.S. EPA (2014), Speciate 4.4
	Non-ferrous Foundries	Primary Metal Production - Average	0.01002	9000730	U.S. EPA (2014), Speciate 4.4
	Die Casting	Cast Iron Cupola - Composite	0.0091	91157	U.S. EPA (2014), Speciate 4.4
Mining and Rock Quarrying	Rock, Sand and Gravel	Sand	0.00265	3665	U.S. EPA (2014), Speciate 4.4
	Metal Mining	Incinerator (avg)	0.06658	3286 3287 3288 3290	U.S. EPA (2014), Speciate 4.4
		Diesel Exhaust	0.77124	3914	U.S. EPA (2014), Speciate 4.4
		Average of large stack BC/PM <sub>2.5</sub> fractions	0.06658		Weighted average
	Coal Mining Industry	Mineral Products–Avg–Simplified	0.01467	92120	U.S. EPA (2014), Speciate 4.4
	Potash	Phosphate Manufacturing - Composite	0.0274	91165	U.S. EPA (2014), Speciate 4.4
		Average of large stack BC/PM <sub>2.5</sub> fractions	0.0274	91165	U.S. EPA (2014), Speciate 4.4
	Silica Production	Mineral Products–Avg–Simplified	0.01467	92120	U.S. EPA (2014), Speciate 4.4
	Limestone	Mineral Products–Avg–Simplified	0.01467	92120	U.S. EPA (2014), Speciate 4.4
	Other Minerals	Mineral Products–Average	0.01537	9001310 900132.5 9001330 90013C	U.S. EPA (2014), Speciate 4.4
		Natural Gas Combustion - Simplified	0.384	92112	U.S. EPA (2014), Speciate 4.4
		Oil Combustion	0.42997	3864	U.S. EPA (2014), Speciate 4.4
		Diesel Exhaust	0.77124	3914	U.S. EPA (2014), Speciate 4.4
Average of large stack BC/PM <sub>2.5</sub> fractions		0.13074		Weighted average	

Table C-1 Black Carbon/PM<sub>2.5</sub> Ratios for Industrial Source Emission Calculations (cont'd)

Sector	Subsector	BC/PM <sub>2.5</sub> Fractions		Profile	Reference
		Description	Value (w/w)		
Pulp and Paper	Pulp and Paper Industry	Kraft Recovery Furnace - Simplified	0.0153	92119	U.S. EPA (2014), Speciate 4.4
		Wood-Fired Boiler - Simplified	0.03709	92114	U.S. EPA (2014), Speciate 4.4
		Residual Oil Combustion	0.01	4737	U.S. EPA (2014), Speciate 4.4
		Hog fuel and bunker crude use	0.03167	92114 (80%) 4737 (20%)	U.S. EPA (2014), Speciate 4.4
		Lime Kiln	0.00464	23202C	U.S. EPA (2014), Speciate 4.4
		Gas-Fired Combined Cycle and Cogeneration Plants	0.025	5671	U.S. EPA (2014), Speciate 4.4
		Oil-Fired Boilers	0.071	5672	U.S. EPA (2014), Speciate 4.4
		Average of large stack BC/PM <sub>2.5</sub> fractions	0.02827		Weighted average
	Converted Paper Product Manufacturing (TBA)	Pulp & Paper Mills - Simplified	0.001	92144	U.S. EPA (2014), Speciate 4.4
	Wood Products	Sawmills	Wood-Fired Boiler - Simplified	0.03709	92114
Wood Products - Sawing - Simplified			0.038	92131	U.S. EPA (2014), Speciate 4.4
Panel Board Mills		Wood-Fired Boiler - Simplified	0.03709	92114	U.S. EPA (2014), Speciate 4.4
		Wood Products - Drying - Composite	0.08	91128	U.S. EPA (2014), Speciate 4.4
		Composite wood and natural gas boilers	0.21054	91114 91112	U.S. EPA (2014), Speciate 4.4
		Average of large stack BC/PM <sub>2.5</sub> fractions	0.0897		Weighted average
Other Wood Products		Wood-Fired Boiler - Simplified	0.03709	92114	U.S. EPA (2014), Speciate 4.4
		Wood Products - Drying - Composite	0.08	91128	U.S. EPA (2014), Speciate 4.4
		Average of large stack BC/PM <sub>2.5</sub> fractions	0.03784		Weighted average
		Diesel Exhaust	0.77124	3914	U.S. EPA (2014), Speciate 4.4
Upstream Petroleum Industry	Natural Gas Combustion - Simplified	0.384	92112	U.S. EPA (2014), Speciate 4.4	
	Flaring	0.24	-	McEwen (2013)	

