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CANADA'S AIR POLLUTANT EMISSIONS INVENTORY REPORT 1990–2017

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LIST OF ABBREVIATIONS, CHEMICAL FORMULAS AND UNITS

Abbreviations

AAFC	Agriculture and Agri-Food Canada
APEI	Air Pollutant Emissions Inventory
CAC	Criteria air contaminant
CANSIM	Canadian Socio-Economic Information Management System
CCME	Canadian Council of Ministers of the Environment
CEA	Canadian Electricity Association
CEIP	Centre on Emission Inventories and Projections
CEPA	*Canadian Environmental Protection Act, 1999*
CLRTAP	Convention on Long-range Transboundary Air Pollution
CORINAIR	Core Inventory of Air Emissions in Europe
CPI	Consumer Price Index
D/F	Dioxins and furans
EEA	European Environment Agency
EF	Emission factor
EIIP	Emission Inventory Improvement Program
EMEP	European Monitoring and Evaluation Programme
FVRD	Fraser Valley Regional District
GVRD	Greater Vancouver Regional District
ICAO	International Civil Aviation Organization
LPG	Liquefied petroleum gas
MOVES	Motor Vehicle Emission Simulator
NAESI	National Agri-Environmental Standards Initiative
NAHARP	National Agri-Environmental Health Analysis and Reporting
NAICS	North American Industry Classification System
NFR	Nomenclature for Reporting
NG	Natural Gas
NPRI	National Pollutant Release Inventory
NRCan	Natural Resources Canada
PAH	Polycyclic aromatic hydrocarbon
PM	Particulate matter
PM_{10}	Particulate matter less than or equal to 10 microns
$PM_{2.5}$	Fine particulate matter less than or equal to 2.5 microns
POP	Persistent organic pollutant

QA	Quality Assurance
QC	Quality control
RESD	Report on Energy Supply-Demand Canada
SOMA	Sulphur Oxides Management Area
TPM	Total particulate matter
U.S. EPA	United States Environmental Protection Agency
UNECE	United Nations Economic Commission for Europe
VOC	Volatile organic compound

Chemical Formulas

B(a)p	Benzo(a)pyrene
B(b)f	Benzo(b)fluoranthene
B(k)f	Benzo(k)fluoranthene
Cd	Cadmium
CH_4	Methane
CO	Carbon monoxide
HCB	Hexachlorobenzene
Hg	Mercury
I(cd)p	Indeno(1,2,3-cd)pyrene
NH_3	Ammonia
NO_2	Nitrogen dioxide
NO_x	Nitrogen oxides
Pb	Lead
SO_2	Sulphur dioxide
SO_x	Sulphur oxides
TCDD	2,3,7,8-Tetrachlorodibenzo-*p*-dioxin

Units

g	Gram
gTEQ	Gram of toxic equivalent
kg	Kilogram
kt	Kilotonne
Mt	Megatonne
t	Tonne

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EXECUTIVE SUMMARY

Canada's Air Pollutant Emissions Inventory (APEI) has been prepared and published by Environment and Climate Change Canada since 1973. The APEI is a comprehensive inventory of anthropogenic emissions of 17 air pollutants at the national and provincial/territorial levels. This inventory serves many purposes: it fulfills Canada's international reporting obligations under the 1979 Convention on Long-range Transboundary Air Pollution (CLRTAP) and the associated protocols ratified by Canada for the reduction of emissions of sulphur oxides (SO_x), nitrogen oxides (NO_x), cadmium (Cd), lead (Pb), mercury (Hg), volatile organic compounds (VOCs), dioxins and furans (D/F), and other persistent organic pollutants (POPs). The APEI also reports emissions of additional air pollutants not covered by protocols including ammonia (NH_3), carbon monoxide (CO), fine particulate matter ($PM_{2.5}$), coarse particulate matter (PM_{10}) and total particulate matter (TPM). In addition, the APEI supports monitoring and reporting obligations under the Canada-U.S. Air Quality Agreement and the development of air quality management strategies, policies and regulations, provides data for air quality forecasting, and informs Canadians about pollutants that affect their health and the environment.

While the APEI provides valuable information on emissions within Canada, air quality issues may arise from localized emissions; information on these emissions are aggregated with all other emissions at the provincial and territorial level in the APEI.

The APEI is compiled from many different data sources. Emissions data reported by individual facilities to Environment and Climate Change Canada's National Pollutant Release Inventory (NPRI) and, to a lesser extent, data provided directly by the provinces are supplemented with well documented, science-based estimation tools and methodologies to quantify total emissions. Together, these data sources provide a comprehensive coverage of air pollutant emissions across Canada.

This edition of the APEI Report summarizes the most recent estimates of air pollutant emissions for 1990–2017 as of February 2019. The inventory indicates that 14 of the 17 reported air pollutants show decreases compared to historical levels, and specifically indicate that:[1]

- Emissions of SO_x were 0.9 million tonnes in 2017, 35% below the emission ceiling of 1.45 million tonnes established under the 1999 Gothenburg Protocol to Abate Acidification, Eutrophication and Ground-level Ozone.
- Emissions of NO_x were 1.8 million tonnes in 2017, 21% below the emission ceiling of 2.25 million tonnes established under the 1999 Gothenburg Protocol.
- In 2017, emissions of non-methane VOCs were 14% below the emission ceiling of 2.1 million tonnes established under the 1999 Gothenburg Protocol.
- In 2017, emissions of Cd, Pb, and Hg were 85%, 72% and 82% below the ceilings established under the 1998 Aarhus Protocol on Heavy Metals.
- In 2017, emissions of all POPs were below the ceilings established under the 1998 Aarhus Protocol on Persistent Organic Pollutants, including the four species of polycyclic aromatic hydrocarbons (PAHs) (69% below), hexachlorobenzene (HCB) (92% below), and D/F (85% below).
- Carbon monoxide (CO) decreased by 54% from 1990 to 2017.
- Fine particulate emissions (particulate matter less than or equal to 2.5 microns in diameter [$PM_{2.5}$]) decreased from all sources except from dust from paved and unpaved roads, agriculture fuel use, as well as construction operations, with total $PM_{2.5}$ emissions in 2017 being 15% below 1990 levels.

Canada's Air Pollution Emission Trends (1990 to 2017)

The last year saw no significant change in the general downward trend in pollutant emissions. Industrial emissions of SO_x continued to decline, largely due to decreasing emissions from the oil and gas industry, and were down 52% from 1990 levels. Emissions from non-ferrous refining and smelting were down 79% from 1990 levels and electric power generation (utilities) were down 60%.

1 Throughout this report, data are presented as rounded figures. However, all calculations (including percentages) were performed using unrounded data.

Improved agricultural practices and the adoption of more recent wood combustion equipment also contributed to a 15% decrease in emissions of $PM_{2.5}$.

A few sources of pollutants exerted a dominant influence in the downward trends in emissions. In particular, decreases in emissions of SO_x, Cd, Pb, Hg and PAH from non-ferrous refining and smelting and from mining and rock quarrying strongly contributed to the overall downward trends in emissions of these pollutants. In addition, reductions in NO_x emissions from light-duty gasoline trucks and vehicles, as well as in VOC and CO emissions associated with the combustion of gasoline, liquid petroleum gas or natural gas by off-road equipment were instrumental in reducing national emissions of these pollutants.

Improvements in incineration technologies contributed significantly to decreases in emissions of HCB and D/F. The 11% increase in PM_{10} emissions since 1990 constrast with the general trends decribed above; it is largely due to increased transportation on paved and unpaved roads as well as construction operations. another exception to the general downward trends is the observed increase in emissions of ammonia (NH_3), which were 19% above 1990 levels in 2017; the upward trend in ammonia emissions is driven by fertilizer application and animal production.

Irrespective of the downward trends observed in Canadian emissions, localized air issues may still arise when emissions sources are spatially concentrated.

Canada's Air Emissions Regulations and Measures

Downward trends in emissions of air pollutants reflect the ongoing implementation of a wide range of regulatory and non-regulatory instruments that aim to reduce or eliminate pollutants in order to improve and maintain air quality in Canada. Regulations under the *Canadian Environmental Protection Act, 1999* (CEPA) related to the 17 APEI pollutants include, but are not limited to, the following:

- Multi-Sector Air Pollutants Regulations
- Export of Substances on the Export Control List Regulations
- On-Road Vehicle and Engine Emission Regulations
- Sulphur in Gasoline Regulations
- Products Containing Mercury Regulations
- Renewable Fuels Regulations
- Off-Road Compression-Ignition Engine Emission Regulations
- Sulphur in Diesel Fuel Regulations
- Benzene in Gasoline Regulations
- Marine Spark-Ignition Engine, Vessel and Off-Road Recreational Vehicle Emission Regulations
- Gasoline Regulations
- Volatile Organic Compound (VOC) Concentration Limits for Automotive Refinishing Products Regulations
- Volatile Organic Compound (VOC) Concentration Limits for Architectural Coatings Regulations
- Off-Road Small Spark-Ignition Engine Emission Regulations
- Gasoline and Gasoline Blend Dispensing Flow Rate Regulations
- Pulp and Paper Mill Effluent Chlorinated Dioxins and Furans Regulations
- Contaminated Fuel Regulations
- Secondary Lead Smelter Release Regulations

All regulations administered under CEPA are available on the registry: https://www.ec.gc.ca/lcpe-cepa/default.asp?n=D44ED61E-1.

Non-regulatory instruments include guidelines for new stationary combustion turbines, codes of practice, and performance agreements. Pollution prevention planning notices were published to reduce air pollutant emissions from the aluminum, iron, steel and ilmenite, iron ore pellets, potash, pulp and paper, base-metals smelting sectors.

1

INTRODUCTION

1.1. Background on the Air Pollutant Emissions Inventory

Canada's Air Pollutant Emissions Inventory (APEI) is a comprehensive inventory of air pollutant emissions at the national and provincial/territorial levels. The APEI is prepared and published by Environment and Climate Change Canada (ECCC) and serves many purposes, including the following:

- contribute to tracking and quantifying air pollutants in accordance with Canada's domestic and international reporting obligations;
- support to the development of domestic air quality management strategies, policies and regulations;
- inform Canadians about pollutants that affect their health and the environment; and
- provide data to support air quality forecasting.

The first national inventory of air pollutant emissions in Canada was compiled in 1973, with national and provincial/territorial estimates of emissions of carbon monoxide (CO), sulphur oxides (SO_x), nitrogen oxides (NO_x), hydrocarbons and particulate matter (PM) for the year 1970. Since then, air emission estimates for Canada have continued to be published on a regular basis.

Today the APEI includes emissions data for 17 air pollutants that contribute to smog, acid rain and diminished air quality, including:

- smog precursors: total particulate matter (TPM), PM less than or equal to 10 microns (PM_{10}), PM less than or equal to 2.5 microns ($PM_{2.5}$), SO_x, NO_x, volatile organic compounds (VOCs), CO and ammonia (NH_3);
- heavy metals: mercury (Hg), lead (Pb) and cadmium (Cd); and
- persistent organic pollutants (POPs): dioxins and furans (D/F), four polycyclic aromatic hydrocarbon (PAH) compounds (benzo[a]pyrene, benzo[b] fluoranthene, benzo[k]fluoranthene and indeno[1,2,3-cd]pyrene), and hexachlorobenzene (HCB).

The reporting format for the APEI organizes emissions into 11 source categories that are further broken down into 74 sectors and 72 associated subsectors (Table 1–1). The APEI is compiled and published on an annual basis. The time series of annual emissions contained in this report is updated across the times series, from 1990 to the most recent inventory year, to indicate the trend in emissions are based on consistent and current methodological approaches and data.

Facility emissions data captured in the APEI originate primarily from the National Pollutant Release Inventory (NPRI), supplemented with data provided by provincial governments (Alberta, Manitoba, New Brunswick, Newfoundland and Labrador, Ontario and Quebec). For example, Alberta provides additional data for the Upstream Petroleum sector for the pre-2006 years, and Alberta and Newfoundland provide supplementary information for selected sources that are not reported to the NPRI. In addition to supplementing the NPRI data with additional data sources as described above, the APEI incorporates estimated emissions for sources not reported to the NPRI, for example when an APEI sector includes facilities that are below the NPRI reporting threshold.

Table 1–1 **Air Pollutant Emissions Inventory Sector Descriptions**

APEI Source/Sector	Sector Descriptions
ORE AND MINERAL INDUSTRIES	
Aluminium Industry	Alumina production through bauxite refining, primary aluminium production through smelting and refining and secondary aluminium production in which aluminium is recovered from aluminium-containing scrap.
Asphalt Paving Industry	Asphalt concrete (or hot-mix asphalt) manufacturing. Emissions are from permanent and portable hot-mix asphalt installations.
Cement and Concrete Industry	Entire process of cement production in rotary kilns, as well as the preparation of concrete and ready-mix concrete, lime manufacture and concrete batching and products.
Foundries	Castings of various types of ferro-alloys as well as small iron and steel foundries not associated with integrated iron and steel facilities. The types of foundries included are: open ferrous, electric arc and induction foundries.
Iron and Steel Industry	Steel production, including blast furnaces, basic oxygen furnaces, electric arc furnaces, sintering, direct reduction of iron, hot forming and semi-finishing, coke production.
Iron Ore Industry	Iron ore mining, beneficiation by concentration and sintering into pellets are included.
Mineral Products Industry	Manufacture of brick, clay products such as pipes, liner and tiles and other mineral products such as gypsum and glass products.
Mining and Rock Quarrying	Overburden removal, drilling in rock, blasting, crushing of rock, loading of materials, transporting raw materials by conveyors or haulage trucks, scraping, bulldozing, grading, open storage pile losses and wind erosion from exposed areas.
Non-Ferrous Refining and Smelting Industry	Primary copper and nickel production using pyrometallurgical operations, lead ore crushing, concentrating and metallurgic processing and zinc metal production through electrolytic processes.
OIL AND GAS INDUSTRY	
Downstream Oil and Gas Industry	Refining and processing of crude oil to make fuels or other products such as solvents or asphalt. Storage and distribution of refined petroleum products, natural gas distribution and liquid natural gas (LNG) processing.
Upstream Oil and Gas Industry	Drilling, testing and servicing of wells, conventional oil and gas production, in situ bitumen extraction and open pit mining, oil sands upgrading, natural gas processing, crude oil transmission, natural gas transmission and storage.
ELECTRIC POWER GENERATION (UTILITIES)	
Coal	Electric power generation from combustion of coal by utilities (both publicly and privately owned) for commercial sale and/or private use.
Diesel	Electric power generation from combustion of diesel by utilities (both publicly and privately owned) for commercial sale and/or private use.
Natural Gas	Electric power generation from combustion of natural gas by utilities (both publicly and privately owned) for commercial sale and/or private use.
Waste Materials	Electric power generation from combustion of waste materials by utilities (both publicly and privately) for commercial sale and/or private use.
Other (Electric Power Generation)	Electric power generation from other energy sources by utilities (both publicly and privately owned) for commercial sale and/or private use.
MANUFACTURING	
Abrasives Manufacturing	Manufacturing of abrasive grinding wheels, abrasive-coated materials and other abrasive products.
Bakeries	Manufacturing of bakery products, including frozen baked products.
Biofuel Production	Production of ethanol for fuel or oils for biodiesel.
Chemicals Industry	Large number of different product industries including fertilizer manufacturing, plastic resins, paints and varnishes, petrochemicals, inorganic chemicals, and pharmaceuticals. The raw materials, processes used and products produced are in many cases unique to individual plants.
Electronics	Manufacturing of electronics, such as communications equipment, semiconductors and electronic components, navigational and guidance instruments, electric lamp bulb and parts, transformers, switchgear, relay and industrial control.
Food Preparation	Activities related to food production for human or animal consumption, such as manufacturing of dog and cat food, sugar and confectionery products, frozen food, dairy products, meat products, and beverage products; seafood product preparation and packaging; and fruit and vegetable canning, pickling and drying; snack, dressing, and tobacco products.
Glass Manufacturing	Making of glass from sand and cullet as well as the remelting, pressing, blowing or otherwise shaping purchased glass.
Grain Industry	Primary, process, terminal and transfer elevators, as well as manufacturing or processing grain for use in other products.
Metal Fabrication	Activities related to metal fabrication, such as: iron and steel mills and ferro-alloy manufacturing; production of iron and steel pipes and tubes, cold-rolling steel bars, sheets, strips and other steel shapes; steel wire drawing; smelting of non-ferrous metals; copper rolling, drawing, extruding and alloying; forging; stamping; and other metal manufacturing.
Plastics Manufacturing	Manufacturing of plastics bags, plastic film and sheet, unlaminated plastic profile shapes, plastic pipes and pipe fittings, laminating plastic profile shapes (plates, sheets and rods), polystyrene foam products, urethane, and other foam products.
Pulp and Paper Industry	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.
Textiles	Textile product-related activities, including: fibre, yarn and thread manufacturing; textile and fabric finishing; fabric coating; carpet and rug manufacturing; clothing knitting; as well as clothing accessories and other clothing manufacturing.
Vehicle Manufacturing (Engines, Parts, Assembly, Painting)	Activities related to: vehicle manufacturing, such as manufacturing of motor vehicles plastic parts, engine and power transmission equipment, automobile and light-duty motor vehicles, heavy-duty trucks, truck trailers, motor vehicle brake systems, seating and interior trim, and vehicle parts; urban transit systems; and support activities for rail transportation.
Wood Products	Sawmills, panelboard mills (including veneer, plywood, waferboard, particle board and medium-density fiberboard mills), and other wood products manufacturing establishments (including furniture and cabinet makers, wood treating plants, wood pellet mills and Masonite manufacturers).
Other (Manufacturing)	Manufacturing and processing industries that are not included under a specific industrial sector, such as asphalt shingle and coating activities, rubber manufacturing, and ship building and repair.

Table 1–1 **Air Pollutant Emissions Inventory Sector Descriptions** (cont'd)

APEI Source/Sector	Sector Descriptions
TRANSPORTATION AND MOBILE EQUIPMENT	
Air Transportation	Piston and turbine aircraft used for military, commercial and private operations.
Heavy-duty Diesel Vehicles	Diesel vehicles over 3 856 kilograms.
Heavy-duty Gasoline Vehicles	Gasoline vehicles over 3 856 kilograms.
Heavy-duty LPG/NG Vehicles	Propane and natural gas vehicles over 3 856 kilograms.
Light-duty Diesel Trucks	Diesel trucks under 3 856 kilograms.
Light-duty Diesel Vehicles	Diesel vehicles under 3 856 kilograms.
Light-duty Gasoline Trucks	Gasoline trucks under 3 856 kilograms.
Light-duty Gasoline Vehicles	Gasoline vehicles under 3 856 kilograms.
Light Duty LPG/NG Trucks	Propane and natural gas trucks under 3 856 kilograms.
Light Duty LPG/NG Vehicles	Propane and natural gas vehicles under 3 856 kilograms.
Marine Transportation	Marine craft in anchored, berth and underway phases.
Motorcycles	Motorcycles.
Off-road Diesel Vehicles and Equipment	Off-road vehicles and mobile equipment using diesel fuel in mining, construction, agriculture, commercial purposes, logging, railway maintenance, and airport ground support; lawn and garden equipment using diesel fuel; and recreational vehicles using diesel fuel.
Off-road Gasoline/LPG/NG Vehicles and Equipment	Off-road vehicles and mobile equipment using gasoline, liquid petroleum gas, and compressed natural gas in mining, construction, agriculture, commercial purposes, logging, railway maintenance, airport ground support; lawn and garden equipment using gasoline, liquid petroleum gas, or compressed natural gas; and recreational vehicles using gasoline, liquid petroleum gas, and compressed natural gas.
Rail Transportation	Freight and passenger trains, including yard switching activities.
Tire Wear and Brake Lining	Tire and brake lining wear from all categories of road transportation.
AGRICULTURE	
Animal Production	Decomposition of animal feed, animal digestion, and manure in housing, storage, applied to agricultural soils, or deposited during grazing.
Crop Production	Application of synthetic nitrogen fertilizers, tillage, wind erosion and crop harvesting.
Fuel Use	Stationary combustion sources in agricultural facilities such as space and water heating and crop drying.
COMMERCIAL / RESIDENTIAL / INSTITUTIONAL	
Cigarette Smoking	Mainstream cigarette smoke, which is directly exhaled by the smoker and sidestream smoke, which is directly released from burning cigarettes.
Commercial and Institutional Fuel Combustion	Combustion of fossil and biogenic fuels used for space/water heating in commercial establishments, health and educational institutions and government/public administration facilities.
Commercial Cooking	Cooking meat and french fries in commercial foodservice operations.
Construction Fuel Combustion	Combustion of fossil fuels used for space heating and the heating of construction materials, such as concrete.
Home Firewood Burning	Burning of wood and pellets as fuelfor space heating and hot water. Includes emissions from fireplaces, wood stoves and wood-fired boilers.
Human	Human respiration, perspiration, dental amalgams and infant diapered waste.
Marine Cargo Handling	Handling, loading and unloading of materials, goods and merchandise between ships and docks.
Residential Fuel Combustion	Combustion of fossil fuels used for space/water heating in residences.
Service Stations	Fuel transfers and storage at service stations, as well as individuals refueling vehicles and off-road equipment.
Other (Commercial / Residential / Institutional)	Hg in products and facility-reported data from sectors that are not included elsewhere.
INCINERATION AND WASTE	
Crematoriums	Combustion of caskets and human bodies, as well as companion animals.
Waste Incineration	Incinerators used to combust municipal, commercial and industrial waste including sewage sludge as well as residential waste burning.
Waste Treatment and Disposal	Landfilling of waste, biological treatment of waste, specialized waste treatment and remediation, waste sorting and transfer as well as municipal wastewater treatment and discharge (including drinking water treatment).
PAINTS AND SOLVENTS	
Dry Cleaning	Dry cleaning of fabric and leather items.
General Solvent Use	Broad range of applications occurring in residential, commercial, industrial and institutional locations. Industrial applications include uses such as: degreasing, adhesives and sealants, aerosols, blowing agents, and resin manufacturing. The use of consumer and commercial products, pesticides and personal care products are also included.
Printing	Manufacturing or use of printing inks, which includes: flexographic, gravure, letterpress, lithographic and other printing.
Surface Coatings	Broad range of applications and industries, including individuals and companies engaged in the manufacturing or use of paints and coatings.
DUST	
Coal Transportation	Transportation of coal by train or truck.
Construction Operations	Soil disturbance on construction sites (residential, industrial-commercial-institutional [ICI], engineering).
Mine Tailings	Wind erosion at mine tailings ponds located on active and inactive mine sites.
Paved Roads	Re-suspension of particulate matter by vehicles travelling on paved roads.
Unpaved Roads	Re-suspension of particulate matter by vehicles travelling on unpaved roads.
FIRES	
Prescribed Burning	Controlled fires used for land management treatments such as reducing logging residues, managing forest production, controlling insects, and minimizing the potential for destructive wildfires. Excludes the burning of agricultural residues.
Structural Fires	Vehicle fires (including trains and airplanes) and fires that burn buildings.

1.2. **Reporting Requirements**

The Convention on Long-range Transboundary Air Pollution (CLRTAP) endeavours to limit and, as far as possible, gradually reduce and prevent air pollution. Since 1979 when it was originally signed, the Convention has been extended by eight protocols, seven of which identify measures to be taken by Parties to achieve the Convention's objectives; the eighth protocol concerns financing. Canada has ratified six of the protocols under the Convention that have come into force including:

- the 1985 Helsinki Protocol on the Reduction of Sulphur Emissions (SO_x);
- the 1994 Oslo Protocol on Further Reduction of Sulphur Emissions (SO_x for a designated "Sulphur Oxides Management Area" [SOMA]);
- the 1988 Sofia Protocol concerning the Control of Emissions of Nitrogen Oxides (NO_x);
- the 1998 Aarhus Protocol on Heavy Metals (Cd, Pb and Hg);
- the 1998 Aarhus Protocol on Persistent Organic Pollutants (including D/F, four species of PAHs, and HCB, among other POPs); and
- the 1999 Protocol to Abate Acidification, Eutrophication and Ground-level Ozone and its 2012 amended version.

These protocols set specific emissions reduction targets for sulphur, NO_x, Cd, Pb, Hg, dioxins and furans, PAHs, HCB, and VOCs. Parties are required to report emissions to the United Nations Economic Commission for Europe (UNECE) each year by February 15.

In addition, Canada collects and publishes data on emissions of NH_3, CO and three categories of PM (TPM, PM_{10} and $PM_{2.5}$) and voluntarily reports the emissions of these five substances, along with the twelve substances for which there are protocols, to the UNECE annually. Canada has ratified the 1984 Geneva Protocol on Long-term Financing of the Cooperative Programme for Monitoring and Evaluation of the Long-range Transmission of Air Pollutants in Europe.

Canada and the United States work jointly to address shared concerns regarding transboundary air pollution. Under the Canada-U.S. Air Quality Agreement, Canada monitors and reports emissions of SO_2, NO_x and VOCs other than methane.

1.3. **Environmental measures and regulations for air pollutants**

Downward trends in emissions of air pollutants reflect the ongoing implementation of a wide range of regulatory and non-regulatory instruments that aim to reduce or eliminate pollutants in order to improve and maintain air quality in Canada. Regulations under the *Canadian Environmental Protection Act, 1999* (CEPA) related to the 17 APEI pollutants include, but are not limited to, the following:

- Multi-Sector Air Pollutants Regulations
- Volatile Organic Compound (VOC) Concentration Limits for Automotive Refinishing Products Regulations
- Volatile Organic Compound (VOC) Concentration Limits for Architectural Coatings Regulations
- Marine Spark-Ignition Engine, Vessel and Off-Road Recreational Vehicle Emission Regulations
- Off-Road Compression-Ignition Engine Emission Regulations
- Off-Road Small Spark-Ignition Engine Emission Regulations
- On-Road Vehicle and Engine Emission Regulations
- Benzene in Gasoline Regulations
- Contaminated Fuel Regulations
- Gasoline and Gasoline Blend Dispensing Flow Rate Regulations
- Gasoline Regulations
- Renewable Fuels Regulations
- Sulphur in Diesel Fuel Regulations
- Sulphur in Gasoline Regulations
- Products Containing Mercury Regulations
- Secondary Lead Smelter Release Regulations
- Export of Substances on the Export Control List Regulations
- Pulp and Paper Mill Effluent Chlorinated Dioxins and Furans Regulations

All regulations administered under CEPA are available on the CEPA Environmental Registry: https://pollution-waste.canada.ca/environmental-protection-registry/regulations.

Non-regulatory instruments include guidelines for new stationary combustion turbines, codes of practice, and performance agreements. Pollution prevention planning notices were published to reduce air pollutant emissions from the aluminium, iron, steel and ilmenite, iron ore pellets, potash, pulp and paper, and base-metals smelting sectors.

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2017 EMISSIONS AND TRENDS

This chapter describes the main sources and sectors contributing to the emissions of each pollutant and their historical trends. A description of source categories, sectors and sub-sectors is provided in Chapter 1 Table 1–1.

The contribution of each source category to total emissions of air pollutants varies by pollutant (Table 2–1)[1], as with the following examples.

- Dust is an important source of particulate matter (PM) emissions, accounting for 60% of emissions of total particulate matter (TPM) less than or equal to 2.5 microns ($PM_{2.5}$).
- Agriculture accounts for most ammonia (NH_3) emissions (94%).
- Incineration and Waste account for a significant proportion of hexachlorobenzene (HCB) (61%) and dioxins and furans (D/F) (37%) emissions.
- The Ore and Mineral Industries account for the largest proportion of sulphur oxides (SO_x) (40%), cadmium (Cd) (67%), lead (Pb) (77%) and mercury (Hg) (42%) emissions.
- Transportation and Mobile Equipment are the largest emitters of nitrogen oxides (NO_x) (52%) and carbon monoxide (CO) (54%).
- The Oil and Gas Industry is the largest emitter of volatile organic compounds (VOCs) (37%).

1 Throughout this report, data are presented as rounded figures. However, all calculations (including percentages) were performed using unrounded data.

- The Commercial / Residential / Institutional category is a particularly significant source of polycyclic aromatic hydrocarbons (PAHs) (90%).

A few key sources exert a relatively large influence on the emissions of several pollutants or their trends. Among industrial sources, the non-ferrous refining and smelting industry is a major source of SO_x (28%), Pb (72%) and Cd (63%). Since 1990, the industry contributed significantly to the downward trends in emissions of these pollutants, as well as of emissions of Hg. Over the years, the upstream oil and gas industry has become a dominant source of VOC (35%) and

Table 2–1 **2017 Total Air Pollutant Emissions for Canada by Source**

Source	Pollutants													
	TPM (kt)	PM_{10} (kt)	$PM_{2.5}$ (kt)	SO_x (kt)	NO_x (kt)	VOC (kt)	CO (kt)	NH_3 (kt)	Pb (kg)	Cd (kg)	Hg (kg)	D/F(gTEQ)	PAH (kg)	HCB (g)
Ore and Mineral Industries	230	92	35	380	76	13	580	1.3	140 000	4 600	1 300	6.3	530	2 300
Oil and Gas Industry	26	18	13	260	480	660	550	2.6	520	250	70	-	18	-
Electric Power Generation (Utilities)	16	7.0	3.3	250	150	1.2	42	0.24	1 700	120	600	2.2	6.5	470
Manufacturing	100	40	16	42	69	97	140	11	3 700	560	110	3.2	110	350
Transportation and Mobile Equipment	47	47	35	17	920	290	3 100	7.8	33 000	85	53	21	8 100	-
Agriculture	3 800	1 600	380	6.5	4.1	120	1.3	450	66	91	10	0.55	0.34	1.0
Commercial / Residential / Institutional	190	180	180	7.2	79	290	1 200	3.0	3 200	1 100	470	7.7	100 000	0.28
Incineration and Waste	6.4	3.8	2.8	2.9	5.4	11	18	4.0	400	35	440	24	710	4 900
Paints and Solvents	0.00	0.03	0.02	0.00	0.02	330	0.00	-	-	0.14	-	-	-	-
Dust	19 000	5 500	1 000	-	-	-	-	-	-	-	-	-	-	-
Fires	7.8	6.7	4.8	0.02	0.99	2.9	52	0.09	-	-	-	1.1	1 400	-
TOTAL	**24 000**	**7 500**	**1 700**	**950**	**1 800**	**1 800**	**5 700**	**480**	**180 000**	**6 800**	**3 000**	**66**	**110 000**	**8 100**

Notes:
Totals may not add up due to rounding.
- Indicates no emission
0.00 Indicates emissions truncated due to rounding

NO_x (26%) emissions in Canada, with increasing trends in emissions of both pollutants. In contrast, there were reductions in emissions of SO_x, NO_x, VOCs, HCB and Hg from coal-powered electric generation. Home firewood burning represents 90% of Canada's PAH emissions and 21% of its CO emissions; it is also the dominant combustion source of $PM_{2.5}$. While transportation and mobile equipment sources remain large contributors to NO_x, VOC and CO emissions, emissions from these sources have decreased significantly since 1990.

The last year saw no significant change in the general downward trends of pollutant emissions. However it should be noted that emissions of $PM_{2.5}$ and HCB have remained relatively stable since 2012, and emissions of NH_3 peaked in 2004 and have since fluctuated. Emissions of SO_x continued to decline, largely due to decreasing emissions from upstream oil and gas operations and coal-fired electric power generation. Improved control measures and changes in sulphur levels in fuel resulted in a decrease in $PM_{2.5}$ emissions from marine transportation. Upgrades to the Rio Tinto Alcan smelter in the province of British Columbia resulted in a significant decrease in PAH emissions from the aluminium industry. Emissions of Cd have steadily declined in recent years, with reductions in emissions from several sources.

The various sectors and subsectors of each source category contribute varying proportions of emissions of each pollutant (Table 2–2). For example, within the dust source category, road dust and construction operations are the largest sources of total PM emissions (almost five times greater than agriculture, the next most significant source). The upstream oil and gas industry is the largest emitter of VOCs. In transportation, heavy-duty diesel vehicles are significant emitters of NO_x, and off-road gasoline vehicles and equipment are large contributors of CO. The subsequent sections of this chapter identify the important sources of emissions for each substance in 2017 and their varying contribution to total emissions over time.

The full time series of national, provincial, and territorial pollutant emissions from 1990 to 2017 are available through the Air Pollutant Emission Inventory Online Data Query Tool (http://ec.gc.ca/inrp-npri/donnees-data/ap/index.cfm?lang=En). The APEI data is also available on-line at the Government of Canada Open Data Portal website (https://open.canada.ca/data/en/dataset/fa1c88a8-bf78-4fcb-9c1e-2a5534b92131).

Table 2–2 **2017 Total Air Pollutant Emissions for Canada by Source, Sector and Subsector**

Source	TPM (t)	PM_{10} (t)	$PM_{2.5}$ (t)	SO_x (t)	NO_x (t)	VOC (t)	CO (t)	NH_3 (t)	Pb (kg)	Cd (kg)	Hg (kg)	D/F (gTEQ)	PAH (kg)	HCB (g)
ORE AND MINERAL INDUSTRIES	**230 000**	**92 000**	**35 000**	**380 000**	**76 000**	**13 000**	**580 000**	**1 300**	**140 000**	**4 600**	**1 300**	**6.3**	**530**	**2 300**
Aluminium Industry	5 700	4 200	3 400	66 000	1 200	950	430 000	-	-	-	22	-	130	-
Alumina (Bauxite Refining)	88	47	42	1.4	300	24	370	-	-	-	-	-	-	-
Primary Aluminium Smelting and Refining	5 600	4 200	3 300	66 000	930	930	430 000	-	-	-	22	-	130	-
Secondary Aluminium Production (Includes Recycling)	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Asphalt Paving Industry	44 000	8 500	1 500	740	1 100	8 400	3 900	-	1 000	22	22	0.01	13	-
Cement and Concrete Industry	44 000	15 000	7 300	23 000	34 000	690	16 000	380	570	9.0	330	0.22	0.62	300
Cement Manufacturing	2 300	1 300	690	20 000	29 000	620	14 000	380	460	8.4	280	0.22	0.62	300
Gypsum Product Manufacturing	140	110	91	2.4	210	1.7	130	-	-	-	54	-	-	-
Lime Manufacturing	1 700	910	430	2 800	4 300	25	1 800	-	5.6	-	1.4	-	-	-
Concrete Batching and Products	40 000	12 000	6 100	0.06	1.5	47	0.70	-	100	0.97	-	-	-	-
Foundries	6 100	5 700	5 200	48	140	310	49 000	-	170	21	-	0.01	-	6.0
Die Casting	10	7.2	5.0	0.00	0.34	-	0.29	-	8.6	-	-	-	-	-
Ferrous Foundries	6 000	5 700	5 200	48	140	310	49 000	-	130	21	-	0.01	-	6.0
Non-ferrous Foundries	2.9	2.7	2.7	-	-	-	-	-	32	0.01	-	-	-	-
Iron and Steel Industry	6 300	3 800	2 500	18 000	11 000	820	27 000	55	5 100	200	730	5.6	390	1 100
Primary (Blast Furnace and DRI)	5 600	3 300	2 100	16 000	8 400	600	24 000	54	4 000	160	250	1.2	390	150
Secondary (Electric Arc Furnaces)	710	530	390	1 600	2 200	220	3 100	0.76	1 100	32	480	4.4	-	900
Steel Recycling	3.7	2.7	2.7	-	-	-	20	-	12	-	5.1	0.00	-	6.0
Other (Iron and Steel Industry)	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Iron Ore Industry	1 400	690	160	160	1 700	38	2 400	-	5.3	0.17	0.16	0.00	-	-
Iron Ore Mining	1 400	690	160	160	1 700	38	2 400	-	5.3	0.17	0.16	0.00	-	-
Pelletizing	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Mineral Products Industry	400	330	230	850	290	72	610	300	-	-	-	-	-	-
Clay Products	17	13	4.0	160	-	-	-	-	-	-	-	-	-	-
Brick Products	79	58	22	98	86	-	260	-	-	-	-	-	-	-
Other (Mineral Products Industry)	300	260	200	590	200	72	350	300	-	-	-	-	-	-
Mining and Rock Quarrying	120 000	52 000	13 000	2 300	25 000	1 300	33 000	83	1 200	53	19	0.02	0.02	7.5
Coal Mining Industry	88 000	39 000	5 100	780	3 900	2.9	15 000	-	27	2.8	1.7	-	0.01	-
Metal Mining	15 000	7 700	3 600	1 200	12 000	540	13 000	43	1 100	47	14	0.02	0.01	4.7
Potash	6 900	3 100	1 600	0.94	2 200	390	2 400	-	-	-	-	-	-	-
Rock, Sand and Gravel	4 800	2 100	2 500	8.7	970	-	420	-	-	-	-	-	-	-
Silica Production	260	130	13	-	-	-	-	-	-	-	-	-	-	-
Limestone	37	15	5.1	-	-	-	-	-	-	-	-	-	-	-
Other (Mining and Rock Quarrying)	1 100	630	390	310	6 500	380	2 100	39	69	3.2	2.8	0.00	-	2.8
Non-Ferrous Refining and Smelting Industry	3 000	2 000	1 300	270 000	1 800	69	15 000	460	130 000	4 300	140	0.44	-	940
Primary Ni, Cu, Zn, Pb	2 900	2 000	1 300	270 000	1 700	39	15 000	420	130 000	4 300	140	0.43	-	940
Secondary Pb, Cu	11	6.6	5.9	1 500	-	30	-	-	150	-	0.01	0.01	-	-
Other (Non-Ferrous Refining and Smelting Industry)	8.5	4.2	4.2	-	80	-	-	44	-	-	-	-	-	0.02

Table 2–2 **2017 Total Air Pollutant Emissions for Canada by Source, Sector and Subsector** (cont'd)

Source	TPM (t)	PM_{10} (t)	$PM_{2.5}$ (t)	SO_x (t)	NO_x (t)	VOC (t)	CO (t)	NH_3 (t)	Pb (kg)	Cd (kg)	Hg (kg)	D/F (gTEQ)	PAH (kg)	HCB (g)
OIL AND GAS INDUSTRY	**26 000**	**18 000**	**13 000**	**260 000**	**480 000**	**660 000**	**550 000**	**2 600**	**520**	**250**	**70**	**-**	**18**	**-**
Downstream Oil and Gas Industry	3 600	2 400	1 500	47 000	17 000	21 000	21 000	58	350	98	47	-	13	-
Petroleum Refining	3 500	2 400	1 500	47 000	16 000	8 800	21 000	58	350	98	47	-	13	-
Refined Petroleum Products Bulk Storage and Distribution	44	4.4	4.4	-	-	12 000	21	-	0.05	-	0.00	-	0.01	-
Refined Petroleum Product Pipelines	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Natural Gas Distribution	2.0	2.0	2.0	0.51	120	240	160	-	-	-	-	-	-	-
Other (Downstream Oil and Gas Industry)	13	10	10	-	580	-	240	-	-	-	-	-	-	-
Upstream Oil and Gas Industry	22 000	16 000	11 000	210 000	460 000	640 000	530 000	2 600	160	150	22	-	4.5	-
Accidents and Equipment Failures	-	-	-	-	-	120 000	-	-	-	-	-	-	-	-
Disposal and Waste Treatment	18	18	18	0.03	23	42	60	0.34	-	-	-	-	-	-
Heavy Crude Oil Cold Production	700	700	700	2 600	13 000	21 000	18 000	43	-	-	-	-	-	-
Light/Medium Crude Oil Production	2 700	2 700	2 700	10 000	41 000	360 000	52 000	16	0.75	1.4	-	-	0.00	-
Natural Gas Production and Processing	2 500	2 500	2 500	110 000	320 000	51 000	400 000	230	-	-	-	-	-	-
Natural Gas Transmission and Storage	130	110	96	22	20 000	830	7 300	0.87	-	-	-	-	-	-
Oil Sands In-Situ Extraction	1 400	1 400	1 400	22 000	40 000	14 000	28 000	930	-	68	11	-	-	-
Oil Sands Mining, Extraction and Upgrading	15 000	8 100	3 700	54 000	34 000	43 000	22 000	1 400	160	80	11	-	4.5	-
Petroleum Liquids Storage	8.5	8.5	8.5	-	58	7 000	23	-	-	-	-	-	-	-
Petroleum Liquids Transportation	14	14	11	130	0.36	15 000	2.0	-	-	-	-	-	-	-
Well Drilling/Servicing/Testing	260	260	260	7 400	160	1 700	730	0.01	-	-	-	-	-	-
ELECTRIC POWER GENERATION (UTILITIES)	**16 000**	**7 000**	**3 300**	**250 000**	**150 000**	**1 200**	**42 000**	**240**	**1 700**	**120**	**600**	**2.2**	**6.5**	**470**
Coal	14 000	5 700	2 200	240 000	110 000	380	19 000	170	1 100	78	580	1.6	-	360
Diesel	250	230	200	74	9 800	54	1 400	-	-	-	-	-	-	-
Natural Gas	500	430	340	1 100	16 000	500	14 000	7.0	91	27	0.01	0.03	0.04	84
Waste Materials	40	33	33	23	390	-	350	12	4.7	1.6	1.7	0.01	-	2.7
Other (Electric Power Generation)	1 100	590	530	8 300	10 000	290	7 800	45	540	15	17	0.60	-	16
MANUFACTURING	**100 000**	**40 000**	**16 000**	**42 000**	**69 000**	**97 000**	**140 000**	**11 000**	**3 700**	**560**	**110**	**3.2**	**110**	**350**
Abrasives Manufacturing	39	28	15	-	-	17	-	-	-	-	-	0.01	-	-
Bakeries	14	10	6.7	0.01	0.95	4 800	0.32	-	-	-	-	-	-	-
Biofuel Production	13	7.9	3.4	-	18	46	-	-	-	-	-	-	-	-
Chemicals Industry	2 800	1 900	1 200	17 000	23 000	9 200	16 000	8 500	45	7.8	17	0.33	25	-
Chemical Manufacturing	1 600	1 100	840	15 000	8 700	3 100	7 900	65	33	0.00	15	0.33	24	-
Fertilizer Production	890	580	190	1 700	9 200	570	5 600	8 500	1.9	4.2	1.0	-	-	-
Paint and Varnish Manufacturing	6.8	5.9	4.0	-	3.4	370	2.8	2.4	1.3	-	-	-	-	-
Petrochemical Industry	140	120	81	140	4 300	1 400	1 700	0.01	8.8	3.6	0.45	-	0.43	-
Plastics and Synthetic Resins Fabrication	120	78	59	3.6	300	3 000	320	19	-	-	0.02	-	-	-
Cleaning Compound Manufacturing	33	24	18	0.00	64	180	200	-	0.01	-	-	-	-	-
Other (Chemical Industry)	16	8.3	6.5	0.13	120	460	34	-	-	-	-	-	-	-
Electronics	1.1	1.0	0.87	-	-	33	-	16	22	-	23	-	-	-
Food Preparation	3 100	1 800	720	370	1 900	14 000	1 300	250	-	-	-	-	-	-
Glass Manufacturing	160	140	130	590	780	200	300	-	-	-	-	-	-	-
Grain Industry	67 000	18 000	2 900	490	1 100	2 200	420	5.5	-	-	-	-	-	-
Grain Processing	66 000	18 000	2 900	490	1 100	2 200	420	5.2	-	-	-	-	-	-
Warehousing and Storage	730	340	60	-	-	-	-	0.29	-	-	-	-	-	-
Metal Fabrication	730	500	430	10	280	4 200	1 200	27	1 800	290	-	0.92	-	240
Plastics Manufacturing	71	58	56	0.01	13	10 000	11	-	1.3	-	-	-	-	-
Pulp and Paper Industry	16 000	11 000	7 200	22 000	30 000	13 000	78 000	1 700	1 300	200	58	1.3	78	110
Pulp and Paper Product Manufacturing	16 000	11 000	7 200	22 000	30 000	13 000	78 000	1 700	1 300	200	58	1.3	78	110
Converted Paper Product Manufacturing	49	38	30	-	-	660	74	-	0.61	-	-	-	-	-
Textiles	1.7	1.7	1.2	19	7.8	79	0.07	-	-	-	-	-	-	-
Vehicle Manufacturing (Engines, Parts, Assembly, Painting)	330	250	170	0.02	600	8 300	920	6.5	69	0.00	-	-	0.02	-
Wood Products	12 000	6 200	3 200	580	11 000	27 000	39 000	710	390	56	13	0.59	6.0	-
Panel Board Mills	5 600	2 900	1 800	330	5 400	13 000	18 000	260	260	34	4.4	0.22	2.2	-
Sawmills	6 800	3 300	1 500	250	5 300	14 000	21 000	450	130	23	8.6	0.37	3.8	-
Other (Wood Products)	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Other (Manufacturing)	350	260	190	1 100	1 200	3 300	670	18	9.0	0.13	0.00	-	-	-
TRANSPORTATION AND MOBILE EQUIPMENT	**47 000**	**47 000**	**35 000**	**17 000**	**920 000**	**290 000**	**3 100 000**	**7 800**	**33 000**	**85**	**53**	**21**	**8 100**	**-**
Air Transportation	990	990	910	6 600	81 000	6 100	50 000	40	32 000	-	-	-	10	-
Heavy-Duty Diesel Vehicles	9 200	9 200	8 400	150	230 000	16 000	62 000	710	-	-	0.00	0.00	600	-
Heavy-Duty Gasoline Vehicles	1 100	1 100	970	190	37 000	12 000	400 000	320	-	-	0.00	0.00	1 900	-
Heavy-Duty LPG/NG Vehicles	3.7	3.7	3.3	0.65	140	67	1 500	1.9	-	-	0.00	0.00	6.7	-
Light-Duty Diesel Trucks	20	20	18	3.7	1 700	1 600	19 000	17	-	-	0.00	0.00	2.2	-
Light-Duty Diesel Vehicles	13	13	12	3.0	830	720	8 200	16	-	-	0.00	0.00	2.1	-
Light-Duty Gasoline Trucks	1 500	1 500	1 300	740	73 000	58 000	730 000	3 100	-	-	0.01	0.00	3 000	-
Light-Duty Gasoline Vehicles	1 200	1 200	1 100	520	44 000	47 000	490 000	2 900	-	-	0.01	0.00	2 400	-
Light-Duty LPG/NG Trucks	0.60	0.60	0.53	0.19	34	30	310	1.1	-	-	0.00	0.00	1.1	-
Light-Duty LPG/NG Vehicles	0.03	0.03	0.03	0.01	1.2	1.3	12	0.06	-	-	0.00	0.00	0.06	-
Marine Transportation	4 600	4 400	4 000	8 200	190 000	8 600	19 000	280	590	32	0.49	20	120	-
Motorcycles	24	24	21	4.5	680	2 000	14 000	40	-	-	0.00	0.00	40	-
Off-road Diesel Vehicles and Equipment	11 000	11 000	11 000	140	140 000	15 000	72 000	190	-	-	-	-	-	-
Off-road Gasoline/LPG/NG Vehicles and Equipment	4 100	4 000	3 700	82	30 000	120 000	1 200 000	90	-	-	-	-	-	-
Rail Transportation	1 900	1 900	1 800	45	91 000	4 200	16 000	49	160	53	53	1.2	32	-
Tire Wear and Brake Lining	12 000	12 000	1 500	-	-	-	-	-	-	-	-	-	-	-
AGRICULTURE	**3 800 000**	**1 600 000**	**380 000**	**6 500**	**4 100**	**120 000**	**1 300**	**450 000**	**66**	**91**	**10**	**0.55**	**0.34**	**1.0**
Animal Production	37 000	10 000	2 100	-	-	120 000	-	290 000	-	-	-	-	-	-
Crop Production	3 800 000	1 600 000	380 000	-	-	-	-	160 000	-	-	-	-	-	-
Fertilizer Application	13 000	6 200	1 800	-	-	-	-	160 000	-	-	-	-	-	-
Harvesting	260 000	120 000	23 000	-	-	-	-	-	-	-	-	-	-	-
Tillage Practices	1 100 000	220 000	110 000	-	-	-	-	-	-	-	-	-	-	-
Wind Erosion	2 500 000	1 200 000	250 000	-	-	-	-	-	-	-	-	-	-	-
Fuel Use	1 100	630	380	6 500	4 100	190	1 300	43	66	91	10	0.55	0.34	1.0

Table 2–2 **2017 Total Air Pollutant Emissions for Canada by Source, Sector and Subsector** (cont'd)

Source	TPM (t)	PM_{10} (t)	$PM_{2.5}$ (t)	SO_x (t)	NO_x (t)	VOC (t)	CO (t)	NH_3 (t)	Pb (kg)	Cd (kg)	Hg (kg)	D/F (gTEQ)	PAH (kg)	HCB (g)
COMMERCIAL / RESIDENTIAL / INSTITUTIONAL	**190 000**	**180 000**	**180 000**	**7 200**	**79 000**	**290 000**	**1 200 000**	**3 000**	**3 200**	**1 100**	**470**	**7.7**	**100 000**	**0.28**
Cigarette Smoking	380	380	380	-	-	6.3	1 800	71	1.1	2.8	0.10	0.01	-	-
Commercial and Institutional Fuel Combustion	2 600	2 500	2 400	1 600	27 000	1 300	19 000	200	250	500	57	0.25	2.3	-
Commercial Cooking	16 000	16 000	15 000	-	-	2 200	6 400	-	-	-	-	-	-	-
Construction Fuel Combustion	170	150	140	410	2 700	46	460	45	6.6	9.0	2.2	0.03	0.22	-
Home Firewood Burning	170 000	160 000	160 000	2 800	20 000	230 000	1 200 000	1 800	2 600	150	40	7.0	100 000	-
Human	-	-	-	-	-	-	-	640	-	-	0.12	-	-	-
Marine Cargo Handling	550	270	87	120	28	-	-	-	51	2.3	-	-	-	-
Residential Fuel Combustion	2 500	2 300	2 200	2 300	30 000	1 600	12 000	310	240	450	72	0.38	2.9	0.28
Service Stations	-	-	-	-	-	51 000	-	-	-	-	-	-	-	-
Other (Commercial / Residential / Institutional)	-	-	-	-	-	-	-	-	-	-	290	-	-	-
INCINERATION AND WASTE	**6 400**	**3 800**	**2 800**	**2 900**	**5 400**	**11 000**	**18 000**	**4 000**	**400**	**35**	**440**	**24**	**710**	**4 900**
Crematoriums	7.2	7.2	7.2	14	23	2.4	19	-	5.6	0.94	280	3.2	0.01	28
Waste Incineration	2 400	2 300	2 300	2 200	2 500	5 000	15 000	200	380	30	59	21	710	4 900
Industrial and Commercial Incineration	110	17	8.3	1 800	730	600	3 100	94	240	4.7	3.7	0.00	-	-
Municipal Incineration	60	44	27	250	890	230	250	20	140	25	55	0.78	-	91
Residential Waste Burning	2 200	2 200	2 200	140	840	4 200	12 000	90	-	-	-	20	710	4 800
Other (Waste Incineration)	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Waste Treatment and Disposal	4 000	1 500	470	710	2 900	5 900	2 600	3 800	16	3.6	100	0.00	0.00	0.09
Landfills	3 800	1 400	380	16	670	4 700	2 100	-	-	-	73	-	-	-
Municipal Wastewater Treatment and Discharge	68	53	53	200	2 000	780	420	3 800	0.54	0.24	14	-	0.00	-
Specialized Waste Treatment and Remediation	60	44	26	490	220	320	71	16	15	3.4	17	0.00	-	0.09
Biological Treatment of Waste	25	12	7.6	0.73	3.6	24	0.45	-	-	-	-	-	-	-
Waste Sorting and Transfer	0.70	0.54	0.54	-	-	-	-	-	-	-	-	-	-	-
PAINTS AND SOLVENTS	**0.88**	**28**	**22**	**0.00**	**17**	**330 000**	**0.35**	**-**	**-**	**0.14**	**-**	**-**	**-**	**-**
Dry Cleaning	-	14	13	-	-	200	-	-	-	-	-	-	-	-
General Solvent Use	-	-	-	-	-	260 000	-	-	-	-	-	-	-	-
Printing	0.03	7.9	7.4	0.00	17	15 000	0.35	-	-	-	-	-	-	-
Surface Coatings	0.85	5.5	1.5	-	-	63 000	-	-	-	0.14	-	-	-	-
DUST	**19 000 000**	**5 500 000**	**1 000 000**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
Coal Transportation	1 200	580	230	-	-	-	-	-	-	-	-	-	-	-
Construction Operations	8 400 000	2 500 000	510 000	-	-	-	-	-	-	-	-	-	-	-
Mine Tailings	33 000	2 600	660	-	-	-	-	-	-	-	-	-	-	-
Paved Roads	3 000 000	580 000	140 000	-	-	-	-	-	-	-	-	-	-	-
Unpaved Roads	7 600 000	2 400 000	350 000	-	-	-	-	-	-	-	-	-	-	-
FIRES	**7 800**	**6 700**	**4 800**	**20**	**990**	**2 900**	**52 000**	**93**	**-**	**-**	**-**	**1.1**	**1 400**	**-**
Prescribed Burning	7 600	6 500	4 600	20	970	2 700	51 000	81	-	-	-	1.1	1 400	-
Structural Fires	210	210	190	-	27	210	1 100	12	-	-	-	-	-	-
GRAND TOTAL	**24 000 000**	**7 500 000**	**1 700 000**	**950 000**	**1 800 000**	**1 800 000**	**5 700 000**	**480 000**	**180 000**	**6 800**	**3 000**	**66**	**110 000**	**8 100**

Note:
Totals may not add up due to rounding.
PAH includes B(a)p, B(b)f, B(k)f, I(1,2,3-cd)p.
- Indicates no emissions
0.00 Indicates emissions truncated due to rounding

2.1. Particulate Matter Less than or Equal to 2.5 Microns in Diameter ($PM_{2.5}$)

In 2017, approximately 1.7 million tonnes (Mt) of $PM_{2.5}$ were emitted in Canada (Table 2–3). Dust sources accounted for 60% (1.0 Mt) of total $PM_{2.5}$ emissions, with the most important dust sources being construction operations at 51% (507 kt) of dust emissions and dust from unpaved and paved roads at 49% (494 kt) of dust emissions. Agriculture was the second largest contributor and accounted for 23% (380 kt) of $PM_{2.5}$ emissions, most of which are attributed to crop production (23% or 378 kt). In these sectors, PM is largely emitted by non-combustion sources.

