CANADA'S **AIR POLLUTANT EMISSIONS INVENTORY** REPORT

1990–2018

2020

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LIST OF ABBREVIATIONS, CHEMICAL FORMULAS AND UNITS

Abbreviations

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

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

Chemical Formulas

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

Units

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

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EXECUTIVE SUMMARY

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

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

This edition of the APEI Report summarizes the most recent estimates of air pollutant emissions for 1990–2018 as of February 2020. The inventory indicates that emissions of 14 of the 17 reported air pollutants show decreases compared to historical levels, and specifically indicate that:[1]

- Emissions of SO_x were 0.8 million tonnes in 2018, 44% below the emission ceiling of 1.45 million tonnes established under the 1999 Gothenburg Protocol to Abate Acidification, Eutrophication and Ground-level Ozone.
- Emissions of NO_x were 1.8 million tonnes in 2018, 21% below the emission ceiling of 2.25 million tonnes established under the 1999 Gothenburg Protocol.
- In 2018, emissions of non-methane VOCs were 9% below the emission ceiling of 2.1 million tonnes established under the 1999 Gothenburg Protocol.
- In 2018, emissions of Cd, Pb, and Hg were 82%, 63% and 82% below the ceilings established under the 1998 Aarhus Protocol on Heavy Metals.
- In 2018, emissions of all POPs were below the ceilings established under the 1998 Aarhus Protocol on Persistent Organic Pollutants, including the four species of polycyclic aromatic hydrocarbons (PAHs) (69% below), hexachlorobenzene (HCB) (91% below), and D/F (84% below).
- Carbon monoxide (CO) decreased by 54% from 1990 to 2018.
- Fine particulate emissions (particulate matter less than or equal to 2.5 microns in diameter [$PM_{2.5}$]) decreased from most sources with the notable exceptions of dust from construction operations and unpaved roads.
    - Total $PM_{2.5}$ emissions in 2018 were 11% below 1990 levels, although emissions have increased since 2009.

Canada's Air Pollution Emission Trends (1990 to 2018)

The last year saw no significant change in the general downward trend in pollutant emissions. A few key sources of pollutants account for a significant portion of the downward trends in emissions. In particular:

- Non-ferrous refining and smelting is a major contributor to emissions of SO_x, Pb, Cd, Hg and HCB; emissions of these pollutants have decreased by 89%, 88%, 95%, 99% and 60% respectively from this source over this time period.
- Home firewood burning is a major contributor to emissions of $PM_{2.5}$, VOC, CO, D/F and PAHs; emissions of these pollutants have decreased by 39%, 36%, 29%, 23% and 26% respectively from this source over this time period, in part due to the adoption of more recent wood combustion equipment.
- Coal-fired electric power generation is a major contributor to emissions of SO_x, Hg and HCB; emissions of these pollutants have decreased by 59%, 71% and 97% respectively from this source over this time period as coal-fired power plants have closed down and have been replaced by cleaner fuels such as natural gas.

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

- Light-duty gasoline trucks and vehicles are major contributors to emissions of NO_x and PAH; emissions of these pollutants have decreased by 58% and 63% respectively from these sources over this time period.
  - The decrease in emissions is despite a 73% increase in the number of these vehicles on the road, and is due to effective fuel and engine regulations.
- Transportation associated with the combustion of gasoline[2] is a major contributor to emissions of VOC and CO; emissions of these pollutants have decreased by 66% and 63% respectively from this source over this time period.
  - The decrease in emissions is despite an increase in on-road and off-road spark-ignition engines, and is due to effective fuel and engine regulations.
- Waste incineration is a major contributor to emissions of HCB and D/F; emissions of these pollutants have decreased by 93% and 94% respectively from this source over this time period, in part due to improvements in incineration technologies.

Despite significant decreases since 1990, emissions of some pollutants, including Pb and $PM_{2.5}$ have begun to rise again in recent years.

In addition, a 39% increase in TPM and 30% increase in PM_{10} emissions since 1990 contrast with the general trends described above; these increases are largely due to increased transportation on unpaved roads as well as construction operations. Another exception to the general downward trends is the steady increase in emissions of ammonia (NH_3), which were 21% above 1990 levels in 2018; the upward trend in ammonia emissions is driven by fertilizer application and animal production.

Irrespective of the downward trends observed in Canadian emissions, air quality issues may still arise when emissions sources are spatially concentrated. While the APEI provides valuable information on emissions within Canada, it does not distinguish localized sources of emissions within the provincial and territorial level aggregations.

Canada's Air Emissions Regulations and Non-Regulatory Measures

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

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

A number of greenhouse gas regulations are also expected to achieve significant co-benefit reductions in air pollutants, including Canada's *Reduction of Carbon Dioxide Emissions from Coal-fired Generation of Electricity Regulations*.

Non-regulatory instruments include guidelines for stationary combustion turbines, as well as codes of practice, performance agreements, and/or pollution prevention planning notices for various sectors. These instruments address emissions from a number of sectors including aluminum, iron, steel and ilmenite, iron ore pellets, potash, base-metals smelting, and pulp and paper.

All regulations and non-regulatory instruments administered under CEPA are available on the registry (https://www.canada.ca/en/environment-climate-change/services/canadian-environmental-protection-act-registry.html).The former are also available on the Department of Justice's online consolidation of federal laws and regulations (https://laws-lois.justice.gc.ca/eng/regulations/).

2 APEI transportation categories considered include light-duty gasoline trucks and vehicles, as well as off-road gasoline/propane/natural gas vehicles and equipment.

CHAPTER 1

INTRODUCTION

1.1. Background on the Air Pollutant Emissions Inventory

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

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

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

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

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

The reporting format for the APEI organizes emissions into 11 source categories that are further broken down into 74 sectors and 74 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 from 1990 to the most recent inventory year, to ensure the trends in emissions are based on consistent and current methodological approaches and data.

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

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 it was originally signed in 1979, the Convention has been extended to a total of eight protocols, of which Canada has ratified seven. Six of these identify measures to be taken by Parties to achieve the Convention's objectives and the seventh concerns financing. Canada is a Party to the following six protocols that identify measures under the Convention:

- the 1985 Helsinki Protocol on the Reduction of Sulphur Emissions (SO_x);
- the 1994 Oslo Protocol on Further Reduction of Sulphur Emissions (SO_x for a designated "Sulphur Oxides Management Area" [SOMA]);
- the 1988 Sofia Protocol concerning the Control of Emissions of Nitrogen Oxides (NO_x);
- the 1998 Aarhus Protocol on Heavy Metals (Cd, Pb and Hg);
- the 1998 Aarhus Protocol on Persistent Organic Pollutants (including dioxins and furans, four species of PAHs, and HCB, among other POPs); and
- the 1999 Gothenburg Protocol to Abate Acidification, Eutrophication and Ground-level Ozone and its 2012 amended version (which covers emissions of six pollutants: SO_2, NO_x, VOCs, NH_3, PM and black carbon).

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

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

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

APEI Source/Sector	Sector Descriptions
TRANSPORTATION AND MOBILE EQUIPMENT	
Air Transportation	Landing and take-off cycles from piston and turbine aircraft used for commercial and private operations. Cruise, landing and take-off cycles from piston and turbine aircraft used for military operations.
Heavy-duty Diesel Vehicles	Diesel vehicles over 3 856 kilograms.
Heavy-duty Gasoline Vehicles	Gasoline vehicles over 3 856 kilograms.
Heavy-duty LPG/NG Vehicles	Propane and natural gas vehicles over 3 856 kilograms.
Light-duty Diesel Trucks	Diesel trucks under 3 856 kilograms.
Light-duty Diesel Vehicles	Diesel vehicles under 3 856 kilograms.
Light-duty Gasoline Trucks	Gasoline trucks under 3 856 kilograms.
Light-duty Gasoline Vehicles	Gasoline vehicles under 3 856 kilograms.
Light Duty LPG/NG Trucks	Propane and natural gas trucks under 3 856 kilograms.
Light Duty LPG/NG Vehicles	Propane and natural gas vehicles under 3 856 kilograms.
Marine Transportation	Marine vessels engaged in domestic and international navigation within Canadian waters.
Motorcycles	Motorcycles.
Off-road Diesel Vehicles and Equipment	Off-road vehicles and mobile equipment using diesel fuel in mining, construction, agriculture, commercial purposes, logging, railway maintenance, and airport ground support; lawn and garden equipment using diesel fuel; and recreational vehicles using diesel fuel.
Off-road Gasoline/LPG/NG Vehicles and Equipment	Off-road vehicles and mobile equipment using gasoline, liquid petroleum gas, and compressed natural gas in mining, construction, agriculture, commercial purposes, logging, railway maintenance, airport ground support; lawn and garden equipment using gasoline, liquid petroleum gas, or compressed natural gas; and recreational vehicles using gasoline, liquid petroleum gas, and compressed natural gas.
Rail Transportation	Freight and passenger trains, including yard switching activities.
Tire Wear and Brake Lining	Tire and brake lining wear from all categories of road transportation.
AGRICULTURE	
Animal Production	Decomposition of animal feed, animal digestion, and manure in housing, storage, applied to agricultural soils, or deposited during grazing.
Crop Production	Application of synthetic nitrogen fertilizers, tillage, wind erosion and crop harvesting.
Fuel Use	Stationary combustion sources in agricultural facilities such as space and water heating and crop drying.
COMMERCIAL / RESIDENTIAL / INSTITUTIONAL	
Cigarette Smoking	Mainstream cigarette smoke, which is directly exhaled by the smoker and sidestream smoke, which is directly released from burning cigarettes.[1]
Commercial and Institutional Fuel Combustion	Combustion of fossil and biogenic fuels used for: space/water heating in commercial establishments; health and educational institutions; and government/public administration facilities.
Commercial Cooking	Cooking meat and french fries in commercial foodservice operations.
Construction Fuel Combustion	Combustion of fossil fuels used for space heating and the heating of construction materials, such as concrete.
Home Firewood Burning	Burning of wood and pellets as fuel for space heating and hot water. Includes emissions from fireplaces, wood stoves and wood-fired boilers.
Human	Human respiration, perspiration, dental amalgams and infant diapered waste.[1]
Marine Cargo Handling	Handling, loading and unloading of materials, goods and merchandise between ships and docks.
Residential Fuel Combustion	Combustion of fossil fuels used for space/water heating in residences.
Service Stations	Fuel transfers and storage at service stations, as well as individuals refueling vehicles and off-road equipment.
Other (Miscellaneous)	Hg in products and facility-reported data from sectors that are not included elsewhere.
INCINERATION AND WASTE	
Crematoriums	Combustion of caskets and human bodies, as well as companion animals.
Waste Incineration	Incinerators used to combust municipal, sewage sludge, and other waste types including hazardous and clinical waste; as well as residential waste burning.
Waste Treatment and Disposal	Landfilling of waste, biological treatment of waste, specialized waste treatment and remediation, waste sorting and transfer as well as municipal wastewater treatment and discharge (including drinking water treatment).
PAINTS AND SOLVENTS	
Dry Cleaning	Dry cleaning of fabric and leather items.
General Solvent Use	Broad range of applications occurring in residential, commercial, industrial and institutional locations. Industrial applications include uses such as: degreasing; adhesives and sealants; aerosols; blowing agents; and resin manufacturing. The use of consumer and commercial products, pesticides and personal care products are also included.
Printing	Manufacturing or use of printing inks, which includes: flexographic; gravure; letterpress; lithographic; and other printing.
Surface Coatings	Broad range of applications and industries, including individuals and companies engaged in the manufacturing or use of paints and coatings.
DUST	
Coal Transportation	Transportation of coal by train or truck.
Construction Operations	Soil disturbance on construction sites (residential, industrial-commercial-institutional [ICI], engineering).
Mine Tailings	Wind erosion at mine tailings ponds located on active and inactive mine sites.
Paved Roads	Re-suspension of particulate matter by vehicles travelling on paved roads.
Unpaved Roads	Re-suspension of particulate matter by vehicles travelling on unpaved roads.
FIRES	
Prescribed Burning	Controlled fires used for land management treatments such as reducing logging residues, managing forest production, controlling insects, and minimizing the potential for destructive wildfires. Excludes the burning of agricultural residues.
Structural Fires	Vehicle fires (including trains and airplanes) and fires that burn buildings.

Note:

1. Cigarette Smoking as well as Infant Diapered Waste (which is included within the Human sector) are being considered for removal from future inventories. If you have any questions, please contact us at ec.iepa-apei.ec@canada.ca or 1-877-877-8375.

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

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

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

1.3. Canada's Air Emissions Regulations and Non-Regulatory Measures

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

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

A number of greenhouse gas regulations are also expected to achieve significant co-benefit reductions in air pollutants, including Canada's *Reduction of Carbon Dioxide Emissions from Coal-fired Generation of Electricity Regulations*.

Non-regulatory instruments include guidelines for new stationary combustion turbines, codes of practice, performance agreements, and/or pollution prevention planning notices for various sectors. These instruments address emissions from a number of sectors including aluminium, iron, steel and ilmenite, iron ore pellets, potash, base-metals smelting, and pulp and paper.

All regulations administered under CEPA are available on the CEPA Environmental Registry (https://www.canada.ca/en/environment-climate-change/services/canadian-environmental-protection-act-registry.html).

CHAPTER 2

2018 EMISSIONS AND TRENDS

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

The contribution of each source category to total emissions of air pollutants for 2018 varies by pollutant (Table 2–1),[1] for example:

- Dust is an important source of particulate matter (PM) emissions, accounting for 59% of emissions of particulate matter less than or equal to 2.5 microns ($PM_{2.5}$).
- Agriculture accounts for most ammonia (NH_3) emissions (93%).
- Incineration and Waste accounts for a significant proportion of hexachlorobenzene (HCB) (56%) and dioxins and furans (D/F) (33%) emissions.
- The Ore and Mineral Industries account for the largest proportion of lead (Pb) (84%), cadmium (Cd) (61%), and mercury (Hg) (43%) emissions.
- Transportation and Mobile Equipment are the largest emitters of carbon monoxide (CO) (56%) and nitrogen oxides (NO_x) (51%).
- The Oil and Gas Industry is the largest emitter of volatile organic compounds (VOCs) (35%) and sulphur oxides (SO_x) (32%).
- The Commercial / Residential / Institutional category is a particularly significant source of polycyclic aromatic hydrocarbons (PAHs) (90%).

The last year saw no significant change in the general downward trend in Canada's air pollutant emissions for the time period 1990 to 2018. A few key sources of pollutants account for a significant portion of the downward trends in emissions. In particular:

- Non-ferrous refining and smelting is a major contributor to emissions of SO_x, Pb, Cd, Hg and HCB; emissions of these pollutants have decreased by 89%, 88%, 95%, 99% and 60% respectively from this source over this time period.
- Home firewood burning is a major contributor to emissions of $PM_{2.5}$, VOC, CO, D/F and PAHs; emissions of these pollutants have decreased by 39%, 36%, 29%, 23% and 26% respectively from this source over this time period, in part due to the adoption of more recent wood combustion equipment.
- Coal-fired electric power generation is a major contributor to emissions of SO_x, Hg and HCB; emissions of these pollutants have decreased by 59%, 71% and 97% respectively from this source over this time period as coal-fired power plants have closed down and have been replaced by cleaner fuels such as natural gas.
- Light-duty gasoline trucks and vehicles are major contributors to emissions of NO_x and PAH; emissions of these pollutants have decreased by 58% and 63% respectively from these sources over this time period.
  - The decreases in emissions is despite a 73% increase in the number of these vehicles on the road, and is due to effective fuel and engine regulations.

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

- Transportation associated with the combustion of gasoline[2] is a major contributor to emissions of VOC and CO; emissions of these pollutants have decreased by 66% and 63% respectively from this source over this time period.
  - The decreases in emissions is despite an increase in on-road and off-road spark-ignition engines, and is due to effective fuel and engine regulations.
- Waste incineration is a major contributor to emissions of HCB and D/F; emissions of these pollutants have decreased by 93% and 94% respectively from this source over this time period, in part due to improvements in incineration technologies.

Despite significant decreases since 1990, emissions of some pollutants, including Pb and $PM_{2.5}$ have begun to rise again in recent years.

In addition, a 39% increase in total particulate matter and 30% increase in PM_{10} emissions since 1990 contrast with the general trends described above; these increases are largely due to increased transportation on unpaved roads as well as construction operations. Another exception to the general downward trends is the steady increase in emissions of ammonia (NH_3), which were 21% above 1990 levels in 2018; the upward trend in ammonia emissions is driven by fertilizer application and animal production.

The subsequent sections of this chapter identify the important sources of emissions for each substance in 2018 and their varying contribution to total emissions over time.

The full time series of national, provincial, and territorial pollutant emissions from 1990 to 2018 are available through the Air Pollutant Emission Inventory Online Data Search Tool (http://ec.gc.ca/inrp-npri/donnees-data/ap/index.cfm?lang=En). The APEI data is also available on-line at the Government of Canada Open Data Portal website (https://open.canada.ca/data/en/dataset/fa1c88a8-bf78-4fcb-9c1e-2a5534b92131).

2 APEI transportation categories considered include light-duty gasoline trucks and vehicles, as well as off-road gasoline/propane/natural gas vehicles and equipment.

Table 2–1 2018 Total Air Pollutant Emissions for Canada by Source

Source	Pollutants													
	TPM (kt)	PM_{10} (kt)	$PM_{2.5}$ (kt)	SO_x (kt)	NO_x (kt)	VOC (kt)	CO (kt)	NH_3 (kt)	Pb (kg)	Cd (kg)	Hg (kg)	D/F (gTEQ)	PAH (kg)	HCB (g)
Ore and Mineral Industries	230	97	34	260	82	12	530	1.5	160 000	4 800	1 300	16	620	3 100
Oil and Gas Industry	24	17	12	260	490	670	570	2.6	570	260	74	-	22	-
Electric Power Generation (Utilities)	16	6.6	3.2	220	130	1.1	36	0.21	1 300	98	590	1.5	0.04	400
Manufacturing	100	41	16	45	69	100	140	12	6 800	590	110	2.5	100	330
Transportation and Mobile Equipment	50	50	37	10	910	300	3 200	8.2	19 000	91	60	21	8 500	-
Agriculture	3 900	1 600	380	6.0	4.1	120	1.3	450	62	89	9.0	0.45	0.35	0.82
Commercial / Residential / Institutional	190	180	180	6.6	83	290	1 200	3.1	3 100	1 100	470	7.5	100 000	0.05
Incineration and Waste	6.5	3.8	2.8	2.3	4.3	10	18	3.9	250	780	460	24	710	4 900
Paints and Solvents	0.02	0.03	0.02	-	0.02	410	-	-	-	0.14	-	-	-	-
Dust	24 000	6 900	950	-	-	-	-	-	-	-	-	-	-	-
Fires	3.9	3.3	2.4	0.01	0.50	1.5	24	0.05	-	-	-	0.53	680	-
TOTAL	**29 000**	**8 900**	**1 600**	**810**	**1 800**	**1 900**	**5 800**	**480**	**190 000**	**7 800**	**3 100**	**73**	**110 000**	**8 800**

Notes:
Totals may not add up due to rounding.
Emissions of pollutants are expressed in either kt, kg, gTEQ or g.
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.
- Indicates no emissions
0.00 Indicates emissions truncated due to rounding

Table 2–2 2018 Total Air Pollutant Emissions for Canada by Source, Sector and Subsector

Source	Pollutants													
	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[1] (kg)	HCB (g)
ORE AND MINERAL INDUSTRIES	**230 000**	**97 000**	**34 000**	**260 000**	**82 000**	**12 000**	**530 000**	**1 500**	**160 000**	**4 800**	**1 300**	**16**	**620**	**3 100**
Aluminium Industry	5 200	3 800	3 100	62 000	1 200	1 600	380 000	-	-	-	24	-	190	-
Alumina (Bauxite Refining)	84	46	41	1.0	280	20	310	-	-	-	-	-	-	-
Primary Aluminium Smelting and Refining	5 100	3 800	3 100	62 000	920	1 600	380 000	-	-	-	24	-	190	-
Secondary Aluminium Production (Includes Recycling)	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Asphalt Paving Industry	35 000	6 800	1 300	740	840	6 000	2 900	-	980	18	18	0.00	10	-
Cement and Concrete Industry	47 000	15 000	7 700	25 000	36 000	760	16 000	480	400	10	300	8.3	0.34	900
Cement Manufacturing	2 500	1 400	800	23 000	31 000	680	14 000	480	290	8.6	250	8.3	0.34	900
Concrete Batching and Products	42 000	13 000	6 300	0.06	35	80	0.76	-	110	1.0	-	-	-	-
Gypsum Product Manufacturing	110	90	84	3.0	230	1.6	150	-	-	-	44	-	-	-
Lime Manufacturing	1 700	950	440	2 700	4 400	7.1	1 800	-	5.1	-	1.3	-	-	-
Foundries	6 100	5 700	5 200	48	140	350	49 000	-	210	21	-	0.00	-	0.00
Die Casting	20	14	11	0.00	0.47	-	0.39	-	0.36	-	-	-	-	-
Ferrous Foundries	6 000	5 700	5 200	48	140	350	49 000	-	200	21	-	0.00	-	0.00
Non-ferrous Foundries	2.8	2.6	2.6	-	-	-	-	-	14	0.01	-	-	-	-
Iron and Steel Industry	6 700	4 100	2 600	19 000	11 000	1 200	28 000	58	6 200	230	610	7.1	400	1 100
Primary (Blast Furnace and DRI)	6 100	3 700	2 300	17 000	8 900	890	24 000	58	4 800	190	260	1.3	400	170
Secondary (Electric Arc Furnaces)	590	440	320	1 600	1 800	300	3 500	-	1 400	39	340	5.8	0.56	930
Steel Recycling	10	6.3	6.2	0.33	-	-	15	-	20	-	4.3	0.00	-	4.6
Other (Iron and Steel Industry)	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Table 2–2 **2018 Total Air Pollutant Emissions for Canada by Source, Sector and Subsector** (cont'd)

Source	Pollutants													
	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[1] (kg)	HCB (g)
Iron Ore Industry	11 000	3 300	880	9 800	9 900	270	16 000	-	2 900	49	73	0.00	18	-
Iron Ore Mining	1 700	820	180	74	1 400	33	2 200	-	6.3	0.19	0.10	0.00	-	-
Pelletizing	9 700	2 500	690	9 700	8 500	240	14 000	-	2 900	48	73	-	18	-
Mineral Products Industry	480	410	290	750	240	110	550	250	-	-	-	-	-	-
Clay Products	14	11	5.6	0.01	0.70	-	1.6	-	-	-	-	-	-	-
Brick Products	110	83	22	120	110	-	330	-	-	-	-	-	-	-
Other (Mineral Products Industry)	360	310	260	630	120	110	220	250	-	-	-	-	-	-
Mining and Rock Quarrying	120 000	56 000	12 000	1 900	22 000	1 400	19 000	120	39 000	250	110	0.02	0.01	6.5
Coal Mining Industry	85 000	38 000	4 300	610	1 500	4.5	4 900	-	540	71	1.3	-	-	-
Metal Mining	16 000	8 200	3 700	900	11 000	570	9 400	90	39 000	180	110	0.02	0.00	4.2
Potash	6 600	3 400	1 700	1.3	2 200	390	2 000	-	0.06	0.02	0.01	-	-	-
Rock, Sand and Gravel	11 000	5 500	1 600	9.0	780	-	410	-	0.03	-	-	-	-	-
Silica Production	280	140	14	-	-	-	-	-	-	-	-	-	-	-
Limestone	87	43	7.7	-	20	-	-	-	-	-	-	-	-	-
Other (Mining and Rock Quarrying)	1 200	750	410	410	6 500	440	2 300	28	150	1.4	5.7	0.00	0.00	2.4
Non-Ferrous Refining and Smelting Industry	3 100	1 500	1 000	140 000	1 600	79	15 000	580	110 000	4 200	200	0.42	0.33	1 100
Primary Ni, Cu, Zn, Pb	3 100	1 500	1 000	140 000	1 600	30	15 000	530	110 000	4 200	200	0.41	-	1 100
Secondary Pb, Cu	11	6.6	5.5	830	-	49	-	-	330	-	0.01	0.01	0.33	-
Other (Non-Ferrous Refining and Smelting Industry)	10	4.8	4.6	-	80	-	-	47	-	-	-	0.00	-	0.13
OIL AND GAS INDUSTRY	**24 000**	**17 000**	**12 000**	**260 000**	**490 000**	**670 000**	**570 000**	**2 600**	**570**	**260**	**74**	**-**	**22**	**-**
Downstream Oil and Gas Industry	3 800	2 500	1 600	48 000	16 000	22 000	29 000	92	400	95	50	-	14	-
Petroleum Refining	3 800	2 500	1 600	48 000	16 000	8 500	29 000	92	400	95	50	-	14	-
Refined Petroleum Products Bulk Storage and Distribution	5.8	3.9	3.9	-	23	13 000	67	-	-	0.09	0.00	-	0.01	-
Refined Petroleum Product Pipelines	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Natural Gas Distribution	1.9	1.9	1.9	0.50	130	250	120	-	-	-	-	-	-	-
Other (Downstream Oil and Gas Industry)	0.87	0.67	0.67	0.05	200	17	32	-	-	-	-	-	-	-
Upstream Oil and Gas Industry	20 000	14 000	11 000	210 000	470 000	650 000	540 000	2 500	170	160	24	-	7.9	-
Accidents and Equipment Failures	-	-	-	-	-	120 000	-	-	-	-	-	-	-	-
Disposal and Waste Treatment	19	19	19	0.03	22	46	60	0.31	-	-	-	-	-	-
Heavy Crude Oil Cold Production	460	460	460	2 000	13 000	20 000	18 000	44	-	-	-	-	-	-
Light/Medium Crude Oil Production	3 000	3 000	3 000	11 000	43 000	390 000	56 000	17	5.0	4.2	-	-	-	-
Natural Gas Production and Processing	2 500	2 500	2 500	110 000	320 000	52 000	410 000	240	-	-	-	-	-	-
Natural Gas Transmission and Storage	97	97	97	22	19 000	800	6 700	0.64	-	-	-	-	-	-
Oil Sands In-Situ Extraction	1 100	1 100	1 100	21 000	39 000	13 000	27 000	940	-	62	11	-	-	-
Oil Sands Mining, Extraction and Upgrading	12 000	7 100	3 400	63 000	35 000	39 000	22 000	1 300	170	94	13	-	7.9	-
Petroleum Liquids Storage	20	18	18	-	33	7 600	21	-	-	-	-	-	-	-
Petroleum Liquids Transportation	15	15	11	130	0.36	16 000	2.0	-	-	-	-	-	-	-
Well Drilling/Servicing/Testing	100	100	100	6 100	82	1 500	290	0.01	-	-	-	-	-	-
ELECTRIC POWER GENERATION (UTILITIES)	**16 000**	**6 600**	**3 200**	**220 000**	**130 000**	**1 100**	**36 000**	**210**	**1 300**	**98**	**590**	**1.5**	**0.04**	**400**
Coal	14 000	5 400	2 200	210 000	92 000	210	15 000	130	810	62	570	0.95	-	300
Diesel	230	220	200	120	9 800	71	1 800	-	-	-	-	-	-	-
Natural Gas	490	430	340	1 400	18 000	570	13 000	10	83	24	2.1	0.00	0.04	81
Waste Materials	17	16	15	-	200	-	230	10	0.36	0.09	0.32	0.01	-	-
Other (Electric Power Generation)	980	540	450	6 800	9 000	280	6 100	56	380	11	22	0.52	-	17
MANUFACTURING	**100 000**	**41 000**	**16 000**	**45 000**	**69 000**	**100 000**	**140 000**	**12 000**	**6 800**	**590**	**110**	**2.5**	**100**	**330**
Abrasives Manufacturing	80	37	17	-	-	18	-	-	-	-	-	0.01	-	-
Bakeries	15	13	10	-	-	4 900	-	-	-	-	-	-	-	-
Biofuel Production	12	7.5	3.2	-	-	43	-	-	-	-	-	-	-	-
Chemicals Industry	3 000	2 100	1 500	20 000	25 000	9 800	14 000	9 300	30	8.2	18	0.00	24	-
Chemical Manufacturing	1 700	1 200	1 000	17 000	9 400	3 000	8 100	84	1.1	0.00	16	0.00	24	-
Cleaning Compound Manufacturing	6.5	6.5	6.5	-	52	-	-	-	0.01	-	-	-	-	-
Fertilizer Production	930	600	290	1 900	9 300	650	3 400	9 200	2.0	4.5	1.1	-	-	-
Paint and Varnish Manufacturing	7.3	6.3	4.1	-	3.9	400	3.3	1.6	18	-	-	-	-	-
Petrochemical Industry	210	150	100	760	5 400	1 700	2 100	0.01	9.0	3.7	0.47	-	0.09	-
Plastics and Synthetic Resins Fabrication	96	63	52	8.3	360	3 600	340	20	-	-	0.02	0.00	-	-
Other (Chemical Industry)	18	11	9.0	0.09	180	400	47	-	-	-	-	-	-	-
Electronics	1.0	0.97	0.82	-	-	24	-	16	23	-	7.8	-	-	-
Food Preparation	3 000	1 600	660	420	1 900	17 000	1 300	240	-	-	-	-	-	-
Glass Manufacturing	160	150	140	600	770	160	300	-	-	-	-	-	-	-
Grain Industry	67 000	19 000	3 000	340	820	2 200	330	4.9	-	-	-	-	-	-
Grain Processing	66 000	19 000	2 900	340	820	2 200	330	4.7	-	-	-	-	-	-
Warehousing and Storage	780	360	64	-	-	-	-	0.23	-	-	-	-	-	-
Metal Fabrication	660	480	400	560	440	4 300	1 300	27	3 300	310	-	0.81	-	230
Plastics Manufacturing	69	56	52	0.01	18	9 700	13	-	1.3	-	-	-	-	-
Pulp and Paper Industry	16 000	10 000	6 800	22 000	29 000	13 000	82 000	1 600	1 500	200	59	1.1	75	100
Pulp and Paper Product Manufacturing	16 000	10 000	6 700	22 000	29 000	12 000	82 000	1 600	1 500	200	59	1.1	75	100
Converted Paper Product Manufacturing	38	31	26	0.06	4.7	1 100	58	-	0.68	-	-	-	-	-
Textiles	1.6	1.6	1.2	19	7.7	510	0.10	-	-	-	-	-	-	-
Vehicle Manufacturing (Engines, Parts, Assembly, Painting)	350	250	200	0.03	660	7 800	930	6.5	64	-	-	-	0.02	-
Wood Products	12 000	6 600	3 400	550	11 000	30 000	36 000	690	1 900	77	25	0.57	5.9	0.09
Panel Board Mills	5 300	2 900	1 800	290	5 200	13 000	17 000	250	1 900	55	17	0.21	2.2	-
Sawmills	6 300	3 200	1 300	240	5 100	14 000	18 000	440	40	22	8.3	0.36	3.7	-
Other (Wood Products)	790	510	330	21	510	3 000	660	-	-	-	-	-	0.00	0.09
Other (Manufacturing)	370	260	200	340	680	2 500	540	40	6.7	0.11	0.56	-	-	-

