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LIST OF ACRONYMS, ABBREVIATIONS AND UNITS

Acronyms and Abbreviations

AAFC	Agriculture and Agri-Food Canada
APEI	Air Pollutant Emission 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
CNG	Compressed natural gas
CORINAIR	Core Inventory of Air Emissions in Europe
CPI	Consumer Price Index
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
NPRI	National Pollutant Release Inventory
NRCan	Natural Resources Canada
PM	Particulate matter

PM_{10}	Particulate matter less than or equal to 10 microns
$PM_{2.5}$	Particulate matter less than or equal to 2.5 microns
POP	Persistent organic pollutant
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
D/F	Dioxins and furans
HCB	Hexachlorobenzene
Hg	Mercury
I(cd)p	Indeno(1,2,3-cd)pyrene
NH_3	Ammonia
NO_2	Nitrogen dioxide
NO_x	Nitrogen oxides
PAH	Polycyclic aromatic hydrocarbon
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 Emission Inventory (APEI) has been prepared and published by Environment and Climate Change Canada since 1973. The APEI is a comprehensive inventory of emissions of 17 air pollutants at the national and provincial/territorial levels. This inventory serves many purposes including fulfilling 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), dioxins and furans, and other persistent organic pollutants (POPs). 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, informs Canadians about pollutants that affect their health and the environment, and provides data for air quality forecasting models.

The APEI is compiled from many different data sources. Emissions data reporting by individual facilities to Environment and Climate Change Canada's National Pollutant Release Inventory 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 overview of air pollutant emissions across Canada.

This edition of the APEI Report summarizes the most recent estimates of air pollutant emissions for 1990–2016 as of February 2018. The inventory indicates that 14 of the 17 reported air pollutants show reductions compared to historical levels.[1]

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

Specifically:

- Emissions of SO_x were 1.1 million tonnes in 2016, 67% below the emission ceiling of 3.3 million tonnes established under the 1985 Helsinki Protocol on the Reduction of Sulphur Emissions or their Transboundary Fluxes.
- Emissions of NO_x were 1.8 million tonnes in 2016, 21% below the emission ceiling of 2.3 million tonnes established under the 1988 Sofia Protocol concerning the Control of Emissions of Nitrogen Oxides or their Transboundary Fluxes.
- In 2016, emissions of Cd, Pb, and Hg were 83%, 75% and 76% below the ceilings established under the 1998 Aarhus Protocol on Heavy Metals.
- In 2016, emissions of all POPs were below ceilings established in the 1998 Aarhus Protocol on Persistent Organic Pollutants, including the four species of polycyclic aromatic hydrocarbons (PAHs) (by 69%), hexachlorobenzene (HCB) (by 91%), and dioxins and furans (by 88%).
- Emissions of non-methane volatile organic compounds (VOCs) and carbon monoxide (CO) decreased by 42% and 54%, respectively, from 1990 to 2016.
- Fine particulate emissions (particulate matter less than or equal to 2.5 microns in diameter ($PM_{2.5}$)) are decreasing from all sources except from dust from paved and unpaved roads, agriculture fuel use, as well as construction; total $PM_{2.5}$ emissions are 18% below 1990 levels.

Canada's Air Pollution Emission Trends (1990–2016)

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 petroleum industry, down 51% since 1990, non-ferrous smelting and refining, down 72% since 1990, and electric power generation (utilities), down 59%.

The adoption of conservation tillage practices in crop production and the use of new fireplace inserts, furnaces and stoves have contributed

to a decrease in emissions of $PM_{2.5}$, however since 1990 there have been increases in $PM_{2.5}$ emissions from paved and unpaved roads, agriculture fuel use, as well as construction operations. Although already on the decline, the aluminium industry experienced a large drop in PAH emissions from 2001 to 2010 due to the implementation of new production technologies, such as the introduction of pre-baked electrodes to replace continuous casting electrodes. Since 2013, the aluminium industry experienced additional decreases, related to the replacement of old smelting equipment with a modern smelter at the facility that has historically contributed the largest portion of PAH emissions. Emissions of Cd continued their steady decline, with reductions in emissions from several sources.

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 and Hg from non-ferrous smelting and refining and from mining and rock quarrying industries 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 compressed 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, dioxins and furans.

An exception to the general downward trends described above is the observed increase in emissions of ammonia (NH_3) which were 20% above 1990 levels in 2016. The upward trend in ammonia emissions is driven by fertilizer application and animal production.

Canada's Air Emissions Regulations

Downward trends in emissions of air pollutants reflect the ongoing implementation of a wide range of regulations that 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 in the registry: https://www.canada.ca/en/environment-climate-change/services/canadian-environmental-protection-act-registry.html.

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INTRODUCTION

1.1. Background on the APEI

Canada's Air Pollutant Emission 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:

- Support to the development of domestic air quality management strategies, policies and regulations;
- Contribute to tracking and quantifying air pollutants according to Canada's domestic and international reporting obligations;
- 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 CO, SO_x, NO_x, hydrocarbons and PM for the year 1970. Since then, air emission estimates for Canada have continued to be published on a regular basis.

Today the APEI comprises emissions of 17 air pollutants that contribute to smog, acid rain and diminished air quality, including:

- Smog precursors: total particulate matter (TPM), particulate matter (PM) less than or equal to 10 microns (PM_{10}), PM less than or equal to 2.5 microns ($PM_{2.5}$), sulphur oxides (SO_x), nitrogen oxides (NO_x), volatile organic compounds (VOCs), carbon monoxide (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 eleven source categories that are further broken down into 75 sectors and 70 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 based on consistent and current methodological approaches and data.

Generally, facility emissions data captured in the APEI originate primarily from the National Pollutant Release Inventory (NPRI), supplemented with limited 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 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 **APEI 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 wel 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 Industries	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 and related clay products such as pipes, liner and tiles.
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 Mining 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.
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.
ELECTRIC POWER GENERATION (UTILITIES)	
Coal	Electric power generation from combustion of coal by utilities and by industry for commercial sale and/or private use.
Diesel	Electric power generation from combustion of diesel by utilities and by industry for commercial sale and/or private use.
Natural Gas	Electric power generation from combustion of natural gas by utilities and by industry for commercial sale and/or private use.
Waste Materials	Electric power generation from combustion of waste materials by utilities and by industry for commercial sale and/or private use.
Other Electric Power Generation	Electric power generation from other energy sources by utilities and by industry for commercial sale and/or private use.
MANUFACTURING	
Abrasives Manufacture	Manufacturing of abrasive grinding wheels, abrasive-coated materials and other abrasive products.
Bakeries	Manufacturing of bakery products, other than for retail sale, 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 and inorganic chemicals. 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 tobacco and beverage products; seafood product preparation and packaging; and fruit and vegetable canning, pickling and drying.
Glass Manufacture	Making of glass from sand and cullet as well as the remelting, pressing, blowing or otherwise shaping purchased glass.
Grain Processing	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 Manufacture	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, motor vehicle plastic parts, tires, rubber and plastic hose and belting, and other rubber 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 Manufacture (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, panel board 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 Industries	Manufacturing, food production or processing industries that are not included under a specific industrial sector.
TRANSPORTATION and MOBILE EQUIPMENT	
Air transportation	Piston and turbine military, commercial and general aviation (landing and take-off only), and in-flight (cruise) emissions for turbine aircraft.
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	Dieselvehicles under 3 856 kilograms.

Table 1–1 **APEI Sector Descriptions** (cont'd)

APEI Source/Sector	Sector Descriptions
TRANSPORTATION AND MOBILE EQUIPMENT (cont'd)	
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/CNG 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	Animal housing, manure storage, and application of manure to the field
Crop Production	Application of synthetic nitrogen fertilizers, tillage, 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	External combustion sources 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 commerical 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 fuel wood and pellets for space heating and hot water. Includes emissions from fireplaces, wood stoves and wood-fired boilers.
Human	Human respiration, perspiration and dental amalgams.
Marine Cargo Handling	Handling, loading and unloading of materials, goods and merchandise from ships to 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 Miscellaneous Sources	Infant-diapered waste 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 solid waste and recover energy.
Waste Treatment and Disposal	Disposal sites used for a variety of wastes, such as domestic, commercial, hazardous, liquid and non-hazardous solid industrial wastes as well as sewage sludge and from on-site burning of residential waste materials in backyard barrels or open-pit burning.
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 Forest 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 five 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), and
- the 1998 Aarhus Protocol on Persistent Organic Pollutants (including dioxins and furans, four species of PAHs, and HCB, among other POPs).

These protocols set specific emissions reduction targets for sulphur, NO_x, Cd, Pb, Hg, dioxins and furans, PAHs, and HCB. 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, VOCs and three categories of PM (TPM, PM_{10} and $PM_{2.5}$) and voluntarily reports the emissions of these six substances, along with the eleven 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 Regulations for Air Pollutants**

To improve and maintain air quality in Canada, a wide range of regulations restrict or eliminate atmospheric pollutants. 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 in its registry: https://www.canada.ca/en/environment-climate-change/services/canadian-environmental-protection-act-registry.html.

2

2016 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 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 with substances (Table 2–1).[1] For example,

- dust source category is an important source of particulate matter (PM) emissions, accounting for 62% of emissions of total particulate matter less than or equal to 2.5 microns ($PM_{2.5}$).
- agriculture source category accounts for most ammonia (NH_3) emissions (93%),
- incineration and waste sources account for a significant proportion of hexachlorobenzene (HCB) (63%) and dioxins/furans (D/F) (41%) emissions.
- ore and mineral industries account for the largest proportion of sulphur oxides (SO_x) (45%), lead (Pb) (73%) and cadmium (Cd) (70%) emissions.
- transportation and mobile equipment source category is the largest emitter of nitrogen oxides (NO_x) (52%) and carbon monoxide (CO) (54%).
- oil and gas industry is the largest emitter of volatile organic compounds (VOCs) (41%).
- ore and mineral industries and the incineration and waste sources each released about one third (33%) of the total mercury (Hg) emissions.
- commercial/residential/institutional source category is a particularly significant source of polycyclic aromatic hydrocarbons (PAHs) (96%).

A few key sources exert a relatively large influence on the emissions of several pollutants or their trends. Among industrial sources, the non-ferrous mining and smelting industry is a major source of SO_x (34%), Pb (65%) and Cd (65%). Since 1990, the industry contributed significantly to the downward trends in emissions of these pollutants, as well as emissions of Hg. Over the years, the upstream oil and gas industry has become a dominant source of VOC (40%) and NO_x (26%) emissions in Canada, with increasing trends in emissions of both pollutants. In contrast,there were reductions in coal-powered electric generation emissions of SO_x, NO_x, VOCs, HCB and Hg. Home firewood burning represents 96% 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. Emissions of SO_x continued to decline, largely due to decreasing emissions from upstream oil and gas operations and coal-fired electric power generation.

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

Table 2–1 **2016 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 Minerals Industries	210	81	33	480	78	13	560	1	120 000	5 500	1 400	6	700	2 300
Oil and Gas Industry	20	15	11	250	480	640	550	2	580	220	81		20	
Electric Power Generation (Utilities)	16	7	3	250	150	1	36	0	1 400	160	720	3	7	570
Manufacturing	100	42	18	43	71	120	130	12	6 500	610	140	4	98	280
Transportation and Mobile Equipment	74	49	36	22	940	310	3 100	8	33 000	170	75	11	120	
Agriculture	3 100	1 300	310	6	4	98	1	460	53	89	7		0	
Commercial / Residential / Institutional	200	190	180	8	77	290	1 200	3	3 200	1 100	540	8	100 000	1
Incineration and Waste	6	4	3	4	5	11	19	5	520	39	1 300	23	700	5 300
Paints and Solvents	0	0	0		0	330								
Dust	19 000	5 500	1 000											
Fires	15	13	9	0	2	5	120	0				2	2 400	
TOTAL	**23 000**	**7 200**	**1 600**	**1 100**	**1 800**	**1 800**	**5 800**	**490**	**170 000**	**7 800**	**4 300**	**57**	**110 000**	**8 500**

Notes:
1. Totals may not add up due to rounding.
2. Emissions of pollutants are expressed in either kt, kg, gTEQ or g.
3. This report's rounding protocol is based on an estimated uncertainty of 10–50% for all sectors, for which the protocol indicates rounding to two (2) significant digits.

Improved control measures and changes in sulphur levels in fuel resulted in a decrease in $PM_{2.5}$ and D/F emissions from marine transport. 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 components 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 six 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 2016 and their varying contribution to total emissions over time.

The full time series of national, provincial, and territorial pollutant emissions from 1990 to 2016 are available through the Air Pollutant Emission Inventory Online Data Query Tool, at http://ec.gc.ca/inrp-npri/donnees-data/ap/index.cfm?lang=En. The APEI data is also available on-line at the Goverbnment of Canada Open Data Portal website http://open.canada.ca/data/en/dataset/fa1c88a8-bf78-4fcb-9c1e-2a5534b92131.

Table 2–2 **2016 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	**210 000**	**81 000**	**33 000**	**480 000**	**78 000**	**13 000**	**560 000**	**1 200**	**120 000**	**5 500**	**1 400**	**5.7**	**690**	**2 300**
Aluminium Industry	5 700	4 300	3 400	64 000	1 200	950	420 000				21		100	
Alumina (Bauxite Refining)	83	49	44	2	310	24	370							
Primary Aluminium Smelting and Refining	5 700	4 200	3 400	64 000	920	930	420 000				21		100	
Secondary Aluminum (Includes Recycling)														
Asphalt Paving Industry	44 000	8 600	1 600	710	1 200	8 500	4 000		1 100	22	23	<0.01	13	
Cement and Concrete Industry	45 000	15 000	7 400	24 000	32 000	450	14 000	360	700	12	340	0.61	0.23	410
Cement Manufacture	2 700	1 600	790	21 000	28 000	400	11 000	340	590	11	290	0.61	0.23	410
Concrete Batching and Products	40 000	12 000	6 000	94	250	41	490		100	0.96				
Lime Manufacture	1 700	920	450	2 500	4 400		1 800	14	5.7	0.34	1.3			
Gypsum Product Manufacturing	100	87	78	1.9	170	1.7	120				49			
Foundries	6 100	5 700	5 200	49	140	360	49 000		200	0.75		0.036		24
Die Casting	9	6.4	4.9	<0.01	0.4		0.34							
Ferrous Foundries	6 000	5 700	5 200	49	140	360	49 000		130	0.75		0.036		24
Non-ferrous Foundries	3.1	2.9	2.9						65					
Iron and Steel Industries	6 500	3 700	2 200	17 000	11 000	820	21 000	56	5 200	210	710	4.7	440	1 000
Primary (Blast Furnace and DRI)	5 800	3 200	1 800	16 000	8 700	620	18 000	55	4 200	180	250	1.3	440	160
Secondary (Electric Arc Furnaces)	620	460	340	1 500	1 900	200	2 600	0.77	990	31	440	2.6	0.32	770
Steel Recycling	3.6	2.6	2.5				19		15		21	0.76		94
Other (Iron and Steel Industries)														
Iron Ore Industry	14 000	3 600	1 000	13 000	11 000	410	18 000		3 300	82	72	<0.01	20	
Iron Ore Mining	1 500	730	140	630	1 300	3.6	2 200		4	0.15	0.51	<0.01		
Pelletizing	12 000	2 900	900	12 000	10 000	400	16 000		3 300	82	71		20	
Mineral Products Industry	410	370	260	1 400	240	140	460	410	15					
Clay Products	21	17	5.5	260			24							
Brick Products														
Other Mineral Products	390	350	250	1 200	240	140	430	410	15					1
Mining and Rock Quarrying	81 000	37 000	10 000	1 600	19 000	1 400	14 000	97	940	16	16	0.026	110	<0.0001
Coal Mining Industry	39 000	17 000	2 100	620	730	0.97	690		26	1.4	1.2		110	<0.0001
Metal Mining	16 000	8 200	3 600	670	7 900	620	9 600	42	830	11	12	0.022	0.029	4.2
Potash	6 400	3 100	1 500	1.2	2 200	430	1 500							
Rock, Sand and Gravel	16 000	8 100	2 400	9.2	460		110							
Silica Production	200	98	9.8											
Limestone	15	5.3	2.6											
Other Minerals	2 700	1 200	510	280	7 300	320	2 300	55	86	3.4	2.1	<0.01		7.3
Non-Ferrous Mining and Smelting Industry	4 600	2 600	1 800	360 000	2 000	65	17 000	320	110 000	5 100	220	0.41	0.3	830
Primary Ni, Cu, Zn, Pb	4 600	2 600	1 800	360 000	1 900	35	17 000	280	110 000	5 100	220	0.41		830
Secondary Pb, Cu	8.7	5	4.4	1 400		30			270			<0.01	0.3	
Other Metals	8.3	4.1	4		75			44						0.014
OIL AND GAS INDUSTRY	**20 000**	**15 000**	**11 000**	**250 000**	**480 000**	**640 000**	**550 000**	**2 400**	**580**	**220**	**81**		**20**	
Downstream Oil and Gas Industry	3 500	2 400	1 500	51 000	18 000	25 000	16 000	55	380	95	53		14	
Petroleum Refining	3 500	2 400	1 500	50 000	17 000	9 100	16 000	55	380	95	53		14	
Refined Petroleum Products Bulk Storage and Distribution						15 000			0.046		<0.01		0.02	
Refined Petroleum Product Pipelines														
Natural Gas Distribution	1.8	1.8	1.8	0.45	190	240	140							
Other Downstream Petroleum Industry	35	16	9.5	1 300	850	400	96							
Upstream Oil and Gas Industry	16 000	12 000	9 700	200 000	460 000	620 000	530 000	2 300	200	120	28		5.8	
Accidents and Equipment Failures						120 000								
Disposal and Waste Treatment	17	17	17	0.032	23	39	55	0.34						
Heavy Crude Oil Cold Production	530	530	530	2 200	13 000	23 000	17 000	42						
Light Medium Crude Oil Production	2 700	2 700	2 700	11 000	41 000	350 000	52 000	17						
Natural Gas Production and Processing	2 400	2 400	2 400	110 000	320 000	52 000	410 000	230						
Oil Sands In-Situ Extraction and Processing	1 100	1 100	1 100	19 000	34 000	12 000	24 000	800	19	65	11			

Table 2–2 **2016 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 Sands Mining, Extraction and Upgrading	9 300	5 400	2 700	47 000	31 000	41 000	22 000	1 200	180	58	17		5.8	
Petroleum Liquids Storage	8.2	8.2	8.1		48	5 600	23							
Petroleum Liquids Transportation	8.1	8.1	7		0.37	14 000	2							
Well Drilling/Servicing/Testing	130	130	130	4 700	86	1 000	370	<0.01						
Natural Gas Transmission	88	88	89	23	20 000	790	6 500	0.68						
ELECTRIC POWER GENERATION (UTILITIES)	**16 000**	**6 900**	**3 300**	**250 000**	**150 000**	**1 200**	**36 000**	**350**	**1 400**	**160**	**720**	**2.9**	**6.8**	**570**
Coal	14 000	5 600	2 200	240 000	120 000	410	16 000	170	770	100	680	1.9		430
Diesel	350	220	200	230	8 400	55	1 300							
Natural Gas	490	440	350	1 700	16 000	570	11 000	100	86	35	11	0.011	0.045	120
Waste Materials	20	17	16	29	360	9.1	280	11	2.8	0.72	2.2	0.16		2.3
Other Electric Power Generation	1 000	640	530	8 200	11 000	200	7 800	62	560	23	30	0.75	6.8	17
MANUFACTURING	**100 000**	**42 000**	**18 000**	**43 000**	**71 000**	**120 000**	**130 000**	**12 000**	**6 500**	**610**	**140**	**4.1**	**98**	**280**
Abrasives Manufacture	43	26	14			20						0.014		
Bakeries	23	17	10	<0.01	0.89	16 000	0.3							
Biofuel Production	13	8.5	4.2		16	42								
Chemicals Industry	2 900	2 000	1 300	20 000	22 000	9 800	16 000	9 200	26	8.1	17	0.31	25	
Chemical Manufacture	1 600	1 000	830	17 000	9 000	3 400	8 100	69	13	<0.01	16	0.31	24	
Fertilizer Production	1 100	740	330	2 200	8 300	1 000	4 700	9 000	2	4.4	1			
Paint and Varnish Manufacturing	6.9	5.8	3.9		2.9	490	620	2	1.6					
Petrochemical Industry	130	120	82	61	4 400	1 400	1 700	0.012	9	3.7	0.46		0.46	
Plastics and Synthetic Resins Fabrication	81	55	42	4.9	350	2 900	220	39			0.018			
Cleaning Compound Mfg	32	24	17	<0.01	66	300	370							
Other Chemical Industries	1.6	1.1	0.73	0.052	17	350	8.4							
Electronics						17		18	2.9		29			
Food Preparation	3 900	1 900	720	280	1 600	15 000	1 200	340						
Glass Manufacture	190	170	160	610	780	260	280		<0.01					
Grain Industries	63 000	17 000	2 900	530	760	2 500	390	5.7						
Grain Processing	61500	16500	2810	530	760	2500	390	5.7	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Warehousing and Storage	1500	500	90	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Metal Fabrication	710	480	410	11	390	3 700	1 100	25	3 300	310	<0.01	0.93		190
Plastics Manufacture	84	67	62		11	9 800	10		4.8					
Pulp and Paper Industry	16 000	10 000	6 900	21 000	31 000	13 000	72 000	1 700	2 800	210	71	2.2	64	88
Pulp and Paper Industry	15990	9990	6890	<0.0001	<0.0001	12 900	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Converted Paper Product Manufacturing	10	10	10	<0.0001	<0.0001	100	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Textiles	0.37	0.37	0.37	<0.01	0.17	580	0.071							
Vehicle Manufacture (Engines, Parts, Assembly, Painting)	380	280	180	46	700	11 000	940	2.2	66				0.014	
Wood Products	18 000	9 300	4 600	680	14 000	33 000	40 000	830	340	71	18	0.65	9.7	0.11
Panel Board Mills	5 800	2 700	1 500	360	6 500	15 000	22 000	310	260	33	4.7	0.23	2.5	
Sawmills	11 000	5 900	2 700	300	6 400	15 000	17 000	520	82	35	13	0.41	7.2	
Other Wood Products	1 000	600	430	19	650	3 400	1 200	0.85	7.3	3.7			<0.01	0.11
Other Manufacturing Industries	330	250	190	1.2	160	1 100	630	30	39	0.06	3.4			
TRANSPORTATION AND MOBILE EQUIPMENT	**74 000**	**49 000**	**36 000**	**22 000**	**940 000**	**310 000**	**3 100 000**	**7 800**	**33 000**	**170**	**75**	**11**	**120**	
Air Transportation	970	970	890	6 400	78 000	5 900	50 000	39	32 000				9.6	
Heavy-duty Diesel Vehicles	19 000	9 300	8 500	160	240 000	17 000	63 000	730			<0.01	<0.0001	0.62	
Heavy-duty Gasoline Vehicles	2 200	1 100	960	180	36 000	12 000	400 000	320			<0.01	<0.0001	1.8	
Heavy-duty LPG/NG Vehicles	4	2	1.8	0.45	80	36	860	1.3			<0.0001	<0.0001	<0.01	
Light-duty Diesel Trucks	35	17	16	3.1	1 500	1 400	17 000	15			<0.0001	<0.0001	<0.01	
Light-duty Diesel Vehicles	28	14	13	3.1	870	750	8 600	17			<0.0001	<0.0001	<0.01	
Light-duty Gasoline Trucks	2 900	1 500	1 300	730	71 000	57 000	720 000	3 100			0.014	<0.0001	2.9	
Light-duty Gasoline Vehicles	2 500	1 300	1 100	540	46 000	48 000	510 000	3 000			0.013	<0.0001	2.5	
Light-duty LPG/NG Trucks	0.052	0.026	0.023	<0.01	0.92	1	9.3	0.051			<0.0001	<0.0001	<0.0001	
Light-duty LPG/NG Vehicles	1	0.52	0.46	0.16	29	26	270	0.95			<0.0001	<0.0001	<0.01	
Marine Transportation	5 500	5 200	4 800	14 000	210 000	7 400	21 000	300	280	98	2.2	9.4	56	
Motorcycles	47	24	21	4.4	670	2 000	13 000	39			<0.0001	<0.0001	0.039	
Off-road Diesel Vehicles and Equipment	11 000	11 000	10 000	130	130 000	14 000	67 000	170						
Off-road Gasoline/LPG/CNG Vehicles and Equipment	4 900	4 700	4 400	92	32 000	140 000	1 200 000	100						
Rail Transportation	2 600	2 600	2 500	390	110 000	5 300	16 000	49	220	73	73	1.2	44	
Tire Wear and Brake Lining	23 000	12 000	1 500											
AGRICULTURE	**3 100 000**	**1 300 000**	**310 000**	**6 200**	**3 800**	**98 000**	**910**	**460 000**	**53**	**89**	**7**	**0.066**	**0.34**	
Animal Production	36 000	10 000	2 100			98 000		300 000						
Crop Production	3 100 000	1 300 000	310 000					160 000						
Fertilizer Application								160 000						
Harvesting	230 000	100 000	21 000											
Tillage Practices	810 000	170 000	81 000											
Wind Erosion	2 000 000	1 000 000	200 000											
Fuel Use	600	420	250	6 200	3 800	150	910	45	53	89	7	0.066	0.34	
COMMERCIAL / RESIDENTIAL / INSTITUTIONAL	**200 000**	**190 000**	**180 000**	**7 700**	**77 000**	**290 000**	**1 200 000**	**3 000**	**3 200**	**1 100**	**540**	**8**	**100 000**	**0.72**
Cigarette Smoking	370	370	370			6.2	1 800	70	1	2.7	0.098	<0.01	0.48	
Commercial and Institutional Fuel Combustion	2 700	2 500	2 400	2 000	26 000	1 300	19 000	190	240	480	57	0.5	2.1	0.51
Commercial Cooking	16 000	16 000	15 000			2 300	6 300						110	
Construction Fuel Combustion	180	160	150	420	3 100	58	540	52	6.7	9.1	2.2	0.04	0.23	
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	100 000	
Human								630			15			
Marine Cargo Handling	530	260	83	91	24				41	2.2				
Residential Fuel Combustion	2 400	2 200	2 100	2 500	29 000	1 500	11 000	330	250	440	67	0.38	3	0.2
Service Stations						55 000								
Other Miscellaneous Sources											360			
INCINERATION AND WASTE	**6 400**	**3 800**	**2 700**	**3 700**	**5 100**	**11 000**	**19 000**	**4 500**	**510**	**39**	**1 300**	**23**	**700**	**5 300**
Crematoriums	7	7	7	13	22	2.3	18		5.4	0.91	270	3.1	<0.01	27
Waste Incineration	2 400	2 300	2 200	2 500	2 700	5 200	16 000	230	470	31	570	20	700	4 900
Industrial and Commercial Incineration	13	9.1	7.3	450	530	650	1 900	72	310	0.59	0.014	<0.01		
Municipal Incineration	54	32	16	230	890	230	200	19	140	25	190	0.11		140
Residential Waste Burning	2 200	2 200	2 200	140	830	4 200	12 000	89			160	20	700	4 800
Other Incineration and Utilities	120	12	3.3	1 600	390	140	1 900	47	11	4.8	210	<0.0001		

Table 2–2 **2016 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)
Waste Treatment and Disposal	4 000	1 500	480	1 200	2 400	5 800	3 000	4 300	44	7.1	470	0.16	0.012	390
Landfills	3 900	1 400	390	2.3	560	4 700	2 200				280			
Water and Sewage Treatment	61	61	59	470	1 600	760	670	4 300	29	5.1	170	0.018	<0.01	110
Specialized Waste Treatment and Remediation	32	31	21	700	230	400	130	16	15	2	19	0.14	<0.01	280
Biological Treatment of Waste	8.8	8.4	8.2	0.73	3.6	<0.01	0.45							
Waste Sorting and Transfer	0.48	0.37	0.29			10								
PAINTS AND SOLVENTS	**21**	**21**	**13**	**<0.01**	**23**	**330 000**	**0.33**			**0.1**				
Dry Cleaning	7.8	7.8	4.5			190								
General Solvent Use						250 000								
Printing	7.3	7.3	6.7	<0.01	23	15 000	0.33							
Surface Coatings	5.8	5.5	1.5			60 000				0.1				
DUST	**19 000 000**	**5 500 000**	**1 000 000**											
Coal Transportation	1 300	670	270											
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	**15 000**	**13 000**	**9 100**	**34**	**1 700**	**4 900**	**120 000**	**160**				**1.8**	**2 400**	
Prescribed Forest Burning	15 000	13 000	8 900	34	1 600	4 700	120 000	140				1.8	2 400	
Structural Fires	200	200	190		26	200	1 100	23						
GRAND TOTAL	**23 000 000**	**7 200 000**	**1 600 000**	**1 100 000**	**1 800 000**	**1 800 000**	**5 800 000**	**490 000**	**170 000**	**7 800**	**4 300**	**57**	**110 000**	**8 500**

Note:

1. Totals may not add up due to rounding.
2. PAH includes B(a)p, B(b)f, B(k)f, I(cd)p.

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

In 2016, approximately 1.6 million tonnes (Mt) of $PM_{2.5}$ were emitted in Canada (Table 2–3). Dust sources accounted for 62% (1.0 Mt) of total $PM_{2.5}$ emissions, with the most important dust sources being construction operations at 51% (506 kt) of dust emisisons and dust from unpaved and paved roads at 49% (493 kt) of dust emissions. Agriculture was the second largest contributor and accounted for 19% (308 kt) of $PM_{2.5}$ emissions, most of which are attributed to crop production (19% or 306 kt of annual $PM_{2.5}$ emissions). In these sectors, PM is largely emitted by non-combustion sources.