Commercial/residential/institutional sources accounted for 11% (183 kt) of total $PM_{2.5}$ emissions in 2017, with the most important contributor being home firewood burning at 10% (162 kt) of total $PM_{2.5}$ emissions. All other commercial/residential/institutional sources accounted for less than 1% of total $PM_{2.5}$ emissions.

Overall, emissions of $PM_{2.5}$ decreased from 1990 to 2009, increased to 2012 and have remained relatively stable since. (Figure 2–1). The downward trend was influenced predominantly by decreasing emissions from crop production, home firewood burning and other sectors. Decreased emissions from crop production can be attributed to the adoption of conservation tillage practices for the period of 1990 to 2011 and have since stabilised. Decreased emissions from home firewood burning are due to the use of new fireplace inserts, furnaces and stoves with improved emission controls and combustion efficiencies. Emissions from construction operations decreased until 2002; increased until 2012; and have since stabilized. Emissions of $PM_{2.5}$ from paved and unpaved roads followed a more gradual, consistent increasing trend from 1990 to 2002 and remained stable between 2002 and 2017. The trend in $PM_{2.5}$ emissions from roads is driven predominantly by the use of unpaved roads in Alberta, Ontario and Quebec.

The most significant changes in $PM_{2.5}$ emissions from 1990 to 2017 include:

- Dust: increase of 57% (364 kt), of which:
  - Construction operations: increase of 112% (268 kt)
  - Paved and unpaved roads: increase of 24% (97 kt total)
- Agriculture: decrease of 44% (298 kt), of which:
  - Crop production: decrease of 44% (298 kt)
- Commercial/residential/institutional: decrease of 35% (99 kt), of which:
  - Home firewood burning: decrease of 38% (100 kt)

Figure 2–1 **Major Contributors to National $PM_{2.5}$ Trends**

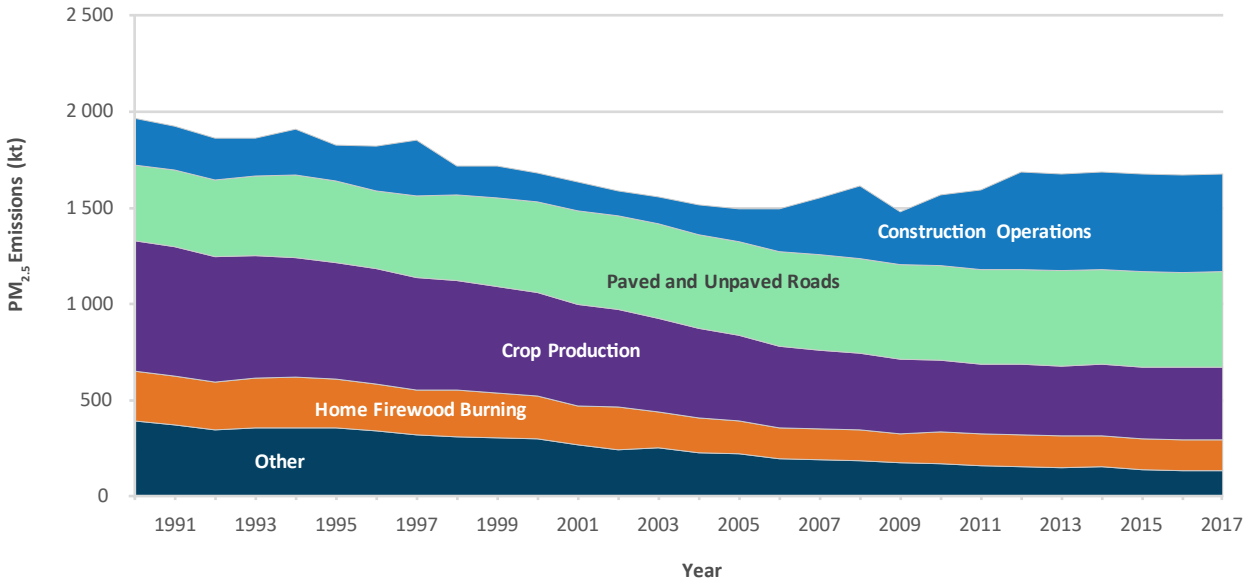

Table 2–3 National Summary of Annual $PM_{2.5}$ Emissions

Source	1990	2000	2005	2012	2013	2014	2015	2016	2017
	(tonnes)								
ORE AND MINERAL INDUSTRIES	**57 000**	**53 000**	**42 000**	**35 000**	**32 000**	**32 000**	**31 000**	**32 000**	**35 000**
Aluminium Industry	5 400	4 500	5 100	4 500	4 100	3 700	3 300	3 400	3 400
Asphalt Paving Industry	1 700	1 500	1 300	1 300	1 200	1 400	1 400	1 500	1 500
Cement and Concrete Industry	11 000	9 900	12 000	7 900	7 900	7 700	7 600	7 100	7 300
Foundries	6 100	5 100	5 200	5 200	5 200	5 200	5 200	5 200	5 200
Iron and Steel Industry	11 000	9 400	5 100	2 600	2 100	2 500	2 400	2 200	2 500
Iron Ore Industry	1 600	4 500	510	310	330	190	120	140	160
Mineral Products Industry	1 200	1 100	960	260	360	370	330	290	230
Mining and Rock Quarrying	10 000	11 000	7 300	11 000	9 300	9 000	8 500	10 000	13 000
Non-Ferrous Refining and Smelting Industry	8 800	6 000	4 700	2 000	1 800	2 000	2 200	1 800	1 300
OIL AND GAS INDUSTRY	**12 000**	**13 000**	**12 000**	**10 000**	**11 000**	**13 000**	**12 000**	**11 000**	**13 000**
Downstream Oil and Gas Industry	5 100	4 900	4 600	1 700	1 700	1 600	1 400	1 500	1 500
Upstream Oil and Gas Industry	7 200	8 400	7 900	8 300	9 400	11 000	11 000	9 700	11 000
ELECTRIC POWER GENERATION (UTILITIES)	**48 000**	**23 000**	**8 900**	**3 300**	**3 300**	**3 600**	**3 500**	**3 400**	**3 300**
Coal	46 000	20 000	5 000	2 300	2 200	2 500	2 400	2 200	2 200
Diesel	260	400	400	200	200	230	250	280	200
Natural Gas	1 200	1 900	1 700	460	490	420	420	380	340
Waste Materials	0.41	2.9	1.6	4.5	2.5	2.3	2.4	16	33
Other (Electric Power Generation)	1 300	740	1 800	320	320	460	460	550	530
MANUFACTURING	**110 000**	**77 000**	**45 000**	**20 000**	**20 000**	**19 000**	**18 000**	**17 000**	**16 000**
Abrasives Manufacturing	390	210	200	7.8	8.1	8.4	15	14	15
Bakeries	-	-	0.36	1.2	1.2	1.1	10	10	6.7
Biofuel Production	-	-	-	4.3	3.9	4.4	4.6	4.2	3.4
Chemicals Industry	4 800	4 500	4 200	1 600	1 700	1 400	1 300	1 300	1 200
Electronics	120	37	4.5	0.43	0.41	2.0	0.91	0.89	0.87
Food Preparation	1 400	2 100	1 700	810	890	800	810	810	720
Glass Manufacturing	920	1 300	1 200	140	140	150	150	160	130
Grain Industry	2 200	2 900	2 000	2 600	2 400	2 800	2 800	2 900	2 900
Metal Fabrication	800	1 300	1 100	900	820	430	430	440	430
Plastics Manufacturing	160	170	140	120	78	69	53	65	56
Pulp and Paper Industry	61 000	25 000	18 000	8 500	9 100	8 500	7 700	7 100	7 200
Textiles	13	22	18	2.7	2.8	2.5	1.2	1.3	1.2
Vehicle Manufacturing (Engines, Parts, Assembly, Painting)	1 700	1 600	620	220	190	170	180	180	170
Wood Products	35 000	30 000	13 000	4 400	4 300	4 000	4 300	3 500	3 200
Other (Manufacturing)	6 200	8 800	3 000	230	210	200	180	200	190
TRANSPORTATION AND MOBILE EQUIPMENT	**95 000**	**95 000**	**80 000**	**53 000**	**50 000**	**46 000**	**38 000**	**34 000**	**35 000**
Air Transportation	640	840	830	860	880	860	870	890	910
Heavy-Duty Diesel Vehicles	15 000	15 000	17 000	11 000	11 000	9 600	8 600	8 400	8 400
Heavy-Duty Gasoline Vehicles	3 500	2 300	2 100	1 200	1 200	960	920	980	970
Heavy-Duty LPG/NG Vehicles	600	680	160	5.0	2.7	1.4	1.2	1.8	3.3
Light-Duty Diesel Trucks	13	14	15	10	11	12	15	16	18
Light-Duty Diesel Vehicles	49	26	16	13	13	13	14	13	12
Light-Duty Gasoline Trucks	2 000	2 400	1 600	1 300	1 300	1 200	1 200	1 300	1 300
Light-Duty Gasoline Vehicles	5 000	3 600	2 200	1 400	1 300	1 200	1 100	1 100	1 100
Light-Duty LPG/NG Trucks	180	83	36	1.1	0.61	0.46	0.41	0.44	0.53
Light-Duty LPG/NG Vehicles	23	12	5.3	0.06	0.03	0.02	0.02	0.02	0.03
Marine Transportation	9 700	13 000	15 000	12 000	11 000	10 000	4 000	4 000	4 000
Motorcycles	22	21	23	21	20	20	20	21	21
Off-Road Diesel Vehicles and Equipment	41 000	42 000	29 000	17 000	16 000	14 000	13 000	10 000	11 000
Off-Road Gasoline/LPG/NG Vehicles and Equipment	13 000	10 000	6 800	4 400	4 100	4 200	4 200	3 700	3 700
Rail Transportation	3 600	3 400	3 300	2 800	2 500	2 300	2 000	1 800	1 800
Tire Wear and Brake Lining	730	1 100	1 200	1 400	1 500	1 500	1 500	1 500	1 500
AGRICULTURE	**680 000**	**540 000**	**450 000**	**370 000**	**370 000**	**370 000**	**370 000**	**380 000**	**380 000**
Animal Production	1 700	2 100	2 300	2 000	2 000	2 000	2 000	2 100	2 100
Crop Production	680 000	540 000	450 000	360 000	370 000	370 000	370 000	370 000	380 000
Fuel Use	120	140	130	420	420	440	390	390	380
COMMERCIAL / RESIDENTIAL / INSTITUTIONAL	**280 000**	**240 000**	**190 000**	**190 000**	**190 000**	**190 000**	**180 000**	**180 000**	**180 000**
Cigarette Smoking	810	690	530	480	410	410	370	370	380
Commercial and Institutional Fuel Combustion	2 000	2 600	2 600	2 200	2 300	2 400	2 300	2 300	2 400
Commercial Cooking	14 000	15 000	17 000	17 000	17 000	16 000	15 000	15 000	15 000
Construction Fuel Combustion	180	110	150	140	130	130	130	140	140
Home Firewood Burning	260 000	220 000	170 000	170 000	160 000	160 000	160 000	160 000	160 000
Human	-	-	-	-	-	-	-	-	-
Marine Cargo Handling	180	140	200	43	79	79	68	85	87
Residential Fuel Combustion	2 400	2 600	2 500	2 300	2 400	2 500	2 400	2 100	2 200
Service Stations	-	-	-	-	-	-	-	-	-
Other (Commercial / Residential / Institutional)	-	-	-	-	-	-	-	-	-
INCINERATION AND WASTE	**5 100**	**4 400**	**4 100**	**2 700**	**2 700**	**2 700**	**2 700**	**2 700**	**2 800**
Crematoriums	4.3	6.6	5.2	5.7	6.1	6.6	6.8	7.0	7.2
Waste Incineration	4 500	3 800	3 400	2 200	2 200	2 200	2 200	2 200	2 300
Waste Treatment and Disposal	600	630	720	460	460	470	480	460	470
PAINTS AND SOLVENTS	**3.7**	**7.1**	**25**	**19**	**15**	**11**	**15**	**16**	**22**
Dry Cleaning	0.32	0.32	0.62	9.4	9.1	4.9	6.1	4.5	13
General Solvent Use	-	-	-	-	-	-	-	-	-
Printing	3.0	6.4	23	8.7	5.5	5.5	8.3	9.8	7.4
Surface Coatings	0.37	0.37	0.94	0.83	0.78	0.63	1.00	1.5	1.5
DUST	**640 000**	**620 000**	**660 000**	**1 000 000**	**1 000 000**	**1 000 000**	**1 000 000**	**1 000 000**	**1 000 000**
Coal Transportation	310	270	230	280	300	280	230	260	230
Construction Operations	240 000	150 000	170 000	510 000	510 000	510 000	510 000	510 000	510 000
Mine Tailings	1 200	1 300	660	660	660	660	660	660	660
Paved Roads	110 000	140 000	140 000	140 000	140 000	140 000	140 000	140 000	140 000
Unpaved Roads	280 000	330 000	350 000	350 000	350 000	350 000	350 000	350 000	350 000
FIRES	**36 000**	**6 900**	**4 500**	**7 600**	**3 200**	**12 000**	**10 000**	**9 100**	**4 800**
Prescribed Burning	36 000	6 600	4 200	7 300	2 900	12 000	10 000	8 900	4 600
Structural Fires	350	280	250	280	260	200	190	190	190
GRAND TOTAL	**2 000 000**	**1 700 000**	**1 500 000**	**1 700 000**	**1 700 000**	**1 700 000**	**1 700 000**	**1 700 000**	**1 700 000**

Notes:
Totals may not add up due to rounding.
- Indicates no emission
0.00 Indicates emissions truncated due to rounding

2.2. **Sulphur Oxides (SO_x)**

In 2017, 954 kt of SO_x were emitted in Canada (Table 2–4). Ore and mineral industries were the largest contributor, accounting for 40% (377 kt) of national emissions. Approximately 71% (267 kt) of the emissions from this source were attributed to the non-ferrous refining and smelting industry. Electric power generation (utilities) was the second-largest source of SO_x, accounting for 26% (246 kt) of total SO_x emissions, almost entirely attributed to coal-fired electricity generation at 25% (236 kt). The oil and gas industry accounts for 27% (256 kt) of total SO_x emissions. The remaining 7% of SO_x emissions were distributed across multiple sources.

Overall, SO_x emissions decreased by 69% (2.1 Mt) between 1990 and 2017 (Figure 2–2). Reductions in emissions from the non-ferrous refining and smelting industry were the largest driver of this downward trend, particularly in the early 1990s, and again from 2008 to 2017. This decrease can be attributed to the preparation and implementation of pollution prevention plans by facilities, the installation of new technology or processes at facilities, and the closure of three major smelters in Manitoba, Ontario and Quebec (ECCC, 2017). Emissions from electric power generation decreased significantly from 2003 to 2017, due primarily to a reduction in coal-fired electricity generation across the country including a complete phase-out in Ontario. Upstream oil and gas industry experienced a gradual decline throughout the time series as a result of a decrease in emissions from oil sands mining, extraction and upgrading and natural gas processing, attributed to better emission control technologies.

The most significant decreases in SO_x emissions from 1990 to 2017 include:

- Ore and mineral industries: decrease of 75% (1.1 Mt), of which:
  - Non-ferrous refining and smelting industry: decrease of 79% (1.0 Mt)
- Electric power generation (utilities): decrease of 60% (373 kt), of which:
  - Coal (electric power generation): decrease of 54% (279 kt)
- Oil and gas industry: decrease of 52% (278 kt), of which:
  - Upstream oil and gas industry: decrease of 48% (195 kt)

Figure 2–2 **Major Contributors to National SO_x Trends**

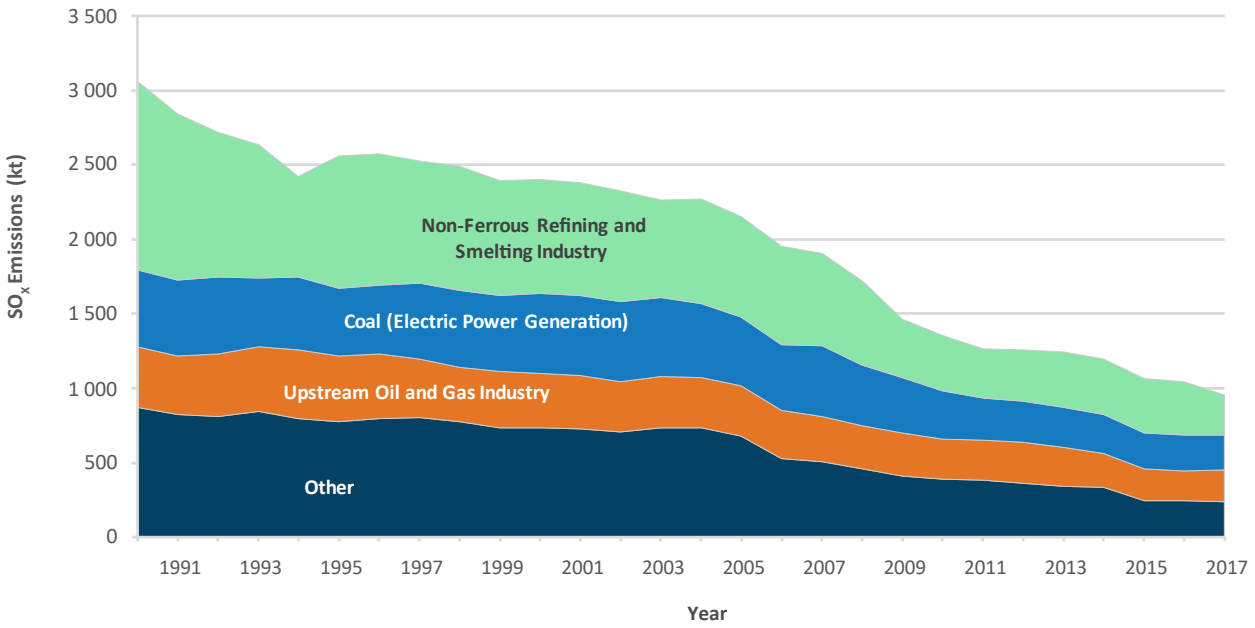

Table 2–4 National Summary of Annual SO_x Emissions

Source	1990	2000	2005	2012	2013	2014	2015	2016	2017
	(tonnes)								
ORE AND MINERAL INDUSTRIES	**1 500 000**	**920 000**	**840 000**	**470 000**	**480 000**	**480 000**	**470 000**	**470 000**	**380 000**
Aluminium Industry	31 000	48 000	63 000	62 000	60 000	55 000	57 000	64 000	66 000
Asphalt Paving Industry	740	650	720	620	580	650	660	720	740
Cement and Concrete Industry	48 000	45 000	54 000	25 000	23 000	20 000	23 000	24 000	23 000
Foundries	1 300	910	720	48	48	48	48	49	48
Iron and Steel Industry	36 000	29 000	30 000	30 000	24 000	24 000	22 000	17 000	18 000
Iron Ore Industry	59 000	17 000	1 200	400	460	420	220	630	160
Mineral Products Industry	1 300	820	1 800	1 500	1 800	1 600	1 400	1 500	850
Mining and Rock Quarrying	35 000	11 000	13 000	3 300	2 500	2 300	2 100	1 900	2 300
Non-Ferrous Refining and Smelting Industry	1 300 000	760 000	680 000	340 000	370 000	370 000	360 000	360 000	270 000
OIL AND GAS INDUSTRY	**530 000**	**500 000**	**450 000**	**330 000**	**310 000**	**280 000**	**260 000**	**250 000**	**260 000**
Downstream Oil and Gas Industry	130 000	140 000	110 000	54 000	55 000	52 000	44 000	50 000	47 000
Upstream Oil and Gas Industry	400 000	370 000	340 000	270 000	260 000	230 000	210 000	200 000	210 000
ELECTRIC POWER GENERATION (UTILITIES)	**620 000**	**620 000**	**520 000**	**280 000**	**280 000**	**270 000**	**250 000**	**250 000**	**250 000**
Coal	510 000	530 000	460 000	280 000	270 000	260 000	240 000	240 000	240 000
Diesel	410	420	300	14	15	39	160	73	74
Natural Gas	29 000	21 000	19 000	650	1 400	2 400	2 100	1 800	1 100
Waste Materials	0.76	21	25	46	37	24	11	29	23
Other (Electric Power Generation)	74 000	63 000	41 000	5 800	5 100	7 000	7 700	8 200	8 300
MANUFACTURING	**220 000**	**150 000**	**140 000**	**51 000**	**49 000**	**53 000**	**49 000**	**45 000**	**42 000**
Abrasives Manufacturing	4 000	860	860	-	-	-	-	-	-
Bakeries	-	-	0.15	0.01	0.01	0.01	0.01	0.01	0.01
Biofuel Production	-	-	-	-	-	-	-	-	-
Chemicals Industry	38 000	31 000	35 000	19 000	19 000	21 000	22 000	20 000	17 000
Electronics	1 700	3 000	3 000	-	-	-	-	0.04	-
Food Preparation	3 500	4 800	6 000	900	740	610	370	280	370
Glass Manufacturing	2 300	2 800	2 500	630	630	600	630	610	590
Grain Industry	230	210	390	660	630	470	510	530	490
Metal Fabrication	2 300	2 700	2 000	200	190	9.0	8.5	11	10
Plastics Manufacturing	470	26	3.3	0.01	0.01	0.01	-	-	0.01
Pulp and Paper Industry	140 000	78 000	66 000	26 000	26 000	29 000	24 000	21 000	22 000
Textiles	390	390	320	41	31	22	17	21	19
Vehicle Manufacturing (Engines, Parts, Assembly, Painting)	2 300	2 100	990	45	150	0.64	0.01	0.01	0.02
Wood Products	2 600	3 000	2 500	560	550	600	570	580	580
Other (Manufacturing)	29 000	25 000	25 000	2 000	1 400	1 400	1 200	1 400	1 100
TRANSPORTATION AND MOBILE EQUIPMENT	**150 000**	**170 000**	**150 000**	**110 000**	**100 000**	**96 000**	**18 000**	**17 000**	**17 000**
Air Transportation	5 300	6 700	7 500	5 900	6 200	6 000	6 200	6 400	6 600
Heavy-Duty Diesel Vehicles	15 000	6 700	6 100	160	170	160	160	150	150
Heavy-Duty Gasoline Vehicles	970	2 000	150	190	190	180	180	190	190
Heavy-Duty LPG/NG Vehicles	240	1 300	9.0	0.92	0.43	0.32	0.38	0.45	0.65
Light-Duty Diesel Trucks	170	78	52	1.6	1.8	2.2	2.8	3.2	3.7
Light-Duty Diesel Vehicles	570	130	110	3.0	3.2	3.2	3.3	3.1	3.0
Light-Duty Gasoline Trucks	3 200	6 400	510	640	670	670	700	740	740
Light-Duty Gasoline Vehicles	7 300	8 400	560	550	560	540	540	550	520
Light-Duty LPG/NG Trucks	190	180	10	0.38	0.20	0.16	0.14	0.16	0.19
Light-Duty LPG/NG Vehicles	23	28	1.4	0.02	0.01	0.01	0.01	0.01	0.01
Marine Transportation	80 000	110 000	130 000	98 000	93 000	88 000	9 600	8 900	8 200
Motorcycles	15	25	2.8	4.0	4.0	4.0	4.2	4.4	4.5
Off-Road Diesel Vehicles and Equipment	28 000	17 000	6 700	150	150	150	150	130	140
Off-Road Gasoline/LPG/NG Vehicles and Equipment	1 400	1 500	83	72	74	78	80	80	82
Rail Transportation	5 700	5 400	5 000	180	50	51	48	45	45
Tire Wear and Brake Lining	-	-	-	-	-	-	-	-	-
AGRICULTURE	**2 200**	**1 500**	**2 900**	**8 100**	**8 500**	**9 300**	**6 900**	**6 400**	**6 500**
Animal Production	-	-	-	-	-	-	-	-	-
Crop Production	-	-	-	-	-	-	-	-	-
Fuel Use	2 200	1 500	2 900	8 100	8 500	9 300	6 900	6 400	6 500
COMMERCIAL / RESIDENTIAL / INSTITUTIONAL	**52 000**	**36 000**	**37 000**	**14 000**	**9 900**	**10 000**	**8 900**	**7 300**	**7 200**
Cigarette Smoking	-	-	-	-	-	-	-	-	-
Commercial and Institutional Fuel Combustion	19 000	19 000	21 000	6 000	3 000	3 300	2 400	1 500	1 600
Commercial Cooking	-	-	-	-	-	-	-	-	-
Construction Fuel Combustion	1 900	620	1 400	650	530	520	620	420	410
Home Firewood Burning	3 600	3 300	2 700	2 900	2 800	2 800	2 800	2 800	2 800
Human	-	-	-	-	-	-	-	-	-
Marine Cargo Handling	0.01	0.00	-	-	140	140	88	91	120
Residential Fuel Combustion	28 000	14 000	11 000	4 300	3 400	3 200	3 000	2 500	2 300
Service Stations	-	-	-	-	-	-	-	-	-
Other (Commercial / Residential / Institutional)	-	-	-	-	-	-	-	-	-
INCINERATION AND WASTE	**2 300**	**3 000**	**3 200**	**2 400**	**2 500**	**2 700**	**3 000**	**2 800**	**2 900**
Crematoriums	5.5	7.1	9.1	11	12	13	13	13	14
Waste Incineration	1 900	2 600	2 700	2 100	2 100	2 100	2 200	2 100	2 200
Waste Treatment and Disposal	440	400	420	200	350	520	800	710	710
PAINTS AND SOLVENTS	**2.1**	**1.5**	**0.63**	**-**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
Dry Cleaning	0.01	0.01	-	-	-	-	-	-	-
General Solvent Use	-	-	-	-	-	-	-	-	-
Printing	2.0	1.5	0.63	-	0.00	0.00	0.00	0.00	0.00
Surface Coatings	0.01	0.01	-	-	-	-	-	-	-
DUST	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
Coal Transportation	-	-	-	-	-	-	-	-	-
Construction Operations	-	-	-	-	-	-	-	-	-
Mine Tailings	-	-	-	-	-	-	-	-	-
Paved Roads	-	-	-	-	-	-	-	-	-
Unpaved Roads	-	-	-	-	-	-	-	-	-
FIRES	**180**	**28**	**18**	**34**	**13**	**53**	**41**	**34**	**20**
Prescribed Burning	180	28	18	34	13	53	41	34	20
Structural Fires	-	-	-	-	-	-	-	-	-
GRAND TOTAL	**3 100 000**	**2 400 000**	**2 200 000**	**1 300 000**	**1 200 000**	**1 200 000**	**1 100 000**	**1 000 000**	**950 000**

Notes:
Totals may not add up due to rounding.
- Indicates no emissions
0.00 Indicates emissions truncated due to rounding

2.3. Nitrogen Oxides (NO_x)

Approximately 1.8 Mt of NO_x were released in Canada in 2017 (Table 2–5). Transportation and mobile equipment was the largest contributor, accounting for 52% (0.9 Mt) of total NO_x emissions. Within this source category, heavy-duty diesel vehicles, marine transportation, and off-road diesel vehicles and equipment were the largest emitters, collectively contributing 32% (562 kt) of total NO_x emissions. The oil and gas industry accounted for 27% (481 kt) of total NO_x emissions in 2017, with the upstream oil and gas industry accounting for nearly all of the national total (464 kt). Electric power generation (utilities) contributed 8% (146 kt) of total NO_x emissions, with coal-fired generation contributing 6% (110 kt) of the national total. The remaining 13% of NO_x emissions were distributed across multiple sources.

From 1990 to 2017, national NO_x emissions decreased by 26% (631 kt) (Figure 2–3). A significant driver of this trend was the consistent reduction in emissions from light-duty gasoline trucks and vehicles across the entire time series, as a result of increasingly stringent vehicle regulations. Emissions from off-road diesel vehicles and equipment and heavy-duty diesel vehicles increased at the beginning of the time series and decreased after 2000 and 2005, respectively. Within electric power generation (utilities), coal contributed to the downward trend across the time series, with a gradual decrease in emissions from 1998 to 2017. Finally, the upstream oil and gas industry and marine transportation are the only major contributors to NO_x emissions that experienced an increase in emissions across the time series. This increase is attributed to expansion and growth in the oil and gas industry and in marine transportation, respectively.

The most significant changes in NO_x emissions from 1990 to 2017 include:

- Transportation and mobile equipment: decrease of 35% (494 kt), of which:
  - Off-road diesel vehicles and equipment: decrease of 59% (197 kt)
  - Light-duty gasoline trucks and vehicles: decrease of 51% (176 kt)
  - Marine transportation: increase of 38% (53 kt)
  - Heavy-duty diesel vehicles: decrease of 20% (60 kt)
- Electric power generation (utilities): decrease of 43% (111 kt), of which:
  - Coal: decrease of 46% (96 kt)
- Oil and gas industry: increase of 39% (135 kt), of which:
  - Upstream oil and gas industry: increase of 49% (153 kt)
  - Downstream oil and gas industry: decrease of 51% (18 kt)

Figure 2–3 **Major Contributors to National NO_X Trends**

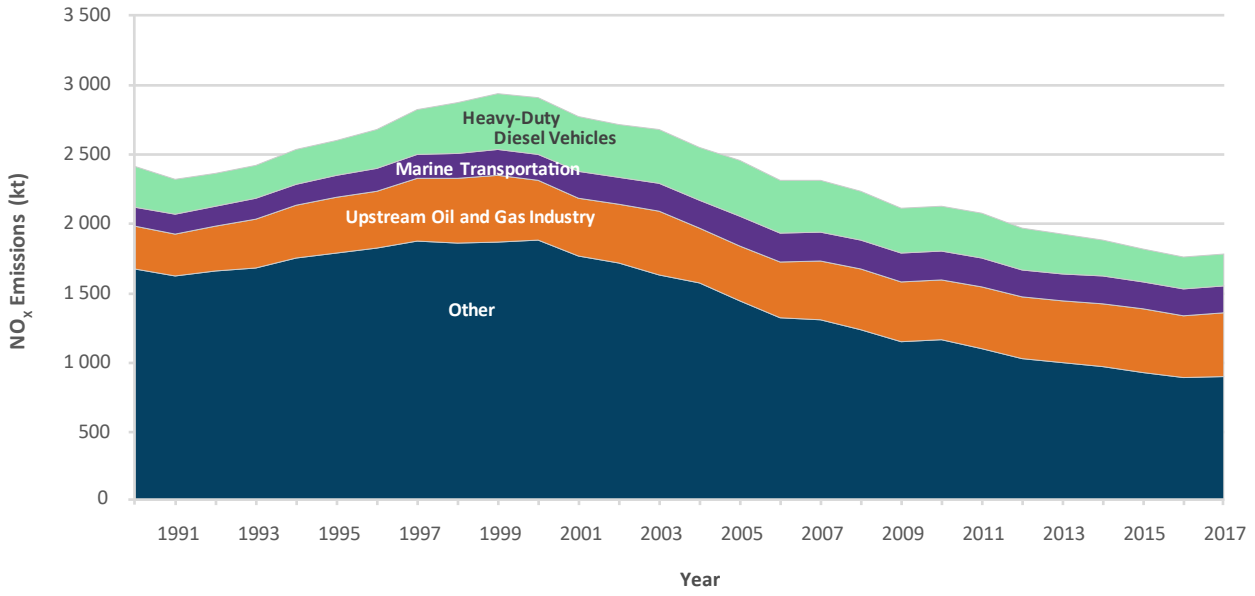

Table 2–5 National Summary of Annual NO_X Emissions

Source	1990	2000	2005	2012	2013	2014	2015	2016	2017
	(tonnes)								
ORE AND MINERAL INDUSTRIES	**110 000**	**99 000**	**98 000**	**77 000**	**71 000**	**72 000**	**71 000**	**68 000**	**76 000**
Aluminium Industry	1 600	1 300	2 000	1 400	1 300	1 100	1 100	1 200	1 200
Asphalt Paving Industry	1 200	1 100	1 200	1 100	1 000	1 200	1 200	1 100	1 100
Cement and Concrete Industry	43 000	45 000	54 000	36 000	32 000	31 000	35 000	32 000	34 000
Foundries	490	640	540	140	140	140	140	140	140
Iron and Steel Industry	19 000	16 000	13 000	12 000	11 000	12 000	11 000	11 000	11 000
Iron Ore Industry	10 000	10 000	380	760	1 500	1 600	1 200	1 300	1 700
Mineral Products Industry	1 300	560	1 100	260	300	310	290	300	290
Mining and Rock Quarrying	25 000	21 000	24 000	25 000	22 000	23 000	20 000	19 000	25 000
Non-Ferrous Refining and Smelting Industry	4 300	3 800	1 800	1 500	1 600	1 600	1 600	1 900	1 800
OIL AND GAS INDUSTRY	**350 000**	**460 000**	**430 000**	**460 000**	**460 000**	**480 000**	**480 000**	**470 000**	**480 000**
Downstream Oil and Gas Industry	35 000	30 000	31 000	19 000	18 000	17 000	17 000	17 000	17 000
Upstream Oil and Gas Industry	310 000	430 000	400 000	440 000	450 000	460 000	460 000	450 000	460 000
ELECTRIC POWER GENERATION (UTILITIES)	**260 000**	**330 000**	**250 000**	**170 000**	**160 000**	**170 000**	**150 000**	**150 000**	**150 000**
Coal	210 000	230 000	190 000	130 000	120 000	130 000	110 000	120 000	110 000
Diesel	3 000	8 200	8 300	9 300	9 500	10 000	11 000	10 000	9 800
Natural Gas	20 000	65 000	38 000	22 000	21 000	19 000	17 000	17 000	16 000
Waste Materials	45	520	240	300	190	170	210	360	390
Other (Electric Power Generation)	28 000	28 000	21 000	10 000	8 300	10 000	11 000	10 000	10 000
MANUFACTURING	**190 000**	**170 000**	**140 000**	**69 000**	**70 000**	**69 000**	**69 000**	**68 000**	**69 000**
Abrasives Manufacturing	240	90	74	-	-	-	-	-	-
Bakeries	4.0	4.0	-	0.86	1.1	1.0	0.89	0.89	0.95
Biofuel Production	-	-	-	18	18	17	18	16	18
Chemicals Industry	41 000	47 000	37 000	24 000	22 000	21 000	23 000	22 000	23 000
Electronics	150	160	71	-	-	-	-	0.01	-
Food Preparation	2 400	2 900	3 300	1 600	1 700	1 700	1 800	1 700	1 900
Glass Manufacturing	7 000	7 400	6 100	900	920	890	920	780	780
Grain Industry	1 400	1 300	1 600	1 000	950	1 000	780	760	1 100
Metal Fabrication	5 900	9 000	1 200	280	220	240	320	350	280
Plastics Manufacturing	880	810	100	41	0.95	0.91	9.0	11	13
Pulp and Paper Industry	72 000	49 000	45 000	29 000	31 000	30 000	30 000	29 000	30 000
Textiles	120	170	110	30	33	33	8.2	7.8	7.8
Vehicle Manufacturing (Engines, Parts, Assembly, Painting)	2 500	3 500	1 500	550	630	610	650	610	600
Wood Products	17 000	21 000	18 000	10 000	11 000	11 000	11 000	11 000	11 000
Other (Manufacturing)	33 000	30 000	22 000	1 300	1 200	1 200	1 100	1 200	1 200
TRANSPORTATION AND MOBILE EQUIPMENT	**1 400 000**	**1 800 000**	**1 400 000**	**1 100 000**	**1 100 000**	**1 000 000**	**960 000**	**910 000**	**920 000**
Air Transportation	52 000	64 000	68 000	69 000	73 000	72 000	75 000	78 000	81 000
Heavy-Duty Diesel Vehicles	290 000	410 000	410 000	300 000	290 000	260 000	240 000	230 000	230 000
Heavy-Duty Gasoline Vehicles	60 000	82 000	60 000	44 000	44 000	37 000	35 000	37 000	37 000
Heavy-Duty LPG/NG Vehicles	15 000	34 000	4 500	220	110	59	61	80	140
Light-Duty Diesel Trucks	790	1 500	2 100	1 200	1 200	1 300	1 400	1 600	1 700
Light-Duty Diesel Vehicles	2 200	2 200	1 200	980	990	940	920	860	830
Light-Duty Gasoline Trucks	97 000	190 000	130 000	82 000	77 000	70 000	68 000	72 000	73 000
Light-Duty Gasoline Vehicles	200 000	220 000	120 000	60 000	57 000	50 000	46 000	46 000	44 000
Light-Duty LPG/NG Trucks	7 500	5 900	2 900	84	43	31	27	29	34
Light-Duty LPG/NG Vehicles	820	740	280	2.6	1.1	0.81	0.73	0.89	1.2
Marine Transportation	140 000	190 000	210 000	200 000	200 000	200 000	200 000	190 000	190 000
Motorcycles	320	440	530	630	630	620	640	680	680
Off-Road Diesel Vehicles and Equipment	330 000	360 000	280 000	190 000	190 000	170 000	170 000	130 000	140 000
Off-Road Gasoline/LPG/NG Vehicles and Equipment	53 000	37 000	28 000	29 000	28 000	30 000	30 000	29 000	30 000
Rail Transportation	160 000	150 000	130 000	120 000	110 000	110 000	98 000	91 000	91 000
Tire Wear and Brake Lining	-	-	-	-	-	-	-	-	-
AGRICULTURE	**2 100**	**2 200**	**2 100**	**4 400**	**4 400**	**4 600**	**4 100**	**4 200**	**4 100**
Animal Production	-	-	-	-	-	-	-	-	-
Crop Production	-	-	-	-	-	-	-	-	-
Fuel Use	2 100	2 200	2 100	4 400	4 400	4 600	4 100	4 200	4 100
COMMERCIAL / RESIDENTIAL / INSTITUTIONAL	**87 000**	**90 000**	**86 000**	**80 000**	**80 000**	**83 000**	**80 000**	**77 000**	**79 000**
Cigarette Smoking	-	-	-	-	-	-	-	-	-
Commercial and Institutional Fuel Combustion	23 000	30 000	30 000	25 000	25 000	27 000	26 000	26 000	27 000
Commercial Cooking	-	-	-	-	-	-	-	-	-
Construction Fuel Combustion	3 900	2 000	2 700	2 900	2 600	2 500	2 500	2 600	2 700
Home Firewood Burning	25 000	23 000	19 000	20 000	20 000	20 000	20 000	20 000	20 000
Human	-	-	-	-	-	-	-	-	-
Marine Cargo Handling	0.20	0.06	-	-	29	31	26	24	28
Residential Fuel Combustion	35 000	35 000	35 000	32 000	33 000	34 000	32 000	29 000	30 000
Service Stations	-	-	-	-	-	-	-	-	-
Other (Commercial / Residential / Institutional)	-	-	-	-	-	-	-	-	-
INCINERATION AND WASTE	**7 900**	**8 000**	**9 300**	**4 400**	**4 800**	**4 500**	**4 400**	**4 400**	**5 400**
Crematoriums	8.3	12	15	18	19	21	21	22	23
Waste Incineration	2 500	2 800	3 700	2 900	2 900	2 600	2 400	2 500	2 500
Waste Treatment and Disposal	5 400	5 100	5 700	1 600	1 900	1 900	2 000	2 000	2 900
PAINTS AND SOLVENTS	**110**	**120**	**130**	**23**	**23**	**23**	**23**	**23**	**17**
Dry Cleaning	1.1	1.6	-	-	-	-	-	-	-
General Solvent Use	-	-	-	-	-	-	-	-	-
Printing	110	120	130	23	23	23	23	23	17
Surface Coatings	0.12	0.12	-	-	-	-	-	-	-
DUST	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
Coal Transportation	-	-	-	-	-	-	-	-	-
Construction Operations	-	-	-	-	-	-	-	-	-
Mine Tailings	-	-	-	-	-	-	-	-	-
Paved Roads	-	-	-	-	-	-	-	-	-
Unpaved Roads	-	-	-	-	-	-	-	-	-
FIRES	**7 500**	**1 400**	**890**	**1 500**	**650**	**2 600**	**2 000**	**1 700**	**990**
Prescribed Burning	7 400	1 400	850	1 500	610	2 600	2 000	1 600	970
Structural Fires	49	39	35	39	36	28	26	26	27
GRAND TOTAL	**2 400 000**	**2 900 000**	**2 500 000**	**2 000 000**	**1 900 000**	**1 900 000**	**1 800 000**	**1 800 000**	**1 800 000**

Notes:
Totals may not add up due to rounding.
- Indicates no emissions
0.00 Indicates emissions truncated due to rounding

2.4. Volatile Organic Compounds (VOCs)

In 2017, approximately 1.8 Mt of VOCs were released in Canada (Table 2–6). The oil and gas industry was the largest contributor at 37% (663 kt) of total emissions (with the upstream oil and gas industry emitting 35% (641 kt) of total VOCs). Paints and solvents were the next-largest contributor, accounting for 18% (335 kt) of emissions, with general solvent use accounting for 14% (256 kt) of the national total. Transportation and mobile equipment sources accounted for 16% (288 kt) of emissions, with off-road gasoline, liquefied petroleum gas (LPG) or natural gas (NG) vehicles and equipment contributing 6% (116 kt) of the national total.