Table 2–2 **2018 Total Air Pollutant Emissions for Canada by Source, Sector and Subsector** (cont'd)

Source	Pollutants													
	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[1] (kg)	HCB (g)
TRANSPORTATION AND MOBILE EQUIPMENT	**50 000**	**50 000**	**37 000**	**10 000**	**910 000**	**300 000**	**3 200 000**	**8 200**	**19 000**	**91**	**60**	**21**	**8 500**	**-**
Air Transportation	360	360	290	520	7 300	2 200	36 000	4.9	18 000	-	-	-	4.4	-
Heavy-duty Diesel Vehicles	10 000	10 000	9 300	170	260 000	18 000	68 000	790	-	-	0.00	0.00	660	-
Heavy-duty Gasoline Vehicles	1 100	1 100	1 000	200	38 000	13 000	420 000	340	-	-	0.00	0.00	2 000	-
Heavy-duty LPG/NG Vehicles	3.8	3.8	3.3	0.65	140	68	1 500	2.0	-	-	0.00	0.00	6.7	-
Light-duty Diesel Trucks	22	22	21	4.2	2 000	1 800	21 000	20	-	-	0.00	0.00	2.4	-
Light-duty Diesel Vehicles	13	13	12	3.0	830	730	8 300	16	-	-	0.00	0.00	2.1	-
Light-duty Gasoline Trucks	1 600	1 600	1 400	800	78 000	63 000	790 000	3 400	-	-	0.01	0.00	3 200	-
Light-duty Gasoline Vehicles	1 300	1 300	1 100	530	45 000	48 000	500 000	3 000	-	-	0.01	0.00	2 500	-
Light-duty LPG/NG Trucks	0.60	0.60	0.53	0.19	34	30	310	1.1	-	-	0.00	0.00	1.1	-
Light-duty LPG/NG Vehicles	0.03	0.03	0.03	0.01	1.2	1.3	12	0.06	-	-	0.00	0.00	0.06	-
Marine Transportation	4 600	4 400	4 100	7 600	190 000	8 800	20 000	290	600	32	0.47	20	120	-
Motorcycles	25	25	22	4.7	720	2 100	14 000	42	-	-	0.00	0.00	42	-
Off-road Diesel Vehicles and Equipment	12 000	12 000	12 000	160	150 000	17 000	81 000	220	-	-	-	-	-	-
Off-road Gasoline/LPG/NG Vehicles and Equipment	4 400	4 200	4 000	87	31 000	120 000	1 200 000	96	-	-	-	-	-	-
Rail Transportation	2 100	2 100	2 000	52	100 000	4 500	18 000	58	180	59	59	1.4	36	-
Tire Wear and Brake Lining	12 000	12 000	1 600	-	-	-	-	-	-	-	-	-	-	-
AGRICULTURE	**3 900 000**	**1 600 000**	**380 000**	**6 000**	**4 100**	**120 000**	**1 300**	**450 000**	**62**	**89**	**9.0**	**0.45**	**0.35**	**0.82**
Animal Production	37 000	10 000	2 100	-	-	120 000	-	290 000	-	-	-	-	-	-
Crop Production	3 800 000	1 600 000	380 000	-	-	-	-	170 000	-	-	-	-	-	-
Harvesting	260 000	120 000	23 000	-	-	-	-	-	-	-	-	-	-	-
Inorganic Fertilizer Application	13 000	6 200	1 800	-	-	-	-	160 000	-	-	-	-	-	-
Sewage Sludge Application	-	-	-	-	-	-	-	5 200	-	-	-	-	-	-
Tillage Practices	1 000 000	220 000	100 000	-	-	-	-	-	-	-	-	-	-	-
Wind Erosion	2 500 000	1 300 000	250 000	-	-	-	-	-	-	-	-	-	-	-
Fuel Use	970	580	360	6 000	4 100	190	1 300	44	62	89	9.0	0.45	0.35	0.82
COMMERCIAL / RESIDENTIAL / INSTITUTIONAL	**190 000**	**180 000**	**180 000**	**6 600**	**83 000**	**290 000**	**1 200 000**	**3 100**	**3 100**	**1 100**	**470**	**7.5**	**100 000**	**0.05**
Cigarette Smoking[2]	380	380	380	-	-	6.3	1 800	71	1.1	2.8	0.10	0.01	0.49	-
Commercial and Institutional Fuel Combustion	2 700	2 600	2 600	960	28 000	1 400	20 000	190	220	480	61	0.18	2.2	-
Commercial Cooking	17 000	17 000	15 000	-	-	2 300	6 400	-	-	-	-	-	110	-
Construction Fuel Combustion	170	160	150	410	2 800	47	480	46	7.2	10	2.4	0.03	0.22	-
Home Firewood Burning	170 000	160 000	160 000	2 800	19 000	230 000	1 200 000	1 800	2 600	150	40	7.0	100 000	-
Human[2]	-	-	-	-	-	-	-	640	-	-	1.8	-	-	-
Marine Cargo Handling	500	240	98	97	26	-	-	-	50	2.5	-	-	-	-
Residential Fuel Combustion	2 700	2 600	2 500	2 400	33 000	1 800	13 000	340	260	480	80	0.28	3.2	0.05
Service Stations	-	-	-	-	-	51 000	-	-	-	-	-	-	-	-
Other (Miscellaneous)	-	-	-	-	-	-	-	-	-	-	290	-	-	-
INCINERATION AND WASTE	**6 500**	**3 800**	**2 800**	**2 300**	**4 300**	**10 000**	**18 000**	**3 900**	**250**	**780**	**460**	**24**	**710**	**4 900**
Crematoriums	7.5	7.5	7.5	14	23	2.5	19	-	5.8	0.98	290	3.3	0.01	29
Waste Incineration	2 400	2 300	2 300	2 100	2 100	4 400	14 000	160	160	770	66	21	710	4 900
Municipal Incineration	56	44	28	230	850	38	200	19	150	770	33	0.05	-	62
Residential Waste Burning	2 300	2 300	2 300	140	850	4 200	12 000	90	-	-	-	20	710	4 900
Sewage Sludge Incineration	120	12	3.4	1 700	410	150	2 000	49	11	5.1	30	0.00	-	-
Other (Waste Incineration)	1.3	0.57	0.18	0.67	42	16	2.6	-	0.69	0.06	3.4	0.08	-	3.7
Waste Treatment and Disposal	4 000	1 500	470	220	2 100	5 500	3 400	3 700	88	7.2	100	-	0.00	0.22
Biological Treatment of Waste	7.5	7.5	7.5	0.70	4.0	0.01	0.58	-	-	-	-	-	-	-
Landfills	3 900	1 400	390	16	630	4 400	3 000	-	7.6	0.05	82	-	-	-
Municipal Wastewater Treatment and Discharge	73	58	58	200	1 400	820	380	3 700	0.76	0.13	13	-	0.00	-
Specialized Waste Treatment and Remediation	18	18	12	-	85	240	39	8.4	79	7.0	5.7	-	-	0.22
Waste Sorting and Transfer	-	-	-	-	-	44	-	-	-	-	-	-	-	-
PAINTS AND SOLVENTS	**23**	**31**	**23**	**-**	**15**	**410 000**	**-**	**-**	**-**	**0.14**	**-**	**-**	**-**	**-**
Dry Cleaning	13	16	13	-	-	190	-	-	-	-	-	-	-	-
General Solvent Use	-	-	-	-	-	310 000	-	-	-	-	-	-	-	-
Printing	7.5	7.7	7.3	-	15	19 000	-	-	-	-	-	-	-	-
Surface Coatings	2.4	7.0	2.4	-	-	82 000	-	-	-	0.14	-	-	-	-
DUST	**24 000 000**	**6 900 000**	**950 000**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
Coal Transportation	1 100	560	220	-	-	-	-	-	-	-	-	-	-	-
Construction Operations	8 400 000	2 500 000	510 000	-	-	-	-	-	-	-	-	-	-	-
Mine Tailings	3 400	2 800	690	-	-	-	-	-	-	-	-	-	-	-
Paved Roads	450 000	89 000	23 000	-	-	-	-	-	-	-	-	-	-	-
Unpaved Roads	15 000 000	4 200 000	420 000	-	-	-	-	-	-	-	-	-	-	-
FIRES	**3 900**	**3 300**	**2 400**	**10**	**500**	**1 500**	**24 000**	**52**	**-**	**-**	**-**	**0.53**	**680**	**-**
Prescribed Burning	3 700	3 100	2 200	10	470	1 300	23 000	40	-	-	-	0.53	680	-
Structural Fires	210	210	190	-	27	210	1 200	12	-	-	-	-	-	-
GRAND TOTAL	**29 000 000**	**8 900 000**	**1 600 000**	**810 000**	**1 800 000**	**1 900 000**	**5 800 000**	**480 000**	**190 000**	**7 800**	**3 100**	**73**	**110 000**	**8 800**

Notes:
Totals may not add up due to rounding.
1. PAH includes B(a)p, B(b)f, B(k)f, I(1,2,3-cd)p.
2. Cigarette Smoking as well as Infant Diapered Waste (which is included within the Human sector) are being considered for removal from future inventories. If you have any questions, please contact us at ec.iepa-apei.ec@canada.ca or 1-877-877-8375.
- Indicates no emissions
0.00 Indicates emissions truncated due to rounding

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

In 2018, approximately 1.6 million tonnes (Mt) of $PM_{2.5}$ were emitted in Canada (Table 2–3). Dust sources accounted for 59% (0.95 Mt) of total $PM_{2.5}$ emissions, with the most important dust sources being construction operations at 31% (507 kt) and unpaved roads at 26% (422 kt) of total $PM_{2.5}$ emissions. Agriculture was the second largest contributor and accounted for 24% (383 kt) of $PM_{2.5}$ emissions, most of which are attributed to crop production (23% or 380 kt). In these sectors, PM is largely emitted by non-combustion sources.

Commercial/residential/institutional sources accounted for 11% (182 kt) of total $PM_{2.5}$ emissions in 2018, with the most important contributor being home firewood burning at 10% (161 kt) of total $PM_{2.5}$ emissions. All other commercial/residential/institutional sources accounted for less than 1% of total $PM_{2.5}$ emissions.

Overall, emissions of $PM_{2.5}$ decreased from 1990 to 2009, and have gradually increased since then (Figure 2–1). The downward trend was influenced predominantly by decreasing emissions from crop production and home firewood burning. Emissions from crop production decreased for the period of 1990 to 2011 due to a reduction in summerfallow and the adoption of conservation tillage practices, but have since been offset by an increase in wind erosion emissions that is resulting from increased production of pulse crops. Decreased emissions from home firewood burning are due to the reduction in the use of conventional fireplaces and wood stoves; replaced with fireplace inserts, furnaces and stoves with improved emission controls and combustion efficiencies; as well as a reduction in the use of wood as a heating fuel. Emissions from construction operations decreased until 2002; increased until 2012; and have since stabilized. Emissions of $PM_{2.5}$ from unpaved roads followed a more gradual, consistent increasing trend from 1990 through to 2018. The trend in $PM_{2.5}$ emissions from roads is driven predominantly by the use of unpaved roads in Alberta, Saskatchewan, Manitoba and Ontario.

The most significant changes in $PM_{2.5}$ emissions from 1990 to 2018 include:

- Dust: increase of 93% (459 kt), of which:
  - Construction operations: increase of 112% (268 kt)
  - Paved and unpaved roads: increase of 78% (191 kt total)
- Agriculture: decrease of 44% (295 kt), of which:
  - Crop production: decrease of 44% (296 kt)
- Commercial/residential/institutional: decrease of 35% (99 kt), of which:
  - Home firewood burning: decrease of 39% (101 kt)

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

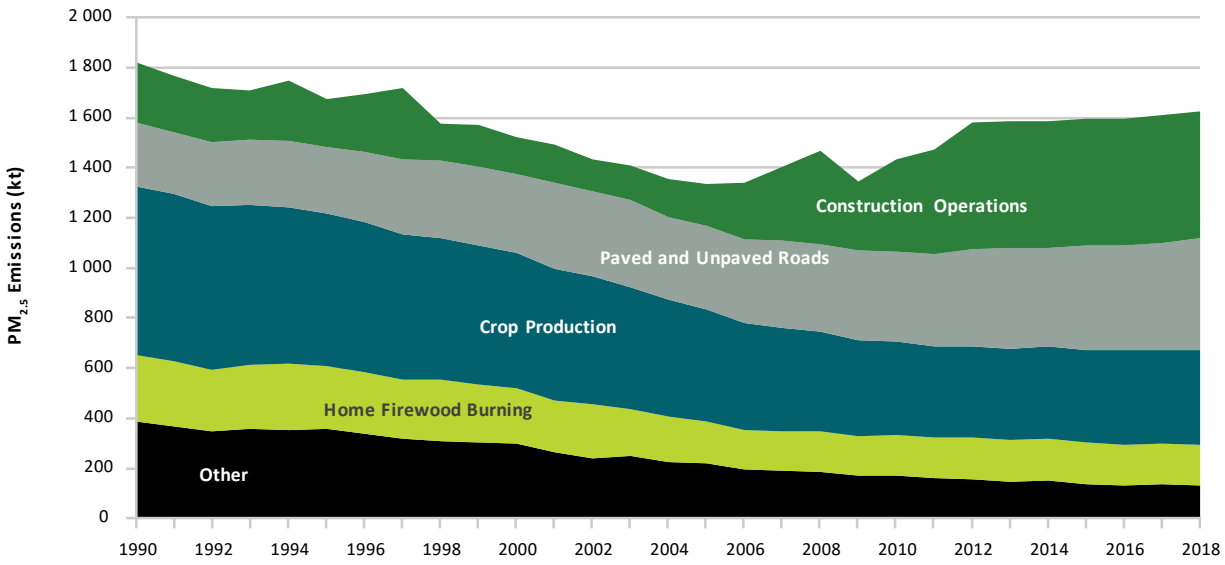


Table 2–3 National Summary of Annual $PM_{2.5}$ Emissions

Source	1990	2000	2005	2013	2014	2015	2016	2017	2018
	(tonnes)								
ORE AND MINERAL INDUSTRIES	**55 000**	**52 000**	**42 000**	**33 000**	**33 000**	**31 000**	**32 000**	**35 000**	**34 000**
Aluminium Industry	5 400	4 500	5 100	4 100	3 700	3 300	3 400	3 400	3 100
Asphalt Paving Industry	1 900	1 700	1 500	1 400	1 600	1 300	1 300	1 300	1 300
Cement and Concrete Industry	11 000	9 600	12 000	7 800	7 600	7 600	7 100	7 300	7 700
Foundries	6 100	5 100	5 200	5 200	5 200	5 200	5 200	5 200	5 200
Iron and Steel Industry	11 000	9 400	5 100	2 100	2 500	2 400	2 200	2 500	2 600
Iron Ore Industry	1 600	4 500	1 700	1 100	950	950	1 000	940	880
Mineral Products Industry	1 200	1 100	940	350	370	320	290	230	290
Mining and Rock Quarrying	8 500	9 700	6 300	9 000	8 700	8 100	10 000	13 000	12 000
Non-Ferrous Refining and Smelting Industry	8 800	6 000	4 100	1 800	1 900	2 100	1 700	1 300	1 000
OIL AND GAS INDUSTRY	**12 000**	**13 000**	**12 000**	**11 000**	**13 000**	**12 000**	**11 000**	**13 000**	**12 000**
Downstream Oil and Gas Industry	5 100	4 900	4 600	1 700	1 600	1 400	1 500	1 500	1 600
Upstream Oil and Gas Industry	6 800	8 500	7 800	9 200	11 000	11 000	9 700	11 000	11 000
ELECTRIC POWER GENERATION (UTILITIES)	**48 000**	**23 000**	**8 900**	**3 200**	**3 600**	**3 500**	**3 400**	**3 300**	**3 200**
Coal	46 000	20 000	5 000	2 200	2 500	2 400	2 200	2 200	2 200
Diesel	270	410	400	180	200	210	220	180	200
Natural Gas	1 200	1 900	1 700	500	420	420	390	340	340
Waste Materials	0.41	1.6	1.0	1.9	2.1	2.3	16	16	15
Other (Electric Power Generation)	1 300	730	1 800	320	450	460	550	530	450
MANUFACTURING	**120 000**	**78 000**	**45 000**	**20 000**	**19 000**	**18 000**	**17 000**	**17 000**	**16 000**
Abrasives Manufacturing	390	210	200	8.1	8.4	15	14	15	17
Bakeries	-	-	0.36	1.2	1.1	7.2	7.5	6.7	10
Biofuel Production	-	-	-	12	5.3	4.6	4.2	3.4	3.2
Chemicals Industry	4 800	4 500	4 100	1 600	1 400	1 300	1 300	1 200	1 500
Electronics	120	37	4.5	0.41	1.00	0.91	0.89	0.87	0.82
Food Preparation	1 400	2 100	1 700	810	770	740	720	720	660
Glass Manufacturing	920	1 300	1 100	140	150	150	160	130	140
Grain Industry	2 200	2 900	2 000	2 400	2 800	2 800	2 900	3 000	3 000
Metal Fabrication	800	1 300	890	780	420	410	410	440	400
Plastics Manufacturing	160	170	120	78	69	53	61	56	52
Pulp and Paper Industry	61 000	25 000	18 000	8 900	8 400	7 600	6 900	7 200	6 800
Textiles	13	22	18	2.8	2.5	1.2	1.3	1.2	1.2
Vehicle Manufacturing (Engines, Parts, Assembly, Painting)	1 700	1 600	570	190	170	180	170	170	200
Wood Products	37 000	31 000	14 000	4 800	4 400	4 700	3 800	3 600	3 400
Other (Manufacturing)	6 200	8 800	2 900	220	220	190	210	200	200
TRANSPORTATION AND MOBILE EQUIPMENT	**94 000**	**95 000**	**79 000**	**49 000**	**45 000**	**37 000**	**33 000**	**35 000**	**37 000**
Air Transportation	260	330	290	290	280	270	270	280	290
Heavy-duty Diesel Vehicles	15 000	15 000	17 000	11 000	9 600	8 600	8 400	8 800	9 300
Heavy-duty Gasoline Vehicles	3 500	2 300	2 100	1 200	960	920	980	990	1 000
Heavy-duty LPG/NG Vehicles	600	680	160	2.7	1.4	1.2	1.8	3.3	3.3
Light-duty Diesel Trucks	13	14	15	11	12	15	16	19	21
Light-duty Diesel Vehicles	49	26	16	13	13	14	13	13	12
Light-duty Gasoline Trucks	2 000	2 400	1 600	1 300	1 200	1 200	1 300	1 300	1 400
Light-duty Gasoline Vehicles	5 000	3 600	2 200	1 300	1 200	1 100	1 100	1 100	1 100
Light-duty LPG/NG Trucks	180	83	36	0.61	0.46	0.41	0.44	0.52	0.53
Light-duty LPG/NG Vehicles	23	12	5.3	0.03	0.02	0.02	0.02	0.03	0.03
Marine Transportation	9 700	13 000	15 000	11 000	10 000	4 000	4 000	4 000	4 100
Motorcycles	22	21	23	20	20	20	21	22	22
Off-Road Diesel Vehicles and Equipment	41 000	42 000	29 000	16 000	14 000	13 000	10 000	11 000	12 000
Off-Road Gasoline/LPG/NG Vehicles and Equipment	13 000	10 000	6 800	4 100	4 200	4 200	3 700	3 800	4 000
Rail Transportation	3 600	3 400	3 300	2 500	2 300	2 000	1 800	2 000	2 000
Tire Wear and Brake Lining	730	1 100	1 200	1 500	1 500	1 500	1 500	1 600	1 600
AGRICULTURE	**680 000**	**540 000**	**450 000**	**370 000**	**370 000**	**370 000**	**380 000**	**380 000**	**380 000**
Animal Production	1 700	2 100	2 300	2 000	2 000	2 000	2 100	2 100	2 100
Crop Production	680 000	540 000	450 000	370 000	370 000	370 000	370 000	380 000	380 000
Fuel Use	120	140	130	420	440	390	390	380	360
COMMERCIAL / RESIDENTIAL / INSTITUTIONAL	**280 000**	**240 000**	**190 000**	**190 000**	**190 000**	**180 000**	**180 000**	**180 000**	**180 000**
Cigarette Smoking[1]	810	690	530	410	410	360	370	370	380
Commercial and Institutional Fuel Combustion	2 000	2 600	2 600	2 300	2 400	2 300	2 300	2 500	2 600
Commercial Cooking	14 000	15 000	17 000	17 000	16 000	15 000	15 000	15 000	15 000
Construction Fuel Combustion	180	110	150	130	130	130	140	140	150
Home Firewood Burning	260 000	220 000	170 000	160 000	160 000	160 000	160 000	160 000	160 000
Human[1]	-	-	-	-	-	-	-	-	-
Marine Cargo Handling	180	140	190	79	79	67	110	110	98
Residential Fuel Combustion	2 400	2 600	2 500	2 400	2 500	2 400	2 100	2 200	2 500
Service Stations	-	-	-	-	-	-	-	-	-
Other (Miscellaneous)	-	-	-	-	-	-	-	-	-
INCINERATION AND WASTE	**5 100**	**4 400**	**4 100**	**2 700**	**2 700**	**2 700**	**2 700**	**2 800**	**2 800**
Crematoriums	4.3	6.1	4.6	6.1	6.6	6.8	7.1	7.3	7.5
Waste Incineration	4 500	3 800	3 400	2 200	2 200	2 200	2 200	2 300	2 300
Waste Treatment and Disposal	600	630	700	440	450	460	450	460	470
PAINTS AND SOLVENTS	**-**	**-**	**9.0**	**15**	**11**	**15**	**16**	**23**	**23**
Dry Cleaning	-	-	0.62	9.0	4.9	6.1	4.5	14	13
General Solvent Use	-	-	-	-	-	-	-	-	-
Printing	-	-	7.6	5.5	5.5	8.3	10	7.4	7.3
Surface Coatings	-	-	0.94	0.78	0.63	1.00	1.5	1.5	2.4
DUST	**490 000**	**460 000**	**500 000**	**910 000**	**900 000**	**920 000**	**930 000**	**930 000**	**950 000**
Coal Transportation	320	300	240	370	300	230	250	220	220
Construction Operations	240 000	150 000	170 000	510 000	510 000	510 000	510 000	510 000	510 000
Mine Tailings	270	290	320	500	530	620	580	660	690
Paved Roads	24 000	19 000	19 000	22 000	21 000	22 000	22 000	22 000	23 000
Unpaved Roads	230 000	290 000	310 000	380 000	370 000	390 000	400 000	410 000	420 000
FIRES	**36 000**	**6 900**	**4 500**	**3 200**	**12 000**	**10 000**	**9 100**	**4 800**	**2 400**
Prescribed Burning	36 000	6 600	4 200	2 900	12 000	10 000	8 900	4 600	2 200
Structural Fires	350	280	250	260	200	190	190	190	190
GRAND TOTAL	**1 800 000**	**1 500 000**	**1 300 000**	**1 600 000**	**1 600 000**	**1 600 000**	**1 600 000**	**1 600 000**	**1 600 000**

Notes:

Totals may not add up due to rounding.

1. Cigarette Smoking as well as Infant Diapered Waste (which is included within the Human sector) are being considered for removal from future inventories. If you have any questions, please contact us at ec.iepa-apei.ec@canada.ca or 1-877-877-8375.

- Indicates no emissions

0.00 Indicates emissions truncated due to rounding

2.2. Sulphur Oxides (SO_x)

In 2018, 811 kt of SO_x were emitted in Canada (Table 2–4). Ore and mineral industries were one of the largest contributor, accounting for 32% (259 kt) of national emissions. Approximately 54% (140 kt) of the emissions from this source were attributed to the non-ferrous refining and smelting industry. The oil and gas industry also accounts for 32% (261 kt) of total SO_x emissions. Electric power generation (utilities) was the third-largest source of SO_x, accounting for 27% (220 kt) of total SO_x emissions, almost entirely attributed to coal-fired electricity generation at 26% (212 kt). The remaining 9% of SO_x emissions were distributed across multiple sources.

Overall, SO_x emissions decreased by 73% (2.2 Mt) between 1990 and 2018 (Figure 2–2). Reductions in emissions from the non-ferrous refining and smelting industry were the largest driver of this downward trend, particularly in the early 1990s, and again from 2008 to 2018. This decrease can be attributed to the preparation and implementation of pollution prevention plans by facilities, the installation of new technology or processes at facilities, and the closure of three major smelters in Manitoba, Ontario and Quebec (ECCC, 2017). Emissions from electric power generation decreased significantly from 2003 to 2018, due primarily to the closure of, or improvements to, generating stations burning heavy fuel oil. Improvements consist of the installation of pollution control equipment or switching to low sulphur heavy fuel oil. Upstream oil and gas industry experienced a gradual decline throughout the time series as a result of a decrease in emissions from oil sands mining, extraction and upgrading and natural gas processing, attributed to better emission control technologies.