Table C-2 Black Carbon/PM<sub>2.5</sub> Ratios for Non Industrial Source Emission Calculations

Sector	Subsector	BC/PM <sub>2.5</sub> Fractions		Profile	Reference
		Description	Value (w/w)		
Commercial Fuel Combustion		Kerosene & Stove Oil	0.1	91115	U.S. EPA (2014), Speciate 4.4
		Light Fuel Oil	0.1	91115	U.S. EPA (2014), Speciate 4.4
		Natural Gas	0.384	91112	U.S. EPA (2014), Speciate 4.4
		Natural Gas Liquids	0.384	91112	U.S. EPA (2014), Speciate 4.4
Electric Power Generation (Utilities)	Coal	Bituminous Coal Combustion - Simplified	0.01696	92104	U.S. EPA (2014), Speciate 4.4
	Natural Gas	Gas-Fired Combined Cycle and Cogeneration Plants	0.025	5671	U.S. EPA (2014), Speciate 4.4
	Other Process	Residual Oil Combustion	0.01	4737	U.S. EPA (2014), Speciate 4.4
		Bunker C and Natural Gas	0.197	4737 92112	U.S. EPA (2014), Speciate 4.4
		Distillate Oil Combustion	0.1	4736	U.S. EPA (2014), Speciate 4.4
		Diesel Exhaust	0.77124	92106	U.S. EPA (2014), Speciate 4.4
		Gas-Fired Combined Cycle and Cogeneration Plants	0.025	5671	U.S. EPA (2014), Speciate 4.4
		Wood Fired Boiler - Simplified	0.037088024	92114	U.S. EPA (2014), Speciate 4.4
		Oil Combustion	0.429969	3864	U.S. EPA (2014), Speciate 4.4
Residential Fuel Combustion		Kerosene & Stove Oil	0.1	91115	U.S. EPA (2014), Speciate 4.4
		Light Fuel Oil	0.1	91115	U.S. EPA (2014), Speciate 4.4
		Natural Gas	0.067	421072.5	U.S. EPA (2014), Speciate 4.4
		Natural Gas Liquids	0.067	421072.5	U.S. EPA (2014), Speciate 4.4
Residential Wood Combustion	Advanced Technology Fireplace	Non-Catalytic	0.055791381	92105	U.S. EPA (2014), Speciate 4.4
	Conventional Fireplace	With Glass Doors	0.055791381	92105	U.S. EPA (2014), Speciate 4.4
		Without Glass Doors	0.055791381	92105	U.S. EPA (2014), Speciate 4.4
	Fireplace Insert	Advanced Technology	0.055791381	92105	U.S. EPA (2014), Speciate 4.4
		Conventional	0.055791381	92105	U.S. EPA (2014), Speciate 4.4
	Pellet Stove	All	0.055791381	92105	U.S. EPA (2014), Speciate 4.4
	Wood Stove	Conventional	0.055791381	92105	U.S. EPA (2014), Speciate 4.4
		EPA Certified	0.055791381	92105	U.S. EPA (2014), Speciate 4.4
	Wood Furnace	All	0.138	4704	U.S. EPA (2014), Speciate 4.4