Commercial/residential/institutional sources represented 16% (286 kt) of VOC emissions, attributed mainly to home firewood burning (13% or 230 kt). The other contributing VOC sources are manufacturing, agriculture, incineration and waste, ore and mineral industries, and fires. Of these, manufacturing sources represented 5% (97 kt) of emissions and agricultural sources accounted for 6% (115 kt) of total VOC emissions.

Between 1990 and 2017, VOC emissions decreased by 40% (1.2 Mt) (Figure 2–4). The most significant driver of this trend is a persistent decrease in emissions from off-road gasoline, LPG or NG vehicles and equipment throughout the time series, due to increasingly stringent regulations on spark-ignition engines. The consistent decrease in emissions from light-duty gasoline vehicles and trucks throughout the time series also contributed to this trend.

Although emissions from most sources decreased, the oil and gas industry experienced an overall increase in emissions between 1990 and 2017. VOC emissions from the downstream oil and gas industry declined overall from 1990 to 2006, with emissions remaining relatively stable after that time, but the upstream oil and gas industry experienced increased emissions, which were more pronounced from 2012 to 2014. In 2017, VOC emissions from the upstream oil and gas industry declined compared to 2015, due to a 5% decrease in conventional oil production (Statistics Canada, n.d.).

The most significant changes in VOC emissions from 1990 to 2017 include:

- Transportation and mobile equipment : decrease of 76% (920 kt), from which:
  - Off-road gasoline/LPG/NG vehicles and equipment: decrease of 85% (648 kt)
  - Light-duty gasoline vehicles and trucks: decrease of 58% (214 kt)
- Oil and gas industry : increase of 10% (63 kt), from which:
- Downstream oil and gas industry: decrease of 83% (107 kt)
- Upstream oil and gas industry: increase of 36% (170 kt)

Figure 2–4 **Major Contributors to National VOC Trends**

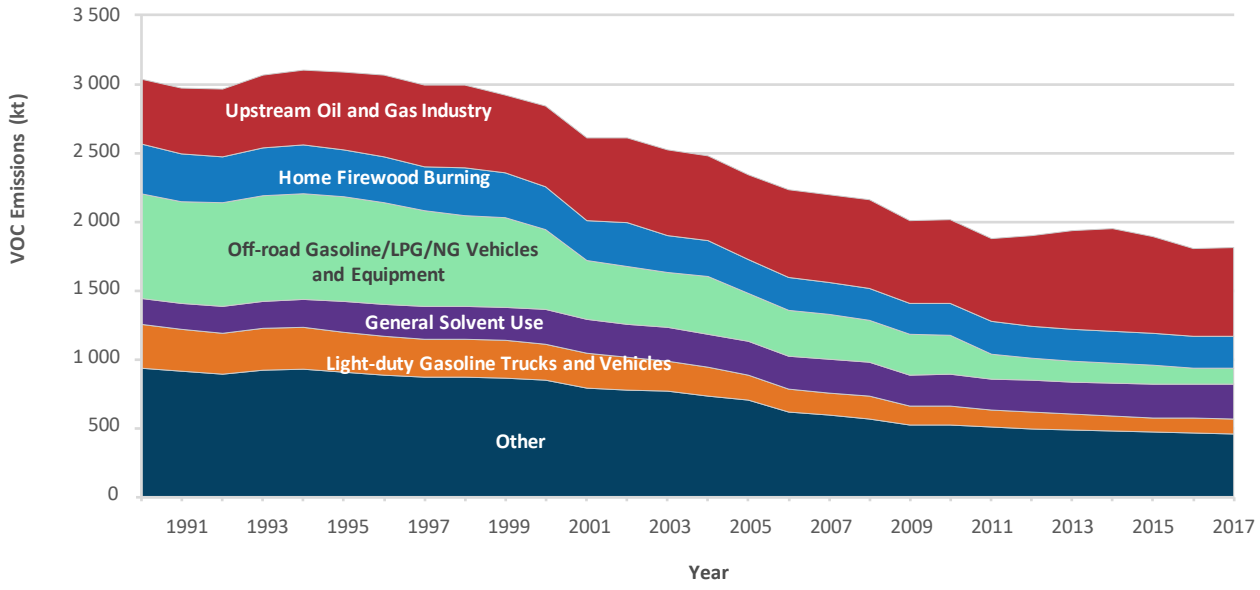

Table 2–6 National Summary of Annual VOC Emissions

Source	1990	2000	2005	2012	2013	2014	2015	2016	2017
	(tonnes)								
ORE AND MINERAL INDUSTRIES	**20 000**	**20 000**	**15 000**	**13 000**	**12 000**	**13 000**	**13 000**	**13 000**	**13 000**
Aluminium Industry	710	1 100	1 200	1 300	1 400	970	930	950	950
Asphalt Paving Industry	6 500	6 200	6 000	7 800	7 100	8 400	8 500	8 400	8 400
Cement and Concrete Industry	590	620	1 200	410	440	410	400	440	690
Foundries	1 700	1 100	920	580	520	450	380	360	310
Iron and Steel Industry	5 800	4 200	2 000	1 300	920	1 100	870	820	820
Iron Ore Industry	570	3 200	13	-	-	-	18	3.6	38
Mineral Products Industry	160	320	200	74	100	120	110	140	72
Mining and Rock Quarrying	4 100	3 200	3 300	1 900	1 800	1 600	1 900	1 400	1 300
Non-Ferrous Refining and Smelting Industry	340	36	51	65	69	66	67	65	69
OIL AND GAS INDUSTRY	**600 000**	**670 000**	**680 000**	**680 000**	**740 000**	**770 000**	**730 000**	**660 000**	**660 000**
Downstream Oil and Gas Industry	130 000	86 000	64 000	23 000	24 000	23 000	24 000	24 000	21 000
Upstream Oil and Gas Industry	470 000	580 000	610 000	660 000	710 000	740 000	700 000	640 000	640 000
ELECTRIC POWER GENERATION (UTILITIES)	**2 500**	**3 600**	**3 300**	**1 300**	**1 300**	**1 400**	**1 400**	**1 300**	**1 200**
Coal	1 300	950	1 300	380	390	450	410	410	380
Diesel	77	280	220	53	53	46	84	55	54
Natural Gas	480	1 600	1 500	570	600	610	630	630	500
Waste Materials	0.70	5.6	-	17	8.2	11	13	9.1	-
Other (Electric Power Generation)	630	770	350	250	290	270	220	200	290
MANUFACTURING	**250 000**	**250 000**	**180 000**	**120 000**	**110 000**	**110 000**	**100 000**	**100 000**	**97 000**
Abrasives Manufacturing	1 500	590	610	90	94	59	18	20	17
Bakeries	4 000	4 700	5 100	4 800	4 800	4 800	4 800	4 900	4 800
Biofuel Production	-	-	-	100	100	98	100	42	46
Chemicals Industry	47 000	36 000	25 000	11 000	14 000	13 000	11 000	9 800	9 200
Electronics	1 300	540	380	68	69	53	49	39	33
Food Preparation	10 000	13 000	15 000	16 000	15 000	15 000	15 000	15 000	14 000
Glass Manufacturing	2 000	2 300	620	260	280	240	200	190	200
Grain Industry	2 200	2 300	2 200	2 600	2 500	3 000	3 000	2 500	2 200
Metal Fabrication	9 100	14 000	11 000	5 000	4 800	4 100	4 400	3 700	4 200
Plastics Manufacturing	14 000	16 000	15 000	14 000	12 000	10 000	11 000	10 000	10 000
Pulp and Paper Industry	27 000	24 000	23 000	18 000	16 000	14 000	13 000	13 000	13 000
Textiles	860	1 500	850	530	490	570	620	580	79
Vehicle Manufacturing (Engines, Parts, Assembly, Painting)	22 000	23 000	16 000	8 400	8 300	8 200	8 400	9 300	8 300
Wood Products	100 000	91 000	56 000	31 000	32 000	32 000	29 000	29 000	27 000
Other (Manufacturing)	11 000	21 000	9 200	3 500	3 400	3 200	3 400	3 100	3 300
TRANSPORTATION AND MOBILE EQUIPMENT	**1 200 000**	**980 000**	**640 000**	**360 000**	**340 000**	**320 000**	**310 000**	**290 000**	**290 000**
Air Transportation	5 100	6 000	5 400	6 400	6 300	6 200	6 200	5 900	6 100
Heavy-Duty Diesel Vehicles	10 000	18 000	24 000	21 000	20 000	18 000	17 000	16 000	16 000
Heavy-Duty Gasoline Vehicles	24 000	28 000	22 000	15 000	15 000	12 000	12 000	12 000	12 000
Heavy-Duty LPG/NG Vehicles	7 100	12 000	2 300	100	53	26	26	36	67
Light-Duty Diesel Trucks	770	1 000	1 600	1 100	1 100	1 200	1 300	1 400	1 600
Light-Duty Diesel Vehicles	2 200	1 500	920	810	800	780	800	750	720
Light-Duty Gasoline Trucks	90 000	110 000	82 000	60 000	58 000	55 000	55 000	58 000	58 000
Light-Duty Gasoline Vehicles	230 000	150 000	95 000	57 000	54 000	50 000	49 000	49 000	47 000
Light-Duty LPG/NG Trucks	8 100	3 700	1 900	66	35	26	24	25	30
Light-Duty LPG/NG Vehicles	1 100	540	230	2.6	1.1	0.85	0.82	1.00	1.3
Marine Transportation	5 800	7 600	8 600	8 400	8 300	8 200	8 200	8 400	8 600
Motorcycles	1 600	1 700	1 800	1 900	1 900	1 800	1 900	2 000	2 000
Off-Road Diesel Vehicles and Equipment	53 000	53 000	37 000	21 000	20 000	19 000	18 000	15 000	15 000
Off-Road Gasoline/LPG/NG Vehicles and Equipment	760 000	580 000	350 000	160 000	150 000	140 000	140 000	110 000	120 000
Rail Transportation	6 700	6 200	6 100	5 900	5 400	5 100	4 500	4 100	4 200
Tire Wear and Brake Lining	-	-	-	-	-	-	-	-	-
AGRICULTURE	**100 000**	**120 000**	**130 000**	**110 000**	**120 000**	**120 000**	**110 000**	**110 000**	**120 000**
Animal Production	100 000	120 000	130 000	110 000	120 000	120 000	110 000	110 000	120 000
Crop Production	-	-	-	-	-	-	-	-	-
Fuel Use	81	91	82	200	200	200	190	200	190
COMMERCIAL / RESIDENTIAL / INSTITUTIONAL	**430 000**	**390 000**	**320 000**	**290 000**	**290 000**	**290 000**	**290 000**	**290 000**	**290 000**
Cigarette Smoking	13	12	8.8	8.0	6.8	6.9	6.1	6.2	6.3
Commercial and Institutional Fuel Combustion	1 000	1 400	1 400	1 200	1 300	1 300	1 300	1 300	1 300
Commercial Cooking	2 000	2 300	2 500	2 500	2 500	2 400	2 300	2 300	2 200
Construction Fuel Combustion	71	34	41	50	44	43	42	44	46
Home Firewood Burning	360 000	310 000	250 000	230 000	230 000	230 000	230 000	230 000	230 000
Human	-	-	-	-	-	-	-	-	-
Marine Cargo Handling	0.34	0.92	1.9	10	-	-	-	-	-
Residential Fuel Combustion	1 500	1 700	1 700	1 600	1 700	1 800	1 700	1 500	1 600
Service Stations	72 000	74 000	65 000	50 000	50 000	50 000	50 000	50 000	51 000
Other (Commercial / Residential / Institutional)	-	-	-	-	-	-	-	-	-
INCINERATION AND WASTE	**16 000**	**15 000**	**15 000**	**10 000**	**10 000**	**11 000**	**11 000**	**11 000**	**11 000**
Crematoriums	0.95	1.4	1.7	1.9	2.1	2.2	2.3	2.4	2.4
Waste Incineration	9 900	8 500	8 800	4 900	4 700	4 900	4 900	5 000	5 000
Waste Treatment and Disposal	6 500	6 500	6 000	5 300	5 700	5 900	5 800	5 900	5 900
PAINTS AND SOLVENTS	**360 000**	**400 000**	**370 000**	**310 000**	**310 000**	**320 000**	**330 000**	**330 000**	**330 000**
Dry Cleaning	740	790	200	190	200	200	180	190	200
General Solvent Use	190 000	260 000	250 000	230 000	240 000	240 000	250 000	250 000	260 000
Printing	37 000	48 000	42 000	19 000	17 000	17 000	16 000	15 000	15 000
Surface Coatings	130 000	89 000	77 000	60 000	59 000	61 000	61 000	60 000	63 000
DUST	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
Coal Transportation	-	-	-	-	-	-	-	-	-
Construction Operations	-	-	-	-	-	-	-	-	-
Mine Tailings	-	-	-	-	-	-	-	-	-
Paved Roads	-	-	-	-	-	-	-	-	-
Unpaved Roads	-	-	-	-	-	-	-	-	-
FIRES	**41 000**	**4 200**	**3 400**	**7 100**	**2 000**	**8 100**	**5 900**	**4 900**	**2 900**
Prescribed Burning	40 000	3 900	3 100	6 800	1 700	7 900	5 700	4 700	2 700
Structural Fires	390	310	280	310	290	220	200	210	210
GRAND TOTAL	**3 000 000**	**2 800 000**	**2 300 000**	**1 900 000**	**1 900 000**	**2 000 000**	**1 900 000**	**1 800 000**	**1 800 000**

Notes:
Totals may not add up due to rounding.
- Indicates no emission
0.00 Indicates emissions truncated due to rounding

2.5. **Carbon Monoxide (CO)**

In 2017, approximately 5.7 Mt of CO were released in Canada (Table 2–7). Transportation and mobile equipment accounted for 54% (3.1 Mt) of total emissions, with light-duty gasoline vehicles and trucks contributing 22% (1.2 Mt) and off-road gasoline/Liquid Petroleum Gas (LPG)/Natural Gas (NG) vehicles and equipment contributing 21% (1.2 Mt) of total CO emissions. The next-largest contributors are commercial/residential/institutional sources, which in 2017 also accounted for 22% (1.2 Mt) of emissions, mostly due to contributions from home firewood burning. The upstream oil and gas industry and aluminium industry were the largest-emitting industrial contributors, accounting for 9% (531 kt) and 8% (433 kt) of CO emissions, respectively.

Between 1990 and 2017, CO emissions decreased by 54% (6.7 Mt) (Figure 2–5). Of the many contributors to the overall decrease in emissions, two in particular—light-duty gasoline trucks and vehicles, and off-road gasoline/LPG/NG vehicles and equipment (spark ignition engines)—had the largest impact on emission reductions. The decreasing emission trend in these sectors is due to increasingly stringent engine and vehicle regulations. Emissions from home firewood burning gradually decreased across the time series, resulting from improved combustion efficiency in modern fireplace inserts, stoves and fireplaces and from a reduction in the use of wood as heating fuel. (ECCC, Residential Fuelwood Consumption in Canada, 2014)

The most significant changes in CO emissions from 1990 to 2017 include:

- Transportation and mobile equipment: decrease of 62% (5.1 Mt), of which:
  - Light-duty gasoline trucks and vehicles: decrease of 69% (3.3 Mt)
  - Off-road gasoline/LPG/NG vehicles and equipment: decrease of 51% (1.2 Mt)
- Commercial/residential/institutional: decrease of 28% (471 kt), of which:
  - Home firewood burning: decrease of 28% (473 kt)
- Oil and gas industry: increase of 64 % (216 kt), of which:
  - Upstream oil and gas industry: increase of 73% (224 kt)

Figure 2–5 **Major Contributors to National CO Trends**

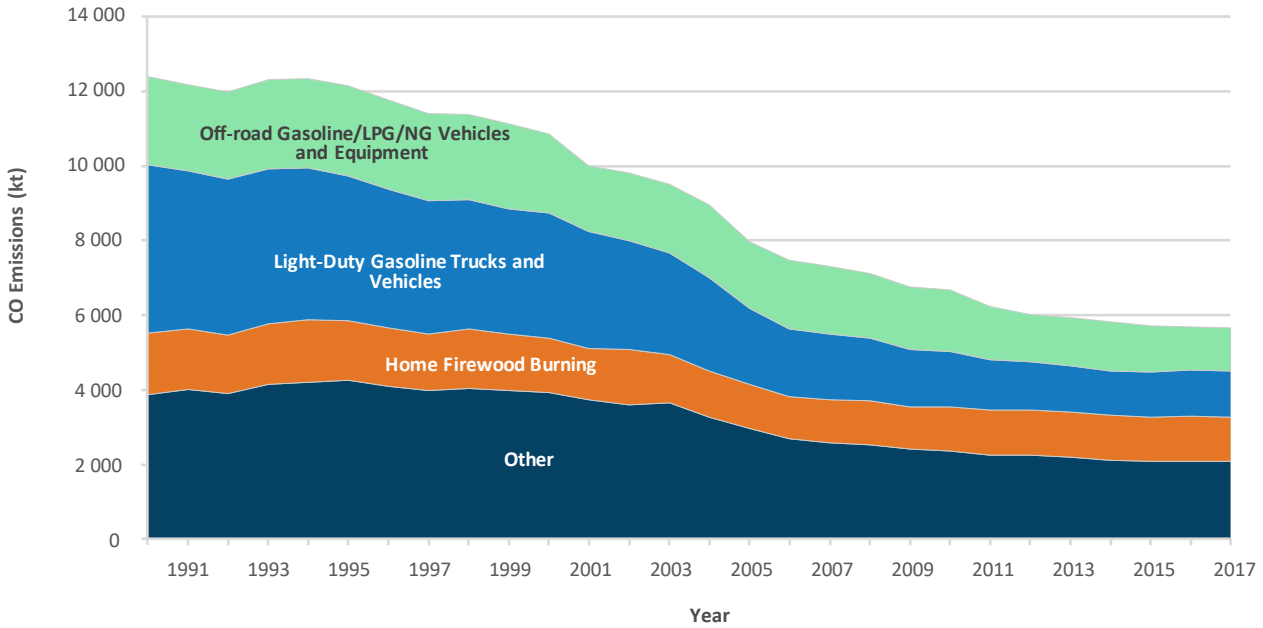

Table 2–7 National Summary of Annual CO Emissions

Source	1990	2000	2005	2012	2013	2014	2015	2016	2017
	(tonnes)								
ORE AND MINERAL INDUSTRIES	**390 000**	**400 000**	**480 000**	**530 000**	**530 000**	**500 000**	**500 000**	**550 000**	**580 000**
Aluminium Industry	240 000	250 000	310 000	400 000	410 000	380 000	380 000	420 000	430 000
Asphalt Paving Industry	4 200	4 200	4 500	3 800	3 700	4 000	4 000	3 900	3 900
Cement and Concrete Industry	16 000	23 000	27 000	17 000	14 000	12 000	10 000	13 000	16 000
Foundries	55 000	48 000	49 000	49 000	49 000	49 000	49 000	49 000	49 000
Iron and Steel Industry	43 000	48 000	64 000	28 000	23 000	24 000	21 000	21 000	27 000
Iron Ore Industry	18 000	9 600	33	2 500	3 400	3 300	2 400	2 200	2 400
Mineral Products Industry	3 900	3 400	3 200	600	670	580	640	660	610
Mining and Rock Quarrying	14 000	14 000	10 000	20 000	14 000	15 000	13 000	14 000	33 000
Non-Ferrous Refining and Smelting Industry	280	360	13 000	13 000	11 000	13 000	13 000	17 000	15 000
OIL AND GAS INDUSTRY	**340 000**	**440 000**	**490 000**	**530 000**	**560 000**	**550 000**	**560 000**	**540 000**	**550 000**
Downstream Oil and Gas Industry	29 000	23 000	21 000	16 000	42 000	16 000	22 000	16 000	21 000
Upstream Oil and Gas Industry	310 000	420 000	470 000	520 000	520 000	530 000	540 000	520 000	530 000
ELECTRIC POWER GENERATION (UTILITIES)	**50 000**	**43 000**	**52 000**	**35 000**	**35 000**	**40 000**	**40 000**	**37 000**	**42 000**
Coal	41 000	18 000	25 000	9 500	13 000	15 000	16 000	16 000	19 000
Diesel	360	1 200	1 200	1 200	1 200	1 400	1 600	1 400	1 400
Natural Gas	4 400	17 000	17 000	18 000	16 000	15 000	14 000	12 000	14 000
Waste Materials	82	400	260	320	180	340	230	280	350
Other (Electric Power Generation)	4 400	7 200	8 600	5 300	4 600	8 000	7 300	8 000	7 800
MANUFACTURING	**1 300 000**	**1 000 000**	**510 000**	**180 000**	**180 000**	**160 000**	**140 000**	**130 000**	**140 000**
Abrasives Manufacturing	610	240	240	-	-	-	-	-	-
Bakeries	7.0	6.0	0.44	0.17	0.35	0.34	0.30	0.30	0.32
Biofuel Production	-	-	-	-	-	-	-	-	-
Chemicals Industry	27 000	30 000	18 000	13 000	14 000	14 000	15 000	16 000	16 000
Electronics	26	39	19	-	-	-	-	0.26	-
Food Preparation	1 200	1 400	1 600	1 000	1 000	980	1 200	1 200	1 300
Glass Manufacturing	490	570	690	260	260	280	300	280	300
Grain Industry	1 900	2 700	610	390	370	390	370	390	420
Metal Fabrication	8 800	8 700	7 700	3 000	2 400	1 800	1 200	1 100	1 200
Plastics Manufacturing	220	350	220	12	0.42	10	9.0	10	11
Pulp and Paper Industry	180 000	150 000	99 000	48 000	57 000	64 000	68 000	73 000	78 000
Textiles	45	78	53	0.02	0.06	0.06	0.07	0.07	0.07
Vehicle Manufacturing (Engines, Parts, Assembly, Painting)	3 800	4 000	2 900	1 500	940	930	750	880	920
Wood Products	1 100 000	770 000	370 000	110 000	100 000	73 000	51 000	42 000	39 000
Other (Manufacturing)	31 000	61 000	11 000	750	660	630	630	700	670
TRANSPORTATION AND MOBILE EQUIPMENT	**8 100 000**	**7 300 000**	**5 100 000**	**3 400 000**	**3 300 000**	**3 200 000**	**3 100 000**	**3 000 000**	**3 100 000**
Air Transportation	60 000	47 000	43 000	51 000	49 000	46 000	49 000	51 000	50 000
Heavy-Duty Diesel Vehicles	34 000	63 000	91 000	77 000	75 000	70 000	63 000	61 000	62 000
Heavy-Duty Gasoline Vehicles	590 000	1 100 000	830 000	500 000	490 000	410 000	380 000	400 000	400 000
Heavy-Duty LPG/NG Vehicles	130 000	310 000	67 000	2 500	1 300	630	640	860	1 500
Light-Duty Diesel Trucks	13 000	15 000	20 000	12 000	12 000	13 000	16 000	17 000	19 000
Light-Duty Diesel Vehicles	29 000	17 000	9 300	8 600	8 800	8 700	9 200	8 600	8 200
Light-Duty Gasoline Trucks	1 600 000	1 600 000	1 100 000	710 000	700 000	680 000	690 000	730 000	730 000
Light-Duty Gasoline Vehicles	2 900 000	1 700 000	950 000	580 000	560 000	520 000	510 000	520 000	490 000
Light-Duty LPG/NG Trucks	140 000	54 000	24 000	690	360	270	240	260	310
Light-Duty LPG/NG Vehicles	14 000	6 000	2 300	24	9.8	7.7	7.3	8.9	12
Marine Transportation	13 000	17 000	19 000	19 000	19 000	18 000	18 000	19 000	19 000
Motorcycles	12 000	14 000	15 000	14 000	13 000	13 000	13 000	13 000	14 000
Off-Road Diesel Vehicles and Equipment	220 000	240 000	170 000	110 000	100 000	93 000	88 000	69 000	72 000
Off-Road Gasoline/LPG/NG Vehicles and Equipment	2 400 000	2 100 000	1 800 000	1 300 000	1 300 000	1 300 000	1 300 000	1 100 000	1 200 000
Rail Transportation	16 000	15 000	15 000	18 000	18 000	18 000	17 000	16 000	16 000
Tire Wear and Brake Lining	-	-	-	-	-	-	-	-	-
AGRICULTURE	**630**	**690**	**520**	**1 300**	**1 300**	**1 400**	**1 300**	**1 300**	**1 300**
Animal Production	-	-	-	-	-	-	-	-	-
Crop Production	-	-	-	-	-	-	-	-	-
Fuel Use	630	690	520	1 300	1 300	1 400	1 300	1 300	1 300
COMMERCIAL / RESIDENTIAL / INSTITUTIONAL	**1 700 000**	**1 500 000**	**1 200 000**	**1 300 000**	**1 200 000**	**1 200 000**	**1 200 000**	**1 200 000**	**1 200 000**
Cigarette Smoking	3 800	3 300	2 500	2 300	1 900	2 000	1 700	1 800	1 800
Commercial and Institutional Fuel Combustion	15 000	19 000	19 000	17 000	18 000	19 000	18 000	18 000	19 000
Commercial Cooking	5 700	6 400	7 100	7 000	6 900	6 700	6 300	6 300	6 400
Construction Fuel Combustion	670	360	460	490	450	440	440	450	460
Home Firewood Burning	1 700 000	1 500 000	1 200 000	1 200 000	1 200 000	1 200 000	1 200 000	1 200 000	1 200 000
Human	-	-	-	-	-	-	-	-	-
Marine Cargo Handling	0.16	0.05	-	-	-	-	-	-	-
Residential Fuel Combustion	13 000	13 000	13 000	12 000	13 000	13 000	13 000	11 000	12 000
Service Stations	-	-	-	-	-	-	-	-	-
Other (Commercial / Residential / Institutional)	-	-	-	-	-	-	-	-	-
INCINERATION AND WASTE	**45 000**	**28 000**	**28 000**	**17 000**	**18 000**	**18 000**	**18 000**	**18 000**	**18 000**
Crematoriums	7.4	11	13	15	16	17	18	18	19
Waste Incineration	42 000	26 000	24 000	15 000	15 000	15 000	15 000	15 000	15 000
Waste Treatment and Disposal	3 300	2 800	3 800	2 900	3 200	3 100	3 000	2 800	2 600
PAINTS AND SOLVENTS	**23**	**73**	**21**	**-**	**0.47**	**0.46**	**0.37**	**0.33**	**0.35**
Dry Cleaning	0.95	0.81	-	-	-	-	-	-	-
General Solvent Use	-	-	-	-	-	-	-	-	-
Printing	22	72	21	-	0.47	0.46	0.37	0.33	0.35
Surface Coatings	0.10	0.10	-	-	-	-	-	-	-
DUST	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
Coal Transportation	-	-	-	-	-	-	-	-	-
Construction Operations	-	-	-	-	-	-	-	-	-
Mine Tailings	-	-	-	-	-	-	-	-	-
Paved Roads	-	-	-	-	-	-	-	-	-
Unpaved Roads	-	-	-	-	-	-	-	-	-
FIRES	**440 000**	**78 000**	**52 000**	**92 000**	**34 000**	**140 000**	**130 000**	**120 000**	**52 000**
Prescribed Burning	440 000	76 000	51 000	90 000	33 000	140 000	130 000	120 000	51 000
Structural Fires	2 100	1 700	1 500	1 700	1 600	1 200	1 100	1 100	1 100
GRAND TOTAL	**12 000 000**	**11 000 000**	**8 000 000**	**6 000 000**	**5 900 000**	**5 800 000**	**5 700 000**	**5 700 000**	**5 700 000**

Notes:
Totals may not add up due to rounding.
- Indicates no emission
0.00 Indicates emissions truncated due to rounding

2.6. **Ammonia (NH_3)**

In 2017, approximately 476 kt of NH_3 were released in Canada (Table 2–8). NH_3 emissions originated primarily from agriculture, which accounted for 94% (446 kt) of total emissions. All other sources combined accounted for only 6% of emissions.

From 1990 to 2017, Canada's NH_3 emissions increased by 16% (77 kt) (Figure 2–6); NH_3 emissions peaked in 2004 and have since fluctuated. This trend is driven by emissions from animal production and increasing use of nitrogen fertilizers in crop production. Animal production, which dominates the emissions throughout the time series, experienced a steady increase in emissions from 1990 to 2005, followed by a decrease from 2006 to 2017. Emissions from crop production, however, have been steadily increasing since 2006.

The most significant changes in NH_3 emissions from 1990 to 2017 include:

- Agriculture: increase of 24% (86 kt), from which:
  - Crop production: increase of 102% (81 kt)
  - Animal production: increase of 2% (5 kt)
- Other sources, dominated by manufacturing, incineration and waste, and transportation and mobile equipment: decrease of 36% (12 kt)

Figure 2–6 **Major Contributors to National NH_3 Trends**

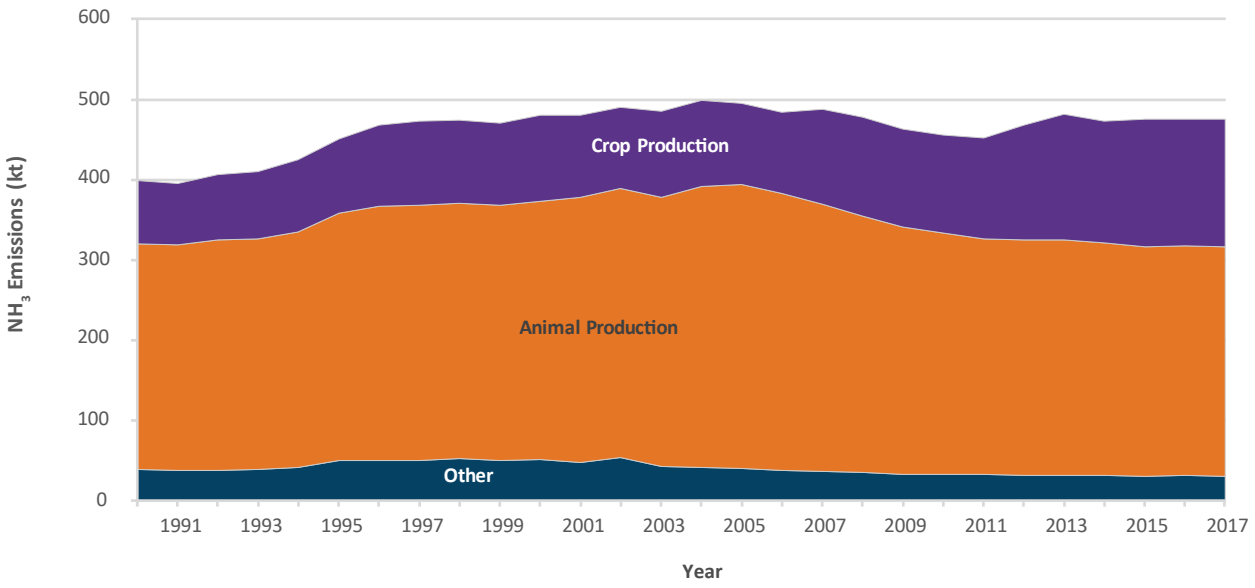

Table 2–8 National Summary of Annual NH_3 Emissions

Source	1990	2000	2005	2012	2013	2014	2015	2016	2017
	(tonnes)								
ORE AND MINERAL INDUSTRIES	**1 800**	**2 200**	**1 200**	**1 100**	**1 400**	**1 300**	**1 200**	**1 200**	**1 300**
Aluminium Industry	29	34	13	-	-	-	-	-	-
Asphalt Paving Industry	0.60	1.3	1.2	-	-	-	-	-	-
Cement and Concrete Industry	600	630	340	330	430	440	480	360	380
Foundries	11	12	8.0	-	-	-	-	-	-
Iron and Steel Industry	180	230	85	91	78	89	59	56	55
Iron Ore Industry	160	160	22	-	-	-	-	-	-
Mineral Products Industry	82	110	110	230	420	440	340	410	300
Mining and Rock Quarrying	510	540	82	67	93	67	52	97	83
Non-Ferrous Refining and Smelting Industry	210	450	510	420	350	300	280	320	460
OIL AND GAS INDUSTRY	**650**	**1 800**	**2 500**	**2 200**	**2 600**	**2 700**	**2 200**	**2 400**	**2 600**
Downstream Oil and Gas Industry	360	250	110	75	180	78	68	55	58
Upstream Oil and Gas Industry	290	1 500	2 400	2 100	2 400	2 600	2 100	2 300	2 600
ELECTRIC POWER GENERATION (UTILITIES)	**740**	**1 500**	**990**	**340**	**780**	**760**	**380**	**350**	**240**
Coal	62	110	530	37	580	610	170	170	170
Diesel	3.7	6.0	2.8	-	-	-	-	-	-
Natural Gas	270	700	180	200	110	95	130	100	7.0
Waste Materials	23	26	-	-	-	-	5.3	11	12
Other (Electric Power Generation)	380	620	280	95	82	62	70	62	45
MANUFACTURING	**20 000**	**25 000**	**17 000**	**12 000**	**11 000**	**11 000**	**12 000**	**12 000**	**11 000**
Abrasives Manufacturing	-	-	0.12	-	-	-	-	-	-
Bakeries	-	-	-	-	-	-	0.34	-	-
Biofuel Production	-	-	-	-	-	-	-	-	-
Chemicals Industry	9 800	15 000	11 000	9 100	8 500	8 500	9 000	9 300	8 500
Electronics	29	76	56	18	17	17	19	18	16
Food Preparation	170	320	300	270	300	270	240	220	250
Glass Manufacturing	86	110	120	-	-	-	-	-	-
Grain Industry	6.2	6.7	1.5	15	7.5	7.6	5.0	5.7	5.5
Metal Fabrication	79	190	39	2.8	2.1	2.4	25	25	27
Plastics Manufacturing	26	28	3.7	-	-	-	-	-	-
Pulp and Paper Industry	4 400	3 600	2 600	1 700	1 700	1 600	1 600	1 700	1 700
Textiles	12	26	16	-	-	-	-	-	-
Vehicle Manufacturing (Engines, Parts, Assembly, Painting)	64	180	47	0.11	0.77	-	2.3	2.2	6.5
Wood Products	4 600	4 600	2 400	730	750	800	780	780	710
Other (Manufacturing)	500	360	180	25	21	22	32	30	18
TRANSPORTATION AND MOBILE EQUIPMENT	**5 500**	**12 000**	**11 000**	**8 400**	**8 300**	**7 800**	**7 700**	**7 900**	**7 800**
Air Transportation	29	35	37	37	38	37	38	39	40
Heavy-Duty Diesel Vehicles	210	390	560	740	760	750	730	710	710
Heavy-Duty Gasoline Vehicles	160	250	270	330	340	310	310	330	320
Heavy-Duty LPG/NG Vehicles	55	170	21	2.5	1.2	0.88	1.1	1.3	1.9
Light-Duty Diesel Trucks	2.4	4.6	4.6	6.9	8.1	10	13	15	17
Light-Duty Diesel Vehicles	10	11	11	15	17	17	18	17	16
Light-Duty Gasoline Trucks	1 100	3 700	3 700	3 000	3 000	2 900	2 900	3 100	3 100
Light-Duty Gasoline Vehicles	3 300	6 300	5 600	3 600	3 500	3 200	3 000	3 000	2 900
Light-Duty LPG/NG Trucks	77	110	82	2.5	1.3	0.96	0.85	0.93	1.1
Light-Duty LPG/NG Vehicles	14	21	14	0.14	0.06	0.04	0.04	0.05	0.06
Marine Transportation	160	220	250	260	260	260	270	270	280
Motorcycles	4.4	7.0	12	33	34	35	37	39	40
Off-Road Diesel Vehicles and Equipment	170	210	200	190	190	190	200	180	190
Off-Road Gasoline/LPG/NG Vehicles and Equipment	170	130	91	82	84	88	89	88	90
Rail Transportation	51	48	48	57	55	56	53	49	49
Tire Wear and Brake Lining	-	-	-	-	-	-	-	-	-
AGRICULTURE	**360 000**	**430 000**	**450 000**	**440 000**	**450 000**	**440 000**	**440 000**	**440 000**	**450 000**
Animal Production	280 000	320 000	350 000	290 000	290 000	290 000	290 000	290 000	290 000
Crop Production	79 000	110 000	100 000	140 000	160 000	150 000	160 000	160 000	160 000
Fuel Use	44	41	28	47	47	52	45	45	43
COMMERCIAL / RESIDENTIAL / INSTITUTIONAL	**3 900**	**3 600**	**3 200**	**3 100**	**3 100**	**3 100**	**3 100**	**3 000**	**3 000**
Cigarette Smoking	110	110	88	83	76	77	69	70	71
Commercial and Institutional Fuel Combustion	310	340	320	200	210	220	210	200	200
Commercial Cooking	-	-	-	-	-	-	-	-	-
Construction Fuel Combustion	70	38	50	49	44	44	44	44	45
Home Firewood Burning	2 300	2 100	1 700	1 800	1 800	1 800	1 800	1 800	1 800
Human	490	530	560	600	610	620	620	630	640
Marine Cargo Handling	0.00	-	-	-	-	-	-	-	-
Residential Fuel Combustion	690	560	530	400	380	380	360	330	310
Service Stations	-	-	-	-	-	-	-	-	-
Other (Commercial / Residential / Institutional)	-	-	-	-	-	-	-	-	-
INCINERATION AND WASTE	**5 400**	**5 500**	**4 500**	**4 300**	**4 400**	**4 400**	**4 300**	**4 500**	**4 000**
Crematoriums	0.00	0.00	0.00	-	-	-	-	-	-
Waste Incineration	220	280	410	200	200	200	200	200	200
Waste Treatment and Disposal	5 200	5 200	4 100	4 100	4 200	4 200	4 100	4 300	3 800
PAINTS AND SOLVENTS	**14**	**14**	**0.88**	**-**	**-**	**-**	**-**	**-**	**-**
Dry Cleaning	0.05	0.05	-	-	-	-	-	-	-
General Solvent Use	-	-	-	-	-	-	-	-	-
Printing	14	14	0.88	-	-	-	-	-	-
Surface Coatings	0.08	0.08	-	-	-	-	-	-	-
DUST	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
Coal Transportation	-	-	-	-	-	-	-	-	-
Construction Operations	-	-	-	-	-	-	-	-	-
Mine Tailings	-	-	-	-	-	-	-	-	-
Paved Roads	-	-	-	-	-	-	-	-	-
Unpaved Roads	-	-	-	-	-	-	-	-	-
FIRES	**1 100**	**130**	**100**	**210**	**67**	**240**	**180**	**150**	**93**
Prescribed Burning	1 100	110	88	190	51	230	170	140	81
Structural Fires	22	17	16	18	16	12	12	12	12
GRAND TOTAL	**400 000**	**480 000**	**490 000**	**470 000**	**480 000**	**470 000**	**470 000**	**480 000**	**480 000**

Notes:
Totals may not add up due to rounding.
- Indicates no emission
0.00 Indicates emissions truncated due to rounding

2.7. **Lead (Pb)**

In 2017, approximately 181 tonnes (t) of Pb were emitted in Canada (Table 2–9). Ore and mineral industries were the largest contributor at 77% (139 t) of emissions, with the non-ferrous refining and smelting industry accounting for the largest share at 72% (131 t) of total Pb emissions. Transportation and mobile equipment was the second largest contributor at 18% (33 t) of total emissions (almost all of which was from air transportation).

Overall, lead emissions decreased by 86% (1.1 kt) from 1990 to 2017 (Figure 2–7). This decreasing trend is partly attributable to the closure of outdated smelters and partly to the implementation, since 2006, of regulated pollution prevention plans. (ECCC, 2015 Progress Report: Pollution Prevention Planning by Base Metals Smelters and Refineries and Zinc Plants, 2017). However, since 2013 lead emissions attributed to the non-ferrous refining and smelting industry have slowly increased. Reductions in emissions from mining and rock quarrying from 1990 to 1998 also influenced the overall trend, as well as emission reductions in air transportation across the time series.

The most significant changes in Pb emissions from 1990 to 2017 include:

- Ore and mineral industries: decrease of 88% (1.0 kt), of which:
  - Non-ferrous refining and smelting industry: decrease of 85% (756 t)
  - Mining and rock quarrying: decrease of 99% (197 t)
- Transportation and mobile equipment: decrease of 59% (46 t), of which:
  - Air transportation: decrease of 59% (46 t)

Figure 2–7 **Major Contributors to National Pb Trends**

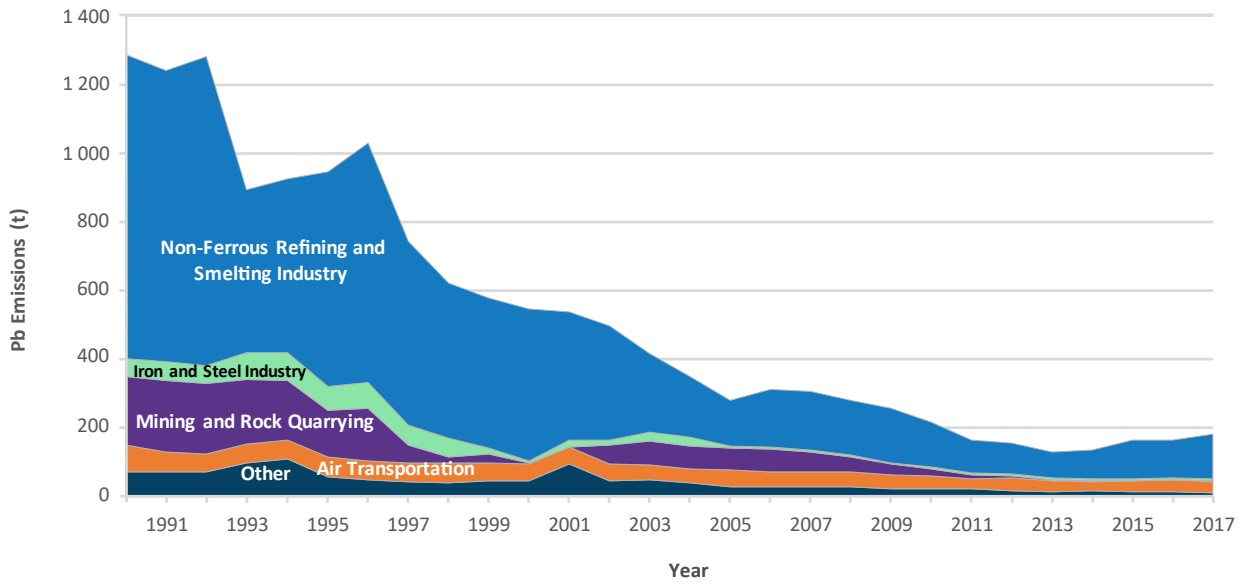

Table 2–9 National Summary of Annual Pb Emissions

Source	1990	2000	2005	2012	2013	2014	2015	2016	2017
	(kg)								
ORE AND MINERAL INDUSTRIES	**1 100 000**	**460 000**	**210 000**	**100 000**	**85 000**	**94 000**	**120 000**	**120 000**	**140 000**
Aluminium Industry	84	84	-	-	-	-	-	-	-
Asphalt Paving Industry	1 400	1 200	1 200	990	980	1 000	1 100	1 000	1 000
Cement and Concrete Industry	550	610	960	620	530	600	870	700	570
Foundries	2 000	6 600	1 600	430	210	190	210	200	170
Iron and Steel Industry	54 000	8 000	5 700	6 700	5 200	6 100	5 500	5 200	5 100
Iron Ore Industry	-	-	-	75	77	48	3.9	4.0	5.3
Mineral Products Industry	-	-	0.19	-	-	-	-	15	-
Mining and Rock Quarrying	200 000	260	65 000	7 100	3 100	900	980	1 100	1 200
Non-Ferrous Refining and Smelting Industry	890 000	440 000	130 000	88 000	75 000	85 000	110 000	110 000	130 000
OIL AND GAS INDUSTRY	**340**	**300**	**720**	**990**	**1 100**	**670**	**510**	**580**	**520**
Downstream Oil and Gas Industry	200	81	450	320	380	300	320	380	350
Upstream Oil and Gas Industry	140	220	260	660	700	370	190	200	160
ELECTRIC POWER GENERATION (UTILITIES)	**11 000**	**14 000**	**1 900**	**2 600**	**1 400**	**1 800**	**1 500**	**1 400**	**1 700**
Coal	8 300	10 000	1 300	2 100	860	1 200	820	770	1 100
Diesel	-	-	-	-	-	-	-	-	-
Natural Gas	430	530	72	89	85	93	97	86	91
Waste Materials	-	0.03	6.6	1.6	0.27	0.38	2.9	2.8	4.7
Other (Electric Power Generation)	2 600	3 200	590	320	430	490	530	560	540
MANUFACTURING	**48 000**	**16 000**	**17 000**	**4 700**	**4 600**	**6 400**	**5 900**	**6 500**	**3 700**
Abrasives Manufacturing	-	-	-	-	-	-	-	-	-
Bakeries	-	-	-	-	-	-	-	-	-
Biofuel Production	-	-	-	-	-	-	-	-	-
Chemicals Industry	12 000	300	1 800	72	85	82	120	45	45
Electronics	2 000	710	96	24	20	18	17	19	22
Food Preparation	-	-	-	-	-	-	-	-	-
Glass Manufacturing	21	6.0	25	0.34	0.30	0.00	0.00	0.00	-
Grain Industry	-	-	-	-	-	-	-	-	-
Metal Fabrication	28 000	9 200	10 000	2 300	2 100	3 600	1 900	3 200	1 800
Plastics Manufacturing	76	46	21	23	0.01	4.7	4.8	4.8	1.3
Pulp and Paper Industry	2 100	840	2 400	1 300	1 400	2 200	3 400	2 800	1 300
Textiles	-	-	0.01	0.00	-	-	-	-	-
Vehicle Manufacturing (Engines, Parts, Assembly, Painting)	950	2 400	770	61	65	68	68	66	69
Wood Products	3 500	2 500	1 400	860	820	520	320	320	390
Other (Manufacturing)	-	220	150	15	32	32	25	39	9.3
TRANSPORTATION AND MOBILE EQUIPMENT	**79 000**	**52 000**	**48 000**	**38 000**	**33 000**	**29 000**	**32 000**	**33 000**	**33 000**
Air Transportation	78 000	51 000	47 000	37 000	31 000	28 000	31 000	33 000	32 000
Heavy-Duty Diesel Vehicles	-	-	-	-	-	-	-	-	-
Heavy-Duty Gasoline Vehicles	-	-	-	-	-	-	-	-	-
Heavy-Duty LPG/NG Vehicles	-	-	-	-	-	-	-	-	-
Light-Duty Diesel Trucks	-	-	-	-	-	-	-	-	-
Light-Duty Diesel Vehicles	-	-	-	-	-	-	-	-	-
Light-Duty Gasoline Trucks	-	-	-	-	-	-	-	-	-
Light-Duty Gasoline Vehicles	-	-	-	-	-	-	-	-	-
Light-Duty LPG/NG Trucks	-	-	-	-	-	-	-	-	-
Light-Duty LPG/NG Vehicles	-	-	-	-	-	-	-	-	-
Marine Transportation	600	740	830	930	1 100	1 200	560	570	590
Motorcycles	-	-	-	-	-	-	-	-	-
Off-Road Diesel Vehicles and Equipment	-	-	-	-	-	-	-	-	-
Off-Road Gasoline/LPG/NG Vehicles and Equipment	-	-	-	-	-	-	-	-	-
Rail Transportation	310	290	290	240	210	200	170	160	160
Tire Wear and Brake Lining	-	-	-	-	-	-	-	-	-
AGRICULTURE	**30**	**30**	**26**	**74**	**76**	**84**	**70**	**68**	**66**
Animal Production	-	-	-	-	-	-	-	-	-
Crop Production	-	-	-	-	-	-	-	-	-
Fuel Use	30	30	26	74	76	84	70	68	66
COMMERCIAL / RESIDENTIAL / INSTITUTIONAL	**6 300**	**4 800**	**4 600**	**4 000**	**3 500**	**3 200**	**3 200**	**3 200**	**3 200**
Cigarette Smoking	2.3	1.9	1.5	1.3	1.1	1.2	1.0	1.0	1.1
Commercial and Institutional Fuel Combustion	250	290	420	1 000	510	230	250	240	250
Commercial Cooking	-	-	-	-	-	-	-	-	-
Construction Fuel Combustion	10	4.9	11	8.5	7.5	7.3	7.7	6.7	6.6
Home Firewood Burning	3 500	3 200	2 600	2 700	2 700	2 600	2 600	2 600	2 600
Human	-	-	-	-	-	-	-	-	-
Marine Cargo Handling	2 000	970	1 200	2.9	59	20	10	41	51
Residential Fuel Combustion	490	410	390	310	290	300	280	250	240
Service Stations	-	-	-	-	-	-	-	-	-
Other (Commercial / Residential / Institutional)	-	-	-	-	-	-	-	-	-
INCINERATION AND WASTE	**330**	**390**	**570**	**590**	**420**	**440**	**420**	**400**	**400**
Crematoriums	2.0	2.8	3.6	4.4	4.7	5.2	5.3	5.4	5.6
Waste Incineration	330	390	530	390	390	410	390	380	380
Waste Treatment and Disposal	-	0.00	39	200	24	27	23	15	16
PAINTS AND SOLVENTS	**4.3**	**6.3**	**-**	**-**	**0.06**	**0.00**	**-**	**-**	**-**
Dry Cleaning	-	-	-	-	-	-	-	-	-
General Solvent Use	-	-	-	-	-	-	-	-	-
Printing	4.3	6.3	-	-	-	-	-	-	-
Surface Coatings	-	-	-	-	0.06	0.00	-	-	-
DUST	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
Coal Transportation	-	-	-	-	-	-	-	-	-
Construction Operations	-	-	-	-	-	-	-	-	-
Mine Tailings	-	-	-	-	-	-	-	-	-
Paved Roads	-	-	-	-	-	-	-	-	-
Unpaved Roads	-	-	-	-	-	-	-	-	-
FIRES	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
Prescribed Burning	-	-	-	-	-	-	-	-	-
Structural Fires	-	-	-	-	-	-	-	-	-
GRAND TOTAL	**1 300 000**	**550 000**	**280 000**	**160 000**	**130 000**	**140 000**	**160 000**	**170 000**	**180 000**

Notes:
Totals may not add up due to rounding.
- Indicates no emission
0.00 Indicates emissions truncated due to rounding

2.8. **Cadmium (Cd)**

Approximately 6.8 t of Cd were emitted in Canada in 2017 (Table 2–10). Ore and mineral industries accounted for 67% (4.6 t) of national emissions, with the non-ferrous refining and smelting industry contributing 63% (4.3 t) of the total. Commercial/residential/institutional sources contributed 16% (1.1 t) of total Cd emissions.