The most significant decreases in SO_x emissions from 1990 to 2018 include:

- Ore and mineral industries: decrease of 83% (1.2 Mt), of which:
  - Non-ferrous refining and smelting industry: decrease of 89% (1.1 Mt)
- Electric power generation (utilities): decrease of 64% (398 kt), of which:
  - Coal (electric power generation): decrease of 59% (303 kt)
- Oil and gas industry: decrease of 51% (270 kt), of which:
  - Upstream oil and gas industry: decrease of 47% (187 kt)

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

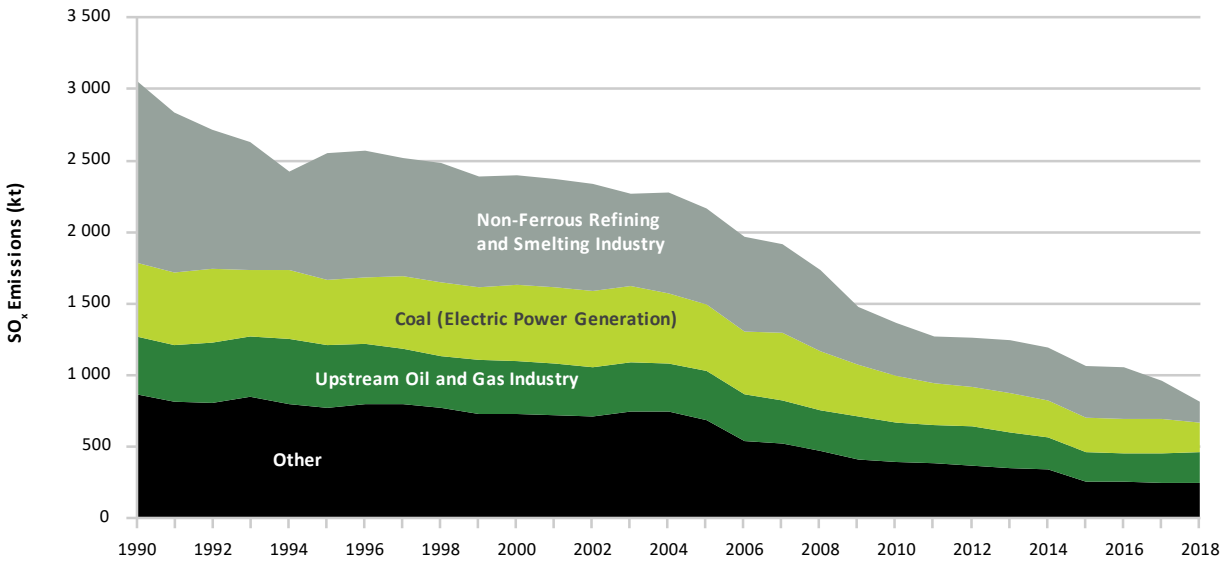


Table 2–4 National Summary of Annual SO_x Emissions

Source	1990	2000	2005	2013	2014	2015	2016	2017	2018
	(tonnes)								
ORE AND MINERAL INDUSTRIES	**1 500 000**	**910 000**	**860 000**	**490 000**	**490 000**	**480 000**	**480 000**	**390 000**	**260 000**
Aluminium Industry	31 000	48 000	63 000	60 000	55 000	57 000	64 000	66 000	62 000
Asphalt Paving Industry	740	650	940	650	720	630	680	710	740
Cement and Concrete Industry	48 000	45 000	54 000	23 000	20 000	23 000	24 000	23 000	25 000
Foundries	1 300	910	720	48	48	48	49	48	48
Iron and Steel Industry	36 000	29 000	30 000	24 000	24 000	22 000	17 000	18 000	19 000
Iron Ore Industry	59 000	17 000	19 000	11 000	10 000	12 000	13 000	12 000	9 800
Mineral Products Industry	1 300	820	1 800	1 800	1 600	1 400	1 500	850	750
Mining and Rock Quarrying	32 000	9 500	11 000	2 500	2 300	2 100	1 900	2 300	1 900
Non-Ferrous Refining and Smelting Industry	1 300 000	760 000	680 000	370 000	370 000	360 000	360 000	270 000	140 000
OIL AND GAS INDUSTRY	**530 000**	**500 000**	**450 000**	**310 000**	**280 000**	**250 000**	**240 000**	**250 000**	**260 000**
Downstream Oil and Gas Industry	130 000	140 000	110 000	55 000	52 000	44 000	50 000	47 000	48 000
Upstream Oil and Gas Industry	400 000	370 000	340 000	250 000	230 000	210 000	190 000	210 000	210 000
ELECTRIC POWER GENERATION (UTILITIES)	**620 000**	**620 000**	**520 000**	**280 000**	**270 000**	**250 000**	**250 000**	**250 000**	**220 000**
Coal	510 000	530 000	460 000	270 000	260 000	240 000	240 000	240 000	210 000
Diesel	430	440	330	15	39	160	73	74	120
Natural Gas	29 000	21 000	19 000	1 400	2 400	2 100	1 800	1 100	1 400
Waste Materials	0.76	1.4	-	-	-	-	-	-	-
Other (Electric Power Generation)	74 000	63 000	41 000	5 100	7 000	7 700	8 200	8 300	6 800
MANUFACTURING	**230 000**	**160 000**	**150 000**	**50 000**	**53 000**	**49 000**	**45 000**	**43 000**	**45 000**
Abrasives Manufacturing	4 000	860	860	-	-	-	-	-	-
Bakeries	-	-	0.15	0.01	0.01	0.01	0.01	0.01	-
Biofuel Production	-	-	-	1.7	0.33	-	-	-	-
Chemicals Industry	38 000	31 000	36 000	19 000	21 000	23 000	21 000	18 000	20 000
Electronics	1 700	3 000	3 000	-	-	-	0.04	-	-
Food Preparation	3 500	4 800	6 000	740	610	370	280	370	420
Glass Manufacturing	2 300	2 800	2 500	630	600	630	610	590	600
Grain Industry	230	210	390	630	470	510	530	490	340
Metal Fabrication	2 300	2 700	2 000	880	580	700	540	550	560
Plastics Manufacturing	470	26	3.3	0.01	0.01	-	-	0.01	0.01
Pulp and Paper Industry	140 000	78 000	66 000	26 000	29 000	24 000	21 000	22 000	22 000
Textiles	390	390	320	31	22	17	21	19	19
Vehicle Manufacturing (Engines, Parts, Assembly, Painting)	2 300	2 100	990	150	0.64	0.01	0.01	0.02	0.03
Wood Products	3 300	3 400	2 900	570	640	590	600	600	550
Other (Manufacturing)	29 000	25 000	24 000	730	650	350	400	360	340
TRANSPORTATION AND MOBILE EQUIPMENT	**140 000**	**160 000**	**150 000**	**94 000**	**88 000**	**12 000**	**11 000**	**11 000**	**10 000**
Air Transportation	790	820	900	620	560	440	450	470	520
Heavy-duty Diesel Vehicles	15 000	6 700	6 100	170	160	160	150	160	170
Heavy-duty Gasoline Vehicles	970	2 000	150	190	180	180	190	190	200
Heavy-duty LPG/NG Vehicles	240	1 300	9.0	0.43	0.32	0.38	0.45	0.65	0.65
Light-duty Diesel Trucks	170	78	52	1.8	2.2	2.8	3.2	3.8	4.2
Light-duty Diesel Vehicles	570	130	110	3.2	3.2	3.3	3.1	3.1	3.0
Light-duty Gasoline Trucks	3 200	6 400	510	670	670	700	740	760	800
Light-duty Gasoline Vehicles	7 300	8 400	560	560	540	540	550	530	530
Light-duty LPG/NG Trucks	190	180	10	0.20	0.16	0.14	0.16	0.18	0.19
Light-duty LPG/NG Vehicles	23	28	1.4	0.01	0.01	0.01	0.01	0.01	0.01
Marine Transportation	80 000	110 000	130 000	91 000	86 000	9 700	9 000	8 300	7 600
Motorcycles	15	25	2.8	4.0	4.0	4.2	4.4	4.5	4.7
Off-Road Diesel Vehicles and Equipment	28 000	17 000	6 700	150	150	150	130	150	160
Off-Road Gasoline/LPG/NG Vehicles and Equipment	1 400	1 500	83	74	78	80	80	83	87
Rail Transportation	5 700	5 400	5 000	50	51	48	45	51	52
Tire Wear and Brake Lining	-	-	-	-	-	-	-	-	-
AGRICULTURE	**2 200**	**1 500**	**2 900**	**8 500**	**9 300**	**6 900**	**6 400**	**6 400**	**6 000**
Animal Production	-	-	-	-	-	-	-	-	-
Crop Production	-	-	-	-	-	-	-	-	-
Fuel Use	2 200	1 500	2 900	8 500	9 300	6 900	6 400	6 400	6 000
COMMERCIAL / RESIDENTIAL / INSTITUTIONAL	**52 000**	**36 000**	**37 000**	**9 900**	**10 000**	**8 900**	**7 300**	**7 100**	**6 600**
Cigarette Smoking[1]	-	-	-	-	-	-	-	-	-
Commercial and Institutional Fuel Combustion	19 000	19 000	21 000	3 000	3 300	2 400	1 500	1 500	960
Commercial Cooking	-	-	-	-	-	-	-	-	-
Construction Fuel Combustion	1 900	620	1 400	530	520	620	420	440	410
Home Firewood Burning	3 600	3 300	2 700	2 800	2 800	2 800	2 800	2 800	2 800
Human[1]	-	-	-	-	-	-	-	-	-
Marine Cargo Handling	0.01	0.00	-	140	140	88	91	120	97
Residential Fuel Combustion	28 000	14 000	11 000	3 400	3 200	3 000	2 500	2 300	2 400
Service Stations	-	-	-	-	-	-	-	-	-
Other (Miscellaneous)	-	-	-	-	-	-	-	-	-
INCINERATION AND WASTE	**2 700**	**2 800**	**2 900**	**2 200**	**2 200**	**2 500**	**2 200**	**2 300**	**2 300**
Crematoriums	5.0	7.0	8.9	12	13	13	14	14	14
Waste Incineration	2 300	2 400	2 400	2 000	2 000	2 100	2 000	2 100	2 100
Waste Treatment and Disposal	440	400	420	170	210	380	220	220	220
PAINTS AND SOLVENTS	**-**	**-**	**0.05**	**0.00**	**0.00**	**0.00**	**-**	**-**	**-**
Dry Cleaning	-	-	-	-	-	-	-	-	-
General Solvent Use	-	-	-	-	-	-	-	-	-
Printing	-	-	0.05	0.00	0.00	0.00	-	-	-
Surface Coatings	-	-	-	-	-	-	-	-	-
DUST	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
Coal Transportation	-	-	-	-	-	-	-	-	-
Construction Operations	-	-	-	-	-	-	-	-	-
Mine Tailings	-	-	-	-	-	-	-	-	-
Paved Roads	-	-	-	-	-	-	-	-	-
Unpaved Roads	-	-	-	-	-	-	-	-	-
FIRES	**180**	**28**	**18**	**13**	**53**	**41**	**34**	**20**	**10**
Prescribed Burning	180	28	18	13	53	41	34	20	10
Structural Fires	-	-	-	-	-	-	-	-	-
GRAND TOTAL	**3 100 000**	**2 400 000**	**2 200 000**	**1 200 000**	**1 200 000**	**1 100 000**	**1 100 000**	**960 000**	**810 000**

Notes:
Totals may not add up due to rounding.
1. Cigarette Smoking as well as Infant Diapered Waste (which is included within the Human sector) are being considered for removal from future inventories. If you have any questions, please contact us at ec.iepa-apei.ec@canada.ca or 1-877-877-8375.
- Indicates no emissions
0.00 Indicates emissions truncated due to rounding

2.3. Nitrogen Oxides (NO_x)

Approximately 1.8 Mt of NO_x were released in Canada in 2018 (Table 2–5). Transportation and mobile equipment was the largest contributor, accounting for 51% (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 34% (602 kt) of total NO_x emissions. The oil and gas industry accounted for 27% (486 kt) of total NO_x emissions in 2018, with the upstream oil and gas industry accounting for nearly all of the oil and gas industry total (470 kt). Electric power generation (utilities) contributed 7% (129 kt) of total NO_x emissions, with coal-fired generation contributing 5% (92 kt) of the national total. The remaining 15% of NO_x emissions were distributed across multiple sources.

From 1990 to 2018, national NO_x emissions decreased by 25% (601 kt) (Figure 2–3). A significant driver of this trend was the decrease in emissions from light-duty gasoline trucks and vehicles, as a result of increasingly stringent vehicle regulations. Emissions from off-road diesel vehicles and equipment and heavy-duty diesel vehicles increased at the beginning of the time series and decreased after 2000 and 2005, respectively. Within electric power generation (utilities), coal contributed to the downward trend across the time series, with a gradual decrease in emissions from 1998 to 2018. 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 an increase in marine activity.

The most significant changes in NO_x emissions from 1990 to 2018 include:

- Transportation and mobile equipment: decrease of 34% (461 kt), of which:
  - Off-road diesel vehicles and equipment: decrease of 54% (179 kt)
  - Light-duty gasoline trucks and vehicles: decrease of 58% (170 kt)
  - Rail Transportation: decrease of 38% (62 kt)
  - Marine transportation: increase of 37% (51 kt)
- Electric power generation (utilities): decrease of 50% (128 kt), of which:
  - Coal: decrease of 55% (114 kt)
- Oil and gas industry: increase of 41% (140 kt), of which:
  - Upstream oil and gas industry: increase of 51% (159 kt)
  - Downstream oil and gas industry: decrease of 54% (19 kt)

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

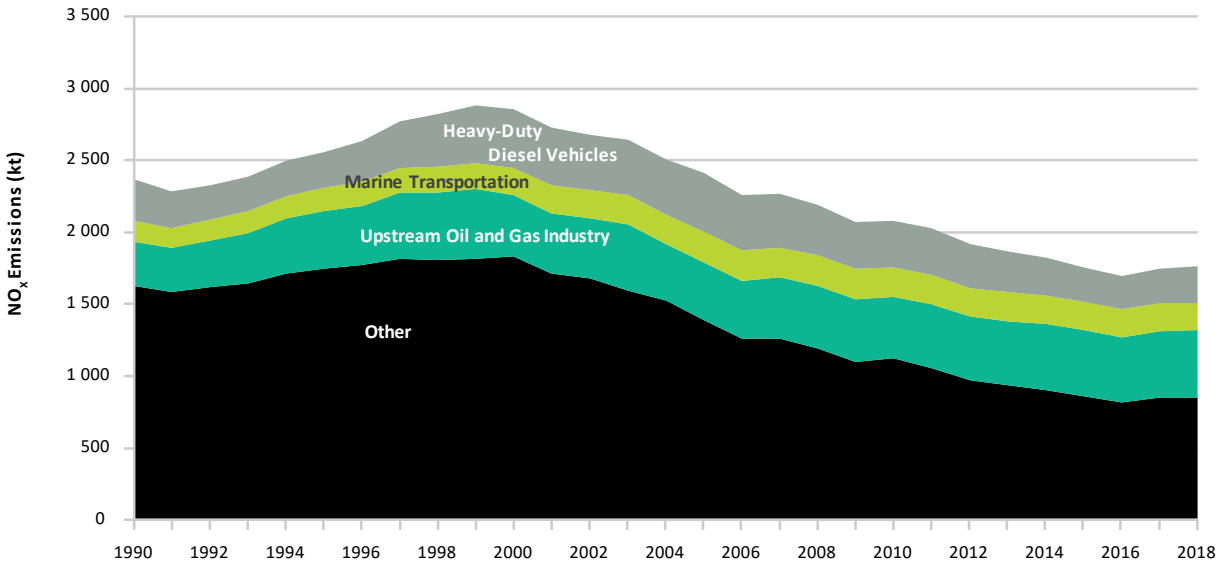


Table 2–5 National Summary of Annual NO_X Emissions

Source	1990	2000	2005	2013	2014	2015	2016	2017	2018
	(tonnes)								
ORE AND MINERAL INDUSTRIES	**100 000**	**99 000**	**110 000**	**83 000**	**82 000**	**81 000**	**78 000**	**86 000**	**82 000**
Aluminium Industry	1 600	1 300	2 000	1 300	1 100	1 100	1 200	1 200	1 200
Asphalt Paving Industry	1 200	1 100	1 200	1 000	1 200	910	890	840	840
Cement and Concrete Industry	43 000	45 000	54 000	32 000	31 000	35 000	32 000	34 000	36 000
Foundries	490	640	540	140	140	140	140	140	140
Iron and Steel Industry	19 000	16 000	13 000	11 000	12 000	11 000	11 000	11 000	11 000
Iron Ore Industry	10 000	10 000	9 800	13 000	12 000	12 000	11 000	12 000	9 900
Mineral Products Industry	1 300	560	1 100	300	310	290	300	290	240
Mining and Rock Quarrying	24 000	20 000	23 000	22 000	23 000	20 000	19 000	25 000	22 000
Non-Ferrous Refining and Smelting Industry	4 300	3 800	1 800	1 600	1 600	1 600	1 900	1 800	1 600
OIL AND GAS INDUSTRY	**350 000**	**460 000**	**430 000**	**460 000**	**480 000**	**480 000**	**470 000**	**480 000**	**490 000**
Downstream Oil and Gas Industry	35 000	30 000	31 000	18 000	17 000	17 000	17 000	17 000	16 000
Upstream Oil and Gas Industry	310 000	430 000	400 000	450 000	460 000	460 000	450 000	460 000	470 000
ELECTRIC POWER GENERATION (UTILITIES)	**260 000**	**330 000**	**250 000**	**160 000**	**170 000**	**150 000**	**150 000**	**150 000**	**130 000**
Coal	210 000	230 000	190 000	120 000	130 000	110 000	120 000	110 000	92 000
Diesel	3 100	8 300	8 500	8 600	9 200	9 900	9 100	8 900	9 800
Natural Gas	20 000	65 000	38 000	21 000	19 000	17 000	17 000	16 000	18 000
Waste Materials	45	200	88	52	94	110	220	260	200
Other (Electric Power Generation)	28 000	28 000	21 000	8 000	10 000	11 000	10 000	9 700	9 000
MANUFACTURING	**190 000**	**170 000**	**140 000**	**70 000**	**69 000**	**69 000**	**69 000**	**70 000**	**69 000**
Abrasives Manufacturing	240	90	74	-	-	-	-	-	-
Bakeries	4.0	4.0	-	1.1	1.0	0.89	0.89	0.95	-
Biofuel Production	-	-	-	33	41	18	16	18	-
Chemicals Industry	41 000	47 000	37 000	23 000	22 000	23 000	23 000	23 000	25 000
Electronics	150	160	71	-	-	-	0.01	-	-
Food Preparation	2 400	2 900	3 300	1 700	1 700	1 800	1 700	1 900	1 900
Glass Manufacturing	7 000	7 400	6 100	920	890	920	780	780	770
Grain Industry	1 400	1 300	1 600	950	1 000	780	760	1 100	820
Metal Fabrication	5 900	9 000	1 200	370	360	470	490	420	440
Plastics Manufacturing	880	810	100	0.95	0.91	9.0	11	13	18
Pulp and Paper Industry	72 000	49 000	45 000	31 000	30 000	30 000	29 000	30 000	29 000
Textiles	120	170	110	33	33	8.2	7.8	7.8	7.7
Vehicle Manufacturing (Engines, Parts, Assembly, Painting)	2 500	3 500	1 500	630	610	650	610	600	660
Wood Products	18 000	22 000	19 000	11 000	12 000	11 000	12 000	11 000	11 000
Other (Manufacturing)	33 000	30 000	22 000	620	580	480	510	560	680
TRANSPORTATION AND MOBILE EQUIPMENT	**1 400 000**	**1 700 000**	**1 400 000**	**1 000 000**	**940 000**	**890 000**	**840 000**	**880 000**	**910 000**
Air Transportation	6 700	6 700	6 700	6 400	6 100	6 300	6 500	6 800	7 300
Heavy-duty Diesel Vehicles	290 000	410 000	410 000	290 000	260 000	240 000	230 000	240 000	260 000
Heavy-duty Gasoline Vehicles	60 000	82 000	60 000	44 000	37 000	35 000	37 000	37 000	38 000
Heavy-duty LPG/NG Vehicles	15 000	34 000	4 500	110	59	61	80	140	140
Light-duty Diesel Trucks	790	1 500	2 100	1 200	1 300	1 400	1 600	1 800	2 000
Light-duty Diesel Vehicles	2 200	2 200	1 200	990	940	920	860	860	830
Light-duty Gasoline Trucks	97 000	190 000	130 000	77 000	70 000	68 000	72 000	74 000	78 000
Light-duty Gasoline Vehicles	200 000	220 000	120 000	57 000	50 000	46 000	46 000	45 000	45 000
Light-duty LPG/NG Trucks	7 500	5 900	2 900	43	31	27	29	34	34
Light-duty LPG/NG Vehicles	820	740	280	1.1	0.81	0.73	0.89	1.2	1.2
Marine Transportation	140 000	190 000	210 000	200 000	200 000	190 000	190 000	190 000	190 000
Motorcycles	320	440	530	630	620	640	680	700	720
Off-Road Diesel Vehicles and Equipment	330 000	360 000	280 000	190 000	170 000	170 000	130 000	140 000	150 000
Off-Road Gasoline/LPG/NG Vehicles and Equipment	53 000	37 000	28 000	28 000	30 000	30 000	29 000	30 000	31 000
Rail Transportation	160 000	150 000	130 000	110 000	110 000	98 000	88 000	100 000	100 000
Tire Wear and Brake Lining	-	-	-	-	-	-	-	-	-
AGRICULTURE	**2 100**	**2 200**	**2 100**	**4 400**	**4 600**	**4 100**	**4 200**	**4 200**	**4 100**
Animal Production	-	-	-	-	-	-	-	-	-
Crop Production	-	-	-	-	-	-	-	-	-
Fuel Use	2 100	2 200	2 100	4 400	4 600	4 100	4 200	4 200	4 100
COMMERCIAL / RESIDENTIAL / INSTITUTIONAL	**87 000**	**90 000**	**86 000**	**80 000**	**83 000**	**80 000**	**77 000**	**79 000**	**83 000**
Cigarette Smoking[1]	-	-	-	-	-	-	-	-	-
Commercial and Institutional Fuel Combustion	23 000	30 000	30 000	25 000	27 000	26 000	26 000	27 000	28 000
Commercial Cooking	-	-	-	-	-	-	-	-	-
Construction Fuel Combustion	3 900	2 000	2 700	2 600	2 500	2 500	2 600	2 700	2 800
Home Firewood Burning	25 000	23 000	19 000	20 000	20 000	20 000	20 000	20 000	19 000
Human[1]	-	-	-	-	-	-	-	-	-
Marine Cargo Handling	0.20	0.06	-	29	31	47	24	28	26
Residential Fuel Combustion	35 000	35 000	35 000	33 000	34 000	32 000	29 000	30 000	33 000
Service Stations	-	-	-	-	-	-	-	-	-
Other (Miscellaneous)	-	-	-	-	-	-	-	-	-
INCINERATION AND WASTE	**7 900**	**7 600**	**9 000**	**4 500**	**4 200**	**4 200**	**4 200**	**5 200**	**4 400**
Crematoriums	8.2	12	15	19	21	21	22	23	23
Waste Incineration	2 500	2 500	4 000	2 700	2 400	2 400	2 400	2 400	2 300
Waste Treatment and Disposal	5 400	5 100	5 000	1 800	1 800	1 900	1 800	2 700	2 100
PAINTS AND SOLVENTS	**-**	**-**	**35**	**23**	**23**	**23**	**23**	**17**	**15**
Dry Cleaning	-	-	-	-	-	-	-	-	-
General Solvent Use	-	-	-	-	-	-	-	-	-
Printing	-	-	35	23	23	23	23	17	15
Surface Coatings	-	-	-	-	-	-	-	-	-
DUST	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
Coal Transportation	-	-	-	-	-	-	-	-	-
Construction Operations	-	-	-	-	-	-	-	-	-
Mine Tailings	-	-	-	-	-	-	-	-	-
Paved Roads	-	-	-	-	-	-	-	-	-
Unpaved Roads	-	-	-	-	-	-	-	-	-
FIRES	**7 500**	**1 400**	**890**	**650**	**2 600**	**2 000**	**1 700**	**990**	**500**
Prescribed Burning	7 400	1 400	850	610	2 600	2 000	1 600	970	470
Structural Fires	49	39	35	36	28	27	27	27	27
GRAND TOTAL	**2 400 000**	**2 900 000**	**2 400 000**	**1 900 000**	**1 800 000**	**1 800 000**	**1 700 000**	**1 700 000**	**1 800 000**

Notes:

Totals may not add up due to rounding.

1. Cigarette Smoking as well as Infant Diapered Waste (which is included within the Human sector) are being considered for removal from future inventories. If you have any questions, please contact us at ec.iepa-apei.ec@canada.ca or 1-877-877-8375.

- Indicates no emissions

0.00 Indicates emissions truncated due to rounding

2.4. Volatile Organic Compounds (VOCs)

In 2018, approximately 1.9 Mt of VOCs were released in Canada (Table 2–6). The oil and gas industry was the largest contributor at 35% (674 kt) of total emissions (with the upstream oil and gas industry emitting 34% (652 kt) of total VOCs). Paints and solvents were the next-largest contributor, accounting for 22% (412 kt) of emissions, with general solvent use accounting for 16% (311 kt) of the national total. Transportation and mobile equipment sources accounted for 16% (302 kt) of emissions, with off-road gasoline, liquefied petroleum gas (LPG) or natural gas (NG) vehicles and equipment contributing 6% (123 kt) of the national total.

Commercial/residential/institutional sources represented 15% (285 kt) of VOC emissions, attributed mainly to home firewood burning (12% or 228 kt). The other contributing VOC sources are agriculture, manufacturing and incineration and waste. Of these, agricultural sources accounted for 6% (116 kt) of emissions and manufacturing sources represented 5% (102 kt) of total VOC emissions.

Between 1990 and 2018, VOC emissions decreased by 37% (1.1 Mt) (Figure 2–4). The most significant driver of this trend is a decrease in emissions from off-road gasoline, LPG or CNG vehicles and equipment, due to increasingly stringent regulations on these spark-ignition engines. The consistent decrease in emissions from light-duty gasoline vehicles and trucks throughout the time series also contributed to this trend.

Although emissions from most sources decreased, the oil and gas industry experienced an overall increase in emissions between 1990 and 2018. VOC emissions from the downstream oil and gas industry declined overall from 1990 to 2007, with emissions remaining relatively stable after that time, but the upstream oil and gas industry experienced increased emissions, which were more pronounced from 2013 to 2015. In 2018, VOC emissions from the upstream oil and gas industry declined compared to 2015, due to an 18% decrease in the number of oil spills (AER, 2019a; BCOGC, 2019; CNLOPB, 2019; MB, 2019; SK MER, 2019a), as well as a 28% reduction in reported volumes of vented gas from crude oil batteries (AER, 2019b; SK MER, 2019b).