Commercial/residential/institutional sources accounted for 11% (184 kt) of total $PM_{2.5}$ emissions in 2016, with the most important sector being home firewood burning at 10% (163 kt) of total $PM_{2.5}$ emissions. All other commercial/residential/institutional sources accounted for less than 2% of total $PM_{2.5}$ emissions.

Overall, emissions of $PM_{2.5}$ decreased from 1990 to 2016 (Figure 2–1), despite an increasing trend from construction operations, as well as paved and unpaved roads. The downward trend was influenced predominantly by decreasing emissions from crop production, home firewood burning and other sectors. Decreases in emissions from crop production can be attributed to the adoption of conservation tillage practices. Decreases in home firewood burning are due to the use of new fireplace inserts, furnaces and stoves with improved $PM_{2.5}$ emission controls and combustion efficiencies. Emissions from construction operations tended to decrease until 2002, followed by an increase from 2002 to 2012. $PM_{2.5}$ emissions from paved and unpaved roads followed a more gradual, consistent increasing trend from 1990 to 2002 and remained stable between 2002 and 2016. 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 2016 include:

- Dust sources: increase of 57% (363 kt)
  - Construction operations: increase of 112% (268 kt)
  - Dust from paved and unpaved roads: increase of 24% (97 kt total)
- Agriculture sources: decrease of 54% (369kt)
  - Crop production: decrease of 55% (369 kt)
- Commercial/residential/institutional sources: decrease of 35% (98 kt)
  - Home firewood burning: decrease of 38% (99 kt)

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

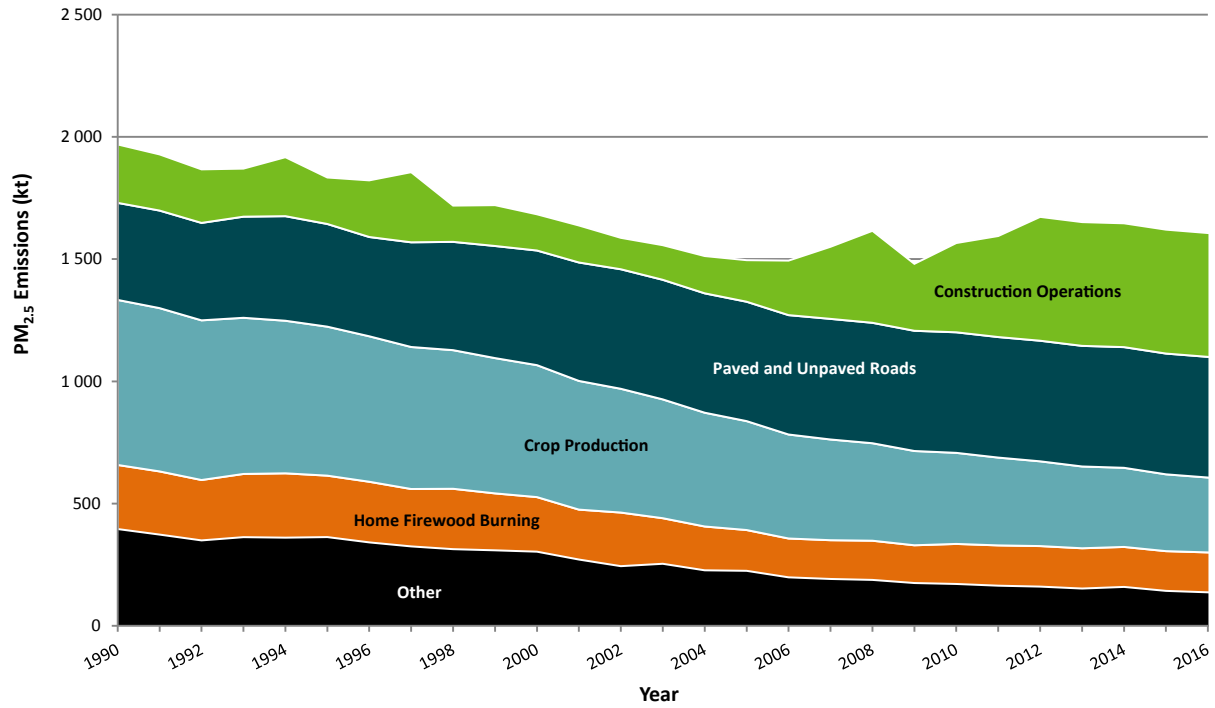

Table 2–3 National Summary of Annual $PM_{2.5}$ Emissions

Sector	1990	2000	2005	2011	2012	2013	2014	2015	2016
	(tonnes)								
ORE AND MINERAL INDUSTRIES	**59 000**	**55 000**	**44 000**	**35 000**	**36 000**	**33 000**	**33 000**	**32 000**	**33 000**
Aluminium Industry	5 400	4 500	4 700	4 500	4 500	4 100	3 700	3 300	3 400
Asphalt Paving Industry	1 900	1 700	1 500	1 800	1 500	1 400	1 600	1 600	1 600
Cement and Concrete Industry	11 000	9 600	13 000	7 500	7 800	7 800	7 600	7 600	7 400
Foundries	6 100	5 100	5 200	5 200	5 200	5 200	5 200	5 200	5 200
Iron and Steel Industries	11 000	9 400	5 100	2 100	2 600	2 100	2 500	2 400	2 200
Iron Ore Industry	1 600	4 500	1 700	1 100	1 100	1 100	950	950	1 000
Mineral Products Industry	1 200	1 100	940	270	230	330	350	300	260
Mining and Rock Quarrying	12 000	13 000	8 000	10 000	11 000	9 100	8 900	8 300	10 000
Non-Ferrous Mining and Smelting Industry	8 800	6 000	4 800	1 900	1 900	1 800	1 900	2 100	1 800
OIL AND GAS INDUSTRY	**12 000**	**13 000**	**12 000**	**9 600**	**10 000**	**11 000**	**13 000**	**12 000**	**11 000**
Downstream Oil and Gas Industry	5 100	4 900	4 600	1 900	1 800	1 700	1 600	1 400	1 500
Upstream Oil and Gas Industry	7 200	8 400	7 800	7 600	8 300	9 400	11 000	11 000	9 700
ELECTRIC POWER GENERATION (UTILITIES)	**49 000**	**23 000**	**9 000**	**4 300**	**3 200**	**3 200**	**3 500**	**3 400**	**3 300**
Coal	46 000	20 000	5 000	2 500	2 300	2 200	2 500	2 400	2 200
Diesel	260	400	380	170	160	160	180	190	200
Natural Gas	1 300	2 000	1 800	1 300	440	470	390	390	350
Waste Materials	0.41	2.9	1.6	4.0	4.5	2.5	2.3	2.4	16
Other Electric Power Generation	1 300	740	1 800	430	330	340	440	450	530
MANUFACTURING	**120 000**	**79 000**	**44 000**	**21 000**	**20 000**	**21 000**	**19 000**	**19 000**	**18 000**
Abrasives Manufacture	390	210	200	5.4	7.8	8.1	8.4	15	14
Bakeries	0.54	0.54	0.43	2.0	0.87	0.78	0.76	6.9	10
Biofuel Production				4.2	4.3	3.9	4.4	4.6	4.2
Chemicals Industry	4 800	4 500	4 000	1 400	1 500	1 600	1 400	1 300	1 300
Electronics	120	39	5.2	0.46			0.55	0.49	
Food Preparation	1 400	2 100	1 700	780	730	810	770	740	720
Glass Manufacture	920	1 300	1 100	230	140	140	150	150	160
Grain Industries	2 200	2 900	2 000	2 500	2 600	2 400	2 800	2 800	2 900
Metal Fabrication	820	1 300	960	850	850	780	420	410	410
Plastics Manufacture	170	180	110	130	110	79	70	53	62
Pulp and Paper Industry	61 000	25 000	17 000	9 200	8 400	9 000	8 400	7 600	6 900
Textiles	16	23	18	3.4	2.7	2.8	2.5	1.2	0.37
Vehicle Manufacture (Engines, Parts, Assembly, Painting)	1 700	1 600	600	330	220	210	190	180	180
Wood Products	37 000	31 000	14 000	5 300	5 600	5 600	4 700	5 100	4 600
Other Manufacturing Industries	6 200	8 800	2 900	200	170	190	180	170	190
TRANSPORTATION AND MOBILE EQUIPMENT	**96 000**	**97 000**	**80 000**	**60 000**	**55 000**	**53 000**	**51 000**	**40 000**	**36 000**
Air Transportation	640	840	830	770	860	880	860	870	890
Heavy-duty Diesel Vehicles	15 000	15 000	17 000	12 000	11 000	11 000	9 800	8 700	8 500
Heavy-duty Gasoline Vehicles	3 300	2 300	2 100	1 200	1 200	1 100	950	910	960
Heavy-duty LPG/NG Vehicles	600	680	160	8.5	5.0	2.7	1.4	1.2	1.8
Light-duty Diesel Trucks	13	13	14	11	9.8	10	12	14	16
Light-duty Diesel Vehicles	49	27	16	14	13	13	13	14	13
Light-duty Gasoline Trucks	2 000	2 400	1 600	1 300	1 300	1 300	1 200	1 200	1 300
Light-duty Gasoline Vehicles	4 800	3 500	2 200	1 400	1 300	1 300	1 200	1 100	1 100
Light-duty LPG/NG Trucks	23	12	5.3	0.13	0.062	0.027	0.020	0.018	0.023
Light-duty LPG/NG Vehicles	180	84	36	1.8	1.2	0.61	0.46	0.41	0.46
Marine Transportation	9 700	13 000	15 000	13 000	13 000	13 000	13 000	4 700	4 800
Motorcycles	21	21	23	21	21	20	19	20	21
Off-road Diesel Vehicles and Equipment	41 000	42 000	29 000	20 000	17 000	16 000	14 000	14 000	10 000
Off-road Gasoline/LPG/CNG Vehicles and Equipment	15 000	12 000	7 700	5 800	5 200	4 900	4 900	4 900	4 400
Rail Transportation	3 600	3 400	3 300	2 900	2 900	2 800	2 900	2 700	2 500
Tire Wear and Brake Lining	710	1 100	1 200	1 400	1 400	1 400	1 400	1 500	1 500
AGRICULTURE	**680 000**	**540 000**	**450 000**	**360 000**	**350 000**	**340 000**	**330 000**	**320 000**	**310 000**
Animal Production	1 700	2 100	2 300	2 000	2 000	2 000	2 000	2 100	2 100
Crop Production	670 000	540 000	450 000	360 000	350 000	330 000	320 000	310 000	310 000
Fuel Use	120	140	130	280	280	280	290	260	250
COMMERCIAL / RESIDENTIAL / INSTITUTIONAL	**280 000**	**240 000**	**190 000**	**190 000**	**190 000**	**190 000**	**190 000**	**180 000**	**180 000**
Cigarette Smoking	810	690	530	490	480	410	410	370	370
Commercial and Institutional Fuel Combustion	2 000	2 600	2 600	2 400	2 300	2 400	2 600	2 400	2 400
Commercial Cooking	14 000	15 000	17 000	17 000	17 000	17 000	16 000	15 000	15 000
Construction Fuel Combustion	180	110	160	150	160	150	140	140	150
Home Firewood Burning	260 000	220 000	170 000	160 000	170 000	160 000	160 000	160 000	160 000
Human									
Marine Cargo Handling	180	140	100	46	43	75	75	68	83
Residential Fuel Combustion	2 400	2 600	2 500	2 500	2 300	2 400	2 500	2 400	2 100
Service Stations									
Other Miscellaneous Sources									
INCINERATION AND WASTE	**5 100**	**4 500**	**3 800**	**2 900**	**2 700**	**2 700**	**2 700**	**2 700**	**2 700**
Crematoriums	4.3	6.6	5.1	5.9	6.1	6.4	6.6	7.1	7.0
Waste Incineration	4 500	3 800	3 100	2 400	2 200	2 200	2 200	2 200	2 200
Waste Treatment and Disposal	620	650	630	490	490	480	510	510	480
PAINTS AND SOLVENTS	**3.7**	**7.1**	**25**	**22**	**19**	**15**	**11**	**15**	**13**
Dry Cleaning	0.32	0.32	0.62	15	9.4	9.1	4.9	6.1	4.5
General Solvent Use									
Printing	3.0	6.4	23	7.3	8.7	5.5	5.5	8.3	6.7
Surface Coatings	0.37	0.37	0.94		0.83	0.78	0.63	1	1.5
DUST	**640 000**	**620 000**	**660 000**	**910 000**	**1 000 000**	**1 000 000**	**1 000 000**	**1 000 000**	**1 000 000**
Coal Transportation	310	270	230	270	280	300	280	240	270
Construction Operations	240 000	150 000	170 000	410 000	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	130 000	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**	**6 400**	**7 600**	**3 200**	**12 000**	**10 000**	**9 100**
Prescribed Forest Burning	36 000	6 600	4 200	6 200	7 300	2 900	12 000	10 000	8 900
Structural Fires	350	280	250	280	280	280	200	190	190
GRAND TOTAL	**2 000 000**	**1 700 000**	**1 500 000**	**1 600 000**	**1 700 000**	**1 700 000**	**1 600 000**	**1 600 000**	**1 600 000**

Note: Totals may not add up due to rounding.

2.2. **Sulphur Oxides (SO_x)**

In 2016, 1.1 Mt of SO_x were emitted in Canada (Table 2–4). Ore and mineral industries were the largest contributor, accounting for 45% (481 kt) of national emissions. Approximately 74% (360 kt) of the emissions from this source was attributed to the non-ferrous mining and smelting industry. Electric power generation (utilities) was the second-largest source of SO_x, accounting for 24% (253 kt) of total SO_x emissions, including coal-fired electricity generation at 23% (243 kt). Oil and gas industry sources follow, accounting for 23% (249 kt) of total SO_x emissions. The remaining 8% of SO_x emissions were distributed across multiple sources.

Overall, SO_x emissions decreased by 65% (2.0 Mt) between 1990 and 2016 (Figure 2–2). Reductions in emissions from the non-ferrous mining and smelting industry were the largest driver of this downward trend, particularly in the early 1990s, and again from 2008 to 2016. This decrease is attributed to federal and provincial/territorial government initiatives to reduce acid rain, the installation of new technology or processes at facilities, and the closure of three major smelters in Manitoba, Ontario and Quebec. Emissions from electric power generation significantly decreased from 2003 to 2016, due primarily to decreased coal-fired electricity generation across the country, including the complete phase-out of coal electricity generation in Ontario. Upstream oil and gas experienced a gradual decline throughout the time series as a result of a decrease in emissions from bitumen and heavy oil upgrading and natural gas processing, attributed to better emission control technologies.

The most significant decreases in SO_x emissions from 1990 to 2016 include:

- Ore and mineral industries: decrease of 68% (1.0 Mt)
  - Non-ferrous smelting and refining industry: decrease of 72% (912 kt)
- Electric power generation (utilities): decrease of 59% (365 kt)
  - Coal (electric power generation): decrease of 53% (272 kt)
- Oil and gas industry: decrease of 53% (285 kt)
  - Upstream oil and gas industry: decrease of 51% (206 kt)

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

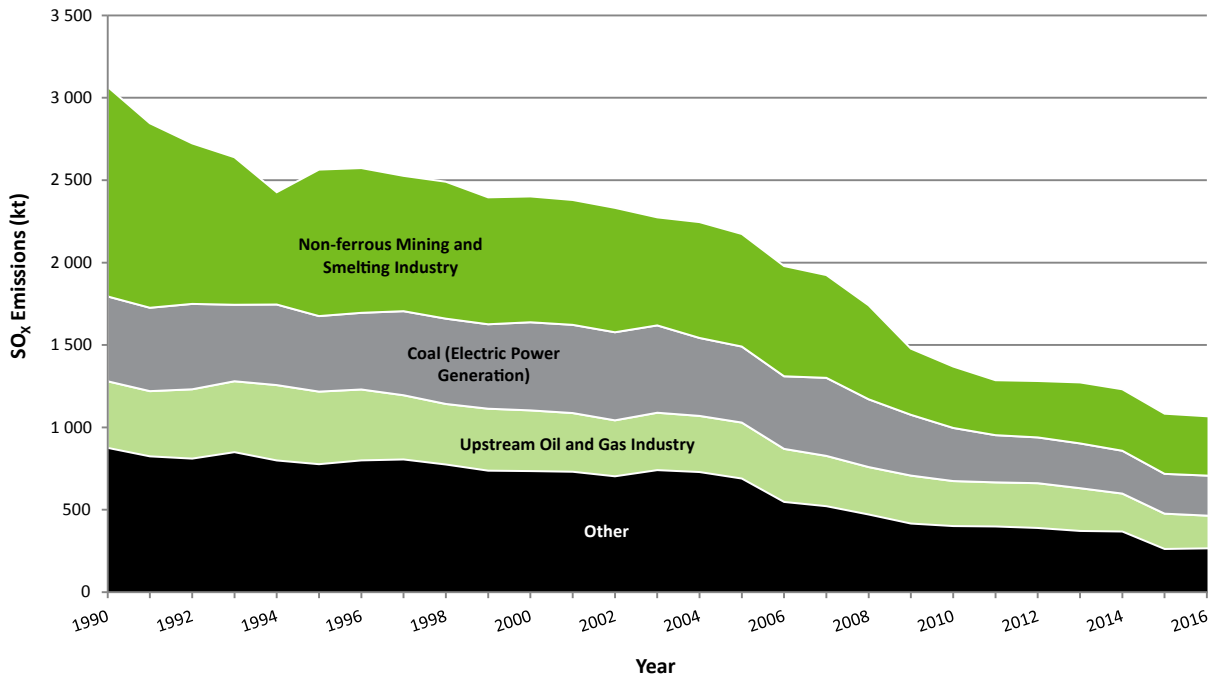

Table 2–4 National Summary of Annual SO_x Emissions

Sector	1990	2000	2005	2011	2012	2013	2014	2015	2016
	(tonnes)								
ORE AND MINERAL INDUSTRIES	**1 500 000**	**920 000**	**860 000**	**470 000**	**480 000**	**490 000**	**490 000**	**480 000**	**480 000**
Aluminium Industry	31 000	48 000	63 000	65 000	63 000	60 000	55 000	57 000	64 000
Asphalt Paving Industry	740	650	720	850	620	580	650	660	710
Cement and Concrete Industry	48 000	45 000	54 000	22 000	25 000	23 000	20 000	24 000	24 000
Foundries	1 300	910	720	48	48	48	48	48	49
Iron and Steel Industries	36 000	29 000	30 000	29 000	30 000	24 000	24 000	22 000	17 000
Iron Ore Industry	59 000	17 000	19 000	12 000	13 000	11 000	10 000	12 000	13 000
Mineral Products Industry	1 300	820	1 400	1 400	1 500	1 800	1 500	1 300	1 400
Mining and Rock Quarrying	35 000	11 000	6 300	5 900	3 000	2 200	2 000	1 800	1 600
Non-Ferrous Mining and Smelting Industry	1 300 000	760 000	680 000	330 000	340 000	370 000	370 000	370 000	360 000
OIL AND GAS INDUSTRY	**530 000**	**500 000**	**450 000**	**330 000**	**330 000**	**320 000**	**280 000**	**260 000**	**250 000**
Downstream Oil and Gas Industry	130 000	140 000	110 000	58 000	56 000	56 000	53 000	45 000	51 000
Upstream Oil and Gas Industry	400 000	370 000	340 000	270 000	270 000	260 000	230 000	210 000	200 000
ELECTRIC POWER GENERATION (UTILITIES)	**620 000**	**620 000**	**530 000**	**290 000**	**280 000**	**280 000**	**270 000**	**250 000**	**250 000**
Coal	510 000	530 000	460 000	290 000	280 000	270 000	260 000	240 000	240 000
Diesel	410	420	300	56	55	59	110	270	230
Natural Gas	29 000	21 000	19 000	680	570	1 300	2 200	2 000	1 700
Waste Materials	0.76	21	25	47	46	37	24	11	29
Other Electric Power Generation	74 000	63 000	46 000	6 000	5 800	5 100	7 000	7 700	8 200
MANUFACTURING	**230 000**	**160 000**	**140 000**	**53 000**	**50 000**	**49 000**	**53 000**	**48 000**	**43 000**
Abrasives Manufacture	4 000	860	860						
Bakeries	0.053	0.052	0.16	0.0060	0.0051	0.0064	0.0062	0.0054	0.0054
Biofuel Production									
Chemicals Industry	38 000	31 000	35 000	23 000	20 000	20 000	21 000	22 000	20 000
Electronics	1 700	3 000	3 000						
Food Preparation	3 500	4 800	5 200	1 700	900	740	610	370	280
Glass Manufacture	2 300	2 800	2 500	590	630	630	600	630	610
Grain Industries	230	210	390	700	660	630	470	510	530
Metal Fabrication	2 300	2 700	2 000	200	200	190	9.2	8.6	11
Plastics Manufacture	470	27	12	0.11	0.0068	0.0079	0.0069		
Pulp and Paper Industry	140 000	78 000	62 000	26 000	26 000	26 000	29 000	24 000	21 000
Textiles	380	390	320	51	41	31	22	17	0.0011
Vehicle Manufacture (Engines, Parts, Assembly, Painting)	2 300	2 100	1 800	970	660	610	390	57	46
Wood Products	3 300	3 500	3 100	640	580	570	660	630	680
Other Manufacturing Industries	29 000	25 000	23 000	24	0.88	0.7	0.79	1.1	1.2
TRANSPORTATION AND MOBILE EQUIPMENT	**150 000**	**170 000**	**150 000**	**120 000**	**120 000**	**120 000**	**120 000**	**22 000**	**22 000**
Air Transportation	5 300	6 700	7 500	5 200	5 900	6 200	6 000	6 200	6 400
Heavy-duty Diesel Vehicles	15 000	6 700	6 100	160	160	170	160	160	160
Heavy-duty Gasoline Vehicles	940	1 900	150	170	180	190	180	180	180
Heavy-duty LPG/NG Vehicles	240	1 300	9.5	1.0	0.93	0.43	0.32	0.38	0.45
Light-duty Diesel Trucks	170	75	49	1.5	1.6	1.8	2.2	2.8	3.1
Light-duty Diesel Vehicles	570	130	110	2.9	3.0	3.2	3.2	3.4	3.1
Light-duty Gasoline Trucks	3 200	6 300	500	580	640	660	660	690	730
Light-duty Gasoline Vehicles	7 100	8 200	560	520	550	550	530	540	540
Light-duty LPG/NG Trucks	23	28	1.4	0.038	0.018	0.0073	0.0059	0.0056	0.0067
Light-duty LPG/NG Vehicles	190	180	10	0.62	0.38	0.20	0.16	0.15	0.16
Marine Transportation	80 000	110 000	130 000	110 000	110 000	110 000	110 000	13 000	14 000
Motorcycles	14	24	2.8	3.6	4.0	4.0	4.0	4.1	4.4
Off-road Diesel Vehicles and Equipment	28 000	17 000	6 600	240	150	150	140	150	130
Off-road Gasoline/LPG/CNG Vehicles and Equipment	1 600	1 700	94	86	83	85	90	92	92
Rail Transportation	5 700	5 400	5 000	450	450	430	440	420	390
Tire Wear and Brake Lining									
AGRICULTURE	**2 200**	**1 500**	**2 900**	**9 000**	**7 900**	**8 300**	**9 100**	**6 700**	**6 200**
Animal Production									
Crop Production									
Fuel Use	2 200	1 500	2 900	9 000	7 900	8 300	9 100	6 700	6 200
COMMERCIAL / RESIDENTIAL / INSTITUTIONAL	**52 000**	**36 000**	**37 000**	**17 000**	**14 000**	**10 000**	**10 000**	**9 000**	**7 700**
Cigarette Smoking									
Commercial and Institutional Fuel Combustion	19 000	19 000	21 000	7 500	6 200	3 300	3 600	2 500	2 000
Commercial Cooking									
Construction Fuel Combustion	1 900	620	1 400	850	650	530	520	620	420
Home Firewood Burning	3 600	3 300	2 700	2 800	2 900	2 800	2 800	2 800	2 800
Human									
Marine Cargo Handling	0.0050	0.0010				140	140	88	91
Residential Fuel Combustion	28 000	14 000	11 000	6 200	4 300	3 400	3 200	3 000	2 500
Service Stations									
Other Miscellaneous Sources									
INCINERATION AND WASTE	**3 200**	**2 900**	**3 000**	**3 200**	**3 200**	**3 100**	**3 300**	**3 800**	**3 700**
Crematoriums	5.0	7.0	9.0	11	12	12	13	14	13
Waste Incineration	2 400	2 000	2 400	2 500	2 600	2 500	2 500	2 500	2 500
Waste Treatment and Disposal	790	930	600	680	620	610	840	1 200	1 200
PAINTS AND SOLVENTS	**2.1**	**1.5**	**0.63**	**0.0038**		**0.0040**	**0.0040**	**0.0030**	**0.0030**
Dry Cleaning	0.0068	0.0086							
General Solvent Use									
Printing	2.0	1.5	0.63	0.0038		0.0040	0.0040	0.0030	0.0030
Surface Coatings	0.015	0.015							
DUST									
Coal Transportation									
Construction Operations									
Mine Tailings									
Paved Roads									
Unpaved Roads									
FIRES	**180**	**28**	**18**	**27**	**34**	**13**	**53**	**41**	**34**
Prescribed Forest Burning	180	28	18	27	34	13	53	41	34
Structural Fires									
GRAND TOTAL	**3 100 000**	**2 400 000**	**2 200 000**	**1 300 000**	**1 300 000**	**1 300 000**	**1 200 000**	**1 100 000**	**1 100 000**

Note: Totals may not add up due to rounding.

2.3. Nitrogen Oxides (NO_x)

Approximately 1.8 Mt of NO_x were released in Canada in 2016 (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 31% (570 kt) of total NO_x emissions. The oil and gas industry accounted for 26% (480 kt) of NO_x emissions in 2016, including the upstream oil and gas industry, which accounted for 26% (463 kt) of the national total. Electric power generation (utilities) contributed 8% (152 kt) of NO_x emissions, including coal-fired generation, which contributed 6% (117 kt) of national emissions. The remaining 14% of NO_x emissions were distributed across multiple sources.