From 1990 to 2017, national Cd emissions decreased by 92% (84 t) (Figure 2–8). This trend is almost entirely driven by the non-ferrous refining and smelting industry. Emissions from this industry fluctuated greatly between 1990 and 2006, but decreased steadily from 2007 onward. As with lead emissions, reductions in Cd emissions coincide with the closure of outdated smelters and implementation of pollution prevention plans (ECCC, 2015 Progress Report: Pollution Prevention Planning by Base Metals Smelters and Refineries and Zinc Plants, 2017). Fluctuations in emissions prior to 2010 are almost entirely driven by emissions from a single smelter in Manitoba.

The most significant changes in Cd emissions from 1990 to 2017 include:

- Ore and mineral industries: decrease of 94% (76 t), of which:
  - Non-ferrous refining and smelting industry: decrease of 95% (74 t)

Figure 2–8 **Major Contributors to National Cd Trends**

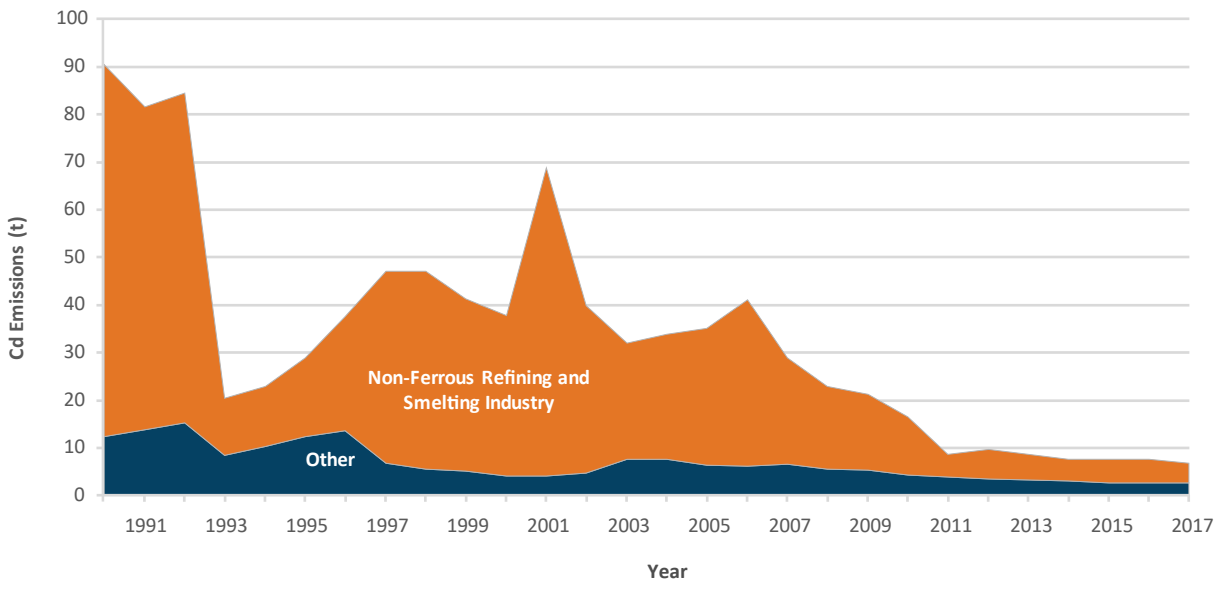

Table 2–10 National Summary of Annual Cd Emissions

Source	1990	2000	2005	2012	2013	2014	2015	2016	2017
	(kg)								
ORE AND MINERAL INDUSTRIES	**81 000**	**35 000**	**32 000**	**6 800**	**5 900**	**5 300**	**5 300**	**5 400**	**4 600**
Aluminium Industry	1.0	1.0	-	-	-	-	-	-	-
Asphalt Paving Industry	26	24	25	21	21	22	22	22	22
Cement and Concrete Industry	47	46	44	28	16	13	14	12	9.4
Foundries	2.0	2.0	26	1.9	1.7	62	21	0.75	21
Iron and Steel Industry	150	160	310	250	230	300	220	210	200
Iron Ore Industry	-	-	-	8.0	8.3	5.5	0.40	0.15	0.17
Mineral Products Industry	-	-	-	-	-	-	-	-	-
Mining and Rock Quarrying	2 200	830	2 900	330	320	330	50	52	53
Non-Ferrous Refining and Smelting Industry	78 000	34 000	29 000	6 200	5 300	4 600	5 000	5 100	4 300
OIL AND GAS INDUSTRY	**130**	**190**	**190**	**270**	**240**	**210**	**220**	**220**	**250**
Downstream Oil and Gas Industry	110	150	130	120	100	110	94	95	98
Upstream Oil and Gas Industry	25	38	61	150	140	110	130	120	150
ELECTRIC POWER GENERATION (UTILITIES)	**130**	**130**	**250**	**430**	**360**	**160**	**140**	**160**	**120**
Coal	87	91	170	360	300	93	42	100	78
Diesel	-	-	-	-	-	-	-	-	-
Natural Gas	29	30	56	50	47	43	52	35	27
Waste Materials	-	-	0.87	0.36	0.27	0.09	0.81	0.72	1.6
Other (Electric Power Generation)	14	14	27	20	20	27	45	25	15
MANUFACTURING	**1 100**	**950**	**940**	**650**	**620**	**590**	**580**	**590**	**560**
Abrasives Manufacturing	-	-	-	-	-	-	-	-	-
Bakeries	-	-	-	-	-	-	-	-	-
Biofuel Production	-	-	-	-	-	-	-	-	-
Chemicals Industry	140	130	71	7.3	7.7	7.3	7.9	8.1	7.8
Electronics	-	-	-	-	-	-	-	-	-
Food Preparation	-	-	-	-	-	-	-	-	-
Glass Manufacturing	1.0	1.0	1.9	-	-	-	-	-	-
Grain Industry	-	-	-	-	-	-	-	-	-
Metal Fabrication	460	410	290	380	340	330	320	310	290
Plastics Manufacturing	5.0	6.0	3.6	0.55	0.18	-	-	-	-
Pulp and Paper Industry	370	190	330	210	220	200	200	210	200
Textiles	-	-	-	-	-	-	-	-	-
Vehicle Manufacturing (Engines, Parts, Assembly, Painting)	2.0	88	1.1	-	-	-	-	-	0.00
Wood Products	130	130	110	56	56	55	48	59	56
Other (Manufacturing)	-	-	140	0.08	0.19	0.68	0.06	0.06	0.13
TRANSPORTATION AND MOBILE EQUIPMENT	**300**	**370**	**410**	**280**	**230**	**180**	**91**	**86**	**85**
Air Transportation	-	-	-	-	-	-	-	-	-
Heavy-Duty Diesel Vehicles	-	-	-	-	-	-	-	-	-
Heavy-Duty Gasoline Vehicles	-	-	-	-	-	-	-	-	-
Heavy-Duty LPG/NG Vehicles	-	-	-	-	-	-	-	-	-
Light-Duty Diesel Trucks	-	-	-	-	-	-	-	-	-
Light-Duty Diesel Vehicles	-	-	-	-	-	-	-	-	-
Light-Duty Gasoline Trucks	-	-	-	-	-	-	-	-	-
Light-Duty Gasoline Vehicles	-	-	-	-	-	-	-	-	-
Light-Duty LPG/NG Trucks	-	-	-	-	-	-	-	-	-
Light-Duty LPG/NG Vehicles	-	-	-	-	-	-	-	-	-
Marine Transportation	190	280	320	200	160	110	35	34	32
Motorcycles	-	-	-	-	-	-	-	-	-
Off-Road Diesel Vehicles and Equipment	-	-	-	-	-	-	-	-	-
Off-Road Gasoline/LPG/NG Vehicles and Equipment	-	-	-	-	-	-	-	-	-
Rail Transportation	100	98	95	80	71	66	57	52	53
Tire Wear and Brake Lining	-	-	-	-	-	-	-	-	-
AGRICULTURE	**51**	**54**	**64**	**95**	**88**	**87**	**84**	**92**	**91**
Animal Production	-	-	-	-	-	-	-	-	-
Crop Production	-	-	-	-	-	-	-	-	-
Fuel Use	51	54	64	95	88	87	84	92	91
COMMERCIAL / RESIDENTIAL / INSTITUTIONAL	**1 100**	**1 200**	**1 200**	**1 200**	**1 100**	**1 100**	**1 100**	**1 100**	**1 100**
Cigarette Smoking	6.0	5.1	3.9	3.5	3.0	3.0	2.7	2.7	2.8
Commercial and Institutional Fuel Combustion	340	510	480	500	470	480	470	480	500
Commercial Cooking	-	-	-	-	-	-	-	-	-
Construction Fuel Combustion	11	7.0	10	9.1	8.9	8.9	8.9	9.1	9.1
Home Firewood Burning	200	180	150	160	160	160	150	150	150
Human	-	-	-	-	-	-	-	-	-
Marine Cargo Handling	-	-	47	0.08	2.3	1.2	0.50	2.2	2.3
Residential Fuel Combustion	540	500	500	490	480	490	460	440	450
Service Stations	-	-	-	-	-	-	-	-	-
Other (Commercial / Residential / Institutional)	-	-	-	-	-	-	-	-	-
INCINERATION AND WASTE	**7 000**	**200**	**46**	**32**	**33**	**35**	**35**	**33**	**35**
Crematoriums	0.34	0.48	0.61	0.74	0.79	0.86	0.89	0.91	0.94
Waste Incineration	7 000	200	44	31	30	30	30	30	30
Waste Treatment and Disposal	-	-	1.3	0.49	2.1	4.0	4.5	2.3	3.6
PAINTS AND SOLVENTS	**1.0**	**1.0**	**-**	**0.12**	**0.12**	**0.12**	**0.14**	**0.10**	**0.14**
Dry Cleaning	-	-	-	-	-	-	-	-	-
General Solvent Use	-	-	-	-	-	-	-	-	-
Printing	1.0	1.0	-	-	-	-	-	-	-
Surface Coatings	-	-	-	0.12	0.12	0.12	0.14	0.10	0.14
DUST	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
Coal Transportation	-	-	-	-	-	-	-	-	-
Construction Operations	-	-	-	-	-	-	-	-	-
Mine Tailings	-	-	-	-	-	-	-	-	-
Paved Roads	-	-	-	-	-	-	-	-	-
Unpaved Roads	-	-	-	-	-	-	-	-	-
FIRES	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
Prescribed Burning	-	-	-	-	-	-	-	-	-
Structural Fires	-	-	-	-	-	-	-	-	-
GRAND TOTAL	**91 000**	**38 000**	**35 000**	**9 800**	**8 600**	**7 700**	**7 600**	**7 700**	**6 800**

Notes:
Totals may not add up due to rounding.
- Indicates no emission
0.00 Indicates emissions truncated due to rounding

2.9. **Mercury (Hg)**

Approximately 3.0 t of Hg were emitted in Canada in 2017 (Table 2–11). Ore and mineral industries accounted for 42% (1.3 t) of Hg emissions in 2017, with iron and steel industries contributing 24% (0.73 t) of the annual total. Electric power generation (utilities) accounted for 20% (0.60 t) of 2017 emissions, most of which were emitted from coal-powered electric generation (19% of annual total, 0.58 t). Incineration and waste sources accounted for 15% (0.44 t) of Hg emissions in 2017, with crematoriums being the largest contributor at 9% (0.28 t).

Between 1990 and 2017, Hg emissions decreased by 91% (31 t) (Figure 2–9). This decrease in emissions is mainly due to a large drop in emissions from the non-ferrous refining and smelting industry. As with lead and cadmium emissions, reductions in mercury emissions coincide with the closure of outdated smelters, the implementation of pollution prevention plans and, to a smaller extent, with increased emission control measures, such as separation or changing of production materials, improved particulate matter emission controls and fuel switching. (ECCC, 2015 Progress Report: Pollution Prevention Planning by Base Metals Smelters and Refineries and Zinc Plants, 2017).

Emission reductions from electric power generation (utilities) are largely due to the closure of coal-fired electricity generation facilities and from the addition of mercury controls to plants. For the Incineration and Waste categories, decreases in emissions resulted from a reduction of Hg in products, such as dental amalgams and mercury-containing lamps, going into the waste stream.

The most significant changes in Hg emissions from 1990 to 2017 include:

- Ore and mineral industry: decrease of 95% (25 kt), of which:
  - Non-ferrous refining and smelting industry: decrease of 99% (25 kt)
- Incineration and waste: decrease of 85% (2.5 t) of which:
  - Waste treatment and disposal: decrease of 94% (1.7 t)
- Electric power generation: decrease of 74% (1.7 t), of which:
  - Coal (electric power generation): decrease of 70% (1.3 t)

Figure 2–9 **Major Contributors to National Hg Trends**

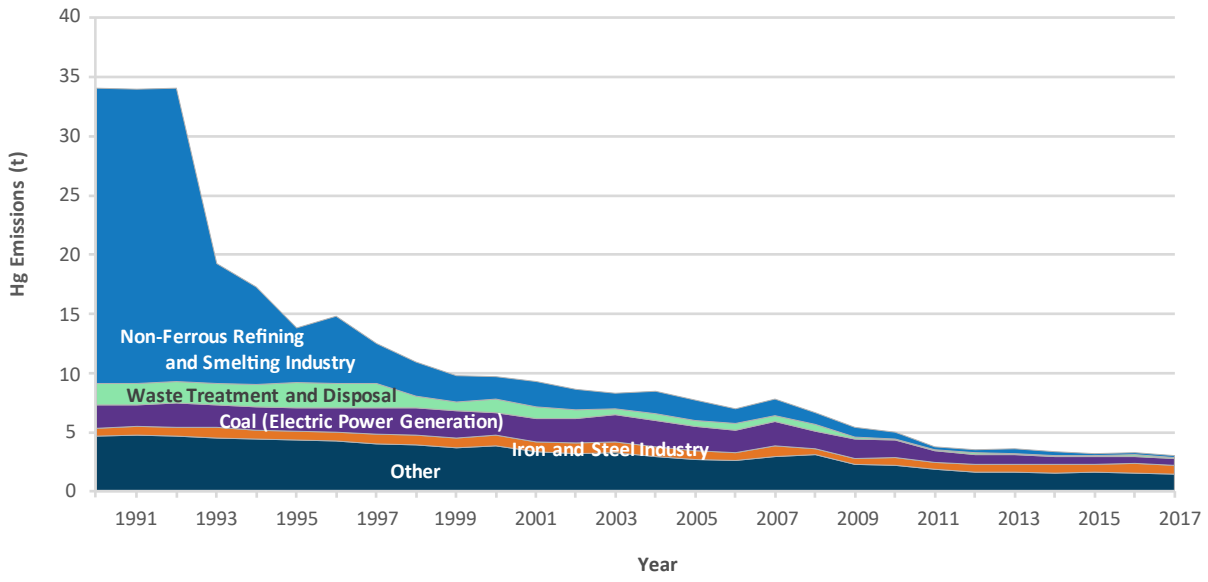

Table 2–11 National Summary of Annual Hg Emissions

Source	1990	2000	2005	2012	2013	2014	2015	2016	2017
	(kg)								
ORE AND MINERAL INDUSTRIES	**26 000**	**3 400**	**2 800**	**1 300**	**1 400**	**1 300**	**1 300**	**1 400**	**1 300**
Aluminium Industry	17	32	43	15	21	19	21	21	22
Asphalt Paving Industry	24	22	22	21	20	22	23	22	22
Cement and Concrete Industry	450	390	210	300	310	300	380	340	330
Foundries	210	120	4.2	-	-	-	-	-	-
Iron and Steel Industry	710	830	740	680	700	680	650	810	730
Iron Ore Industry	60	60	50	-	-	0.16	0.13	0.51	0.16
Mineral Products Industry	-	-	-	-	-	-	-	-	-
Mining and Rock Quarrying	12	12	29	5.1	8.6	20	20	16	19
Non-Ferrous Refining and Smelting Industry	25 000	1 900	1 700	250	360	290	180	220	140
OIL AND GAS INDUSTRY	**120**	**61**	**83**	**100**	**120**	**89**	**74**	**81**	**70**
Downstream Oil and Gas Industry	110	26	46	45	48	46	49	53	47
Upstream Oil and Gas Industry	3.0	36	38	59	68	44	25	28	22
ELECTRIC POWER GENERATION (UTILITIES)	**2 300**	**2 100**	**2 200**	**860**	**850**	**710**	**740**	**670**	**600**
Coal	1 900	2 000	2 000	810	800	660	680	630	580
Diesel	-	-	-	-	-	-	-	-	-
Natural Gas	12	22	27	23	23	19	26	11	0.01
Waste Materials	50	96	7.1	1.5	0.64	0.80	6.0	2.2	1.7
Other (Electric Power Generation)	290	62	91	23	23	28	26	30	17
MANUFACTURING	**1 100**	**1 400**	**520**	**110**	**100**	**100**	**110**	**130**	**110**
Abrasives Manufacturing	-	-	-	-	-	-	-	-	-
Bakeries	-	-	-	-	-	-	-	-	-
Biofuel Production	-	-	-	-	-	-	-	-	-
Chemicals Industry	170	81	58	23	17	18	15	17	17
Electronics	380	750	56	6.3	6.8	6.4	8.3	30	23
Food Preparation	-	-	0.30	-	-	-	-	-	-
Glass Manufacturing	28	28	21	-	-	-	-	-	-
Grain Industry	-	-	-	-	-	-	-	-	-
Metal Fabrication	16	17	17	11	7.5	-	-	-	-
Plastics Manufacturing	-	-	-	-	-	-	-	-	-
Pulp and Paper Industry	93	130	58	53	50	60	70	71	58
Textiles	-	-	-	-	-	-	-	-	-
Vehicle Manufacturing (Engines, Parts, Assembly, Painting)	-	-	0.02	-	-	-	-	-	-
Wood Products	260	190	89	20	19	18	17	16	13
Other (Manufacturing)	150	180	220	0.02	-	-	-	-	0.00
TRANSPORTATION AND MOBILE EQUIPMENT	**110**	**100**	**100**	**84**	**74**	**68**	**57**	**53**	**53**
Air Transportation	-	-	-	-	-	-	-	-	-
Heavy-Duty Diesel Vehicles	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Heavy-Duty Gasoline Vehicles	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Heavy-Duty LPG/NG Vehicles	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Light-Duty Diesel Trucks	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Light-Duty Diesel Vehicles	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Light-Duty Gasoline Trucks	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Light-Duty Gasoline Vehicles	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Light-Duty LPG/NG Trucks	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Light-Duty LPG/NG Vehicles	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Marine Transportation	4.3	6.2	7.2	4.4	3.3	2.1	0.56	0.52	0.49
Motorcycles	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Off-Road Diesel Vehicles and Equipment	-	-	-	-	-	-	-	-	-
Off-Road Gasoline/LPG/NG Vehicles and Equipment	-	-	-	-	-	-	-	-	-
Rail Transportation	100	98	95	80	71	66	57	52	53
Tire Wear and Brake Lining	-	-	-	-	-	-	-	-	-
AGRICULTURE	**2.8**	**3.4**	**3.2**	**11**	**11**	**11**	**10**	**10**	**9.8**
Animal Production	-	-	-	-	-	-	-	-	-
Crop Production	-	-	-	-	-	-	-	-	-
Fuel Use	2.8	3.4	3.2	11	11	11	10	10	9.8
COMMERCIAL / RESIDENTIAL / INSTITUTIONAL	**1 100**	**800**	**760**	**630**	**570**	**550**	**510**	**480**	**470**
Cigarette Smoking	0.21	0.18	0.14	0.13	0.11	0.11	0.10	0.10	0.10
Commercial and Institutional Fuel Combustion	47	62	63	54	54	58	55	55	57
Commercial Cooking	-	-	-	-	-	-	-	-	-
Construction Fuel Combustion	2.6	1.7	2.6	2.2	2.2	2.1	2.2	2.2	2.2
Home Firewood Burning	54	48	40	41	41	40	40	40	40
Human	110	24	18	8.5	6.9	5.2	3.5	1.8	0.12
Marine Cargo Handling	-	-	2.8	-	-	-	-	-	-
Residential Fuel Combustion	64	76	75	71	76	80	75	67	72
Service Stations	-	-	-	-	-	-	-	-	-
Other (Commercial / Residential / Institutional)	820	590	560	460	390	370	340	310	290
INCINERATION AND WASTE	**2 900**	**1 800**	**1 300**	**460**	**450**	**460**	**460**	**450**	**440**
Crematoriums	100	140	180	220	240	260	260	270	280
Waste Incineration	990	590	570	110	91	82	76	73	59
Waste Treatment and Disposal	1 800	1 100	500	130	120	120	120	110	100
PAINTS AND SOLVENTS	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
Dry Cleaning	-	-	-	-	-	-	-	-	-
General Solvent Use	-	-	-	-	-	-	-	-	-
Printing	-	-	-	-	-	-	-	-	-
Surface Coatings	-	-	-	-	-	-	-	-	-
DUST	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
Coal Transportation	-	-	-	-	-	-	-	-	-
Construction Operations	-	-	-	-	-	-	-	-	-
Mine Tailings	-	-	-	-	-	-	-	-	-
Paved Roads	-	-	-	-	-	-	-	-	-
Unpaved Roads	-	-	-	-	-	-	-	-	-
FIRES	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
Prescribed Burning	-	-	-	-	-	-	-	-	-
Structural Fires	-	-	-	-	-	-	-	-	-
GRAND TOTAL	**34 000**	**9 700**	**7 700**	**3 500**	**3 600**	**3 300**	**3 200**	**3 300**	**3 000**

Notes:
Totals may not add up due to rounding.
- Indicates no emission
0.00 Indicates emissions truncated due to rounding

2.10. **Dioxins and Furans (D/F)**

In 2017, emissions of dioxins and furans (D/F) in Canada totalled approximately 66 grams of toxicity equivalent (gTEQ) (Table 2–12). Incineration and waste sources accounted for the largest share of these emissions (37% or 24 gTEQ), with waste incineration accounting for 32% (21 gTEQ). Transportation and mobile equipment contributed 31% (21 gTEQ) of 2017 D/F emissions, 30% (20 gTEQ) of which are attributed to marine transportation. Commercial/residential/institutional sources were also significant contributors (12% and 7.7 gTEQ). Ore and mineral industries collectively accounted for 10% (6.3 gTEQ) of 2016 D/F emissions.

Between 1990 and 2017, D/F emissions decreased by 85% (387 gTEQ) (Figure 2–10). This decrease is due to large reductions in emissions from waste incineration.

The most significant changes in D/F emissions from 1990 to 2017 include:

- Incineration and waste: decrease of 93% (322 gTEQ), of which:
  - Waste incineration: decrease of 94% (324 gTEQ)

Figure 2–10 **Major Contributors to National D/F Trends**

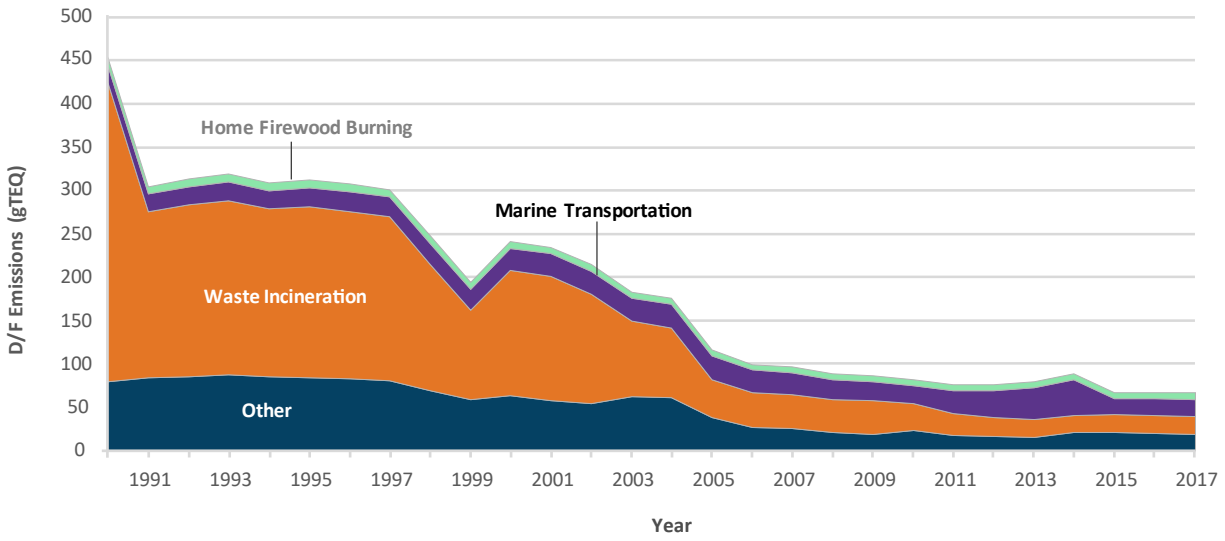

Table 2–12 National Summary of Annual Dioxins and Furans Emissions

Source	1990	2000	2005	2012	2013	2014	2015	2016	2017
	(gTEQ)								
ORE AND MINERAL INDUSTRIES	**45**	**28**	**10**	**4.1**	**3.8**	**6.7**	**7.3**	**5.7**	**6.3**
Aluminium Industry	3.0	4.0	-	-	-	-	-	-	-
Asphalt Paving Industry	0.02	0.02	0.01	0.00	0.00	0.00	0.01	0.01	0.01
Cement and Concrete Industry	3.0	1.8	2.6	0.65	0.54	1.9	1.6	0.61	0.22
Foundries	-	0.07	0.01	0.01	0.00	0.04	0.03	0.04	0.01
Iron and Steel Industry	35	17	4.0	2.9	2.9	4.4	5.2	4.7	5.6
Iron Ore Industry	-	-	-	-	-	0.00	0.00	0.00	0.00
Mineral Products Industry	1.0	1.0	1.0	-	-	-	-	-	-
Mining and Rock Quarrying	-	0.14	1.1	0.04	0.03	0.05	0.09	0.03	0.02
Non-Ferrous Refining and Smelting Industry	3.0	3.3	1.3	0.48	0.38	0.29	0.38	0.41	0.44
OIL AND GAS INDUSTRY	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
Downstream Oil and Gas Industry	-	-	-	-	-	-	-	-	-
Upstream Oil and Gas Industry	-	-	-	-	-	-	-	-	-
ELECTRIC POWER GENERATION (UTILITIES)	**3.0**	**6.4**	**5.5**	**1.6**	**1.7**	**2.1**	**1.9**	**2.9**	**2.2**
Coal	2.3	3.1	3.9	1.5	1.5	1.8	1.6	1.9	1.6
Diesel	-	-	-	-	-	-	-	-	-
Natural Gas	0.46	1.0	1.2	0.02	0.02	0.04	0.01	0.01	0.03
Waste Materials	0.00	0.19	0.01	0.01	0.00	0.01	0.02	0.16	0.01
Other (Electric Power Generation)	0.23	2.1	0.43	0.13	0.17	0.19	0.19	0.75	0.60
MANUFACTURING	**17**	**16**	**13**	**3.3**	**3.7**	**3.0**	**2.9**	**4.0**	**3.2**
Abrasives Manufacturing	-	-	0.05	0.02	0.02	0.02	0.01	0.01	0.01
Bakeries	-	-	-	-	-	-	-	-	-
Biofuel Production	-	-	-	-	-	-	-	-	-
Chemicals Industry	2.0	0.10	0.07	0.27	0.13	0.27	0.26	0.31	0.33
Electronics	-	-	-	-	-	-	-	-	-
Food Preparation	-	-	0.07	-	-	-	-	-	-
Glass Manufacturing	-	-	-	-	-	-	-	-	-
Grain Industry	-	-	-	-	-	-	-	-	-
Metal Fabrication	2.0	7.1	5.0	1.4	1.1	0.90	0.87	0.92	0.92
Plastics Manufacturing	-	-	-	-	-	-	-	-	-
Pulp and Paper Industry	11	5.2	4.9	1.0	1.8	1.1	1.1	2.1	1.3
Textiles	-	-	-	-	-	-	-	-	-
Vehicle Manufacturing (Engines, Parts, Assembly, Painting)	-	1.3	0.44	-	-	-	-	-	-
Wood Products	1.8	2.6	1.8	0.60	0.62	0.66	0.64	0.64	0.59
Other (Manufacturing)	-	-	0.12	-	-	-	-	-	-
TRANSPORTATION AND MOBILE EQUIPMENT	**21**	**26**	**29**	**32**	**37**	**42**	**20**	**20**	**21**
Air Transportation	-	-	-	-	-	-	-	-	-
Heavy-Duty Diesel Vehicles	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Heavy-Duty Gasoline Vehicles	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Heavy-Duty LPG/NG Vehicles	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Light-Duty Diesel Trucks	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Light-Duty Diesel Vehicles	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Light-Duty Gasoline Trucks	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Light-Duty Gasoline Vehicles	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Light-Duty LPG/NG Trucks	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Light-Duty LPG/NG Vehicles	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Marine Transportation	20	25	28	31	36	41	19	19	20
Motorcycles	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Off-Road Diesel Vehicles and Equipment	-	-	-	-	-	-	-	-	-
Off-Road Gasoline/LPG/NG Vehicles and Equipment	-	-	-	-	-	-	-	-	-
Rail Transportation	1.2	1.2	1.2	1.4	1.3	1.4	1.3	1.2	1.2
Tire Wear and Brake Lining	-	-	-	-	-	-	-	-	-
AGRICULTURE	**0.06**	**0.05**	**0.04**	**0.63**	**0.61**	**0.64**	**0.59**	**0.58**	**0.55**
Animal Production	-	-	-	-	-	-	-	-	-
Crop Production	-	-	-	-	-	-	-	-	-
Fuel Use	0.06	0.05	0.04	0.63	0.61	0.64	0.59	0.58	0.55
COMMERCIAL / RESIDENTIAL / INSTITUTIONAL	**13**	**12**	**10**	**8.2**	**8.1**	**8.1**	**8.8**	**7.7**	**7.7**
Cigarette Smoking	0.02	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Commercial and Institutional Fuel Combustion	0.37	0.37	0.33	0.25	0.26	0.45	1.3	0.27	0.25
Commercial Cooking	-	-	-	-	-	-	-	-	-
Construction Fuel Combustion	0.07	0.03	0.04	0.04	0.03	0.03	0.03	0.03	0.03
Home Firewood Burning	9.0	8.2	6.7	7.2	7.1	7.1	7.0	7.0	7.0
Human	-	-	-	-	-	-	-	-	-
Marine Cargo Handling	-	-	-	-	-	-	-	-	-
Residential Fuel Combustion	1.5	1.2	1.1	0.72	0.64	0.58	0.44	0.39	0.38
Service Stations	-	-	-	-	-	-	-	-	-
Other (Commercial / Residential / Institutional)	2.0	2.0	2.0	-	-	-	-	-	-
INCINERATION AND WASTE	**350**	**150**	**47**	**24**	**23**	**23**	**23**	**23**	**24**
Crematoriums	1.1	1.6	2.0	2.5	2.7	2.9	3.0	3.1	3.2
Waste Incineration	350	150	43	22	21	20	20	20	21
Waste Treatment and Disposal	0.01	4.3	1.9	0.01	0.00	0.00	0.00	0.00	0.00
PAINTS AND SOLVENTS	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
Dry Cleaning	-	-	-	-	-	-	-	-	-
General Solvent Use	-	-	-	-	-	-	-	-	-
Printing	-	-	-	-	-	-	-	-	-
Surface Coatings	-	-	-	-	-	-	-	-	-
DUST	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
Coal Transportation	-	-	-	-	-	-	-	-	-
Construction Operations	-	-	-	-	-	-	-	-	-
Mine Tailings	-	-	-	-	-	-	-	-	-
Paved Roads	-	-	-	-	-	-	-	-	-
Unpaved Roads	-	-	-	-	-	-	-	-	-
FIRES	**7.6**	**1.5**	**0.92**	**1.6**	**0.68**	**2.8**	**2.2**	**1.8**	**1.1**
Prescribed Burning	7.6	1.5	0.92	1.6	0.68	2.8	2.2	1.8	1.1
Structural Fires	-	-	-	-	-	-	-	-	-
GRAND TOTAL	**450**	**240**	**120**	**76**	**79**	**88**	**67**	**66**	**66**

Notes:
Totals may not add up due to rounding.
- Indicates no emission
0.00 Indicates emissions truncated due to rounding

2.11. **Polycyclic Aromatic Hydrocarbons (PAHs)**

The APEI reports emissions of four PAHs: benzo(a) pyrene (B(a)p), benzo(b)fluoranthene (B(b)f), benzo(k) fluoranthene (B(k)f) and indeno[1,2,3-cd]pyrene (I(1,2,3-cd)p). The analysis presented here is based on the aggregate total of all four substances. In 2017, 112 t of PAHs were emitted in Canada (Table 2–13), with 90% (102 t) attributed to commercial/residential/ institutional sources. This is almost entirely due to home firewood burning. Transportation and Mobile Equipment, as the next largest source, contributed 7% (8 t) of PAH emissions in 2017.

Home firewood burning dominates PAH emissions throughout the time series. This source experienced a 26% (35 t) emission decrease from 1990 to 2017. This can be attributed to a reduction in the use of wood as heating fuel and to the increased use of newer technologies in fireplace inserts, furnaces and stoves that improve combustion efficiency and as a result limit the emission of both wood smoke and PAHs. (ECCC, Residential Fuelwood Consumption in Canada, 2014)

From 1990 to 2017, PAH emissions decreased by 69% (248 t) (Figure 2–11), primarily due to emission reductions in the aluminium industry and iron and steel industry. Emissions from the aluminium industry experienced a large drop in PAH emissions from 2001 to 2010 due to process improvements and the progressive phase-out of old Söderberg aluminium production technology (ECCC, Alcoa Ltd. Environmental Performance Agreement Overview, 2008) . Additional decreases occurred between 2014 and 2017, related to the replacement of old smelting equipment with a modern smelter at the facility which historically contributed the largest share of PAH emissions (ECCC, Annual Public Report of Environmental Performance Agreement Concerning Atmospheric Emissions of PolycycliAromatic Hydrocarbons between Environment and Climate Change Canada and Rio Tinto Alcan, 2014).

PAH emissions from iron and steel industry experienced a large drop earlier in the time series, from 1993 to 2006, and remained quite small until 2017. Reductions here are a result of effective emission controls on coke ovens and electric arc furnaces (ECCC, Environmental Code of Practice for Integrated Steel Mills—CEPA 1999 Code of Practice, 2001).

PAH emissions from Transportation and Mobile Equipment have decreased across the time series due to increasingly stringent engine and vehicle regulations.

The most significant changes in PAH emissions from 1990 to 2017 include:

- Ore and mineral industries : decrease of almost 100% (188 t), of which:
  - Aluminium industry: decrease of almost 100% (109 t)
  - Iron and steel industry: decrease of 100% (79 t)
- Commercial/residential/ institutional: decrease of 26% (35 t), of which:
  - Home firewood burning: decrease of 26% (35 t)
- Transportation and Mobile Equipment: decrease of 67% (16 t), of which:
  - Light-duty Gasoline Trucks and Vehicles: decrease of 65% (10 t)

Figure 2–11 **Major Contributors to National PAH Trends**

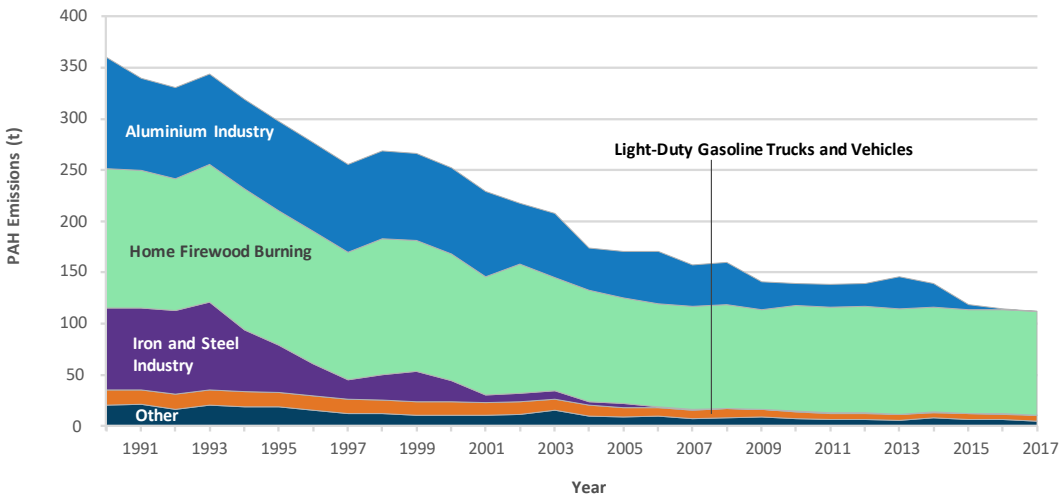

Table 2–13 National Summary of Annual PAH Emissions

Source	1990	2000	2005	2012	2013	2014	2015	2016	2017
	(kg)								
ORE AND MINERAL INDUSTRIES	**190 000**	**100 000**	**50 000**	**24 000**	**32 000**	**24 000**	**5 400**	**670**	**530**
Aluminium Industry	110 000	84 000	45 000	23 000	31 000	23 000	4 900	100	130
Asphalt Paving Industry	14	14	15	12	12	13	13	13	13
Cement and Concrete Industry	17	13	19	1.6	1.7	3.1	2.8	0.23	0.62
Foundries	-	-	-	-	-	-	-	-	-
Iron and Steel Industry	80 000	20 000	4 600	740	550	400	400	440	390
Iron Ore Industry	-	-	-	-	-	-	-	-	-
Mineral Products Industry	-	-	-	-	-	-	-	-	-
Mining and Rock Quarrying	0.30	0.50	-	0.25	160	250	110	110	0.02
Non-Ferrous Refining and Smelting Industry	2.0	3.0	0.69	0.27	0.31	0.31	0.32	0.30	0.33
OIL AND GAS INDUSTRY	**150**	**95**	**46**	**28**	**27**	**25**	**24**	**20**	**18**
Downstream Oil and Gas Industry	150	92	43	19	18	16	19	14	13
Upstream Oil and Gas Industry	2.3	3.3	2.3	8.2	9.0	9.8	4.8	5.8	4.5
ELECTRIC POWER GENERATION (UTILITIES)	**370**	**360**	**240**	**7.8**	**6.7**	**6.4**	**6.1**	**6.8**	**6.5**
Coal	240	240	240	-	-	-	-	-	-
Diesel	-	-	-	-	-	-	-	-	-
Natural Gas	2.9	2.3	0.23	0.07	0.03	0.03	0.04	0.05	0.04
Waste Materials	-	-	-	-	-	-	-	-	-
Other (Electric Power Generation)	130	110	-	7.7	6.7	6.4	6.0	6.8	6.5
MANUFACTURING	**320**	**300**	**300**	**170**	**130**	**170**	**110**	**96**	**110**
Abrasives Manufacturing	-	-	-	-	-	-	-	-	-
Bakeries	-	-	-	-	-	-	-	-	-
Biofuel Production	-	-	-	-	-	-	-	-	-
Chemicals Industry	-	23	30	28	25	24	25	25	25
Electronics	-	-	-	-	-	-	-	-	-
Food Preparation	-	-	-	-	-	-	-	-	-
Glass Manufacturing	-	-	-	-	-	-	-	-	-
Grain Industry	-	-	-	-	-	-	-	-	-
Metal Fabrication	-	-	8.3	4.1	4.1	-	-	-	-
Plastics Manufacturing	-	-	-	-	-	-	-	-	-
Pulp and Paper Industry	110	130	190	120	91	130	73	64	78
Textiles	-	-	-	-	-	-	-	-	-
Vehicle Manufacturing (Engines, Parts, Assembly, Painting)	-	-	-	0.01	0.02	0.03	0.02	0.01	0.02
Wood Products	210	150	72	12	11	9.7	8.6	7.9	6.0
Other (Manufacturing)	-	0.93	2.2	-	-	-	-	-	-
TRANSPORTATION AND MOBILE EQUIPMENT	**24 000**	**20 000**	**15 000**	**9 500**	**9 200**	**8 400**	**7 900**	**8 200**	**8 100**
Air Transportation	13	11	7.7	8.3	8.6	8.6	9.2	9.6	10
Heavy-Duty Diesel Vehicles	910	990	1 200	800	750	690	610	600	600
Heavy-Duty Gasoline Vehicles	6 200	4 300	4 200	2 300	2 300	1 900	1 800	1 900	1 900
Heavy-Duty LPG/NG Vehicles	1 100	1 300	330	9.6	5.2	2.8	2.5	3.5	6.7
Light-Duty Diesel Trucks	2.1	2.7	2.8	1.6	1.6	1.7	1.8	2.0	2.2
Light-Duty Diesel Vehicles	7.8	5.4	3.4	2.6	2.6	2.5	2.4	2.2	2.1
Light-Duty Gasoline Trucks	4 500	5 400	3 800	3 000	2 900	2 800	2 800	3 000	3 000
Light-Duty Gasoline Vehicles	11 000	7 600	5 000	3 100	2 900	2 700	2 500	2 500	2 400
Light-Duty LPG/NG Trucks	380	170	80	2.4	1.3	0.95	0.85	0.93	1.1
Light-Duty LPG/NG Vehicles	47	25	12	0.12	0.05	0.04	0.04	0.04	0.06
Marine Transportation	120	150	170	190	210	240	110	110	120
Motorcycles	39	38	42	39	38	37	37	40	40
Off-Road Diesel Vehicles and Equipment	-	-	-	-	-	-	-	-	-
Off-Road Gasoline/LPG/NG Vehicles and Equipment	-	-	-	-	-	-	-	-	-
Rail Transportation	63	59	58	48	43	40	34	32	32
Tire Wear and Brake Lining	-	-	-	-	-	-	-	-	-
AGRICULTURE	**0.32**	**0.31**	**0.21**	**0.36**	**0.36**	**0.38**	**0.34**	**0.35**	**0.34**
Animal Production	-	-	-	-	-	-	-	-	-
Crop Production	-	-	-	-	-	-	-	-	-
Fuel Use	0.32	0.31	0.21	0.36	0.36	0.38	0.34	0.35	0.34
COMMERCIAL / RESIDENTIAL / INSTITUTIONAL	**140 000**	**120 000**	**100 000**	**100 000**	**100 000**	**100 000**	**100 000**	**100 000**	**100 000**
Cigarette Smoking	1.0	0.90	0.68	0.62	0.53	0.54	0.48	0.48	0.49
Commercial and Institutional Fuel Combustion	2.6	3.1	3.0	2.1	2.3	2.4	2.3	2.2	2.3
Commercial Cooking	100	110	120	120	120	120	110	110	110
Construction Fuel Combustion	0.45	0.19	0.41	0.32	0.26	0.26	0.28	0.22	0.22
Home Firewood Burning	140 000	120 000	100 000	100 000	100 000	100 000	100 000	100 000	100 000
Human	-	-	-	-	-	-	-	-	-
Marine Cargo Handling	-	-	-	-	-	-	-	-	-
Residential Fuel Combustion	5.3	4.6	4.3	3.5	3.4	3.5	3.3	3.0	2.9
Service Stations	-	-	-	-	-	-	-	-	-
Other (Commercial / Residential / Institutional)	-	-	-	-	-	-	-	-	-
INCINERATION AND WASTE	**670**	**630**	**690**	**680**	**680**	**690**	**690**	**700**	**710**
Crematoriums	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.01
Waste Incineration	670	630	690	680	680	690	690	700	710
Waste Treatment and Disposal	-	-	-	0.00	0.00	0.00	0.00	0.01	0.00
PAINTS AND SOLVENTS	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
Dry Cleaning	-	-	-	-	-	-	-	-	-
General Solvent Use	-	-	-	-	-	-	-	-	-
Printing	-	-	-	-	-	-	-	-	-
Surface Coatings	-	-	-	-	-	-	-	-	-
DUST	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
Coal Transportation	-	-	-	-	-	-	-	-	-
Construction Operations	-	-	-	-	-	-	-	-	-
Mine Tailings	-	-	-	-	-	-	-	-	-
Paved Roads	-	-	-	-	-	-	-	-	-
Unpaved Roads	-	-	-	-	-	-	-	-	-
FIRES	**9 800**	**2 000**	**1 200**	**2 000**	**880**	**3 600**	**2 900**	**2 400**	**1 400**
Prescribed Burning	9 800	2 000	1 200	2 000	880	3 600	2 900	2 400	1 400
Structural Fires	-	-	-	-	-	-	-	-	-
GRAND TOTAL	**360 000**	**250 000**	**170 000**	**140 000**	**150 000**	**140 000**	**120 000**	**110 000**	**110 000**

Notes:
Totals may not add up due to rounding.
- Indicates no emission
0.00 Indicates emissions truncated due to rounding

2.12. **Hexachlorobenzene (HCB)**

In 2017, approximately 8.1 kg of HCB were emitted in Canada (Table 2–14). Waste incineration was the largest contributor in 2017 with 61% (4.9 kg) of total HCB emissions. The ore and mineral industries were the second-largest contributor, with 29% (2.3 kg) of total emissions, largely attributed to iron and steel industries, which represented 13% (1.0 kg) of the national total.