The most significant changes in VOC emissions from 1990 to 2018 include:

- Transportation and mobile equipment: decrease of 75% (904 kt), from which:
  - Off-road gasoline/LPG/NG vehicles and equipment: decrease of 84% (640 kt)
  - Light-duty gasoline vehicles and trucks: decrease of 65% (208 kt)
- Oil and gas industry: increase of 12% (74 kt), from which:
  - Downstream oil and gas industry: decrease of 83% (107 kt)
  - Upstream oil and gas industry: increase of 38% (181 kt)

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

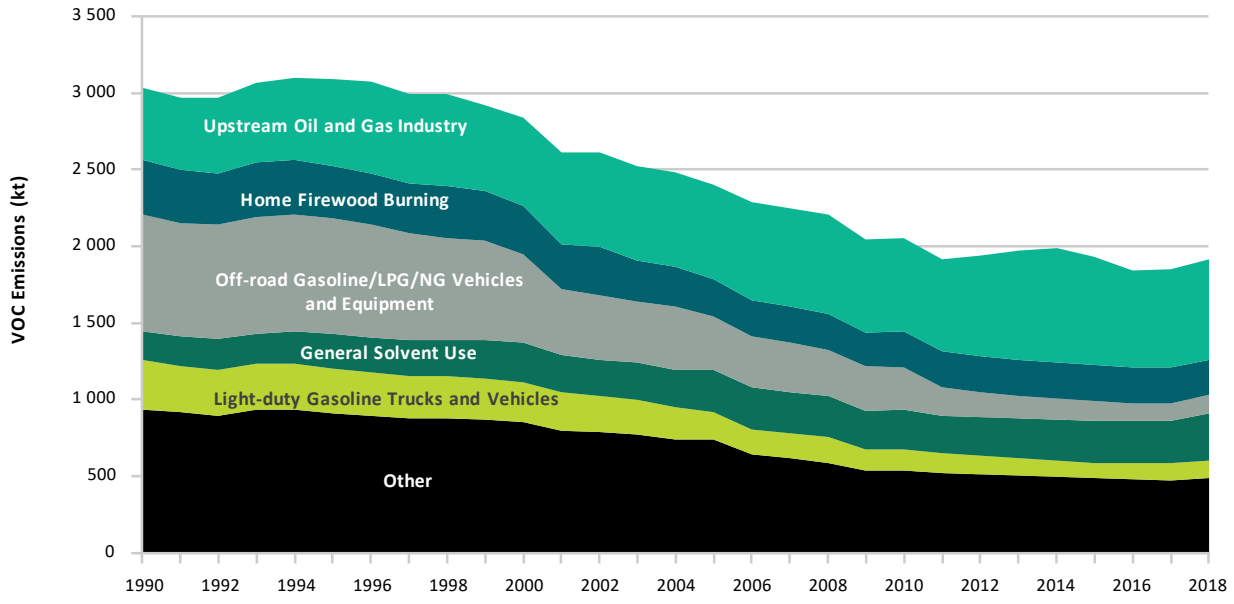


Table 2–6 National Summary of Annual VOC Emissions

Source	1990	2000	2005	2013	2014	2015	2016	2017	2018
	(tonnes)								
ORE AND MINERAL INDUSTRIES	**19 000**	**20 000**	**16 000**	**13 000**	**13 000**	**11 000**	**11 000**	**11 000**	**12 000**
Aluminium Industry	710	1 100	1 200	1 400	970	930	950	950	1 600
Asphalt Paving Industry	6 500	6 200	6 000	7 000	8 400	6 300	6 200	6 000	6 000
Cement and Concrete Industry	590	620	1 200	440	410	400	440	690	760
Foundries	1 700	1 100	920	520	450	380	360	310	350
Iron and Steel Industry	5 800	4 200	2 000	920	1 100	870	820	820	1 200
Iron Ore Industry	570	3 200	1 600	290	320	300	410	280	270
Mineral Products Industry	160	320	200	100	120	110	140	72	110
Mining and Rock Quarrying	3 000	2 600	2 300	1 800	1 600	1 900	1 400	1 300	1 400
Non-Ferrous Refining and Smelting Industry	340	36	51	69	66	67	65	69	79
OIL AND GAS INDUSTRY	**600 000**	**670 000**	**680 000**	**740 000**	**770 000**	**730 000**	**660 000**	**660 000**	**670 000**
Downstream Oil and Gas Industry	130 000	86 000	64 000	24 000	23 000	24 000	24 000	21 000	22 000
Upstream Oil and Gas Industry	470 000	580 000	610 000	710 000	750 000	710 000	640 000	640 000	650 000
ELECTRIC POWER GENERATION (UTILITIES)	**2 500**	**3 600**	**3 300**	**1 600**	**1 700**	**1 600**	**1 600**	**1 300**	**1 100**
Coal	1 300	950	1 300	390	450	410	410	380	210
Diesel	77	280	220	53	46	84	55	54	71
Natural Gas	480	1 600	1 500	880	900	910	890	630	570
Waste Materials	0.70	3.0	-	8.2	11	13	9.0	-	-
Other (Electric Power Generation)	630	770	350	290	270	220	200	290	280
MANUFACTURING	**260 000**	**260 000**	**190 000**	**120 000**	**110 000**	**110 000**	**100 000**	**100 000**	**100 000**
Abrasives Manufacturing	1 500	590	610	94	59	18	20	17	18
Bakeries	4 000	4 700	5 100	4 800	4 800	4 800	4 900	4 800	4 900
Biofuel Production	-	-	-	200	400	100	42	46	43
Chemicals Industry	47 000	36 000	25 000	13 000	12 000	10 000	9 800	9 200	9 800
Electronics	1 300	540	380	69	53	49	39	33	24
Food Preparation	10 000	13 000	15 000	15 000	15 000	15 000	15 000	14 000	17 000
Glass Manufacturing	2 000	2 300	620	280	240	200	190	200	160
Grain Industry	2 200	2 300	2 200	2 500	3 000	3 000	2 500	2 200	2 200
Metal Fabrication	9 100	14 000	12 000	4 800	4 200	4 400	3 700	4 100	4 300
Plastics Manufacturing	14 000	16 000	15 000	12 000	10 000	11 000	10 000	10 000	9 700
Pulp and Paper Industry	27 000	24 000	23 000	16 000	14 000	13 000	13 000	13 000	13 000
Textiles	860	1 500	850	490	570	470	490	880	510
Vehicle Manufacturing (Engines, Parts, Assembly, Painting)	22 000	23 000	16 000	8 300	8 200	8 400	9 300	8 300	7 800
Wood Products	110 000	98 000	64 000	36 000	36 000	33 000	32 000	30 000	30 000
Other (Manufacturing)	11 000	21 000	7 900	3 000	2 800	2 800	2 700	2 800	2 500
TRANSPORTATION AND MOBILE EQUIPMENT	**1 200 000**	**970 000**	**630 000**	**330 000**	**320 000**	**300 000**	**280 000**	**290 000**	**300 000**
Air Transportation	2 800	2 400	1 800	2 800	2 700	2 600	2 300	2 300	2 200
Heavy-duty Diesel Vehicles	10 000	18 000	24 000	20 000	18 000	17 000	16 000	17 000	18 000
Heavy-duty Gasoline Vehicles	24 000	28 000	22 000	15 000	12 000	12 000	12 000	12 000	13 000
Heavy-duty LPG/NG Vehicles	7 100	12 000	2 300	53	26	26	36	68	68
Light-duty Diesel Trucks	770	1 000	1 600	1 100	1 200	1 300	1 400	1 700	1 800
Light-duty Diesel Vehicles	2 200	1 500	920	800	780	800	750	750	730
Light-duty Gasoline Trucks	90 000	110 000	82 000	58 000	55 000	55 000	58 000	60 000	63 000
Light-duty Gasoline Vehicles	230 000	150 000	95 000	54 000	50 000	49 000	49 000	48 000	48 000
Light-duty LPG/NG Trucks	8 100	3 700	1 900	35	26	24	25	30	30
Light-duty LPG/NG Vehicles	1 100	540	230	1.1	0.85	0.82	1.00	1.3	1.3
Marine Transportation	5 800	7 600	8 600	8 200	8 100	8 000	8 300	8 500	8 800
Motorcycles	1 600	1 700	1 800	1 900	1 800	1 900	2 000	2 000	2 100
Off-Road Diesel Vehicles and Equipment	53 000	53 000	37 000	20 000	19 000	18 000	15 000	16 000	17 000
Off-Road Gasoline/LPG/NG Vehicles and Equipment	760 000	580 000	350 000	150 000	140 000	140 000	110 000	120 000	120 000
Rail Transportation	6 700	6 200	6 100	5 400	5 100	4 500	3 800	4 400	4 500
Tire Wear and Brake Lining	-	-	-	-	-	-	-	-	-
AGRICULTURE	**100 000**	**120 000**	**130 000**	**120 000**	**120 000**	**110 000**	**110 000**	**120 000**	**120 000**
Animal Production	100 000	120 000	130 000	120 000	120 000	110 000	110 000	120 000	120 000
Crop Production	-	-	-	-	-	-	-	-	-
Fuel Use	81	91	82	200	200	190	200	190	190
COMMERCIAL / RESIDENTIAL / INSTITUTIONAL	**430 000**	**390 000**	**320 000**	**290 000**	**290 000**	**290 000**	**290 000**	**290 000**	**290 000**
Cigarette Smoking[1]	13	12	8.8	6.8	6.9	6.1	6.1	6.2	6.3
Commercial and Institutional Fuel Combustion	1 000	1 400	1 400	1 300	1 300	1 300	1 300	1 400	1 400
Commercial Cooking	2 000	2 300	2 500	2 500	2 400	2 300	2 300	2 300	2 300
Construction Fuel Combustion	71	34	41	44	43	42	44	46	47
Home Firewood Burning	360 000	310 000	250 000	230 000	230 000	230 000	230 000	230 000	230 000
Human[1]	-	-	-	-	-	-	-	-	-
Marine Cargo Handling	-	-	-	-	-	-	-	-	-
Residential Fuel Combustion	1 500	1 700	1 700	1 700	1 800	1 700	1 500	1 600	1 800
Service Stations	72 000	74 000	65 000	50 000	49 000	50 000	51 000	51 000	51 000
Other (Miscellaneous)	-	-	-	-	-	-	-	-	-
INCINERATION AND WASTE	**17 000**	**14 000**	**14 000**	**9 400**	**9 700**	**9 900**	**10 000**	**10 000**	**10 000**
Crematoriums	0.95	1.3	1.6	2.1	2.2	2.3	2.4	2.5	2.5
Waste Incineration	9 700	8 100	8 200	4 300	4 500	4 500	4 700	4 700	4 500
Waste Treatment and Disposal	7 000	6 300	5 900	5 200	5 200	5 300	5 500	5 500	5 500
PAINTS AND SOLVENTS	**360 000**	**400 000**	**430 000**	**350 000**	**360 000**	**360 000**	**360 000**	**370 000**	**410 000**
Dry Cleaning	740	790	180	160	160	170	170	180	190
General Solvent Use	190 000	260 000	280 000	260 000	260 000	270 000	270 000	280 000	310 000
Printing	37 000	48 000	42 000	20 000	19 000	18 000	17 000	17 000	19 000
Surface Coatings	130 000	89 000	100 000	73 000	74 000	74 000	74 000	75 000	82 000
DUST	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
Coal Transportation	-	-	-	-	-	-	-	-	-
Construction Operations	-	-	-	-	-	-	-	-	-
Mine Tailings	-	-	-	-	-	-	-	-	-
Paved Roads	-	-	-	-	-	-	-	-	-
Unpaved Roads	-	-	-	-	-	-	-	-	-
FIRES	**41 000**	**4 200**	**3 400**	**2 000**	**8 100**	**5 900**	**4 900**	**2 900**	**1 500**
Prescribed Burning	40 000	3 900	3 100	1 700	7 900	5 700	4 700	2 700	1 300
Structural Fires	390	310	280	290	220	210	210	210	210
GRAND TOTAL	**3 000 000**	**2 800 000**	**2 400 000**	**2 000 000**	**2 000 000**	**1 900 000**	**1 800 000**	**1 800 000**	**1 900 000**

Notes:

Totals may not add up due to rounding.

1. Cigarette Smoking as well as Infant Diapered Waste (which is included within the Human sector) are being considered for removal from future inventories. If you have any questions, please contact us at ec.iepa-apei.ec@canada.ca or 1-877-877-8375.

- Indicates no emissions

0.00 Indicates emissions truncated due to rounding

2.5. Carbon Monoxide (CO)

In 2018, approximately 5.8 Mt of CO were released in Canada (Table 2–7). Transportation and mobile equipment accounted for 56% (3.2 Mt) of total emissions, with light-duty gasoline vehicles and trucks contributing 23% (1.3 Mt) and off-road gasoline/Liquid Petroleum Gas (LPG)/Natural Gas (NG) vehicles and equipment contributing 21% (1.2 Mt) of total CO emissions. The next-largest contributors are commercial/residential/institutional sources, which in 2018 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 contributors, accounting for 9% (568 kt) and 7% (380 kt) of CO emissions, respectively.

Between 1990 and 2018, CO emissions decreased by 54% (6.6 Mt) (Figure 2–5). Of the many contributors to the overall decrease in emissions, two in particular—light-duty gasoline trucks and vehicles, and off-road gasoline/LPG/NG vehicles and equipment (spark ignition engines)—had the largest impact on emission reductions. The decreasing emission trend in these sectors is due to increasingly stringent engine and vehicle regulations. Emissions from home firewood burning gradually decreased across the time series, resulting from improved combustion efficiency in modern fireplace inserts, stoves and fireplaces and from a reduction in the use of wood as heating fuel.

The most significant changes in CO emissions from 1990 to 2018 include:

- Transportation and mobile equipment: decrease of 60% (4.9 Mt), of which:
  - Light-duty gasoline trucks and vehicles: decrease of 71% (3.2 Mt)
  - Off-road gasoline/LPG/NG vehicles and equipment: decrease of 48% (1.1 Mt)
- Commercial/residential/institutional: decrease of 28% (476 kt), of which:
  - Home firewood burning: decrease of 29% (480 kt)
- Oil and gas industry: increase of 69% (232 kt), of which:
  - Upstream oil and gas industry: increase of 76% (232 kt)

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

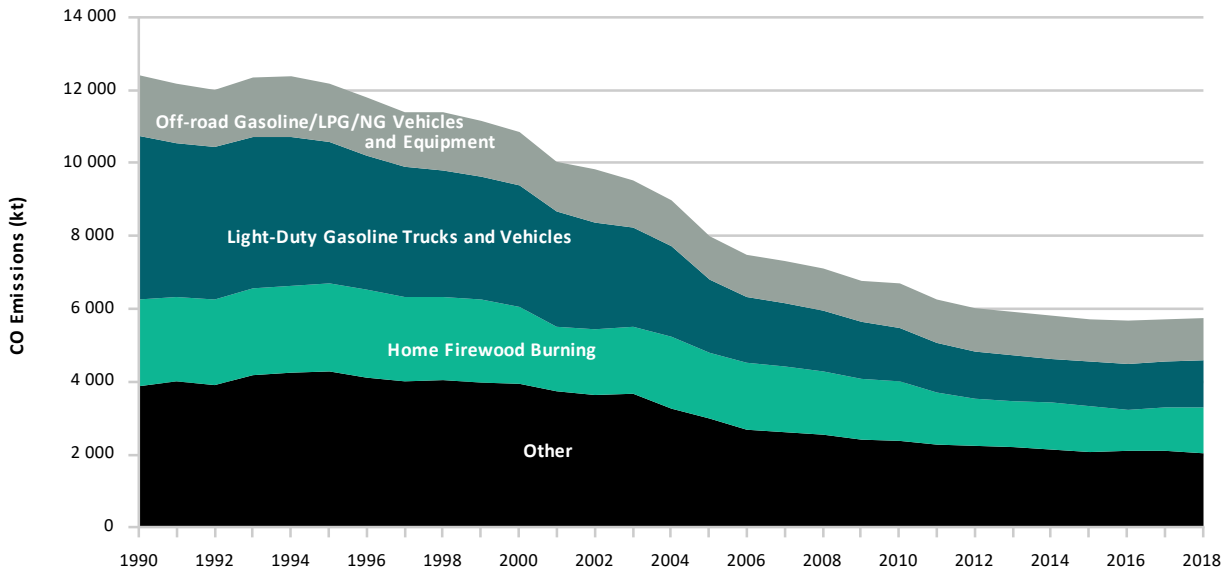


Table 2–7 National Summary of Annual CO Emissions

Source	1990	2000	2005	2013	2014	2015	2016	2017	2018
	(tonnes)								
ORE AND MINERAL INDUSTRIES	**390 000**	**400 000**	**500 000**	**550 000**	**510 000**	**510 000**	**560 000**	**590 000**	**530 000**
Aluminium Industry	240 000	250 000	310 000	410 000	380 000	380 000	420 000	430 000	380 000
Asphalt Paving Industry	4 200	4 200	4 500	3 700	4 000	3 200	3 100	2 900	2 900
Cement and Concrete Industry	16 000	23 000	27 000	14 000	12 000	10 000	13 000	16 000	16 000
Foundries	55 000	48 000	49 000	49 000	49 000	49 000	49 000	49 000	49 000
Iron and Steel Industry	43 000	48 000	64 000	23 000	24 000	21 000	21 000	27 000	28 000
Iron Ore Industry	18 000	9 600	23 000	20 000	20 000	20 000	18 000	19 000	16 000
Mineral Products Industry	3 900	3 400	3 200	670	580	640	660	610	550
Mining and Rock Quarrying	14 000	14 000	10 000	14 000	15 000	13 000	14 000	26 000	19 000
Non-Ferrous Refining and Smelting Industry	280	360	13 000	11 000	13 000	13 000	17 000	15 000	15 000
OIL AND GAS INDUSTRY	**340 000**	**440 000**	**490 000**	**560 000**	**550 000**	**560 000**	**540 000**	**550 000**	**570 000**
Downstream Oil and Gas Industry	29 000	23 000	21 000	42 000	16 000	22 000	16 000	21 000	29 000
Upstream Oil and Gas Industry	310 000	420 000	470 000	520 000	530 000	530 000	520 000	530 000	540 000
ELECTRIC POWER GENERATION (UTILITIES)	**50 000**	**43 000**	**52 000**	**35 000**	**40 000**	**40 000**	**38 000**	**43 000**	**36 000**
Coal	41 000	18 000	25 000	13 000	15 000	16 000	16 000	19 000	15 000
Diesel	370	1 200	1 300	1 200	1 400	1 600	1 400	1 500	1 800
Natural Gas	4 400	17 000	17 000	16 000	15 000	15 000	12 000	14 000	13 000
Waste Materials	82	390	250	180	340	230	270	330	230
Other (Electric Power Generation)	4 400	7 200	8 500	4 500	7 900	7 200	7 900	7 700	6 100
MANUFACTURING	**1 300 000**	**1 100 000**	**530 000**	**180 000**	**160 000**	**140 000**	**140 000**	**140 000**	**140 000**
Abrasives Manufacturing	610	240	240	-	-	-	-	-	-
Bakeries	7.0	6.0	0.44	0.35	0.34	0.30	0.30	0.32	-
Biofuel Production	-	-	-	8.7	-	-	-	-	-
Chemicals Industry	27 000	30 000	18 000	14 000	15 000	15 000	16 000	16 000	14 000
Electronics	26	39	19	-	-	-	0.26	-	-
Food Preparation	1 200	1 400	1 600	1 000	980	1 200	1 200	1 300	1 300
Glass Manufacturing	490	570	690	260	280	300	280	300	300
Grain Industry	1 900	2 700	610	370	390	370	390	420	330
Metal Fabrication	8 800	8 700	7 700	2 400	1 900	1 200	1 100	1 200	1 300
Plastics Manufacturing	220	350	220	0.42	10	9.0	10	11	13
Pulp and Paper Industry	180 000	150 000	98 000	56 000	64 000	69 000	73 000	78 000	82 000
Textiles	45	78	53	0.06	0.06	0.07	0.07	0.07	0.10
Vehicle Manufacturing (Engines, Parts, Assembly, Painting)	3 800	4 000	2 900	940	930	750	880	920	930
Wood Products	1 100 000	790 000	390 000	100 000	73 000	51 000	43 000	40 000	36 000
Other (Manufacturing)	31 000	61 000	11 000	590	530	560	610	550	540
TRANSPORTATION AND MOBILE EQUIPMENT	**8 100 000**	**7 300 000**	**5 100 000**	**3 300 000**	**3 200 000**	**3 100 000**	**3 000 000**	**3 100 000**	**3 200 000**
Air Transportation	51 000	36 000	31 000	37 000	34 000	37 000	39 000	38 000	36 000
Heavy-duty Diesel Vehicles	34 000	63 000	91 000	75 000	70 000	63 000	61 000	65 000	68 000
Heavy-duty Gasoline Vehicles	590 000	1 100 000	830 000	490 000	410 000	380 000	400 000	410 000	420 000
Heavy-duty LPG/NG Vehicles	130 000	310 000	67 000	1 300	630	640	860	1 500	1 500
Light-duty Diesel Trucks	13 000	15 000	20 000	12 000	13 000	16 000	17 000	20 000	21 000
Light-duty Diesel Vehicles	29 000	17 000	9 300	8 800	8 700	9 200	8 600	8 600	8 300
Light-duty Gasoline Trucks	1 600 000	1 600 000	1 100 000	700 000	680 000	690 000	730 000	750 000	790 000
Light-duty Gasoline Vehicles	2 900 000	1 700 000	950 000	560 000	520 000	510 000	520 000	500 000	500 000
Light-duty LPG/NG Trucks	140 000	54 000	24 000	360	270	240	260	310	310
Light-duty LPG/NG Vehicles	14 000	6 000	2 300	10	7.7	7.3	8.9	12	12
Marine Transportation	13 000	17 000	19 000	18 000	18 000	18 000	19 000	19 000	20 000
Motorcycles	12 000	14 000	15 000	13 000	13 000	13 000	13 000	14 000	14 000
Off-Road Diesel Vehicles and Equipment	220 000	240 000	170 000	100 000	93 000	88 000	69 000	75 000	81 000
Off-Road Gasoline/LPG/NG Vehicles and Equipment	2 400 000	2 100 000	1 800 000	1 300 000	1 300 000	1 300 000	1 100 000	1 200 000	1 200 000
Rail Transportation	16 000	15 000	15 000	18 000	18 000	17 000	16 000	18 000	18 000
Tire Wear and Brake Lining	-	-	-	-	-	-	-	-	-
AGRICULTURE	**630**	**690**	**520**	**1 300**	**1 400**	**1 300**	**1 300**	**1 300**	**1 300**
Animal Production	-	-	-	-	-	-	-	-	-
Crop Production	-	-	-	-	-	-	-	-	-
Fuel Use	630	690	520	1 300	1 400	1 300	1 300	1 300	1 300
COMMERCIAL / RESIDENTIAL / INSTITUTIONAL	**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**
Cigarette Smoking[1]	3 800	3 300	2 500	1 900	1 900	1 700	1 700	1 800	1 800
Commercial and Institutional Fuel Combustion	15 000	19 000	19 000	18 000	19 000	18 000	18 000	20 000	20 000
Commercial Cooking	5 700	6 400	7 100	6 900	6 700	6 300	6 300	6 400	6 400
Construction Fuel Combustion	670	360	460	450	440	440	450	460	480
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[1]	-	-	-	-	-	-	-	-	-
Marine Cargo Handling	0.16	0.05	-	-	-	-	-	-	-
Residential Fuel Combustion	13 000	13 000	13 000	13 000	13 000	13 000	11 000	12 000	13 000
Service Stations	-	-	-	-	-	-	-	-	-
Other (Miscellaneous)	-	-	-	-	-	-	-	-	-
INCINERATION AND WASTE	**45 000**	**27 000**	**25 000**	**16 000**	**16 000**	**16 000**	**16 000**	**16 000**	**18 000**
Crematoriums	7.4	10	12	16	17	18	18	19	19
Waste Incineration	42 000	25 000	21 000	13 000	14 000	14 000	14 000	14 000	14 000
Waste Treatment and Disposal	3 300	2 800	3 700	2 800	2 700	2 600	2 400	2 400	3 400
PAINTS AND SOLVENTS	**-**	**-**	**6.4**	**0.47**	**0.46**	**0.37**	**-**	**-**	**-**
Dry Cleaning	-	-	-	-	-	-	-	-	-
General Solvent Use	-	-	-	-	-	-	-	-	-
Printing	-	-	6.4	0.47	0.46	0.37	-	-	-
Surface Coatings	-	-	-	-	-	-	-	-	-
DUST	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
Coal Transportation	-	-	-	-	-	-	-	-	-
Construction Operations	-	-	-	-	-	-	-	-	-
Mine Tailings	-	-	-	-	-	-	-	-	-
Paved Roads	-	-	-	-	-	-	-	-	-
Unpaved Roads	-	-	-	-	-	-	-	-	-
FIRES	**440 000**	**78 000**	**52 000**	**34 000**	**140 000**	**130 000**	**120 000**	**52 000**	**24 000**
Prescribed Burning	440 000	76 000	51 000	33 000	140 000	130 000	120 000	51 000	23 000
Structural Fires	2 100	1 700	1 500	1 600	1 200	1 100	1 200	1 200	1 200
GRAND TOTAL	**12 000 000**	**11 000 000**	**8 000 000**	**5 900 000**	**5 800 000**	**5 700 000**	**5 700 000**	**5 700 000**	**5 800 000**

Notes:
Totals may not add up due to rounding.
1. Cigarette Smoking as well as Infant Diapered Waste (which is included within the Human sector) are being considered for removal from future inventories. If you have any questions, please contact us at ec.iepa-apei.ec@canada.ca or 1-877-877-8375.
- Indicates no emissions
0.00 Indicates emissions truncated due to rounding

2.6. Ammonia (NH_3)

In 2018, approximately 484 kt of NH_3 were released in Canada (Table 2–8). NH_3 emissions originated primarily from agriculture, which accounted for 93% (453 kt) of total emissions. All other sources combined accounted for only 7% of emissions.

From 1990 to 2018, Canada's NH_3 emissions increased by 21% (83 kt) (Figure 2–6); NH_3 emissions peaked in 2004 and have since fluctuated. This trend is driven by emissions from animal production and increasing use of nitrogen fertilizers in crop production. Animal production, which dominates the emissions throughout the time series, experienced a steady increase in emissions from 1990 to 2005, followed by a decrease from 2006 to 2011, and has since remained stable. Emissions from crop production, however, have been steadily increasing since 2006.