From 1990 to 2016, national NO_x emissions decreased by 25% (593 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 & 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), the coal sector contributed to the decreasing trend across the time series, with a gradual decrease in emissions from 1998 to 2016. 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 2016 include:

- Transportation and mobile equipment emissions: decrease of 33% (462 kt)
  - Off-road diesel vehicles and equipment: decrease of 62% (208 kt)
  - Light-duty gasoline trucks and vehicles: decrease of 59% (167 kt)
  - Marine transportation: increase of 49% (68 kt)
  - Heavy-duty diesel vehicles: decrease of 19% (56 kt)
- Electric power generation (utilities) emissions: decrease of 41% (105 kt)
  - Coal: decrease of 43% (89kt)
- Oil and gas industry emissions: increase of 39% (134 kt)
  - Upstream oil and gas industry: increase of 49% (152 kt)
  - Downstream oil and gas industry: decrease of 49% (17 kt)

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

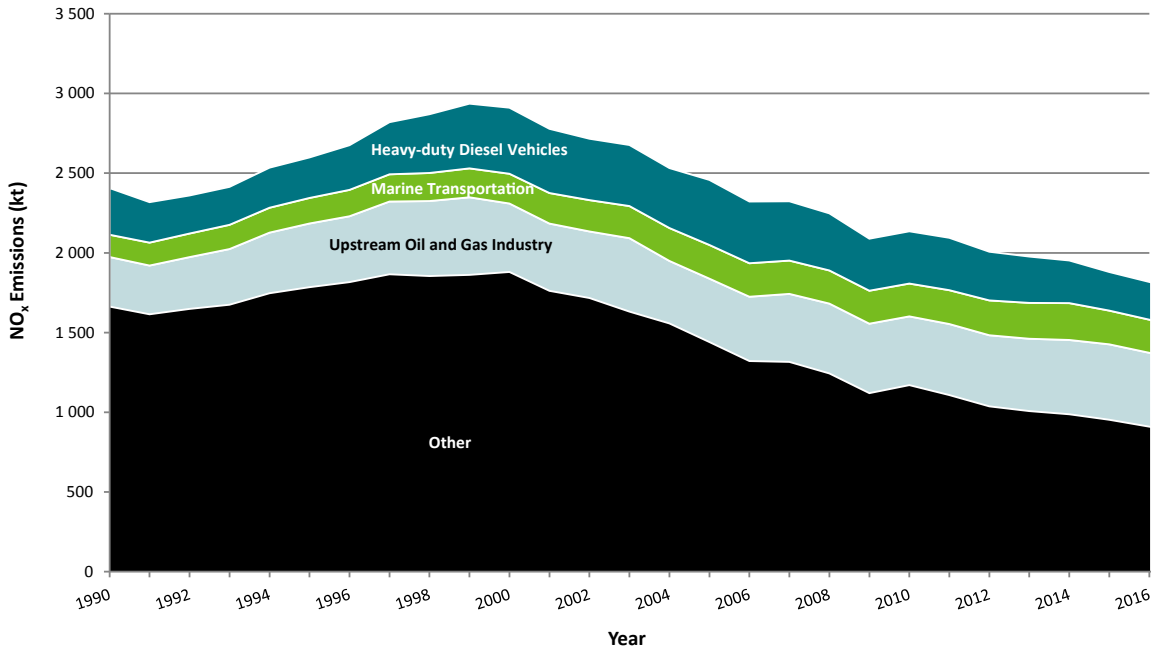

Table 2–5 National Summary of Annual NO_x Emissions

Sector	1990	2000	2005	2011	2012	2013	2014	2015	2016
	(tonnes)								
ORE AND MINERAL INDUSTRIES	**110 000**	**99 000**	**110 000**	**86 000**	**89 000**	**83 000**	**82 000**	**82 000**	**78 000**
Aluminium Industry	1 600	1 400	2 000	1 100	1 400	1 300	1 200	1 100	1 200
Asphalt Paving Industry	1 200	1 100	1 200	1 300	1 100	1 000	1 200	1 200	1 200
Cement and Concrete Industry	43 000	45 000	55 000	32 000	36 000	32 000	31 000	35 000	32 000
Foundries	490	640	530	140	140	140	140	140	140
Iron and Steel Industries	19 000	16 000	13 000	11 000	12 000	11 000	12 000	11 000	11 000
Iron Ore Industry	10 000	10 000	9 800	13 000	13 000	13 000	12 000	12 000	11 000
Mineral Products Industry	1 300	560	770	130	190	250	270	240	240
Mining and Rock Quarrying	25 000	21 000	23 000	25 000	24 000	22 000	23 000	20 000	19 000
Non-Ferrous Mining and Smelting Industry	4 300	3 800	2 000	1 600	1 500	1 600	1 600	1 600	2 000
OIL AND GAS INDUSTRY	**350 000**	**460 000**	**430 000**	**460 000**	**470 000**	**470 000**	**480 000**	**490 000**	**480 000**
Downstream Oil and Gas Industry	35 000	30 000	31 000	19 000	19 000	18 000	18 000	18 000	18 000
Upstream Oil and Gas Industry	310 000	430 000	400 000	450 000	450 000	450 000	470 000	470 000	460 000
ELECTRIC POWER GENERATION (UTILITIES)	**260 000**	**330 000**	**250 000**	**200 000**	**170 000**	**160 000**	**170 000**	**150 000**	**150 000**
Coal	210 000	230 000	190 000	130 000	130 000	120 000	130 000	110 000	120 000
Diesel	3 000	8 200	7 600	8 000	7 800	8 000	8 600	9 100	8 400
Natural Gas	20 000	65 000	36 000	49 000	22 000	21 000	18 000	16 000	16 000
Waste Materials	45	520	220	320	300	190	170	210	360
Other Electric Power Generation	28 000	28 000	21 000	11 000	11 000	8 600	11 000	11 000	11 000
MANUFACTURING	**190 000**	**180 000**	**130 000**	**70 000**	**68 000**	**69 000**	**68 000**	**69 000**	**71 000**
Abrasives Manufacture	240	90	74						
Bakeries	4.1	4.0		1.0	0.86	1.1	1.0	0.89	0.89
Biofuel Production				19	18	18	17	18	16
Chemicals Industry	41 000	47 000	36 000	23 000	24 000	22 000	21 000	23 000	22 000
Electronics	150	160	71						
Food Preparation	2 400	2 900	3 100	2 000	1 600	1 700	1 700	1 600	1 600
Glass Manufacture	7 000	7 400	6 100	940	900	920	890	920	780
Grain Industries	1 400	1 300	1 600	850	1 000	950	1 000	780	760
Metal Fabrication	5 900	9 000	1 400	340	310	240	260	340	390
Plastics Manufacture	880	810	120	36	41	0.95	0.91	9.4	11
Pulp and Paper Industry	72 000	49 000	41 000	31 000	29 000	31 000	30 000	30 000	31 000
Textiles	120	170	110	43	30	33	33	8.2	0.17
Vehicle Manufacture (Engines, Parts, Assembly, Painting)	2 500	3 500	1 700	880	760	840	790	730	700
Wood Products	19 000	24 000	21 000	10 000	11 000	11 000	12 000	12 000	14 000
Other Manufacturing Industries	33 000	30 000	21 000	190	170	140	140	160	160
TRANSPORTATION AND MOBILE EQUIPMENT	**1 400 000**	**1 700 000**	**1 400 000**	**1 200 000**	**1 100 000**	**1 100 000**	**1 100 000**	**1 000 000**	**940 000**
Air Transportation	52 000	64 000	68 000	61 000	69 000	73 000	72 000	75 000	78 000
Heavy-duty Diesel Vehicles	290 000	410 000	410 000	330 000	310 000	290 000	270 000	240 000	240 000
Heavy-duty Gasoline Vehicles	58 000	81 000	60 000	44 000	44 000	43 000	36 000	34 000	36 000
Heavy-duty LPG/NG Vehicles	15 000	34 000	4 500	370	220	110	59	61	80
Light-duty Diesel Trucks	790	1 400	1 900	1 300	1 200	1 200	1 300	1 400	1 500
Light-duty Diesel Vehicles	2 200	2 300	1 200	1 100	990	990	950	930	870
Light-duty Gasoline Trucks	94 000	190 000	130 000	88 000	81 000	76 000	70 000	67 000	71 000
Light-duty Gasoline Vehicles	190 000	220 000	120 000	67 000	60 000	56 000	49 000	45 000	46 000
Light-duty LPG/NG Trucks	820	740	280	5.6	2.6	1.1	0.82	0.74	0.92
Light-duty LPG/NG Vehicles	7 500	5 900	2 900	140	84	43	31	27	29
Marine Transportation	140 000	190 000	210 000	210 000	220 000	220 000	230 000	210 000	210 000
Motorcycles	310	440	520	620	630	620	610	630	670
Off-road Diesel Vehicles and Equipment	330 000	360 000	280 000	220 000	190 000	180 000	170 000	170 000	130 000
Off-road Gasoline/LPG/CNG Vehicles and Equipment	54 000	38 000	28 000	31 000	31 000	30 000	32 000	33 000	32 000
Rail Transportation	160 000	150 000	130 000	120 000	120 000	120 000	120 000	120 000	110 000
Tire Wear and Brake Lining									
AGRICULTURE	**2 100**	**2 200**	**2 100**	**4 000**	**4 000**	**4 100**	**4 300**	**3 800**	**3 800**
Animal Production									
Crop Production									
Fuel Use	2 100	2 200	2 100	4 000	4 000	4 100	4 300	3 800	3 800
COMMERCIAL / RESIDENTIAL / INSTITUTIONAL	**87 000**	**90 000**	**86 000**	**85 000**	**81 000**	**81 000**	**84 000**	**80 000**	**77 000**
Cigarette Smoking									
Commercial and Institutional Fuel Combustion	23 000	30 000	30 000	27 000	26 000	26 000	27 000	26 000	26 000
Commercial Cooking									
Construction Fuel Combustion	3 900	2 000	3 000	3 300	3 500	3 100	3 000	3 000	3 100
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	0.059				29	31	26	24
Residential Fuel Combustion	35 000	35 000	35 000	34 000	32 000	33 000	34 000	32 000	29 000
Service Stations									
Other Miscellaneous Sources									
INCINERATION AND WASTE	**8 400**	**8 000**	**8 600**	**4 800**	**5 000**	**5 500**	**5 200**	**5 000**	**5 100**
Crematoriums	8.2	12	15	18	19	20	21	22	22
Waste Incineration	2 500	2 400	2 500	3 000	3 100	3 000	2 800	2 600	2 700
Waste Treatment and Disposal	5 800	5 600	6 100	1 800	1 900	2 400	2 400	2 400	2 400
PAINTS AND SOLVENTS	**110**	**120**	**130**	**23**	**23**	**23**	**23**	**23**	**23**
Dry Cleaning	1.1	1.6							
General Solvent Use									
Printing	110	120	130	23	23	23	23	23	23
Surface Coatings	0.12	0.12							
DUST									
Coal Transportation									
Construction Operations									
Mine Tailings									
Paved Roads									
Unpaved Roads									
FIRES	**7 500**	**1 400**	**890**	**1 300**	**1 500**	**650**	**2 600**	**2 000**	**1 700**
Prescribed Forest Burning	7 400	1 400	850	1 300	1 500	610	2 600	2 000	1 600
Structural Fires	49	39	35	39	39	39	28	27	26
GRAND TOTAL	**2 400 000**	**2 900 000**	**2 500 000**	**2 100 000**	**2 000 000**	**2 000 000**	**2 000 000**	**1 900 000**	**1 800 000**

Note: Totals may not add up due to rounding.

2.4. Volatile Organic Compounds (VOCs)

In 2016, approximately 1.8 Mt of VOCs were released in Canada (Table 2–6). The oil and gas industry was the largest contributor at 35% (641 kt) of total emissions (with the upstream oil and gas industry emitting 33% (617 kt) of total VOCs). Paints and solvents were the next-largest contributor, accounting for 17% (326 kt) of emissions, with general solvent use accounting for 13% (250 kt) of the national total. Transportation and mobile equipment sources accounted for 17% (314 kt) of emissions, with off-road gasoline, liquefied petroleum gas (LPG) or compressed natural gas (CNG) vehicles and equipment contributing 8% (143 kt) of the national total. Commercial/residential/institutional sources represented 16% (292 kt) of VOC emissions, mainly attributed to home firewood burning (13% or 231 kt). The other contributing VOC sources are manufacturing, agriculture, incineration and waste, ore and mineral industries, and fires. Of these, manufacturing sources accounted for 6% (116 kt) and agricultural sources for 5% (98 kt) of total VOC emissions.

Between 1990 and 2016, VOC emissions decreased by 42% (1.3 Mt) (Figure 2–4). The most significant driver of this trend is a persistent decrease in emissions from off-road gasoline, LPG or CNG vehicles and equipment throughout the time series, due to increasingly stringent regulations on spark-ignition engines. Emissions from light-duty gasoline vehicles and trucks also contributed to this trend, with a consistent decrease in emissions throughout the time series.

Although emissions from most sources decreased, the oil and gas industry experienced an overall increase in emissions between 1990 and 2016. 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 2016, VOC emissions from the upstream oil and gas industry declined compared to 2015, due to declining conventional production and decreased drilling activity.

The most significant changes in VOC emissions from 1990 to 2016 include:

- Transportation and mobile equipment source emissions: decrease of 76% (977 kt)
  - Off-road gasoline/LPG/CNG vehicles and equipment: decrease of 83% (639kt)
  - Light-duty gasoline vehicles and trucks: decrease of 56% (203 kt)
- Oil and gas industry source emissions: increase of 7% (42 kt)
  - Downstream oil and gas industry: decrease of 81% (104 kt)
  - Upstream oil and gas industry: increase of 31% (145 kt)

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

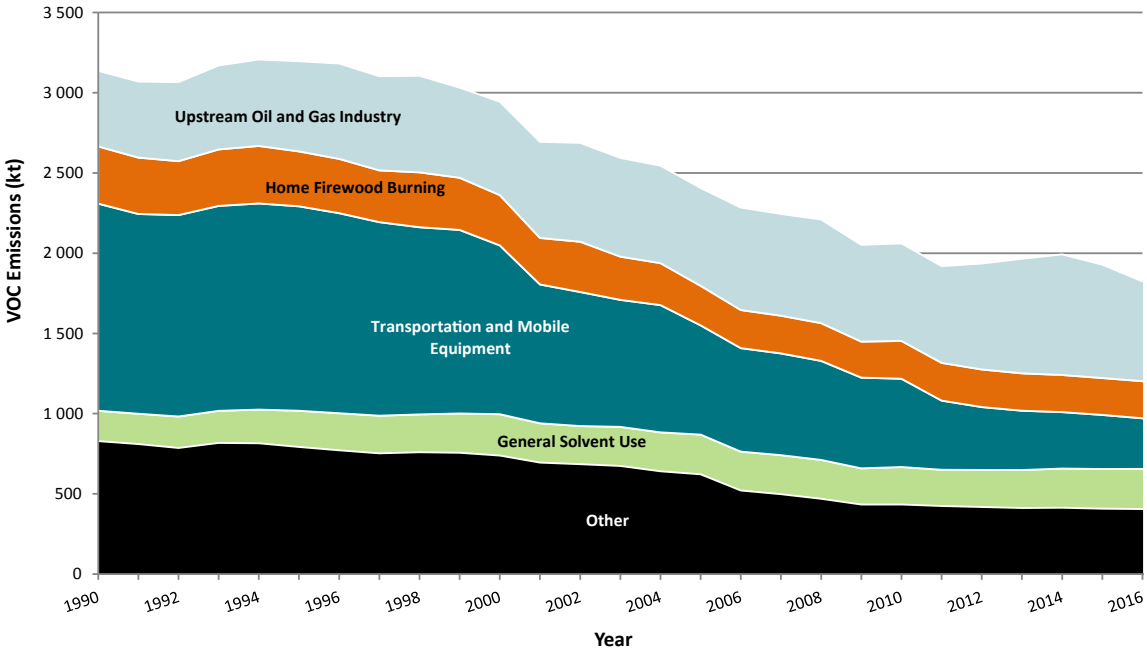

Table 2–6 National Summary of Annual VOC Emissions

Sector	1990	2000	2005	2011	2012	2013	2014	2015	2016
	(tonnes)								
ORE AND MINERAL INDUSTRIES	**21 000**	**20 000**	**17 000**	**16 000**	**14 000**	**13 000**	**13 000**	**13 000**	**13 000**
Aluminium Industry	710	1 100	1 200	1 500	1 300	1 400	970	930	950
Asphalt Paving Industry	6 600	6 400	6 100	9 500	7 900	7 100	8 500	8 500	8 500
Cement and Concrete Industry	720	780	1 300	370	420	450	420	410	450
Foundries	1 700	1 100	920	560	580	520	450	380	360
Iron and Steel Industries	5 800	4 200	2 000	1 400	1 300	920	1 100	870	820
Iron Ore Industry	570	3 200	1 600	38	170	290	320	300	410
Mineral Products Industry	170	320	210	68	74	100	120	110	140
Mining and Rock Quarrying	4 100	3 200	3 300	2 600	1 900	1 800	1 600	1 900	1 400
Non-Ferrous Mining and Smelting Industry	330	37	52	73	65	70	66	67	65
OIL AND GAS INDUSTRY	**600 000**	**670 000**	**670 000**	**630 000**	**680 000**	**740 000**	**780 000**	**730 000**	**640 000**
Downstream Oil and Gas Industry	130 000	86 000	64 000	26 000	23 000	25 000	24 000	24 000	25 000
Upstream Oil and Gas Industry	470 000	580 000	610 000	600 000	660 000	710 000	750 000	710 000	620 000
ELECTRIC POWER GENERATION (UTILITIES)	**2 500**	**3 600**	**3 200**	**1 900**	**1 200**	**1 300**	**1 300**	**1 300**	**1 200**
Coal	1 300	950	1 300	360	380	390	450	410	410
Diesel	77	280	220	54	53	53	46	84	55
Natural Gas	480	1 600	1 400	1 200	530	560	550	570	570
Waste Materials	0.7	5.6		15	17	8.2	11	13	9.1
Other Electric Power Generation	630	770	300	300	250	290	270	220	200
MANUFACTURING	**260 000**	**270 000**	**200 000**	**120 000**	**120 000**	**120 000**	**120 000**	**110 000**	**120 000**
Abrasives Manufacture	1 500	590	610	30	90	94	59	18	20
Bakeries	3 500	6 900	11 000	13 000	11 000	11 000	13 000	14 000	16 000
Biofuel Production				97	100	100	98	100	42
Chemicals Industry	47 000	36 000	25 000	12 000	11 000	14 000	13 000	11 000	9 800
Electronics	1 300	540	320	98	41	36	33	19	17
Food Preparation	10 000	13 000	15 000	17 000	16 000	15 000	15 000	15 000	15 000
Glass Manufacture	2 000	2 300	600	260	260	280	240	200	260
Grain Industries	2 200	2 300	2 200	2 600	2 600	2 500	3 000	3 000	2 500
Metal Fabrication	9 100	14 000	11 000	5 500	5 200	4 800	4 200	4 500	3 700
Plastics Manufacture	14 000	16 000	14 000	13 000	13 000	12 000	9 600	10 000	9 800
Pulp and Paper Industry	27 000	24 000	18 000	19 000	18 000	16 000	14 000	13 000	13 000
Textiles	870	1 500	840	700	530	490	570	620	580
Vehicle Manufacture (Engines, Parts, Assembly, Painting)	22 000	23 000	18 000	9 400	9 800	9 600	9 400	9 400	11 000
Wood Products	110 000	110 000	77 000	31 000	35 000	36 000	36 000	33 000	33 000
Other Manufacturing Industries	11 000	21 000	5 600	1 300	1 100	1 400	1 300	1 300	1 100
TRANSPORTATION AND MOBILE EQUIPMENT	**1 300 000**	**1 100 000**	**680 000**	**430 000**	**390 000**	**370 000**	**350 000**	**340 000**	**310 000**
Air Transportation	5 100	6 000	5 400	5 800	6 400	6 300	6 200	6 200	5 900
Heavy-duty Diesel Vehicles	10 000	18 000	25 000	23 000	21 000	20 000	19 000	17 000	17 000
Heavy-duty Gasoline Vehicles	23 000	28 000	22 000	15 000	15 000	15 000	12 000	11 000	12 000
Heavy-duty LPG/NG Vehicles	7 100	12 000	2 300	190	100	53	26	26	36
Light-duty Diesel Trucks	770	970	1 500	1 100	1 000	1 000	1 100	1 300	1 400
Light-duty Diesel Vehicles	2 200	1 500	920	870	810	800	800	810	750
Light-duty Gasoline Trucks	88 000	110 000	81 000	62 000	59 000	57 000	54 000	54 000	57 000
Light-duty Gasoline Vehicles	220 000	150 000	94 000	61 000	57 000	54 000	49 000	48 000	48 000
Light-duty LPG/NG Trucks	1 100	540	230	5.5	2.7	1.1	0.86	0.83	1.0
Light-duty LPG/NG Vehicles	8 100	3 700	1 900	110	67	35	26	24	26
Marine Transportation	5 800	7 600	8 600	8 800	9 100	9 400	9 700	7 100	7 400
Motorcycles	1 500	1 700	1 800	1 900	1 900	1 900	1 800	1 800	2 000
Off-road Diesel Vehicles and Equipment	53 000	53 000	37 000	25 000	21 000	20 000	19 000	18 000	14 000
Off-road Gasoline/LPG/CNG Vehicles and Equipment	860 000	660 000	390 000	220 000	190 000	180 000	170 000	170 000	140 000
Rail Transportation	6 700	6 200	6 100	6 100	6 100	5 900	6 100	5 800	5 300
Tire Wear and Brake Lining									
AGRICULTURE	**94 000**	**110 000**	**110 000**	**99 000**	**99 000**	**99 000**	**99 000**	**98 000**	**98 000**
Animal Production	94 000	110 000	110 000	99 000	99 000	99 000	99 000	98 000	98 000
Crop Production									
Fuel Use	81	91	82	140	150	150	150	150	150
COMMERCIAL / RESIDENTIAL / INSTITUTIONAL	**450 000**	**410 000**	**340 000**	**300 000**	**290 000**	**290 000**	**290 000**	**290 000**	**290 000**
Cigarette Smoking	13	12	8.8	8.1	8.0	6.8	6.9	6.1	6.2
Commercial and Institutional Fuel Combustion	1 000	1 400	1 400	1 300	1 300	1 300	1 400	1 300	1 300
Commercial Cooking	2 000	2 300	2 500	2 500	2 500	2 500	2 400	2 300	2 300
Construction Fuel Combustion	71	34	51	61	68	59	56	55	58
Home Firewood Burning	360 000	310 000	250 000	240 000	230 000	230 000	230 000	230 000	230 000
Human									
Marine Cargo Handling	0.34	0.92	1.9	17	10.0				
Residential Fuel Combustion	1 500	1 700	1 700	1 700	1 600	1 700	1 800	1 700	1 500
Service Stations									
Other Miscellaneous Sources									
INCINERATION AND WASTE	**16 000**	**15 000**	**15 000**	**11 000**	**11 000**	**11 000**	**11 000**	**11 000**	**11 000**
Crematoriums	0.95	1.3	1.7	2.0	2.0	2.2	2.2	2.4	2.3
Waste Incineration	9 800	8 000	8 200	5 300	5 100	4 900	5 100	5 100	5 200
Waste Treatment and Disposal	6 100	6 500	6 400	5 500	5 500	5 600	5 600	5 700	5 800
PAINTS AND SOLVENTS	**360 000**	**400 000**	**370 000**	**300 000**	**310 000**	**310 000**	**320 000**	**330 000**	**330 000**
Dry Cleaning	740	790	200	190	190	200	200	180	190
General Solvent Use	190 000	260 000	250 000	230 000	230 000	240 000	240 000	250 000	250 000
Printing	37 000	48 000	42 000	19 000	19 000	18 000	17 000	17 000	15 000
Surface Coatings	130 000	89 000	77 000	60 000	60 000	59 000	61 000	61 000	60 000
DUST									
Coal Transportation									
Construction Operations									
Mine Tailings									
Paved Roads									
Unpaved Roads									
FIRES	**41 000**	**4 200**	**3 400**	**4 200**	**7 100**	**2 000**	**8 100**	**5 900**	**4 900**
Prescribed Forest Burning	40 000	3 900	3 100	3 900	6 800	1 700	7 900	5 700	4 700
Structural Fires	390	310	280	310	310	310	220	210	200
GRAND TOTAL	**3 100 000**	**2 900 000**	**2 400 000**	**1 900 000**	**1 900 000**	**2 000 000**	**2 000 000**	**1 900 000**	**1 800 000**

Note: Totals may not add up due to rounding.

2.5. **Carbon Monoxide (CO)**

In 2016, approximately 5.8 Mt of CO were released in Canada (Table 2–7). Transportation and mobile equipment accounted for 54% (3.1 Mt) of total emissions, including light-duty gasoline vehicles and trucks at 21% (1.2 Mt) and off-road gasoline/LPG/CNG vehicles and equipment at 21% (1.2 Mt) of total CO emissions. The next-largest contributors are commercial/residential/institutional sources, which in 2016 also accounted for 21% (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 sectors, accounting for 9% (533 kt) and 7% (425 kt) of CO, respectively.

Between 1990 and 2016, CO emissions decreased by 54% (6.7 Mt) (Figure 2–5). Of the many sectors that contributed to the overall decrease in emissions, two sectors in particular – light-duty gasoline trucks and vehicles, and off-road gasoline/LPG/CNG 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, due to improved combustion efficiency in modern fireplace inserts, stoves and fireplaces and to a decrease in the use of wood as heating fuel.