Overall, a 92% (90 kg) decrease in HCB emissions occurred between 1990 and 2013; since 2013 HCB emissions have been stable (Figure 2–12). Most of the decrease is due to a drop in emissions from waste incineration since 1997, specifically as a result of a steady decline in the use of conical burners for municipal waste incineration in Newfoundland and Labrador (Newfoundland Municipal Affairs and Environment, 2017). Emission reductions were also observed as a result of the phasing out of coal electricity generation in Ontario between 2000 and 2014.[2]

The most significant changes in HCB emissions from 1990 to 2017 include:

- Incineration and waste : decrease of over 93% (68 kg), of which:
  - Waste incineration: decrease of over 93% (68 kg)
- Electric power generation (utilities) : decrease of 96% (11 kg), of which:
  - Coal (electricity power generation): decrease of 96% (10 kg)

2 See the End of Coal: https://www.ontario.ca/page/end-coal (accessed January 8, 2019).

Figure 2–12 **Major Contributors to National HCB Trends**

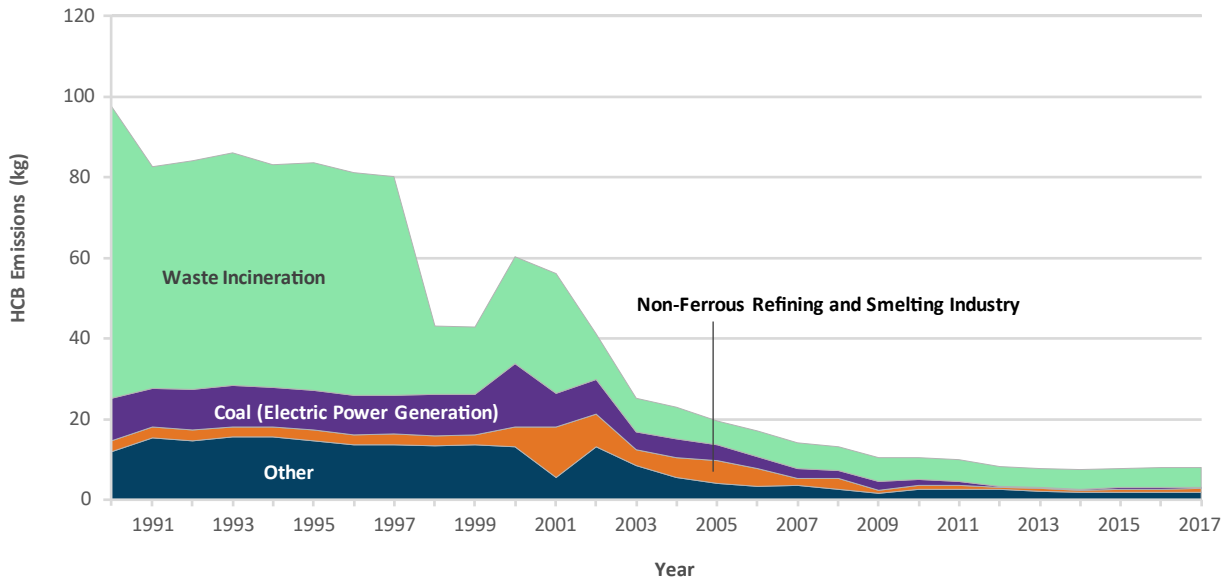

Table 2–14 National Summary of Annual HCB Emissions

Source	1990	2000	2005	2012	2013	2014	2015	2016	2017
	(g)								
ORE AND MINERAL INDUSTRIES	**5 500**	**8 100**	**8 100**	**2 500**	**2 300**	**1 900**	**2 100**	**2 300**	**2 300**
Aluminium Industry	-	-	-	-	-	-	-	-	-
Asphalt Paving Industry	-	-	-	-	-	-	-	-	-
Cement and Concrete Industry	1 600	2 100	880	420	420	280	290	410	300
Foundries	-	-	-	0.01	-	29	23	24	6.0
Iron and Steel Industry	1 100	980	1 500	1 400	1 100	1 100	1 100	1 000	1 100
Iron Ore Industry	-	-	-	-	-	-	-	-	-
Mineral Products Industry	-	-	-	-	-	-	-	-	-
Mining and Rock Quarrying	13	13	44	18	13	12	17	12	7.5
Non-Ferrous Refining and Smelting Industry	2 700	5 000	5 600	660	730	530	700	830	940
OIL AND GAS INDUSTRY	**1.3**	**1.6**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
Downstream Oil and Gas Industry	-	-	-	-	-	-	-	-	-
Upstream Oil and Gas Industry	1.3	1.6	-	-	-	-	-	-	-
ELECTRIC POWER GENERATION (UTILITIES)	**11 000**	**17 000**	**4 100**	**370**	**390**	**430**	**600**	**570**	**470**
Coal	10 000	16 000	3 900	200	190	240	430	430	360
Diesel	-	-	-	-	-	-	-	-	-
Natural Gas	640	1 300	170	140	140	140	150	120	84
Waste Materials	4.8	19	-	40	40	30	4.9	2.3	2.7
Other (Electric Power Generation)	-	190	-	-	25	23	16	17	16
MANUFACTURING	**8 600**	**8 200**	**1 500**	**460**	**330**	**360**	**350**	**280**	**350**
Abrasives Manufacturing	-	-	-	-	-	-	-	-	-
Bakeries	-	-	-	-	-	-	-	-	-
Biofuel Production	-	-	-	-	-	-	-	-	-
Chemicals Industry	680	330	480	-	-	-	-	-	-
Electronics	-	-	-	-	-	-	-	-	-
Food Preparation	-	2.9	3.0	-	-	-	-	-	-
Glass Manufacturing	-	-	-	-	-	-	-	-	-
Grain Industry	-	-	-	-	-	-	-	-	-
Metal Fabrication	450	470	52	350	230	290	210	190	240
Plastics Manufacturing	-	-	0.00	-	-	-	-	-	-
Pulp and Paper Industry	140	180	310	120	94	73	140	88	110
Textiles	-	-	-	-	-	-	-	-	-
Vehicle Manufacturing (Engines, Parts, Assembly, Painting)	7 000	6 700	-	-	-	-	-	-	-
Wood Products	340	580	610	-	1.7	-	-	-	-
Other (Manufacturing)	-	-	-	-	-	-	-	-	-
TRANSPORTATION AND MOBILE EQUIPMENT	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
Air Transportation	-	-	-	-	-	-	-	-	-
Heavy-Duty Diesel Vehicles	-	-	-	-	-	-	-	-	-
Heavy-Duty Gasoline Vehicles	-	-	-	-	-	-	-	-	-
Heavy-Duty LPG/NG Vehicles	-	-	-	-	-	-	-	-	-
Light-Duty Diesel Trucks	-	-	-	-	-	-	-	-	-
Light-Duty Diesel Vehicles	-	-	-	-	-	-	-	-	-
Light-Duty Gasoline Trucks	-	-	-	-	-	-	-	-	-
Light-Duty Gasoline Vehicles	-	-	-	-	-	-	-	-	-
Light-Duty LPG/NG Trucks	-	-	-	-	-	-	-	-	-
Light-Duty LPG/NG Vehicles	-	-	-	-	-	-	-	-	-
Marine Transportation	-	-	-	-	-	-	-	-	-
Motorcycles	-	-	-	-	-	-	-	-	-
Off-Road Diesel Vehicles and Equipment	-	-	-	-	-	-	-	-	-
Off-Road Gasoline/LPG/NG Vehicles and Equipment	-	-	-	-	-	-	-	-	-
Rail Transportation	-	-	-	-	-	-	-	-	-
Tire Wear and Brake Lining	-	-	-	-	-	-	-	-	-
AGRICULTURE	**-**	**-**	**-**	**1.2**	**1.2**	**1.2**	**1.1**	**1.1**	**1.0**
Animal Production	-	-	-	-	-	-	-	-	-
Crop Production	-	-	-	-	-	-	-	-	-
Fuel Use	-	-	-	1.2	1.2	1.2	1.1	1.1	1.0
COMMERCIAL / RESIDENTIAL / INSTITUTIONAL	**1.6**	**4.4**	**1.3**	**0.73**	**0.68**	**0.58**	**0.31**	**0.23**	**0.28**
Cigarette Smoking	-	-	-	-	-	-	-	-	-
Commercial and Institutional Fuel Combustion	0.11	3.0	0.01	-	-	-	-	-	-
Commercial Cooking	-	-	-	-	-	-	-	-	-
Construction Fuel Combustion	-	-	-	-	-	-	-	-	-
Home Firewood Burning	-	-	-	-	-	-	-	-	-
Human	-	-	-	-	-	-	-	-	-
Marine Cargo Handling	-	-	-	-	-	-	-	-	-
Residential Fuel Combustion	1.5	1.4	1.3	0.73	0.68	0.58	0.31	0.23	0.28
Service Stations	-	-	-	-	-	-	-	-	-
Other (Commercial / Residential / Institutional)	-	-	-	-	-	-	-	-	-
INCINERATION AND WASTE	**73 000**	**27 000**	**5 900**	**4 900**	**4 800**	**4 800**	**4 800**	**4 900**	**4 900**
Crematoriums	10	14	18	22	24	26	27	27	28
Waste Incineration	73 000	27 000	5 800	4 800	4 800	4 800	4 800	4 900	4 900
Waste Treatment and Disposal	0.49	260	99	3.6	3.8	0.71	0.15	0.09	0.09
PAINTS AND SOLVENTS	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
Dry Cleaning	-	-	-	-	-	-	-	-	-
General Solvent Use	-	-	-	-	-	-	-	-	-
Printing	-	-	-	-	-	-	-	-	-
Surface Coatings	-	-	-	-	-	-	-	-	-
DUST	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
Coal Transportation	-	-	-	-	-	-	-	-	-
Construction Operations	-	-	-	-	-	-	-	-	-
Mine Tailings	-	-	-	-	-	-	-	-	-
Paved Roads	-	-	-	-	-	-	-	-	-
Unpaved Roads	-	-	-	-	-	-	-	-	-
FIRES	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
Prescribed Burning	-	-	-	-	-	-	-	-	-
Structural Fires	-	-	-	-	-	-	-	-	-
GRAND TOTAL	**98 000**	**60 000**	**20 000**	**8 200**	**7 800**	**7 500**	**7 900**	**8 100**	**8 100**

Notes:
Totals may not add up due to rounding.
- Indicates no emission
0.00 Indicates emissions truncated due to rounding

3

KEY COMPONENTS OF THE AIR POLLUTANT EMISSIONS INVENTORY

The Air Pollutant Emissions Inventory (APEI) is a comprehensive and detailed inventory of air pollutant emissions in Canada, developed using two types of information:

- facility-reported data, consisting of emissions from relatively large industrial, commercial and institutional facilities; and
- in-house estimates, including diffuse sources and other sources that are too numerous to be accounted for individually, such as road and non-road vehicles, agricultural activities, construction, and solvent use.

The APEI is developed using many sources of information, procedures and emission estimation models. Emissions data reported by individual facilities to Environment and Climate Change Canada's (ECCC's) National Pollutant Release Inventory (NPRI) are supplemented with documented, science-based estimation tools to quantify total emissions. Together, these data sources provide a comprehensive overview of pollutant emissions across Canada.

A compilation framework has been developed that makes use of the best available data, while ensuring that there is no double-counting or omissions. Additional information on the inventory compilation process is provided in Annex 2.

3.1. Facility-Reported Emissions Data

Facility-reported emissions data generally refers to any stationary sources that emit pollutants through stacks or other equipment at specific locations. The major source of facility-reported data is the NPRI, Canada's legislated, publicly accessible inventory of pollutant releases (to air, water and land), disposals and transfers for recycling. The NPRI has provided facility-reported data on the 17 pollutants included in the APEI for more than 6,000 industrial and commercial facilities since 2002 and for 10 pollutants (polycyclic aromatic hydrocarbons [PAHs], heavy metals, dioxins and furans [D/F], hexachlorobenze [HCB] and ammonia [NH_3]) since 1994. Prior to 2002, facility-level emissions for the criteria air contaminants were collected and compiled by provincial, territorial and regional environmental authorities across Canada and provided to Environment and Climate Change Canada for compilation of the APEI.

Facility-reported data from the NPRI are used in the APEI without modifications, except when data quality issues are detected and not addressed during the quality control exercise. The NPRI reporting requirements and thresholds vary by pollutant and, in some cases, by industry. Details on these reporting requirements and thresholds are available on Environment and Climate Change Canada's website in the National Pollutant Release Inventory: https://www.canada.ca/en/environment-climate-change/services/national-pollutant-release-inventory/report.html.

A distinction has been made between reporting facilities and non-reporting facilities. Reporting facilities meet the threshold required to report to the NPRI; while non-reporting facilities do not meet the threshold due to their size or emission levels and are therefore not required to report to the NPRI. Some facilities may be required to report emissions on only certain pollutants. Therefore, emissions from the non-reporting facilities or of non-reported pollutants must be estimated in-house to ensure complete coverage.

3.2. In-house Emission Estimates

In-house estimates are calculated with information such as production data and activity data, using various estimation methodologies, emission models and emission factors.[1] These emission estimates are at the provincial, territorial and national level rather than at any specific geographic location. The estimates include emissions from non-industrial, residential, commercial, transportation, and other sources, such as open burning of waste, agricultural activities and construction operations. The APEI uses in-house estimates for the following emission sources:

- any residential, governmental, institutional, or commercial operation that does not report to the NPRI;

1 The U.S. EPA defines an emission factor as "…a representative value that attempts to relate the quantity of a pollutant released to the atmosphere with an activity associated with the release of that pollutant. These factors are usually expressed as the weight of pollutant divided by a unit weight, volume, distance, or duration of the activity emitting the pollutant (e.g., kilograms of particulate emitted per megagram of coal burned)."

- on-site solid waste disposal facilities;
- motor vehicles, aircraft, vessels or other transportation equipment or devices; and
- other sources, such as open burning of waste, agricultural activities and construction operations.

The in-house emission estimate methodologies and emission models used in Canada are often based on those developed by the United States Environmental Protection Agency (U.S. EPA) and are adapted to reflect the Canadian climate, fuels, technologies and practices. Methods used in Canada's APEI are therefore generally consistent with those used in the United States or those recommended in the emission inventory guidebook (EEA, 2016).

The APEI reports air pollutant emissions from mobile sources such as on-road vehicles, off-road vehicles and engines. For the current edition of the APEI, an emissions estimation model developed by the U.S. EPA (MOVES) was used (see "on-road vehicles" in Table A2–5 of Annex 2). The emissions for off-road vehicles and engines (such as graders, heavy trucks, outboard motors and lawnmowers) were estimated using the U.S. EPA's NONROAD emission estimation model (see "off-road vehicles and equipment" in Table A2–5 of Annex 2). The parameters in both models were modified to take into account variations in the Canadian vehicle fleet, emission control technologies, types of fuels, vehicle standards, and types of equipment engines and their application in various industries. The emission estimates for civil and international aviation, railways and navigation are estimated using detailed vehicle movement statistics coupled with fuel consumption, engine information, and emission rates by vehicle types.

3.3. Recalculations

Emission recalculation is an essential practice in the maintenance of an up-to-date air pollutant emission inventory. The APEI is continuously updated with improved estimation methodologies, statistics and more recent and appropriate emission factors. As new information and data become available, previous estimates are updated and recalculated to ensure a consistent and comparable trend in emissions. Recalculations of previously reported emission estimates are common for both in-house estimates and facility-reported emission data. More information on recalculations is provided in Annex 2.

3.4. Reconciliation

In several sectors, such as the upstream oil and gas industry, estimation of total emissions involves combining estimates provided by facilities with estimates developed in-house by Environment and Climate Change Canada. To prevent double counting of emissions and to confirm that the APEI includes all emissions, a comparison and reconciliation of emission estimates from various sources is performed for each pollutant, industry sector and geographical region, as appropriate. More information on the reconciliation process is provided in Annex 2.

4

DATA QUALITY CONTROL

Quality control for the inventory takes place in two phases. In Phase 1, quality control is performed on the most recently submitted National Pollutant Release Inventory (NPRI) facility-reported data, prior to inclusion of the data in the Air Pollutant Emissions Inventory (APEI). A summary of the process for the APEI is presented in Section 4.1.

Phase 2 of the quality control occurs after the facility-reported data and in-house estimates are compiled and reconciled to form the APEI. During Phase 2, emissions are verified on the basis of established criteria (a description of this process is provided in Section 4.2).

4.1. Phase 1: Emission Data from Facilities

The quality control process involves a system of documented activities and procedures performed by a dedicated team to identify data outliers, inconsistencies, missing data, inaccuracies and errors. It includes communications with facilities to resolve identified issues. The quality control process can be adapted so that category-specific or sector-specific quality control procedures are applied, as appropriate.

An essential part of the quality control exercise is to identify missing NPRI facility reports/reporters and the assessment of new reports/reporters, to ensure that the correct data are captured.

The identification of outliers (i.e. reports that significantly depart from comparable NPRI facility-reported data) is of critical importance to ensure the usability of the NPRI facility-reported data. Identification, facility follow-up and resolution of such issues are conducted at the earliest stage of the quality control review.

Potential outliers are defined as any NPRI facility report that:

- has a large year-over-year change, and/or
- contributes an unrealistically high proportion of the total reported quantity of an air pollutant in the current or previous reporting year

The quality control review includes analysis of:

- the impact of first-year reporting;
- substances that are no longer reported;
- substance reports with a large change in contribution/impact on the reported total;
- substance reports with identical reported quantities of an air pollutant within a five-year period;
- substance reports with significant variation over a five-year period; and
- facilities assigned to incorrect subsectors.

In the past, a common reporting error related to APEI pollutant reporting was the misreporting of the different-sized fractions of particulate matter (PM). Starting in 2013, data input checks have been implemented in the online data collection, which reduced the frequency of this type of error. Additional quality control checks were performed in 2018 on outstanding issues of particulate matter emissions.

Quality control checks are also performed on facility information. These checks include the verification of reported North American Industry Classification System (NAICS) codes, facility identification numbers and geographical information (i.e. city, province, address and latitude/longitude).

The quality control team continues to follow up on the few remaining unresolved issues, and any updates to the data will be reflected in the next inventory edition.

4.2. Phase 2: Compiled Air Pollutant Emission Inventory

The objective of Phase 2 of the quality control process is to identify and verify inconsistencies in the APEI at the subsector level. A series of verification and quality control checks are undertaken on the in-house emission estimates of the current year to ensure quality, accuracy and consistency. The following are verified:

- activity data;
- emission factors;
- unit conversions; and
- emission calculations.

Phase 2 of the quality control is carried out through the following measures for the compiled APEI:

- manual verification of the updated emissions data as they are entered in central APEI database; and
- comparison of the emissions to those of the previous year's inventory and to the previous year's trends.

The inventory data is reviewed, and any significant changes from year to year are identified and explained. Additionally, any significant changes in recalculated emissions are identified and explained.

4.3. Completeness

The reporting of substances by facilities to the NPRI remains the primary source of data collection on air pollutant emissions for Canada. Sectors with significant sources of facility-reported data (e.g. oil refineries, smelters) are well represented by emissions data from the NPRI.

The completeness of the APEI is assessed by the level of inclusion of all known, quantifiable sources of pollutant emissions in the provincial/territorial and national totals that are attributed to anthropogenic activities. Where NPRI facility-reported data does not provide for complete sector coverage, additional estimates are developed in-house by Environment and Climate Change Canada. An overall estimation of completeness in this case is related to the availability and reliability of activity data and compilation methodologies used for the in-house estimates.

The development of complementary in-house estimates is not required in sectors where NPRI facility data provides complete coverage of air pollutant emissions (e.g. pulp and paper). To produce a complete inventory of emissions, complementary in-house estimates are necessary for those sectors that have facilities not reporting to the NPRI because they do not meet the reporting threshold (e.g. upstream oil and gas industry, wood products facilities and foundries).

Other sources of air pollutants, such as residential fuel combustion, transportation or fires, are not subject to reporting to the NPRI, and coverage is assured solely through the calculation of in-house emission estimates for these sources.

Although all major sources of air pollutant emissions are included in the APEI, a number of sources are not included in the national inventory, such as the burning of agricultural wastes and demolition activities in the construction industry.

ANNEX 1

DEFINITIONS OF THE AIR POLLUTANTS

This annex provides definitions for the 17 air pollutants inventoried by the Air Pollutant Emissions Inventory (APEI). Chapter 2 summarizes the air emissions of these air pollutants from various sectors.

A1.1. Criteria Air Contaminants

Particulate Matter (PM)

PM consists of microscopic solid and liquid particles of various origins that remain suspended in air for any length of time. PM includes a broad range of chemical species, such as elemental carbon and organic carbon compounds, oxides of silicon, aluminium and iron, trace metals, sulphates, nitrates and ammonia (NH_3). It is ubiquitous, being emitted from both natural and anthropogenic (human) sources. Emissions of fine PM ($PM_{2.5}$) and its precursor gases originate typically from combustion processes—motor vehicles, industrial processes, vegetative burning and crop production.

Total Particulate Matter (TPM)

TPM includes any PM with a diameter less than 100 microns.[1]

Particulate Matter Less Than or Equal to 10 Microns (PM_{10})

PM_{10} includes any PM with a diameter less than or equal to 10 microns.[2]

Particulate Matter Less Than or Equal to 2.5 Microns ($PM_{2.5}$)

$PM_{2.5}$ includes any PM with a diameter less than or equal to 2.5 microns.

Sulphur Oxides (SO_x)

SO_x are a family of gases that consist mostly of sulphur dioxide (SO_2), a colourless gas. It can be chemically transformed into acidic pollutants, such as sulphuric acid and sulphates (sulphates are a major component of ambient fine particles). SO_2 is generally a by-product of industrial processes and the burning of fossil fuels, with the main contributors being ore smelting, coal-fired power generators and natural gas processing. SO_2 transformed to sulphuric acid is the main ingredient of acid rain, which can damage crops, forests and ecosystems.

Nitrogen Oxides (NO_x)

NO_x include nitrogen dioxide (NO_2) and nitrogen oxide (NO), both of which are reported as NO_2 equivalent. NO_x reacts photochemically with volatile organic compounds (VOCs) in the presence of sunlight to form ground-level ozone. It can transform into ambient PM (nitrate particles) and is a component of acid rain. NO_x originate from both anthropogenic and natural sources. The main anthropogenic sources are mobile (on-road vehicles), electric power generation and the upstream petroleum industry, and the main natural sources are lightning and soil microbial activity.

Volatile Organic Compounds (VOCs)

VOCs are organic compounds containing one or more carbon atoms that evaporate readily to the atmosphere and react photochemically to form ground-level ozone.[3] VOCs may condense in the atmosphere to contribute to ambient PM formation. Besides biogenic sources (e.g. vegetation), other major sources include the petroleum industry, mobile sources and solvent use. Some VOCs, such as formaldehyde and benzene, are carcinogenic.

Carbon Monoxide (CO)

CO is an odourless gas that, when inhaled, reduces the body's ability to use oxygen. It participates to a small degree in the formation of ground-level ozone. The principal human source of CO is combustion, primarily from mobile sources (on-road vehicles). Ambient CO concentrations are much higher in urban areas due to the larger number of human sources.

1 TPM includes PM_{10} and $PM_{2.5}$

2 PM_{10} includes $PM_{2.5}$

3 Environment and Climate Change Canada's definition of VOCs can be found in the *Canada Gazette,* Part II. Statutory Instruments. Vol. 137, No. 14 http://www.gazette.gc.ca/rp-pr/p2/2003/2003-07-02/pdf/g2-13714.pdf

Ammonia (NH_3)

Gaseous NH_3, which originates from anthropogenic sources, has been identified as one of the principal precursors to $PM_{2.5}$. Major sources of NH_3 emissions include agricultural fertilizer use, agricultural livestock and synthetic fertilizer manufacturing.

A1.2. Selected Heavy Metals

Lead (Pb)

Pb occurs naturally in the Earth's crust. It is declared toxic under the *Canadian Environmental Protection Act, 1999* (CEPA) and is used extensively in industry to manufacture products such as lead-acid batteries and radiation shields. Metals processing is the major source of Pb emissions to air, with the highest levels of Pb air emissions originating from the non-ferrous smelting and refining industry.

Cadmium (Cd)

Cd, declared toxic under CEPA, is present in the air as a result of anthropogenic activities and natural processes. The largest anthropogenic source is metal production (particularly base-metal smelting and refining).

Mercury (Hg)

Hg is declared toxic under CEPA. Its unique properties are utilized to produce various consumer products, such as fluorescent lights. When Hg is released to the atmosphere, it can be transported on wind currents, deposited onto land and re-emitted into the atmosphere several times.

A1.3. Persistent Organic Compounds

Dioxins and Furans (D/F)

Dioxins and furans are a family of toxic compounds that vary widely in toxicity. Both dioxin and furan "congeners" are expressed in terms of toxic equivalents (TEQs) to the most toxic form of dioxin: 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD). The largest source of dioxins and furans in Canada is the burning of municipal and medical waste. Other major sources include the production of iron and steel, backyard burning of household waste, and fuel combustion for transportation and home heating.

Polycyclic Aromatic Hydrocarbons (PAHs)

PAHs are a group of organic compounds emitted to the Canadian environment from natural and anthropogenic sources. Comprehensive air emissions information is available for the following four PAHs: benzo[a]pyrene, benzo[b]fluoranthene, benzo[k]fluoranthene and indeno[1,2,3-cd]pyrene. National Pollutant Release Inventory facility-reported data are available for additional PAHs. The largest anthropogenic sources of PAHs released to the atmosphere are residential wood heating and aluminium smelters.

Hexachlorobenzene (HCB)

HCB is a persistent organic pollutant that is released in trace amounts as a by-product of the manufacture and use of chlorinated solvents and pesticides through long-range transport and deposition, incineration, and other industrial processes.

ANNEX 2

INVENTORY DEVELOPMENT

A2.1. Overview of the Compilation Process

The process of compiling emission estimates for the Air Pollutant Emissions Inventory (APEI) consists of developing in-house estimates, categorizing facility-reported data and, where necessary, reconciling the in-house estimates and the facility-reported data in a central database (Figure A2–1).

First, facility-reported data are compiled with the extraction of National Pollutant Release Inventory (NPRI) facility and emissions data from the verified NPRI database. New facilities are identified in the extracted data and classified among the APEI sector and subsector categories according to the nature of their activities. A quality control process is performed on the point source data prior to its inclusion in the APEI. A summary of this quality control process is presented in Chapter 4. A list of the facility-reported data is then produced and transferred to a central APEI database.

In-house estimates are based on documented estimation methodologies, periodically reviewed and updated through literature searches, the collection and analysis of recent emission factors and activity data, and comparisons with alternative sources of information. Improvements to methods or data are implemented as appropriate, and estimates may be recalculated for part of or across the entire time series. Updated estimates are calculated using new and/or updated activity data. Calculations are typically performed in spreadsheets or database-driven emission models.

The next step in the compilation process is the elimination of any double-counting of emissions between the in-house estimates and the facility-reported data by a process of reconciliation. Reconciliation of the in-house estimates with the facility-reported data is required for sectors or subsectors when both in-house and facility-reported estimates exist (Table A2–1). For 2017, reconciliation was performed for about 25 sectors. More information on reconciliation is available in section A2.5.1.

The final steps in the compilation process involve aggregating all reconciled data in the central database to produce draft emissions summaries for quality assurance/control and consultation purposes. The final emissions database is also used to generate the emissions tables required to fulfill Canada's international and domestic reporting obligations.

A2.2. In-House Estimates

The compilation of in-house estimates relies on information such as production data or activity levels for each sector. Calculations of in-house estimates are based on the latest data available at the time of compilation. When possible, the data are updated each year.

Table A2–1 lists the sectors and subsectors of the APEI for which emissions are based on in-house estimates and provides the activity data year on which the 2017 in-house estimate is based.

The in-house emissions estimation methodologies and emission models used in Canada are generally based on those developed by the United States Environmental Protection Agency (U.S. EPA) and adapted to utilize Canadian data, thereby accounting for differences

in climate, fuels, technologies and practices. Methods used in Canada's APEI are therefore generally consistent with those used in the United States or those recommended in the *EMEP/EEA Air Pollutant Emission Inventory Guidebook* (EEA, EMEP/EEA, 2016).

Tables A2–2 through A2–12 summarize, for each source category, the in-house estimation methodologies for the entire time series. For each source category, these tables provide a short description of:

- the emission sources and pollutants covered;
- the general inventory approach; and
- references for the activity data, emission factors and/or emission models.

Figure A2–1 **Overview of the Annual Air Pollutant Emissions Inventory Compilation Process**

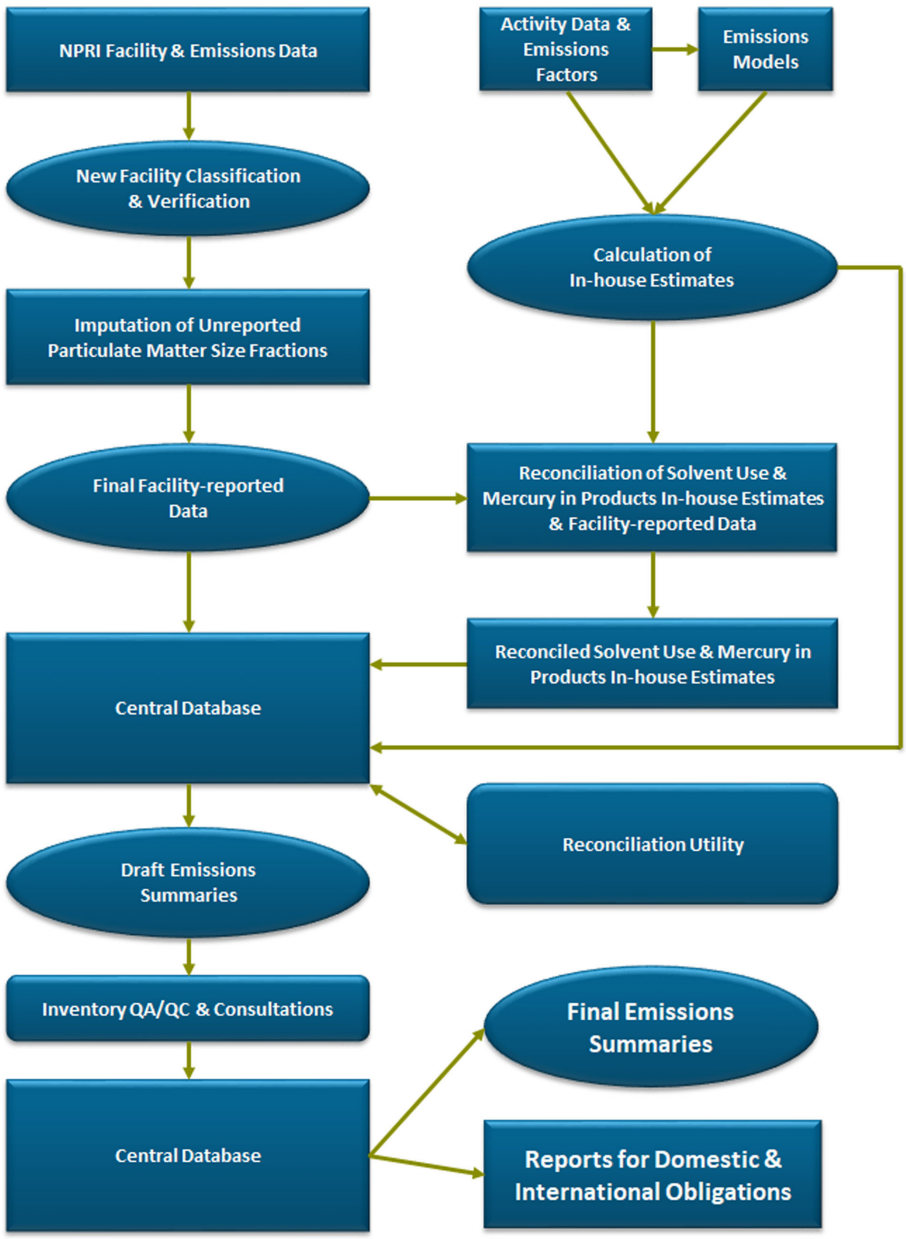

Table A2–1 2017 Air Pollutant Emissions Inventory

Air Pollutant Emissions Inventory sectors	Facility-reported data[a]	In-house estimates[b]	Activity data used for in-house estimates
ORE AND MINERAL INDUSTRIES			
Aluminium Industry			
Alumina (Bauxite Refining)	✓		
Primary Aluminium Smelting and Refining	✓		
Secondary Aluminium Production (Includes Recycling)	✓		
Asphalt Paving Industry	✓	✓	2015
Cement and Concrete Industry			
Cement Manufacturing	✓		
Concrete Batching and Products	✓	✓	2017
Gypsum Product Manufacturing	✓		
Lime Manufacturing	✓		
Foundries			
Die Casting	✓		
Ferrous Foundries	✓	✓	2011
Non-ferrous Foundries	✓		
Iron and Steel Industry			
Primary (Blast Furnace and DRI)	✓		
Secondary (Electric Arc Furnaces)	✓	✓	2017 (Hg in Products)
Steel Recycling	✓	✓	2017 (Hg in Products)
Other (Iron and Steel Industry)		✓	2006
Iron Ore Industry			
Iron Ore Mining	✓		
Pelletizing	✓		
Mineral Products Industry			
Clay Products	✓		
Brick Products	✓		
Other (Mineral Products Industry)	✓		
Mining and Rock Quarrying			
Coal Mining Industry	✓		
Metal Mining	✓		
Potash	✓		
Rock, Sand and Gravel	✓	✓	2017
Silica Production		✓	2017
Limestone	✓		
Other (Mining and Rock Quarrying)	✓		
Non-Ferrous Refining and Smelting Industry			
Primary Ni, Cu, Zn, Pb	✓		
Secondary Pb, Cu	✓		
Other (Non-Ferrous Refining and Smelting Industry)	✓		
OIL AND GAS INDUSTRY			
Downstream Oil and Gas Industry			
Petroleum Refining	✓		
Refined Petroleum Products Bulk Storage and Distribution	✓	✓	2016
Refined Petroleum Product Pipelines	✓		
Natural Gas Distribution	✓	✓	2016
Other (Downstream Oil and Gas Industry)	✓		
Upstream Oil and Gas Industry			
Accidents and Equipment Failures		✓	2017
Disposal and Waste Treatment		✓	2017
Heavy Crude Oil Cold Production		✓	2017
Light/Medium Crude Oil Production[c]	✓	✓	2017
Natural Gas Production and Processing[d]	✓	✓	2017
Natural Gas Transmission and Storage	✓	✓	2016
Oil Sands In-Situ Extraction	✓	✓	2017
Oil Sands Mining, Extraction and Upgrading	✓		
Petroleum Liquids Storage	✓		
Petroleum Liquids Transportation		✓	2017
Well Drilling/Servicing/Testing		✓	2017
ELECTRIC POWER GENERATION (UTILITIES)			
Coal	✓		
Diesel	✓		
Natural Gas	✓		
Waste Materials	✓		
Other (Electric Power Generation)	✓		
MANUFACTURING			
Abrasives Manufacturing	✓		
Bakeries	✓	✓	2017
Biofuel Production	✓		
Chemicals Industry			
Chemical Manufacturing	✓		
Cleaning Compound Manufacturing	✓		
Fertilizer Production	✓		
Paint and Varnish Manufacturing	✓		
Petrochemical Industry	✓		
Plastics and Synthetic Resins Fabrication	✓		
Other (Chemical Industry)	✓		
Electronics	✓	✓	2017 (Hg in Products)
Food Preparation	✓		
Glass Manufacturing	✓		
Grain Industry			
Grain Processing	✓	✓	2017
Warehousing and Storage	✓		2017
Metal Fabrication	✓		

Table A2–1 **2017 Air Pollutant Emissions Inventory** (cont'd)

APEI Sectors	Facility-reported Data (NPRI)[a]	In-house Estimates (Estimated by ECCC)	Activity Data Used for In-house Estimates
Plastics Manufacturing	✓		
Pulp and Paper Industry			
Pulp and Paper Product Manufacturing	✓	✓	2006
Converted Paper Product Manufacturing	✓		
Textiles	✓		
Vehicle Manufacture (Engines, Parts, Assembly, Painting)	✓		
Wood Products[e]			
Panel Board Mills	✓	✓	2017
Sawmills	✓	✓	2017
Other (Wood Products)	✓		
Other (Manufacturing)	✓	✓	2008, 2017 (Hg in Products)
TRANSPORTATION AND MOBILE EQUIPMENT			
Air Transportation		✓	2017
Heavy-duty Diesel Vehicles		✓	2017
Heavy-duty Gasoline Vehicles		✓	2017
Heavy-duty LPG/NG Vehicles		✓	2017
Light-duty Diesel Trucks		✓	2017
Light-duty Diesel Vehicles		✓	2017
Light-duty Gasoline Trucks		✓	2017
Light-duty Gasoline Vehicles		✓	2017
Light-duty LPG/NG Trucks		✓	2017
Light-duty LPG/NG Vehicles		✓	2017
Marine Transportation		✓	2015
Motorcycles		✓	2017
Off-road Diesel Vehicles and Equipment		✓	2017
Off-road Gasoline/LPG/NG Vehicles and Equipment		✓	2017
Rail Transportation		✓	2017
Tire Wear and Brake Lining		✓	2017
AGRICULTURE			
Animal Production		✓	2017
Crop Production			
Fertilizer Application		✓	2017
Harvesting		✓	2017
Tillage Practices		✓	2017
Wind Erosion		✓	2017
Fuel Use	✓	✓	2014
COMMERCIAL / RESIDENTIAL / INSTITUTIONAL			
Cigarette Smoking		✓	2017
Commercial and Institutional Fuel Combustion	✓	✓	2017
Commercial Cooking		✓	2016
Construction Fuel Combustion		✓	2017
Home Firewood Burning		✓	2017
Human[f]		✓	2017
Marine Cargo Handling	✓		
Residential Fuel Combustion		✓	2014
Service Stations		✓	2017
Other (Commercial / Residential / Institutional)[g]		✓	2008
INCINERATION AND WASTE			
Crematoriums	✓	✓	2017
Waste Incineration			
Industrial and Commercial Incineration		✓	2011
Municipal Incineration	✓	✓	2017
Residential Waste Burning[h]		✓	2016
Other (Waste Incineration)		✓	2017
Waste Treatment and Disposal			
Landfills	✓	✓	2014
Municipal Wastewater Treatment and Discharge	✓		
Specialized Waste Treatment and Remediation	✓		
Biological Treatment of Waste	✓		
Waste Sorting and Transfer	✓		
PAINTS AND SOLVENTS			
Dry Cleaning	✓	✓	2016
General Solvent Use		✓	2016
Printing	✓	✓	2016
Surface Coatings	✓	✓	2016
DUST			
Coal Transportation		✓	2015
Construction Operations		✓	2012
Mine Tailings		✓	2006
Paved Roads		✓	2002
Unpaved Roads	✓	✓	2002
FIRES			
Prescribed Burning		✓	2015
Structural Fires		✓	2017
Mercury in Products[i]		✓	2017

Notes:

✓ denotes yes

a. All facility-reported data were obtained from the NPRI Reporting Year 2017.

b. Estimated by ECCC

c. Facility-reported data consists of facilities located in Atlantic Canada. For other provinces, it consists of in-house estimates.

d. Facility-reported data consists of facilities located in Atlantic Canada and SO_2 emissions from Alberta's natural gas processing facilities.

e. In-house estimates for Wood Products were estimated by the Forestry Products group of the Environmental Stewardship Branch at ECCC. All other in-house estimates were estimated by PIRD.

f. Ammonia emissions from infant-diapered waste, which were previously reported under Other (Commercial / Residential / Institutional), are now reported under the Human sector.

g. Emissions reported under Other (Commercial / Residential / Institutional) are from breakage, transport and recycling of mercury-containing products using the Hg in Products Methodology. Products include: automotive mercury switches, batteries, dental amalgams, fluorescent lamps, fungicides, measurement and control devices, non-fluorescent lamps, switches and relays, thermometers, thermostats and tire balancers.

h. Hg in Products estimates for Residential Waste Burning are not estimated after 2008 as a result of the updates for the Hg in Products models.

i. Emissions from Hg-containing products were calculated as a separate inventory. Emissions are reported under many sectors such as Iron and Steel Industry, Municipal Incineration, Human, Other (Commercial / Residential / Institutional) and Landfills. All in-house estimates for Hg in product emissions continue to be estimated and reported under these sectors.