The most significant changes in NH_3 emissions from 1990 to 2018 include:

- Agriculture: increase of 25% (90 kt), from which:
  - Crop production: increase of 105% (86 kt)
  - Animal production: increase of 2% (4 kt)
- Other sources, dominated by manufacturing, incineration and waste, and transportation and mobile equipment: decrease of 22% (7 kt)

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

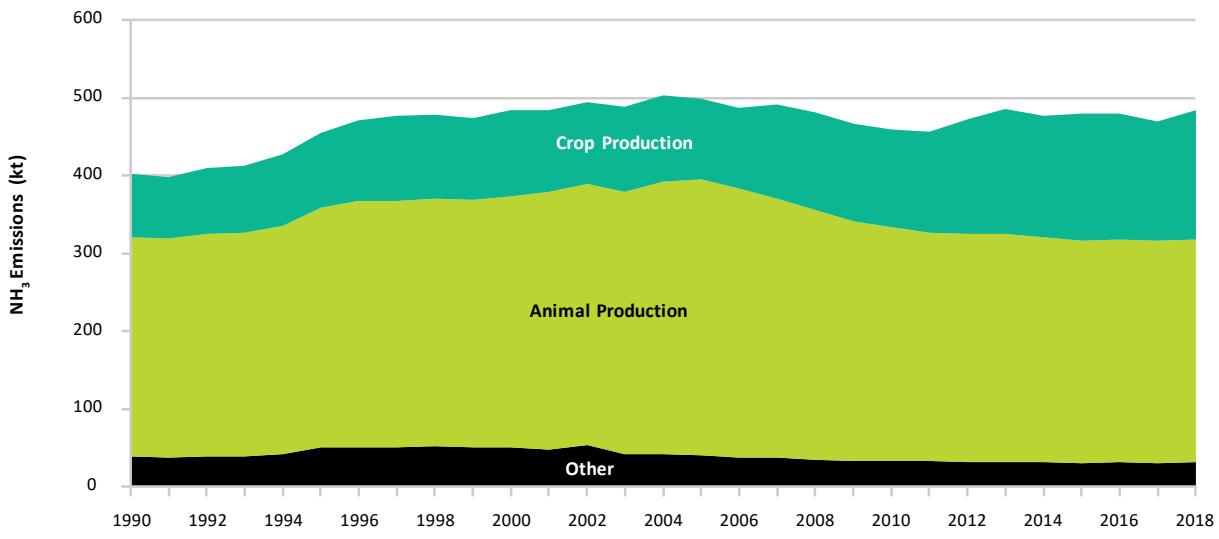


Table 2–8 National Summary of Annual NH_3 Emissions

Source	1990	2000	2005	2013	2014	2015	2016	2017	2018
	(tonnes)								
ORE AND MINERAL INDUSTRIES	**1 800**	**2 200**	**1 200**	**1 400**	**1 300**	**1 200**	**1 200**	**1 300**	**1 500**
Aluminium Industry	29	34	13	-	-	-	-	-	-
Asphalt Paving Industry	0.60	1.3	1.2	-	-	-	-	-	-
Cement and Concrete Industry	600	630	340	430	440	480	360	380	480
Foundries	11	12	8.0	-	-	-	-	-	-
Iron and Steel Industry	180	230	85	78	89	59	56	55	58
Iron Ore Industry	160	160	22	-	-	-	-	-	-
Mineral Products Industry	82	100	95	420	430	330	400	290	250
Mining and Rock Quarrying	510	540	82	93	67	52	97	83	120
Non-Ferrous Refining and Smelting Industry	210	460	520	350	310	290	330	470	580
OIL AND GAS INDUSTRY	**650**	**1 800**	**2 500**	**2 600**	**2 700**	**2 200**	**2 400**	**2 600**	**2 600**
Downstream Oil and Gas Industry	360	250	110	180	78	68	55	58	92
Upstream Oil and Gas Industry	290	1 500	2 400	2 400	2 600	2 100	2 300	2 600	2 500
ELECTRIC POWER GENERATION (UTILITIES)	**710**	**1 400**	**990**	**780**	**760**	**380**	**350**	**240**	**210**
Coal	62	110	530	580	610	170	170	170	130
Diesel	3.7	6.0	2.8	-	-	-	-	-	-
Natural Gas	270	700	180	110	95	130	100	7.0	10
Waste Materials	0.26	1.7	-	-	-	5.3	11	12	10
Other (Electric Power Generation)	380	620	280	82	62	70	62	45	56
MANUFACTURING	**20 000**	**25 000**	**17 000**	**11 000**	**11 000**	**12 000**	**12 000**	**11 000**	**12 000**
Abrasives Manufacturing	-	-	0.12	-	-	-	-	-	-
Bakeries	-	-	-	-	-	0.34	-	-	-
Biofuel Production	-	-	-	-	-	-	-	-	-
Chemicals Industry	9 800	15 000	11 000	8 500	8 500	9 000	9 300	8 500	9 300
Electronics	29	76	56	17	17	19	18	16	16
Food Preparation	170	320	300	300	270	240	220	250	240
Glass Manufacturing	86	110	120	-	-	-	-	-	-
Grain Industry	6.2	6.7	1.5	7.5	7.6	5.0	5.7	5.5	4.9
Metal Fabrication	79	190	39	2.1	2.4	25	25	27	27
Plastics Manufacturing	26	28	3.7	-	-	-	-	-	-
Pulp and Paper Industry	4 400	3 600	2 600	1 700	1 600	1 600	1 700	1 700	1 600
Textiles	12	26	16	-	-	-	-	-	-
Vehicle Manufacturing (Engines, Parts, Assembly, Painting)	64	180	47	0.77	-	2.3	2.2	6.5	6.5
Wood Products	4 800	4 800	2 600	750	800	780	780	710	690
Other (Manufacturing)	500	360	180	21	22	32	30	18	40
TRANSPORTATION AND MOBILE EQUIPMENT	**5 500**	**12 000**	**11 000**	**8 300**	**7 800**	**7 700**	**7 900**	**7 900**	**8 200**
Air Transportation	5.0	4.8	4.6	4.6	4.4	4.5	4.6	4.7	4.9
Heavy-duty Diesel Vehicles	210	390	560	760	750	730	710	750	790
Heavy-duty Gasoline Vehicles	160	250	270	340	310	310	330	330	340
Heavy-duty LPG/NG Vehicles	55	170	21	1.2	0.88	1.1	1.3	2.0	2.0
Light-duty Diesel Trucks	2.4	4.6	4.6	8.1	10	13	15	18	20
Light-duty Diesel Vehicles	10	11	11	17	17	18	17	17	16
Light-duty Gasoline Trucks	1 100	3 700	3 700	3 000	2 900	2 900	3 100	3 200	3 400
Light-duty Gasoline Vehicles	3 300	6 300	5 600	3 500	3 200	3 000	3 000	3 000	3 000
Light-duty LPG/NG Trucks	77	110	82	1.3	0.96	0.85	0.93	1.1	1.1
Light-duty LPG/NG Vehicles	14	21	14	0.06	0.04	0.04	0.05	0.06	0.06
Marine Transportation	160	220	250	260	260	260	270	280	290
Motorcycles	4.4	7.0	12	34	35	37	39	40	42
Off-Road Diesel Vehicles and Equipment	170	210	200	190	190	200	180	200	220
Off-Road Gasoline/LPG/NG Vehicles and Equipment	170	130	91	84	88	89	88	92	96
Rail Transportation	51	48	48	55	56	53	49	56	58
Tire Wear and Brake Lining	-	-	-	-	-	-	-	-	-
AGRICULTURE	**360 000**	**430 000**	**460 000**	**450 000**	**450 000**	**450 000**	**450 000**	**440 000**	**450 000**
Animal Production	280 000	320 000	350 000	290 000	290 000	290 000	290 000	290 000	290 000
Crop Production	82 000	110 000	100 000	160 000	160 000	160 000	160 000	150 000	170 000
Fuel Use	44	41	28	47	52	45	45	45	44
COMMERCIAL / RESIDENTIAL / INSTITUTIONAL	**3 900**	**3 600**	**3 200**	**3 100**	**3 100**	**3 100**	**3 000**	**3 000**	**3 100**
Cigarette Smoking[1]	110	110	88	76	77	69	69	70	71
Commercial and Institutional Fuel Combustion	310	340	320	210	220	210	200	200	190
Commercial Cooking	-	-	-	-	-	-	-	-	-
Construction Fuel Combustion	70	38	50	44	44	44	44	45	46
Home Firewood Burning	2 300	2 100	1 700	1 800	1 800	1 800	1 800	1 800	1 800
Human[1]	490	530	560	610	620	620	630	640	640
Marine Cargo Handling	0.00	-	-	-	-	-	-	-	-
Residential Fuel Combustion	690	560	530	380	380	360	330	320	340
Service Stations	-	-	-	-	-	-	-	-	-
Other (Miscellaneous)	-	-	-	-	-	-	-	-	-
INCINERATION AND WASTE	**5 400**	**5 400**	**4 400**	**4 300**	**4 400**	**4 200**	**4 500**	**4 000**	**3 900**
Crematoriums	-	-	-	-	-	-	-	-	-
Waste Incineration	210	220	340	150	150	150	150	160	160
Waste Treatment and Disposal	5 200	5 200	4 100	4 200	4 200	4 100	4 300	3 900	3 700
PAINTS AND SOLVENTS	**-**	**0.05**	**0.05**	**-**	**-**	**-**	**-**	**-**	**-**
Dry Cleaning	-	-	-	-	-	-	-	-	-
General Solvent Use	-	-	-	-	-	-	-	-	-
Printing	-	0.05	0.05	-	-	-	-	-	-
Surface Coatings	-	-	-	-	-	-	-	-	-
DUST	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
Coal Transportation	-	-	-	-	-	-	-	-	-
Construction Operations	-	-	-	-	-	-	-	-	-
Mine Tailings	-	-	-	-	-	-	-	-	-
Paved Roads	-	-	-	-	-	-	-	-	-
Unpaved Roads	-	-	-	-	-	-	-	-	-
FIRES	**1 100**	**130**	**100**	**67**	**240**	**180**	**150**	**93**	**52**
Prescribed Burning	1 100	110	88	51	230	170	140	81	40
Structural Fires	22	17	16	16	12	12	12	12	12
GRAND TOTAL	**400 000**	**480 000**	**500 000**	**490 000**	**480 000**	**480 000**	**480 000**	**470 000**	**480 000**

Notes:

Totals may not add up due to rounding.

1. Cigarette Smoking as well as Infant Diapered Waste (which is included within the Human sector) are being considered for removal from future inventories. If you have any questions, please contact us at ec.iepa-apei.ec@canada.ca or 1-877-877-8375.

- Indicates no emissions

0.00 Indicates emissions truncated due to rounding

2.7. **Lead (Pb)**

In 2018, approximately 191 tonnes (t) of Pb were emitted in Canada (Table 2–9). Ore and mineral industries were the largest contributor at 84% (160 t) of emissions, with the non-ferrous refining and smelting industry accounting for the largest share at 58% (110 t) of total Pb emissions. Transportation and mobile equipment was the second largest contributor at 10% (19 t) of total emissions (almost all of which was from air transportation).

Overall, lead emissions decreased by 82% (842 t) from 1990 to 2018 (Figure 2–7). This decreasing trend is partly attributable to the closure of outdated smelters and partly to the implementation, since 2006, of regulated pollution prevention plans (ECCC, 2017). However, since 2013 lead emissions attributed to the non-ferrous refining and smelting industry have slowly increased. Reductions in emissions in air transportation across the time series has also influenced the trend.

The most significant changes in Pb emissions from 1990 to 2018 include:

- Ore and mineral industries: decrease of 83% (784 t), of which:
  - Non-ferrous refining and smelting industry: decrease of 88% (776 t)
- Manufacturing: decrease of 86% (42 t), of which:
  - Metal Fabrication: decrease of 88% (24 t)
  - Chemicals Industry: decrease of 99% (12 t)
- Transportation and mobile equipment: decrease of 24% (5.8 t), of which:
  - Air transportation: decrease of 24% (5.7 t)

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

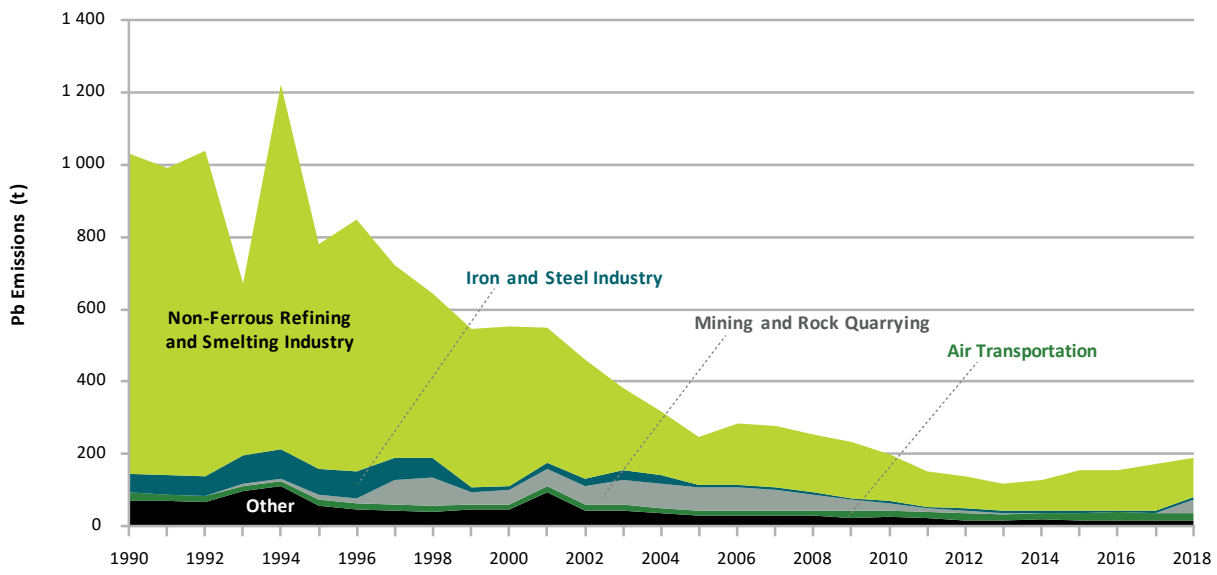


Table 2–9 National Summary of Annual Pb Emissions

Source	1990	2000	2005	2013	2014	2015	2016	2017	2018
	(kg)								
ORE AND MINERAL INDUSTRIES	**940 000**	**500 000**	**210 000**	**87 000**	**97 000**	**120 000**	**120 000**	**140 000**	**160 000**
Aluminium Industry	84	84	-	-	-	-	-	-	-
Asphalt Paving Industry	1 400	1 200	1 200	980	1 100	1 000	1 000	980	980
Cement and Concrete Industry	550	610	960	530	600	870	700	570	400
Foundries	2 000	6 600	1 600	210	190	210	200	170	210
Iron and Steel Industry	54 000	8 000	5 700	5 200	6 100	5 500	5 200	5 100	6 200
Iron Ore Industry	-	-	-	2 100	2 700	2 600	3 300	3 800	2 900
Mineral Products Industry	-	-	0.19	-	-	-	15	-	-
Mining and Rock Quarrying	-	42 000	65 000	3 100	900	980	1 100	1 200	39 000[1]
Non-Ferrous Refining and Smelting Industry	890 000	440 000	130 000	75 000	85 000	110 000	110 000	130 000	110 000
OIL AND GAS INDUSTRY	**340**	**300**	**720**	**1 100**	**670**	**510**	**580**	**520**	**570**
Downstream Oil and Gas Industry	200	81	450	380	300	320	380	350	400
Upstream Oil and Gas Industry	140	220	260	700	370	190	200	160	170
ELECTRIC POWER GENERATION (UTILITIES)	**11 000**	**15 000**	**1 900**	**1 400**	**1 800**	**1 500**	**1 400**	**1 700**	**1 300**
Coal	8 300	11 000	1 300	860	1 200	820	770	1 100	810
Diesel	-	-	-	-	-	-	-	-	-
Natural Gas	430	530	72	85	93	97	86	91	83
Waste Materials	-	-	-	-	-	0.44	0.37	0.35	0.36
Other (Electric Power Generation)	2 600	3 200	590	430	490	530	560	540	380
MANUFACTURING	**48 000**	**16 000**	**17 000**	**4 700**	**6 500**	**5 900**	**6 500**	**3 700**	**6 800**
Abrasives Manufacturing	-	-	-	-	-	-	-	-	-
Bakeries	-	-	-	-	-	-	-	-	-
Biofuel Production	-	-	-	-	-	-	-	-	-
Chemicals Industry	12 000	300	1 800	85	82	120	45	59	30
Electronics	2 000	710	96	20	18	17	19	22	23
Food Preparation	-	-	-	-	-	-	-	-	-
Glass Manufacturing	21	6.0	25	0.30	0.00	0.00	0.00	-	-
Grain Industry	-	-	-	-	-	-	-	-	-
Metal Fabrication	28 000	9 200	10 000	2 200	3 600	1 900	3 200	1 800	3 300
Plastics Manufacturing	76	46	21	0.01	4.7	4.8	4.8	1.3	1.3
Pulp and Paper Industry	2 100	840	2 400	1 400	2 200	3 400	2 800	1 300	1 500
Textiles	-	-	0.01	-	-	-	-	-	-
Vehicle Manufacturing (Engines, Parts, Assembly, Painting)	950	2 400	770	65	68	68	66	69	64
Wood Products	3 500	2 500	1 400	830	530	330	330	390	1 900
Other (Manufacturing)	-	220	150	32	32	25	39	9.0	6.7
TRANSPORTATION AND MOBILE EQUIPMENT	**24 000**	**16 000**	**16 000**	**19 000**	**18 000**	**20 000**	**21 000**	**21 000**	**19 000**
Air Transportation	24 000	15 000	15 000	18 000	17 000	19 000	20 000	20 000	18 000
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	1 100	1 200	550	570	580	600
Motorcycles	-	-	-	-	-	-	-	-	-
Off-Road Diesel Vehicles and Equipment	-	-	-	-	-	-	-	-	-
Off-Road Gasoline/LPG/NG Vehicles and Equipment	-	-	-	-	-	-	-	-	-
Rail Transportation	310	290	290	210	200	170	150	170	180
Tire Wear and Brake Lining	-	-	-	-	-	-	-	-	-
AGRICULTURE	**30**	**30**	**26**	**76**	**84**	**70**	**68**	**67**	**62**
Animal Production	-	-	-	-	-	-	-	-	-
Crop Production	-	-	-	-	-	-	-	-	-
Fuel Use	30	30	26	76	84	70	68	67	62
COMMERCIAL / RESIDENTIAL / INSTITUTIONAL	**4 300**	**4 800**	**4 600**	**3 500**	**3 200**	**3 200**	**3 200**	**3 200**	**3 100**
Cigarette Smoking[2]	2.3	1.9	1.5	1.1	1.2	1.0	1.0	1.0	1.1
Commercial and Institutional Fuel Combustion	250	290	420	510	230	250	240	240	220
Commercial Cooking	-	-	-	-	-	-	-	-	-
Construction Fuel Combustion	10	4.9	11	7.5	7.3	7.7	6.7	7.1	7.2
Home Firewood Burning	3 500	3 200	2 600	2 700	2 600	2 600	2 600	2 600	2 600
Human[2]	-	-	-	-	-	-	-	-	-
Marine Cargo Handling	-	970	1 200	59	20	10	41	51	50
Residential Fuel Combustion	490	410	390	290	300	280	250	240	260
Service Stations	-	-	-	-	-	-	-	-	-
Other (Miscellaneous)	-	-	-	-	-	-	-	-	-
INCINERATION AND WASTE	**210**	**150**	**340**	**200**	**210**	**190**	**250**	**240**	**250**
Crematoriums	2.0	2.8	3.6	4.7	5.2	5.3	5.5	5.7	5.8
Waste Incineration	200	150	300	170	180	170	160	160	160
Waste Treatment and Disposal	-	-	38	24	22	12	80	69	88
PAINTS AND SOLVENTS	**-**	**-**	**-**	**0.06**	**0.00**	**-**	**-**	**-**	**-**
Dry Cleaning	-	-	-	-	-	-	-	-	-
General Solvent Use	-	-	-	-	-	-	-	-	-
Printing	-	-	-	-	-	-	-	-	-
Surface Coatings	-	-	-	0.06	0.00	-	-	-	-
DUST	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
Coal Transportation	-	-	-	-	-	-	-	-	-
Construction Operations	-	-	-	-	-	-	-	-	-
Mine Tailings	-	-	-	-	-	-	-	-	-
Paved Roads	-	-	-	-	-	-	-	-	-
Unpaved Roads	-	-	-	-	-	-	-	-	-
FIRES	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
Prescribed Burning	-	-	-	-	-	-	-	-	-
Structural Fires	-	-	-	-	-	-	-	-	-
GRAND TOTAL	**1 000 000**	**550 000**	**250 000**	**120 000**	**130 000**	**150 000**	**160 000**	**170 000**	**190 000**

Notes:
Totals may not add up due to rounding.
1. Estimate under review
2. Cigarette Smoking as well as Infant Diapered Waste (which is included within the Human sector) are being considered for removal from future inventories. If you have any questions, please contact us at ec.iepa-apei.ec@canada.ca or 1-877-877-8375.

- Indicates no emissions
0.00 Indicates emissions truncated due to rounding

2.8. **Cadmium (Cd)**

Approximately 7.1 t of Cd were emitted in Canada in 2018 (Table 2–10). Ore and mineral industries accounted for 69% (4.8 t) of national emissions, with the non-ferrous refining and smelting industry contributing 60% (4.2 t) of the total. Commercial/residential/institutional sources contributed 16% (1.1 t) of total Cd emissions.

From 1990 to 2018, national Cd emissions decreased by 92% (81 t) (Figure 2–8). This trend is almost entirely driven by the non-ferrous refining and smelting industry. Emissions from this industry fluctuated greatly between 1990 and 2006, but decreased steadily from 2007 onward. As with lead emissions, reductions in Cd emissions coincide with the closure of outdated smelters and implementation of pollution prevention plans (ECCC, 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 2018 include:

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

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

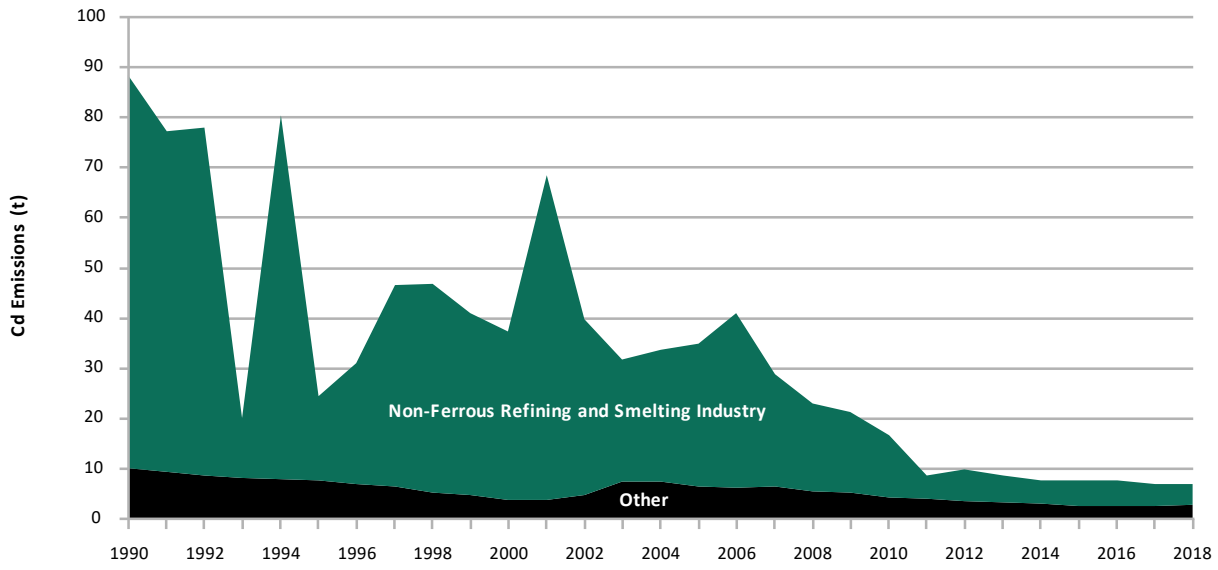


Table 2–10 National Summary of Annual Cd Emissions

Source	1990	2000	2005	2013	2014	2015	2016	2017	2018
					(kg)				
ORE AND MINERAL INDUSTRIES	**79 000**	**34 000**	**32 000**	**6 000**	**5 400**	**5 400**	**5 500**	**4 700**	**4 800**
Aluminium Industry	1.0	1.0	-	-	-	-	-	-	-
Asphalt Paving Industry	26	24	25	21	23	19	19	18	18
Cement and Concrete Industry	47	46	44	16	13	14	12	9.0	10
Foundries	2.0	2.0	26	1.7	62	21	0.75	21	21
Iron and Steel Industry	150	160	310	230	300	220	210	200	230
Iron Ore Industry	-	-	-	69	88	83	82	84	49
Mineral Products Industry	-	-	-	-	-	-	-	-	-
Mining and Rock Quarrying	-	550	2 900	320	330	50	52	53	250
Non-Ferrous Refining and Smelting Industry	78 000	34 000	29 000	5 300	4 600	5 000	5 100	4 300	4 200
OIL AND GAS INDUSTRY	**130**	**190**	**190**	**240**	**210**	**220**	**220**	**250**	**260**
Downstream Oil and Gas Industry	110	150	130	100	110	94	95	98	95
Upstream Oil and Gas Industry	25	38	61	140	110	130	120	150	160
ELECTRIC POWER GENERATION (UTILITIES)	**130**	**130**	**250**	**360**	**160**	**140**	**160**	**120**	**98**
Coal	87	91	170	300	94	43	100	78	62
Diesel	-	-	-	-	-	-	-	-	-
Natural Gas	29	30	56	47	43	52	35	27	24
Waste Materials	-	-	-	-	-	0.11	0.09	0.08	0.09
Other (Electric Power Generation)	14	14	27	20	27	45	25	16	11
MANUFACTURING	**1 100**	**950**	**940**	**640**	**590**	**580**	**600**	**560**	**590**
Abrasives Manufacturing	-	-	-	-	-	-	-	-	-
Bakeries	-	-	-	-	-	-	-	-	-
Biofuel Production	-	-	-	-	-	-	-	-	-
Chemicals Industry	140	130	71	7.7	7.3	7.9	8.1	7.8	8.2
Electronics	-	-	-	-	-	-	-	-	-
Food Preparation	-	-	-	-	-	-	-	-	-
Glass Manufacturing	1.0	1.0	1.9	-	-	-	-	-	-
Grain Industry	-	-	-	-	-	-	-	-	-
Metal Fabrication	460	410	290	340	330	320	310	290	310
Plastics Manufacturing	5.0	6.0	3.6	0.18	-	-	-	-	-
Pulp and Paper Industry	370	190	320	210	200	200	210	200	200
Textiles	-	-	-	-	-	-	-	-	-
Vehicle Manufacturing (Engines, Parts, Assembly, Painting)	2.0	88	1.1	-	-	-	-	0.00	-
Wood Products	130	130	110	83	58	51	63	59	77
Other (Manufacturing)	-	-	140	0.19	0.68	0.06	0.06	0.13	0.11
TRANSPORTATION AND MOBILE EQUIPMENT	**300**	**370**	**410**	**230**	**180**	**92**	**85**	**91**	**91**
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	160	110	36	34	33	32
Motorcycles	-	-	-	-	-	-	-	-	-
Off-Road Diesel Vehicles and Equipment	-	-	-	-	-	-	-	-	-
Off-Road Gasoline/LPG/NG Vehicles and Equipment	-	-	-	-	-	-	-	-	-
Rail Transportation	100	98	95	71	66	57	51	58	59
Tire Wear and Brake Lining	-	-	-	-	-	-	-	-	-
AGRICULTURE	**51**	**54**	**64**	**88**	**87**	**84**	**92**	**92**	**89**
Animal Production	-	-	-	-	-	-	-	-	-
Crop Production	-	-	-	-	-	-	-	-	-
Fuel Use	51	54	64	88	87	84	92	92	89
COMMERCIAL / RESIDENTIAL / INSTITUTIONAL	**1 100**	**1 200**	**1 200**	**1 100**	**1 100**	**1 100**	**1 100**	**1 100**	**1 100**
Cigarette Smoking[1]	6.0	5.1	3.9	3.0	3.0	2.7	2.7	2.7	2.8
Commercial and Institutional Fuel Combustion	340	510	480	470	480	470	480	480	480
Commercial Cooking	-	-	-	-	-	-	-	-	-
Construction Fuel Combustion	11	7.0	10	8.9	8.9	8.9	9.0	9.0	10
Home Firewood Burning	200	180	150	160	160	150	150	150	150
Human[1]	-	-	-	-	-	-	-	-	-
Marine Cargo Handling	-	-	47	2.3	1.2	0.50	2.2	2.3	2.5
Residential Fuel Combustion	540	500	500	480	490	460	440	450	480
Service Stations	-	-	-	-	-	-	-	-	-
Other (Miscellaneous)	-	-	-	-	-	-	-	-	-
INCINERATION AND WASTE	**7 000**	**200**	**45**	**34**	**36**	**36**	**34**	**36**	**36**
Crematoriums	0.34	0.48	0.61	0.79	0.86	0.89	0.92	0.96	0.98
Waste Incineration	7 000	200	44	31	33	32	31	32	28
Waste Treatment and Disposal	-	-	1.2	2.1	2.0	3.5	2.3	3.0	7.2
PAINTS AND SOLVENTS	**-**	**-**	**0.01**	**0.12**	**0.12**	**0.14**	**0.10**	**0.14**	**0.14**
Dry Cleaning	-	-	-	-	-	-	-	-	-
General Solvent Use	-	-	-	-	-	-	-	-	-
Printing	-	-	0.01	-	-	-	-	-	-
Surface Coatings	-	-	-	0.12	0.12	0.14	0.10	0.14	0.14
DUST	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
Coal Transportation	-	-	-	-	-	-	-	-	-
Construction Operations	-	-	-	-	-	-	-	-	-
Mine Tailings	-	-	-	-	-	-	-	-	-
Paved Roads	-	-	-	-	-	-	-	-	-
Unpaved Roads	-	-	-	-	-	-	-	-	-
FIRES	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
Prescribed Burning	-	-	-	-	-	-	-	-	-
Structural Fires	-	-	-	-	-	-	-	-	-
GRAND TOTAL	**88 000**	**37 000**	**35 000**	**8 700**	**7 800**	**7 700**	**7 700**	**6 900**	**7 100**

Notes:
Totals may not add up due to rounding.
1. Cigarette Smoking as well as Infant Diapered Waste (which is included within the Human sector) are being considered for removal from future inventories. If you have any questions, please contact us at ec.iepa-apei.ec@canada.ca or 1-877-877-8375.
- Indicates no emissions
0.00 Indicates emissions truncated due to rounding

2.9. **Mercury (Hg)**

Approximately 3.1 t of Hg were emitted in Canada in 2018 (Table 2–11). Ore and mineral industries accounted for 43% (1.3 t) of Hg emissions in 2018, with iron and steel industries contributing 19% (0.60 t) of the annual total. Electric power generation (utilities) accounted also for 19% (0.59 t) of 2018 emissions, most of which were emitted from coal-powered electric generation (18% of annual total, 0.57 t). Incineration and waste sources accounted for 15% (0.46 t) of Hg emissions in 2018, with crematoriums being the largest contributor at 9% (0.29 t).