The most significant changes in CO emissions from 1990 to 2016 include:

- Transportation and mobile equipment emissions: decrease of 62% (5.1 Mt)
  - Light-duty gasoline trucks and vehicles: decrease of 71% (3.1 Mt)
  - Off-road gasoline/LPG/CNG vehicles and equipment: decrease of 53% (1.4 Mt)
- Commercial/residential/institutional emissions: decrease of 27% (465 kt)
  - Home firewood burning: decrease of 28% (465 kt)
- Oil and gas industry: increase of 63 % (213 kt)
  - Upstream oil and gas industry: increase of 74% (226 kt)

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

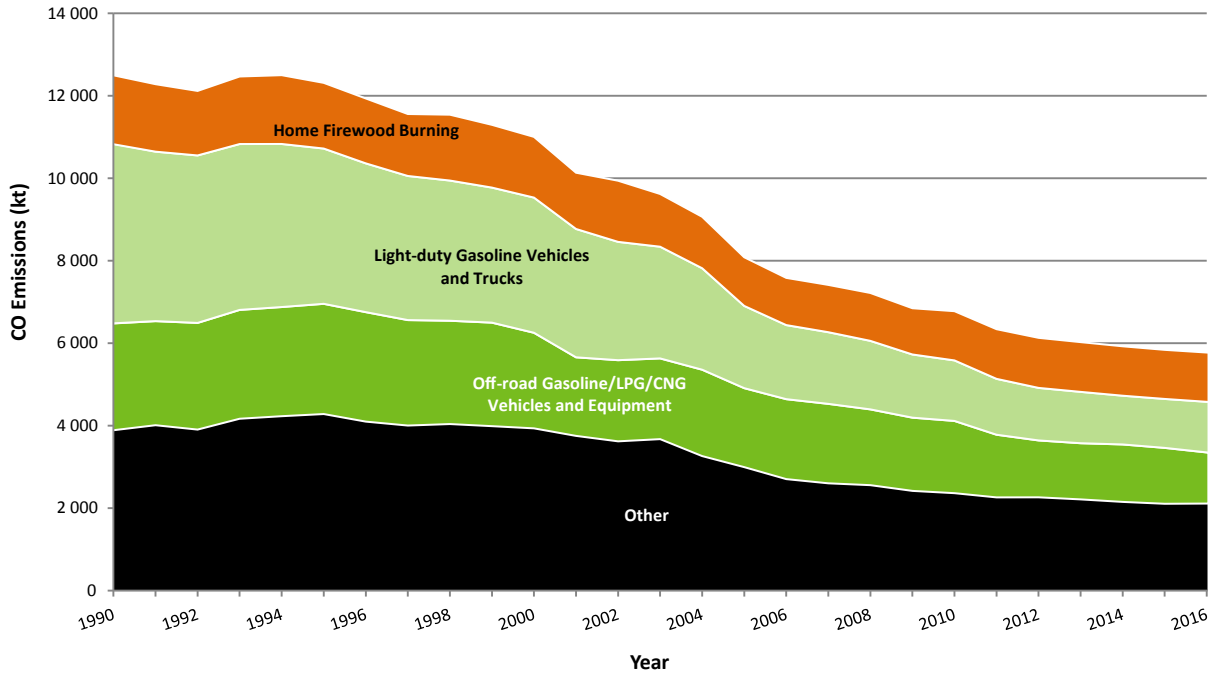

Table 2–7 National Summary of Annual CO Emissions

Sector	1990	2000	2005	2011	2012	2013	2014	2015	2016
	(tonnes)								
ORE AND MINERAL INDUSTRIES	**390 000**	**400 000**	**500 000**	**540 000**	**550 000**	**550 000**	**510 000**	**510 000**	**560 000**
Aluminium Industry	240 000	250 000	310 000	400 000	400 000	410 000	380 000	380 000	420 000
Asphalt Paving Industry	4 200	4 200	4 500	4 600	3 800	3 700	4 000	4 000	4 000
Cement and Concrete Industry	16 000	23 000	27 000	16 000	18 000	15 000	12 000	11 000	14 000
Foundries	55 000	48 000	49 000	49 000	49 000	49 000	49 000	49 000	49 000
Iron and Steel Industries	43 000	48 000	64 000	21 000	28 000	23 000	24 000	21 000	21 000
Iron Ore Industry	18 000	9 600	23 000	22 000	20 000	20 000	20 000	20 000	18 000
Mineral Products Industry	3 900	3 400	2 800	390	380	500	430	450	460
Mining and Rock Quarrying	14 000	14 000	10 000	17 000	20 000	14 000	15 000	13 000	14 000
Non-Ferrous Mining and Smelting Industry	280	360	13 000	11 000	13 000	11 000	13 000	13 000	17 000
OIL AND GAS INDUSTRY	**340 000**	**440 000**	**490 000**	**530 000**	**540 000**	**570 000**	**560 000**	**570 000**	**550 000**
Downstream Oil and Gas Industry	29 000	23 000	21 000	19 000	16 000	42 000	18 000	24 000	16 000
Upstream Oil and Gas Industry	310 000	420 000	470 000	510 000	520 000	530 000	540 000	550 000	530 000
ELECTRIC POWER GENERATION (UTILITIES)	**50 000**	**43 000**	**49 000**	**41 000**	**33 000**	**34 000**	**39 000**	**39 000**	**36 000**
Coal	41 000	18 000	25 000	13 000	9 500	13 000	15 000	16 000	16 000
Diesel	360	1 200	740	1 200	1 100	1 100	1 300	1 500	1 300
Natural Gas	4 400	17 000	15 000	19 000	17 000	15 000	14 000	14 000	11 000
Waste Materials	82	400	210	380	320	180	340	230	280
Other Electric Power Generation	4 400	7 200	7 800	7 900	5 400	4 600	7 800	7 200	7 800
MANUFACTURING	**1 300 000**	**1 100 000**	**530 000**	**170 000**	**180 000**	**180 000**	**160 000**	**140 000**	**130 000**
Abrasives Manufacture	610	240	240						
Bakeries	5.9	5.8	1.2	0.20	0.17	0.35	0.34	0.3	0.3
Biofuel Production									
Chemicals Industry	27 000	30 000	18 000	14 000	13 000	14 000	14 000	15 000	16 000
Electronics	27	40	18						
Food Preparation	1 200	1 400	1 500	990	1 000	1 000	980	1 200	1 200
Glass Manufacture	490	570	690	240	260	260	280	300	280
Grain Industries	1 900	2 700	610	390	390	370	390	370	390
Metal Fabrication	8 800	8 700	7 700	2 800	3 200	2 500	1 900	1 200	1 100
Plastics Manufacture	220	350	250	8.5	12	0.42	10	9.3	10
Pulp and Paper Industry	180 000	150 000	93 000	77 000	48 000	57 000	64 000	68 000	72 000
Textiles	45	78	53	0.027	0.023	0.057	0.063	0.069	0.071
Vehicle Manufacture (Engines, Parts, Assembly, Painting)	3 800	4 000	3 000	2 300	1 400	910	930	770	940
Wood Products	1 100 000	800 000	390 000	73 000	110 000	100 000	73 000	48 000	40 000
Other Manufacturing Industries	31 000	61 000	11 000	710	620	610	580	580	630
TRANSPORTATION AND MOBILE EQUIPMENT	**8 200 000**	**7 400 000**	**5 200 000**	**3 700 000**	**3 500 000**	**3 400 000**	**3 300 000**	**3 200 000**	**3 100 000**
Air Transportation	60 000	47 000	43 000	41 000	51 000	49 000	46 000	49 000	50 000
Heavy-duty Diesel Vehicles	34 000	63 000	92 000	83 000	78 000	76 000	71 000	65 000	63 000
Heavy-duty Gasoline Vehicles	570 000	1 100 000	830 000	510 000	500 000	490 000	400 000	370 000	400 000
Heavy-duty LPG/NG Vehicles	130 000	310 000	67 000	4 600	2 500	1 300	630	640	860
Light-duty Diesel Trucks	13 000	14 000	18 000	13 000	11 000	11 000	13 000	15 000	17 000
Light-duty Diesel Vehicles	29 000	18 000	9 300	9 000	8 600	8 800	8 800	9 300	8 600
Light-duty Gasoline Trucks	1 500 000	1 600 000	1 000 000	740 000	700 000	690 000	670 000	680 000	720 000
Light-duty Gasoline Vehicles	2 800 000	1 700 000	940 000	610 000	570 000	550 000	520 000	510 000	510 000
Light-duty LPG/NG Trucks	14 000	6 000	2 300	49	24	10	7.8	7.4	9.3
Light-duty LPG/NG Vehicles	140 000	54 000	24 000	1 100	700	370	270	250	270
Marine Transportation	13 000	17 000	19 000	20 000	20 000	21 000	22 000	21 000	21 000
Motorcycles	12 000	14 000	15 000	14 000	13 000	13 000	12 000	13 000	13 000
Off-road Diesel Vehicles and Equipment	220 000	240 000	170 000	130 000	110 000	100 000	93 000	88 000	67 000
Off-road Gasoline/LPG/CNG Vehicles and Equipment	2 600 000	2 300 000	1 900 000	1 500 000	1 400 000	1 400 000	1 400 000	1 400 000	1 200 000
Rail Transportation	16 000	15 000	15 000	18 000	18 000	17 000	18 000	17 000	16 000
Tire Wear and Brake Lining									
AGRICULTURE	**630**	**690**	**520**	**880**	**920**	**930**	**950**	**910**	**910**
Animal Production									
Crop Production									
Fuel Use	630	690	520	880	920	930	950	910	910
COMMERCIAL / RESIDENTIAL / INSTITUTIONAL	**1 700 000**	**1 500 000**	**1 200 000**	**1 200 000**	**1 300 000**	**1 200 000**	**1 200 000**	**1 200 000**	**1 200 000**
Cigarette Smoking	3 800	3 300	2 500	2 300	2 300	1 900	2 000	1 700	1 800
Commercial and Institutional Fuel Combustion	15 000	19 000	19 000	19 000	17 000	18 000	20 000	19 000	19 000
Commercial Cooking	5 700	6 400	7 100	6 900	7 000	6 900	6 700	6 300	6 300
Construction Fuel Combustion	670	360	520	560	600	540	520	520	540
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	13 000	12 000	13 000	13 000	13 000	11 000
Service Stations									
Other Miscellaneous Sources									
INCINERATION AND WASTE	**46 000**	**27 000**	**25 000**	**19 000**	**18 000**	**19 000**	**19 000**	**19 000**	**19 000**
Crematoriums	7.4	11	13	15	16	17	18	18	18
Waste Incineration	42 000	24 000	22 000	16 000	15 000	15 000	15 000	16 000	16 000
Waste Treatment and Disposal	3 500	3 100	2 900	2 900	3 000	3 400	3 300	3 300	3 000
PAINTS AND SOLVENTS	**23**	**73**	**21**	**0.48**		**0.47**	**0.46**	**0.37**	**0.33**
Dry Cleaning	0.95	0.81							
General Solvent Use									
Printing	22	72	21	0.48		0.47	0.46	0.37	0.33
Surface Coatings	0.10	0.10							
DUST									
Coal Transportation									
Construction Operations									
Mine Tailings									
Paved Roads									
Unpaved Roads									
FIRES	**440 000**	**78 000**	**52 000**	**73 000**	**92 000**	**35 000**	**140 000**	**130 000**	**120 000**
Prescribed Forest Burning	440 000	76 000	51 000	71 000	90 000	33 000	140 000	130 000	120 000
Structural Fires	2 100	1 700	1 500	1 700	1 700	1 700	1 200	1 100	1 100
GRAND TOTAL	**12 000 000**	**11 000 000**	**8 100 000**	**6 300 000**	**6 100 000**	**6 000 000**	**5 900 000**	**5 800 000**	**5 800 000**

Note: Totals may not add up due to rounding.

2.6. **Ammonia (NH_3)**

In 2016, approximately 492 kt of NH_3 were released in Canada (Table 2–8). NH_3 emissions originated primarily from agriculture, which accounted for 94% (460 kt) of total emissions. All other sectors combined accounted for only 6% of emissions.

From 1990 to 2016, Canada's NH_3 emissions increased by 20% (82 kt) (Figure 2–6). This trend is driven by emissions from animal production and fertilizer application within the agriculture sector. 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 2016. Emissions from crop production, however, have been steadily increasing since 2006 due to an increase in sales and use of synthetic nitrogen fertilizers.

The most significant changes in NH_3 emissions from 1990 to 2016 include:

- Agriculture: increase of 24% (90 kt)
  - Crop production: increase of 97% (77 kt)
  - Animal production: increase of 5% (13 kt)
- Other emissions, dominated by manufacturing, incineration and waste, and transportation and mobile equipment sources: decrease of 31% (7.0 kt)

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

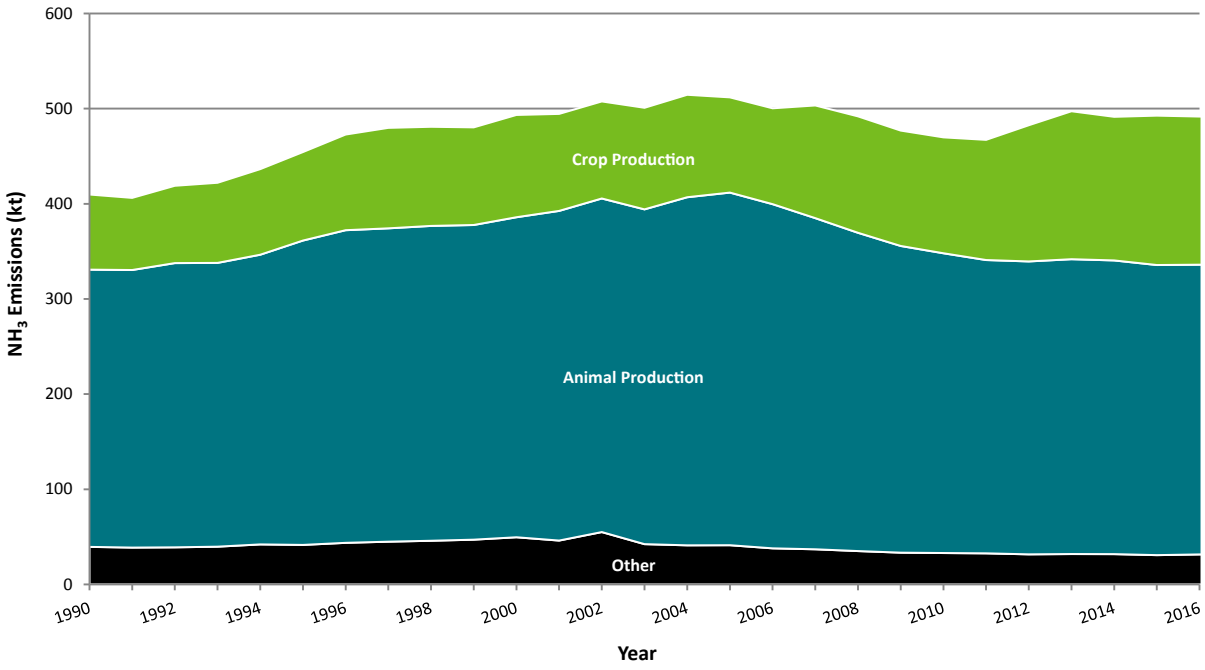

Table 2–8 National Summary of Annual NH_3 Emissions

Sector	1990	2000	2005	2011	2012	2013	2014	2015	2016
	(tonnes)								
ORE AND MINERAL INDUSTRIES	**1 800**	**2 100**	**1 100**	**1 600**	**1 100**	**1 400**	**1 300**	**1 200**	**1 200**
Aluminium Industry	29	34	13						
Asphalt Paving Industry	0.6	1.3	1.2						
Cement and Concrete Industry	600	630	380	320	330	430	440	480	360
Foundries	12	13	8.5						
Iron and Steel Industries	180	230	83	96	91	78	89	59	56
Iron Ore Industry	160	160	23						
Mineral Products Industry	83	110	94	290	230	420	440	340	410
Mining and Rock Quarrying	510	530	82	410	67	93	67	52	97
Non-Ferrous Mining and Smelting Industry	210	440	380	460	420	350	300	280	320
OIL AND GAS INDUSTRY	**650**	**1 800**	**3 700**	**2 000**	**2 200**	**2 600**	**2 700**	**2 200**	**2 400**
Downstream Oil and Gas Industry	360	250	110	73	75	180	78	68	55
Upstream Oil and Gas Industry	290	1 500	3 600	1 900	2 100	2 400	2 600	2 100	2 300
ELECTRIC POWER GENERATION (UTILITIES)	**740**	**1 400**	**970**	**760**	**340**	**780**	**760**	**380**	**350**
Coal	62	110	540	62	37	580	610	170	170
Diesel	3.7	6.0	2.8						
Natural Gas	270	680	180	590	200	110	95	130	100
Waste Materials	23	26						5.3	11
Other Electric Power Generation	380	620	250	99	95	82	62	70	62
MANUFACTURING	**20 000**	**23 000**	**17 000**	**12 000**	**12 000**	**11 000**	**11 000**	**12 000**	**12 000**
Abrasives Manufacture	0.76	0.76	0.12						
Bakeries	0.11	0.11						0.34	
Biofuel Production									
Chemicals Industry	9 800	14 000	11 000	9 100	9 100	8 500	8 500	8 800	9 200
Electronics	31	55	54	25	18	17	17	19	18
Food Preparation	180	310	290	230	380	410	380	360	340
Glass Manufacture	88	110	120						
Grain Industries	6.2	6.7	1.5	13	15	7.5	7.6	5.0	5.7
Metal Fabrication	93	200	40	18	2.8	2.1	2.4	25	25
Plastics Manufacture	31	32	4.9						
Pulp and Paper Industry	4 400	3 200	2 300	1 700	1 700	1 700	1 600	1 600	1 700
Textiles	13	28	16						
Vehicle Manufacture (Engines, Parts, Assembly, Painting)	73	160	47	15	0.11	0.77		2.3	2.2
Wood Products	4 800	4 800	2 700	690	730	750	800	820	830
Other Manufacturing Industries	500	360	170	9.2	25	21	22	32	30
TRANSPORTATION AND MOBILE EQUIPMENT	**5 400**	**11 000**	**11 000**	**8 800**	**8 300**	**8 300**	**7 800**	**7 700**	**7 800**
Air Transportation	29	35	37	32	37	38	37	38	39
Heavy-duty Diesel Vehicles	210	390	560	740	750	770	770	750	730
Heavy-duty Gasoline Vehicles	160	240	270	300	320	340	310	300	320
Heavy-duty LPG/NG Vehicles	55	170	21	2.6	2.5	1.2	0.88	1.1	1.3
Light-duty Diesel Trucks	2.4	4.4	4.3	6.4	6.6	7.9	10	13	15
Light-duty Diesel Vehicles	10	11	11	15	15	17	17	18	17
Light-duty Gasoline Trucks	1 100	3 600	3 700	3 100	3 000	3 000	2 900	2 900	3 100
Light-duty Gasoline Vehicles	3 200	6 200	5 600	3 900	3 600	3 500	3 100	3 000	3 000
Light-duty LPG/NG Trucks	14	21	14	0.29	0.14	0.059	0.046	0.041	0.051
Light-duty LPG/NG Vehicles	77	110	83	4.0	2.5	1.3	0.97	0.86	0.95
Marine Transportation	160	220	250	260	270	280	290	290	300
Motorcycles	4.3	6.9	12	30	32	34	34	37	39
Off-road Diesel Vehicles and Equipment	170	210	190	200	180	190	190	200	170
Off-road Gasoline/LPG/CNG Vehicles and Equipment	200	150	100	100	95	96	100	100	100
Rail Transportation	51	48	48	56	57	55	56	53	49
Tire Wear and Brake Lining									
AGRICULTURE	**370 000**	**440 000**	**470 000**	**430 000**	**450 000**	**470 000**	**460 000**	**460 000**	**460 000**
Animal Production	290 000	340 000	370 000	310 000	310 000	310 000	310 000	300 000	300 000
Crop Production	79 000	110 000	100 000	130 000	140 000	160 000	150 000	160 000	160 000
Fuel Use	44	41	28	52	47	47	52	45	45
COMMERCIAL / RESIDENTIAL / INSTITUTIONAL	**3 900**	**3 600**	**3 300**	**3 200**	**3 200**	**3 100**	**3 100**	**3 100**	**3 000**
Cigarette Smoking	110	110	88	88	83	76	77	69	70
Commercial and Institutional Fuel Combustion	310	340	320	220	200	200	220	210	190
Commercial Cooking									
Construction Fuel Combustion	70	38	55	57	59	52	52	52	52
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	600	610	620	620	630
Marine Cargo Handling	0.0010								
Residential Fuel Combustion	690	560	530	460	400	380	380	360	330
Service Stations									
Other Miscellaneous Sources									
INCINERATION AND WASTE	**5 800**	**5 800**	**4 300**	**4 400**	**4 300**	**4 400**	**4 500**	**4 300**	**4 500**
Crematoriums									
Waste Incineration	210	210	340	230	220	220	220	230	230
Waste Treatment and Disposal	5 600	5 600	3 900	4 200	4 100	4 200	4 200	4 100	4 300
PAINTS AND SOLVENTS	**14**	**14**	**0.88**						
Dry Cleaning	0.046	0.046							
General Solvent Use									
Printing	14	14	0.88						
Surface Coatings	0.080	0.080							
DUST									
Coal Transportation									
Construction Operations									
Mine Tailings									
Paved Roads									
Unpaved Roads									
FIRES	**1 100**	**130**	**100**	**130**	**210**	**68**	**240**	**180**	**160**
Prescribed Forest Burning	1 100	110	88	110	190	51	230	170	140
Structural Fires	22	17	16	18	18	18	12	12	23
GRAND TOTAL	**410 000**	**490 000**	**510 000**	**470 000**	**480 000**	**500 000**	**490 000**	**490 000**	**490 000**

Note: Totals may not add up due to rounding.

2.7. **Lead (Pb)**

In 2016, approximately 170 tonnes (t) of Pb were emitted in Canada (Table 2–9). Ore and mineral industries were the largest contributor at 73% (123 t) of emissions, with the non-ferrous smelting and refining industry accounting for the largest share at 66% (112 t) of total Pb emissions. Transportation and mobile equipment is the second largest contributor at 20% (33 t) of total emissions (almost all of which is from air transportation).

Lead emissions decreased by 87% (1.1 kt) from 1990 to 2016 (Figure 2–7). This decreasing trend coincides with the closure of outdated smelters and that the remaining facilities have prepared and are implementing pollution prevention plans as a result of the publication in 2006 by the Department of a Notice requiring the preparation and implementation of pollution prevention plans. Under this notice, 2008 and 2015 site-specific emission target limits are identified as factors to consider for particulate matter emissions containing metals, including lead. (ECCC 2017). 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 2016 include:

- Ore and mineral industries: decrease of 89% (1.0 kt)
  - Non-ferrous smelting and refining industry: decrease of 87% (775 t)
  - Mining and rock quarrying: decrease of 100% (198 t)
- Transportation and mobile equipment: decrease of 58% (46 t)
  - Air transportation: decrease of 59% (46 t)

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

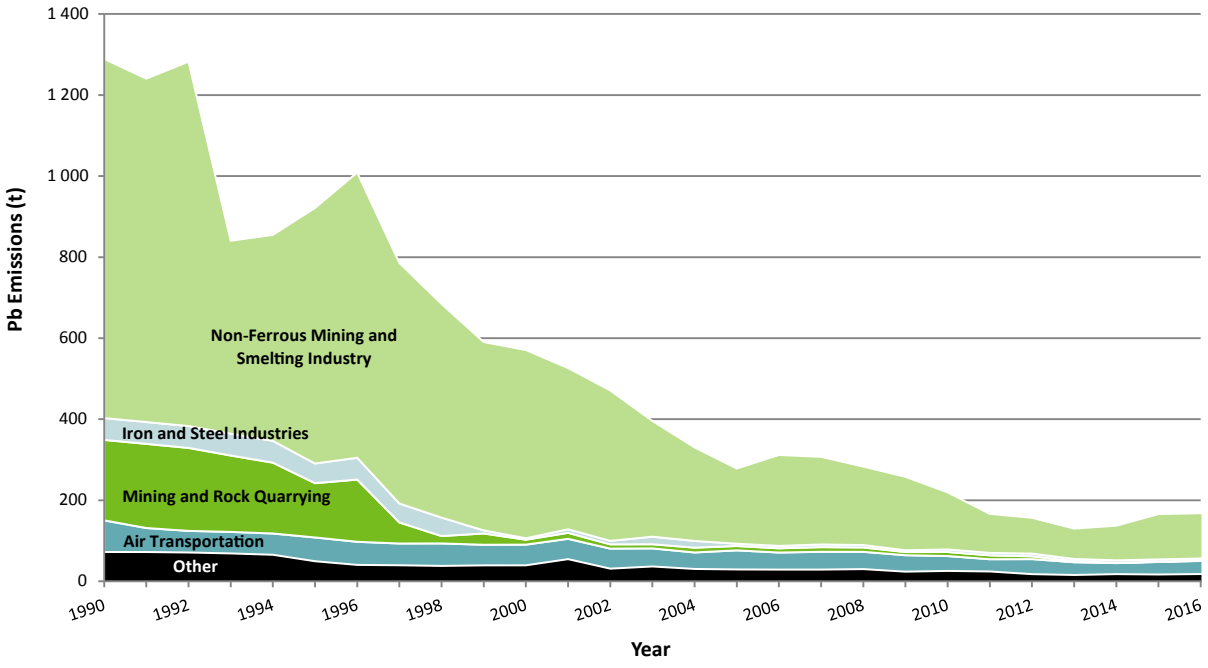

Table 2–9 National Summary of Annual Pb Emissions

Sector	1990	2000	2005	2011	2012	2013	2014	2015	2016
	(kg)								
ORE AND MINERAL INDUSTRIES	**1 100 000**	**480 000**	**210 000**	**120 000**	**110 000**	**87 000**	**97 000**	**120 000**	**120 000**
Aluminium Industry	84	84							
Asphalt Paving Industry	1 400	1 200	1 200	1 300	990	980	1 000	1 100	1 100
Cement and Concrete Industry	550	610	980	630	620	530	600	870	700
Foundries	2 000	2 900	1 500	440	430	200	180	210	200
Iron and Steel Industries	54 000	3 500	5 700	6 100	6 700	5 200	6 100	5 500	5 200
Iron Ore Industry				1 800	1 900	2 100	2 700	2 600	3 300
Mineral Products Industry									15
Mining and Rock Quarrying	200 000	12 000	11 000	9 600	6 900	3 000	730	780	940
Non-Ferrous Mining and Smelting Industry	890 000	460 000	190 000	96 000	88 000	75 000	85 000	110 000	110 000
OIL AND GAS INDUSTRY	**340**	**300**	**720**	**930**	**990**	**1 100**	**670**	**510**	**580**
Downstream Oil and Gas Industry	200	81	450	320	320	380	300	320	380
Upstream Oil and Gas Industry	140	220	260	610	660	700	370	190	200
ELECTRIC POWER GENERATION (UTILITIES)	**11 000**	**14 000**	**1 600**	**2 800**	**2 600**	**1 400**	**1 800**	**1 400**	**1 400**
Coal	8 300	10 000	890	2 200	2 100	860	1 200	820	770
Diesel									
Natural Gas	430	530	72	160	89	85	93	97	86
Waste Materials			7.0	5.1	1.6	0.27	0.38	2.9	2.8
Other Electric Power Generation	2 600	3 200	590	450	320	430	490	530	560
MANUFACTURING	**49 000**	**14 000**	**17 000**	**11 000**	**4 700**	**4 600**	**6 400**	**5 800**	**6 500**
Abrasives Manufacture									
Bakeries									
Biofuel Production									
Chemicals Industry	12 000	290	1 800	74	72	64	29	27	26
Electronics	2 000	680	57	4.9	4.5	4.3	4.1	2.6	2.9
Food Preparation									
Glass Manufacture	22	7.4	25	0.45	0.34	0.3	0.0030	0.0020	0.0016
Grain Industries									
Metal Fabrication	28 000	7 800	10 000	8 800	2 300	2 200	3 600	1 900	3 300
Plastics Manufacture	76	26	24	35	23	0.034	4.7	4.8	4.8
Pulp and Paper Industry	2 100	710	2 400	1 500	1 300	1 400	2 200	3 400	2 800
Textiles		0.38			0.0030				
Vehicle Manufacture (Engines, Parts, Assembly, Painting)	960	1 900	770	95	61	65	68	68	66
Wood Products	3 500	2 600	1 400	480	860	830	530	340	340
Other Manufacturing Industries	840	290	96	24	15	33	32	25	39
TRANSPORTATION AND MOBILE EQUIPMENT	**79 000**	**52 000**	**48 000**	**31 000**	**38 000**	**32 000**	**28 000**	**31 000**	**33 000**
Air Transportation	78 000	51 000	47 000	30 000	37 000	31 000	27 000	31 000	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	560	490	420	340	280	280
Motorcycles									
Off-road Diesel Vehicles and Equipment									
Off-road Gasoline/LPG/CNG Vehicles and Equipment									
Rail Transportation	310	290	290	250	250	240	250	240	220
Tire Wear and Brake Lining									
AGRICULTURE	**30**	**30**	**26**	**64**	**59**	**61**	**69**	**55**	**53**
Animal Production									
Crop Production									
Fuel Use	30	30	26	64	59	61	69	55	53
COMMERCIAL / RESIDENTIAL / INSTITUTIONAL	**6 300**	**4 800**	**4 600**	**3 900**	**4 000**	**3 500**	**3 200**	**3 200**	**3 200**
Cigarette Smoking	2.3	1.9	1.5	1.4	1.3	1.1	1.2	1.0	1.0
Commercial and Institutional Fuel Combustion	250	290	420	920	1 000	510	230	250	240
Commercial Cooking									
Construction Fuel Combustion	10	4.9	11	9.0	8.5	7.5	7.3	7.7	6.7
Home Firewood Burning	3 500	3 200	2 600	2 700	2 700	2 700	2 600	2 600	2 600
Human									
Marine Cargo Handling	2 000	970	1 200	9.1	2.9	59	20	9.8	41
Residential Fuel Combustion	490	410	390	350	310	290	300	280	250
Service Stations									
Other Miscellaneous Sources									
INCINERATION AND WASTE	**200**	**110**	**620**	**530**	**710**	**540**	**550**	**560**	**510**
Crematoriums	2.0	2.8	3.6	4.6	4.7	5.0	5.2	5.5	5.4
Waste Incineration	200	110	500	470	470	470	480	470	470
Waste Treatment and Disposal			120	56	240	66	69	88	44
PAINTS AND SOLVENTS	**4.3**	**6.3**				**0.06**	**0.0023**		
Dry Cleaning									
General Solvent Use									
Printing	4.3	6.3							
Surface Coatings						0.06	0.0023		
DUST									
Coal Transportation									
Construction Operations									
Mine Tailings									
Paved Roads									
Unpaved Roads									
FIRES									
Prescribed Forest Burning									
Structural Fires									
GRAND TOTAL	**1 300 000**	**570 000**	**280 000**	**170 000**	**160 000**	**130 000**	**140 000**	**170 000**	**170 000**

Note: Totals may not add up due to rounding.

2.8. **Cadmium (Cd)**

Approximately 7.8t of Cd were emitted in Canada in 2016 (Table 2–10). Ore and mineral industries accounted for 70% (5.5 t) of national emissions, including the non-ferrous smelting and refining industry at 66% (5.1 t) of the total emissions. Commercial/ residential/ institutional sources contributed 14% (1.1 t) of the total Cd emissions.