Table A2–2 **Estimation Methodologies for Ore and Mineral Industries**

Sector/Subsector	
ASPHALT PAVING INDUSTRY	
Description	Asphalt Paving Industry consists of emissions released during asphalt concrete (or hot-mix asphalt) manufacturing and application. Asphalt concrete manufacturing includes the heating and mixing of asphaltic cement with a mixture of graded aggregates. The sector applies to both permanent or portable hot-mix asphalt installations.
General Inventory Method	Pollutant(s) estimated: TPM, PM_{10}, $PM_{2.5}$, SO_x, NO_x, VOCs, CO, Pb, Cd, Hg, dioxins/furans, B(a)p, B(b)f, B(k)f, I(cd)p Total usage of asphalt by province/territory is multiplied by pollutant-specific emission factors.
Activity Data	Cutback and emulsion asphalt data to calculate VOC emissions from paving process: (SNC/GECO Canada Inc. & Ontario Research Foundation, 1981) Asphalt usage data from construction: (Statistics Canada, RESD, n.d.)
Emission Factors (EF)	TPM, PM_{10}, $PM_{2.5}$, SO_x, NO_x, VOCs, CO, Pb, Cd, Hg, dioxins/furans, B(a)p, B(b)f, B(k)f, I(cd)p: (Senes Consultants, 2008) VOCs from paving: (SNC/GECO Canada Inc. & Ontario Research Foundation, 1981)
CONCRETE BATCHING AND PRODUCTS (under CEMENT AND CONCRETE INDUSTRY)	
Description	Concrete Batching and Products include emissions produced by activities at concrete batching plants. Concrete is composed essentially of water, cement, fine aggregate (i.e. sand) and coarse aggregate (i.e. gravel, crushed stone or iron blast furnace slag). Concrete batching plants store, convey, measure and discharge these constituents into trucks for transport to a construction site or process, for use in the manufacturing of concrete pipe, concrete blocks, etc.
General Inventory Method	Pollutant(s) estimated: TPM, PM_{10}, $PM_{2.5}$, Pb, Cd Total usage of cement by province/territory (using national data with a provincial/territory population distribution) is multiplied by pollutant-specific emission factors.
Activity Data	Cement consumption distribution for the provinces: (CANMET, 1993) Cement production and export data: (Statistics Canada, Table 16-10-0009-01, 2017) Population data for the provinces: (Statistics Canada, Table 051-0001, n.d.)
Emission Factors (EF)	TPM, PM_{10}, $PM_{2.5}$, Pb, Cd: (U.S. EPA, *Compilation of Air Pollutant Emission Factors*, Volume I: Stationary Point and Area Sources, 1998; U.S. EPA, PM Calculator, 2010) Emission factors for TPM, PM_{10} and $PM_{2.5}$ emitted by loading mixers and loading trucks: (U.S. EPA, *Compilation of air pollutant emission factors*, Volume I: Stationary point and area sources, 2006). PM_{10} and $PM_{2.5}$ emission factors for sand and aggregate transfer are derived from a weighted combination of TPM emission factors, using information from the U.S. EPA's PM Calculator database (U.S. EPA, PM Calculator, 2010) (using SCC 30501101): $EF_{PM10}=0.51*EF_{TPM}$ $EF_{PM2.5}=0.15*EF_{TPM}$
FERROUS FOUNDRIES (under FOUNDRIES)	
Description	Ferrous Foundries include facilities that produce castings of various types of ferro-alloys, as well as small iron and steel foundries not associated with integrated iron and steel facilities. The types of foundries found in Canada include open ferrous, electric arc and induction foundries.
General Inventory Method	Pollutant(s) estimated: TPM, PM_{10}, $PM_{2.5}$, SO_x, NO_x, VOCs, CO Methodology under review. The in-house estimates were last calculated for 2011 and were carried forward to 2017.
Activity Data	Methodology under review.
Emission Factors (EF)	Methodology under review.
ROCK, SAND AND GRAVEL (under MINING AND ROCK QUARRYING)	
Description	Rock, Sand and Gravel encompasses emissions from rock quarrying, stone processing, and sand and gravel operations. Rock quarrying activities typically include: 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. Stone processing is categorized into three activities, depending on the size of stone required: crushed stone, pulverized stone and building stone. Sand and gravel deposits are quarried, transported to the plant, and then classified and stockpiled. Processing is accomplished by crushing, screening, washing, blending and stockpiling materials according to product specifications. Products are used for road construction, as an aggregate for asphalt and concrete, and for other construction purposes such as fill and mortar sand. Sand is also used in the glassmaking, foundry and abrasives industries.
General Inventory Method	Pollutant(s) estimated: TPM, PM_{10}, $PM_{2.5}$ Total quantity of rock, sand and gravel produced by province/territory is multiplied by pollutant-specific emission factors.
Activity Data	*Annual Statistics, Mineral Production of Canada, by Province and Territory*, (NRCan, *Minerals and mining statistics on-line: Mineral production of Canada by province and territory,* 2017).
Emission Factors (EF)	TPM, PM_{10}, $PM_{2.5}$: (EEA, EMEP/EEA, 2013)

Table A2–2 **Estimation Methodologies for Ore and Mineral Industries** (cont'd)	
Sector/Subsector	
SILICA PRODUCTION (under MINING AND ROCK QUARRYING)	
Description	Silica Production applies to silica sand quarrying and processing mainly for the glass and refining and smelting industries. Industrial sand processing operations are similar to those of construction sand production, with dust emissions originating mainly from crushing and screening operations, especially when grinding to very fine particle sizes. Dry or wet screening and air classification may be carried out to achieve the desired size distribution. Both wet and dry methods of dust control are used, and baghouses are commonly used.
General Inventory Method	Pollutant(s) estimated: TPM, PM_{10}, $PM_{2.5}$ Total quantity of silica produced by province/territory is multiplied by pollutant-specific emission factors.
Activity Data	Annual mineral production: (NRCan, *Minerals and mining statistics on-line: Mineral production of Canada by province and territory*, 2017) Confidential provincial production values are estimated with population distributions: (Statistics Canada, Table 051-0001, n.d.)
Emission Factors (EF)	TPM, PM_{10}, $PM_{2.5}$: (EEA, EMEP/EEA, 2013)

Table A2–3 **Estimation Methodologies for the Oil and Gas Industry**	
Sector/Subsector	
REFINED PETROLEUM PRODUCTS BULK STORAGE AND DISTRIBUTION (under DOWNSTREAM OIL AND GAS INDUSTRY)	
Description	Refined Petroleum Products Bulk Storage and Distribution covers fugitive VOC emissions from bulk distribution terminals and bulk plants. It includes volatile components of fuels that are emitted as fuel moves from the refinery to the end user whenever tanks are filled or emptied or while tanks are open to the atmosphere, be they large above-ground tanks, tank trucks, or railcars. In addition, the subsector includes emissions that occur from the evaporation of fuels spilled during transfer operations. Only fugitive VOC emissions from bulk plants are estimated in-house.
General Inventory Method	Pollutant(s) estimated: VOCs Emissions are calculated using the gross sales of gasoline for on-road motor vehicles multiplied by emission factors developed by (Tecsult Inc, 2006)
Activity Data	Gross sales of gasoline for motor vehicles: (Statistics Canada, RESD, n.d.)
Emission Factors (EF)	Study on gasoline vapour recovery in Stage 1 distribution networks in Canada: (Tecsult Inc, 2006)
NATURAL GAS DISTRIBUTION (under DOWNSTREAM OIL AND GAS INDUSTRY)	
Description	Natural Gas Distribution includes emissions from all infrastructure used to receive high-pressure natural gas from transmission pipelines and then reduce the pressure for distribution to end users. This sector consists of distribution pipelines (distribution mains and service lines) and measurement and regulation stations, up to and including customer meters. Emissions from related construction activities, ancillary structures and operations (buildings, offices, etc.), and mobile sources are included under the Construction Operations, Commercial and Institutional Fuel Combustion, and Transportation and Mobile Equipment sources (respectively) of the APEI.
General Inventory Method	Pollutant(s) estimated: TPM, PM_{10}, $PM_{2.5}$, SO_x, NO_x, VOCs, CO, NH_3 Emission estimates are generated using data from comprehensive inventories (EC, *Technical report on Canada's upstream oil and gas industry*, 2014; CAPP, *A national inventory of GHG, CAC and H_2S emissions by the upstream oil and gas industry*, 2005) and extrapolated (CAPP, *Extrapolation of the 2000 UOG emission inventory to 2001, 2002 and 2003*, 2005) from 2012 onwards based on pipeline length.
Activity Data	Gas Pipeline Distance, by province[1]
Emission Factors (EF)	(EC, *Technical report on Canada's upstream oil and gas industry*, 2014)
NATURAL GAS TRANSMISSION AND STORAGE (under UPSTREAM OIL AND GAS INDUSTRY)	
Description	Natural Gas Transmission includes emissions from all infrastructure used to transport pipeline quality natural gas to local distribution companies. This sector consists of large diameter pipelines, compressor stations and metering facilities. Natural Gas Storage includes emissions from all infrastructure used to store natural gas produced during off-peak times (i.e. summer) for delivery during peak demand periods (i.e. winter). Gas is stored in spent production fields, aquifers or salt caverns with facilities consisting of piping, meters, compressor stations and dehydrators. Emissions from midstream services (e.g. straddle plants) and gas plants are included under Natural Gas Production and Processing. Emissions from related construction activities, ancillary structures and operations (buildings, offices, etc.) and mobile sources are included under the Construction Operations, Commercial and Institutional Fuel Combustion, and Transportation and Mobile Equipment sources (respectively) of the APEI.
General Inventory Method	Pollutant(s) estimated: TPM, PM_{10}, $PM_{2.5}$, SO_x, NO_x, VOCs, CO, NH_3 Emission estimates are generated using data from comprehensive inventories (EC, *Technical report on Canada's upstream oil and gas industry*, 2014; CAPP, *A national inventory of GHG, CAC and H_2S emissions by the upstream oil and gas industry,* 2005) and extrapolated (CAPP, *Extrapolation of the 2000 UOG emission inventory to 2001, 2002 and 2003*, 2005) from 2012 onwards. Natural gas transmission emissions are extrapolated based on pipeline length, while natural gas storage emissions are extrapolated based on annual volumes of gas injected and withdrawn.
Activity Data	Gas Pipeline Distance, by province[2] Natural gas injections to storage and withdrawals from storage (Statistics Canada, Table 25-10-0057-01, n.d.)
Emission Factors (EF)	(EC, *Technical report on Canada's upstream oil and gas industry*, 2014)

1 Statistics Canada, Personal communication (email from da Silva D. [Environment, Energy, and Transportation Statistics Division, Statistics Canada] to Smyth S, [Pollutant Inventories and Reporting Division, Environment and Climate Change Canada], dated 2018 Oct 2), 2018

2 Statistics Canada, Personal communication (email from da Silva D [Environment, Energy, and Transportation Statistics Division, Statistics Canada] to Smyth S, [Pollutant Inventories and Reporting Division, Environment and Climate Change Canada], dated 2018 Oct 2), 2018

Table A2–3 **Estimation Methodologies for the Oil and Gas Industry** (cont'd)	
Sector/Subsector	
UPSTREAM OIL AND GAS INDUSTRY	
Description	Upstream Oil and Gas Industry includes emissions from all infrastructure used to locate, extract, produce, process/treat and transport natural gas, crude oil (light/medium oil, heavy oil, crude bitumen), liquefied petroleum gas (LPG) and condensate to market. It also includes emissions from onshore and offshore facilities, as well as drilling and exploration, conventional oil and gas production, open pit mining and in situ oil sands production, natural gas processing and oil transmission. Specifically, it includes the following subsectors: • Accidents and Equipment Failures • Disposal and Waste Treatment • Heavy Crude Oil Cold Production • Light Medium Crude Oil Production • Natural Gas Production and Processing • Oil Sands In-Situ Extraction • Petroleum Liquids Transportation • Well Drilling/Servicing/Testing Emissions from related construction activities, ancillary structures and operations (buildings, offices, etc.), and mobile sources are included under the Construction Operations, Commercial and Institutional Fuel Combustion, and Transportation and Mobile Equipment sources (respectively) of the APEI.
General Inventory Method	Pollutant(s) estimated: TPM, PM_{10}, $PM_{2.5}$, SO_x, NO_x, VOCs, CO, NH_3 Emission estimates are generated using data from comprehensive inventories (EC, *Technical report on Canada's upstream oil and gas industry, 2014*; CAPP, *A national inventory of GHG, CAC and H_2S emissions by the upstream oil and gas industry, 2005*) and are extrapolated (CAPP, *Extrapolation of the 2000 UOG emission inventory to 2001, 2002 and 2003, 2005*) from 2012 onwards using various provincial-level activity data.
Activity Data	(EC, *Technical report on Canada's upstream oil and gas industry, 2014*; AER, *Upstream petroleum industry flaring and venting report, 2018*; AER, *Alberta Energy Resource Industries Monthly Statistics, Gas Supply and Disposition, 2018*; AER, *Alberta's energy reserves and supply/demand outlook, 2018*; AER, *VPR6800 Supply and disposition of gas (economics), 2018*; AER, *AER Compliance Dashboard – Incidents, 2018*; BC, 2018; BCOGC, 2018; *CAPP, Statistical handbook for Canada's upstream petroleum industry, 2018*; CNLOPB, *Production summary by well – Hebron, 2018*) (CNLOPB, *Production summary by well – Hibernia, 2018*; CNLOPB, *Production summary by well – Terra Nova, 2018*; CNLOPB, *Production summary by well – White Rose, 2018*; CNLOPB, *Production summary by well – North Amethyst, 2018*; CNLOPB, *Environment statistics: Spill frequency and volume annual summary, 2018*) (MB, 2018; NBERD, 2017; *SK MOE, 2017 crude oil volume and value summary*, 2018; SK MOE, *2017 natural gas volume and value summary*, 2018; SK MOE, *Saskatchewan fuel, flare and vent, 2018*; SK MOE, *Saskatchewan upstream oil and gas IRIS incident report, 2018*) (Statistics Canada, Table 25-10-0055-01, n.d.; Statistics Canada, Table 25-10-0047-01, n.d.; Statistics Canada, Table 25-10-0063-01, n.d.; Statistics Canada, Table 25-10-0014-01, n.d.). In addition to the extrapolated estimates, the SO_x estimates for Alberta Natural Gas Processing are adjusted to account for regulations that were developed after the model was originally created. The adjustments are made with both historical provincial data and NPRI data up to 2005. From 2006 onwards, NPRI data for Alberta SO_x emissions from gas plants are used due to the complete facility coverage. NPRI data for the Atlantic provinces are used in place of the model estimates due to the complete facility coverage for the region. Additionally, extrapolated estimates for the Oil Sands In-Situ Extraction facilities are reconciled with NPRI data to eliminate double-counting. NPRI data for Oil Sands Mining, Extraction and Upgrading are used due to the complete facility coverage of the subsector.
Emission Factors (EF)	(EC, *Technical report on Canada's upstream oil and gas industry, 2014*)

Table A2–4 **Estimation Methodologies for Manufacturing**	
Sector/Subsector	
BAKERIES	
Description	Bakeries release VOCs during the leavening process of industrial baking. Emissions from products leavened by baking powder (used mainly for pastries) are negligible, but VOCs are released when yeast is used for leavening. Yeast is used nearly exclusively in the production of bread and bread-like pastries.
General Inventory Method	Pollutant(s) estimated: VOCs Total quantity of wheat flour available per person is multiplied by population, the fraction of flour use in yeast-leavened baked goods, ratio of product to flour ratio, and an emission factor for VOCs.
Activity Data	Bread production values are estimated using: • National wheat flour available: (Statistics Canada, Table 32-10-0054-01, 2017) • Population data for provinces and territories: (Statistics Canada, Table 051-0001, n.d.) • Fraction of flour use in yeast-leavened baked goods and ratio of product to flour ratio: (Cheminfo Services, *Survey of small and medium commercial baking establishments to estimate average VOC emission factors*, 2005)
Emission Factors (EF)	(Cheminfo Services, *Survey of small and medium commercial baking establishments to estimate average VOC emission factors*, 2005) EF_{VOC} = 2.35 kg per tonne of baked goods
GRAIN INDUSTRY	
Description	Grain Industry covers emissions from grain elevators. Grain elevators are divided into four groups in the APEI: **Primary elevators** receive grain by truck from producers for either storage or forwarding. These elevators sometimes clean or dry grain before it is transported to terminal or process elevators (U.S. EPA, *Compilation of Air Pollutant Emission Factors*, 1985) **Process elevators** are grain processing plants or mills. While the elevator operations of unloading, conveying and storing are performed at these locations, direct manufacturing or processing of grain for use in other products are also carried out (U.S. EPA, *Compilation of Air Pollutant Emission Factors*, 1985). **Terminal elevators** dry, clean, blend and store grain for shipment. **Transfer elevators** generally perform the same function as terminal elevators.

Table A2–4 **Estimation Methodologies for Manufacturing** (cont'd)

Sector/Subsector	
General Inventory Method	Pollutant(s) estimated: TPM, PM_{10}, $PM_{2.5}$ Total grain production by province/territory is multiplied by process-specific emission factors through primary elevators, process elevators, transfer elevators and terminal elevators. Calculated emissions are reconciled with emissions reported through the NPRI.
Activity Data	The Canadian Grain Commission (CGC) provides year-to-date deliveries and shipment data for grains for Western provinces (AB, BC, MB and SK) at weekly periods where the majority of grain crops are grown. These data include primary, process, transfer and terminal elevators. The reports follow an 'August to July' crop production cycle so three representative weekly reports are selected to estimate the grain throughput for a calendar year; Weeks 21–22 (W22), week 52 (W52) from the previous year (PY) and week 21–22 (W22) from current year (CY). PY-W52 represents grain throughput from August and July and PY-W22 represents throughputs from August to December of the previous year (CGC, 2017). The current calendar year's estimate of grain throughput is calculated as: Grain throughputs = (PY-W52) – (PY-W22) + (CY-W22) **Estimation of grain distribution among provinces**: The CGC do not report primary delivery data from Eastern provinces (NS, NB, PE). Consequently, grains that are delivered to primary elevators outside of Western provinces are assumed to be consistent with the grain deliveries in Ontario (ON). The division of grains between Western Canada and Eastern Canada is performed based on the Total Canadian grain (Statistics Canada, Table 32-10-0351-01, 2017). However, the sum of each grain type shows the annual receipts in Western Canada as one value not by province, and therefore, two assumptions are made in order to estimate the provincial grain receipts. First, it is assumed all grains received by ON primary elevators are transferred to process elevators in ON (including inter-provincial transfers). Second, the portion of receipts shared by each province is calculated based on the provincial proportions from the 1995 Criteria Air Contaminants (CAC) inventory. This inventory also provides the provincial distribution for transfer elevators. All grains from process elevators in ON are subsequently transported to terminal elevators, while transfer elevators in Ontario receive and ship grains from Western provinces. Unlike process elevators, terminal elevators, are only located in four ports among three provinces: BC (Vancouver, Prince Rupert), ON (Thunderbay, MB (Churchill). With receipts and shipment data of each port from CGC statistics, terminal elevator throughputs are computed by averaging the received and shipped grains of the three ports ON (Thunder Bay), BC (Vancouver, Prince Rupert) and MB (Churchill).
Emission Factors (EF)	Emission for each process are calculated by multiplying the total activity level (grain throughputs in thousand metric tonnes) by the emission factor, control efficiency and handling ratio. The handling ratio represents the actual amount of grains treated in a process. Handling process emissions are regulated by the "control efficiency" factor. It is assumed that no loss occurs between processes, so the activity level is identical at all processes in each elevator. Accordingly, the total Canadian TPM, PM_{10} and $PM_{2.5}$ annual emission is the sum of emissions from all processes involved in the four elevators. The emission factors and parameters are listed in following section. $$Emission = Activity\ level \times (1 - Control\ Efficiency) \times Emission\ factor \times Handling\ ratio$$ All emission factors and parameters are identical in all provinces. Source: (Pinchin Environmental Ltd, 2007).

Process	Emission factor (kg/t)			Control Efficiency (%)	Handling Ratio
	TPM	PM_{10}	$PM_{2.5}$		
Primary elevator					
Shipping & Receiving	0.10	0.03	0.01	75	1
Transfer conveying	0.04	0.01	0.00	0	0.5
Cleaning	1.50	0.38	0.07	75	0.5
Drying	1.40	0.35	0.06	75	N/A*
Headhouse	2.25	0.35	0.06	75	N/A
Process elevator					
Receiving	0.05	0.02	0.00	75	1
Pre-cleaning & Handling	0.04	0.01	0.00	0	1
Cleaning House	0.04	0.01	0.00	0	1
Mill House	35.00	17.50	2.98	97	1
Transfer elevator					
Receiving & Shipping	0.10	0.03	0.00	90	1
Transfer conveying	0.01	0.00	0.00	90	1.2
Headhouse	0.03	0.02	0.00	90	2.2
Terminal elevator					
Shipping & Receiving	0.04	0.01	0.00	90	1
Transfer Conveying	0.01	0.00	0.00	90	2
Cleaning	0.04	0.01	0.00	0	0.5
Drying	1.50	0.38	0.07	90	0
Headhouse	0.03	0.02	0.00	90	3

*Not applicable (not included in calculation for these processes)

Reconciliation: The emissions calculated at the provincial scale are considered as area source (AS) estimates. Point source (PS) values are those directly reported by the grain handling facilities to National Pollutant Release Inventory and they serve as the most reliable estimate of emission values. Thus, a reconciliation procedure is administered between the AS and PS estimates before submission to the inventory. When cumulative AS values for a province were found to be lower than the cumulative PS value from the same province, the AS value was replaced by PS value. The precedence of PS values over AS is determined based on their reliability.

Warehousing and Storage: These are PM emissions categorized for facilities that store the grains. The PS emissions are summed by province for the reporting facilities.

Table A2–4 **Estimation Methodologies for Manufacturing** (cont'd)	
Sector/Subsector	
SAWMILLS, PANEL BOARD MILLS AND OTHER (WOOD PRODUCTS) (under WOOD PRODUCTS)	
Description	**Sawmills** cover emissions from facilities that typically produce hardwood and softwood lumber from logs. The process of converting wet logs into dry lumber includes debarking, sawing, drying and planing steps, which all release air emissions. **Panel Board Mills** include emissions from several types of mills, all producing hardwood and softwood-based materials. These include: • veneer and plywood mills • waferboard mills, consisting primarily of oriented strand board (OSB) mills • particle board and medium-density fiberboard (MDF) mills **Other Wood Products** encompass emissions from furniture and cabinet manufacturers, wood treating plants, wood pellet mills and masonite manufacturers. The combustion of various fuels for energy production or waste disposal, notably wood residues, natural gas, liquefied petroleum gas (LPG) and fuel oil is a common practice at wood products facilities. Significant amounts of air pollutant emissions result from combustion in this sector.
General Inventory Method	Pollutant(s) estimated: TPM, PM_{10}, $PM_{2.5}$, SO_x, NO_x, VOCs, CO, NH_3, Pb, Cd, Hg, dioxins/furans, B(a)p, B(b)f, B(k)f, I(cd)p Sawmills and panel board mills: • TPM, PM_{10} and $PM_{2.5}$: Estimation methodology makes use of the NPRI facility-reported data in addition to a number of production and capacity indicators to estimate the PM of the facilities not reporting to the NPRI (Natural Resources Canada, Forest Products Association of Canada and the Composite Panel Association, corporate website information, annual reports, Resource Information Systems Inc. publications, Madison publications and occasional discussion with industry representatives); • All other pollutants: Production rate estimates, hog fuel combustion data, and other fuel use data are used to estimate emissions of the remaining pollutants (Meil et al., 2009; U.S. EPA, WebFIRE [database on the Internet], 2014). The in-house estimates for panel board mills were carried forward in 2016 based on 2015 mill capacities. Updated capacity data was available for 2017. Other wood products: All pollutants: In-house estimates are not calculated for this subsector. Since 2005, emissions are from NPRI facility-reported data.
Activity Data	NPRI 2017 data and data sources for facilities not reporting to the NPRI, including: • *Natural Resources Canada: Status of Energy Use in the Canadian Wood Products sector* (Meil et al., 2009) • Forest Products Association of Canada annual reports (proprietary reports) • Environment and Climate Change Canada's Forestry Products Group • *RISI North American Wood Panels and Engineered Wood Products Capacity Report* (RISI, 2013) • Madison's 2017 Online Lumber Directory (Madison, 2017) • Verbal communications with industry representatives (unpublished)
Emission Factors (EF)	Sawmills: (U.S. EPA, *EPA memorandum – EPA Region 10 HAP and VOC emission factors for lumber drying*, 2012) Plywood manufacturing, particle board, oriented strand board: (U.S. EPA, *Compilation of Air Pollutant Emission Factors*, Volume I: Stationary Point and Area Sources, 1995) Fuel combustion: (Meil et al., 2009; U.S. EPA, *Compilation of Air Pollutant Emissions Factors*, Volume I: Stationary Point and Area Sources, 1992; U.S. EPA, *Compilation of Air Pollutant Emission Factors, Volume I: Stationary Point and Area Sources*, 1995; U.S. EPA, WebFIRE [database on the Internet], 2014)

Table A2–5 **Estimation Methodologies for Transportation and Mobile Equipment**	
Sector/Subsector	
AIR TRANSPORTATION	
Description	Air Transportation covers emissions from aircraft but not airport support equipment (captured as off-road applications).
General Inventory Method	Pollutant(s) estimated: TPM, PM_{10}, $PM_{2.5}$, SO_x, NO_x, VOCs, CO, NH_3, Pb, B(a)p, B(b)f, B(k)f, I(cd)p Aircraft-specific activity (landing/take-offs) by province/territory is multiplied by pollutant-specific emission factors.
Activity Data	The emission estimates from Air Transportation are calculated using Aircraft Movement Statistics (Statistics Canada, Aircraft Movement Statistics (database), n.d.), a database developed by Statistics Canada based on flight-by-flight data, recorded at airport towers operated by NAV Canada post-1996 and Transport Canada pre-1996. The data are of the highest resolution available and are the only known such aircraft movement data within Canada.
Emission Factors (EF)	For aircraft using turbo aviation fuel, hydrocarbon (HC), CO and NO_x emission factors are taken from the International Civil Aviation Organization (ICAO) databank (ICAO, 2009) for landing/take-offs (LTO) and from the *EMEP/CORINAIR Emission Inventory Guidebook* 2006 (EEA, EMEP/CORINAIR, 2006) for the cruise stage. Emission factors are mapped to representative aircraft on the basis of engine characteristics. SO_2 is estimated as a sulphur balance, using data from the *Sulphur in liquid fuels* reports (EC, *Sulphur in liquid fuels*, 2013). The NH_3 emission factor is taken from (Coe et al., 1996). Emissions of PM during LTO are based on a paper by (Wayson et al., 2009), which relates the smoke number from the ICAO databank to an emission factor in g/kg fuel consumed. For aircraft using aviation gasoline, VOC, CO, PM_{10} and NO_x emission factors are taken from the Federal Office of Civil Aviation (FOCA, 2007). No quantification of these emissions is performed at the cruise stage, due to a lack of emission factors. SO_2 is estimated as a sulphur balance, using data from the *Sulphur in liquid fuels* reports (EC, *Sulphur in liquid fuels*, 2013). The NH_3 emission factor is taken from (Coe et al., 1996). $PM_{2.5}$ is calculated as 69% of PM_{10} as per (U.S. EPA, *Documentation for Aircraft, Commercial Marine Vessel, Locomotive, and other Nonroad Components of the National Emissions Inventory, Vol 1 – Methodology*, 2005). Lead is estimated as a lead balance, using the U.S. EPA's 5% retention (U.S. EPA, *Calculating Piston-Engine Aircraft Airport Inventories for Lead for the 2011 National Emissions Inventory*, 2013). TPM is equal to PM_{10} (U.S. EPA, *Documentation for Aircraft, Commercial Marine Vessel, Locomotive, and other Nonroad Components of the National Emissions Inventory*, Vol 1 – Methodology, 2005). Emissions of non-standard CACs are estimated as a ratio to PM_{10} or HC/VOCs based on speciation profiles from the U.S. EPA (U.S. EPA, *Documentation for Aircraft, Commercial Marine Vessel, Locomotive, and other Nonroad Components of the National Emissions Inventory*, Vol 1 – Methodology, 2005).

Table A2–5 **Estimation Methodologies for Transportation and Mobile Equipment** (cont'd)

Sector/Subsector	
MARINE TRANSPORTATION	
Description	Marine Transportation covers emissions from commercial marine vessels, but not recreational marine engines (captured as off-road applications).
General Inventory Method	Pollutant(s) estimated: TPM, PM_{10}, $PM_{2.5}$, SO_x, NO_x, VOCs, CO, NH_3, Pb, Cd, Hg, dioxins/furans, B(a)p, B(b)f, B(k)f, I(1,2,3-cd)p Vessel-specific activity (movements) is multiplied by pollutant-specific emission factors.
Activity Data	The main source of data is from the Marine Emission Inventory Tool (MEIT) (ECCC, MEIT 2015, 2018; ECCC, MEIT V.4.3.1, 2016) which provides emissions for NO_x, CO, HC, SO_2, TPM, PM_{10}, $PM_{2.5}$ and NH_3. MEIT provides data for 1980, 1985, 1987, 1990, 1995, 2000, 2005, 2010, 2015 and forecast for 2020.
Emission Factors (EF)	NO_x, CO, HC, SO_2, TPM, PM_{10}, $PM_{2.5}$ and NH_3 are taken directly from MEIT. B(a)p, B(b)f, B(k)f, I(1,2,3-cd)p, Pb, Cd, Hg, dioxins/furans are estimated as ratios of PM based on speciation profiles from the *Documentation for the Commercial Marine Vessel Component of the National Emissions Inventory Methodology* (U.S. EPA, Contract No. EPA420-F-09-025, 2009). The correlation factor for HC to VOCs is taken from Emission Factors for Locomotives document (U.S. EPA, Contract No. EPA420-F-09-025, 2009).
ON-ROAD VEHICLES	
Description	On-road Vehicles include: Heavy-duty Diesel Vehicles, Heavy-duty Gasoline Vehicles, Light-duty Diesel Trucks, Light-duty Diesel Vehicles, Light-duty Gasoline Trucks, Light-duty Gasoline Vehicles, Propane and Natural Gas Vehicles, Motorcycles, and Tire Wear and Brake Lining.
General Inventory Method	Pollutant(s) estimated: TPM, PM_{10}, $PM_{2.5}$, SO_x, NO_x, VOCs, CO, NH_3, Pb, Cd, Hg, dioxins/furans, B(a)p, B(b)f, B(k)f, I(cd)p Vehicle-specific activity (vehicle kilometres travelled) is multiplied by pollutant-specific emission factors in the MOVES model (version MOVES2014 was used for this submission). Refuelling VOC emissions are included under Service Stations.
Activity Data	Data on the vehicle fleet (counts), defined by fuel type, model-year and gross vehicle weight rating, originate from (DAC, 2017) and (Polk & Co, 2017) for light- and heavy-duty vehicles, respectively. Motorcycle populations originate from the publication Road motor vehicle, trailer and snowmobile registration (registrations) (Statistics Canada, Table 405-0001, n.d.; Statistics Canada, Table 405-0004, n.d.). The *Annual Industry Statistics* report (MMIC, 2013) is used to estimate the age distribution of motorcycles by model year which is applied to motorcycle populations obtained from Statistics Canada. The actual activity level is vehicle kilometres travelled (VKT). To arrive at estimates of VKT, vehicle counts are multiplied by mileage accumulation rates from Stewart-Brown Associates (Stewart-Brown Associates, 2012).
Emission Factors (EF)	Emission factors for on-road vehicles are embedded in the MOVES model. More information on MOVES is available online at www.epa.gov/otaq/models/moves/, in the U.S. EPA user guides (U.S. EPA, *User guide for MOVES2010b*, 2012; U.S. EPA, *User guide for MOVES2014*, 2014) and in U.S. EPA technical guidance document (U.S. EPA, *Technical guidance on the use of MOVES2010 for emission inventory preparation in state implementation plans and transportation conformity,* 2010).
OFF-ROAD VEHICLES AND EQUIPMENT	
Description	Off-road Vehicles and Equipment consists of Off-road Diesel Vehicles and Equipment and Off-road gasoline/LPG/NG Vehicles and Equipment.
General Inventory Method	Pollutant(s) estimated: TPM, PM_{10}, $PM_{2.5}$, SO_x, NO_x, VOCs, CO, NH_3 Application-specific activity (hours-of-use, load factor) is multiplied by pollutant-specific emission factors in the NONROAD model.
Activity Data	Data on the applications (vehicle/engine counts, load factor, hours-of-use), defined by fuel type, model year and source classification code, originate from (EC, *Canadian off-road equipment population*, 2011). The hours-of-use parameter was updated in 2018 for select equipment types. For example, snowmobile hours of use is now distinct by stroke type (ECCC, *Off-road Equipment Analysis – Snowmobiles*, 2018). Construction equipment populations used in oil sands mining operations are now sourced from The Parker Bay Company (ECCC, *Off-road Equipment Analysis – Oil Sands Mining Equipment*, 2018).
Emission Factors (EF)	Emission factors for off-road applications are embedded in the NONROAD model. For this iteration of the APEI, NONROAD version 2012C was used. This version is based on the U.S. EPA's NONROAD2008, and modified by Environment and Climate Change Canada to exploit detailed activity data. Model operation is conducted following the user guide for NONROAD2005/2008 (U.S. EPA, *User's guide for the final NONROAD2005 model*, 2005), given that the functionality of the models is the same. More information on the NONROAD model is available online at http://www.epa.gov/otaq/nonrdmdl.htm.
RAIL TRANSPORTATION	
Description	Rail Transportation covers emissions from the fuel consumed by locomotive engines.
General Inventory Method	Pollutant(s) estimated: TPM, PM_{10}, $PM_{2.5}$, SO_x, NO_x, VOCs, CO, NH_3, Pb, Cd, Hg, dioxins/furans, B(a)p, B(b)f, B(k)f, I(cd)p Railway activity (fuel consumption) is multiplied by pollutant-specific emission factors.
Activity Data	Fuel consumption data: (Statistics Canada, RESD, n.d.)
Emission Factors (EF)	HC, CO, SO_2, PM_{10} and NO_x emission factors are taken from the *Locomotive Emissions Monitoring Program 2011* report (Railway Association of Canada, *Locomotive Emissions Monitoring Program 2011*, 2013) and the *Locomotive Emissions Monitoring Program 2015* report (Railway Association of Canada, *Locomotive Emissions Monitoring Program 2015*, 2018). The correlation factor for HC to VOCs and TPM to PM_{10} is taken from Emission Factors for Locomotives document (U.S. EPA, Contract No. EPA420-F-09-025, 2009). $PM_{2.5}$, NH_3, Pb, Cd, Hg, B(a)p, B(b)f, B(k)f, I(cd)p are estimated as ratios to PM_{10} or VOCs, based on speciation profiles from are taken from the Documentation for Locomotive Component of the National Emissions Inventory Methodology (U.S. EPA, *Documention for Locomotive Component of the National Emissions Inventory Methodology*, 2011). The dioxin/furan emission factor (0.54 ng/L) is taken from the *An inventory of sources and environmental releases of dioxin-like compounds in the United States for the years 1987, 1995, and 2000 report* (U.S. EPA, EPA/600/P-03/002F, 2006).

Table A2–6 **Estimation Methodologies for Agriculture**

Sector/Subsector	
ANIMAL PRODUCTION	
Description	Animal Production reports emissions from the volatilization of NH_3 from nitrogen in manure, particulate matter that is released from feeding and housing, and non-methane volatile organic compounds (NMVOCs) that are released during livestock feeding, housing and manure management. Ammonia volatilization is a chemical process that occurs when manure is excreted or stored without a cover. Once excreted, manure moves through a number of stages until it is eventually cycled back to farm fields. Ammonia volatilization occurs at each stage of this cycle, including animal housing, transport to long-term storage, storage, and application of manure to the field. Livestock production results in primary PM emissions from the aerial transport of feed particles, feather fragments, fecal material, skin debris or dander, animal wastes, mould spores, bacteria, fungus, litter fragments, etc. Ventilation systems in livestock buildings are required for air exchange and, as a result, a portion of the PM in confined livestock buildings will be emitted into the atmosphere via the ventilation system. NMVOC emissions from livestock production are the result of biological processes that partially break down feed, especially silage, during storage and digestion. Emissions from excreted manure also occur during all stages of the manure management cycle. Sites of emission therefore include silage stores, livestock housing, manure stores and agricultural fields on which manure is applied or that are used for grazing.
General Inventory Method	Pollutant(s) estimated: TPM, PM_{10}, $PM_{2.5}$, NH_3, NMVOCs **Ammonia (NH_3)** The methodologies for ammonia emissions were developed by Environment and Climate Change Canada in collaboration with Agriculture and Agri-Food Canada (AAFC) through a national research project: the National Agri-Environmental Standards Initiative (NAESI). Methods describing the estimates of NH_3 emissions from Canadian livestock are published for most major livestock categories (dairy, non-dairy, swine and poultry). Details on parameters used and animal category-specific methodologies are available from the following publications: (Sheppard & Bittman, *Farm survey used to guide estimates of nitrogen intake and ammonia emissions for beef cattle*, including early season grazing and piosphere effects, 2010; Sheppard & Bittman, *Farm practices as they affect NH_3 emissions from beef cattle*, 2012; Sheppard et al., *Sensitivity analysis of alternative model structures for an indicator of ammonia emissions from agriculture*, 2007; Sheppard et al., *Estimation of ammonia emission episodes for a national inventory using a farmer survey and probable number of field working days*, 2007; Sheppard et al., *Ecoregion and farm size differences in feed and manure nitrogen management: 1. Survey methods and results for poultry*, 2009; Sheppard et al., *Monthly NH_3 emissions from poultry in 12 Ecoregions of Canada*, 2009; Sheppard et al., *Farm practices survey and modelling to estimate monthly NH_3 emissions from swine production in 12 Ecoregions of Canada*, 2010; Sheppard et al., *Monthly NH_3 emissions from poultry in 12 Ecoregions of Canada*, 2009) (Sheppard et al., *Modelling monthly NH_3 emissions from dairy in 12 Ecoregions of Canada*, 2011; Sheppard et al., *Ecoregion and farm size differences in dairy feed and manure nitrogen management: A survey*, 2011; Chai et al., 2016). For dairy and swine, the methodology used to estimate ammonia emissions has been updated to make it compatible with the current methodology used for the estimation of Greenhouse Gases (see Annex 3.4 of the *National Inventory Report*). Although the specific emission factors used in estimating ammonia emissions have not been modified, the total emissions per head have changed, as a result of changes in rates of N excretion per animal and the proportions of manure stored in different manure systems over time. Methodologies for minor animals, such as horses, goats, fur-bearing animals (mink, fox), wild boars, deer, elk, rabbit and poultry, were taken from (Battye et al., 1994). **Particulate Matter (TPM, PM_{10}, $PM_{2.5}$)** The methodologies for particulate matter emissions from livestock production are developed by AAFC for publication in the National Agri-Environmental Health Analysis and Reporting Program (NAHARP), published every five years with the Agricultural Census. The method is consistent with the *EMEP/CORINAIR Emission Inventory Guidebook* (EEA, EMEP/CORINAIR, 2002), but uses country-specific emission factors. Methodologies are published in (Pattey & Qiu Guowang, 2012) and (Pattey et al., 2015). **Non-Methane Volatile Organic Compounds (NMVOCs)** For all livestock except dairy cattle, the methodology for estimating NMVOC emissions was based on the Tier 1 methodology outlined in the 2013 *EMEP/EEA Air Pollutant Emission Inventory Guidebook* (EEA, EMEP/EEA, 2013). Emissions for dairy cattle were calculated using the tier 2 approach provided in the 2013 EMEP/EEA Air Pollutant Emission Inventory Guidebook. Country-specific parameters, including feed gross energy intake, silage content, and time spent in housing, are consistent with those used to calculate GHG emissions in the National Inventory Report 1990–2016: Greenhouse Gas Sources and Sinks in Canada (NIR), as described in Annex 3.4 of Part II of the NIR[3].
Activity Data	Annual cattle, sheep and swine populations are calculated as the simple mean of semi-annual or quarterly surveys (Statistics Canada, Table 32-10-0130-01, n.d.; Statistics Canada, Table 32-10-0129-01, n.d.; Statistics Canada, Table 32-10-0145-01, n.d.; Statistics Canada, Table 32-10-0290-01, n.d.). These smaller surveys are corrected to the Census of Agriculture (COA) population estimates that are collected every five years to ensure the accuracy of the estimates. The populations of other livestock, such as horses, goats, bison, llamas and alpacas, deer and elk, wild boars, rabbits, and poultry, are taken from the COA exclusively, and annual populations are developed by linear interpolation in order to avoid large changes in census years. Where populations for certain alternative livestock animal categories were not available in the COA, values were held constant or extrapolated back to zero. The breeding mink and fox population estimates were taken from an annual Statistics Canada survey titled Supply and Disposition of Mink and Fox on Fur Farms (Statistics Canada, Table 32-10-0116-01, n.d.). Rabbit populations were taken from responses to the COA as provided on the AAFC Red Meat Market website (AAFC, 2016).

3 https://www.canada.ca/en/environment-climate-change/services/climate-change/greenhouse-gas-emissions/inventory.html

Table A2–6 **Estimation Methodologies for Agriculture** (cont'd)

Sector/Subsector	
Emission Factors (EF)	**Ammonia** Non-dairy cattle and poultry ammonia emission factors are a weighted average of a variety of different emission fractions that occur during the stages of the manure and animal production cycle. The input to the emission factor equation originates from a combination of the Livestock Farm Practices Survey (LFPS), which defines feed distribution to and consumption by animals throughout the year, and generic parameters derived from scientific literature or expert opinion. This information is distributed spatially across Canada by ecoregion. Animal populations are reassigned to a matrix of animal housing and manure management systems based on their relative proportion in the overall farm population. The fractions of NH_3 emitted at each step in the manure cycle are taken in part from the *EMEP/CORINAIR Emission Inventory Guidebook* (EEA, EMEP/CORINAIR, 2002) and in part from Canadian studies. The resulting weighted emission factors are applied to populations of animal subcategories taken from census data at the ecoregion spatial scale. The models employed to calculate NH_3 emissions from beef and swine production are described in (Sheppard & Bittman, *Farm survey used to guide estimates of nitrogen intake and ammonia emissions for beef cattle*, including early season grazing and piosphere effects, 2010; Sheppard & Bittman, *Farm practices as they affect NH_3 emissions from beef cattle*, 2012; Sheppard et al., *Farm practices survey and modelling to estimate monthly NH_3 emissions from swine production in 12 Ecoregions of Canada*, 2010; Sheppard & Bittman, *Farm practices as they affect NH_3 emissions from beef cattle,* 2012). Dairy cattle: Ammonia emissions are calculated according to (Sheppard et al., *Farm practices survey and modelling to estimate monthly NH_3 emissions from swine production in 12 Ecoregions of Canada*, 2010), with modifications according to (Chai et al., 2016) and based on the activity data and methodology outlined for Agriculture in the *National Inventory Report: 1990–2017, Greenhouse Gas Sources and Sinks in Canada*. Total N excretion for dairy cattle is calculated according to the Tier 2 methodology as described in the IPCC 2006 Guidelines (IPCC, 2006). Ammonia emission factors from Sheppard et al. (Sheppard et al., *Modelling monthly NH_3 emissions from dairy in 12 Ecoregions of Canada,* 2011) are expressed as fractions of total N using calculated TAN fractions (Chai et al., 2016) to produce ammonia N loss factors by ecoregion for housing and manure storage, manure application, and manure deposited on pasture, range, and paddock. Manure management storage information was derived from (Sheppard et al., *Ecoregion and farm size differences in dairy feed and manure nitrogen management: A survey*, 2011) to identify proportions of manure excreted on pasture and in exercise yards and information on the quantity of manure stored as liquid and solid manure was drawn from (Statistics Canada, *Farm Inputs Management Survey* (1995), 1996), the Farm Environmental Management Surveys (2001, 2006, 2011) (Statistics Canada, F*arm Environmental Management Survey (FEMS)*, n.d.) and the *Livestock Farm Practices Survey* (2005) (Statistics Canada, *Livestock Farm Practices Survey* (2005), 2007). A time series of manure storage was developed on the basis of relationships between liquid storage and time on pasture with farm size to account for changes in manure storage between 1990 and the present. Emissions from manure applied to agricultural soils were consistent with (Sheppard et al., *Monthly ammonia emissions from fertilizers in 12 Canadian Ecoregions*, 2010) as modified according to (Chai et al., 2016). Swine: Ammonia emissions are calculated according to Sheppard et al. (Sheppard et al., *Farm practices survey and modelling to estimate monthly NH_3 emissions from swine production in 12 Ecoregions of Canada*, 2010) with modifications used to convert TAN fractions to Total N that are consistent with the method used for dairy (Chai et al., 2016) and based on the activity data and methodology outlined for Agriculture in the *National Inventory Report: 1990–2017, Greenhouse Gas Sources and Sinks in Canada*. Total N excretion for swine is calculated according to the Tier 1 methodology described in the IPCC 2006 Guidelines (IPCC, 2006), and modified to use a country-specific animal mass time series for market swine as described in Annex 3.4 of the NIR. Ammonia emission factors from Sheppard et al. (Sheppard et al., *Farm practices survey and modelling to estimate monthly NH_3 emissions from swine production in 12 Ecoregions of Canada*, 2010) are expressed as fractions of total N using calculated TAN fractions (Chai et al., 2016) to produce ammonia N loss factors by ecoregion for housing and manure storage, and manure application to agricultural soils. Manure management storage information on the quantity of manure stored as liquid and solid manure was drawn from a series of Farm Management Surveys for years 1995, 2005, 2006 and 2011. A time series of manure storage was developed on the basis of relationships between liquid storage and farm size to account for changes in manure storage between 1990 and the present. **Particulate Matter** Total particulate matter (TPM) emission factors for poultry are taken from (Van Heyst, Final report: *Evaluation of emission factors for the improvement of the estimation methodology for particulate matter from agricultural poultry industry*, 2005) and (Van Heyst & Roumeliotis, *Size fractionated particulate matter emissions from a broiler house in southern Ontario, Canada*, 2007). Emission factors for cattle and swine are average values from (Takai et al., 1998) and (Seedorf, 2004). In the case of PM_{10} and $PM_{2.5}$, emissions are estimated from TPM emission factors multiplied by 0.45 and 0.1 to produce PM_{10} and $PM_{2.5}$ emission factors, respectively. Average animal weights are used to convert emission factors in the form of $g\ d^{-1}\ AU^{-1}$ to units of $kg\ head^{-1}\ year^{-1}$. The emission factors for cattle are also assigned to the other animal types by assuming that the emission factors per animal unit for sheep, goats, bison, llamas, alpacas and horses are the same as those for cattle. Average body weight of cattle are consistent with information provided by (Boadi et al., 2004) and with weight corrections for cattle according to the methodology outlined in the *National Inventory Report: 1990–2017, Greenhouse Gas Sources and Sinks in Canada* (ECCC, 2019). All other animal weights were consistent with values used to estimate nitrogen excretion in (ECCC, *National Inventory Report 1990–2017: Greenhouse Gas Sources and Sinks in Canada*, 2019). Currently no emissions are estimated for mink, fox, wild boars, deer, elk or rabbit. **Non-Methane Volatile Organic Compounds (NMVOCs)** The emission factors for all animals except dairy cattle were taken from Table 3-3 of the *EMEP/EEA Air Pollutant Emission Inventory Guidebook* 2013 (EEA, EMEP/EEA, 2013). For livestock categories where a choice of emission factors was provided, the non-silage emission factor was selected, except for beef cattle in feedlots where the silage emission factor was used. A weighted emission factor for beef cattle was calculated using the fraction of time spent during each stage of production according to (Boadi et al., 2004). For dairy cattle, emission factors were calculated for six separate sources of emissions as described in the EMEP/EEA tier 2 methodology. Gross energy intake, silage content of feed, and fraction of time spent in barns, were all calculated based on country-specific data compiled in order to estimate greenhouse gas emissions (see Annex 3.4 of the NIR). In the EMEP/EEA tier 2 methodology, ammonia emissions are used as a proxy to estimate the proportion of NMVOC emissions that occur in housing, manure storage and on manure application. The proportions were derived from ammonia emissions from the Canadian Ammonia Model, which was modified to account for the shift in manure management practices in the dairy sector (see ammonia methodology).

Table A2–6 **Estimation Methodologies for Agriculture** (cont'd)

Sector/Subsector	
FERTILIZER APPLICATION (under CROP PRODUCTION)	
Description	Fertilizer Application includes emissions emitted when synthetic nitrogen fertilizers are applied for annual and perennial crop production.
General Inventory Method	Pollutant(s) estimated: TPM, PM_{10}, $PM_{2.5}$, NH_3 Ammonia: The method is a simplified version of the approach adopted by (Sheppard et al., *Monthly ammonia emissions from fertilizers in 12 Canadian Ecoregions*, 2010) for application on an annual time step. The methodology uses a regression model developed by (Bouwman et al., 2002) and derived NH_3 emission factors, taking into account the most important parameters influencing emissions from synthetic nitrogen fertilizer application, based on a meta-analysis of scientific literature. Particulates: Methodology is under review.
Activity Data	Data on the types of nitrogen fertilizer used on farms are published by Statistics Canada (Statistics Canada, Table 32-10-0038-01, n.d.) Areas of seeded annual and perennial crops: (Statistics Canada, Table 32-10-0359-01, n.d.). Soil properties, including pH and cation exchange capacity, are included in calculations using soil polygon information from a national-scale spatial database (http://sis.agr.gc.ca/cansis/nsdb/slc/index.html) describing the types of soils associated with landforms.
Emission Factors (EF)	Ammonia emission factors are calculated using the multiple linear regression equation from (Bouwman et al., 2002). The approach uses different regression parameters for synthetic nitrogen fertilizer types, method of nitrogen application, crop type, and soil pH and cation exchange capacity. A matrix of emission factors for each combination of these conditions occurring across Canada is derived. The average provincial and national emission factors are weighted averages of the relative proportion of each combination of fertilizer type and fertilizer application practice on different soil types in different ecodistricts across the country. TPM, PM_{10} and $PM_{2.5}$ methodology is under review.
HARVESTING (under CROP PRODUCTION)	
Description	Agricultural harvest activities entrain particulate matter into the air. Particulate matter generated from agricultural harvesting, also known as grain dust, includes grain and dry plant particles, moulds, pollen and spores, silica, bacteria, fungi, insects, and possibly pesticide residues. These emissions are generated by vehicles traveling over the soil or by the processing of plant materials by agricultural equipment.
General Inventory Method	Pollutant(s) estimated: TPM, PM_{10}, $PM_{2.5}$ Particulate matter emissions from agricultural harvest operations are computed by multiplying an emission factor and an activity factor relating emissions to the area harvested.
Activity Data	Activity data for PM emission estimates from crop harvesting rely on a combination of data from the Census of Agriculture and area estimates based on Earth Observation data. Activity data on areas of major field crops at an ecodistrict level from 1990 to 2017 are consistent with the data reported in the Agriculture and the Cropland remaining Cropland category of the Land Use, Land-use Change and Forestry sector for the National Inventory Report 1990–2017: Greenhouse Gas Sources and Sinks in Canada (ECCC, National Inventory Report 1990–2017: Greenhouse Gas Sources and Sinks in Canada, 2019).
Emission Factors (EF)	There are no emission factors for agricultural harvest in Canada. The PM_{10} emission factors proposed by the California Air Resources Board (CARB, Emission inventory procedural manual – Volume III: Methods for assessing area source emissions, 2003) are used to calculate PM emissions from crop harvest. Where the specific emission factors for some crops are not available from (CARB, Emission inventory procedural manual – Volume III: Methods for assessing area source emissions, 2003), the emission factors for these crops are based on an approximation from the closest representation (Pattey & Qiu Guowang, 2012).
TILLAGE PRACTICES (under CROP PRODUCTION)	
Description	Tillage practices produce PM emissions from mechanical disturbances such as seeding, seed bed preparation and cultivation.
General Inventory Method	Pollutant(s) estimated: TPM, PM_{10}, $PM_{2.5}$ Agricultural tillage is the common method used by farmers to prepare land for seeding and weed control. Particulate matter emissions are generated from airborne soil particles during tillage operations due to the mechanical disturbance of the soil surface. Particulate matter emissions from agricultural tillage operations are proportional to the area tilled. They are also dependent on the type of tillage practice as well as the number of tillage events per year. The calculations are described in more detail in (Pattey & Qiu Guowang, 2012). The number of tillage events per year is dependent on tillage practices. There are fewer tillage events per year for conservation tillage compared to conventional tillage. Therefore, a reduction in particulate matter emissions from reduced tillage and no-till is observed.
Activity Data	Activity data for PM emission estimates from tillage practices rely mainly on a combination of data from the Census of Agriculture and area estimates based on Earth Observation analyses. Activity data on areas of major field crops, including summerfallow, and on tillage practices at an ecodistrict level from 1990 to 2016 are consistent with the data reported in the Cropland Remaining Cropland category of the Land Use, Land-use Change and Forestry sector for the National Inventory Report 1990–2017: Greenhouse Gas Sources and Sinks in Canada (ECCC, National Inventory Report 1990–2017: Greenhouse Gas Sources and Sinks in Canada, 2019) Information on the number of tillage events per year for crop type and tillage practices is taken from soil cover indicators (Huffman et al., 2012).
Emission Factors (EF)	Emission factors for tillage practices are calculated using the method described in (U.S. EPA, Compilation of Air Pollutant Emission Factors, 1985).
WIND EROSION (under CROP PRODUCTION)	
Description	Wind erosion occurs when wind blows across exposed agricultural land, resulting in PM emissions from the entrained particles.
General Inventory Method	Pollutant(s) estimated: TPM, PM_{10}, $PM_{2.5}$ Wind erosion emissions from agricultural lands are calculated by multiplying the cultivated cropland area by an emission factor.