Between 1990 and 2018, Hg emissions decreased by 91% (31 t) (Figure 2–9). This decrease in emissions is mainly due to a large drop in emissions from the non-ferrous refining and smelting industry. As with lead and cadmium emissions, reductions in mercury emissions coincide with the closure of outdated smelters, the implementation of pollution prevention plans and, to a smaller extent, with increased emission control measures, such as separation or changing of production materials, improved particulate matter emission controls and fuel switching (ECCC, 2017).

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

The most significant changes in Hg emissions from 1990 to 2018 include:

- Ore and mineral industry: decrease of 95% (25 t), of which:
  - Non-ferrous refining and smelting industry: decrease of 99% (25 t)
- Incineration and waste: decrease of 86% (2.8 t). of which:
  - Waste treatment and disposal: decrease of 94% (1.7 t)
- Electric power generation: decrease of 74% (1.7 t), of which:
  - Coal (electric power generation): decrease of 71% (1.4 t)

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

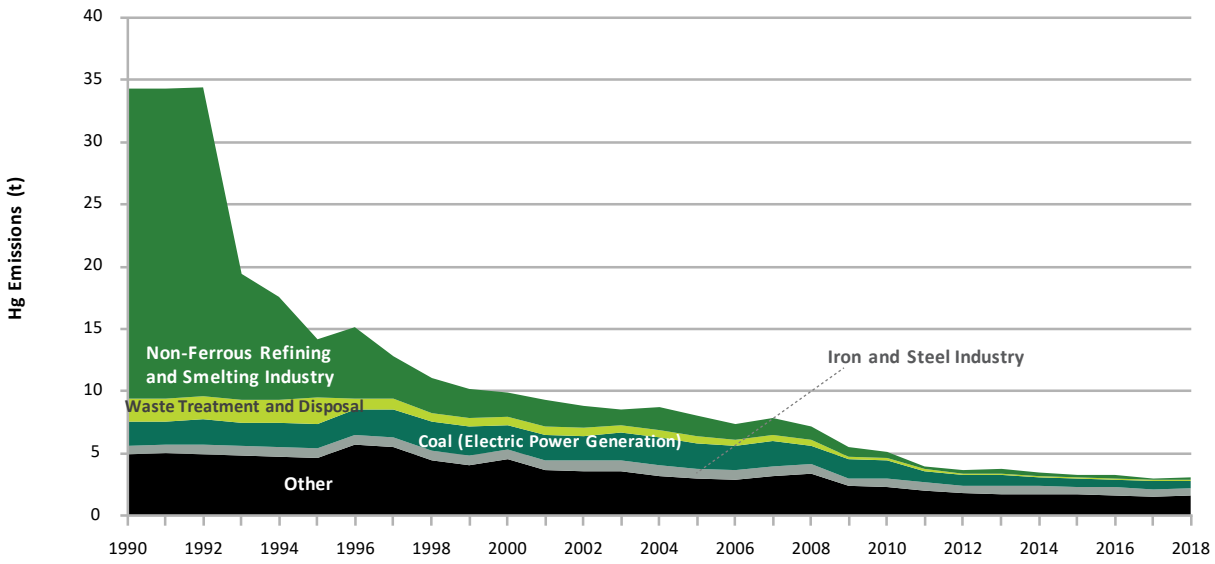


Table 2–11 National Summary of Annual Hg Emissions

Source	1990	2000	2005	2013	2014	2015	2016	2017	2018
	(kg)								
ORE AND MINERAL INDUSTRIES	**26 000**	**3 400**	**2 900**	**1 500**	**1 400**	**1 300**	**1 400**	**1 200**	**1 300**
Aluminium Industry	17	32	43	21	19	21	21	22	24
Asphalt Paving Industry	24	22	22	20	23	19	19	18	18
Cement and Concrete Industry	450	390	210	310	300	380	340	330	300
Foundries	210	120	4.2	-	-	-	-	-	-
Iron and Steel Industry	720	800	860	690	680	640	680	610	610
Iron Ore Industry	60	60	50	100	74	72	72	70	73
Mineral Products Industry	-	-	-	-	-	-	-	-	-
Mining and Rock Quarrying	12	12	29	8.6	20	20	16	19	110
Non-Ferrous Refining and Smelting Industry	25 000	1 900	1 700	360	290	180	220	140	200
OIL AND GAS INDUSTRY	**120**	**61**	**83**	**120**	**89**	**74**	**81**	**70**	**74**
Downstream Oil and Gas Industry	110	26	46	48	46	49	53	47	50
Upstream Oil and Gas Industry	3.0	36	38	68	44	25	28	22	24
ELECTRIC POWER GENERATION (UTILITIES)	**2 200**	**2 000**	**2 200**	**850**	**710**	**730**	**670**	**630**	**590**
Coal	1 900	2 000	2 000	800	660	680	630	610	570
Diesel	-	-	-	-	-	-	-	-	-
Natural Gas	12	22	27	23	19	26	11	0.01	2.1
Waste Materials	-	-	0.03	0.03	0.11	0.92	0.49	0.12	0.32
Other (Electric Power Generation)	290	62	91	23	28	26	30	17	22
MANUFACTURING	**1 100**	**1 400**	**510**	**110**	**100**	**110**	**120**	**100**	**110**
Abrasives Manufacturing	-	-	-	-	-	-	-	-	-
Bakeries	-	-	-	-	-	-	-	-	-
Biofuel Production	-	-	-	-	-	-	-	-	-
Chemicals Industry	170	81	58	17	18	15	17	17	18
Electronics	400	760	60	3.9	3.5	4.3	15	11	7.8
Food Preparation	-	-	0.30	-	-	-	-	-	-
Glass Manufacturing	28	28	21	-	-	-	-	-	-
Grain Industry	-	-	-	-	-	-	-	-	-
Metal Fabrication	16	17	17	7.5	-	-	-	-	-
Plastics Manufacturing	-	-	-	-	-	-	-	-	-
Pulp and Paper Industry	93	130	58	50	60	70	71	58	59
Textiles	-	-	-	-	-	-	-	-	-
Vehicle Manufacturing (Engines, Parts, Assembly, Painting)	-	-	0.02	-	-	-	-	-	-
Wood Products	260	190	89	31	18	17	16	13	25
Other (Manufacturing)	130	170	210	-	-	-	-	0.00	0.56
TRANSPORTATION AND MOBILE EQUIPMENT	**110**	**100**	**100**	**74**	**68**	**57**	**51**	**58**	**60**
Air Transportation	-	-	-	-	-	-	-	-	-
Heavy-duty Diesel Vehicles	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Heavy-duty Gasoline Vehicles	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Heavy-duty LPG/NG Vehicles	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Light-duty Diesel Trucks	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Light-duty Diesel Vehicles	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Light-duty Gasoline Trucks	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Light-duty Gasoline Vehicles	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Light-duty LPG/NG Trucks	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Light-duty LPG/NG Vehicles	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Marine Transportation	4.3	6.2	7.2	3.3	2.1	0.58	0.54	0.51	0.47
Motorcycles	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Off-Road Diesel Vehicles and Equipment	-	-	-	-	-	-	-	-	-
Off-Road Gasoline/LPG/NG Vehicles and Equipment	-	-	-	-	-	-	-	-	-
Rail Transportation	100	98	95	71	66	57	51	58	59
Tire Wear and Brake Lining	-	-	-	-	-	-	-	-	-
AGRICULTURE	**2.8**	**3.4**	**3.2**	**11**	**11**	**10**	**10**	**10**	**9.0**
Animal Production	-	-	-	-	-	-	-	-	-
Crop Production	-	-	-	-	-	-	-	-	-
Fuel Use	2.8	3.4	3.2	11	11	10	10	10	9.0
COMMERCIAL / RESIDENTIAL / INSTITUTIONAL	**1 100**	**800**	**760**	**590**	**570**	**520**	**480**	**480**	**470**
Cigarette Smoking[1]	0.21	0.18	0.14	0.11	0.11	0.10	0.10	0.10	0.10
Commercial and Institutional Fuel Combustion	47	62	63	54	58	55	55	59	61
Commercial Cooking	-	-	-	-	-	-	-	-	-
Construction Fuel Combustion	2.6	1.7	2.6	2.2	2.1	2.2	2.2	2.2	2.4
Home Firewood Burning	54	48	40	41	40	40	40	40	40
Human[1]	110	24	18	6.9	5.2	3.5	1.8	1.8	1.8
Marine Cargo Handling	-	-	2.8	-	-	-	-	-	-
Residential Fuel Combustion	64	76	75	76	80	75	67	71	80
Service Stations	-	-	-	-	-	-	-	-	-
Other (Miscellaneous)	820	590	560	410	380	340	310	300	290
INCINERATION AND WASTE	**3 200**	**2 200**	**1 500**	**470**	**520**	**470**	**470**	**460**	**460**
Crematoriums	100	140	180	240	260	260	270	280	290
Waste Incineration	1 300	1 300	840	100	140	85	81	69	67
Waste Treatment and Disposal	1 800	690	490	130	130	120	110	110	100
PAINTS AND SOLVENTS	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
Dry Cleaning	-	-	-	-	-	-	-	-	-
General Solvent Use	-	-	-	-	-	-	-	-	-
Printing	-	-	-	-	-	-	-	-	-
Surface Coatings	-	-	-	-	-	-	-	-	-
DUST	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
Coal Transportation	-	-	-	-	-	-	-	-	-
Construction Operations	-	-	-	-	-	-	-	-	-
Mine Tailings	-	-	-	-	-	-	-	-	-
Paved Roads	-	-	-	-	-	-	-	-	-
Unpaved Roads	-	-	-	-	-	-	-	-	-
FIRES	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
Prescribed Burning	-	-	-	-	-	-	-	-	-
Structural Fires	-	-	-	-	-	-	-	-	-
GRAND TOTAL	**34 000**	**9 900**	**8 100**	**3 700**	**3 500**	**3 300**	**3 300**	**3 000**	**3 100**

Notes:

Totals may not add up due to rounding.

1. Cigarette Smoking as well as Infant Diapered Waste (which is included within the Human sector) are being considered for removal from future inventories. If you have any questions, please contact us at ec.iepa-apei.ec@canada.ca or 1-877-877-8375.

- Indicates no emissions

0.00 Indicates emissions truncated due to rounding

2.10. Dioxins and Furans (D/F)

In 2018, emissions of dioxins and furans (D/F) in Canada totalled approximately 73 grams of toxicity equivalent (gTEQ) (Table 2–12). Incineration and waste sources accounted for the largest share of these emissions (33% or 24 gTEQ), with waste incineration accounting for 28% (21 gTEQ). Transportation and mobile equipment contributed 29% (21 gTEQ) of 2018 D/F emissions, 27% (20 gTEQ) of which are attributed to marine transportation. Ore and mineral industries collectively accounted for 22% (16 gTEQ) of 2018 D/F emissions. Commercial/residential/institutional sources were also significant contributors (10% and 7.5 gTEQ).

Between 1990 and 2018, D/F emissions decreased by 84% (377 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 2018 include:

- Incineration and waste: decrease of 93% (323 gTEQ), of which:
  - Waste incineration: decrease of 94% (325 gTEQ)

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

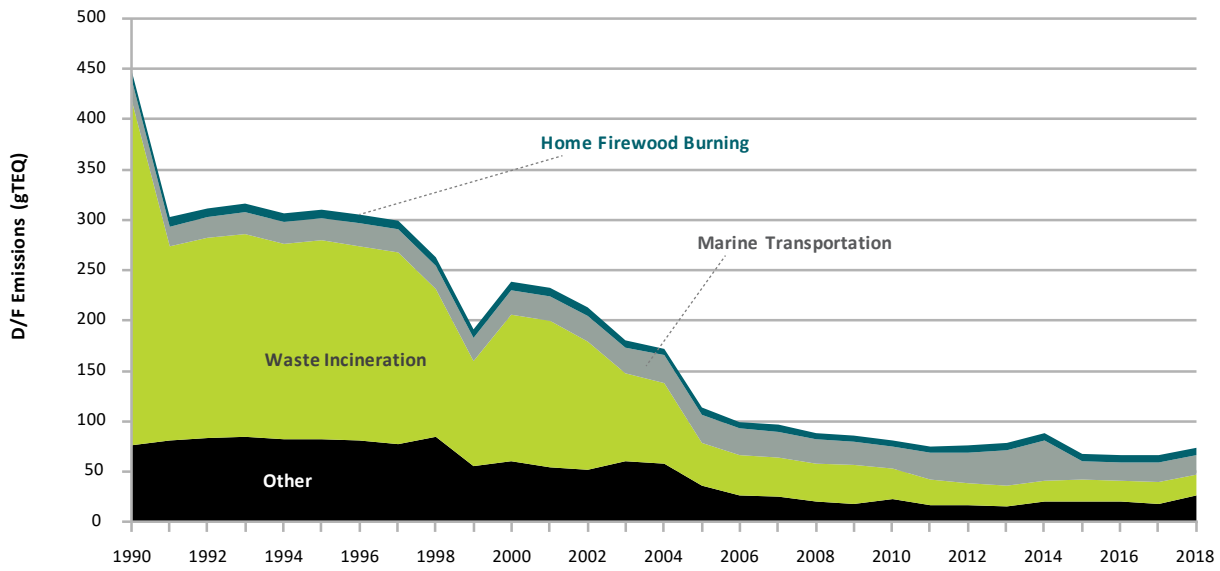


Table 2–12 National Summary of Annual Dioxins and Furans Emissions

Source	1990	2000	2005	2013	2014	2015	2016	2017	2018
	(gTEQ)								
ORE AND MINERAL INDUSTRIES	**45**	**28**	**9.0**	**3.8**	**6.7**	**7.3**	**5.7**	**6.3**	**16**
Aluminium Industry	3.0	4.0	-	-	-	-	-	-	-
Asphalt Paving Industry	0.02	0.02	0.01	0.00	0.01	0.00	0.00	0.00	0.00
Cement and Concrete Industry	3.0	1.8	2.6	0.54	1.9	1.6	0.61	0.22	8.3
Foundries	-	0.07	0.01	0.00	0.04	0.03	0.04	0.01	0.00
Iron and Steel Industry	35	17	4.0	2.9	4.4	5.2	4.7	5.6	7.1
Iron Ore Industry	-	-	-	-	0.00	0.00	0.00	0.00	0.00
Mineral Products Industry	1.0	1.0	1.0	-	-	-	-	-	-
Mining and Rock Quarrying	-	-	0.50	0.03	0.05	0.09	0.03	0.02	0.02
Non-Ferrous Refining and Smelting Industry	3.0	3.3	1.3	0.38	0.29	0.38	0.41	0.44	0.42
OIL AND GAS INDUSTRY	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
Downstream Oil and Gas Industry	-	-	-	-	-	-	-	-	-
Upstream Oil and Gas Industry	-	-	-	-	-	-	-	-	-
ELECTRIC POWER GENERATION (UTILITIES)	**3.0**	**6.2**	**5.5**	**1.7**	**2.0**	**1.9**	**2.9**	**2.2**	**1.5**
Coal	2.3	3.1	3.9	1.5	1.8	1.6	1.9	1.6	0.95
Diesel	-	-	-	-	-	-	-	-	-
Natural Gas	0.46	1.0	1.2	0.02	0.04	0.01	0.01	0.03	0.00
Waste Materials	0.00	0.02	0.01	0.00	0.01	0.01	0.16	0.01	0.01
Other (Electric Power Generation)	0.23	2.1	0.43	0.17	0.19	0.19	0.75	0.60	0.52
MANUFACTURING	**17**	**16**	**13**	**3.7**	**3.0**	**2.9**	**4.0**	**3.2**	**2.5**
Abrasives Manufacturing	-	-	0.05	0.02	0.02	0.01	0.01	0.01	0.01
Bakeries	-	-	-	-	-	-	-	-	-
Biofuel Production	-	-	-	-	-	-	-	-	-
Chemicals Industry	2.0	0.10	0.07	0.13	0.27	0.26	0.31	0.33	0.00
Electronics	-	-	-	-	-	-	-	-	-
Food Preparation	-	-	0.07	-	-	-	-	-	-
Glass Manufacturing	-	-	-	-	-	-	-	-	-
Grain Industry	-	-	-	-	-	-	-	-	-
Metal Fabrication	2.0	7.1	5.0	1.1	0.90	0.87	0.92	0.92	0.81
Plastics Manufacturing	-	-	-	-	-	-	-	-	-
Pulp and Paper Industry	11	5.2	4.9	1.8	1.1	1.1	2.1	1.3	1.1
Textiles	-	-	-	-	-	-	-	-	-
Vehicle Manufacturing (Engines, Parts, Assembly, Painting)	-	1.3	0.44	-	-	-	-	-	-
Wood Products	1.8	2.7	2.5	0.62	0.66	0.64	0.64	0.59	0.57
Other (Manufacturing)	-	-	0.12	-	-	-	-	-	-
TRANSPORTATION AND MOBILE EQUIPMENT	**21**	**26**	**29**	**37**	**42**	**20**	**20**	**21**	**21**
Air Transportation	-	-	-	-	-	-	-	-	-
Heavy-duty Diesel Vehicles	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Heavy-duty Gasoline Vehicles	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Heavy-duty LPG/NG Vehicles	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Light-duty Diesel Trucks	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Light-duty Diesel Vehicles	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Light-duty Gasoline Trucks	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Light-duty Gasoline Vehicles	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Light-duty LPG/NG Trucks	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Light-duty LPG/NG Vehicles	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Marine Transportation	20	25	28	35	40	18	19	19	20
Motorcycles	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Off-Road Diesel Vehicles and Equipment	-	-	-	-	-	-	-	-	-
Off-Road Gasoline/LPG/NG Vehicles and Equipment	-	-	-	-	-	-	-	-	-
Rail Transportation	1.2	1.2	1.2	1.3	1.4	1.3	1.2	1.4	1.4
Tire Wear and Brake Lining	-	-	-	-	-	-	-	-	-
AGRICULTURE	**0.06**	**0.05**	**0.04**	**0.61**	**0.64**	**0.59**	**0.58**	**0.56**	**0.45**
Animal Production	-	-	-	-	-	-	-	-	-
Crop Production	-	-	-	-	-	-	-	-	-
Fuel Use	0.06	0.05	0.04	0.61	0.64	0.59	0.58	0.56	0.45
COMMERCIAL / RESIDENTIAL / INSTITUTIONAL	**11**	**10**	**8.2**	**8.1**	**8.1**	**8.8**	**7.7**	**7.5**	**7.5**
Cigarette Smoking[1]	0.02	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Commercial and Institutional Fuel Combustion	0.37	0.37	0.33	0.26	0.45	1.3	0.27	0.23	0.18
Commercial Cooking	-	-	-	-	-	-	-	-	-
Construction Fuel Combustion	0.07	0.03	0.04	0.03	0.03	0.03	0.03	0.03	0.03
Home Firewood Burning	9.0	8.2	6.7	7.1	7.1	7.0	7.0	7.0	7.0
Human[1]	-	-	-	-	-	-	-	-	-
Marine Cargo Handling	-	-	-	-	-	-	-	-	-
Residential Fuel Combustion	1.5	1.2	1.1	0.64	0.58	0.44	0.39	0.26	0.28
Service Stations	-	-	-	-	-	-	-	-	-
Other (Miscellaneous)	-	-	-	-	-	-	-	-	-
INCINERATION AND WASTE	**350**	**150**	**47**	**23**	**23**	**24**	**24**	**24**	**24**
Crematoriums	1.1	1.6	2.1	2.7	2.9	3.0	3.1	3.2	3.3
Waste Incineration	350	150	43	21	20	21	20	21	21
Waste Treatment and Disposal	-	3.8	1.9	-	-	-	-	-	-
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**	**0.68**	**2.8**	**2.2**	**1.8**	**1.1**	**0.53**
Prescribed Burning	7.6	1.5	0.92	0.68	2.8	2.2	1.8	1.1	0.53
Structural Fires	-	-	-	-	-	-	-	-	-
GRAND TOTAL	**450**	**240**	**110**	**79**	**88**	**68**	**66**	**66**	**73**

Notes:
Totals may not add up due to rounding.
1. Cigarette Smoking as well as Infant Diapered Waste (which is included within the Human sector) are being considered for removal from future inventories. If you have any questions, please contact us at ec.iepa-apei.ec@canada.ca or 1-877-877-8375.
- Indicates no emissions
0.00 Indicates emissions truncated due to rounding

2.11. Polycyclic Aromatic Hydrocarbons (PAHs)

The APEI reports emissions of four PAHs: benzo(a)pyrene (B(a)p), benzo(b)fluoranthene (B(b)f), benzo(k)fluoranthene (B(k)f) and indeno[1,2,3-cd]pyrene (I(1,2,3-cd)p). The analysis presented here is based on the aggregate total of all four substances. In 2018, 111 t of PAHs were emitted in Canada (Table 2–13), with 90% (101 t) attributed to commercial/residential/institutional sources. This is almost entirely due to home firewood burning. Transportation and Mobile Equipment, as the next largest source, contributed 8% (8 t) of PAH emissions in 2018.

Home firewood burning dominates PAH emissions throughout the time series. This source experienced a 26% (36 t) emission decrease from 1990 to 2018. This can be attributed to a reduction in the use of wood as heating fuel and to the increased use of newer technologies in fireplace inserts, furnaces and stoves that improve combustion efficiency and as a result limit the emission of both wood smoke and PAHs.

From 1990 to 2018, PAH emissions decreased by 69% (249 t) (Figure 2–11), primarily due to emission reductions in the aluminium industry and iron and steel industry. Emissions from the aluminium industry experienced a large drop in PAH emissions from 2008 to 2016 due to process improvements and the progressive phase-out of old Söderberg aluminium production technologies (ECCC, Annual Public Report of Environmental Performance Agreement Concerning Atmospheric Emissions of Polycyclic Aromatic Hydrocarbons between Environment and Climate Change Canada and Rio Tinto Alcan, 2014).

Emissions of these four types of PAHs from iron and steel industry experienced a large drop earlier in the time series, from 1993 to 2006, and emissions remained quite small through 2018. Reductions here are a result of effective emission controls on coke ovens and coke by-product plants (EC, 2001).

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

The most significant changes in PAH emissions from 1990 to 2018 include:

- Ore and mineral industries: decrease of almost 100% (188 t), of which:
  - Aluminium industry: decrease of almost 100% (109 t)
  - Iron and steel industry: decrease of almost 100% (79 t)
- Commercial/residential/institutional: decrease of 26% (36 t), of which:
  - Home firewood burning: decrease of 26% (36 t)
- Transportation and Mobile Equipment: decrease of 65% (16 t), of which:
  - Light-duty Gasoline Trucks and Vehicles: decrease of 63% (10 t)