**Table C-2 Black Carbon/PM<sub>2.5</sub> Ratios for Non Industrial Source Emission Calculations (cont'd)**

Sector	Subsector	BC/PM <sub>2.5</sub> Fractions		Profile	Reference
		Description	Value (w/w)		
Agriculture - Fuel Combustion		Kerosene & Stove Oil	0.1	91115	U.S. EPA (2014), Speciate 4.4
		Light Fuel Oil	0.1	91115	U.S. EPA (2014), Speciate 4.4
		Natural Gas	0.067	421072.5	U.S. EPA (2014), Speciate 4.4
		Natural Gas Liquids	0.067	421072.5	U.S. EPA (2014), Speciate 4.4
Construction Fuel Combustion		Kerosene & Stove Oil	0.1	91115	U.S. EPA (2014), Speciate 4.4
		Light Fuel Oil	0.1	91115	U.S. EPA (2014), Speciate 4.4
		Natural Gas	0.384	91112	U.S. EPA (2014), Speciate 4.4

**Table C-3 Black Carbon/PM<sub>2.5</sub> Ratios for Mobile Source Emission Calculations**

Sector	BC/PM <sub>2.5</sub> Fractions		Profile	Reference
	Description	Value (w/w)		
Air Transportation	Aviation Turbo Fuel (Jet A or B)	0.771241	92106	U.S. EPA (2014), Speciate 4.4
	Aviation Gasoline	0.12178	92113	U.S. EPA (2014), Speciate 4.4
Marine Transportation	Heavy Fuel Oil	0.12		EMEP/EEA (2013), Table A2
	Marine Diesel Oil	0.31		EMEP/EEA (2013), Table A2
	Marine Gasoline Oil	0.31		EMEP/EEA (2013), Table A2
On-Road	Diesel	ECCC data extracted from MOVES model; values are variable according to model input and vehicle class		U.S. EPA (2010), MOVES
	Gasoline	ECCC data extracted from MOVES model; values are variable according to model input and vehicle class		U.S. EPA (2010), MOVES
Off-road Fuel Use	Diesel	0.771241	92106	U.S. EPA (2014), Speciate 4.4
	Gasoline	0.12178	92113	U.S. EPA (2014), Speciate 4.4
	Natural Gas	0.384	92112	U.S. EPA (2014), Speciate 4.4
Rail Transportation	Diesel	0.771241	92106	U.S. EPA (2014), Speciate 4.4
	Biodiesel	0.771241	92106	U.S. EPA (2014), Speciate 4.4

# Annex D: UNECE Report on Black Carbon Emissions

Canada is using the UNECE report (template) and the associated Nomenclature for Reporting (NFR) codes for reporting its black carbon emissions internationally. Table D-1 lists the NFR codes used for reporting Canada's black carbon emissions in 2014.

The emissions from the three large point source (LPS) sectors (see Chapter 2) were mapped to the NFR codes in Table D-1. The resulting UNECE report can be seen in Table D-2.

The "IE" (included elsewhere) code indicates emissions were estimated but included elsewhere in the inventory instead of the listed source category.