Table A2–6 **Estimation Methodologies for Agriculture** (cont'd)	
Sector/Subsector	
Activity Data	Activity data for PM emission estimates from wind erosion rely mainly on a combination of data from the Census of Agriculture and area estimates based on Earth Observation. Activity data on areas of major field crops, including summerfallow, and on tillage practices at an ecodistrict level from 1990 to 2016 are consistent with the data reported in the Cropland Remaining Cropland category of the Land Use, Land-use Change and Forestry sector for the *National Inventory Report 1990–2017: Greenhouse Gas Sources and Sinks in Canada* (ECCC, *National Inventory Report 1990–2017: Greenhouse Gas Sources and Sinks in Canada*, 2019)
Emission Factors (EF)	The PM emission factor for wind erosion is calculated using the wind erosion equation (Woodruff & Siddoway, 1965) but considers the impact of soil and crop cover on PM emissions (Huffman et al., 2012). The emission factor for windblown PM emissions from agricultural lands is calculated using the methodology described in (Pattey & Qiu Guowang, 2012).
FUEL USE	
Description	Fuel Use includes emissions resulting primarily from combustion sources used for space/water heating and crop drying.
General Inventory Method	Pollutant(s) estimated: TPM, PM_{10}, $PM_{2.5}$, SO_x, NO_x, VOCs, CO, NH_3, Pb, Cd, Hg, dioxins/furans, B(a)p, B(b)f, B(k)f, I(cd)p Emissions are calculated for 10 types of fuel: natural gas, natural gas liquids, kerosene and stove oils, light fuel oil, heavy fuel oil, Canadian bituminous coal, sub-bituminous coal, lignite coal, anthracite coal, and imported coal. Total usage by fuel type and province/territory is multiplied by pollutant-specific emission factors.
Activity Data	(Statistics Canada, RESD, n.d.)
Emission Factors (EF)	TPM, PM_{10}, $PM_{2.5}$, SO_x, NO_x, VOCs, CO: (U.S. EPA, *Compilation of Air Pollutant Emission Factors,* Volume I: Stationary Point and Area Sources, 1998) (Emission factors are chosen to represent the typical type of combustion equipment for each fuel type.) TPM, PM_{10}, $PM_{2.5}$, SO_x, NO_x, VOCs, CO for natural gas fuel: (U.S. EPA, WebFIRE. Factor Information Retrieval (FIRE) Data System, 2004) Sulphur contents of liquid fuels: (EC, *Sulphur in liquid fuels*, 2010) Sulphur contents of coal: (CEA, 2002) NH_3: (Battye et al., 1994); (Coe et al., 1996) Pb, Cd, Hg, dioxins/furans, B(a)p, B(b)f, B(k)f: (CARB, California Air Toxics Emission Factor Database, 2005; U.S. EPA, Compilation of Air Pollutant Emission Factors, Volume I: Stationary Point and Area Sources, 1998; U.S. EPA, Draft Dioxin Reassessment, 2003; U.S. EPA, WebFIRE. Factor Information Retrieval (FIRE) Data System, 2004) (Emission factors are selected to represent the typical type of combustion equipment for each fuel type.)

Table A2–7 **Estimation Methodologies for Commercial/Residential/Institutional**	
Sector/Subsector	
CIGARETTE SMOKING	
Description	Two sources of emissions are included under Cigarette Smoking: 1. mainstream cigarette smoke, which is directly exhaled by the smoker 2. sidestream smoke, which is directly released from burning cigarettes
General Inventory Method	Pollutant(s) estimated: TPM, PM_{10}, $PM_{2.5}$, VOCs, CO, NH_3, Pb, Cd, Hg, dioxins/furans, B(a)p, B(b)f, B(k)f The average number of cigarettes smoked per year by the smoking population by province/territory is calculated and then multiplied by pollutant-specific emission factors.
Activity Data	Tobacco use/smoking prevalence: (Health Canada, 2017) Population data: Statistics Canada 1991–2018
Emission Factors (EF)	TPM, PM_{10}, $PM_{2.5}$: (Ott et al., *Particle concentrations inside a tavern before and after prohibition of smoking: evaluating the performance of an indoor air quality model*, 1996) VOCs: (Wallace et al., 1987) CO: (Ott et al., *A time series model for cigarette smoking activity patterns: Model validation for carbon monoxide and respirable particles in a chamber and an automobile*, 1992) NH_3: (Roe et al., 2004) Hg, Cd, Pb: (Gray & Boyle, 2002) Dioxins/furans: (U.S. EPA, *Exposure and Human Health Reassessment of 2, 3, 7, 8-Tetrachlorodibenzo-p-Dioxin (TCDD) and Related Compounds*, 2004) B(a)p, B(b)f, B(b)k: (Ding et al., 2005)
COMMERCIAL AND INSTITUTIONAL FUEL COMBUSTION, CONSTRUCTION FUEL COMBUSTION AND RESIDENTIAL FUEL COMBUSTION	
Description	Commercial and Institutional Fuel Combustion, Construction Fuel Combustion and Residential Fuel Combustion include emissions resulting primarily from external combustion sources used for space/water heating and material heating. Commercial establishments, health and educational institutions, government/public administration facilities, and residences all fall under these categories, in addition to construction sites.
General Inventory Method	Pollutant(s) estimated: TPM, PM_{10}, $PM_{2.5}$, SO_x, NO_x, VOCs, CO, NH_3, Pb, Cd, Hg, dioxins/furans, B(a)p, B(b)f, B(k)f, I(cd)p Emissions are calculated for 10 types of fuel: natural gas, natural gas liquids, kerosene and stove oils, light fuel oil, heavy fuel oil, Canadian bituminous coal, sub-bituminous coal, lignite coal, anthracite coal, and imported coal. Total usage by fuel type and province/territory is multiplied by pollutant-specific emission factors.
Activity Data	(Statistics Canada, RESD, n.d.)

Table A2–7 **Estimation Methodologies for Commercial/Residential/Institutional** (cont'd)

Sector/Subsector	
Emission Factors (EF)	TPM, PM_{10}, $PM_{2.5}$, SO_x, NO_x, VOCs, CO: (U.S. EPA, *Compilation of Air Pollutant Emission Factors,* Volume I: Stationary Point and Area Sources, 1998) (Emission factors are chosen to represent the typical type of combustion equipment for each fuel type.) TPM, PM_{10}, $PM_{2.5}$, SO_x, NO_x, VOCs, CO for natural gas fuel: (U.S. EPA, WebFIRE. Factor Information Retrieval (FIRE) Data System, 2004) Sulphur contents of liquid fuels: (EC, *Sulphur in liquid fuels*, 2010) Sulphur contents of coal: (CEA, 2002) NH_3: (Battye et al., 1994); (Coe et al., 1996) Pb, Cd, Hg, dioxins/furans, B(a)p, B(b)f, B(k)f: (CARB, California Air Toxics Emission Factor Database, 2005; U.S. EPA, *Compilation of Air Pollutant Emission Factors*, Volume I: Stationary Point and Area Sources, 1998; U.S. EPA, *Draft Dioxin Reassessment,* 2003; U.S. EPA, WebFIRE. Factor Information Retrieval (FIRE) Data System, 2004) (Emission factors are selected to represent the typical type of combustion equipment for each fuel type.)
COMMERCIAL COOKING	
Description	Commercial Cooking includes emissions from cooking meat and french fries in commercial operations that are classified under five foodservice types: ethnic, fast food, family, seafood, and steak and BBQ. The types of meat considered include beef steak, hamburger, poultry with skin, poultry without skin, pork, seafood and other. Five types of commercial cooking equipment are taken into account including: chain driven charbroilers, underfired charbroilers, deep-fat fryers, flat griddles and clamshell griddles. The commercial operations inventoried are defined as all commercial foodservice points of distribution that are open to the public, offer prepared meals and snacks for consumption on/off-premises, and operate in a fixed location.
General Inventory Method	Pollutant(s) estimated: TPM, PM_{10}, $PM_{2.5}$, VOCs, CO, B(a)p Commercial meat cooking (1999 to 2017): 1. determined the number of restaurants in each province/territory that were classified as ethnic, fast food, family, seafood, steak and BBQ 2. determined the fraction of restaurants with commercial cooking equipment (i.e. chain driven charbroilers, underfired charbroilers, deep-fat fryers, flat griddles and clamshell griddles), the average number of units of each type of equipment per restaurant, and the average amount of food cooked (i.e. steak, hamburger, poultry with skin, poultry without skin, pork, seafood and other) on each type of equipment 3. applied pollutant-specific emission factors to each type of food for each type of commercial cooking equipment to get the final emission estimates Commercial meat cooking (1990 to 1998): Emission estimates for 1999 were back-casted to 1990 using the gross domestic product (GDP) for NAICS [72]: Accommodation and Food Services (Statistics Canada, Table 379-0019 , n.d.). Commercial cooking of french fries: The annual national consumption rate of frozen fries was multiplied by the annual provincial/territorial population and by a VOC-specific emission factor.
Activity Data	Commercial meat cooking (1999 to 2017 only): Activity data were estimated using: • annual restaurant census for Canada: ReCount Database (The NPD Group Inc., 2017) • statistics on the prevalence of commercial cooking equipment, for the five restaurant types (E.H. Pechan & Associates Inc., 2003) • statistics on the average number of pounds of meat cooked on each type of equipment per week for the seven types of meat (E.H. Pechan & Associates Inc., 2003) Commercial cooking of french fries: Activity data were estimated using: • provincial/territorial population data (Statistics Canada, Table 051-0001, n.d.) • annual Canadian consumption rates of frozen fries (USDA FAS, 2015) • assumed 80% of french fries were purchased in restaurants (E.H. Pechan & Associates Inc., 2003)
Emission Factors (EF)	Commercial meat cooking: TPM, PM_{10}, $PM_{2.5}$, VOCs, CO, B(a)p: (E.H. Pechan & Associates Inc., 2003) Commercial cooking of french fries: VOCs: (E.H. Pechan & Associates Inc., 2003)
HOME FIREWOOD BURNING	
Description	Home Firewood Burning encompasses emissions from wood burned in urban and rural homes for primary and supplementary heating, as well as for aesthetics and hot water, in both main and secondary residences. This covers household wood-burning devices such as wood-burning fireplaces, wood stoves, pellet stoves, outdoor boilers and a variety of other devices used in limited quantities, such as wood-fired cooking stoves.
General Inventory Method	Pollutant(s) estimated: TPM, PM_{10}, $PM_{2.5}$, SO_x, NO_x, VOCs, CO, NH_3, Pb, Cd, Hg, dioxins/furans, B(a)p, B(b)f, B(k)f, I(cd)p The quantity of wood burned by device type and province is multiplied by pollutant-specific emission factors by device type.
Activity Data	Activity data from (Canadian Facts, *Residential fuelwood combustion in Canada*: Volumes I, II, III, 1997; Canadian Facts, *Residential fuelwood combustion in Canada*, 2006; TNS Canada, 2012) are converted from volume to mass utilizing the reported wood species burnt. Wood consumption is interpolated and extrapolated from the three points (1996, 2006 and 2012) to the time series using statistical information on household wood-burning devices from (Statistics Canada, *Products shipped by Canadian manufacturers* (1995), 1997; Statistics Canada, *Spending patterns in Canada* (2009), 2010; Tracey, 2016).
Emission Factors (EF)	TPM, PM_{10}, $PM_{2.5}$, SO_x, NO_x, VOCs, CO, NH_3: (Gulland, 2000) Pb, Cd, Hg, B(a)p, B(b)f, B(k)f: (U.S. EPA, Compilation of Air Pollutant Emission Factors, Volume I: Stationary Point and Area Sources, 1995) Dioxins/furans: (EC, *Characterization of organic compounds from selected residential wood stoves and fuels*, 2000)

Table A2–7 **Estimation Methodologies for Commercial/Residential/Institutional** (cont'd)

Sector/Subsector	
HUMAN	
Description	Sources of ammonia emissions in the Human sector include respiration and perspiration and infant-diapered waste.
General Inventory Method	Pollutant(s) estimated: NH_3 Respiration and perspiration: Annual population data by province/territory are multiplied by an NH_3 emission factor. Infant-diapered waste: An annual estimate of the population aged 0-3 years by province/territory is multiplied by an NH_3 emission factor.
Activity Data	Respiration and perspiration: Population data: (Statistics Canada, Table 051-0001, n.d.) Infant-diapered waste: Number of children aged 0-3 years by province/territory: Statistics (Statistics Canada, Table 051-0001, n.d.).
Emission Factors (EF)	Respiration and perspiration and Infant-diapered waste: NH_3: (Roe et al., 2004).
SERVICE STATIONS	
Description	Service Stations estimates covers fugitive VOC emissions from fuel transfers and storage from refined petroleum products retail, as well as fugitive emissions from the refuelling of on- and off-road vehicles. Off-road refuelling emissions include all non-vehicle gasoline usage (lawn mowers, snow blowers, etc.).
General Inventory Method	Pollutant(s) estimated: VOCs **Refined petroleum products retail** Emissions are calculated using gasoline usage data multiplied by emission factors for underground tank filling and breathing. For British Columbia and Ontario, emissions from service stations are broken down into regulated versus unregulated areas. An emission control efficiency of 50% is applied to the filling of underground storage tanks in regulated areas in British Columbia and Ontario. The rest of the country is assumed to have no control efficiency. **Off-road refuelling** Off-road refuelling emissions are calculated using off-road gasoline usage data multiplied by an emission factor for uncontrolled vehicle refuelling. **On-road refuelling** On-road refuelling estimates are produced using the MOVES model. This year's estimates were made using MOVES2014. Vehicle-specific activity (vehicle kilometres travelled) is multiplied by pollutant-specific emission factors.
Activity Data	Refined petroleum products retail: Gross sales of gasoline for motor vehicles: (Statistics Canada, Table 23-10-0066-01, n.d.). Off-road refuelling: Off-road gasoline usage data (ECCC, *Off-road gasoline usage data from 1980 to 2017,* 2018) On-road refuelling: Data on the vehicle fleet (counts), defined by fuel type, model-year and gross vehicle weight rating, originate from DesRosiers Automotive Consultants (DAC, 2017) and R. L. Polk & Co. (Polk & Co, 2017) for light- and heavy-duty vehicles, respectively. Motorcycle populations originate from the Road motor vehicle, trailer and snowmobile registration database (Statistics Canada, Table 405-0001 , n.d.). The Annual Industry Statistics report (MMIC, 2013) is used to estimate the age distribution of motorcycles by model year which is applied to motorcycle populations obtained from Statistics Canada. The actual activity level is vehicle kilometres travelled (VKT). To arrive at estimates of VKT, vehicle counts are multiplied by mileage accumulation rates from Stewart-Brown Associates (Stewart-Brown Associates, 2012).
Emission Factors (EF)	Refined petroleum products retail and off-road refuelling: Evaporative emissions from gasoline service station operations (U.S. EPA, SPECIATE 4.2: Speciation database development documentation, 2008) On-road refuelling: Emission factors for on-road vehicles are embedded in the MOVES model. More information on MOVES is available online at www.epa.gov/otaq/models/moves/, in the U.S. EPA user guides (U.S. EPA, *User guide for MOVES2010b*, 2012; U.S. EPA, *User guide for MOVES2014*, 2014) and in the U.S. EPA technical guidance document (U.S. EPA, *Technical guidance on the use of MOVES2010 for emission inventory preparation in state implementation plans and transportation conformity,* 2010).

Table A2–8 **Estimation Methodologies for Incineration and Waste**

Sector/Subsector	
CREMATORIUMS	
Description	Crematoriums cover emissions from the combustion of caskets and human bodies. The combustion of fuel associated with the operation of a crematorium furnace or crematory fire is excluded from the sector. Fuel combustion emissions from cremations are captured under the Commercial and Institutional Fuel Combustion sector. In-house estimates do not cover animal cremation, as these emissions are reported through the NPRI.
General Inventory Method	Pollutant(s) estimated: TPM, PM_{10}, $PM_{2.5}$, SO_x, NO_x, CO, Pb, Cd, Hg, dioxins/furans, B(a)p, B(b)f, B(k)f, I(cd)p, HCB Number of human cremations per year by province/territory is multiplied by pollutant-specific emission factors.
Activity Data	Activity data for the years 2002 to 2017 is obtained from annual reports produced by the Cremation Association of North America (CANA). The *CANA Annual Statistics Report 2012: Executive Summary* (CANA, *Annual CANA statistics report 2012: Executive summary*, 2013) covers 2002 to 2007 and the CANA Annual Statistics Report (CANA, *Annual CANA statistics report*, 2018) includes data from 2008 to 2017. Given the unavailability of data for some years, emission estimates are calculated using linear interpolation for all provinces/territories for the year 2001 to 2002, and as well as Quebec for the years 2002 to 2007.
Emission Factors (EF)	TPM, PM_{10}, $PM_{2.5}$: (U.S. EPA, WebFIRE [database on the Internet], 2014) VOCs, HCB: (EEA, EMEP/EEA, 2013) SO_x, NO_x, CO: (EEA, EMEP/EEA, 2009) Hg, Cd, Pb: (U.S. EPA, WebFIRE [database on the Internet], 2014) Dioxins/furans: (U.S. EPA, WebFIRE [database on the Internet], 2014) B(a)p, B(b)f, B(b)k, I(cd)p: (U.S. EPA, WebFIRE [database on the Internet], 2014) An average weight per body and casing of approximately 150 lbs. is assumed.
INDUSTRIAL AND COMMERCIAL INCINERATION (under WASTE INCINERATION)	
Description	Industrial and Commercial Incineration involves the incineration of waste from industrial, commercial and institutional facilities.
General Inventory Method	Pollutant(s) estimated: TPM, PM_{10}, $PM_{2.5}$, SO_x, NO_x, VOCs, CO, NH_3, Pb, Cd, Hg, Methodology under review.
Activity Data	Methodology under review.
Emission Factors (EF)	Methodology under review.
MUNICIPAL INCINERATION (under WASTE INCINERATION)	
Description	Municipal Incineration involves the incineration of domestic waste, as well as non-hazardous and industrial waste.
General Inventory Method	Pollutant(s) estimated: TPM, PM_{10}, $PM_{2.5}$, SO_x, NO_x, VOCs, CO, NH_3, Pb, Cd, dioxins/furans Methodology under review.
Activity Data	Methodology under review.
Emission Factors (EF)	Methodology under review.
LANDFILLS (under WASTE TREATMENT AND DISPOSAL)	
Description	Landfills include emissions from bulk non-hazardous waste disposed of in landfills across Canada. Materials deposited into landfills are covered daily with soil to prevent scattering of litter by wind, scavenging by animals, and odours. As a result, PM emissions are due to wind erosion, the movement of heavy vehicles and the dumping of waste. VOC emissions are emitted as a small component of landfill gas (LFG) generated by the anaerobic decomposition of organic waste within the landfill.
General Inventory Method	Pollutant(s) estimated: TPM, PM_{10}, $PM_{2.5}$, VOCs The quantity of waste landfilled for each province/territory is multiplied by PM emission factors to determine the amount of PM released. VOC emissions are calculated as a concentration of the total fugitive landfill gas released, derived from CH_4 emissions.
Activity Data	The tonnage of waste landfilled is calculated on the basis of the total amount of waste disposed by province as reported by Statistics Canada (Statistics Canada, Table 153-0041, n.d.), the amount of waste exported out of the province, and the amount of waste incinerated. Landfilled waste is assumed to be any disposed waste that is not exported or incinerated. Where landfill data is available directly from provincial sources, it is integrated into the activity data set. The provincial CH_4 emissions calculated for *Canada's National Inventory Report* (NIR) are used to estimate VOC emissions for the APEI. CH_4 emissions are calculated using a First Order Decay model, as described in the NIR.
Emission Factors (EF)	TPM: (BCMELP, 1997) PM_{10}, $PM_{2.5}$: (GVRD & FVRD, 2003). The EF_{PM10} is calculated using a distribution percentage of 8% of the EF_{TPM}. The $EF_{PM2.5}$ is calculated using a distribution percentage of 2% of the EF_{TPM}. VOCs: (U.S. EPA, *Compilation of Air Pollutant Emission Factors,* Volume I: Stationary Point and Area Sources, 1995). The default concentration of VOC in landfill gas is 835 ppmv.

Table A2–8 **Estimation Methodologies for Incineration and Waste** (cont'd)	
Sector/Subsector	
RESIDENTIAL WASTE BURNING (under WASTE INCINERATION)	
Description	Emissions from Residential Waste Burning are related to on-site burning of residential waste materials in backyard barrels or to open-pit burning in rural areas.
General Inventory Method	Pollutant(s) estimated: TPM, PM_{10}, $PM_{2.5}$, SO_x, NO_x, VOCs, CO, NH_3, dioxins/furans, B(a)p, B(b)f, B(k)f, I(cd)p, HCB Methodology under review.
Activity Data	Methodology under review.
Emission Factors (EF)	Methodology under review.
OTHER (WASTE INCINERATION)	
Description	Other (Waste Incineration) applies to emissions from sewage sludge incineration and other small incinerators. This sector includes only emissions estimated in-house.
General Inventory Method	Pollutant(s) estimated: TPM, PM_{10}, $PM_{2.5}$, SO_x, NO_x, VOCs, CO, NH_3, Pb, Cd, Hg, dioxins/furans The volume of sewage sludge incinerated is multiplied by default emission factors.
Activity Data	Activity data is developed based on Environment and Climate Change Canada waste incineration survey (ECCC, *Waste Incineration in Canada 1990–2018 – A summary of fiindings from Surveys Conducted in 2006–2018*, 2018)
Emission Factors (EF)	TPM, PM_{10}, $PM_{2.5}$, Cd, Pb, Hg, D/F, NO_x, SO_x, NH_3, CO, VOC: (EEA, EMEP/EEA, 2016)

Table A2–9 **Estimation Methodologies for Paints and Solvents**	
Sector/Subsector	
DRY CLEANING, GENERAL SOLVENT USE, PRINTING AND SURFACE COATINGS	
Description	Dry Cleaning includes emissions from companies that provide dry cleaning of fabric and leather items. General Solvent Use consists of emissions from a broad range of applications occurring in residential, commercial, industrial and institutional settings. Industrial applications include uses such as degreasing, adhesives and sealants, aerosols, blowing agents and resin manufacturing. The use of consumer and commercial products, pesticides and personal care products is also included under General Solvent Use. Printing covers emissions from the manufacturing or use of printing inks. The sector consists of flexographic, gravure, letterpress, lithographic and other printing. Surface Coatings encompasses emissions from a broad range of applications and industries, including individuals and companies engaged in the manufacturing or use of paints and coatings.
General Inventory Method	Pollutant(s) estimated: VOCs The analysis methodology used is largely a "top-down" national mass balance approach that involves gathering statistical activity data on the production, distribution, end-use patterns and disposal of VOC-containing products and then building relationships between stages. More detailed data on solvent quantities and practices are collected from a subset of solvent and formulated product users, producers and distributors in Canada.
Activity Data	Solvent use quantities (1990 to 2004): (Cheminfo Services, *Volatile organic compound (VOC) emissions from the use of solvents in Canada – Inventory improvement and trends compilation – Task #2: VOC emission trends compilation 1985–2005*, 2007) Solvent use quantities (2005 to 2017): (Cheminfo Services, *Compilation of volatile organic compound (VOC) emissions from the use of solvents in Canada: Inventory update. VOC emission trends compilation: 2005 to 2017*, 2016) Domestic consumption is determined using a national mass balance approach. Information on production, trade and inventory changes is obtained from various literature sources, Statistics Canada and interviews with a subset of solvent producers and distributors. Projected estimates of national total solvent use for the years 2015–2017 were developed based on historical base year national total solvent use and macroeconomic growth and solvent growth ratios (Cheminfo Services, User manual for the solvent VOC database model, 2016). Macroeconomic growth data (GDP by NAICS): (Statistics Canada, Table 379-0031, n.d.).
Emission Factors (EF)	The estimated use of emission control technologies is applied in each solvent application area. More specifically, emissions are calculated by taking the estimated quantity of solvent used in an application area multiplied by the estimated percentage of uncontrolled VOCs or: $$E_{VOCs} = Quantity_{solventused} \times (100\% - \%\ Controlled_{VOCs})$$ where EVOCs is the emission estimate of VOCs. Emission controls (1990 to 2004): (Cheminfo Services, *Volatile organic compound (VOC) emissions from the use of solvents in Canada – Inventory improvement and trends compilation – Task #2: VOC emission trends compilation 1985–2005*, 2007) Emission controls (2005 to 2014): (Cheminfo Services, *Compilation of volatile organic compound (VOC) emissions from the use of solvents in Canada: Inventory update. VOC emission trends compilation: 2005 to 2017*, 2016) If there is no estimated use of control technologies, then 100% of the solvent VOCs is assumed to evaporate. Only a small portion of the estimated VOC emissions is reduced by the application of control technologies. Control efficiencies are applied (as percentages) in the following applications: flexographic, rotogravure and lithographic printing, aircraft coatings, automotive original equipment manufacture (OEM) coatings, metal can manufacturing, metal coil coating, metal furniture manufacturing, adhesives and sealants, and resin manufacturing (Cheminfo Services, *Compilation of volatile organic compound (VOC) emissions from the use of solvents in Canada: Inventory update. VOC emission trends compilation: 2005 to 2017*, 2016).

Table A2–10 **Estimation Methodologies for Dust**

Sector/Subsector	
COAL TRANSPORTATION	
Description	Coal Transportation includes PM emissions resulting from the transportation of coal by open-top rail, truck or barge. Most of the coal mined in Canada is carried to trans-shipment terminals (ports, for export) or to end use facilities by unit trains. Coal imported into Canada is predominantly shipped in lake and ocean vessels – some imported coal is landed directly at the end use facility; some is transported inland from import terminals by train or truck. Coal imported from central and western United States is generally transported by rail to end use facilities. Trucks are typically only used for coal shipment over shorter distances, whether to rail load-out (where it is shipped by rail the rest of the journey), or directly to the end-user / trans-shipment (port) terminals (Cope and Bhattacharyya 2001). Load-in and load-out losses, including transportation within the mine-site and to mine-mouth facilities, are estimated and reported by mine facilities to the NPRI as part of fugitive emissions. Emissions from fuel combustion during coal transport (diesel, gasoline or oil) are inventoried separately as part of the Transportation and Mobile Equipment source category.
General Inventory Method	Pollutant(s) estimated: TPM, PM_{10}, $PM_{2.5}$ Emissions are estimated for each source-destination rail, truck or barge transportation route and summed by province. Emission factors for TPM for each rail or truck transportation route (source-destination) are derived from the distance travelled, the emission control/dust-mitigation effectiveness, and moisture (precipitation) along the route. For each province that a route crosses, the route emissions attributed to that province are determined from the proportion of the province-segment of the route to total route length. The PM_{10} and $PM_{2.5}$ emissions are calculated from the total particulate matter emissions based on a scaling factor. The mass of coal transported along each route is determined on the basis of either mine production of marketable coal (for mine to port or mine to end-user) or coal demand by end-user (for imported coal to end users) . Coal mine production sent to multiple destinations is proportioned on the basis of documented coal shipping volumes to each destination, reported coal demand for coal-users, or estimates from (Cope & Bhattacharyya, 2001). Where no information was available, the coal production was proportioned to the various destinations on the basis of the distance between the mine and the destination.
Activity Data	Coal mine production and coal-user demand: (Statistics Canada, Table 135-0002, n.d.; Statistics Canada, Table 25-10-0048-01, n.d.; Statistics Canada, RESD, n.d.) ; (Cope & Bhattacharyya, 2001) and company websites (Accessed 2017). Monthly climate summaries: (ECCC, Monthly climate summaries, 2017) Rail Transportation Network: (NRCan, *Transport networks in Canada – CanVec – Transport Features*, n.d.)(1:1M scale used) Mine Locations: (BC MINEFILE, 2017; AER, Coal Mine Locator, 2015), environmental assessment reports, and in-house remote-sensing.
Emission Factors (EF)	(Cope & Bhattacharyya, 2001)
CONSTRUCTION OPERATIONS	
Description	Construction Operations include PM emissions primarily resulting from soil disturbance on construction sites. The amount of soil disturbance is related to the surface area and duration of a construction project. The geographic region, type of construction (residential, industrial-commercial-institutional [ICI], engineering) and soil characteristics are all considered.
General Inventory Method	Pollutant(s) estimated: TPM, PM_{10}, $PM_{2.5}$ Residential construction: Emission factors (SNC-Lavalin Environment, *CAC fugitive emissions from the Canadian construction and demolition sector, Final Report,* 2005) are applied to the number of housing starts, the average lengths of construction (duration) and buildings-to-hectares conversion factors, by province/territory and dwelling type. The number of houses with basements, average basement area and depth (volume of earth moved) are also considered. Emission factors are corrected for soil texture using average provincial soil silt contents weighted by the areas of highest residential construction or average territorial level soil silt contents. Thornthwaite's precipitation-evaporation (PE) index by province/territory is used to correct the emission factors for soil moisture. ICI and engineering construction: Methodology under review The in-house estimates for ICI were last calculated for 2012 and were carried forward to 2017.
Activity Data	Residential construction: Dwelling starts: (Statistics Canada, Table 027-0009, n.d.; CMHC, 2017) Average lengths of construction: (CMHC, 2017) Buildings to hectares conversion factors: (*SNC-Lavalin Environment, CAC fugitive emissions from the Canadian construction and demolition sector*, Final Report, 2005) Average basement area and depth: (*SNC-Lavalin Environment, CAC fugitive emissions from the Canadian construction and demolition sector,* Final Report, 2005) Number of homes with basements: (*SNC-Lavalin Environment, CAC fugitive emissions from the Canadian construction and demolition sector,* Final Report, 2005) ICI and engineering construction: Methodology under review
Emission Factors (EF)	Residential construction: TPM, PM_{10}, $PM_{2.5}$: (*SNC-Lavalin Environment, CAC fugitive emissions from the Canadian construction and demolition sector*, Final Report, 2005). Correction factors: % silt content[4] Precipitation-Evaporation (PE) Index: (*SNC-Lavalin Environment, CAC fugitive emissions from the Canadian construction and demolition sector*, Final Report, 2005). ICI and engineering construction: Methodology under review.

4 Flemming, C. 2017. Personal communication (email from Flemming C to Reza K, Environment and Climate Change Canada, dated July 20, 2017). AFOLU Section, Pollutant Inventories and Reporting Division, Environment and Climate Change Canada.

Table A2–10 **Estimation Methodologies for Dust** (cont'd)

Sector/Subsector	
MINE TAILINGS	
Description	Mine Tailings covers emissions of particulates resulting primarily from wind erosion at mine tailings ponds located on active and inactive mine sites. Concentrators used for mining produce both a finely-milled concentrate rich in the desired metal(s) and a solids-laden mine tailings stream. This slurry is sent to a tailings pond where the solids settle out of suspension and the supernatant solution is either recycled back in the process or discharged as effluent. It is common practice to keep the solids in the tailings pond submerged, even when the mine is inactive or closed. If the solids in the pond are no longer submerged, fugitive particulate emissions occur through wind dispersion.
General Inventory Method	Pollutant(s) estimated: TPM, PM_{10}, $PM_{2.5}$ Methodology under review. The in-house estimates were last calculated for 2005 and were carried forward to 2017.
Activity Data	Methodology under review.
Emission Factors (EF)	Methodology under review.
PAVED ROADS	
Description	Emissions from the Paved Roads sector originate from primary (road abrasion) and secondary (re-suspended) PM emissions.
General Inventory Method	Pollutant(s) estimated: TPM, PM_{10}, $PM_{2.5}$ Road abrasion, or **primary** paved road emissions, are produced by multiplying the total vehicle kilometres travelled for each province/territory by pollutant-specific emission factors. The methodology for **secondary (re-suspended)** emissions is currently under review. The emissions were last estimated for 2002 and were carried forward to 2016. The method used up to 2002 was based on an empirical equation from the US EPA AP-42 Section 13.2.1 (U.S. EPA, *Compilation of Air Pollutant Emission Factors*, Volume I: Stationary Point and Area Sources, 1995).
Activity Data	The same method used to calculate VKT for Transportation and Mobile Equipment sources was used to estimate VKT for the primary and secondary emissions. Methodology under review for secondary emissions. The former method, based on the (U.S. EPA, *Compilation of Air Pollutant Emission Factors*, Volume I: Stationary Point and Area Sources, 1995) calculation, required information on silt loading, average vehicle weights, road types, precipitation and distance travelled by vehicles (VKT) on the road.
Emission Factors (EF)	Primary—(EEA, EMEP/EEA, 2013) Secondary—Methodology under review.
UNPAVED ROADS	
Description	Emissions of dust from Unpaved Roads originate from suspension and re-suspension PM emissions.
General Inventory Method	Pollutant(s) estimated: TPM, PM_{10}, $PM_{2.5}$ Methodology under review. The estimates were last calculated for 2002 and were forward to 2017.
Activity Data	Methodology under review. The former method, based on the (U.S. EPA, *Compilation of Air Pollutant Emission Factors*, Volume I: Stationary Point and Area Sources, 1995) calculation required information on road surface material silt content, average vehicle weights, road surface material moisture content, and distance travelled by vehicles (VKT) on the road. The same method used to calculate VKT for Transportation and Mobile Equipment sources was used to estimate VKT for the dust from Unpaved Roads.
Emission Factors (EF)	Methodology under review.

Table A2–11 **Estimation Methodologies for Fires**	
Sector/Subsector	
PRESCRIBED BURNING	
Description	Prescribed Burning includes emissions from controlled fires used for land management treatments. Prescribed burning is used to reduce logging residues, manage forest production, control insects and minimize potential for destructive wildfires. The practice of prescribed burning is carried out by the logging industry and forestry officials to manage Crown lands. This sector excludes the burning of agricultural residues.
General Inventory Method	Pollutant(s) estimated: TPM, PM_{10}, $PM_{2.5}$, SO_x, NO_x, VOCs, CO, NH_3, dioxins/furans, B(a)p, B(b)f, B(k)f, I(cd)p Total annual mass of forest debris burned by fire and by province/territory is multiplied by pollutant-specific emission factors.
Activity Data	The total number of hectares burned in each province/territory per year (CIFFC, 2016; PCA, 2016; NFD, 2016) is multiplied by a conversion factor for each province/territory (EC, *Canada's greenhouse gas emissions: Estimates for 1990*, 1992) to convert the area burned into the mass of forest debris burned. Pollutant and province-specific emission factors are then applied to the mass of forest debris to determine the release of pollutants from the burn.
Emission Factors (EF)	TPM, PM_{10}, $PM_{2.5}$, SO_x, NO_x, VOCs, CO, NH_3: All provinces/territories (except British Columbia): (U.S. EPA, *Compilation of Air Pollutant Emission Factors,* Volume I: Stationary Point and Area Sources, 1995). British Columbia: (GVRD & FVRD, 2003; BCMWLAP, 2004) Dioxins/furans, B(b)f, B(k)f: (Lemieux et al., 2004), B(a)p, I(cd)p: (Johnson et al., 1992)
STRUCTURAL FIRES	
Description	Structural Fires cover emissions from vehicle fires (such as fires from cars, trains and airplanes) and buildings fires. Structural fires emit large quantities of pollutants due to rapid but incomplete combustion. This sector includes only emissions estimated in-house.
General Inventory Method	Pollutant(s) estimated: TPM, PM_{10}, $PM_{2.5}$, NO_x, VOCs, CO, NH_3 Tonnes of structures burned per year, by province/territory, are multiplied by pollutant-specific emission factors.
Activity Data	The Secretary/Treasurer of the Council of Canadian Fire Marshals and Fire Commissioners[5] (CCMFC) and the following members of the CCMFC are contacted to obtain the number of annual structural fires in their jurisdictions: • Government of Nunavut[6] (carried forward) • Fire and Emergency Services, Newfoundland and Labrador[7] (carried forward) • Office of the Fire Marshal and Emergency Management (Ontario)[8] (carried forward) • Office of the Fire Commissioner (Manitoba)[9] (carried forward) • Emergency Management and Fire Safety Branch (Saskatchewan)[10] (carried forward) • Canadian Forces Fire Marshal[11] (2016 data) • Office of Public Safety (Prince Edward Island)[12] (carried forward) • Yukon Government[13] (2016 data) • Department of Labour and Advanced Education (Nova Scotia)[14] (2016 data) • Department of Municipal and Community Affairs (Government of the Northwest Territories)[15] (2016 data) • Department of Public Safety (New Brunswick)[16] (2016 data) • Office of the Fire Commissioner (Alberta)[17] (2016 data) • Emergency Management British Columbia[18] (2016 data) • Ministère de la Sécurité publique[19] (carried forward) Number of structure fires in each province/territory is multiplied by a loading factor to convert the number of fires into tonnes of structure burned (EIIP, 2001). Loading factor = 1.04 t of structure burned/fire Given the unavailability of activity data, emission estimates for 2001, 2002 and 2004 are calculated using linear interpolation.
Emission Factors (EF)	TPM, PM_{10}, $PM_{2.5}$, NO_x, VOCs, CO: (GVRD & FVRD, 2003) NH_3: (Battye et al., 1994)

5 Gourley P. 2015. Personal communication (email from Gourley P to Inventories Engineer dated May 25, 2015). Council of Canadian Fire Marshals and Fire Commissioner.

6 Prima R. 2015. Personal communication (email from Prima R to Inventories Engineer dated June 22, 2015). Government of Nunavut.

7 King A. 2015. Personal communication (email from King A to Inventories Engineer dated June 19, 2015). Fire and Emergency Services, Newfoundland and Labrador.

8 Robinson B. 2015. Personal communication (email from Robinson B to Inventories Engineer dated June 18, 2015). Office of the Fire Marshal and Emergency Management (Ontario).

9 Dimayuga P. 2015. Personal communication (email from Dimayuga P to Inventories Engineer dated June 17, 2015). Office of the Fire Commissioner (Manitoba).

10 Catley K. 2015. Personal communication (email from Catley K to Inventories Engineer dated June 16, 2015). Emergency Management and Fire Safety Branch (Saskatchewan).

11 Page L. 2017. Personal communication (email from Page L to Inventories Engineer dated Sept 11, 2017). Canadian Forces Fire Marshal (Canadian Forces).

12 Rossiter D. 2015 Personal communication (email from Rossiter D to Inventories Engineer dated June 10, 2015). Office of Public Safety (Prince Edward Island).

13 Marcuson M. 2017 Personal communication (email from Marcuson M to Inventories Engineer dated July 11, 2017). Yukon Government.

14 Pothier H. 2017 Personal communication (email from Pothier H to Inventories Engineer dated Sept 11, 2017). Department of Labour and Advanced Education (Nova Scotia).

15 Dewar C. 2017 Personal communication (email from Dewar C to Inventories Engineer dated June 9, 2017). Department of Municipal and Community Affairs (Government of the Northwest Territories).

16 Nowlan M. 2017 Personal communication (email from Nowlan M to Inventories Engineer dated June 9, 2017). Department of Public Safety (New Brunswick).

17 Kevin M. 2017 Personal communication (email from Kevin M to Inventories Engineer dated June 9, 2017). Office of the Fire Commissioner (Alberta).

18 Simpson F. 2017 Personal communication (email from Simpson F to Inventories Engineer dated June 22, 2017). Emergency Management British Columbia.

19 Mathurin S. 2015 Personal communication (email from Mathurin S to Inventories Engineer dated June 1, 2015). Ministère de la Sécurité publique.

Table A2–12 **Estimation Methodology for Mercury in Products**

Sector/Subsector	
MERCURY IN PRODUCTS	
Description	Mercury in Products covers emissions from Hg contained in products throughout their life cycle from manufacture to final disposition. The following products are included: • automotive switches • switches and relays • batteries • dental amalgams • fluorescent tubes • non-fluorescent lamps • measurement and control devices • thermometers • thermostats • tire balancers Emissions from the above devices impact the following sectors/subsectors: • Iron and Steel Industry—Secondary (Electric Arc Furnaces) • Iron and Steel Industry—Steel Recycling • Electronics • Other (Manufacturing) • Human Other (Commercial / Residential / Institutional) • Municipal Incineration • Landfills • Residential Waste Burning • Municipal Wastewater Treatment and Discharge • Industrial and Commercial Incineration
General Inventory Method	Pollutant(s) estimated: Hg Mercury emissions are estimated based on the model *Substance Flow Analysis of Mercury in Products* originally developed by the Minnesota Pollution Control Agency, modified by ToxEcology Environmental and updated by ChemInfo Services in 2018 (Barr Engineering, 2001; ToxEcology, *Mass balance study for mercury-containing products model*, 2007; ToxEcology, *Mass balance study for mercury-containing products report,* 2007; ToxEcology, Mercury mass balance model_2008.xls[excel spreadsheet], 2009; Cheminfo Services, *Updating Environment and Climate Change Canada's mercury-in-products flow model for the purpose of improving Canada's air pollution emission inventory*, 2018). The current update focuses on improvements to 2009-2017 of the time series, incorporating more Canadian data to better reflect current Canadian conditions. This includes the impact of risk management instruments for mercury-containing products, such as restrictions in manufacturing an importing as well as enhanced recovery and recycling. The Mercury in Products model generally uses a lifecycle approach which considers releases from manufacture, sales, in-service, breakage, disposal, recycling, transportation of items to disposal, disposal point, and the ultimate fate of the contained Hg. Note that while the model apportions releases to air, water and land, only the air portion is used.
Activity Data	(Cheminfo Services, *Updating Environment and Climate Change Canada's mercury-in-products flow model for the purpose of improving Canada's air pollution emission inventory*, 2018).
Emission Factors (EF)	A modified version of the model, entitled *Substance Flow Analysis of Mercury in Products* by (Barr Engineering, 2001) used with updates from (ToxEcology, Mass balance study for mercury-containing products model, 2007; ToxEcology, *Mass balance study for mercury-containing products report,* 2007; Cheminfo Services, *Updating Environment and Climate Change Canada's mercury-in-products flow model for the purpose of improving Canada's air pollution emission inventory*, 2018). The model includes partitioning factors to the various streams from manufacture through final disposal, including emission factors at every point along the way. The model produces emissions at the provincial, territorial and national level. For 1990 to 2008, provincial/territorial level estimates are obtained for emissions by source (e.g. electric arc furnaces, sewage, landfill, etc.) which are distributed based on population or surrogates developed from reported point sources (electric arc furnaces, incinerators, lamp manufacturers). For 2009 forward, provincial/territorial level estimates are obtained by product group, where releases are allocated to air, water and land.

A2.3. **Recalculations**

Emission recalculation is an essential practice in the maintenance of up-to-date and consistent trends in air pollutant emissions. Circumstances that warrant a change or refinement of data and/or methods include:

- correction of errors detected by quality control procedures;
- incorporation of updates to activity data including changes to data sources;
- re-allocation of activities to different categories (which will affect sub-totals);
- refinements of methodologies and emission factors; and
- inclusion of categories previously not estimated (which improves inventory completeness).

Resubmissions of facility-reported data previously reported to the NPRI can also result in revised historical estimates. Generally, these recalculations by facilities are completed for only a few years in their historical emissions.

In contrast, new activity data are incorporated into the in-house estimates as they become available, and these updates are reflected in the trends on an ongoing basis. Updated trends, based on updated facility-reported data and in-house estimates, are published on a yearly basis. For example, the calculation of emissions from commercial fuel combustion, residential fuel combustion, agricultural fuel use and construction fuel combustion sectors rely on the latest fuel use quantities from the Statistics Canada annual publication *Report on Energy Supply and Demand in Canada* (RESD) (Statistics Canada, RESD, n.d.).

The following in-house emissions estimates were recalculated for the 2018 edition of the APEI. Brief descriptions of the recalculations and the impacts on emission levels are provided in Tables A2–13 to A2–19.

- Oil and Gas Industry: Refined Petroleum Products Bulk Storage and Distribution; Natural Gas Distribution; Accidents and Equipment Failures; Disposal and Waste Treatment; Heavy Crude Oil Cold Production; Light/Medium Crude Oil Production; Natural Gas Production and Processing; Natural Gas Transmission and Storage; Oil Sands In-Situ Extraction; Petroleum Liquids Storage; Petroleum Liquids Transportation; Well Drilling/Servicing/Testing
- Manufacturing: Bakeries; Wood Products
- Transportation and Mobile Equipment: Marine Transportation; On-Road Vehicles; Off-Road Vehicles and Equipment
- Agriculture: Animal Production; Crop Production; Fuel Use
- Commercial/Residential/Institutional: Commercial and Institutional Fuel Combustion; Construction Fuel Combustion; Residential Fuel Combustion
- Incineration and Waste: Waste Incineration; Landfills
- Mercury in Products

For the purpose of Tables A2–13 to A2–19, the term "significant" refers to changes greater than ±10% in emission levels.

Table A2–13 **Recalculations for Oil and Gas Industry**

Sector	Pollutant(s)	Description	Impact on Emissions
REFINED PETROLEUM PRODUCTS BULK STORAGE AND DISTRIBUTION (under DOWNSTREAM OIL AND GAS INDUSTRY)			
	VOCs	For the period 2013 to 2017, some emissions previously allocated to petroleum refining are now reported in this category.	Changes in allocation resulted in a maximum emission increase of about 1.3% in 2014.
NATURAL GAS DISTRIBUTION (under DOWNSTREAM OIL AND GAS INDUSTRY)			
	TPM, PM_{10}, $PM_{2.5}$, SO_x, NO_x, VOCs, CO	Recalculations occurred from 2003 through 2016 as a result of updates to the reported NPRI data and improved allocation of NPRI data to the Oil and Gas Industry subsectors.	This resulted in changes to emissions at the national level from 2003 through 2016 for CO (largest difference in 2004: +293.0 t, +15.7%), from 2003 through 2016 for NO_x (largest difference in 2004: -46.0t, -24.0%), from 2015 through 2016 for SO_x (largest difference in 2016: +0.1t, +12.2%), 2003 through 2016 for PM_{10} (largest difference in 2005: -11.4t, -33.8%), from 2004 through 2016 for TPM (largest difference in 2010: +0.2t, +19.3%). For VOC and $PM_{2.5}$, this recalculation did not result in an emissions change greater than ±10%.