From 1990 to 2016, national Cd emissions decreased by 91% (83 t) (Figure 2–8). This trend is almost entirely driven by the non-ferrous mining and smelting industry. Emissions in this sector fluctuated greatly between 1990 and 2006, but decreased steadily from 2007 to 2014, followed by a small increase by 0.5 t by 2016. As with lead emissions, reductions in cadmium emissions from this sector coincide with the closure of outdated smelters and the publication by the Department of a Notice requiring the preparation and implementation of pollution prevention plans (ECCC 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 2016 include:

- Ore and mineral industries: decrease of 93% (75 t)
  - Non-ferrous mining and smelting industry: decrease of 93% (73 t)

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

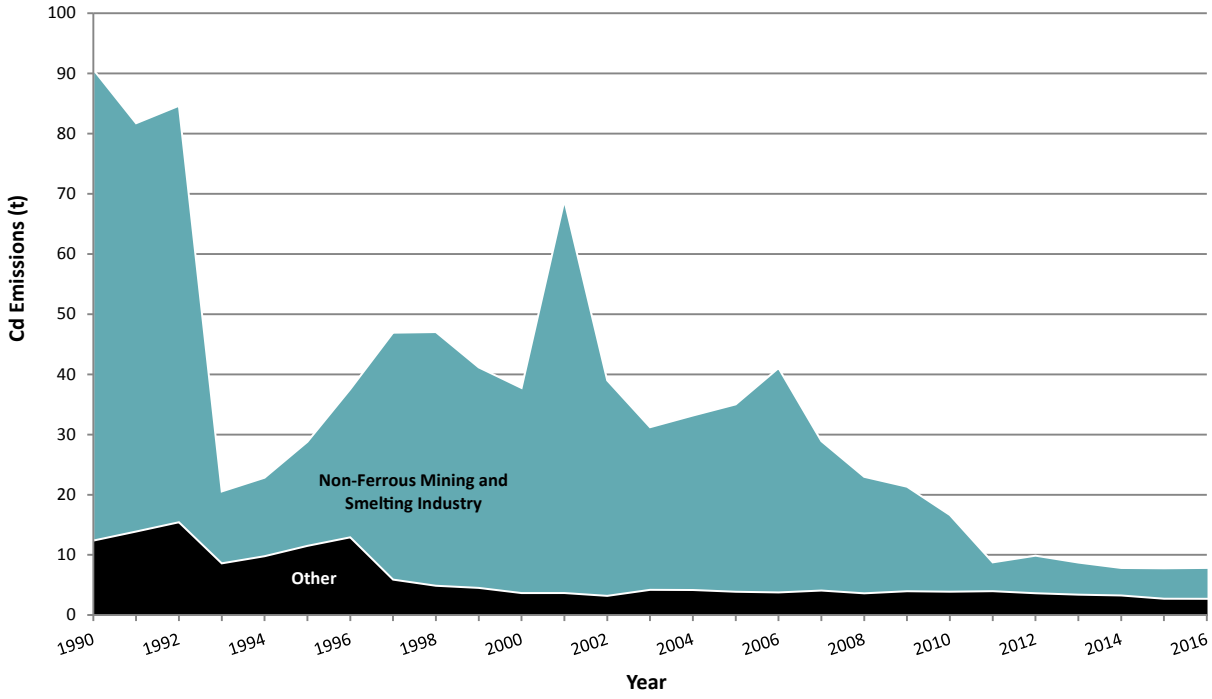

Table 2–10 National Summary of Annual Cd Emissions

Sector	1990	2000	2005	2011	2012	2013	2014	2015	2016
	(kg)								
ORE AND MINERAL INDUSTRIES	**81 000**	**35 000**	**32 000**	**5 400**	**6 900**	**6 000**	**5 400**	**5 400**	**5 500**
Aluminium Industry	0.67	0.98							
Asphalt Paving Industry	26	24	25	26	21	21	22	22	22
Cement and Concrete Industry	46	46	45	30	28	16	13	14	12
Foundries	1.8	1.3	26	8.0	1.9	1.7	62	21	0.75
Iron and Steel Industries	150	160	310	240	250	230	300	220	210
Iron Ore Industry				50	58	69	88	83	82
Mineral Products Industry									
Mining and Rock Quarrying	2 200	280	360	290	300	290	320	19	16
Non-Ferrous Mining and Smelting Industry	78 000	34 000	31 000	4 800	6 200	5 300	4 600	5 100	5 100
OIL AND GAS INDUSTRY	**130**	**190**	**190**	**260**	**270**	**240**	**210**	**220**	**220**
Downstream Oil and Gas Industry	110	150	130	120	120	100	110	94	95
Upstream Oil and Gas Industry	25	38	60	140	150	140	110	130	120
ELECTRIC POWER GENERATION (UTILITIES)	**130**	**130**	**250**	**750**	**430**	**360**	**160**	**140**	**160**
Coal	87	91	170	520	360	300	93	42	100
Diesel									
Natural Gas	29	30	56	190	50	47	43	52	35
Waste Materials			1.0	1.1	0.36	0.27	0.09	0.81	0.72
Other Electric Power Generation	14	14	28	40	20	20	27	44	23
MANUFACTURING	**1 200**	**1 000**	**940**	**680**	**680**	**650**	**600**	**580**	**610**
Abrasives Manufacture									
Bakeries									
Biofuel Production									
Chemicals Industry	140	130	71	6.4	5.8	6.4	6.1	7.9	8.1
Electronics									
Food Preparation									
Glass Manufacture	1.3	1.4	2.6	0.47					
Grain Industries									
Metal Fabrication	470	420	290	390	380	340	330	320	310
Plastics Manufacture	5.2	5.7	3.0	1.4	0.55	0.18			
Pulp and Paper Industry	370	150	320	220	210	220	200	200	210
Textiles									
Vehicle Manufacture (Engines, Parts, Assembly, Painting)	1.5	88	1.0						
Wood Products	130	130	110	59	80	83	58	54	71
Other Manufacturing Industries	76	83	140	0.089	0.076	0.19	0.68	0.063	0.06
TRANSPORTATION AND MOBILE EQUIPMENT	**300**	**370**	**410**	**340**	**300**	**250**	**220**	**170**	**170**
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	250	210	170	130	95	98
Motorcycles									
Off-road Diesel Vehicles and Equipment									
Off-road Gasoline/LPG/CNG Vehicles and Equipment									
Rail Transportation	100	98	95	83	84	81	83	79	73
Tire Wear and Brake Lining									
AGRICULTURE	**51**	**54**	**64**	**86**	**93**	**87**	**85**	**83**	**89**
Animal Production									
Crop Production									
Fuel Use	51	54	64	86	93	87	85	83	89
COMMERCIAL / RESIDENTIAL / INSTITUTIONAL	**1 100**	**1 200**	**1 200**	**1 200**	**1 200**	**1 100**	**1 100**	**1 100**	**1 100**
Cigarette Smoking	6.0	5.1	3.9	3.6	3.5	3.0	3.0	2.7	2.7
Commercial and Institutional Fuel Combustion	340	510	480	490	500	470	480	470	480
Commercial Cooking									
Construction Fuel Combustion	11	7.0	10	9.1	9.1	8.9	8.9	8.9	9.1
Home Firewood Burning	200	180	150	160	160	160	160	150	150
Human									
Marine Cargo Handling			47	0.41	0.077	2.3	1.2	0.5	2.2
Residential Fuel Combustion	540	500	500	520	490	480	490	460	440
Service Stations									
Other Miscellaneous Sources									
INCINERATION AND WASTE	**7 000**	**200**	**64**	**50**	**44**	**53**	**50**	**49**	**39**
Crematoriums	0.34	0.48	0.61	0.77	0.79	0.83	0.87	0.93	0.91
Waste Incineration	7 000	200	44	34	31	31	31	31	31
Waste Treatment and Disposal			19	16	12	22	18	18	7.1
PAINTS AND SOLVENTS	**1.0**	**1.0**			**0.12**	**0.12**	**0.12**	**0.14**	**0.10**
Dry Cleaning									
General Solvent Use									
Printing	1.0	1.0							
Surface Coatings					0.12	0.12	0.12	0.14	0.10
DUST									
Coal Transportation									
Construction Operations									
Mine Tailings									
Paved Roads									
Unpaved Roads									
FIRES									
Prescribed Forest Burning									
Structural Fires									
GRAND TOTAL	**91 000**	**38 000**	**35 000**	**8 800**	**9 900**	**8 700**	**7 800**	**7 800**	**7 800**

Note: Totals may not add up due to rounding.

2.9. **Mercury (Hg)**

Approximately 4.3 t of Hg were emitted in Canada in 2016 (Table 2–11). Ore and mineral industries accounted for 33% (1.4 t) of Hg in 2016, with iron and steel industries contributing 17% (0.71 t) of the annual total. Incineration and waste sources also accounted for 31% (1.3 t) of Hg in 2016, with the waste sector being the largest contributor at 13% (0.57 t). Electric power generation (utilities) sources accounted for 17% (0.71 t) of 2016 emissions, most of which were emitted from coal-powered electric generation (16% of annual total, 0.68 t).

Between 1990 and 2016, Hg emissions decreased by 88% (31 t) (Figure 2–9). This decrease in emissions is mainly due to a large drop in emissions from the non-ferrous smelting and mining industry. Reductions in this sector coincide with facilities changing from pyrometallurgical to hydrometallurgical zinc production. As with lead and cadmium emissions, reductions in mercury emissions from this sector coincide with the closure of outdated smelters and the publication of a Notice requiring the preparation and implementation of pollution prevention plans and, to a smaller extent, to increased emission control measures, such as separation or changing of production materials, improved particulate matter emission controls and fuel switching (ECCC 2017).

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. The Canadian Council of Ministers of the Environment (CCME) also developed several Canada-wide standards aimed at reducing the amount of Hg released into waste streams and to the environment, including standards for mercury-containing lamps, dental amalgam waste, as well as mercury emissions from coal-fired electric power generation plants.

The most significant changes in Hg emissions from 1990 to 2016 include:

- Ore and mineral industry source emissions: decrease of 95% (25 kt)
  - Non-ferrous smelting and mining industry: decrease of 99% (25 kt)
- Incineration and waste source emissions: decrease of 64% (2.3 t)
  - Waste treatment and disposal: decrease of 76% (1.5 t)
- Electric power generation source emissions: decrease of 69% (1.6 t)
  - Coal (electric power generation): decrease of 65% (1.3 t)

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

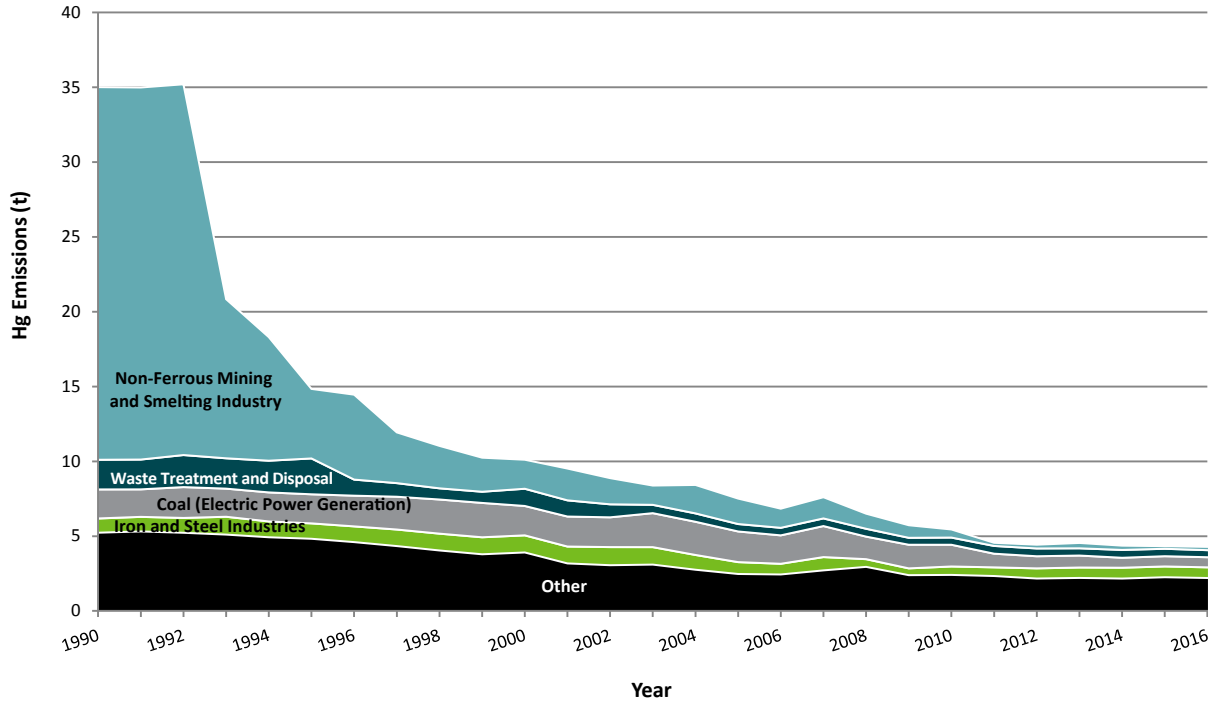

Table 2–11 National Summary of Annual Hg Emissions

Sector	1990	2000	2005	2011	2012	2013	2014	2015	2016
	(kg)								
ORE AND MINERAL INDUSTRIES	**27 000**	**3 700**	**2 900**	**1 200**	**1 400**	**1 500**	**1 400**	**1 400**	**1 400**
Aluminium Industry	18	31	43	19	15	21	19	21	21
Asphalt Paving Industry	24	22	22	27	21	20	22	23	23
Cement and Concrete Industry	460	390	210	300	300	310	300	380	340
Foundries	210	120	4.2						
Iron and Steel Industries	950	1 100	790	580	680	700	720	720	710
Iron Ore Industry	60	60	50	100	98	100	74	72	72
Mineral Products Industry									
Mining and Rock Quarrying	12	12	28	3.9	5.0	8.5	20	20	16
Non-Ferrous Mining and Smelting Industry	25 000	1 900	1 700	210	250	360	290	180	220
OIL AND GAS INDUSTRY	**120**	**61**	**83**	**100**	**100**	**120**	**89**	**74**	**81**
Downstream Oil and Gas Industry	110	26	46	46	45	48	46	49	53
Upstream Oil and Gas Industry	3.0	36	38	59	59	68	44	25	28
ELECTRIC POWER GENERATION (UTILITIES)	**2 300**	**2 100**	**2 200**	**1 000**	**860**	**850**	**710**	**740**	**720**
Coal	1 900	2 000	2 000	910	810	800	670	680	680
Diesel									
Natural Gas	12	22	27	56	23	23	19	26	11
Waste Materials	50	96	7.1	1.7	1.5	0.64	0.80	6.0	2.2
Other Electric Power Generation	290	62	91	46	23	23	28	26	30
MANUFACTURING	**1 100**	**1 400**	**300**	**110**	**140**	**130**	**120**	**130**	**140**
Abrasives Manufacture									
Bakeries									
Biofuel Production									
Chemicals Industry	170	82	58	16	23	17	18	15	17
Electronics	380	750	56	17	17	17	17	18	29
Food Preparation	0.14	0.14	0.3						
Glass Manufacture	28	28	21						
Grain Industries									
Metal Fabrication	16	17	17	11	11	7.5	<0.01	<0.01	0.0080
Plastics Manufacture	0.0050	0.0050							
Pulp and Paper Industry	98	130	59	42	53	50	60	70	71
Textiles									
Vehicle Manufacture (Engines, Parts, Assembly, Painting)	0.012	0.012	0.023						
Wood Products	260	190	90	21	31	31	18	18	18
Other Manufacturing Industries	150	180	4.0	3.8	3.4	3.4	3.4	3.4	3.4
TRANSPORTATION AND MOBILE EQUIPMENT	**110**	**100**	**100**	**89**	**89**	**85**	**86**	**81**	**75**
Air Transportation									
Heavy-duty Diesel Vehicles	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Heavy-duty Gasoline Vehicles	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Heavy-duty LPG/NG Vehicles	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Light-duty Diesel Trucks	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Light-duty Diesel Vehicles	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Light-duty Gasoline Trucks	<0.01	<0.01	<0.01	0.011	0.011	0.012	0.012	0.013	0.014
Light-duty Gasoline Vehicles	0.011	0.012	0.013	0.013	0.013	0.013	0.013	0.013	0.013
Light-duty LPG/NG Trucks	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Light-duty LPG/NG Vehicles	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Marine Transportation	4.3	6.2	7.2	5.7	4.8	3.9	3	2.1	2.2
Motorcycles	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Off-road Diesel Vehicles and Equipment									
Off-road Gasoline/LPG/CNG Vehicles and Equipment									
Rail Transportation	100	98	95	83	84	81	83	79	73
Tire Wear and Brake Lining									
AGRICULTURE	**2.8**	**3.4**	**3.2**	**7.4**	**7.5**	**7.8**	**8.3**	**7.3**	**7.0**
Animal Production									
Crop Production									
Fuel Use	2.8	3.4	3.2	7.4	7.5	7.8	8.3	7.3	7.0
COMMERCIAL / RESIDENTIAL / INSTITUTIONAL	**1 100**	**600**	**560**	**550**	**540**	**550**	**560**	**550**	**540**
Cigarette Smoking	0.21	0.18	0.14	0.13	0.13	0.11	0.11	0.097	0.098
Commercial and Institutional Fuel Combustion	47	62	63	58	57	58	62	57	57
Commercial Cooking									
Construction Fuel Combustion	2.6	1.7	2.6	2.2	2.2	2.2	2.1	2.2	2.2
Home Firewood Burning	54	48	40	41	41	41	40	40	40
Human	110	20	15	15	15	15	15	15	15
Marine Cargo Handling			2.8						
Residential Fuel Combustion	64	76	75	77	71	76	80	75	67
Service Stations									
Other Miscellaneous Sources	870	390	360	360	360	360	360	360	360
INCINERATION AND WASTE	**3 600**	**2 100**	**1 400**	**1 400**	**1 300**	**1 300**	**1 300**	**1 300**	**1 300**
Crematoriums	100	140	180	230	230	250	260	280	270
Waste Incineration	1 500	810	750	680	570	570	570	570	570
Waste Treatment and Disposal	2 000	1 200	500	520	520	480	520	500	470
PAINTS AND SOLVENTS									
Dry Cleaning									
General Solvent Use									
Printing									
Surface Coatings									
DUST									
Coal Transportation									
Construction Operations									
Mine Tailings									
Paved Roads									
Unpaved Roads									
FIRES									
Prescribed Forest Burning									
Structural Fires									
GRAND TOTAL	**35 000**	**10 000**	**7 500**	**4 600**	**4 400**	**4 500**	**4 400**	**4 300**	**4 300**

Note: Totals may not add up due to rounding.

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

In 2016, emissions of dioxins and furans (D/F) in Canada were approximately 57 grams of toxicity equivalent (gTEQ) (Table 2–12). Incineration and waste sources accounted for the largest share of these emissions (41% or 23 gTEQ), with the waste incineration sector accounting for 36% (20 gTEQ). Transportation and mobile equipment contributed 19% (11 gTEQ) of 2016 D/F emissions, most of which are attributed to marine transportation, with 17% (9.4 gTEQ). Commercial/residential/institutional sources were also significant contributors (14% and 8.0 gTEQ). Ore and mineral industries collectively accounted for 10% (5.7 gTEQ) of 2016 D/F emissions.

Between 1990 and 2016, D/F emissions decreased by 88% (399 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 2016 include:

- Incineration and waste source emissions: decrease of 93% (323 gTEQ)
    - Waste Incineration: decrease of 94% (325 gTEQ)

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

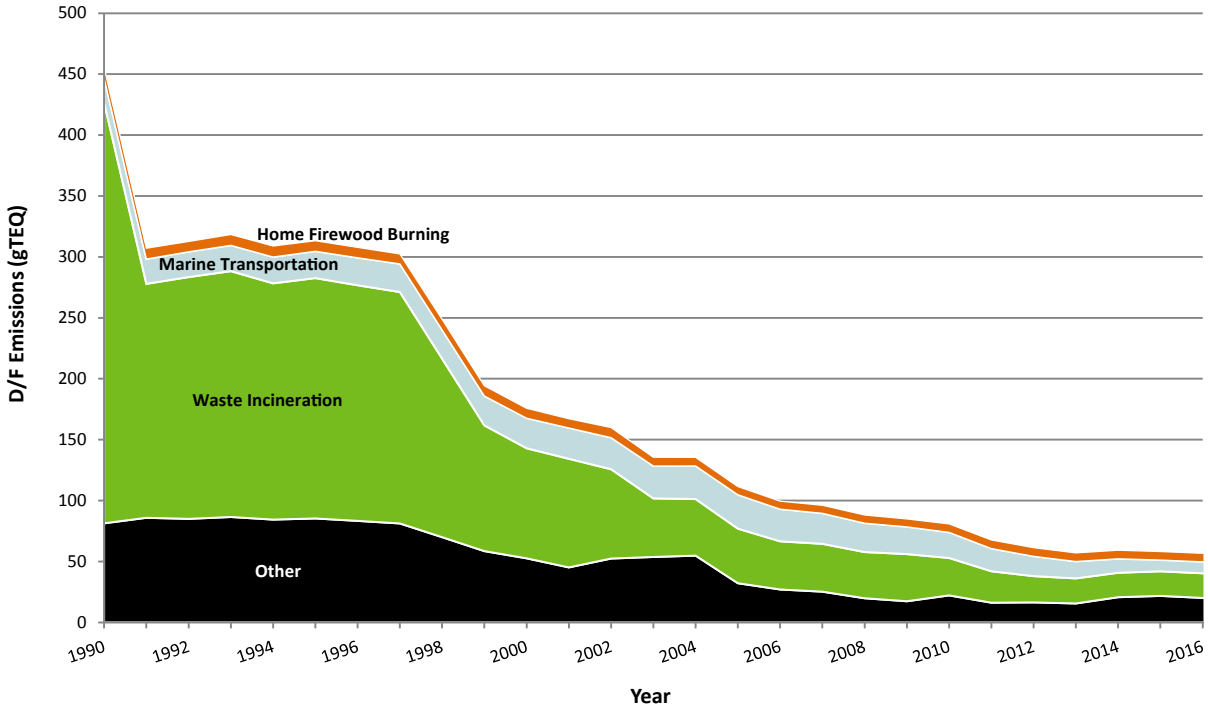

Table 2–12 National Summary of Annual Dioxins/Furans Emissions

Sector	1990	2000	2005	2011	2012	2013	2014	2015	2016
	(gTEQ)								
ORE AND MINERAL INDUSTRIES	**45**	**27**	**8.4**	**3.6**	**4.1**	**3.8**	**6.7**	**7.3**	**5.7**
Aluminium Industry	2.8	4.1		0.4					
Asphalt Paving Industry	0.019	0.021	0.013	0.0062	0.0048	0.0047	0.0048	0.0051	0.0051
Cement and Concrete Industry	3	1.8	2.7	0.4	0.65	0.54	1.9	1.6	0.61
Foundries				0.01	0.01	0.0001	0.043	0.034	0.036
Iron and Steel Industries	35	16	3	2.3	2.9	2.9	4.4	5.2	4.7
Iron Ore Industry							0.0007	0.0007	0.0003
Mineral Products Industry	0.81	1.2	0.81						
Mining and Rock Quarrying		0.14	0.58	0.056	0.044	0.032	0.046	0.058	0.026
Non-Ferrous Mining and Smelting Industry	3.4	3.5	1.3	0.47	0.48	0.37	0.28	0.41	0.41
OIL AND GAS INDUSTRY									
Downstream Oil and Gas Industry									
Upstream Oil and Gas Industry									
ELECTRIC POWER GENERATION (UTILITIES)	**3**	**5.2**	**3.4**	**1.7**	**1.6**	**1.7**	**2.1**	**1.9**	**2.9**
Coal	2.3	4	2	1.4	1.5	1.5	1.8	1.6	1.9
Diesel									
Natural Gas	0.46	0.8	1	0.0054	0.015	0.02	0.043	0.01	0.011
Waste Materials	0.0021	0.0023	<0.0001	0.016	0.01	0.0035	0.0099	0.018	0.16
Other Electric Power Generation	0.23	0.42	0.43	0.24	0.13	0.17	0.19	0.19	0.75
MANUFACTURING	**20**	**13**	**10**	**4**	**3.3**	**3.7**	**3.1**	**3**	**4.1**
Abrasives Manufacture									
Bakeries									
Biofuel Production									
Chemicals Industry	2.2	0.097	0.058	0.35	0.27	0.13	0.27	0.26	0.31
Electronics									
Food Preparation									
Glass Manufacture									
Grain Industries									
Metal Fabrication	4.1	4.3	4	1.3	1.4	1.1	0.91	0.87	0.93
Plastics Manufacture									
Pulp and Paper Industry	11	5.2	4.9	1.2	1	1.8	1.2	1.2	2.2
Textiles									
Vehicle Manufacture (Engines, Parts, Assembly, Painting)	0.3	1.3		0.082					
Wood Products	1.8	1.8	1.3	1.1	0.6	0.62	0.65	0.65	0.65
Other Manufacturing Industries			0.12						
TRANSPORTATION AND MOBILE EQUIPMENT	**21**	**26**	**29**	**20**	**18**	**15**	**13**	**11**	**11**
Air Transportation									
Heavy-duty Diesel Vehicles	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Heavy-duty Gasoline Vehicles	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Heavy-duty LPG/NG Vehicles	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Light-duty Diesel Trucks	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Light-duty Diesel Vehicles	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Light-duty Gasoline Trucks	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Light-duty Gasoline Vehicles	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Light-duty LPG/NG Trucks	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Light-duty LPG/NG Vehicles	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Marine Transportation	20	25	28	19	16	14	11	9.2	9.4
Motorcycles	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Off-road Diesel Vehicles and Equipment									
Off-road Gasoline/LPG/CNG Vehicles and Equipment									
Rail Transportation	1.2	1.2	1.2	1.4	1.4	1.3	1.4	1.3	1.2
Tire Wear and Brake Lining									
AGRICULTURE	**0.058**	**0.054**	**0.044**	**0.075**	**0.07**	**0.068**	**0.074**	**0.064**	**0.066**
Animal Production									
Crop Production									
Fuel Use	0.058	0.054	0.044	0.075	0.07	0.068	0.074	0.064	0.066
COMMERCIAL / RESIDENTIAL / INSTITUTIONAL	**13**	**12**	**10**	**8.5**	**8.7**	**8.6**	**8.7**	**8.8**	**8**
Cigarette Smoking	0.019	0.016	0.012	0.011	0.011	0.0095	0.0096	0.0085	0.0086
Commercial and Institutional Fuel Combustion	0.37	0.37	0.33	0.48	0.76	0.74	1	1.3	0.5
Commercial Cooking									
Construction Fuel Combustion	0.068	0.029	0.046	0.052	0.055	0.044	0.043	0.044	0.04
Home Firewood Burning	9	8.2	6.7	7.1	7.2	7.1	7.1	7	7
Human									
Marine Cargo Handling									
Residential Fuel Combustion	1.5	1.2	1.1	0.84	0.72	0.64	0.58	0.44	0.38
Service Stations									
Other Miscellaneous Sources	2	2	2						
INCINERATION AND WASTE	**350**	**92**	**49**	**28**	**24**	**23**	**23**	**24**	**23**
Crematoriums	1.1	1.6	2	2.6	2.7	2.8	2.9	3.1	3.1
Waste Incineration	350	90	45	26	22	21	20	20	20
Waste Treatment and Disposal	0.013	0.014	2.2	0.021	0.12	0.013	0.023	1	0.16
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**	**1.4**	**1.6**	**0.68**	**2.8**	**2.2**	**1.8**
Prescribed Forest Burning									
Structural Fires	7.6	1.5	0.92	1.4	1.6	0.68	2.8	2.2	1.8
GRAND TOTAL	**460**	**180**	**110**	**68**	**61**	**57**	**59**	**58**	**57**

Note: Totals may not add up 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 2016, 106 t of PAHs were emitted in Canada (Table 2–13), with 96% (102 t) attributed to commercial/residential/institutional sources. This is almost entirely due to home firewood burning, which contributed 96% (102 t) of total PAH emissions. Fires contributed almost all the remaining 2% (2.4 t) of PAH emissions in 2016.