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

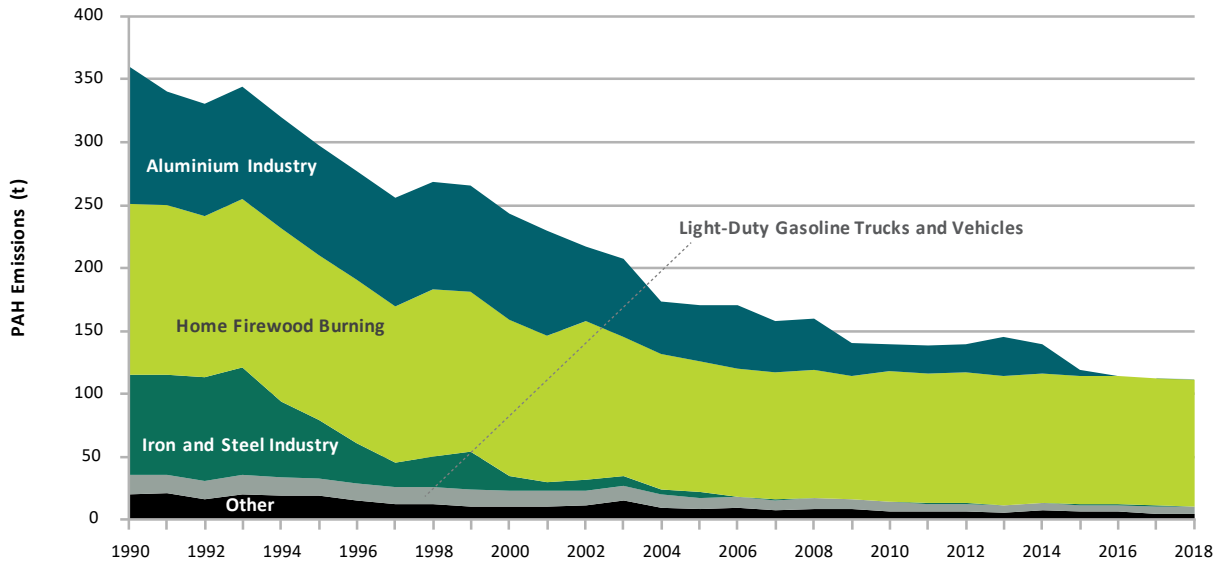


Table 2–13 National Summary of Annual PAH Emissions

Source	1990	2000	2005	2013	2014	2015	2016	2017	2018
	(kg)								
ORE AND MINERAL INDUSTRIES	**190 000**	**95 000**	**50 000**	**32 000**	**24 000**	**5 400**	**690**	**550**	**620**
Aluminium Industry	110 000	84 000	45 000	31 000	23 000	4 900	100	130	190
Asphalt Paving Industry	14	14	15	12	13	11	11	10	10
Cement and Concrete Industry	17	13	19	1.7	3.1	2.8	0.23	0.62	0.34
Foundries	-	-	-	-	-	-	-	-	-
Iron and Steel Industry	80 000	11 000	4 600	550	400	400	440	390	400
Iron Ore Industry	-	-	-	18	19	20	20	21	18
Mineral Products Industry	-	-	-	-	-	-	-	-	-
Mining and Rock Quarrying	-	-	-	160	250	110	110	0.02	0.01
Non-Ferrous Refining and Smelting Industry	2.0	3.0	0.69	0.31	0.31	0.32	0.30	0.33	0.33
OIL AND GAS INDUSTRY	**150**	**95**	**46**	**27**	**25**	**24**	**20**	**18**	**22**
Downstream Oil and Gas Industry	150	92	43	18	16	19	14	13	14
Upstream Oil and Gas Industry	2.3	3.3	2.3	9.0	10	4.8	5.8	4.5	7.9
ELECTRIC POWER GENERATION (UTILITIES)	**370**	**360**	**240**	**6.7**	**6.4**	**6.1**	**6.8**	**6.5**	**0.04**
Coal	240	240	240	-	-	-	-	-	-
Diesel	-	-	-	-	-	-	-	-	-
Natural Gas	2.9	2.3	0.23	0.03	0.03	0.04	0.05	0.04	0.04
Waste Materials	-	-	-	-	-	-	-	-	-
Other (Electric Power Generation)	130	110	-	6.7	6.4	6.0	6.8	6.5	-
MANUFACTURING	**320**	**300**	**300**	**58**	**170**	**110**	**96**	**110**	**100**
Abrasives Manufacturing	-	-	-	-	-	-	-	-	-
Bakeries	-	-	-	-	-	-	-	-	-
Biofuel Production	-	-	-	-	-	-	-	-	-
Chemicals Industry	-	24	30	25	24	25	25	25	24
Electronics	-	-	-	-	-	-	-	-	-
Food Preparation	-	-	-	-	-	-	-	-	-
Glass Manufacturing	-	-	-	-	-	-	-	-	-
Grain Industry	-	-	-	-	-	-	-	-	-
Metal Fabrication	-	-	8.3	4.1	-	-	-	-	-
Plastics Manufacturing	-	-	-	-	-	-	-	-	-
Pulp and Paper Industry	110	130	190	18	130	73	64	78	75
Textiles	-	-	-	-	-	-	-	-	-
Vehicle Manufacturing (Engines, Parts, Assembly, Painting)	-	-	-	0.02	0.03	0.02	0.01	0.02	0.02
Wood Products	210	150	72	11	10	8.6	7.9	6.0	5.9
Other (Manufacturing)	-	-	2.2	-	-	-	-	-	-
TRANSPORTATION AND MOBILE EQUIPMENT	**24 000**	**20 000**	**15 000**	**9 200**	**8 400**	**7 900**	**8 200**	**8 300**	**8 500**
Air Transportation	8.4	6.0	2.8	3.4	3.4	3.6	3.5	3.9	4.4
Heavy-duty Diesel Vehicles	910	990	1 200	750	690	610	600	630	660
Heavy-duty Gasoline Vehicles	6 200	4 300	4 200	2 300	1 900	1 800	1 900	1 900	2 000
Heavy-duty LPG/NG Vehicles	1 100	1 300	330	5.2	2.8	2.5	3.5	6.7	6.7
Light-duty Diesel Trucks	2.1	2.7	2.8	1.6	1.7	1.8	2.0	2.3	2.4
Light-duty Diesel Vehicles	7.8	5.4	3.4	2.6	2.5	2.4	2.2	2.2	2.1
Light-duty Gasoline Trucks	4 500	5 400	3 800	2 900	2 800	2 800	3 000	3 000	3 200
Light-duty Gasoline Vehicles	11 000	7 600	5 000	2 900	2 700	2 500	2 500	2 500	2 500
Light-duty LPG/NG Trucks	380	170	80	1.3	0.95	0.85	0.93	1.1	1.1
Light-duty LPG/NG Vehicles	47	25	12	0.05	0.04	0.04	0.04	0.06	0.06
Marine Transportation	120	150	170	210	240	110	110	120	120
Motorcycles	39	38	42	38	37	37	40	41	42
Off-Road Diesel Vehicles and Equipment	-	-	-	-	-	-	-	-	-
Off-Road Gasoline/LPG/NG Vehicles and Equipment	-	-	-	-	-	-	-	-	-
Rail Transportation	63	59	58	43	40	34	31	35	36
Tire Wear and Brake Lining	-	-	-	-	-	-	-	-	-
AGRICULTURE	**0.32**	**0.31**	**0.21**	**0.36**	**0.38**	**0.34**	**0.35**	**0.35**	**0.35**
Animal Production	-	-	-	-	-	-	-	-	-
Crop Production	-	-	-	-	-	-	-	-	-
Fuel Use	0.32	0.31	0.21	0.36	0.38	0.34	0.35	0.35	0.35
COMMERCIAL / RESIDENTIAL / INSTITUTIONAL	**140 000**	**120 000**	**100 000**	**100 000**	**100 000**	**100 000**	**100 000**	**100 000**	**100 000**
Cigarette Smoking[1]	1.0	0.90	0.68	0.53	0.53	0.47	0.48	0.48	0.49
Commercial and Institutional Fuel Combustion	2.6	3.1	3.0	2.3	2.4	2.3	2.2	2.2	2.2
Commercial Cooking	100	110	120	120	120	110	110	110	110
Construction Fuel Combustion	0.45	0.19	0.41	0.26	0.26	0.28	0.22	0.23	0.22
Home Firewood Burning	140 000	120 000	100 000	100 000	100 000	100 000	100 000	100 000	100 000
Human[1]	-	-	-	-	-	-	-	-	-
Marine Cargo Handling	-	-	-	-	-	-	-	-	-
Residential Fuel Combustion	5.3	4.6	4.3	3.4	3.5	3.3	3.0	3.0	3.2
Service Stations	-	-	-	-	-	-	-	-	-
Other (Miscellaneous)	-	-	-	-	-	-	-	-	-
INCINERATION AND WASTE	**670**	**630**	**690**	**680**	**690**	**690**	**700**	**710**	**710**
Crematoriums	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.01
Waste Incineration	670	630	690	680	690	690	700	710	710
Waste Treatment and Disposal	-	-	-	0.00	0.00	0.00	0.01	0.00	0.00
PAINTS AND SOLVENTS	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
Dry Cleaning	-	-	-	-	-	-	-	-	-
General Solvent Use	-	-	-	-	-	-	-	-	-
Printing	-	-	-	-	-	-	-	-	-
Surface Coatings	-	-	-	-	-	-	-	-	-
DUST	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
Coal Transportation	-	-	-	-	-	-	-	-	-
Construction Operations	-	-	-	-	-	-	-	-	-
Mine Tailings	-	-	-	-	-	-	-	-	-
Paved Roads	-	-	-	-	-	-	-	-	-
Unpaved Roads	-	-	-	-	-	-	-	-	-
FIRES	**9 800**	**2 000**	**1 200**	**880**	**3 600**	**2 900**	**2 400**	**1 400**	**680**
Prescribed Burning	9 800	2 000	1 200	880	3 600	2 900	2 400	1 400	680
Structural Fires	-	-	-	-	-	-	-	-	-
GRAND TOTAL	**360 000**	**240 000**	**170 000**	**150 000**	**140 000**	**120 000**	**110 000**	**110 000**	**110 000**

Notes:
Totals may not add up due to rounding.
1. Cigarette Smoking as well as Infant Diapered Waste (which is included within the Human sector) are being considered for removal from future inventories. If you have any questions, please contact us at ec.iepa-apei.ec@canada.ca or 1-877-877-8375.
- Indicates no emissions
0.00 Indicates emissions truncated due to rounding

2.12. Hexachlorobenzene (HCB)

In 2018, approximately 8.8 kg of HCB were emitted in Canada (Table 2–14). Waste incineration was the largest contributor in 2018 with 56% (4.9 kg) of total HCB emissions. The ore and mineral industries were the second-largest contributor, with 35% (3.1 kg) of total emissions, largely attributed to iron and steel industries, which represented 13% (1.1 kg) of the national total.

Overall, HCB emissions decreased by 91% (89 kg) from 1990 to 2018. HCB emissions decreased between 1990 and 2014; since 2014 HCB emissions have been stable (Figure 2–12). Most of the decrease is due to a drop in emissions from waste incineration since 1998, specifically as a result of a decline in the use of batch incinerators for municipal waste incineration. For example, Newfoundland and Labrador has had a steady decline in the use of conical burners (Newfoundland Municipal Affairs and Environment, 2017). Emission reductions were also observed as a result of the phasing out of coal electricity generation in Ontario between 2000 and 2014.[3]

The most significant changes in HCB emissions from 1990 to 2018 include:

- Incineration and waste: decrease of over 93% (68 kg), of which:
  - Waste incineration: decrease of over 93% (68 kg)
- Electric power generation (utilities): decrease of 96% (11 kg), of which:
  - Coal (electricity power generation): decrease of 97% (10 kg)

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

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

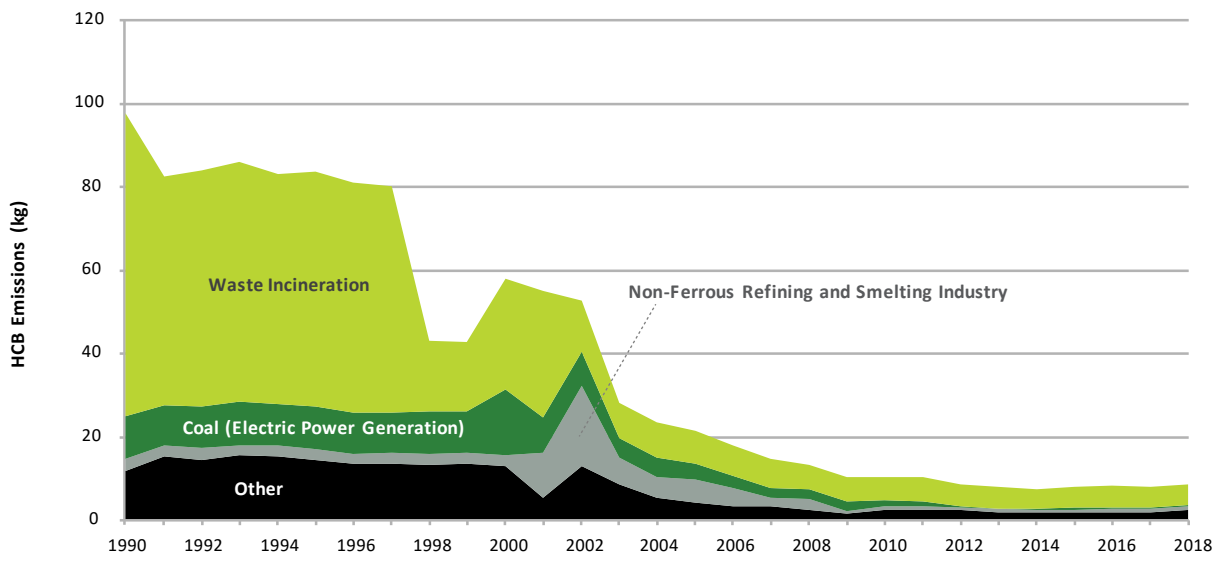


Table 2–14 National Summary of Annual HCB Emissions

Source	1990	2000	2005	2013	2014	2015	2016	2017	2018
					(g)				
ORE AND MINERAL INDUSTRIES	**5 500**	**5 700**	**8 100**	**2 300**	**1 900**	**2 100**	**2 300**	**2 400**	**3 100**
Aluminium Industry	-	-	-	-	-	-	-	-	-
Asphalt Paving Industry	-	-	-	-	-	-	-	-	-
Cement and Concrete Industry	1 600	2 100	880	420	280	290	410	300	900
Foundries	-	-	-	-	29	23	24	6.0	0.00
Iron and Steel Industry	1 100	980	1 500	1 100	1 100	1 100	1 000	1 100	1 100
Iron Ore Industry	-	-	-	-	-	-	-	-	-
Mineral Products Industry	-	-	-	-	-	-	-	-	-
Mining and Rock Quarrying	-	-	44	13	12	17	12	7.5	6.5
Non-Ferrous Refining and Smelting Industry	2 700	2 600	5 600	730	530	700	830	1 000	1 100
OIL AND GAS INDUSTRY	**1.3**	**1.6**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
Downstream Oil and Gas Industry	-	-	-	-	-	-	-	-	-
Upstream Oil and Gas Industry	1.3	1.6	-	-	-	-	-	-	-
ELECTRIC POWER GENERATION (UTILITIES)	**11 000**	**17 000**	**4 100**	**350**	**400**	**600**	**570**	**460**	**400**
Coal	10 000	16 000	3 900	190	240	430	430	360	300
Diesel	-	-	-	-	-	-	-	-	-
Natural Gas	640	1 300	170	140	140	150	120	84	81
Waste Materials	4.8	-	-	-	-	-	-	-	-
Other (Electric Power Generation)	-	190	-	25	23	16	17	16	17
MANUFACTURING	**8 600**	**8 200**	**1 500**	**330**	**360**	**350**	**280**	**350**	**330**
Abrasives Manufacturing	-	-	-	-	-	-	-	-	-
Bakeries	-	-	-	-	-	-	-	-	-
Biofuel Production	-	-	-	-	-	-	-	-	-
Chemicals Industry	680	330	480	-	-	-	-	-	-
Electronics	-	-	-	-	-	-	-	-	-
Food Preparation	-	2.9	3.0	-	-	-	-	-	-
Glass Manufacturing	-	-	-	-	-	-	-	-	-
Grain Industry	-	-	-	-	-	-	-	-	-
Metal Fabrication	450	470	52	230	290	210	190	240	230
Plastics Manufacturing	-	-	0.00	-	-	-	-	-	-
Pulp and Paper Industry	140	180	310	94	73	140	88	110	100
Textiles	-	-	-	-	-	-	-	-	-
Vehicle Manufacturing (Engines, Parts, Assembly, Painting)	7 000	6 700	-	-	-	-	-	-	-
Wood Products	340	580	620	1.9	0.26	0.11	0.11	0.09	0.09
Other (Manufacturing)	-	-	-	-	-	-	-	-	-
TRANSPORTATION AND MOBILE EQUIPMENT	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
Air Transportation	-	-	-	-	-	-	-	-	-
Heavy-duty Diesel Vehicles	-	-	-	-	-	-	-	-	-
Heavy-duty Gasoline Vehicles	-	-	-	-	-	-	-	-	-
Heavy-duty LPG/NG Vehicles	-	-	-	-	-	-	-	-	-
Light-duty Diesel Trucks	-	-	-	-	-	-	-	-	-
Light-duty Diesel Vehicles	-	-	-	-	-	-	-	-	-
Light-duty Gasoline Trucks	-	-	-	-	-	-	-	-	-
Light-duty Gasoline Vehicles	-	-	-	-	-	-	-	-	-
Light-duty LPG/NG Trucks	-	-	-	-	-	-	-	-	-
Light-duty LPG/NG Vehicles	-	-	-	-	-	-	-	-	-
Marine Transportation	-	-	-	-	-	-	-	-	-
Motorcycles	-	-	-	-	-	-	-	-	-
Off-Road Diesel Vehicles and Equipment	-	-	-	-	-	-	-	-	-
Off-Road Gasoline/LPG/NG Vehicles and Equipment	-	-	-	-	-	-	-	-	-
Rail Transportation	-	-	-	-	-	-	-	-	-
Tire Wear and Brake Lining	-	-	-	-	-	-	-	-	-
AGRICULTURE	**-**	**-**	**-**	**1.2**	**1.2**	**1.1**	**1.1**	**1.0**	**0.82**
Animal Production	-	-	-	-	-	-	-	-	-
Crop Production	-	-	-	-	-	-	-	-	-
Fuel Use	-	-	-	1.2	1.2	1.1	1.1	1.0	0.82
COMMERCIAL / RESIDENTIAL / INSTITUTIONAL	**1.6**	**4.4**	**1.3**	**0.68**	**0.58**	**0.31**	**0.23**	**-**	**0.05**
Cigarette Smoking[1]	-	-	-	-	-	-	-	-	-
Commercial and Institutional Fuel Combustion	0.11	3.0	0.01	-	-	-	-	-	-
Commercial Cooking	-	-	-	-	-	-	-	-	-
Construction Fuel Combustion	-	-	-	-	-	-	-	-	-
Home Firewood Burning	-	-	-	-	-	-	-	-	-
Human[1]	-	-	-	-	-	-	-	-	-
Marine Cargo Handling	-	-	-	-	-	-	-	-	-
Residential Fuel Combustion	1.5	1.4	1.3	0.68	0.58	0.31	0.23	-	0.05
Service Stations	-	-	-	-	-	-	-	-	-
Other (Miscellaneous)	-	-	-	-	-	-	-	-	-
INCINERATION AND WASTE	**73 000**	**27 000**	**7 900**	**5 200**	**4 900**	**4 900**	**5 200**	**5 000**	**4 900**
Crematoriums	10	14	18	24	26	27	28	28	29
Waste Incineration	73 000	27 000	7 800	5 200	4 800	4 900	5 200	5 000	4 900
Waste Treatment and Disposal	-	230	96	0.76	0.47	0.08	0.08	0.08	0.22
PAINTS AND SOLVENTS	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
Dry Cleaning	-	-	-	-	-	-	-	-	-
General Solvent Use	-	-	-	-	-	-	-	-	-
Printing	-	-	-	-	-	-	-	-	-
Surface Coatings	-	-	-	-	-	-	-	-	-
DUST	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
Coal Transportation	-	-	-	-	-	-	-	-	-
Construction Operations	-	-	-	-	-	-	-	-	-
Mine Tailings	-	-	-	-	-	-	-	-	-
Paved Roads	-	-	-	-	-	-	-	-	-
Unpaved Roads	-	-	-	-	-	-	-	-	-
FIRES	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
Prescribed Burning	-	-	-	-	-	-	-	-	-
Structural Fires	-	-	-	-	-	-	-	-	-
GRAND TOTAL	**98 000**	**58 000**	**22 000**	**8 200**	**7 600**	**8 000**	**8 400**	**8 200**	**8 800**

Notes:
Totals may not add up due to rounding.
1. Cigarette Smoking as well as Infant Diapered Waste (which is included within the Human sector) are being considered for removal from future inventories. If you have any questions, please contact us at ec.iepa-apei.ec@canada.ca or 1-877-877-8375.
- Indicates no emissions
0.00 Indicates emissions truncated due to rounding

CHAPTER 3

AIR POLLUTANT EMISSIONS INVENTORY DEVELOPMENT

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

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

The APEI is developed using many sources of information, procedures and emission estimation models. Emissions data reported by individual facilities to Environment and Climate Change Canada's (ECCC's) National Pollutant Release Inventory (NPRI) are supplemented with documented, science-based estimation tools to quantify total emissions. Together, these data sources provide a comprehensive overview of pollutant emissions across Canada. A framework has been developed that makes use of the best available data, while ensuring that there is no double-counting or omissions. This chapter presents information about the inventory development process.

3.1. Overview of Inventory Development

The process of developing comprehensive emission estimates for the APEI consists of categorizing facility-reported data (section 3.2), calculating in-house estimates (section 3.3), reconciling the facility-reported data and the in-house estimates in a database where necessary (section 3.4), followed by compiling and reporting the results (Figure 3–1). Quality control is performed throughout inventory development (section 3.5), and continuous improvement often results in revisions to previously published estimates (section 3.6).

Facility-Reported Emissions

As a first step, seventeen pollutants reported in the APEI are extracted from the NPRI verified database, which contains facility-reported data. New facilities are identified in the extracted data and classified within the APEI according to the nature of their activities. This step results in a compiled database containing all needed facility-reported emissions for the air pollutant inventory report.

Facility-reported data from the NPRI are used in the inventory without modifications except when 1) data quality issues are detected and 2) adjustments are needed to PM fractions.

More information on facility-reported emissions is presented in section 3.2.

In-House Emission Estimates

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. Updated estimates are calculated using new and/or updated activity data. Where possible, inventory estimates calculated in-house use the most rigorous (highest-tier) methods; however, owing to practical limitations, the exhaustive development of all emissions categories is not possible. In these cases, estimates are generally calculated using activity data and emission factors following relatively basic (lower-tier) methodologies. Calculations are performed in spreadsheets (Excel), SQL queries (MS Access and SQL server), or using computational scripts (R and Python) and may include spatial data quantified using geographic information systems software (GIS-ArcGIS and QGIS).

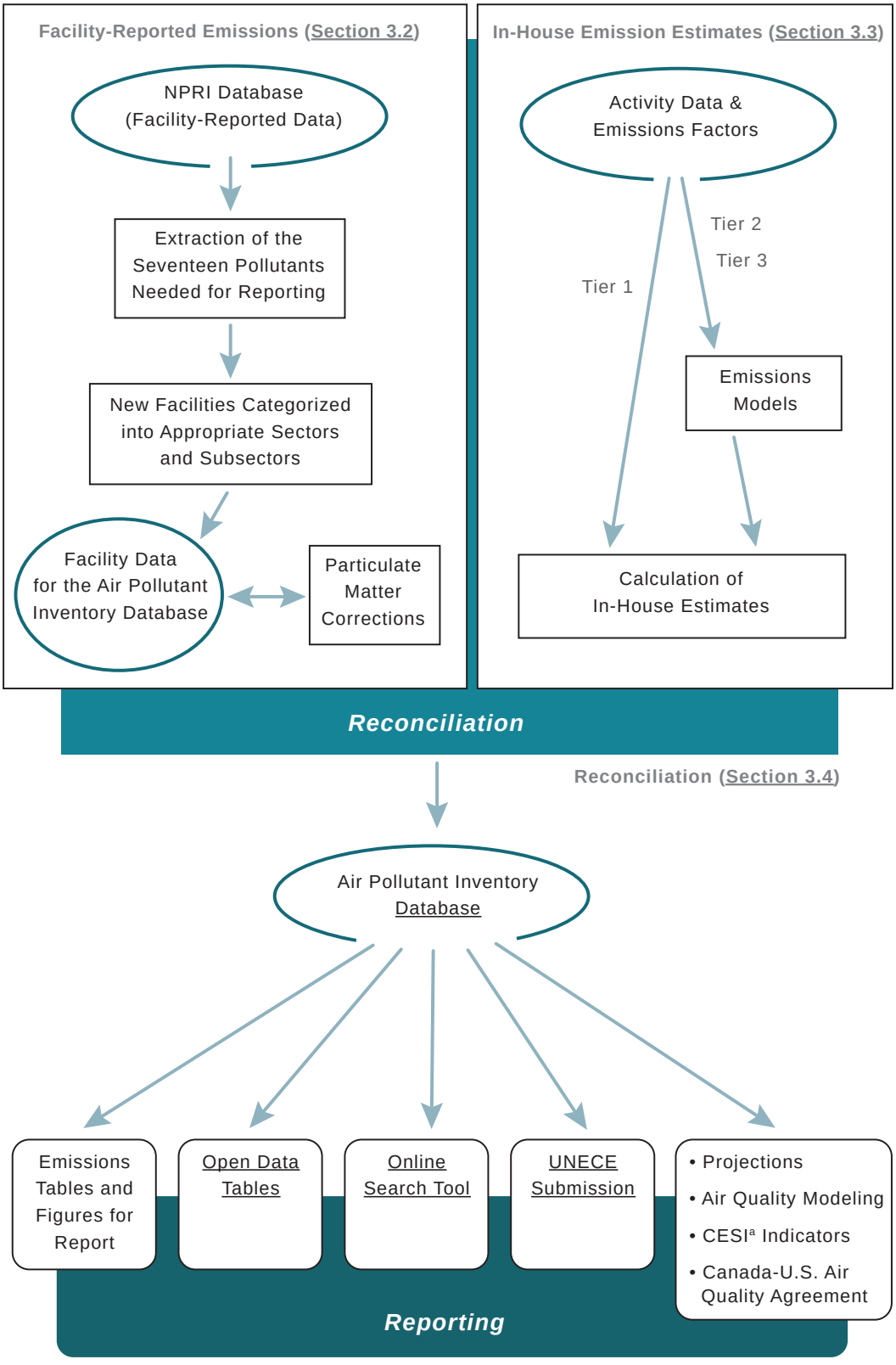
More information on in-house estimates can be found in section 3.3.

Reconciliation

The next step in the compilation process is the elimination of any double-counting of emissions between the in-house estimates and the facility-reported data by a process of reconciliation. Table 3–1 illustrates the origin of the emissions for each sector and subsector: facility-reported data, in-house calculated data or a combination of both, for the latest available year. Note the origin can change depending on the year. Reconciliation of in-house estimates with facility-reported data is required for sectors or subsectors where both in-house and facility-reported estimates exist. For 2018, reconciliation was performed for about 28 sectors.

More information on reconciliation is available in section 3.4.

Figure 3–1 **Overview of the Annual Air Pollutant Emissions Inventory Compilation Process**



Note:
a Canadian Environmental Sustainability Indicators

Table 3–1 2018 Air Pollutant Emissions Inventory

Air Pollutant Emissions Inventory sectors	Facility-reported data[a]	In-house estimates[b]	Activity data used for in-house estimates
ORE AND MINERAL INDUSTRIES			
Aluminium Industry			
Alumina (Bauxite Refining)	☑		
Primary Aluminium Smelting and Refining	☑		
Secondary Aluminium Production (Includes Recycling)	☑		
Asphalt Paving Industry	☑	☑	2018
Cement and Concrete Industry			
Cement Manufacturing	☑		
Concrete Batching and Products	☑	☑	2018
Gypsum Product Manufacturing	☑		
Lime Manufacturing	☑		
Foundries			
Die Casting	☑		
Ferrous Foundries	☑	☑	2011
Non-ferrous Foundries	☑		
Iron and Steel Industry			
Primary (Blast Furnace and DRI)	☑		
Secondary (Electric Arc Furnaces)	☑	☑	2018 (Hg in Products)
Steel Recycling	☑	☑	2018 (Hg in Products)
Iron Ore Industry			
Iron Ore Mining	☑		
Pelletizing	☑		
Mineral Products Industry			
Clay Products	☑		
Brick Products	☑		
Other (Mineral Products Industry)	☑		
Mining and Rock Quarrying			
Coal Mining Industry	☑		
Metal Mining	☑		
Potash	☑		
Rock, Sand and Gravel	☑	☑	2018
Silica Production		☑	2018
Limestone	☑		
Other (Mining and Rock Quarrying)	☑		
Non-Ferrous Refining and Smelting Industry			
Primary Ni, Cu, Zn, Pb	☑		
Secondary Pb, Cu	☑		
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	☑	☑	2017
Other (Downstream Oil and Gas Industry)	☑		
Upstream Oil and Gas Industry			
Accidents and Equipment Failures		☑	2018
Disposal and Waste Treatment		☑	2018
Heavy Crude Oil Cold Production		☑	2018
Light/Medium Crude Oil Production[c]	☑	☑	2018
Natural Gas Production and Processing[d]	☑	☑	2018
Natural Gas Transmission and Storage	☑	☑	2017
Oil Sands In-Situ Extraction	☑	☑	2018
Oil Sands Mining, Extraction and Upgrading	☑		
Petroleum Liquids Storage	☑		
Petroleum Liquids Transportation		☑	2018
Well Drilling/Servicing/Testing		☑	2018
ELECTRIC POWER GENERATION (UTILITIES)			
Coal	☑		
Diesel	☑		
Natural Gas	☑		
Waste Materials	☑		
Other (Electric Power Generation)	☑		
MANUFACTURING			
Abrasives Manufacturing	☑		
Bakeries	☑	☑	2018
Biofuel Production	☑		
Chemicals Industry			
Chemical Manufacturing	☑		
Cleaning Compound Manufacturing	☑		
Fertilizer Production	☑		
Paint and Varnish Manufacturing	☑		
Petrochemical Industry	☑		
Plastics and Synthetic Resins Fabrication	☑		
Other (Chemical Industry)	☑		
Electronics	☑	☑	2018 (Hg in Products)
Food Preparation	☑		
Glass Manufacturing	☑		
Grain Industry			
Grain Processing	☑	☑	2018
Warehousing and Storage	☑		2018
Metal Fabrication	☑		
Plastics Manufacturing	☑		
Pulp and Paper Industry			
Pulp and Paper Product Manufacturing	☑		
Converted Paper Product Manufacturing	☑		

Table 3–1 **2018 Air Pollutant Emissions Inventory** (cont'd)

Air Pollutant Emissions Inventory sectors	Facility-reported data[a]	In-house estimates[b]	Activity data used for in-house estimates
Textiles	☑		
Vehicle Manufacture (Engines, Parts, Assembly, Painting)	☑		
Wood Products[e]			
Panel Board Mills	☑	☑	2018
Sawmills	☑	☑	2018
Other (Wood Products)	☑		
Other (Manufacturing)	☑		
TRANSPORTATION AND MOBILE EQUIPMENT			
Air Transportation		☑	2018
Heavy-duty Diesel Vehicles		☑	2018
Heavy-duty Gasoline Vehicles		☑	2018
Heavy-duty LPG/NG Vehicles		☑	2018
Light-duty Diesel Trucks		☑	2018
Light-duty Diesel Vehicles		☑	2018
Light-duty Gasoline Trucks		☑	2018
Light-duty Gasoline Vehicles		☑	2018
Light-duty LPG/NG Trucks		☑	2018
Light-duty LPG/NG Vehicles		☑	2018
Marine Transportation		☑	2015
Motorcycles		☑	2018
Off-road Diesel Vehicles and Equipment		☑	2018
Off-road Gasoline/LPG/NG Vehicles and Equipment		☑	2018
Rail Transportation		☑	2018
Tire Wear and Brake Lining		☑	2018
AGRICULTURE			
Animal Production		☑	2018
Crop Production			
Harvesting		☑	2018
Inorganic Fertilizer Application		☑	2018
Sewage Sludge Application		☑	2018
Tillage Practices		☑	2018
Wind Erosion		☑	2018
Fuel Use	☑	☑	2014
COMMERCIAL / RESIDENTIAL / INSTITUTIONAL			
Cigarette Smoking[f]		☑	2018
Commercial and Institutional Fuel Combustion	☑	☑	2017
Commercial Cooking		☑	2018
Construction Fuel Combustion		☑	2017
Home Firewood Burning		☑	2017
Human[f]		☑	2018
Marine Cargo Handling	☑		
Residential Fuel Combustion		☑	2014
Service Stations		☑	2018
Other (Miscellaneous)[g]		☑	2008
INCINERATION AND WASTE			
Crematoriums	☑	☑	2018
Waste Incineration			
Municipal Incineration	☑	☑	2018
Residential Waste Burning[h]		☑	2016
Sewage Sludge Incineration		☑	2018
Other (Waste Incineration)	☑		
Waste Treatment and Disposal			
Landfills	☑	☑	2018
Municipal Wastewater Treatment and Discharge	☑		
Specialized Waste Treatment and Remediation	☑		
Biological Treatment of Waste	☑		
Waste Sorting and Transfer	☑		
PAINTS AND SOLVENTS			
Dry Cleaning	☑	☑	2018
General Solvent Use		☑	2018
Printing	☑	☑	2018
Surface Coatings	☑	☑	2018
DUST			
Coal Transportation		☑	2018
Construction Operations		☑	2012
Mine Tailings		☑	2018
Paved Roads		☑	2018
Unpaved Roads	☑	☑	2018
FIRES			
Prescribed Burning		☑	2018
Structural Fires		☑	2017
Mercury in Products[i]		☑	2018

Notes:

☑ indicates yes

a. Based on the most recent facility-reported data from NPRI.
b. Estimated by ECCC
c. Facility-reported data consists of facilities located in Atlantic Canada. For other provinces, it consists of in-house estimates.
d. Facility-reported data consists of facilities located in Atlantic Canada and SO_2 emissions from Alberta's natural gas processing facilities.
e. In-house estimates for Wood Products were estimated by the Forestry Products group of the Environmental Stewardship Branch at ECCC. All other in-house estimates were estimated by PIRD.
f. Ammonia emissions from Infant Diapered Waste, which were previously reported under Other (Miscellaneous), are now reported under the Human sector. Infant Diapered Waste as well as Cigarette Smoking (which is included within the Human sector) are being consideringed for removal from future inventories. If you have any questions, please contact us at ec.iepa-apei.ec@canada.ca or 1-877-877-8375.
g. Emissions reported under Other (Miscellaneous) are from breakage, transport and recycling of mercury-containing products using the Hg in Products Methodology. Products include: automotive mercury switches, batteries, dental amalgams, fluorescent lamps, fungicides, measurement and control devices, non-fluorescent lamps, switches and relays, thermometers, thermostats and tire balancers.
h. Hg in Products estimates for Residential Waste Burning are not estimated after 2008 as a result of the updates for the Hg in Products models.
i. Emissions from Hg-containing products were calculated as a separate inventory. Emissions are reported under many sectors such as Iron and Steel Industry, Municipal Incineration, Human, Other (Miscellaneous) and Landfills. All in-house estimates for Hg in product emissions continue to be estimated and reported under these sectors.