Table A2–13 **Recalculations for Oil and Gas Industry** (cont'd)

Sector	Pollutant(s)	Description	Impact on Emissions
ACCIDENTS AND EQUIPMENT FAILURES (under UPSTREAM OIL AND GAS INDUSTRY)			
	VOCs	Recalculations occurred from 2012 through 2016 as a result of updated activity data. (AER, *AER Compliance Dashboard – Incidents*, 2018; BCOGC, 2018; SK MOE, *Saskatchewan upstream oil and gas IRIS incident report*, 2018).	The recalculations did not result in changes greater than ±10% for any pollutants in the impacted years.
DISPOSAL AND WASTE TREATMENT (under UPSTREAM OIL AND GAS INDUSTRY)			
	VOCs, CO	Recalculations occurred from 2013 through 2016 as a result of updated activity data. (AER, *Upstream petroleum industry flaring and venting report,* 2018; AER, *VPR6800 Supply and disposition of gas (economics),* 2018; Statistics Canada, Table 25-10-0063-01, n.d.).	The recalculations resulted in changes in emission levels of less than ±10% for 2012 and 2015.
HEAVY CRUDE OIL COLD PRODUCTION (under UPSTREAM OIL AND GAS INDUSTRY)			
	VOCs	Recalculations occurred from 2013 through 2016 as a result of updated activity data. (AER, *Upstream petroleum industry flaring and venting report*, 2018; AER, *VPR6800 Supply and disposition of gas (economics)*, 2018; SK MOE, *Saskatchewan fuel, flare and vent,* 2018).	The recalculations did not result in changes greater than ±10% for any of the pollutants.
LIGHT MEDIUM CRUDE OIL PRODUCTION (under UPSTREAM OIL AND GAS INDUSTRY)			
	TPM, PM_{10}, $PM_{2.5}$, SO_x, NO_x, VOCs, CO, NH_3	Recalculations occurred from 2012 through 2016 as a result of updated activity data. (AER, *Upstream petroleum industry flaring and venting report*, 2018; AER, *VPR6800 Supply and disposition of gas (economics)*, 2018; BC, 2018; SK MOE, *Saskatchewan fuel, flare and vent*, 2018).	The recalculations did not result in changes greater than ±10% for any of the pollutants.
NATURAL GAS PRODUCTION AND PROCESSING (under UPSTREAM OIL AND GAS INDUSTRY)			
	SO_x	Recalculations occurred from 2006 through 2016 as a result of updates to the reported NPRI data and improved allocation of NPRI data to the Oil and Gas Industry subsectors.	The recalculations did not result in changes greater than ±10% for any of the pollutants.
NATURAL GAS TRANSMISSION AND STORAGE (under UPSTREAM OIL AND GAS INDUSTRY)			
	TPM, PM_{10}, $PM_{2.5}$, SO_x, NO_x, VOCs, CO, NH_3	Recalculations occurred from 2002 through 2016, as a result of updates to the reported NPRI data and the improved allocation of NPRI data to Oil and Gas Industry subsectors.	This resulted in changes to emissions at the national level from 2002 through 2016 for CO (largest difference in 2012: +733.6t, +15.6%), from 2002 through 2016 for NO_x (largest difference in 2004: +3767.0t, 15.9%), from 2002 through 2016 for VOCs (largest difference in 2004: +262t, +20.4%), 2003 through 2016 for SO_x (largest difference in 2010: +747.7t, +3621.0%), from 2002 through 2016 for $PM_{2.5}$ (largest difference in 2003: +83.3t, +27.4%), from 2002 through 2016 for PM_{10} (largest difference in 2016: +25.5t, +28.8%), from 2002 through 2016 for TPM (largest difference in 2011: +84.8t, +91.3%). For NH_3, this resulted in changes to 2016 emissions at the national level (+0.1t, +16.4%).
OIL SANDS IN-SITU EXTRACTION (under UPSTREAM OIL AND GAS INDUSTRY)			
	TPM, PM_{10}, $PM_{2.5}$, SO_x, NO_x, VOCs, CO, NH_3, Cd	Recalculations occurred for the entire time series, from 1990 through 2016, as a result of updates to the reported NPRI data and improved allocation of NPRI data to the Oil and Gas Industry subsectors.	This resulted in changes to emissions at the national level from 1990 through 2016 for TPM (largest difference in 2004: +59.2t, +26.7%), from 2002 through 2005 for Cd (largest difference in 2004: +37.2t, +284.4%), from 2002 through 2016 for SO_x (largest difference in 2003: +536.2t, +10.4%).For all other pollutants, this recalculation did not result in an emissions change of greater than ±10%.
PETROLEUM LIQUIDS STORAGE (under UPSTREAM OIL AND GAS INDUSTRY)			
	VOCs	Recalculations occurred from 2002 through 2016 as a result of updates to the reported NPRI data and improved allocation of NPRI data to the Oil and Gas Industry subsectors.	The recalculations resulted in changes to VOC emissions from 2002 through 2016 (largest difference in 2005: 2940.2t, 150.9%).
PETROLEUM LIQUIDS TRANSPORTATION (under UPSTREAM OIL AND GAS INDUSTRY)			
	TPM, PM_{10}, $PM_{2.5}$, SO_x, NO_x, VOCs, CO	Recalculations occurred from 2012 through 2016 as a result of updates to the reported NPRI data.	This resulted in changes to emissions at the national level from 2012 through 2016 for $PM_{2.5}$ (largest difference in 2016: +5.2t, +73.9%), from 2012 through 2016 for PM_{10} (largest difference in 2016: +7.8t, +96.5%), from 2012 through 2016 for TPM (largest difference in 2016: +7.8t, +96.5%). For SO_x, this resulted in emissions from 2012 through 2016 (i.e. no emissions estimates previously). For all other pollutants, this recalculation did not result in an emissions change of greater than ±10%.
OIL SANDS MINING, EXTRACTION AND UPGRADING (under UPSTREAM OIL AND GAS INDUSTRY)			
	TPM, PM_{10}, $PM_{2.5}$, SO_x, NO_x, VOCs, CO,NH_3, Pb, B(a)p, B(p)f, HCB, B(k)f, I(1,2,3-cd)p	Recalculations occurred from 1996 through 2016 as a result of updates to the reported NPRI data and improved allocation of NPRI data to the Oil and Gas Industry subsectors.	This resulted in changes to emissions at the national level from 1996 through 2005 for NH_3 (largest difference in 1998: +674t, +68.9%), from 2002 through 2005 for Cd (largest difference in 2004: -16.0t,-32.5%), from 2000 through 2005 for B(b)f (largest difference in 2005: -0.4t, -35.6%), from 2000 through 2005 for B(k)f (largest difference in 2005: -0.4t,-40.8%), from 2000 through 2005 for I(1,2,3-cd)p (largest difference -0.3t, -29.4%). For all other pollutants, this recalculation did not result in an emissions change of greater than ±10%.

Table A2–14 Recalculations for Manufacturing

Sector	Pollutant(s)	Description	Impact on Emissions
BAKERIES			
	VOC	A new estimation methodology was implemented to align with that used by the Quebec Government. Updated population and bakeries activity data were used for 1990–2016 estimates.	The recalculations resulted in significant changes in emissions levels (> ±10%) for 1990–2016. The recalculated emissions decreased by 10.9 kt or 69% in 2016 for VOCs.
WOOD PRODUCTS			
	TPM, PM_{10}, $PM_{2.5}$, SO_x, NO_x, VOCs, CO, NH_3, Pb, Cd, Hg, dioxins/furans, B(a)p, B(b)f, B(k)f, I(cd)p,	The recalculations were done using updated activity data provided by the Forestry Products and Fishery Acts Division from 1990 to 2016.	The recalculations resulted in changes in emission levels (> ±10%) for TPM; PM_{10} and $PM_{2.5}$ from 2006 to 2016; NO_x from 2004 to 2005; VOCs for 2005; CO for 2003; Pb for 2004; Cd from 2003 to 2004; dioxins/furans from 1990 to 2008 and 2011 to 2016; and B(a)p from 2002 to 2004.

Table A2–15 Recalculations for Transportation and Mobile Equipment

Sector	Pollutant(s)	Fuel	Description	Impact on Emissions
MARINE TRANSPORTATION				
	B(a)p, B(b)f, B(k)f, I(cd)p, TPM, PM_{10}, $PM_{2.5}$, SO_x, NO_x, VOCs, CO, NH_3, Pb, Cd, Hg, D/F	Heavy Fuel Oil, Marine Diesel Oil, Marine Gasoline Oil	Model updates from Marine Emissions Inventory Tool 2015, new interpolation for the years between 2010–2014 and new extrapolation to 2016.	The recalculations did not impact results for 1990. The recalculations for 2016 resulted in significant changes in the emissions of B(a)p (+103% or +10kg), B(b)f (+103% or +19kg), B(k)f (+103% or +10kg), I(1,2,3-cd)p (+103% or +19kg), TPM (-17% or -940 t), PM_{10} (-17% or -900 t), $PM_{2.5}$ (-17% or -830 t), SO_x (-36% or -4.9 kt), NO_x (-7% or -14 kt), VOCs (+13% or +0.95 kt), CO (-11% or -2.4 kt), NH_3 (-10% or -30 t), Pb (+103 or +290 kg), Cd (-66% or -65 kg), Hg (-76% or -1.7 kg) and D/F (+103% or +10kg).
ON-ROAD VEHICLES (includes the following sectors: Heavy-duty Diesel Vehicles, Heavy-duty Gasoline Vehicles, Heavy-duty LPG/NG Vehicles, Light-duty Diesel Trucks, Light-duty Diesel Vehicles, Light-duty Gasoline Trucks, Light-duty Gasoline Vehicles, Light-duty LPG/NG Vehicles, Light-duty LPG/NG Trucks, Motorcycles, Tire Wear and Brake Lining)				
	all	All transport fuels	Due to the inter-relationship between the On-road and Off-road sectors in terms of how total fuel use is normalized to the *Report on Energy Supply and Demand* (RESD), changes in methodology to any aspect of on-road or off-road will impact both sectors. Relative to the 2018 submission, for the 2019 submission the following methodology changes were implemented for on-road and off-road. Change in assumed hours-of-use for snowmobiles for all year and all provinces/territories (ECCC, *Off-road Equipment Analysis – Snowmobiles,* 2018). Change in estimated number of Diesel off-road vehicles/engines used in Oil Sands mining (ECCC, *Off-road Equipment Analysis – Oil Sands Mining Equipment*, 2018). Change in estimated number of on-road vehicles in all territories for all years. Change in the version of the RESD used for normalization.	The recalculations did not significantly impact results for 1990 or 2016.
OFF-ROAD VEHICLES AND EQUIPMENT				
	all	All transport fuels	Due to the inter-relationship between the On-road and Off-road sectors in terms of how total fuel use is normalized to the Report on Energy Supply and Demand (RESD), changes in methodology to any aspect of on-road or off-road will impact both sectors. Relative to the 2018 submission, for the 2019 submission the following methodology changes were implemented for on-road and off-road. Change in assumed hours-of-use for snowmobiles for all year and all provinces/territories (ECCC, *Off-road Equipment Analysis – Snowmobiles*, 2018). Change in estimated number of Diesel off-road vehicles/engines used in Oil Sands mining. (ECCC, *Off-road Equipment Analysis – Oil Sands Mining Equipment,* 2018). Change in estimated number of on-road vehicles in all territories for all years. Change in the version of the RESD used for normalization.	The net result of methodology changes impact all pollutants for both On-road and Off-road sectors, for all years. However, changes are not large at the national level, with only VOC from off-road being a change greater than 10% in calendar years 1990 and 2016, relative to the 2018 submission estimates for those same calendar years for off-road. The 2019 submission shows a 10.2% (93kt) decrease in VOC from off-road in calendar year 1990, compared with the 2018 submission. Similarly, the 2019 submission shows a 17.9% (28kt) decrease in VOC from off-road in calendar year 2016, compared with the 2018 submission.

Table A2–16 Recalculations for Agriculture

Sector	Pollutant(s)	Description	Impact on emissions
ANIMAL PRODUCTION			
	NH_3	The methodology for estimating ammonia emissions from swine was updated. The previous methodology used per head emission factors fixed in time that varied only regionally. In the updated method, a variable time series of ammonia loss factors are applied to swine N excretion estimates and changes to manure management storage types that also change over time. Swine NH_3 estimates are now responsive to changes in nitrogen excretion resulting from changes in animal weight, and changes in manure storage practices over time.	Emissions of NH_3 decreased slightly by 9.1 kt (-3%) in 1990, 15 kt (-4%) in 2005, and 17 kt (-6%) in 2016.
	TPM, PM_{10}, $PM_{2.5}$	Integration of the 2016 census of agriculture and updates to annual Statistics Canada surveys, resulted in changes to activity data which impacted livestock populations and distribution of livestock on the landscape.	The recalculations did not result in changes in emission levels of greater than 10% for any of the pollutants in 1990, 2005, or 2016.
	VOC	The methodology for estimating emissions of non-methane volatile organic compounds (NMVOCs) for dairy cattle was updated from a Tier 1 method to a Tier 2 method. The new methodology incorporates the impact of feeding practices, especially silage content in feed, and changes in manure management practices, on VOC emissions.	Emissions of VOCs from livestock increased by 9.5 kt (+10%) in 1990, 12 kt (+11%) in 2005, and 17 kt (+17%) in 2016.
CROP PRODUCTION			
	NH_3	Changes in swine manure N excretion rates, and updates to livestock and crop activity data from the 2016 census of agriculture and annual Statistics Canada surveys,, resulted in the redistribution of various synthetic N fertilizers among eco-districts and between perennial and annual crops.	The recalculations did not result in changes in emission levels of greater than 10% for any of the pollutants in 1990, 2005, or 2016.
	TPM, PM_{10}, $PM_{2.5}$	Integration of the 2016 census of agriculture and updates to annual Statistics Canada surveys, resulted in changes to activity data including crop areas and tillage practices.	The recalculations did not result in changes in emission levels of greater than 10% for any of the pollutants in 1990 or 2005. In 2016, emissions of TPM increased by 676 kt (+22%), PM_{10} increased by 258 kt (+20%), and $PM_{2.5}$ increased by 67 kt (+22%)
FUEL USE			
	TPM, PM_{10}, $PM_{2.5}$, SO_x, NO_x, VOCs, CO, NH_3, Pb, Cd, Hg, dioxins/ furans, B(a)p, B(b)f, B(k)f, I(cd)p, HCB	The activity data have been updated to a more recent edition of the RESD.	The recalculations did not result in changes in emission levels for any of the pollutants in 1990. For the year 2016, recalculation resulted in the following changes: 12% for NO_x, 28% for Pb, 35% for VOC, 45% for Hg, 47% for CO, 52% for PM_{10}, 56% for $PM_{2.5}$, and 87% for TPM. The remaining pollutant emissions changed by less than ±10% in 2016.

Table A2–17 Recalculations for Commercial/Residential/Institutional

Sector	Pollutant(s)	Description	Impact on Emissions
COMMERCIAL AND INSTITUTIONAL FUEL COMBUSTION			
	TPM, PM_{10}, $PM_{2.5}$, SO_x, NO_x, VOCs, CO, NH_3, Pb, Cd, Hg, dioxins/furans, B(a)p, B(b)f, B(k)f, I(cd)p, HCB	The activity data have been updated to a more recent edition of the RESD.	The recalculations did not result in changes in emission levels for any of the pollutants in 1990. For the year 2016, SO_x changed by -24%, D/F changed by -46% and due to changes in fuel use, HCB emissions are estimated to be zero in 2016. The remaining pollutant emissions changed by less than ±10% in 2016.
CONSTRUCTION FUEL COMBUSTION			
	TPM, PM_{10}, $PM_{2.5}$, SO_x, NO_x, VOCs, CO, NH_3, Pb, Cd, Hg, dioxins/furans, B(a)p, B(b)f, B(k)f, I(cd)p, HCB	The activity data have been updated to a more recent edition of the RESD.	The recalculations did not result in changes in emission levels of greater than 10% for any of the pollutants in 1990. For the year 2016, D/F changed by -27%, VOC changed by -24%, NO_x changed by -17%, CO changed by -16%, NH_3 changed by -15%, B(a)p changed by -11%, and $PM_{2.5}$ changed by -10%. The remaining pollutant emissions changed by less than ±10% in 2016.
RESIDENTIAL FUEL COMBUSTION			
	TPM, PM_{10}, $PM_{2.5}$, SO_x, NO_x, VOCs, CO, NH_3, Pb, Cd, Hg, dioxins/furans, B(a)p, B(b)f, B(k)f, I(cd)p, HCB	The activity data have been updated to a more recent edition of the RESD, and more detailed RESD data have been incorporated.	The recalculations did not result in changes in emission levels for any of the pollutants in 1990. For the year 2016, HCB changed by 12%. The remaining pollutant emissions changed by less than ±10% in 2016.

Table A2–18 Recalculations for Incineration and Waste Sources

Sector	Pollutant(s)	Description	Impact on Emissions
WASTE INCINERATION			
	Cd, CO, D/F, Hg, NH_3, NO_x, Pb, PM_{10}, $PM_{2.5}$, SO_x, TPM, VOC	Changes affecting estimates include an update of sewage sludge incineration activity data for the complete 1990–2016 time series, using information collected in ECCC waste incineration surveys.	The recalculations resulted in no significant changes in emission levels for Waste Incineration.
LANDFILLS (under WASTE TREATMENT AND DISPOSAL)			
	VOCs, TPM, PM_{10}, $PM_{2.5}$	The amount of waste landfilled was adjusted across the time series using the best available waste disposal data. Additionally, landfill gas capture data was updated and corrections were made across the time series.	The recalculations did not result in more then +/- 10% change for any pollutants in the years 1990 or 2016.

Table A2–19 Recalculations for Mercury in Products

Sector	Pollutant(s)	Description	Impact on Emissions
ORE AND MINERAL INDUSTRIES			
	Hg	The estimation methodologies for mercury in products have been updated from 2009 forward. In addition, recalculations have been done from 1990 to 2008 (when applicable) based on the updated methodologies. Please note that mercury in products Hg emissions are reconciled with point source emissions before publication.	In 1990, Hg changed by -36% or -323 kg. In 2016, Hg changed by -45% or -173 kg.
MANUFACTURING			
	Hg	The estimation methodologies for mercury in products have been updated from 2009 forward. Recalculations have not been done from 1990 to 2008 for this sector. Please note that mercury in products Hg emissions are reconciled with point source emissions before publication.	The recalculations were not done for 1990. In 2016, Hg changed by -16% or -3 kg.
COMMERCIAL / RESIDENTIAL / INSTITUTIONAL			
	Hg	The estimation methodologies for mercury in products have been updated from 2009 forward. In addition, recalculations have been done from 1990 to 2008 (when applicable) based on the updated methodologies. Please note that mercury in products Hg emissions are reconciled with point source emissions before publication.	In 1990, Hg changed by 32% or 206 kg. In 2016, Hg changed by -17% or -61 kg.
INCINERATION AND WASTE			
	Hg	The estimation methodologies for mercury in products have been updated from 2009 forward. In addition, recalculations have been done from 1990 to 2008 (when applicable) based on the updated methodologies. Please note that mercury in products Hg emissions are reconciled with point source emissions before publication.	In 1990, Hg changed by less than ±10% or 160 kg. In 2016, Hg changed by -82% or -821 kg.

A2.4. **Facility-Reported Data**

This section presents the procedures used to incorporate facility-reported data into the APEI.

Information on facility-reported data was provided by the provinces for 1985, 1990, 1995 and 2000. In some cases, additional information was provided to fill in intervening years or to update the original submissions. Trends for the intervening years were interpolated. The compilation of emissions for 2001–2005 occurred during a transition to using emissions data reported to the National Pollutant Release Inventory (NPRI) as the major source of industrial emissions. In general, facility-reported data from the NPRI and data provided by the provinces were used for the 2002, 2004 and 2005 inventories, and interpolation was used for 2001 and 2003.

Since 2005, information on facility-reported data has originated mainly from the NPRI, with limited data obtained from provincial governments (Alberta, Manitoba, New Brunswick, Newfoundland, Ontario and Quebec) on selected sources that are not reported to the NPRI.

The NPRI groups substances into the five parts listed below. Each part has its own reporting thresholds or triggers of mandatory reporting.

- Part 1A—Core Substances, and Part 1B—Alternate Threshold Substances
- Part 2—Polycyclic Aromatic Hydrocarbons
- Part 3—Dioxins, Furans and Hexachlorobenzene
- Part 4—Criteria Air Contaminants (CACs)
- Part 5—Speciated Volatile Organic Compounds (VOCs)

Table A2–20 shows the 17 air pollutants reported in the APEI and their NPRI reporting thresholds. Details on the NPRI reporting requirements for each substance group are available in the *Guide for Reporting to the National Pollutant Release Inventory* (NPRI) (EC, Guide for reporting to the National Pollutant Release Inventory (NPRI) 2014 and 2015, 2015). No VOC data collected under Part 5 is used in the APEI.

In 2017, approximately 6000 facilities reported releases to air of one or more APEI pollutants to the NPRI.

Table A2–20 **National Pollutant Release Inventory Air Pollutant Reporting Thresholds**

Substance	National Pollutant Release Inventory part # (threshold category)	Mass threshold	Concentration threshold
Ammonia	1A	10 tonnes MPO	MPO by weight of ≥ 1%
Benzo(a)pyrene	2	50 kg total PAHs	N/A
Benzo(b)fluoranthene	2	50 kg total PAHs	N/A
Benzo(k)fluoranthene	2	50 kg total PAHs	N/A
Cadmium	1B	5 kg MPO	MPO by weight of ≥ 0.1%
Carbon monoxide	4	20 tonnes air release	N/A
Dioxins and furans	3	Activity-based	N/A
Hexachlorobenzene	3	Activity-based	N/A
Indeno(1,2,3-c,d)pyrene	2	50 kg total PAHs	N/A
Lead	1B	50 kg MPO	MPO by weight of ≥ 0.1%
Mercury	1B	5 kg MPO	N/A
Nitrogen oxides	4	20 tonnes air release	N/A
PM_{10} – particulate matter <= 10 microns	4	0.5 tonnes air release	N/A
$PM_{2.5}$ – particulate matter <= 2.5 microns	4	0.3 tonnes air release	N/A
Sulphur dioxide	4	20 tonnes air release	N/A
Total particulate matter	4	20 tonnes air release	N/A
Volatile organic compounds	4	10 tonnes air release	N/A

MPO—Manufactured, processed or otherwise used

Using the 2017 NPRI database, facility information and air emissions data for the pollutants in Table A2–20 were extracted for each province and territory. The quality control process described in section 4.1 was applied to the NPRI data to identify outliers or missing substance reports. Each extracted NPRI facility was assigned to an APEI source, sector and subsector.

For new NPRI reporting facilities, the North American Industry Classification System (NAICS) codes (Statistics Canada, NAICS, 2012), reported by the facilities, were used to assign the related APEI sector and subsector classifications. In some cases, additional research and verification was required to provide the correct classification for facilities with a number of activities that were different from the NAICS code reported by the facility to the NPRI.

NPRI reporting facilities may not report all three of the PM size fractions. For cases where only one or two of the three PM size fractions were reported to the NPRI, a distribution procedure is applied to estimate a complete set of PM emissions for facilities. The procedure is based on sector-specific PM distribution profiles developed using PM emissions reported by facilities to the NPRI for the 2006 to 2016 inventory years. The ratios were calculated for each facility and averaged by sector. The resulting distributions are presented in Table A2–21.

The PM distribution procedure described in Equations A2–1, A2–2 and A2–3 is applied on a case-by-case basis to fill data gaps.

Equation A2–1 : **PM_{10} distribution ratio**

$$PM_{10}\text{ratio} = \frac{PM_{10}\,\text{emissions}}{\text{TPM emissions}}$$

PM_{10} ratio	=	Ratio of the sector's PM_{10} emissions to TPM emissions
PM_{10} emissions	=	PM_{10} emissions for the sector
TPM emissions	=	TPM emissions for the sector

Equation A2–2 : **$PM_{2.5}$ distribution ratio**

$$PM_{2.5}\text{ratio} = \frac{PM_{2.5}\text{emissions}}{\text{TPM emissions}}$$

$PM_{2.5}$ ratio	=	Ratio of the sector's $PM_{2.5}$ emissions to TPM emissions
$PM_{2.5}$ emissions	=	$PM_{2.5}$ emissions for the sector
TPM emissions	=	TPM emissions for the sector

Equation A2–3 : **$PM_{2.5}/PM_{10}$ distribution ratio**

$$PM_{2.5}/PM_{10}\text{ ratio} = \frac{PM_{2.5}\text{emissions}}{PM_{10}\text{emissions}}$$

$PM_{2.5}/PM_{10}$ ratio	=	Ratio of the sector's $PM_{2.5}$ emissions to the PM_{10} emissions
$PM_{2.5}$ emissions	=	$PM_{2.5}$ emissions for the sector
PM_{10} emissions	=	PM_{10} emissions for the sector

The TPM, PM_{10} and $PM_{2.5}$ emissions calculated using the distribution procedure are added to the list of facility-reported data and flagged as an Environment and Climate Change Canada estimate.

Table A2–21 Particulate Matter (PM) Distribution Ratios[a]

Sector and sub-sector	PM_{10} ratio	$PM_{2.5}$ ratio	$PM_{2.5}/PM_{10}$ ratio
ORE AND MINERAL INDUSTRIES			
Aluminium Industry			
Alumina (Bauxite Refining)	0.399	0.309	0.798
Primary Aluminium Smelting and Refining	0.686	0.559	0.798
Secondary Aluminium Production (Includes Recycling)	0.951	0.937	0.926
Asphalt Paving Industry	0.385	0.177	0.513
Cement and Concrete Industry			
Cement Manufacturing	0.623	0.31	0.474
Concrete Batching and Products	0.497	0.23	0.465
Gypsum Product Manufacturing	0.576	0.309	0.512
Lime Manufacturing	0.623	0.31	0.474
Foundries			
Die Casting	0.711	0.51	0.81
Ferrous Foundries	0.711	0.51	0.723
Non-ferrous Foundries	0.927	0.49	0.719
Iron and Steel Industry			
Primary (Blast Furnace and DRI)	0.598	0.403	0.65
Secondary (Electric Arc Furnaces)	0.616	0.474	0.802
Steel Recycling	0.711	0.51	0.287
Other (Iron and Steel Industry)	-	-	-
Iron Ore Industry			
Iron Ore Mining	0.513	0.191	0.432
Pelletizing	0.48	0.212	0.41
Mineral Products Industry			
Clay Products	0.802	0.094	0.484
Brick Products	0.802	0.094	0.484
Other (Mineral Products Industry)	0.762	0.545	0.665
Mining and Rock Quarrying			
Coal Mining Industry	0.368	0.064	0.147
Metal Mining	0.532	0.283	0.509
Potash	0.599	0.316	0.503
Rock, Sand and Gravel	0.46	0.165	0.397
Silica Production	-	-	-
Limestone	0.488	0.204	0.399
Other (Mining and Rock Quarrying)	0.465	0.197	0.398
Non-Ferrous Refining and Smelting Industry			
Primary Ni, Cu, Zn, Pb	0.649	0.375	0.606
Secondary Pb, Cu	0.574	0.396	0.748
Other (Non-Ferrous Refining and Smelting Industry)	0.494	0.444	0.859
OIL AND GAS INDUSTRY			
Downstream Oil and Gas Industry			
Petroleum Refining	-	-	-
Refined Petroleum Products Bulk Storage and Distribution	0.100	0.100	0.750
Refined Petroleum Product Pipelines	1.000	1.000	1.000
Natural Gas Distribution[b]	1.000	1.000	1.000
Other (Downstream Oil and Gas Industry)	0.743	0.641	0.628
Upstream Oil and Gas Industry			
Accidents and Equipment Failures	-	-	-
Disposal and Waste Treatment	-	-	-
Heavy Crude Oil Cold Production[b]	-	-	-
Light Medium Crude Oil Production[b]	1.000	1.000	1.000
Natural Gas Production and Processing[b]	1.000	1.000	1.000
Natural Gas Transmission and Storage[b]	1.000	1.000	1.000
Oil Sands In-Situ Extraction[b]	1.000	1.000	1.000
Oil Sands Mining and Extraction[c]	0.658	0.447	0.680
Bitumen and Heavy Oil Upgrading[c]	0.677	0.428	0.631
Petroleum Liquids Storage[b]	1.000	0.831	0.831
Petroleum Liquids Transportation	-	-	-
Well Drilling/Servicing/Testing	-	-	-
ELECTRIC POWER GENERATION (UTILITIES)			
Coal	0.578	0.293	0.484
Diesel	0.967	0.962	0.943
Natural Gas	0.909	0.663	0.902
Waste Materials	0.734	0.54	0.76
Other (Electric Power Generation)	0.735	0.608	0.924
MANUFACTURING			
Abrasives Manufacturing	0.747	0.59	0.771
Bakeries	0.747	0.59	0.771
Biofuel Production	-	-	-
Chemicals Industry			
Chemical Manufacturing	0.737	0.595	0.754
Cleaning Compound Manufacturing	0.737	0.595	0.754
Fertilizer Production	0.575	0.235	0.52
Paint and Varnish Manufacturing	0.919	0.564	0.701
Petrochemical Industry	0.894	0.424	0.587
Plastics and Synthetic Resins Fabrication	0.791	0.566	0.744
Other (Chemical Industry)[d]	Varies	Varies	Varies
Electronics	0.958	0.833	0.834
Food Preparation	0.651	0.409	0.634
Glass Manufacturing	0.836	0.755	0.919
Grain Industries			
Grain Processing	0.268	0.044	0.164
Warehousing and Storage	0.464	0.083	0.179
Metal Fabrication	0.747	0.59	0.771
Plastics Manufacturing	0.731	0.474	0.817
Pulp and Paper Industry			
Pulp and Paper Product Manufacturing	0.737	0.56	0.757
Converted Paper Product Manufacturing	0.737	0.56	0.757
Textiles	1	1	0.759
Vehicle Manufacture (Engines, Parts, Assembly, Painting)	0.694	0.427	0.748
Wood Products			
Panel Board Mills	0.596	0.361	0.589
Sawmills	0.423	0.197	0.451
Other (Wood Products)	0.688	0.549	0.732
Other (Manufacturing)[e]	Varies	Varies	Varies

Table A2–21 **Particulate Matter (PM) Distribution Ratios**[a] (cont'd)

Sector	PM_{10} Ratio	$PM_{2.5}$ Ratio	$PM_{2.5}/PM_{10}$ Ratio
TRANSPORTATION AND MOBILE EQUIPMENT			
Air Transportation	–	–	–
Heavy-duty Diesel Vehicles	–	–	–
Heavy-duty Gasoline Vehicles	–	–	–
Heavy-duty LPG/NG Vehicles	–	–	–
Light-duty Diesel Trucks	–	–	–
Light-duty Diesel Vehicles	–	–	–
Light-duty Gasoline Trucks	–	–	–
Light-duty Gasoline Vehicles	–	–	–
Light-duty LPG/NG Trucks	–	–	–
Light-duty LPG/NG Vehicles	–	–	–
Marine Transportation	–	–	–
Motorcycles	–	–	–
Off-road Diesel Vehicles and Equipment	–	–	–
Off-road Gasoline/LPG/CNG Vehicles and Equipment	–	–	–
Rail Transportation	–	–	–
Tire Wear and Brake Lining	–	–	–
AGRICULTURE			
Animal Production	0.289	0.060	0.208
Crop Production			
Fertilizer Application	0.490	0.140	0.286
Harvesting	0.455	0.091	0.200
Tillage Practices	0.210	0.100	0.476
Wind Erosion	0.500	0.100	0.200
Fuel Use	0.646	0.503	0.749
COMMERCIAL / RESIDENTIAL / INSTITUTIONAL			
Cigarette Smoking	–	–	–
Commercial and Institutional Fuel Combustion	0.761	0.581	0.599
Commercial Cooking	–	–	–
Construction Fuel Combustion	–	–	–
Home Firewood Burning	–	–	–
Human	–	–	–
Marine Cargo Handling	0.396	0.147	0.365
Residential Fuel Combustion	–	–	–
Service Stations	–	–	–
Other (Commercial / Residential / Institutional)	–	–	–
INCINERATION AND WASTE			
Crematoriums	1.000	1.000	1.000
Waste Incineration			
Industrial and Commercial Incineration	0.718	0.359	0.479
Municipal Incineration	0.737	0.680	0.913
Residential Waste Burning	–	–	–
Other (Waste Incineration)	0.728	0.520	0.696
Waste Treatment and Disposal			
Landfills	0.778	0.603	0.743
Municipal Wastewater Treatment and Discharge	0.806	0.780	0.955
Specialized Waste Treatment and Remediation	0.778	0.603	0.743
Biological Treatment of Waste	1.000	1.000	1.000
Waste Sorting and Transfer	0.778	0.603	0.743
PAINTS AND SOLVENTS			
Dry Cleaning	1.000	1.000	1.000
General Solvent Use[f]	Varies	Varies	Varies
Printing[f]	Varies	Varies	Varies
Surface Coatings	0.942	0.786	0.792
DUST			
Coal Transportation	–	–	–
Construction Operations	–	–	–
Mine Tailings	–	–	–
Paved Roads	–	–	–
Unpaved Roads[g]	0.265	0.027	0.100
FIRES			
Prescribed Burning	–	–	–
Structural Fires	–	–	–

Notes:

a. Based on the most recent facility-reported data from NPRI.

b. Adapted from Clearstone Engineering Ltd (2014).

c. Adapted from Clearstone Engineering Ltd (2017). Emissions from Bitumen and Heavy Oil Upgrading and Oil Sands Mining and Extraction are combined together and reported as Oil Sands Mining, Extraction and Upgrading in this report.

d. Values for PM ratios for these categories vary by subsector: Other (Chemical Industry)—values range from 0.465 to 0.886.

e. Values for PM ratios for these categories vary by subsector: Other (Manufacturing)—values range from 0.359 to 0.645.

f. Values for PM ratios for these categories vary by subsector: Printing and General Solvent Use—values range from 0.786 to 1.0.

g. Ratios derived from particulate matter ratios provided in the NPRI Toolbox guidance document entitled *Guidance on Estimating Road Dust Emissions from Industrial Unpaved Surfaces* (http://www.ec.gc.ca/inrp-npri).

– PM_{10} and $PM_{2.5}$ ratios are not used for these estimates

A2.5. Reconciliation of Facility-Reported Data and In-House Estimates

A reconciliation process is in place to prevent the double-counting of emissions when combining the in-house estimates and facility-reported data for the purpose of forming the final APEI. Reconciliation is performed separately at the subsector level for each province and territory. Table A2–1 in section A2.2 provides a complete list of sectors and indicates the origins of the estimates for each.

A2.5.1. General Procedures

The approach for reconciling facility-reported data and in-house estimates from a province, sector and subsector and for a specific pollutant is as follows:

- For most industrial sectors, the NPRI facility-reported data captures all facilities' emissions, resulting in in-house estimates not being required (i.e. $\text{InHouseEstimate}_{\text{REC}} = 0$). However, certain industrial sectors still have an in-house estimate component and require reconciliation.
- In general, reconciliation procedures were performed for sector/subsectors that had both in-house estimates and facility-reported data (Table A2–1). For example, for 2017, reconciliation was performed for the asphalt paving industry.
- If the total of the in-house estimates is greater than or equal to the total facility-reported data, the reconciled in-house estimate is equal to the total of the in-house estimates minus the total of the facility-report data, as outlined in Equation A2–4.

Equation 2–4 :

$$\text{If, InHouseEstimate}_{\text{Total}} \geq \text{FacilityReportedData}_{\text{Total}}$$

$$\text{Then, InHouseEstimate}_{\text{REC}} = \text{InHouseEstimate}_{\text{Total}} - \text{FacilityReportedData}_{\text{Total}}$$

- If the total in-house estimate quantity is less than or equal to the total of the facility-reported data for the source, the reconciled in-house estimate is equal to zero, as outlined in Equation A2–5.

Equation 2–5 :

$$\text{If, InHouseEstimate}_{\text{Total}} \leq \text{FacilityReportedData}_{\text{Total}}$$

$$\text{Then, InHouseEstimate}_{\text{REC}} = 0$$

Some points to consider:

- In general, $\text{InHouseEstimate}_{\text{REC}}$ represents non-reporting facilities (including smaller facilities or emissions from reporting facilities that do not meet reporting requirements).
- In cases where $\text{InHouseEstimate}_{\text{REC}} = 0$ (Equation A2–5), facility-reported data are considered to reflect all the sector emitting sources.

A2.5.2. Wood Products

Particulate matter emissions (TPM, PM_{10} and $PM_{2.5}$) from Sawmills and Panel Board Mills (Wood Products sector) were not reconciled using the procedure described in section A2.5.1. Rather, NPRI facility-reported data from Sawmills and Panel Board Mills were used to characterize the entire industry. The facility-reported data, together with a number of production indicators, were used to estimate the PM emissions from facilities that are not required to report to the NPRI. The sum of the resulting emission estimates represents the total emissions for these subsectors. All other pollutants were reconciled at the subsector and provincial level according to the standard procedure and equations outlined in section A2.5.1.

A2.6. Dry Cleaning, General Solvent Use, Printing and Surface Coatings

The in-house estimates in the Dry Cleaning, General Solvent Use, Printing, and Surface Coatings sectors (Paints and Solvents source category) include a total of 92 different kinds of solvents and applications. The challenge is to reconcile the in-house estimates with facility-reported data, which includes a variety of sources (solvent use as well as processes, fuel combustion, road dust, etc.) grouped under the same North American Industry Classification System. Given this sector's complexity, reconciliation of in-house estimates with facility-reported data from the NPRI requires that several steps be performed by a specially designed database application (Cheminfo Services, *Compilation of volatile organic compound*

(VOC) emissions from the use of solvents in Canada: Inventory update. VOC emission trends compilation: 2005 to 2017, 2016):

1. allocating the solvent use in-house estimates to the 4-digit NAICS level from the NPRI
2. allocating the NPRI VOC inventory totals at the 4-digit NAICS level to "Process" and "Solvent" type emissions
3. subtracting the "Solvent" type NPRI emissions from the solvent in-house emissions estimates

If subtraction of the facility-reported data from the in-house estimates for a certain solvent use yields a small negative value, the emission estimate for that in-house estimate is set to zero. However, if the reconciliation yields a large negative value, examination/verification of both the in-house estimates and the facility-reported data and the allocation percentages for that solvent use is performed, and the estimates are adjusted accordingly.

A2.7. Mercury in Products (Hg)

Mercury can be released to air throughout the life cycle of mercury-containing products, including during manufacture, distribution, use, disposal, transportation and final disposition, as well as through waste streams. Releases can also result from breakage and processing. As such, reconciliation of Hg air emissions from mercury in products with NPRI facility-reported data involves a review and characterization of the source of the Hg air emissions included in the facility-reported estimate (primarily in the waste sector, such as landfills) to ensure that the Hg emissions estimated through the life-cycle approach are not duplicated in the facility-reported data.

ANNEX 3

SUBMISSION TO THE UNITED NATIONS ECONOMIC COMMISSION FOR EUROPE

A3.1. Introduction

Canada reports on atmospheric emissions of air pollutants to the United Nations Economic Commission for Europe (UNECE) through the European Monitoring and Evaluation Programme (EMEP) Centre on Emission Inventories and Projections (CEIP)[1] pursuant to the Convention on Long-range Transboundary Air Pollution (CLRTAP) and its associated protocols. Table A3–1 lists the atmospheric pollutants for which annual emissions are reported to the UNECE, along with the corresponding protocols under CLRTAP.

This edition of the Canada's Air Pollutant Emissions Inventory (APEI) Report summarizes the most recent estimates of air pollutant emissions for 1990–2017 as of February 2019. The inventory indicates that 14 of the 17 reported air pollutants show decreases compared to historical levels, and specifically indicate that:

- Emissions of sulphur oxides (SO_x) were 0.9 million tonnes in 2017, 35% below the emission ceiling of 1.45 million tonnes established under the 1999 Gothenburg Protocol to Abate Acidification, Eutrophication and Ground-level Ozone.
- Emissions of nitrogen oxides (NO_x) were 1.8 million tonnes in 2017, 21% below the emission ceiling of 2.25 million tonnes established under the 1999 Gothenburg Protocol.
- In 2017, emissions of non-methane volatile organic compounds (VOCs) were 14% below the emission ceiling of 2.1 million tonnes established under the 1999 Gothenburg Protocol.
- In 2017 emissions of cadmium (Cd), lead (Pb) and mercury (Hg) were 85%, 72% and 82% respectfully below the ceilings established under the 1998 Aarhus Protocol on Heavy Metals.
- In 2017, emissions of all Persistent Organic Pollutants (POPs) were below ceilings established in the 1998 Aarhus Protocol on Persistent Organic Pollutants including the four species of polycyclic aromatic hydrocarbons (PAHs) (69% below), hexachlorobenzene (HCB) (92% below), and dioxins and furans (85% below).

1 CEIP available online at www.ceip.at

Table A3–1 **Pollutant Emissions Reported to the United Nations Economic Commission for Europe and Related Protocols under the Convention on Long-range Transboundary Air Pollution**

Pollutant	Relevant protocols under the CLRTAP	Protocol obligation
$PM_{2.5}$	1999 Gothenburg Protocol	Emission reporting
SO_x	1999 Gothenburg Protocol / 1985 Helsinki Protocol / 1994 Oslo Protocol	2010–2019 emissions ceiling of 1.45 million tonnes Reduction of SO_x emissions by at least 30 percent from 1980 levels Maintain SO_x emissions (excluding natural sources) in the regional Sulphur Oxides Management Area (SOMA) below 1.8 million tonnes
NO_x	1999 Gothenburg Protocol / 1988 Sofia Protocol	2010–2019 emissions ceiling of 2.25 million tonnes Stabilize (not exceed) 1987 NO_x level
VOCs	1999 Gothenburg Protocol	2010–2019 emissions ceiling of 2.1 million tonnes
NH_3	1999 Gothenburg Protocol	Emission reporting
Pb	1998 Aarhus Protocol on Heavy Metals	50% reduction of 1990 level by 2011
Cd	1998 Aarhus Protocol on Heavy Metals	50% reduction of 1990 level by 2011
Hg	1998 Aarhus Protocol on Heavy Metals	50% reduction of 1990 level by 2011
D/F	1998 Aarhus Protocol on POPs	Stabilize (not exceed) 1990 level
B(a)p	1998 Aarhus Protocol on POPs	Stabilize (not exceed) 1990 level
B(b)f	1998 Aarhus Protocol on POPs	Stabilize (not exceed) 1990 level
B(k)f	1998 Aarhus Protocol on POPs	Stabilize (not exceed) 1990 level
I(cd)p	1998 Aarhus Protocol on POPs	Stabilize (not exceed) 1990 level
HCB	1998 Aarhus Protocol on POPs	Stabilize (not exceed) 1990 level
HCB	1998 Aarhus Protocol on POPs	Stabilize (not exceed) 1990 level

- Emissions of carbon monoxide (CO) decreased 54% from 1990 to 2017.
- $PM_{2.5}$ emissions (particulate matter less than or equal to 2.5 microns in diameter) are decreasing from all sources except dust from paved and unpaved roads, agriculture fuel use, as well as construction operations; total $PM_{2.5}$ emissions are 15% below 1990 levels.

Exceptions to the general downward trends described above are noted for emissions of ammonia (NH_3) (19% above 1990 levels in 2017), total particulate matter (TPM) (14% above 1990 levels in 2017), and coarse particulate matter (PM_{10}) (11% above 1990 levels in 2017).

A3.2. Overview of the United Nations Economic Commission for Europe Reporting Template

The UNECE Nomenclature for Reporting (NFR) categories correspond to the sectors described in the EMEP/EEA Air Pollutant Emission Inventory Guidebook 2016 (EEA, 2016). In addition to providing technical guidance for developing inventory methodologies, the 2016 EMEP/EEA guidebook includes instructions for attributing sectoral emissions to NFR codes.

Whereas the APEI report groups emissions by sectors (e.g. pulp and paper industry), the emissions in the UNECE are grouped by process and combustion sources. For example, the pulp and paper industry within the APEI includes both combustion and process emissions. The combustion component is mapped to NFR sector 1A2d (Stationary combustion in manufacturing industries and construction: Pulp, Paper and Print). The process component is mapped to NFR sector 2H1 (Pulp and paper industry).

Table A3–2 illustrates the structure of the UNECE reporting template. The template in its entirety can be found on the CEIP website.

Table A3–2 **Excerpt from United Nations Economic Commission for Europe Nomenclature for Reporting Template for 2019**

Annex 1: National sector emissions: Main pollutants, particulate matter, heavy metals and persistent organic pollutants

	NFR sectors to be reported			Main pollutants (from 1990)				Particulate matter (from 2000)				Other (from 1990)	
				NO_x (as NO_2)	NMVOC	SO_x (as SO_2)	NH_3	$PM_{2.5}$	PM_{10}	TSP	BC	CO	HCB
NFR aggregation for gridding and LPS (GNFR)	NFR Code	Longname	Notes	kt	kt	kt	kt	kt	kt	kt	kt	kt	kg
A_PublicPower	1 A 1 a	Public electricity and heat production											
B_Industry	1 A 1 b	Petroleum refining											
B_Industry	1 A 1 c	Manufacture of solid fuels and other energy industries											
B_Industry	1 A 2 a	Stationary combustion in manufacturing industries and construction: Iron and steel											
B_Industry	1 A 2 b	Stationary combustion in manufacturing industries and construction: Non-ferrous metals											
B_Industry	1 A 2 c	Stationary combustion in manufacturing industries and construction: Chemicals											
B_Industry	1 A 2 d	Stationary combustion in manufacturing industries and construction: Pulp, Paper and Print											
B_Industry	1 A 2 e	Stationary combustion in manufacturing industries and construction: Food processing, beverages and tobacco											
B_Industry	1 A 2 f	Stationary combustion in manufacturing industries and construction: Non-metallic minerals											
I_Offroad	1 A 2 g vii	Mobile combustion in manufacturing industries and construction: (please specify in your IIR)											
B_Industry	1 A 2 g viii	Stationary combustion in manufacturing industries and construction: Other (please specify in your IIR)											

A3.3. Mapping of Air Pollutant Emission Inventory Emissions to the United Nations Economic Commission for Europe's Nomenclature for Reporting Categories

The mapping of APEI sector emissions to UNECE NFR categories involves dividing the sector emissions into their combustion and process components. Whereas certain sectors contribute solely a process component (in the case of road dust) or combustion component (in the case of mobile sources), the majority of sectoral emissions are distributed over both components. This is accomplished using a split ratio, which, apart from a small number of exceptions, is assigned to a particular subsector and pollutant. For example, in the alumina production sector, all Hg, CO, sulphur dioxide (SO_2) and VOC emissions are attributed to combustion activities, while the remaining pollutants are attributed to both the bauxite refining process and combustion activities (Table A3–3).

The mapping of APEI sector emissions to UNECE NFR categories is achieved through the use of database queries. A quality assurance / quality control process is in place to verify the results.

Table A3–3 **Example of Air Pollutant Emission Inventory Subsector mapping to a United Nations Economic Commission for Europe's Nomenclature for Reporting Category**

APEI subsector	APEI subclass code	UNECE NFR category		Pollutant	Split ratios (w/w)	
		Combustion	Process		Combustion	Process
Alumina (bauxite refining)	10201	1A2b: Stationary combustion in manufacturing industries and construction: Non-ferrous metals	2C3: Aluminium	TPM	0.229	0.771
				PM_{10}	0.290	0.710
				$PM_{2.5}$	0.352	0.648
				SO_x	1.000	0.000
				NO_x	0.746	0.254
				CO	1.000	0.000
				VOCs	1.000	0.000
				Hg	1.000	0.000

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