From 1990 to 2016, emissions of PAHs decreased by 68% (230 t) (Figure 2–11). This trend is primarily due to emission reductions in the aluminium industry and iron and steel industries. The aluminium industry experienced a large drop in PAH emissions from 2001 to 2010 due to process improvements and the progressive closure of old Söderberg aluminium production technology (ECCC 2014). It experienced additional decreases between 2014 and 2016, related to the replacement of old smelting equipment with a modern smelter at the facility which historically contributed the largest share of PAH emissions.

PAH emissions from iron and steel industries experienced a large drop earlier in the time series, from 1993 to 2006, and remained quite small and constant from 2006 to 2016. Reductions in this sector are a result of effective emission controls on coke ovens and electric arc furnaces.

Home firewood burning dominates PAH emissions throughout the time series. However, this source experienced a more modest 25% (34 t) emission decrease from 1990 to 2016. 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 limit the emission of both wood smoke and, as a result, PAHs by improving combustion efficiency.

The most significant changes in PAH emissions from 1990 to 2016 include:

- Ore and mineral industries source emissions: decrease of almost 100% (188 t)
  - Aluminium industry: decrease of almost 100% (109 t)
  - Iron and steel industries: decrease of 99% (79 t)
- Commercial/residential/institutional emissions: decrease of 25% (34 t)
  - Home firewood burning: decrease of 25% (34 t)

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

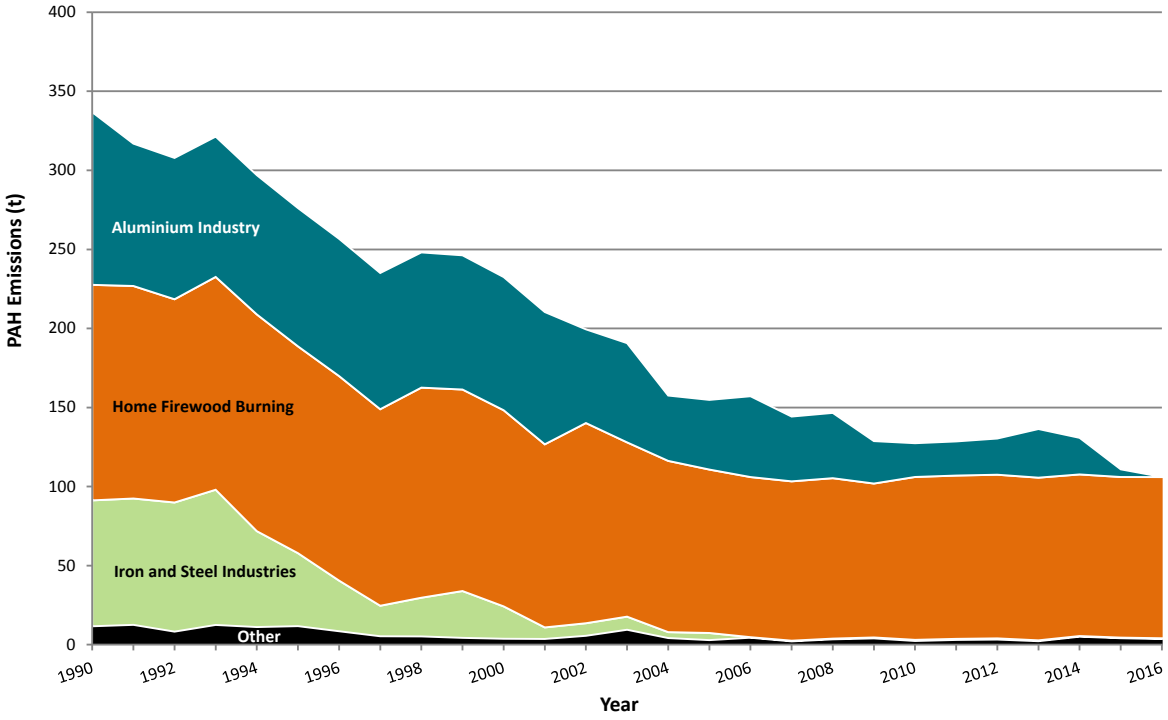

Table 2–13 National Summary of Annual PAH Emissions

Sector	1990	2000	2005	2011	2012	2013	2014	2015	2016
	(kg)								
ORE AND MINERAL INDUSTRIES	**190 000**	**100 000**	**49 000**	**22 000**	**24 000**	**32 000**	**24 000**	**5 400**	**690**
Aluminium Industry	110 000	84 000	44 000	22 000	23 000	31 000	23 000	4 900	100
Asphalt Paving Industry	14	14	15	15	12	12	13	13	13
Cement and Concrete Industry	17	13	19	0.77	1.6	1.7	3.1	2.8	0.23
Foundries									
Iron and Steel Industries	80 000	20 000	4 500	680	740	550	400	400	440
Iron Ore Industry				18	19	18	19	20	20
Mineral Products Industry									
Mining and Rock Quarrying	0.3	0.5		0.3	0.25	160	250	110	110
Non-Ferrous Mining and Smelting Industry	1.9	2.8	0.36	0.33	0.27	0.31	0.31	0.32	0.3
OIL AND GAS INDUSTRY	**150**	**100**	**45**	**24**	**28**	**27**	**25**	**24**	**20**
Downstream Oil and Gas Industry	150	100	42	16	19	18	16	19	14
Upstream Oil and Gas Industry	2.3	3.4	3	8.4	8.2	9	9.8	4.8	5.8
ELECTRIC POWER GENERATION (UTILITIES)	**370**	**340**	**240**	**14**	**7.8**	**6.7**	**6.4**	**6.1**	**6.8**
Coal	240	230	240						
Diesel									
Natural Gas	2.9	2.3	0.22	0.93	0.069	0.032	0.033	0.044	0.045
Waste Materials									
Other Electric Power Generation	130	110		13	7.7	6.7	6.4	6	6.8
MANUFACTURING	**320**	**300**	**300**	**100**	**170**	**130**	**170**	**110**	**98**
Abrasives Manufacture									
Bakeries									
Biofuel Production									
Chemicals Industry	0.6	20	29	28	28	25	24	25	25
Electronics									
Food Preparation									
Glass Manufacture	<0.01	<0.01	1						
Grain Industries									
Metal Fabrication	1.1	1.1	7	4.6	4.1	4.1			
Plastics Manufacture									
Pulp and Paper Industry	110	130	190	59	120	91	130	73	64
Textiles									
Vehicle Manufacture (Engines, Parts, Assembly, Painting)	0.02	0.23			0.015	0.024	0.026	0.021	0.014
Wood Products	210	150	72	13	12	11	9.7	9.7	9.7
Other Manufacturing Industries			2.2						
TRANSPORTATION AND MOBILE EQUIPMENT	**220**	**240**	**250**	**180**	**170**	**150**	**140**	**100**	**120**
Air Transportation	13	11	7.7	6.8	8.3	8.6	8.6	9.2	9.6
Heavy-duty Diesel Vehicles	0.91	0.99	1.2	0.91	0.82	0.77	0.72	0.63	0.62
Heavy-duty Gasoline Vehicles	5.9	4.2	4.2	2.3	2.3	2.3	1.8	1.8	1.8
Heavy-duty LPG/NG Vehicles	1.1	1.3	0.33	0.016	<0.01	<0.01	<0.01	<0.01	<0.01
Light-duty Diesel Trucks	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Light-duty Diesel Vehicles	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Light-duty Gasoline Trucks	4.3	5.3	3.8	3	3	2.9	2.8	2.8	2.9
Light-duty Gasoline Vehicles	11	7.5	5	3.2	3	2.9	2.6	2.5	2.5
Light-duty LPG/NG Trucks	0.047	0.025	0.012	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Light-duty LPG/NG Vehicles	0.38	0.17	0.081	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Marine Transportation	120	150	170	110	97	83	69	39	56
Motorcycles	0.038	0.037	0.042	0.039	0.039	0.037	0.036	0.037	0.039
Off-road Diesel Vehicles and Equipment									
Off-road Gasoline/LPG/CNG Vehicles and Equipment									
Rail Transportation	63	59	58	51	51	49	50	48	44
Tire Wear and Brake Lining									
AGRICULTURE	**0.32**	**0.31**	**0.21**	**0.37**	**0.34**	**0.34**	**0.37**	**0.33**	**0.34**
Animal Production									
Crop Production									
Fuel Use	0.32	0.31	0.21	0.37	0.34	0.34	0.37	0.33	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	0.9	0.68	0.63	0.62	0.53	0.54	0.48	0.48
Commercial and Institutional Fuel Combustion	2.6	3.1	3	2.3	2.2	2.2	2.4	2.2	2.1
Commercial Cooking	100	110	120	120	120	120	120	110	110
Construction Fuel Combustion	0.45	0.19	0.42	0.36	0.34	0.28	0.28	0.29	0.23
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	3.9	3.5	3.4	3.5	3.3	3
Service Stations									
Other Miscellaneous Sources									
INCINERATION AND WASTE	**670**	**630**	**690**	**690**	**680**	**680**	**690**	**690**	**700**
Crematoriums	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Waste Incineration	670	630	690	690	680	680	690	690	700
Waste Treatment and Disposal			3	0.048	0.05	0.13	0.24	0.11	0.012
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**	**1 800**	**2 000**	**880**	**3 600**	**2 900**	**2 400**
Prescribed Forest Burning									
Structural Fires	9 800	2 000	1 200	1 800	2 000	880	3 600	2 900	2 400
GRAND TOTAL	**340 000**	**230 000**	**150 000**	**130 000**	**130 000**	**140 000**	**130 000**	**110 000**	**110 000**

Note: Totals may not add up due to rounding.

2.12. **Hexachlorobenzene (HCB)**

In 2016, approximately 8.5 kg of HCB were emitted in Canada (Table 2–14). Incineration and waste sources were the largest contributor in 2016 with 63% (5.3 kg) of total emissions, due almost entirely to emissions from waste incineration with 58% (4.9 kg) of HCB emissions. The ore and mineral industries were the second-largest contributor, with 27% (2.31 kg) of total emissions, largely due to iron and steel industries, which represented 12% (1.0 kg) of the national total.

Overall, a 63% (53 kg) decrease in HCB emissions occurred between 1990 and 2016 (Figure 2–12). Most of this decrease is due to a drop in emissions from waste incineration since 1997. This important reduction in emissions is a result of a steady decline in the use of conical burners for municipal waste incineration in Newfoundland and Labrador. Emission reductions were also seen in coal-fired electric power generation from 2000 to 2012 as a result of the phasing out of coal electricity generation in Ontario. HCB emissions from waste incineration decreased from 1990 to 2002 and since 2002 have remained relatively constant.

The most significant changes in HCB emissions from 1990 to 2016 include:

- Incineration and waste emissions: decrease of over 93% (67 kg)
  - Waste incineration: decrease of over 93% (68 kg)
- Electric power generation (utilities) source emissions: decrease of 96% (10 kg)
  - Coal (electricity power generation): decrease of 96% (9.9kg)

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

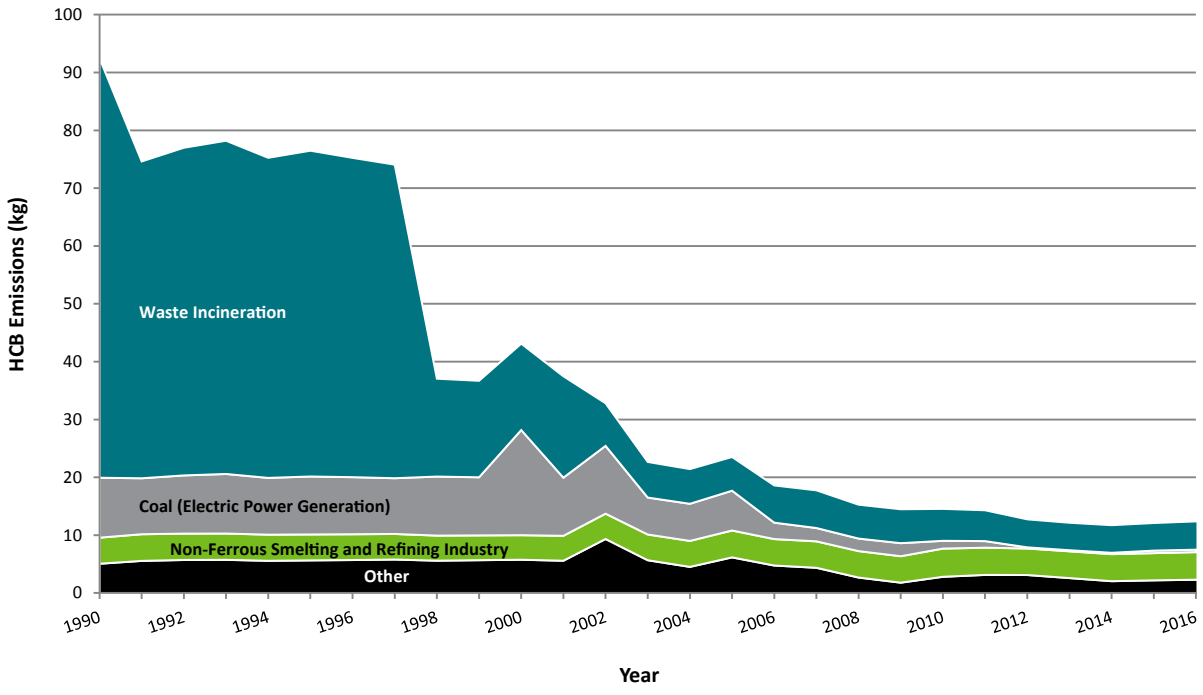

Table 2–14 National Summary of Annual HCB Emissions

Sector	1990	2000	2005	2011	2012	2013	2014	2015	2016
	(g)								
ORE AND MINERAL INDUSTRIES	**5 500**	**5 700**	**8 100**	**3 000**	**2 500**	**2 300**	**1 900**	**2 100**	**2 300**
Aluminium Industry				48					
Asphalt Paving Industry									
Cement and Concrete Industry	1 600	2 100	880	560	420	420	280	290	410
Foundries				0.010	0.010		29	23	24
Iron and Steel Industries	1 100	920	1 500	1 500	1 400	1 100	1 100	1 100	1 000
Iron Ore Industry									
Mineral Products Industry									
Mining and Rock Quarrying	13	13	32	14	18	13	12	17	12
Non-Ferrous Mining and Smelting Industry	2 700	2 600	5 600	940	660	730	530	700	830
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**	**19 000**	**7 000**	**1 300**	**370**	**390**	**430**	**600**	**570**
Coal	10 000	18 000	6 900	1 100	200	190	240	430	430
Diesel									
Natural Gas	640	1 100	170	140	140	140	140	150	120
Waste Materials	4.8	1.3		50	40	40	30	4.9	2.3
Other Electric Power Generation						25	23	16	17
MANUFACTURING	**1 600**	**1 500**	**1 500**	**240**	**460**	**330**	**360**	**350**	**280**
Abrasives Manufacture									
Bakeries									
Biofuel Production									
Chemicals Industry	680	330	480						
Electronics									
Food Preparation			3.0						
Glass Manufacture									
Grain Industries									
Metal Fabrication	460	480	52	110	350	230	290	210	190
Plastics Manufacture									
Pulp and Paper Industry	140	180	310	120	120	94	73	140	88
Textiles									
Vehicle Manufacture (Engines, Parts, Assembly, Painting)	9.5	110							
Wood Products	340	390	620	3.4	0.091	1.9	0.26	0.11	0.11
Other Manufacturing Industries									
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									
Crop Production									
Fuel Use									
COMMERCIAL / RESIDENTIAL / INSTITUTIONAL	**1.6**	**1.4**	**1.3**	**0.89**	**1.9**	**1.8**	**1.8**	**0.83**	**0.72**
Cigarette Smoking									
Commercial and Institutional Fuel Combustion	0.11	0.038		0.0096	1.2	1.2	1.2	0.52	0.51
Commercial Cooking									
Construction Fuel Combustion									
Home Firewood Burning									
Human									
Marine Cargo Handling									
Residential Fuel Combustion	1.5	1.4	1.3	0.88	0.73	0.68	0.58	0.31	0.20
Service Stations									
Other Miscellaneous Sources									
INCINERATION AND WASTE	**73 000**	**15 000**	**7 900**	**5 900**	**5 500**	**5 200**	**4 900**	**5 000**	**5 300**
Crematoriums	10	14	18	23	24	25	26	28	27
Waste Incineration	73 000	15 000	5 800	5 300	4 800	4 800	4 800	4 800	4 900
Waste Treatment and Disposal	0.49	0.051	2 100	560	590	460	61	210	390
PAINTS AND SOLVENTS									
Dry Cleaning									
General Solvent Use									
Printing									
Surface Coatings									
DUST									
Coal Transportation									
Construction Operations									
Mine Tailings									
Paved Roads									
Unpaved Roads									
FIRES									
Prescribed Forest Burning									
Structural Fires									
GRAND TOTAL	**91 000**	**41 000**	**25 000**	**10 000**	**8 800**	**8 300**	**7 600**	**8 100**	**8 500**

Note: Totals may not add up due to rounding.

3

KEY COMPONENTS OF THE APEI

The Air Pollutant Emission 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 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 National Pollutant Release Inventory (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 heavy metals and persistent organic pollutants 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 online at 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 these thresholds due to their size or emission levels, and therefore are 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 and emission models. These emission estimates are at the national level rather than at any specific geographic locations. These include emissions from non-industrial, residential, commercial, transportation, and other sources, such as open burning, 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
- On-site solid waste disposal facilities

- Motor vehicles, aircraft, vessels or other transportation equipment or devices
- Other sources, such as open burning, agricultural activities and construction operations

In general, in-house emission estimates are calculated from activity data and emission factors.[1] Activity data usually comprise statistical production or process data at the provincial, territorial or national level. This information is typically provided by provincial/territorial agencies federal government departments, industry associations, etc. For each source category, activity data are combined with emission factors to produce provincial/territorial-level emission estimates.

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 (EMEP/EEA 2013).

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 petroleum 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.

[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)."

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 Emission 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 based on 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 2017 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 APEI

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
- 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;
- 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 petroleum 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 estimates for these emissions.

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. Home firewood burning estimates have been updated; however, there were no estimates of wood used as fuel for the three Canadian territories (Yukon Territory, Northwest Territories and Nunavut).

A1

DEFINITIONS OF THE AIR POLLUTANTS

This annex provides definitions for the 17 air pollutants inventoried by the 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)

Sulphur oxides (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 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.

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. Available at: **www.publications.gc.ca/site/eng/248253/publication.html**.

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.

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 as a toxic substance 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 as 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)

Mercury is declared as toxic under CEPA. Hg's 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

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 isthe 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 (NPRI) 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 (POP) 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.

A2

INVENTORY DEVELOPMENT

A2.1. Overview of the Compilation Process

The process of compiling emission estimates for the Air Pollutant Emission 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 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 2016, reconciliation was performed for the asphalt paving industry and about 20 other source categories. 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 emissions tables and figures which in turn 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 the 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 2016 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) 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 European emission inventory guidebook (EMEP/EEA 2013).

Tables A2–2 through A2–12 summarize, for each source category, the 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 APEI Compilation Process**

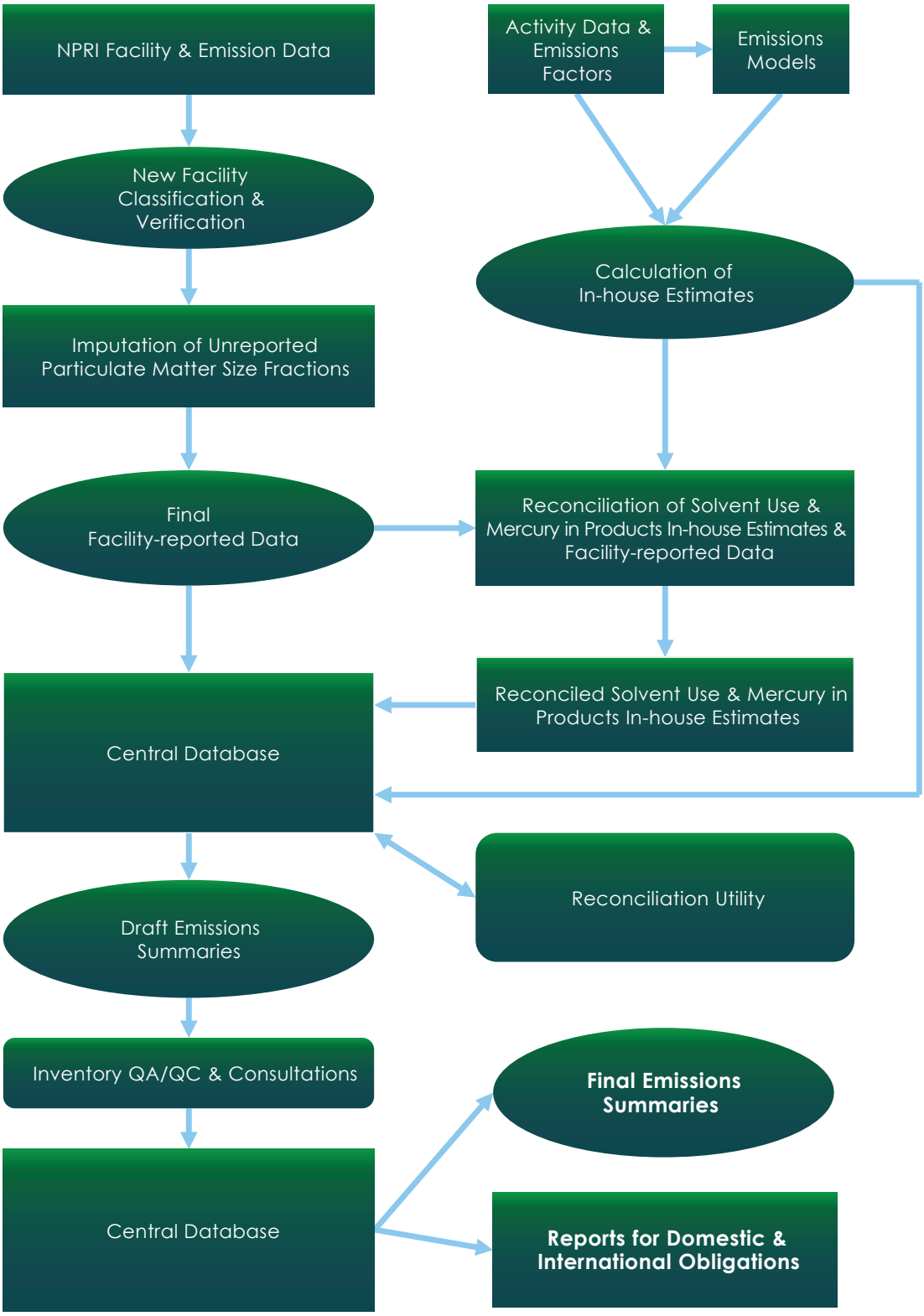

Table A2–1 2016 Air Pollutant Emissions Inventory (APEI)

APEI Sectors	Facility-reported Data (NPRI)[a]	In-house Estimates (Estimated by ECCC)	Activity Data Used for In-house Estimates
ORE AND MINERAL INDUSTRIES			
Aluminium Industry			
Alumina (Bauxite Refining)	✓		
Primary Aluminium Smelting and Refining	✓		
Secondary Aluminum (Includes Recycling)	✓		
Asphalt Paving Industry	✓	✓	2015
Cement and Concrete Industry			
Cement Manufacture	✓		
Concrete Batching and Products	✓	✓	2016
Gypsum Product Manufacturing	✓		
Lime Manufacture	✓		
Foundries			
Die Casting	✓		
Ferrous Foundries	✓	✓	2011
Non-ferrous Foundries	✓		
Iron and Steel Industries			
Primary (Blast Furnace and DRI)	✓		
Secondary (Electric Arc Furnaces)	✓	✓	
Steel Recycling	✓	✓	
Other (Iron and Steel Industries)		✓	2006
Iron Ore Industry			
Iron Ore Mining	✓		
Pelletizing	✓		
Mineral Products Industry			
Clay Products	✓		
Brick Products	✓		
Other Mineral Products	✓		
Mining and Rock Quarrying			
Coal Mining Industry	✓		
Metal Mining	✓		
Potash	✓		
Rock, Sand and Gravel	✓	✓	2015
Silica Production		✓	2016
Other Minerals	✓		
Non-Ferrous Mining and Smelting Industry			
Primary Ni, Cu, Zn, Pb	✓		
Secondary Pb, Cu	✓		
Other Metals	✓		
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	✓	✓	2015
Other Downstream Petroleum Industry	✓		
Upstream Oil and Gas Industry			
Accidents and Equipment Failures		✓	2016
Disposal and Waste Treatment		✓	2016
Heavy Crude Oil Cold Production		✓	2016
Light Medium Crude Oil Production[b]	✓	✓	2016
Natural Gas Production and Processing[c]	✓	✓	2016
Natural Gas Transmission	✓	✓	2015
Oil Sands In-Situ Extraction and Processing	✓	✓	2016
Oil Sands Mining, Extraction and Upgrading	✓		
Petroleum Liquids Storage	✓		
Petroleum Liquids Transportation		✓	2016
Well Drilling/Servicing/Testing		✓	2016
ELECTRIC POWER GENERATION (UTILITIES)			
Coal	✓		
Diesel	✓		
Natural Gas	✓		
Waste Materials	✓		
Other Electric Power Generation	✓		
MANUFACTURING			
Abrasives Manufacture	✓		
Bakeries	✓	✓	2016
Biofuel Production	✓		
Chemicals Industry			
Chemical Manufacture	✓		
Fertilizer Production	✓		
Paint and Varnish Manufacturing	✓		
Petrochemical Industry	✓		
Plastics and Synthetic Resins Fabrication	✓		
Other Chemical Industries	✓		
Electronics	✓	✓	2015
Food Preparation	✓		
Glass Manufacture	✓		
Grain Industries			
Grain Processing	✓	✓	2016
Warehousing and Storage			
Metal Fabrication	✓		
Plastics Manufacture	✓		
Pulp and Paper Industry			

Table A2–1 **2016 Air Pollutant Emissions Inventory (APEI)** (cont'd)

APEI Sectors	Facility-reported Data (NPRI)[a]	In-house Estimates (Estimated by ECCC)	Activity Data Used for In-house Estimates
Pulp and Paper Industry	✓	✓	2006
Converted Paper Product Manufacturing	✓		
Textiles	✓		
Vehicle Manufacture (Engines, Parts, Assembly, Painting)	✓		
Wood Products[d]			
Panel Board Mills	✓	✓	2014
Sawmills	✓	✓	2014
Other Wood Products	✓		
Other Manufacturing Industries	✓	✓	2011
TRANSPORTATION AND MOBILE EQUIPMENT			
Air Transportation		✓	2016
Heavy-duty Diesel Vehicles		✓	2015
Heavy-duty Gasoline Vehicles		✓	2015
Heavy-duty LPG/NG Vehicles		✓	2015
Light-duty Diesel Trucks		✓	2015
Light-duty Diesel Vehicles		✓	2015
Light-duty Gasoline Trucks		✓	2015
Light-duty Gasoline Vehicles		✓	2015
Light-duty LPG/NG Trucks		✓	2015
Light-duty LPG/NG Vehicles		✓	2015
Marine Transportation		✓	2015
Motorcycles		✓	2016
Off-road Diesel Vehicles and Equipment		✓	2013
Off-road Gasoline/LPG/CNG Vehicles and Equipment		✓	2013
Rail Transportation		✓	2016
Tire Wear and Brake Lining		✓	2015
AGRICULTURE			
Animal Production		✓	2016
Crop Production			
Fertilizer Application		✓	2016
Harvesting		✓	2016
Tillage Practices		✓	2016
Wind Erosion		✓	2016
Fuel Use	✓	✓	2014
COMMERCIAL / RESIDENTIAL / INSTITUTIONAL			
Cigarette Smoking		✓	2015
Commercial and Institutional Fuel Combustion	✓	✓	2015
Commercial Cooking		✓	2016
Construction Fuel Combustion		✓	2014
Home Firewood Burning		✓	2015
Human[e]		✓	2016
Marine Cargo Handling	✓		
Residential Fuel Combustion		✓	2014
Service Stations		✓	2015
Other Miscellaneous Sources[f]		✓	2008
INCINERATION AND WASTE			
Crematoriums	✓	✓	2015
Waste Incineration			
Industrial and Commercial Incineration		✓	2011
Municipal Incineration	✓	✓	2011
Residential Waste Burning		✓	2016
Other Incineration and Utilities		✓	2009
Waste Treatment and Disposal			
Landfills	✓	✓	2014
Water and Sewage Treatment	✓		
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 Forest Burning		✓	2015
Structural Fires		✓	2016
Mercury in Products[g]		✓	2008