**Table D-1 UNECE NFR Codes used by the 2014 Black Carbon Report**

NFR Code	Description
1A1a	Public electricity and heat production
1A1c	Manufacture of solid fuels and other energy industries
1A2a	Stationary combustion in manufacturing industries and construction: Iron and steel
1A2b	Stationary combustion in manufacturing industries and construction: Non-ferrous metals
1A2d	Stationary combustion in manufacturing industries and construction: Pulp, paper and print
1A2f	Stationary combustion in manufacturing industries and construction: Non-metallic minerals
1A2gviii	Stationary combustion in manufacturing industries and construction: Other (please specify in the IIR)
1A4ai	Commercial/institutional: Stationary
1A4bi	Residential: Stationary
1B2c	Venting and flaring (oil, gas, combined oil and gas)
1A3bi	Road transport: Passenger cars
1A3bii	Road transport: Light duty vehicles
1A3biii	Road transport: Heavy duty vehicles and buses
1A3biv	Road transport: Mopeds & motorcycles
1A3di(ii)	International inland waterways
1A3dii	National navigation (shipping)
1A3ai(i)	International aviation LTO (civil)
1A3aii(i)	Domestic aviation LTO (civil)
1A2gvii	Mobile Combustion in manufacturing industries and construction: (please specify in the IIR)
1A3c	Railways
1A4aii	Commercial/institutional: Mobile
1A4bii	Residential: Household and gardening (mobile)
1A4cii	Agriculture/Forestry/Fishing: Off-road vehicles and other machinery
1A4ciii	Agriculture/Forestry/Fishing: National fishing
1A5b	Other, Mobile (including military, land based and recreational boats)
5C1bi	Industrial waste incineration
1A3aii(ii)	Domestic aviation cruise (civil)

**Table D-2 2014 Canadian Black Carbon UNECE Report**

NFR Aggregation for Gridding and LPS (GNFR)	NFR Code	Longname	BC Emissions (kt)	
			2013	2014
A_PublicPower	1A1a	Public electricity and heat production	0.19	0.20
B_Industry	1A1c	Manufacture of solid fuels and other energy industries	2.1	2.7
B_Industry	1A2a	Stationary combustion in manufacturing industries and construction: Iron and steel	0.0001	0.0001
B_Industry	1A2b	Stationary combustion in manufacturing industries and construction: Non-ferrous metals	0.1	0.1
B_Industry	1A2d	Stationary combustion in manufacturing industries and construction: Pulp, Paper and Print	0.3	0.2
B_Industry	1A2f	Stationary combustion in manufacturing industries and construction: Non-metallic minerals	0.02	0.02
B_Industry	1A2gviii	Stationary combustion in manufacturing industries and construction: Other (please specify in the IIR)	0.8	0.7
C_OtherStationaryComb	1A4ai	Commercial/institutional: Stationary	0.8	0.8
C_OtherStationaryComb	1A4bi	Residential: Stationary	11.8	11.8
D_Fugitive	1B2c	Venting and flaring (oil, gas, combined oil and gas)	0.002	0.002
F_RoadTransport	1A3bi	Road transport: Passenger cars	0.5	0.5
F_RoadTransport	1A3bii	Road transport: Light duty vehicles	0.6	0.6
F_RoadTransport	1A3biii	Road transport: Heavy duty vehicles and buses	8.0	7.5
F_RoadTransport	1A3biv	Road transport: Mopeds & motorcycles	0.007	0.008
G_Shipping	1A3di(ii)	International inland waterways	IE	IE
G_Shipping	1A3dii	National navigation (shipping)	1.2	0.9
H_Aviation	1A3ai(i)	International aviation LTO (civil)	IE	IE
H_Aviation	1A3aii(i)	Domestic aviation LTO (civil)	0.2	0.2
I_Offroad	1A2gvii	Mobile Combustion in manufacturing industries and construction: (please specify in the IIR)	6.8	6.2
I_Offroad	1A3c	Railways	2.2	2.2
I_Offroad	1A4aii	Commercial/institutional: Mobile	0.9	0.9
I_Offroad	1A4bii	Residential: Household and gardening (mobile)	0.2	0.2
I_Offroad	1A4cii	Agriculture/Forestry/Fishing: Off-road vehicles and other machinery	7.0	6.4
I_Offroad	1A4ciii	Agriculture/Forestry/Fishing: National fishing	IE	IE
I_Offroad	1A5b	Other, Mobile (including military, land based and recreational boats)	0.8	0.8
J_Waste	5C1bi	Industrial waste incineration	0.006	0.006
O_AviCruise	1A3aii(ii)	Domestic aviation cruise (civil)	0.5	0.5

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