Notes:
✓ denotes yes
a. All facility-reported data were obtained from the NPRI Reporting Year 2016.
b. Facility-reported data consists of facilities located in Atlantic Canada. For other provinces, it consists of in-house estimates.
c. Facility-reported data consists of facilities located in Atlantic Canada and SO_2 emissions from Alberta's natural gas processing facilities.
d. 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.
e. Ammonia emissions from infant diapered waste, which were previously reported under Other Miscellaneous Sources, are now reported under the Human sector.
f. Emissions reported under Other Miscellaneous Sources are from breakage, transport and recycling of mercury-containing products. 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.
g. Emissions from Hg-containing products were calculated as a separate inventory. Emissions are reported under many sectors such as Iron and Steel Industries, Municipal Incineration, Human, Other Miscellaneous Sources and Landfills. All in-house estimates for Hg in product emissions continues 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 (1981) Asphalt usage data from construction sector: Statistics Canada1990–2016
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 (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 data: NRCan (2016) Population data for the provinces: Statistics Canada a
Emission Factors (EF)	TPM, PM_{10}, $PM_{2.5}$, Pb, Cd: U.S. EPA (1998, 2010a) Emission factors for TPM, PM_{10} and $PM_{2.5}$ emitted by loading mixers and loading trucks: (U.S. EPA 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 (2010a) (using SCC 30501101): $EFPM_{10}=0.51*EF_{TPM}$ $EFPM_{2.5}=0.15*EF_{TPM}$
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 in 2011 and have been carried forward to 2016.
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 (2017).
Emission Factors (EF)	TPM, PM_{10}, $PM_{2.5}$: 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 (2017) Confidential provincial production values are estimated with population distributions: Statistics Canada a
Emission Factors (EF)	TPM, PM_{10}, $PM_{2.5}$: EMEP/EEA (2013)

Table A2–3 **Estimation Methodologies for 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 (2006)
Activity Data	Gross sales of gasoline for motor vehicles: Statistics Canada 1990–2017
Emission Factors (EF)	Study on gasoline vapour recovery in Stage 1 distribution networks in Canada: Tecsult (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), 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 Fuel Combustion and Mobile 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 2014, CAPP 2005a) and extrapolated (CAPP 2005b) from 2012 onwards based on pipeline length.
Activity Data	Gas Pipeline Distance, by province (Statistics Canada 2017c)
Emission Factors (EF)	EC 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 Fuel Combustion and Mobile 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 2014, CAPP 2005a), and extrapolated (CAPP 2005b) 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 (Statistics Canada 2017c) Natural gas injections to storage and withdrawals from storage (Statistics Canada b)
Emission Factors (EF)	EC 2014

Table A2–3 **Estimation Methodologies for Oil and Gas Industry** (cont'd)	
Sector/Subsector	
UPSTREAM OIL AND GAS INDUSTRY	
Description	The 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, this 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 and Processing • Oil Sands Mining, Extraction and Upgrading • 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 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 2014, CAPP 2005a) and are extrapolated (CAPP 2005b) from 2012 onwards using various provincial-level activity data.
Activity Data	EC (2014), AER (2017a,b,c,d,e), BC (2017), BCOGC (2017), CAPP (2017), CNLOPB (2017a,b,c,d,e), MB (2017), NBERD (2017), SK MOE (2017a,b,c,d), Statistics Canada (c, 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 and Processing 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 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; however, 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 bread produced by province/territory is multiplied by an emission factor for VOCs.
Activity Data	Bread production values are estimated using: • National bread/bakery product shipment values: Statistics Canada e • Provincial bread/bakery product shipment values: Statistics Canada f • Monthly Consumer Price Index (CPI) for Bread/Rolls and Flatbreads: Statistics Canada g
Emission Factors (EF)	Cheminfo (2005) EF_{VOC} = 2.35 kg per tonne of baked goods
GRAIN INDUSTRIES	
Description	Grain Industries 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 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 1985). **Terminal elevators** dry, clean, blend and store grain for shipment. **Transfer elevators** generally perform the same function as terminal elevators.
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 National Pollutant Release Inventory.
Activity Data	Annual grain production data by regions: CGC (2016) Grain data: annual field crop production data by province (Statistics Canada v.)
Emission Factors (EF)	TPM, PM_{10}, $PM_{2.5}$: Pinchin Environmental Ltd (2007)

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 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 2014a). The in-house estimates were last calculated for 2014 and have been carried forward to 2016. **Other Wood Products** All pollutants: In-house estimates are not calculated for this subsector. Since 2005, emissions are from data reported to the NPRI by the facilities.
Activity Data	NPRI 2016 data (ECCC 2018) 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 2014 Online Lumber Directory* (Madison 2014) • Verbal communications with industry representatives (unpublished)
Emission Factors (EF)	Sawmills: U.S. EPA (2012a) Plywood manufacturing, particle board, oriented strand board: U.S. EPA (1995b) Fuel combustion: Meil et al. (2009); U.S. EPA (1992, 1995b, 2014a)

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 i), 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 (2009) databank for landing/take-offs (LTO), and from EMEP/CORINAIR (2006) for the cruise stage. Emission factors are mapped to representative aircraft, based on engine characteristics. SO_2 is estimated as a sulphur balance, using data from the *Sulphur In Liquid Fuels* reports (EC 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 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 (2005a). Lead is estimated as a lead balance, using the U.S. EPA's 5% retention (U.S. EPA 2013). TPM is equal to PM_{10} (U.S. EPA 2005a). 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 2005a).

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(cd)p Vessel-specific activity (movements) is multiplied by pollutant-specific emission factors.
Activity Data	**Vessel-specific movements** 1999–2010 – SNC-Lavalin Environment (2012) 2015 – INNAV (Coast Guard) data and data from the AIS (Automated Identification Systems) from ships Due to the unavailability of activity data, emission estimates are calculated using interpolations for the years 2011 through 2014.
Emission Factors (EF)	Emission factors originate from a variety of sources and are distinct per vessel type and dead weight tonnage, engine size and type, fuel type, and movement component (underway, anchor or berth). For this iteration of the APEI, the *Marine Emission Inventory Tool* (MEIT 2015) was used. Emission factor sources, application and summaries are provided in Environment and Climate Change Canada's "National Marine Emission Inventory – 2015 – Final Report" (in progress). MEIT natively outputs hydrocarbon (HC), but not VOCs. An HC-to-VOC conversion rate is taken from U.S. EPA (2010c). Emissions of non-standard CACs are estimated as a ratio to PM_{10} or HC/VOC, based on speciation profiles from the U.S. EPA (2005a).
ON-ROAD VEHICLES	
Description	On-road Vehicles include: Heavy-duty diesel vehicles, Heavy-duty gasoline trucks, 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 & 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 in under Service Stations.
Activity Data	Data on the vehicle fleet (counts), defined by fuel type, model-year and gross vehicle weight rating, originate from DesRosiers Automotive Consultants (DAC 2014) and R. L. Polk & Co. (Polk & Co. 2013) for light- and heavy-duty vehicles, respectively. Motorcycle populations originate from the publication *Road Motor Vehicle, Trailer and Snowmobile Registration (registrations)* (Statistics Canada j, k). 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 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 2012b, 2014b) and in U.S. EPA technical guidance document (U.S. EPA 2010b).
OFF-ROAD VEHICLES AND EQUIPMENT	
Description	Off-road Vehicles and Equipment consists of Off-road diesel vehicles and equipment and Off-road gasoline/LPG/CNG vehicles and equipment
General Inventory Method	Pollutant(s) Estimated: TPM, PM_{10}, $PM_{2.5}$, SO_x, NO_x, VOCs, CO, NH_3, B(a)p, B(b)f, B(k)f, I(cd)p 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 (2011). The hours-of-use parameter was updated in 2017 for select equipment types
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 2005b), given that the functionality of the models is the same. Emissions of non-standard CACs are estimated as a ratio to PM_{10} or HC/VOC, based on speciation profiles in the $SPECIATE_4$.2 database (U.S. EPA 2008). More information on the NONROAD model is available online at 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 (1991–2017)
Emission Factors (EF)	In 2013, the Rail Association of Canada (RAC) signed a Memorandum of Understanding (MOU) on locomotive emissions with Transport Canada for the period 2011–2015. Under the terms of the MOU, the RAC provides multiple datasets on the industry, including emission factors. HC, CO, SO_2, PM_{10} and NO_x emission factors are taken from RAC (2013). HC emissions are converted to VOCs using the method in U.S. EPA (2011). Ratios of PM_{10} to $PM_{2.5}$ and TPM are taken from the U.S. EPA (U.S. EPA 2005a). The emission factor for NH_3 is taken from Coe et al. (1996). With the exception of dioxins/furans, emissions of non-standard CACs are estimated as a ratio to PM_{10} or HC/VOCs, based on speciation profiles from U.S. EPA (2011). The dioxin/furan emission factor (0.54 ng/L) is taken from U.S. EPA (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 as a result of 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 during storage and digestion. Emissions from excreted manure 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 The methodologies for ammonia emissions are 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 and Bittman (2010, 2012); Sheppard et al. (2007a, 2007b, 2009a, 2009b, 2010a, 2011a; 2011b); Chai et al. (2016). The methodology used for the estimation of ammonia emissions from the Dairy industry 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 (ECCC 2018)). Though 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). The methodologies for emissions of particulate matter 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 European Monitoring and Evaluation Programme (EMEP)/Core Inventory of Air Emissions in Europe (CORINAIR) Guidebook (EMEP/CORINAIR 2002), but uses country-specific emission factors. Methodologies are published in Pattey and Qiu (2012) and Pattey et al. (2015). The methodology for estimating NMVOC emissions was based on tier 1 methodology outlined in the 2013 European Monitoring and Evaluation Programme/European Environment Agency Air Pollutant Emission Inventory Guidebook (EMEP/EEA, 2013).
Activity Data	Annual cattle, sheep and swine populations are calculated as the simple mean of semi-annual or quarterly surveys (Statistics Canada l). These smaller surveys are corrected to the *Census of Agriculture* (COA) population estimates that are collected every 5 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 m). Rabbit populations were taken from responses to the COA as provided on the AAFC Red Meat Market website (AAFC 2016).
Emission Factors (EF)	**Ammonia** Non-dairy cattle, swine 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 European Monitoring and Evaluation Programme (EMEP)/Core Inventory of Air Emissions in Europe (CORINAIR) Guidebook (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. Model to calculate NH_3 emissions: Sheppard et al. (2010a) Dairy Cattle: Ammonia emissions are calculated according to Sheppard et al. 2010a; with modifications according to Chai et al. (2016) and based on the activity data and methodology outlined for **Agriculture** in the *National Inventory Report: 1990–2016, Greenhouse Gas Sources and Sinks in Canada* (ECCC 2018). Total N excretion for dairy cattle is calculated according to the Tier 2 methodology in the IPCC 2006 Guidelines (IPCC 2006). Ammonia emission factors from Sheppard et al. (2011a) 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. (2011b) to identify proportions of manure excreted on pasture and in exercise yards and information on the quantify of manure stored as liquid and solid manure drawn from the Farm Inputs Management Survey (1995) (Statistics Canada 1996), the Farm Environmental Management Surveys (2001, 2006, 2011) (Statistics Canada n and the Livestock Farm Practices Survey (2005) (Statistics Canada 2007). A time series of manure storage was developed based on 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. (2010b) as modified according to Chai et al. (2016).

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

Sector/Subsector	
Emission Factors (EF) (cont'd)	**Particulate Matter** Total particulate matter (TPM) emission factors for poultry are taken from Van Heyst (2005) and Van Heyst and Roumeliotis (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: 1990–2013, Greenhouse Gas Sources and Sinks in Canada* (EC 2015b). All other animal weights were consistent with values used to estimate nitrogen excretion in EC (2015b). Currently no emissions are estimated for mink, fox, wild boars, deer, elk or rabbit. **Non-methane volatile organic compounds** The emission factors for all animals were taken from Table 3-3 of EMEP/EEA (2013). For livestock categories where a choice of emissions factors was provided, the non-silage emission factor was selected, except for dairy cows and 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)
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. (2010b) 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 e). Areas of seeded annual and perennial crops: Statistics Canada h. Soil properties, including pH and cation exchange capacity, are included in calculations using soil polygon information from a national-scale spatial database describing the types of soils associated with landforms (available online at http://sis.agr.gc.ca/cansis/nsdb/slc/index.html).
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 2016 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: 1990–2016, Greenhouse Gas Sources and Sinks in Canada* (ECCC 2018).
Emission Factors (EF)	There are no emission factors for agricultural harvest in Canada. The PM_{10} emission factors proposed by CARB (2003) are used to calculate PM emissions from crop harvest. Where the specific emission factors for some crops are not available from CARB (2003), the emission factors for these crops are based on an approximation from the closest representation (Pattey and Qiu 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 and Qiu (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: 1990–2016, Greenhouse Gas Sources and Sinks in Canada* (ECCC 2018). 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 (1985).

Table A2–6 **Estimation Methodologies for Agriculture** (cont'd)	
Sector/Subsector	
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.
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: 1990–2016, Greenhouse Gas Sources and Sinks in Canada* (ECCC 2018).
Emission Factors (EF)	The PM emission factor for wind erosion is calculated using the wind erosion equation (Woodruff and 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 and Qiu (2012).
FUEL USE	
Description	Agriculture – 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}, $PM_{2.5}$, SOx, NOx, 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 (1991–2016)
Emission Factors (EF)	TPM, PM_{10}, PM_2.5, SOx, NOx, VOCs, CO: U.S. EPA (1998) (Emission factors are chosen to represent the typical type of combustion equipment for each fuel type.) TPM, PM_{10}, PM_2.5, SOx, NOx, VOCs, CO for natural gas fuel: U.S. EPA (2004a) Sulphur contents of liquid fuels: EC (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 (2005); U.S. EPA (1998, 2003, 2004a) (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 1991–2016 Since Health Canada's *Canadian Tobacco, Alcohol and Drugs Survey (CTADS)* is a biennial publication with 2015 being the most recently surveyed year, emission estimates for 2016 were calculated using the 2015 CTADS survey data and 2016 population data.
Emission Factors (EF)	TPM, PM_{10}, $PM_{2.5}$: Ott et al. (1996) VOCs: Wallace et al. (1987) CO: Ott et al. (1992) NH_3: Roe et al. (2004) Hg, Cd, Pb: Gray and Boyle (2002) Dioxins/furans: U.S. EPA (2004b) B(a)p, B(b)f, B(b)k: Ding et al. (2005)

Table A2–7 **Estimation Methodologies for Commercial / Residential / Institutional** (cont'd)	
Sector/Subsector	
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}, $PM_{2.5}$, SOx, NOx, 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 (1991–2016)
Emission Factors (EF)	TPM, PM_{10}, $PM_{2.5}$, SOx, NOx, VOCs, CO: U.S. EPA (1998) (Emission factors are chosen to represent the typical type of combustion equipment for each fuel type.) TPM, PM_{10}, $PM_{2.5}$, SOx, NOx, VOCs, CO for natural gas fuel: U.S. EPA (2004a) Sulphur contents of liquid fuels: EC (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 (2005); U.S. EPA (1998, 2003, 2004a) (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 & 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 2016)** 1. Determined the number of restaurants in each province/territory that were classified as ethnic, fast food, family, seafood, steak & 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 o). **Commercial Cooking of French Fries (1990 to 2016)** 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 2016)** Activity data were estimated using: • Annual restaurant census for Canada: ReCount Database (The NPD Group 2017) • Statistics on the prevalence of commercial cooking equipment, for the five restaurant types (E.H. Pechan & Associates 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 2003) **Commercial Cooking of French Fries (1990 to 2016)** Activity data were estimated using: • Provincial/territorial population data Statistics Canada a • Annual Canadian consumption rates of frozen fries (USDA Foreign Agricultural Service 2015) • Assumed 80% of French fries were purchased in restaurants (E.H. Pechan & Associates 2003)
Emission Factors (EF)	Commercial Meat Cooking: TPM, PM_{10}, $PM_{2.5}$, VOCs, CO, B(a)p: E.H. Pechan & Associates (2003) Commercial Cooking of French Fries: VOCs: (E.H. Pechan & Associates 2003)

Table A2–7 **Estimation Methodologies for Commercial / Residential / Institutional** (cont'd)	
Sector/Subsector	
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}, $PM_{2.5}$, SOx, NOx, 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 (1997, 2006) and 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 (1997, 2010) and Tracey (2016).
Emission Factors (EF)	TPM, PM_{10}, $PM_{2.5}$, SOx, NOx, VOCs, CO, NH_3: Gulland (2000) Pb, Cd, Hg, B(a)p, B(b)f, B(k)f: U.S. EPA (1995b) Dioxins/furans: EC (2000)
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 a **Infant-diapered waste** Number of children aged 0-3 years by province/territory: Statistics Canada a
Emission Factors (EF)	Respiration and perspiration and Infant-diapered waste: NH_3: Roe et al. (2004)
SERVICE STATIONS	
Description	Service Station 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 $MOVES_{2014}$. 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 u) **Off-road refuelling** Off-road gasoline usage data (ECCC 2017b) **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 2014) and R. L. Polk & Co. (Polk & Co. 2013) for light- and heavy-duty vehicles, respectively. Motorcycle populations originate from the Road Motor Vehicle, Trailer and Snowmobile Registration database (Statistics Canada k). 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 2012).
Emission Factors (EF)	Refined petroleum products retail and off-road refuelling: Evaporative emissions from gasoline service station operations (U.S. EPA 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 2012b, 2014b) and in the U.S. EPA technical guidance document (U.S. EPA 2010b).

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 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 2002–2016 is obtained from annual reports produced by the Cremation Association of North America (CANA): the Annual CANA Statistics Report 2012: Executive Summary (CANA 2013) covers 2002–2007 and the draft Annual CANA Statistics Report (CANA 2017) includes data from 2008–2016. Due to the unavailability of data for some years, emission estimates are calculated using linear interpolation for all provinces/territories for the year 2001–2002, and as well as Quebec for the years 2002–2007.
Emission Factors (EF)	TPM, PM_{10}, $PM_{2.5}$: U.S. EPA (2014a) VOCs, HCB: EMEP/EEA (2013) SO_x, NO_x, CO: EMEP/EEA (2009) Hg, Cd, Pb: U.S. EPA (2014a) Dioxins/furans: U.S. EPA (2014a) B(a)p, B(b)f, B(b)k, I(cd)p: U.S. EPA (2014a) 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. The in-house estimates were last calculated for 2011 and were carried forward to 2016
Activity Data	Methodology under review.
Emission Factors (EF)	Methodology under review.
MUNICIPAL INCINERATION (under WASTE INCINERATION)	
Description	The Municipal Incineration sector 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. The in-house estimates were last calculated for 2011 and were carried forward to 2016.
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 applied to PM emission factors. 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 based on the total amount of waste disposed by province as reported by Statistics Canada (Statistics Canada p), 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 was 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 and FVRD (2003). The $EFPM_{10}$ is calculated using a distribution percentage of 8% of the EF_{TPM}. The $EFPM_{2.5}$ is calculated using a distribution percentage of 2% of the EF_{TPM}. VOCs: U.S. EPA (1995a). 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}, $PM_{2.5}$, SOx, NOx, 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 INCINERATION AND UTILITIES	
Description	Other Incineration and Utilities applies to emissions from sewage sludge incineration and other small incinerators. This sector includes only area sources emissions.
General Inventory Method	Pollutant(s) Estimated: TPM, PM_{10}, $PM_{2.5}$, SOx, NOx, VOCs, CO, NH_3, Pb, Cd, Hg, dioxins/furans Methodology under review. The in-house estimates were last calculated for 2011 and were carried forward to 2016.
Activity Data	Methodology under review.
Emission Factors (EF)	Methodology under review.

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 (2007) Solvent use quantities (2005 to 2014): Cheminfo (2016a) 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 and 2016 were developed based on historical base year national total solvent use and macroeconomic growth and solvent growth ratios (Cheminfo 2016b). Macroeconomic growth data (GDP by NAICS): Statistics Canada q
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 E_{VOCs} is the emission estimate of VOCs. Emission controls (1990 to 2004): Cheminfo (2007) Emission controls (2005 to 2014): Cheminfo (2016a) 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 2016a).

Table A2–10 **Estimation Methodologies for Dust**	
Sector/Subsector	
COAL TRANSPORTATION	
Description	Coal Transportation includes PM emissions resulting from the transportation of coal by rail or truck. 1. Most of the coal mined in Canada is carried to trans-shipment or export terminals by unit trains. Coal imported into Canada is shipped in lake and ocean vessels. Some imported coal is landed directly at the end users facility; some is transported by rail or truck inland from import terminals to end users. Coal is shipped by truck to rail load-out, end-user and trans-shipment terminals by truck over shorter distances compared to rail (Cope and Bhattacharyya 2001). Load-in and load-out losses 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 Mobile Sources category.
General Inventory Method	Pollutant(s) Estimated: TPM, PM_{10}, $PM_{2.5}$ Emissions are estimated for each source-destination rail or truck transportation route and summed by province. Emission factors, 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 mass of coal transported along each route is determined based on the mine production (for mine to port or mine to end-user), or based on the coal demand by end-user (for imported coal to end-users) (Statistics Canada r, s, 1991–2017). Coal mine production sent to multiple destinations is proportioned based on documented coal shipping volumes to each destination, reported coal demand for coal-users, or proportioned based on estimates from Cope and Bhattacharyya (2001). Where no information was available, the coal production was proportioned to the various destinations based on the proximity between the mine and the destination. The PM_{10} and $PM_{2.5}$ emissions are calculated from the total particulate matter emissions based on a scaling factor.
Activity Data	Coal mine production and coal-user demand: Statistics Canada r, s, 1991–2017, 2015); Cope and Bhattacharyya (2001) Monthly climate summaries: ECCC (2017a) Rail Transportation Network: NRCan CANVEC (1:1M scale used) Mine Locations: BC Minefile (Accessed 2017), Alberta Energy Regulator (AER) Coal Mine Locator (2015, Accessed 2017), environmental assessment reports, and in-house remote-sensing.
Emission Factors (EF)	Cope and 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, 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 are carried forward to 2016.
Activity Data	**Residential Construction** Dwelling starts: Statistics Canada t CMHC (2017) Average lengths of construction: CMHC (2017) Buildings to hectares conversion factors: SNC Lavalin Environment (2005) Average basement area and depth: SNC Lavalin Environment (2005) Number of homes with basements: SNC Lavalin Environment (2005) **ICI and Engineering Construction** Methodology under review.
Emission Factors (EF)	**Residential Construction** TPM, PM_{10}, $PM_{2.5}$: SNC Lavalin Environment (2005) Correction factors: % Silt Content[1] Precipitation-Evaporation (PE) Index: SNC Lavalin Environment (2005) **ICI and Engineering Construction** Methodology under review.

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 are carried forward to 2015.
Activity Data	Methodology under review.
Emission Factors (EF)	Methodology under review.
PAVED ROADS	
Description	Emissions from the Paved Road Dust 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 kilometers travelled for each province/territory by pollutant-specific emissions factors. The methodology for **secondary (re-suspended)** emissions is currently under review. The emissions were last estimated for 2002 and have been 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 (1995a).
Activity Data	The same method used to calculate VKT for Mobile Sources was used to estimate VKT for the primary and secondary emissions. Methodology under review for secondary emissions. The former method, based on the US EPA AP-42 (1995a) 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 – EMEP/EEA (2013) Secondary – Methodology under review.
UNPAVED ROADS	
Description	Emissions from the **Unpaved Road Dust** sector 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 have been carried forward to 2016.
Activity Data	Methodology under review. The former method, based on the US EPA AP-42 (1995a) 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 Mobile Sources was used to estimate VKT for the Dust from Unpaved Roads.
Emission Factors (EF)	Methodology under review.

[1] 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 A2–11 Estimation Methodologies for Fires

Sector/Subsector	
PRESCRIBED FOREST BURNING	
Description	Prescribed Forest 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 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 (1995a) **British Columbia** GVRD and 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 area sources emissions.
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[1] (CCMFC) and the following members of the CCMFC are contacted to obtain the number of annual structural fires in their jurisdictions: • Government of Nunavut[2] (Carried forward) • Fire and Emergency Services, Newfoundland and Labrador[3] (Carried forward) • Office of the Fire Marshal and Emergency Management (Ontario)[4] (Carried forward) • Office of the Fire Commissioner (Manitoba)[5] (Carried forward) • Emergency Management and Fire Safety Branch (Saskatchewan)[6] (Carried forward) • Canadian Forces Fire Marshal[7] (2016 data) • Office of Public Safety (Prince Edward Island)[8] (Carried forward) • Yukon Government[9] (2016 data) • Department of Labour and Advanced Education (Nova Scotia)[10] (2016 data) • Department of Municipal and Community Affairs (Government of the Northwest Territories)[11] (2016 data) • Department of Public Safety (New Brunswick)[12] (2016 data) • Office of the Fire Commissioner (Alberta)[13] (2016 data) • Emergency Management British Columbia[14] (2016 data) • Ministère de la Sécurité publique[15] (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 Due to 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 and FVRD (2003) NH_3: Battye et al. (1994)

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

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

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

[4] 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).

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

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

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

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

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

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

[11] 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).

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

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

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

[15] 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 Industries – Secondary (Electric Arc Furnaces) • Iron and Steel Industries – Steel Recycling • Electronics • Other Manufacturing Industries • Human • Other Miscellaneous Sources • Municipal Incineration • Landfills • Residential Waste Burning • Water and Sewage Treatment • Other Incineration and Utilities
General Inventory Method	Pollutant(s) Estimated: Hg Methodology under review. The in house estimates were last calculated for 2008 and have been carried forward to 2016.
Activity Data	Methodology under review.
Emission Factors (EF)	Methodology under review.

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 activites 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).

Recalculations of facility-reported data previously reported to the NPRI facilities submit 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 1991–2017).

Emissions in the following in-house 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 A2–21.

- Ore and mineral industries: asphalt paving; rock, sand and gravel; and silica production;
- 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 storage; oil sands in-situ extraction and processing; petroleum liquids storage; petroleum liquids transportation; and well drilling/servicing/testing;

Table A2–13 **Recalculations for Ore and Mineral Industries**

Sector	Pollutant	Description	Impact on Emissions
ASPHALT PAVING			
	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, HCB	The activity data have been updated from a more recent RESD, which including some of historical data (2005–2015).	The recalculations resulted in no significant changes in emission levels (± >10%) for 1990. The recalculations resulted in the following changes in 2015 at the national level: -12% (-58 t) for SO_x.
CEMENT AND CONCRETE			
	TPM, PM_{10}, $PM_{2.5}$, Pb and Cd.	The recalculations were done using updated population and cement activity data since 2005, up to 2015.	No changes in emission levels occurred for 1990. For 2015, estimates for all pollutants decreased by 1.6% (TPM 0.7 kt; PM_{10} 0.2 kt; $PM_{2.5}$ 0.1 kt; Pb 1.7 kg; Cd 0.02 kg).
ROCK, SAND AND GRAVEL (under MINING AND ROCK QUARRYING)			
	TPM, PM_{10}, $PM_{2.5}$	Recalculations of emission estimates for 1990–2015were due to changes in emission factors. Emission factors are now taken from the EMEP/EEA 2013 Guidebook's Tier 1 emission factors for Quarrying and mining of minerals other than coal. Activity level data for the complete time series was updated to reflect the most recent information from NRCan.	The methodology and activity level data updates resulted in decreases to the particulate matter in-house estimates. In 1990, the significant changes at the national level were -23% (2.8kt) for TPM ; -34%(630t) for $PM_{2.5}$; and -23%(1.4kt) for PM_{10} . The recalculations resulted in changes in emission levels of less than ±10% for 2015.
SILICA PRODUCTION (under MINING AND ROCK QUARRYING)			
	TPM, PM_{10}, $PM_{2.5}$	Emissions were recalculated to incorporate updated annual mineral production data for 2015 and updated population data for 2012 to 2015.	The recalculations resulted in changes in emission levels of less than ±10% for 2012 and 2015.

- Manufacturing: bakeries;
- Transportation and mobile equipment: marine transportation; on-road vehicles; and off-road vehicles and equipment;
- Agriculture: animal production; fertilizer application and fuel use;
- Commercial/Residential/Institutional: cigarette smoking; commercial and institutional fuel combustion; construction fuel combustion; human; residential fuel combustion; service stations and other miscellaneous sources;
- Incineration and waste sources: landfills; residential waste burning;
- Paints and solvents: dry cleaning; general solvent use; printing and surface coatings;
- Dust: residential construction, coal transportation;
- Fires: prescribed forest burning;

For the purpose of tables A2–13 to A2–21, the term "significant" refers to changes greater than ±10% in emission levels.

Table A2–14 **Recalculations for Oil and Gas Industry**

Sector	Pollutant	Description	Impact on Emissions
REFINED PETROLEUM PRODUCTS BULK STORAGE AND DISTRIBUTION (under DOWNSTREAM OIL AND GAS INDUSTRY)			
	VOCs	Recalculations occurred for the entire time series because of updated activity data. In addition, for the period 1990 to 2005, some emissions previously allocated to petroleum refining are now reported in this category.	The recalculations resulted in an approximately 1% decrease in emissions for 2015. Changes in allocation resulted in an emission increase of about 20% in 1990.
NATURAL GAS DISTRIBUTION (under DOWNSTREAM OIL AND GAS INDUSTRY)			
	TPM, PM_{10}, $PM_{2.5}$, SO_x, NO_x, VOCs, CO	Recalculations occurred from 1996 through 2015 as a result of changes made to the allocation of NPRI data to Oil and Gas subsectors.	For 2015, on a national level, the allocation changes resulted in significant changes to TPM, PM_{10} and $PM_{2.5}$ (-11 t or -86%), SO_x (-29 t or -98%), NO_x (-4.2 kt or -97%), VOCs (-0.2 kt or -39%), and CO (-4.3 kt or -97%).
ACCIDENTS AND EQUIPMENT FAILURES (under UPSTREAM OIL AND GAS INDUSTRY)			
	VOCs	Recalculations occurred from 2001 through 2015 as a result of updated activity data being made available (AER 2017e, BCOGC 2017, CNLOPB 2017e, MB 2017, SK MOE 2017d).	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)			
	TPM, PM_{10}, $PM_{2.5}$, SO_x, NO_x, VOCs, CO, NH_3	Recalculations occurred from 2001 thru 2015 as a result of updated activity data being made available (AER 2017a, AER 2017d, Statistics Canada d).	The recalculations did not result in changes greater than ±10% for any of the pollutants in 2015.
HEAVY CRUDE OIL COLD PRODUCTION (under UPSTREAM OIL AND GAS INDUSTRY)			
	TPM, PM_{10}, $PM_{2.5}$, SO_x, NO_x, VOCs, CO, NH_3	New activity data was used to estimate emissions from reported venting, flaring and fuel combustion. This resulted in recalculations to emissions from 2001 to 2015 (AER 2017a, AER 2017d, SK MOE 2017c).	The new activity data resulted in significant changes to 2015 emissions at the national level for TPM, PM_{10} and $PM_{2.5}$ (+254 t or +94%), SO_x (+821 t or 51%), NO_x (+2.3 kt or +20%), CO (+3.4 kt or +23%), and NH_3 (+7.5 t or 20%). The recalculations did not result in changes greater than ±10% for VOCs in 2015.
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	New activity data was used to estimate emissions from reported venting, flaring and fuel combustion. This resulted in recalculations to emissions from 2001 to 2015 (AER 2017a, AER 2017d, BC 2017, SK MOE 2017c).	The new activity data resulted in significant changes to 2015 emissions at the national level for TPM, PM_{10} and $PM_{2.5}$ (+662 t or +25%), NO_x (+5.4 kt or +15%), CO (+7.9 kt or +17%), and NH_3 (+1.9 t or 13%). The recalculations did not result in changes greater than ±10% for SO_x or VOCs in 2015.
NATURAL GAS PRODUCTION AND PROCESSING (under UPSTREAM OIL AND GAS INDUSTRY)			
	TPM, PM_{10}, $PM_{2.5}$, SO_x, NO_x, VOCs, CO, NH_3	New activity data was used to estimate emissions from reported venting, flaring and fuel combustion. This resulted in recalculations to emissions from 2001 to 2015 (AER 2017a, AER 2017b, AER 2017d, BC 2017, SK MOE 2017c, Statistics Canada c)	The new activity data resulted in significant changes to 2015 emissions at the national level for TPM, PM_{10} and $PM_{2.5}$ (+381 t or +17%), and SO_x (+20.3 kt or +21%). The recalculations did not result in changes greater than ±10% for any other pollutants in 2015.
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 for the entire time series, from 1990 through 2015, as a result of changes made to the allocation of NPRI data to Oil and Gas subsectors.	The allocation changes resulted in significant changes to 2015 national level emissions for SO_x (+3.1 t or 15%), NO_x (+2.4 kt or +14%), VOCs (+153 t or +22%), CO (+1.0 kt or +19%), and NH_3 (+0.6 t or 325%). The recalculations resulted in changes in 2015 emission levels of less than ±10% for TPM, PM_{10} and $PM_{2.5}$.

Table A2–14 **Recalculations for Oil and Gas Industry** (cont'd)

Sector	Pollutant	Description	Impact on Emissions
OIL SANDS IN-SITU EXTRACTION AND PROCESSING (under UPSTREAM OIL AND GAS INDUSTRY)			
	TPM, PM_{10}, $PM_{2.5}$, SO_x, NO_x, VOCs, CO, NH_3	New activity data was used to estimate emissions from reported venting and flaring for well testing. This resulted in recalculations to emissions from 2001 to 2015 (AER 2017a, AER 2017b).	The new activity data resulted in significant changes to 2015 emissions at the national level for TPM, PM_{10} and $PM_{2.5}$ (+341 t or +50%). The recalculations did not result in changes greater than ±10% for any other pollutants in 2015.
PETROLEUM LIQUIDS STORAGE (under UPSTREAM OIL AND GAS INDUSTRY)			
	TPM, PM_{10}, $PM_{2.5}$, NO_x, VOCs	Changes were made to the method used to allocate NPRI facilities to Oil and Gas subsectors. In addition, changes were made to the PM Distribution ratios (see Table A_2-23)	The recalculations resulted in significant changes to 2015 emissions at the national level for TPM (+4.3 t or 47%), PM_{10} (+5.3 t or +66%), $PM_{2.5}$ (+3.6 t or +48%), and NO_x (+25 t or +66%). The recalculations did not result in changes greater than ±10% for any other pollutants in 2015.
PETROLEUM LIQUIDS STORAGE (under UPSTREAM OIL AND GAS INDUSTRY)			
	TPM, PM_{10}, $PM_{2.5}$, SO_x, NO_x, VOCs, CO	Recalculations occurred from 1990 thru 2015 as a result of updated activity data being made available (Statistics Canada d).	The recalculations resulted in significant changes to 2015 emissions at the national level for TPM (+1.7 t or 26%), PM_{10} (+1.9 t or +29%), $PM_{2.5}$ (+0.9 t or +14%), NO_x (-0.1 t or -12%), and CO (-0.3 t or -12%). The recalculations did not result in changes greater than ±10% for VOCs or SO_x in 2015.
WELL DRILLING/SERVICING/TESTING (under UPSTREAM OIL AND GAS INDUSTRY)			
	TPM, PM_{10}, $PM_{2.5}$, SO_x, NO_x, VOCs, CO	New activity data was used to estimate emissions from reported venting and flaring for well testing. This resulted in recalculations to emissions from 2001 to 2015 (AER 2017a, CAPP 2017).	The new activity data resulted in significant changes to 2015 emissions at the national level for TPM, PM_{10} and $PM_{2.5}$ (+34 t or +15%), SO_x (+4.5 kt or +69%), NO_x (+17 t or +12%), and CO (+95 t or +15%). The recalculations did not result in changes greater than ±10% for VOCs in 2015.

Table A2–15 **Recalculations for Manufacturing**

Sector	Pollutant	Description	Impact on Emissions
BAKERIES			
	VOC	Updated bread and bakery product manufacturing data from 2000 forward. Also performed 2015 estimates (Statistics Canada e,f,g).	There were no changes in the emission levels of VOC for 1990 since population data was not updated previous to 2000. Emissions from bakeries increased by 4.8 kt for the year 2015 (a significant increase for our in-house calculations of 52%).

Table A2–16 **Recalculations for Transportation and Mobile Equipment**

Sector	Pollutant	Fuel	Description	Impact on Emissions
MARINE TRANSPORTATION				
	B(a)p, B(b)f, B(k)f, I(1,2,3-cd)p, NO_x, SO_x, VOC	Heavy Fuel Oil, Marine Diesel Oil, Marine Gasoline Oil	Model updates from Marine Emissions Inventory Tool 2015, new interpolation for the years between 2015 and 2020.	The recalculations did not impact results for 1990. The recalculations for 2015 resulted in significant changes in the emissions of B(a)p (-41% or -3kg), B(b)f (-41% or -5kg), B(k)f (-41% or -3kg), I(1,2,3-cd)p (-41% or -5kg), NO_x (-12% or -26kt), SO_x (+24% or +3kt) and VOCs (-41% or -3kt). The recalculations did not result in changes in emission levels of greater than 10% for any of the other pollutants in 2015.
ON-ROAD VEHICLES (Includes the following sectors: Heavy-duty diesel vehicles, Heavy-duty gasoline trucks, Heavy-duty LPG/NG vehicles, Light-duty diesel trucks, Light-duty diesel vehicles, Light-duty gasoline trucks, Light-duty gasoline vehicles, Light-duty LPG/CNG vehicles, Light-duty LPG/CNG trucks, Motorcycles, Tire Wear & Brake Lining)				
		All transport fuels	Environment and Climate Change Canada (ECCC) aligns estimates of on- and off-road fuel use with fuel data in the RESD. The activity data have been updated to a more recent edition of the RESD.	The recalculations did not significantly impact results for 1990 or 2015.
OFF-ROAD VEHICLES AND EQUIPMENT				
	CO, VOCs, NH_3	All transport fuels	Environment and Climate Change Canada (ECCC) aligns estimates of on- and off-road fuel use with fuel data in the RESD. The activity data have been updated to a more recent edition of the RESD.	The recalculations for 1990 resulted in significant changes in the emissions of CO (+27% or +771kt), NH_3 (+18% or +68t), and VOCs (+29% or +264kt). The recalculations for 2015 resulted in significant changes in the emissions of VOC (+11% or +20kt).

Table A2–17 Recalculations for Agriculture

Sector	Pollutant	Description	Impact on Emissions
ANIMAL PRODUCTION			
	NH_3	The methodology for estimating ammonia emissions from dairy cattle 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 dairy cattle N excretion estimates and changes to manure management storage types that also change over time . Dairy NH_3 estimates now accurately reflect changes in emissions associated with changes in milk production, taking into account changes in manure storage practices and dietary N intake over time.	Emissions of NH_3 increased slightly by 9.8 kt (3%) in 1990, 7.8 kt (2%) in 2005, and 4.9 kt (2%) in 2015.
FERTILIZER APPLICATION (under CROP PRODUCTION)			
	NH_3	Changes in Dairy manure N excretion rates allocation of manure N between perennial and annual crops, and crop N recommendation rates resulted in the redistribution of various synthetic N fertilizers among eco-districts and between perennial and annual crops.	The recalculations resulted in an increase in ammonia emissions of 1.9 kt for 1990, 1.2 kt for 2005, and 1.7 kt for 2015, with a relative change of less than 3%.
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, in addition to incorporating more detailed RESD data.	The recalculations did not result in changes in emission levels of greater than 10% for any of the pollutants in 1990. For the year 2015, recalculation resulted in the following changes: -12% for Hg, -13% for Cd, 55% for B(a)p, -26% for SO_x, -19% for TPM, -17% for PM_{10} and -10% for PM_{25}. The rest of the pollutant emissions changed by less than ±10% in 2015.

Table A2–18 Recalculations Commercial / Residential / Institutional

Sector	Pollutant	Description	Impact on Emissions
CIGARETTE SMOKING			
	TPM, PM_{10}, $PM_{2.5}$, VOCs, CO, NH_3, Pb, Cd, Hg, dioxins/ furans, B(a)p, B(b)f, B(k)f	Updated population data by province and territory were incorporated for the years 2012 to 2015.	The recalculations resulted in changes of less than ±10% in 2012 and -10% for all pollutants in 2015.
COMMERCIAL AND INSTITUTIONNEL 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, in addition to incorporating more detailed RESD data.	The recalculations did not result in changes in emission levels of greater than 10% for any of the pollutants in 1990. For the year 2015, SO_x changed by -20% and HCB was reported where it wasn't in previous years. The rest of the pollutant emissions changed by less than ±10% in 2015.
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, in addition to incorporating more detailed RESD data.	The recalculations did not result in changes in emission levels of greater than 10% for any of the pollutants in 1990. For the year 2015, Pb changed by 25%, D/F changed by 203%, B(a)p changed by 49%, B(a)f changed by 53%, B(k)f changed by 53%, I(1,2,3-cd)p changed by 43%, CO changed by 72%, VOC changed by 170%, SO_x changed by 77%, NO_x changed by 78%, TPM changed by 41%, PM_{10} changed by 41%, PM_{25} changed by 39%, and NH_3 changed by 65%. The rest of the pollutant emissions changed by less than ±10% in 2015.
HUMAN			
	NH_3	Infant-diapered waste emissions were moved from Other Miscellaneous Sources to the Human sector to better categorize this emission source within the inventory. Updated population data by province and territory were incorporated for the years 2012 to 2015 for both infant diapered waste and respiration and perspiration.	The recalculations and re-categorization of emissions resulted in changes in NH_3 emission levels of less than ±10% in 1990, 2012 and 2015.

Table A2–18 Recalculations Commercial / Residential / Institutional (cont'd)

Sector	Pollutant	Description	Impact on Emissions
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, in addition to incorporating more detailed RESD data.	The recalculations did not result in changes in emission levels of greater than 10% for any of the pollutants in 1990. For the year 2015, SO_x changed by 92% and HCB was reported where it wasn't in previous years. The rest of the pollutant emissions changed by less than ±10% in 2015.
SERVICE STATIONS			
	VOCs	Refined petroleum products retail: The estimation methodology for service stations has been changed from a growth factor approach to use of emission factors from U.S. EPA AP-42. The emissions from refuelling on-road vehicles have been removed as they are already included in on-road estimates for recalculation purposes. Off-road refuelling: The activity data have been updated to a more recent edition of the RESD. On-road refuelling Quantification of the impact of the new methodology for estimates of emissions from refuelling of on-road vehicles cannot be calculated because emissions from this source were not calculated separately in the previous estimation methods. The recalculations of VOC emissions related to refuelling of on-road vehicles estimates are included in Table A2–16 for on-road vehicles.	Refined petroleum products retail: The recalculations did not result in changes greater than ±10% for any of the pollutants in 1990 and 2015. Off-road refuelling: The recalculations resulted in a 59% (8502 t) increase in VOC estimates for 1990, and a 56% (3954 t) increase in VOC estimates for 2015.
OTHER MISCELLANEOUS SOURCES			
	NH_3	Infant-diapered waste emissions were moved from Other Miscellaneous Sources to the Human sector to better categorize this emission source within the inventory.	The recalculations resulted in changes in NH_3 emission levels of -100% (-21 t) in both 1990 and 2015.

Table A2–19 Recalculations for Incineration and Waste Sources

Sector	Pollutant	Description	Impact on Emissions
LANDFILLS (under WASTE TREATMENT AND DISPOSAL)			
	TPM, PM_{10}, $PM_{2.5}$, VOCs, Hg	Changes affecting both PM and VOC estimates include replacement of a 13th order polynomial equation with linear interpolation for a data gap 1991–1997, and corrections to export and incineration activity data. Additionally, historical landfill data (1941–1990) was corrected using updated population data and per capita generation rates. Additional changes affecting VOC estimates include updated parameters in the FOD model, specifically updating DOCf factor from 0.6 to 0.5, and updating the oxidation factor from 0 to 0.1 (IPCC, 2006).	VOCs changed by -31% (2046 t) and -40% (-3018 t) in 1990 and 2015, respectively. PM emissions did not change more than ±10%.
RESIDENTIAL WASTE BURNING (under WASTE INCINERATION)			
	TPM, PM_{10}, $PM_{2.5}$, SO_x, NO_x, VOCs, CO, NH_3, Hg, dioxins/furans, B(a)p, B(b)f, B(k)f, I(cd)p, HCB	The 2014 and 2015 emission estimates were recalculated based on updated population data (Statistics Canada a).	The recalculations resulted in no significant changes in emission levels (± >10%) for 2014 and 2015.

Table A2–20 Recalculations for Paints and Solvents

Sector	Pollutant	Description	Impact on Emissions
DRY CLEANING, GENERAL SOLVENT USE, PRINTING, SURFACE COATINGS			
	VOCs	Projected estimates of national total solvent use for the year 2015 were recalculated using updated macroeconomic growth ratios.	The recalculations resulted in changes in the 2015 emission levels of less than ±10% in all solvent use sectors.

Table A2–21 **Recalculations for Dust**

Sector	Pollutant	Description	Impact on Emissions
RESIDENTIAL CONSTRUCTION (under CONSTRUCTION OPERATIONS)			
	TPM, PM_{10}, $PM_{2.5}$	Emission estimates for the provinces were recalculated using: updated housing starts data for 2012 to 2016 (Statistics Canada t), average provincial soil silt contents weighted by the areas of highest residential construction[1], and annual average lengths of construction by dwelling type and by province for 1990 to 2016 (CMHC 2017). Emission estimates for the territories (YT and NT) were recalculated using the same estimation methodology as the provinces. Average territorial-level silt contents, new housing starts data and annual average lengths of construction by dwelling type at the national level were incorporated.	The recalculations resulted in significant changes in emission levels for 1990. Emissions of TPM, PM_{10} and $PM_{2.5}$ all increased by 99% or by 11 kt, 3 kt and 1 kt, respectively. The recalculations for 2015 also resulted in significant changes in TPM (+162% or +33 kt), PM_{10} (+162% or +10 kt) and $PM_{2.5}$ (+162% or +2 kt) emissions.
COAL TRANSPORTATION			
	TPM, PM_{10}, $PM_{2.5}$	The estimation methodology for Coal Transportation dust has been changed from a growth factor approach that started from data-points of the years 2004 and 2005 (in-house, using NRCan Coal Production statistics, following method of Cope and Bhattacharyya 2001) to using the method employed by Cope and Bhattacharyya for the entire time-series. The updated method also drew on a new data source for coal mine production and coal imports (Statistics Canada 2017a; Statistics Canada 2017b)	Emissions of TPM, and PM_{10} decreased by 12.5% in 1990 (0.22 kt for TPM and 0.11 kt for PM_{10}). Emissions of TPM and PM_{10} increased by 21.2% in 2015 (0.21 kt for TPM, 0.10 kt for PM_{10}). $PM_{2.5}$ emissions had significant changes because of an error in the previous methods. The $PM_{2.5}$ emissions increased by 64.8% in 1990 (0.12 kt) and increased by 517% in 2015 (0.20 kt).

[1] 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.

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 A2–22 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 2015a). No VOC data collected under Part 5 is used in the APEI.

In 2016, approximately 6000 facilities reported releases to air of one or more APEI pollutants to the NPRI.

Using the 2016 NPRI database, facility information and air emissions data for the pollutants in Table A2–22 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.

Table A2–22 **NPRI Reporting Thresholds for the Air Pollutants**

Substance	NPRI 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

For new NPRI reporting facilities, the North American Industry Classification System (NAICS) codes (Statistics Canada 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 based on 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 A2–23.

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**

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

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**

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

$PM_{2.5}$ 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**

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

$PM_{2.5}/PM_{10}$ 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.

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. $InHouseEstimate_{REC} = 0$). 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 2015, 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 A2–4 :

$$If, \quad InHouseEstimate_{Total} \geq FacilityReportedData_{Total}$$
$$Then, \quad InHouseEstimate_{REC} = InHouseEstimate_{Total} - FacilityReportedData_{Total}$$

- 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 A2–5 :

$$If, \quad InHouseEstimate_{Total} \leq FacilityReportedData_{Total}$$
$$Then, \quad InHouseEstimate_{REC} = 0$$

Some points to consider:

- In general, InHouseEstimateREC represents non-reporting facilities (including smaller facilities or emissions from reporting facilities that do not meet reporting requirements).
- In cases where $InHouseEstimate_{REC} = 0$ (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.

Table A2–23 **Particulate Matter (PM) Distribution Ratios**[a]

Sector	PM_{10} Ratio	$PM_{2.5}$ Ratio	$PM_{2.5}/PM_{10}$ Ratio
ORE AND MINERAL INDUSTRIES			
Aluminium Industry			
Primary Aluminium Smelting and Refining	0.686	0.559	0.798
Secondary Aluminium (Includes Recycling)	0.951	0.937	0.926
Asphalt Paving Industry	0.385	0.177	0.513
Cement and Concrete Industry			
Cement Manufacture	0.623	0.310	0.474
Concrete Batching and Products	0.497	0.230	0.465
Lime Manufacture	0.576	0.309	0.512
Foundries			
Die Casting	0.711	0.510	0.810
Ferrous Foundries	0.711	0.510	0.723
Non-ferrous Foundries	0.927	0.490	0.719
Iron and Steel Industries			
Primary (Blast Furnace and DRI)	0.598	0.403	0.650
Secondary (Electric Arc Furnaces)	0.616	0.474	0.802
Steel Recycling	0.711	0.510	0.287
Iron Ore Industry			
Iron Ore Mining	0.513	0.191	0.432
Pelletizing	0.480	0.212	0.410
Mineral Products Industry			
Clay Products	0.802	0.094	0.484
Other Mineral Products	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
Rock, Sand and Gravel	0.460	0.165	0.397
Other Minerals[b]	0.465	0.197	0.398
Non-Ferrous Mining and Smelting Industry			
Primary Ni, Cu, Zn, Pb	0.649	0.375	0.606
Secondary Pb, Cu	0.574	0.396	0.748
Other Metals	0.494	0.444	0.859
OIL AND GAS INDUSTRY			
Downstream Oil and Gas Industry			
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[c]	1.000	1.000	1.000
Other Downstream Petroleum Industry	0.743	0.641	0.628
Upstream Oil and Gas Industry			
Bitumen and Heavy Oil Upgrading[d]	0.677	0.428	0.631
Heavy Crude Oil Cold Production[c]	1.000	1.000	1.000
Light Medium Crude Oil Production[c]	1.000	1.000	1.000
Natural Gas Production and Processing[c]	1.000	1.000	1.000
Natural Gas Transmission and Storage[c]	1.000	1.000	1.000
Oil Sands In-Situ Extraction and Processing[c]	1.000	1.000	1.000
Oil Sands Mining Extraction and Processing[d]	0.658	0.447	0.680
Petroleum Liquids Storage[c]	1.000	0.831	0.831
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	0.540	0.760
Other Electric Power Generation	0.735	0.608	0.924
MANUFACTURING			
Abrasives Manufacture	0.842	0.773	0.371
Bakeries	0.947	0.931	0.857
Chemicals Industry			
Chemical Manufacture	0.737	0.595	0.754
Fertilizer Production	0.575	0.235	0.520

Table A2–23 **Particulate Matter (PM) Distribution Ratios**[a] (cont'd)

Sector	PM_{10} Ratio	$PM_{2.5}$ Ratio	$PM_{2.5}/PM_{10}$ Ratio
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 Industries[e]	Varies	Varies	Varies
Electronics	0.958	0.833	0.834
Food Preparation	0.651	0.409	0.634
Glass Manufacture	0.836	0.755	0.919
Grain Industries	0.387	0.140	0.338
Metal Fabrication	0.747	0.590	0.771
Plastics Manufacture	0.731	0.474	0.817
Pulp and Paper Industry	0.737	0.560	0.757
Textiles	1.000	1.000	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 Industries[f]	Varies	Varies	Varies
AGRICULTURE			
Animal Production	0.280	0.058	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			
Commercial and Institutional Fuel Combustion	0.761	0.581	0.599
Marine Cargo Handling	0.396	0.147	0.365
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 Incineration and Utilities			
Waste Treatment and Disposal			
Landfills	0.778	0.603	0.743
Water and Sewage Treatment	1.000	1.000	0.968
Specialized Waste Treatment and Remediation			
Biological Treatment of Waste			
Waste Sorting and Transfer			
PAINTS AND SOLVENTS			
Dry Cleaning	1.000	1.000	1.000
Printing[g]	Varies	Varies	Varies
Surface Coatings	0.942	0.786	0.792
DUST			
Unpaved Roads[h]	0.265	0.027	0.100
Paved Roads	0.192	0.046	0.242
Coal Transportation	0.500	0.200	0.400

Notes:

a. Based on the facility-reported data for 2006 to 2013 except where indicated otherwise.

b. For the purpose of this table, this category does not include Limestone.

c. Adapted from Environment Canada (2014)

d. Adpated from ECCC (2017)

e. Values for PM ratios for these categories vary by subsector: Other Chemical Industries - values range from 0.465 to 0.886.

f. Values for PM ratios for these categories vary by subsector: Other Manufacturing Industries - values range from 0.122 to 0.771.

g. Values for PM ratios for these categories vary by subsector: Printing - values range from 0.786 to 1.0.

h. 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).

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. Due to 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 2016a):

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

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.

A3

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.

[1] CEIP available online at: **http://www.ceip.at/.**

Canada has recently ratified the 1999 Gothenburg Protocol to Abate Acidification, Eutrophication and Ground-level Ozone which covers: sulphur oxides (SO_x), nitrogen oxides (NO_x), volatile organic compounds (VOCs), ammonia (NH_3), and fine particulate matter ($PM_{2.5}$).

The present edition of the APEI indicates that 14 of the 17 reported air pollutants show reductions compared to historical levels:

- Emissions of sulphur oxides (SO_x) were 1.1 million tonnes in 2016 67% below the emission ceiling of 3.3 million tonnes established under the 1985 Helsinki Protocol on the Reduction of Sulphur Emissions or their Transboundary Fluxes.
- Emissions of nitrogen oxides (NO_x) were 1.8 million tonnes in 2016, 21% below the emission ceiling of 2.3 million tonnes established under the 1988 Sofia Protocol concerning the Control of Emissions of Nitrogen Oxides or their Transboundary Fluxes.
- In 2016, emissions of cadmium (Cd), lead (Pb) and mercury (Hg) were 83%, 75% and 76% respectfully below the ceilings established under the 1998 Aarhus Protocol on Heavy Metals.
- In 2016, 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) (91% below), and dioxins and furans (88% below).

Table A3–1 **Pollutant Emissions Reported to the UNECE and Related Protocols under CLTRAP**

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	Pending establishment of target under protocol / 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	Pending establishment of target under protocol / Stabilize (not exceed) 1987 NO_x level
VOCs	1999 Gothenburg Protocol	Pending establishment of target under protocol
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 non-methane volatile organic compounds (VOCs) and carbon monoxide (CO) decreased by 42% and 54%, respectively, from 1990 to 2016.
- Fine particulate emissions (particulate matter less than or equal to 2.5 microns in diameter ($PM_{2.5}$)) are decreasing from all sources except from dust from paved and unpaved roads, agriculture fuel use, as well as construction; total $PM_{2.5}$ emissions are 18% below 1990 levels.

Exceptions to the general downward trends described above occur for emissions of ammonia (NH_3) (20% above 1990 levels in 2016), and total particulate matter (TPM) (10% above 1990 levels in 2016), as well as coarse particulate matter (PM_{10}) (6% above 1990 levels in 2016).

A3.2. Overview of the UNECE Reporting Template

The UNECE Nomenclature for Reporting (NFR) categories correspond to the sectors described in the European Monitoring and Evaluation Programme/European Environment Agency (EMEP/EEA) 2016 Air Pollutant Emission Inventory Guidebook (EMEP/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 $2H_1$ (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 UNECE NFR 14 Reporting Template for 2018**

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 APEI Emissions to UNECE NFR Categories**

The mapping of emissions by APEI sectors to the UNECE NFR categories involves the division of sectoral emissions into their combustion and process components. Whereas certain sectors contribute solely a process component (in the case of road dust) or solely a 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 **APEI Subsector to UNECE NFR Category Mapping Example**

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	$2C_3$: 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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