Compilation and Reporting

The final steps in the development process involves compiling all reconciled data within a final database and generating the results. The final database houses all APEI data and is the source of data for all APEI-related products, including:

- Canada's Air Pollutant Emissions Inventory Report (canada.ca/apei)
- Open Data emissions tables published on open.canada.ca
- Online Search Tool (https://pollution-waste.canada.ca/air-emission-inventory)
- Input to other products such as air pollutant emissions projections, air quality modeling, Canadian Environmental Sustainability Indicators, and reports under the Canada-U.S. Air Quality Agreement
- Canada's submission to the United Nations Economic Commission for Europe under the Convention of Long-range Transboundary Air Pollution (Annex 4)

3.2. Facility-Reported Emissions Data

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

Facility-reported data from the NPRI are used in the APEI without modifications, except when 1) data quality issues are detected and not addressed during the quality control exercise, or 2) adjustments to PM emissions are necessary to respect their size fraction. The NPRI reporting requirements and thresholds vary by pollutant and, in some cases, by industry. Details on these reporting requirements and thresholds are available on Environment and Climate Change Canada's website in the National Pollutant Release Inventory (www.canada.ca/NPRI).

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

Historically (e.g. for the years 1985, 1990, 1995 and 2000), facility-reported data was primarily provided by provinces. In some cases, additional information was calculated 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 NPRI as the major source of industrial emissions. In general, facility-reported data from the NPRI and data provided by provinces were used for years 2002, 2004 and 2005, 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 3–2 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 online (www.canada.ca/NPRI). No VOC data collected under Part 5 is used in the APEI.

In 2018, approximately 6,000 facilities reported releases to air of one or more APEI pollutants to the NPRI.

Using the 2018 NPRI database, with data available as of November 1, 2019, facility information and air emissions data for pollutants listed in Table 3–2 were extracted for each province and territory. The quality control process described in section 3.5 was applied to the NPRI data to identify outliers or missing substance reports. Emissions data for each facility reporting to the NPRI was assigned to an APEI source, sector and subsector.

For facilities reporting to the NPRI for the first time, the North American Industry Classification System (NAICS)

codes (Statistics Canada, 2017), reported by the facilities, is used to assign a preliminary APEI sector and subsector classifications. Then, additional research and verification are performed to confirm or correct the classification.

NPRI reporting facilities may not report all three of the PM size fractions. For cases where only one or two of the three PM size fractions were reported to the NPRI, a distribution procedure is applied to estimate a complete set of PM emissions for facilities. The procedure is based on sector-specific PM distribution profiles developed using PM emissions reported by facilities to the NPRI for the 2006 to 2016 data years. Ratios were calculated for each facility and averaged by sector. The resulting distributions are presented in Table 3–3.

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

Equation 3–1 : **PM_{10} distribution ratio**

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

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

Equation 3–2 : **$PM_{2.5}$ distribution ratio**

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

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

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

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

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

The TPM, PM_{10} and $PM_{2.5}$ emissions calculated using the distribution procedure are added to the list of facility-reported data and flagged as an ECCC estimate within the compiled APEI final database.

Table 3–2 **National Pollutant Release Inventory Air Pollutant Reporting Thresholds**

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

Notes:
MPO Manufactured, processed or otherwise used
NA Not applicable

Table 3–3 **Particulate Matter Distribution Ratios**

Sector and sub-sector	PM_{10} ratio	$PM_{2.5}$ ratio	$PM_{2.5}/PM_{10}$ ratio
ORE AND MINERAL INDUSTRIES			
Aluminium Industry			
Alumina (Bauxite Refining)	0.399	0.309	0.798
Primary Aluminium Smelting and Refining	0.686	0.559	0.798
Secondary Aluminium Production (Includes Recycling)	0.951	0.937	0.926
Asphalt Paving Industry	**0.385**	**0.177**	**0.513**
Cement and Concrete Industry			
Cement Manufacturing	0.623	0.31	0.474
Concrete Batching and Products	0.497	0.23	0.465
Gypsum Product Manufacturing	0.715	0.508	0.643
Lime Manufacturing	0.576	0.309	0.512
Foundries			
Die Casting	0.711	0.51	0.81
Ferrous Foundries	0.711	0.51	0.723
Non-ferrous Foundries	0.927	0.49	0.719
Iron and Steel Industry			
Primary (Blast Furnace and DRI)	0.598	0.403	0.65
Secondary (Electric Arc Furnaces)	0.616	0.474	0.802
Steel Recycling	0.711	0.51	0.287
Other (Iron and Steel Industry)	–	–	–
Iron Ore Industry			
Iron Ore Mining	0.513	0.191	0.432
Pelletizing	0.48	0.212	0.41
Mineral Products Industry			
Clay Products	0.802	0.094	0.484
Brick Products	0.757	0.23	0.323
Other (Mineral Products Industry)	0.762	0.545	0.665
Mining and Rock Quarrying			
Coal Mining Industry	0.368	0.064	0.147
Metal Mining	0.532	0.283	0.509
Potash	0.599	0.316	0.503
Rock, Sand and Gravel	0.46	0.165	0.397
Silica Production	–	–	–
Limestone	0.460	0.165	0.397
Other (Mining and Rock Quarrying)	0.465	0.197	0.398
Non-Ferrous Refining and Smelting Industry			
Primary Ni, Cu, Zn, Pb	0.649	0.375	0.606
Secondary Pb, Cu	0.574	0.396	0.748
Other (Non-Ferrous Refining and Smelting Industry)	0.494	0.444	0.859
OIL AND GAS INDUSTRY			
Downstream Oil and Gas Industry			
Petroleum Refining	–	–	–
Refined Petroleum Products Bulk Storage and Distribution	0.100	0.100	0.750
Refined Petroleum Product Pipelines	1.000	1.000	1.000
Natural Gas Distribution[a]	1.000	1.000	1.000
Other (Downstream Oil and Gas Industry)	0.743	0.641	0.628
Upstream Oil and Gas Industry			
Accidents and Equipment Failures	–	–	–
Disposal and Waste Treatment	–	–	–
Heavy Crude Oil Cold Production[a]	–	–	–
Light Medium Crude Oil Production[a]	1.000	1.000	1.000
Natural Gas Production and Processing[a]	1.000	1.000	1.000
Natural Gas Transmission and Storage[a]	1.000	1.000	1.000
Oil Sands In-Situ Extraction[a]	1.000	1.000	1.000
Oil Sands Mining and Extraction[b]	0.658	0.447	0.680
Bitumen and Heavy Oil Upgrading[b]	0.677	0.428	0.631
Petroleum Liquids Storage[a]	1.000	0.831	0.831
Petroleum Liquids Transportation	–	–	–
Well Drilling/Servicing/Testing	–	–	–
ELECTRIC POWER GENERATION (UTILITIES)			
Coal	0.578	0.293	0.484
Diesel	0.967	0.962	0.943
Natural Gas	0.909	0.663	0.902
Waste Materials	0.734	0.54	0.76
Other (Electric Power Generation)	0.735	0.608	0.924
MANUFACTURING			
Abrasives Manufacturing	**0.415**	**0.231**	**0.669**
Bakeries	**0.861**	**0.744**	**0.76**
Biofuel Production	**–**	**–**	**–**
Chemicals Industry			
Chemical Manufacturing	0.737	0.595	0.754
Cleaning Compound Manufacturing	1	1	1
Fertilizer Production	0.575	0.235	0.52
Paint and Varnish Manufacturing	0.919	0.564	0.701
Petrochemical Industry	0.894	0.424	0.587
Plastics and Synthetic Resins Fabrication	0.791	0.566	0.744
Other (Chemical Industry)	0.485	0.465	0.886
Electronics	**0.958**	**0.833**	**0.834**
Food Preparation	**0.651**	**0.409**	**0.634**
Glass Manufacturing	**0.836**	**0.755**	**0.919**
Grain Industries			
Grain Processing	–	–	–
Warehousing and Storage	–	–	–
Metal Fabrication	**0.747**	**0.59**	**0.771**
Plastics Manufacturing	**0.731**	**0.474**	**0.817**

Table 3–3 **Particulate Matter Distribution Ratios** (cont'd)

Sector and sub-sector	PM_{10} ratio	$PM_{2.5}$ ratio	$PM_{2.5}/PM_{10}$ ratio
Pulp and Paper Industry			
Pulp and Paper Product Manufacturing	0.737	0.56	0.757
Converted Paper Product Manufacturing	0.805	0.64	0.773
Textiles	**1**	**1**	**0.759**
Vehicle Manufacture (Engines, Parts, Assembly, Painting)	**0.694**	**0.427**	**0.748**
Wood Products			
Panel Board Mills	0.596	0.361	0.589
Sawmills	0.423	0.197	0.451
Other (Wood Products)	0.688	0.549	0.732
Asbestos Industry[c]	**0.373**	**0.141**	**0.428**
Rubber Manufacturing[c]	**0.638**	**0.402**	**0.602**
Ship & Boat Building & Repairing[c]	**0.510**	**0.076**	**0.151**
Asphalt Shingle and Coating Material Manufacturing[c]	**0.851**	**0.701**	**0.801**
Other (Manufacturing)	**0.645**	**0.359**	**0.503**
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	–	–	–
Harvesting	–	–	–
Inorganic Fertilizer Application	–	–	–
Sewage Sludge Application	–	–	–
Tillage Practices	–	–	–
Wind Erosion	–	–	–
Fuel Use	**0.646**	**0.503**	**0.749**
COMMERCIAL / RESIDENTIAL / INSTITUTIONAL			
Cigarette Smoking	–	–	–
Commercial and Institutional Fuel Combustion	**0.761**	**0.581**	**0.599**
Commercial Cooking	–	–	–
Construction Fuel Combustion	–	–	–
Home Firewood Burning	–	–	–
Human	–	–	–
Marine Cargo Handling	**0.396**	**0.147**	**0.365**
Residential Fuel Combustion	–	–	–
Service Stations	–	–	–
Other (Commercial / Residential / Institutional)	–	–	–
INCINERATION AND WASTE			
Crematoriums	**1.000**	**1.000**	**1.000**
Waste Incineration			
Municipal Incineration	0.737	0.680	0.913
Residential Waste Burning	–	–	–
Sewage Sludge Incineration	–	–	–
Other (Waste Incineration)	0.718	0.359	0.479
Waste Treatment and Disposal			
Landfills	0.778	0.603	0.743
Municipal Wastewater Treatment and Discharge	0.806	0.780	0.955
Specialized Waste Treatment and Remediation	0.778	0.603	0.743
Biological Treatment of Waste	1.000	1.000	1.000
Waste Sorting and Transfer	0.800	0.200	0.250
PAINTS AND SOLVENTS			
Dry Cleaning	**1.000**	**1.000**	**1.000**
General Solvent Use[d]	**Varies**	**Varies**	**Varies**
Printing[d]	**Varies**	**Varies**	**Varies**
Surface Coatings	**1.000**	**1.000**	**1.000**
DUST			
Coal Transportation	–	–	–
Construction Operations	**0.800**	**0.200**	**0.250**
Mine Tailings	–	–	–
Paved Roads	–	–	–
Unpaved Roads[e]	**0.265**	**0.027**	**0.100**
FIRES			
Prescribed Burning	–	–	–
Structural Fires	–	–	–

Notes:

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

a. Adapted from Clearstone Engineering Ltd (2014).

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

c. Emissions from these subsectors (Asbestos Industry; Rubber Manufacturing; Ship & Boat Building & Repairing; and Asphalt Shingle and Coating Material Manufacturing) are reported under Other (Manufacturing).

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

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

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

3.3. In-House Emission Estimates

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 ECCC. An overall estimation of completeness in this case is related to the availability and reliability of activity data and methodologies used for the in-house estimates.

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

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

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

In-house estimates are calculated with information such as production data and activity data, using various estimation methodologies, emission models and emission factors.[1] Calculations of in-house estimates are based on the latest data available at the time of inventory development. When possible, the data are updated each year. These emission estimates are at the provincial, territorial and national level rather than at any specific geographic location. 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; and
- other sources, such as open burning of waste, agricultural activities and construction operations.

Table 3–1 illustrates 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 2018 in-house estimate is based.

Detailed information on in-house estimation methodologies is presented in Annex 2.

3.4. Reconciliation

In several sectors, such as the upstream oil and gas industry, estimation of total emissions involves combining estimates provided by facilities with estimates developed in-house by ECCC. 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.

3.4.1. 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 3–1).
  - For example, for 2018, 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 3–4.

Equation 3–4 :

$$If,\ InHouseEstimate_{Total} \geq FacilityReportedData_{Total}$$

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

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)."

- 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 3–5.

Equation 3–5 :

$$If,\ InHouseEstimate_{Total} \leq FacilityReportedData_{Total}$$

$$Then,\ InHouseEstimate_{REC} = 0$$

Some points to consider:

- In general, $InHouseEstimate_{REC}$ 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 3–5), facility-reported data are considered to reflect all the sector emitting sources.

3.4.2. 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 3.4.1. 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 3.4.1.

3.4.3. 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 NAICS. Given this sector's complexity, reconciliation of in-house estimates with facility-reported data from the NPRI requires that several steps be performed by a specially designed database application (Cheminfo Services, 2016):

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

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

3.4.4. Mercury in Products (Hg)

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

3.5. Data Quality Control

Quality control for the inventory takes place at each step of the process, in three main phases. In phase 1, quality control is performed on the most recently submitted NPRI facility-reported data, prior to inclusion of the data in the estimates. Phase 2 of the quality control occurs on the in-house estimates at a sub-sectoral level, while phase 3 is performed on the final database of reconciled and compiled emissions.

3.5.1. Phase 1: Facility-Reported Emissions Data

The quality control process involves a system of documented activities and procedures performed to identify data outliers, inconsistencies, missing data, inaccuracies and errors. It includes communications with facilities to resolve identified issues. The quality control process is adapted where necessary such 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.

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

Where unresolved issues persist, any updates to the data will be reflected in the next inventory edition.

3.5.2. Phase 2: In-House Emission Estimates

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

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

3.5.3. Compiled Air Pollutant Emission Inventory

Finally, phase 3 includes all the tests performed once the estimates are reconciled and compiled in a final database. Trend analysis graphics as well as recalculations graphics are produced to analyse the accuracy of the estimates. Any significant changes from year to year and any recalculated emissions are identified and explained.

3.6. Recalculations

Emission recalculation is an essential practice in the maintenance of an up-to-date air pollutant emissions 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 3.

ANNEX 1

DEFINITIONS OF THE AIR POLLUTANTS

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

A1.1. Criteria Air Contaminants

Particulate Matter (PM)

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

Total Particulate Matter (TPM)

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

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

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

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

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

Sulphur Oxides (SO_x)

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

Nitrogen Oxides (NO_x)

NO_x include nitrogen dioxide (NO_2) and nitrogen oxide (NO), both of which are reported as NO_2 equivalent. NO_x reacts photochemically with volatile organic compounds (VOCs) in the presence of sunlight to form ground-level ozone. It can transform into ambient PM (nitrate particles) and is a component of acid rain. NO_x originate from both anthropogenic and natural sources. The main anthropogenic sources are transport and mobile equipment as well as the upstream oil and gas 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 upstream oil and gas industry, general solvent use, and mobile sources. Some VOCs, such as formaldehyde and benzene, are carcinogenic.

Carbon Monoxide (CO)

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

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 livestock, agricultural fertilizer use and synthetic fertilizer manufacturing.

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

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

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

A1.2. Selected Heavy Metals

Lead (Pb)

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

Cadmium (Cd)

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

Mercury (Hg)

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

A1.3. Persistent Organic Compounds

Dioxins and Furans (D/F)

Dioxins and furans are a family of toxic compounds that vary widely in toxicity. Both dioxin and furan "congeners" are expressed in terms of toxic equivalents (TEQs) to the most toxic form of dioxin: 2,3,7,8-tetrachlorodibenzo-*p*-dioxin (TCDD). The largest sources of dioxins and furans in Canada are the burning of residential waste as well as marine transportation. Other major sources include the production of cement and concrete industry, the production of iron and steel, and home firewood burning.

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 home firewood burning as well as transportation and mobile equipment sources.

Hexachlorobenzene (HCB)

HCB is a persistent organic pollutant where the largest sources of emissions are from residential waste burning, iron and steel production, and non-ferrous refining and smelting.

ANNEX 2

IN-HOUSE ESTIMATION METHODOLOGIES

The in-house emissions estimation methodologies and emission models used in Canada are generally based on those developed by the United States Environmental Protection Agency (U.S. EPA) and adapted to utilize Canadian data, thereby accounting for differences in climate, fuels, technologies and practices. Methods used in Canada's Air Pollutant Emissions Inventory (APEI) are therefore generally consistent with those used in the United States or those recommended in the *EMEP/EEA Air Pollutant Emission Inventory Guidebook* (EEA, EMEP/EEA, 2016).

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 A2–4). 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 A2–4). 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.

Table A2–1 through A2–11 summarize, for each source category, the in-house estimation methodologies for the entire time series. For each source category, these tables provide a short description of:

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

Annex 2 Tables:

Table A2–1 **Estimation Methodologies for Ore and Mineral Industries**

For years prior to 2010, there are several source categories for which in-house estimates were developed to use in combination with facility-reported data and historical data from provinces, such as lime manufacturing (1990–2010). Improvement of these estimates is under consideration for future inventories.

Sector/Subsector	
ASPHALT PAVING INDUSTRY	
Description	Asphalt Paving Industry consists of emissions released during asphalt concrete (or hot-mix asphalt) manufacturing and application. Asphalt concrete manufacturing includes the heating and mixing of asphaltic cement with a mixture of graded aggregates. The sector applies to both permanent or portable hot-mix asphalt installations.
General Inventory Method	Pollutant(s) estimated: TPM, PM_{10}, $PM_{2.5}$, SO_x, NO_x, VOCs, CO, Pb, Cd, Hg, dioxins/furans, B(a)p, B(b)f, B(k)f, I(cd)p Total usage of asphalt by province/territory is multiplied by pollutant-specific emission factors.
Activity Data	Cutback and emulsion asphalt data to calculate VOC emissions from paving process: (SNC/GECO Canada Inc. & Ontario Research Foundation, 1981) Asphalt usage data from construction: (Statistics Canada, RESD, n.d.)
Emission Factors (EF)	TPM, PM_{10}, $PM_{2.5}$, SO_x, NO_x, VOCs, CO, Pb, Cd, Hg, dioxins/furans, B(a)p, B(b)f, B(k)f, I(cd)p: (Senes Consultants, 2008) VOCs from paving: (SNC/GECO Canada Inc. & Ontario Research Foundation, 1981)
CONCRETE BATCHING AND PRODUCTS (under CEMENT AND CONCRETE INDUSTRY)	
Description	Concrete Batching and Products include emissions produced by activities at concrete batching plants. Concrete is composed essentially of water, cement, fine aggregate (i.e. sand) and coarse aggregate (i.e. gravel, crushed stone or iron blast furnace slag). Concrete batching plants store, convey, measure and discharge these constituents into trucks for transport to a construction site or process, for use in the manufacturing of concrete pipe, concrete blocks, etc.
General Inventory Method	Pollutant(s) estimated: TPM, PM_{10}, $PM_{2.5}$, Pb, Cd Province/territory cement distribution ratios are calculated based on the province/territory population data and province/territory cement consumption distribution data. To obtain the total usage of cement by province/territory, the province/territory cement distribution ratios are multiplied by the national domestic consumption of cement. The total usage of cement by province/territory is then multiplied by pollutant-specific emission factors.
Activity Data	Cement consumption distribution for the provinces: (CANMET, 1993) Cement production and export data: (Statistics Canada, Table 16-10-0009-01, 2018) Population data for the provinces/territories: (Statistics Canada, Table 17-10-0005-01, n.d.)
Emission Factors (EF)	TPM, PM_{10}, $PM_{2.5}$, Pb, Cd: (U.S. EPA, 1998; U.S. EPA, 2010) 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 (U.S. EPA, 2010) (using SCC 30501101): $EF_{PM_{10}} = 0.51 \times EF_{TPM}$ $EF_{PM_{2.5}} = 0.15 \times EF_{TPM}$
FERROUS FOUNDRIES (under FOUNDRIES)	
Description	Ferrous Foundries include facilities that produce castings of various types of ferro-alloys, as well as small iron and steel foundries not associated with integrated iron and steel facilities. The types of foundries found in Canada include open ferrous, electric arc and induction foundries.
General Inventory Method	Pollutant(s) estimated: TPM, PM_{10}, $PM_{2.5}$, SO_x, NO_x, VOCs, CO Methodology under review. The in-house estimates were last calculated for 2011 and were carried forward to 2018.
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, excluding those from off-road equipment which are reported under Transportation. 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, 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}, $PM_{2.5}$: (EEA, 2013)

Table A2–1 **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, Table 051-0001, n.d.)
Emission Factors (EF)	TPM, PM_{10}, $PM_{2.5}$: (EEA, 2013)

References for this table can be found on page 83.

Table A2–2 **Estimation Methodologies for the Oil and Gas Industry**	
Sector/Subsector	
REFINED PETROLEUM PRODUCTS BULK STORAGE AND DISTRIBUTION (under DOWNSTREAM OIL AND GAS INDUSTRY)	
Description	Refined Petroleum Products Bulk Storage and Distribution covers fugitive VOC emissions from bulk distribution terminals and bulk plants. It includes volatile components of fuels that are emitted as fuel moves from the refinery to the end user whenever tanks are filled or emptied or while tanks are open to the atmosphere, be they large above-ground tanks, tank trucks, or railcars. In addition, the subsector includes emissions that occur from the evaporation of fuels spilled during transfer operations. Only fugitive VOC emissions from bulk plants are estimated in-house.
General Inventory Method	Pollutant(s) estimated: VOCs Emissions are calculated using the gross sales of gasoline for on-road motor vehicles multiplied by emission factors developed by (Tecsult Inc, 2006).
Activity Data	Gross sales of gasoline for motor vehicles: (Statistics Canada, RESD, n.d.)
Emission Factors (EF)	Study on gasoline vapour recovery in Stage 1 distribution networks in Canada: (Tecsult Inc, 2006).
NATURAL GAS DISTRIBUTION (under DOWNSTREAM OIL AND GAS INDUSTRY)	
Description	Natural Gas Distribution includes emissions from all infrastructure used to receive high-pressure natural gas from transmission pipelines and then reduce the pressure for distribution to end users. This sector consists of distribution pipelines (distribution mains and service lines) and measurement and regulation stations, up to and including customer meters. Emissions from related construction activities, ancillary structures and operations (buildings, offices, etc.), and mobile sources are included under the Construction Operations, Commercial and Institutional Fuel Combustion, and Transportation and Mobile Equipment sources (respectively) of the APEI.
General Inventory Method	Pollutant(s) estimated: TPM, PM_{10}, $PM_{2.5}$, SO_x, NO_x, VOCs, CO, NH_3 Emission estimates are generated using data from comprehensive inventories (EC, 2014; CAPP, 2005a) and extrapolated (CAPP, 2005b) from 2012 onwards based on pipeline length.
Activity Data	Gas Pipeline Distance, by province (Statistics Canada, 2019)
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 and Institutional Fuel Combustion, and Transportation and Mobile Equipment sources (respectively) of the APEI.
General Inventory Method	Pollutant(s) estimated: TPM, PM_{10}, $PM_{2.5}$, SO_x, NO_x, VOCs, CO, NH_3 Emission estimates are generated using data from comprehensive inventories (EC, 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, 2019) Natural gas injections to storage and withdrawals from storage (Statistics Canada, Table 25-10-0057-01, n.d.)
Emission Factors (EF)	(EC, 2014)

Table A2–2 **Estimation Methodologies for the Oil and Gas Industry** (cont'd)	
Sector/Subsector	
UPSTREAM OIL AND GAS INDUSTRY	
Description	Upstream Oil and Gas Industry includes emissions from all infrastructure used to locate, extract, produce, process/treat and transport natural gas, crude oil (light/medium oil, heavy oil, crude bitumen), liquefied petroleum gas (LPG) and condensate to market. It also includes emissions from onshore and offshore facilities, as well as drilling and exploration, conventional oil and gas production, open pit mining and in situ oil sands production, natural gas processing and oil transmission. Specifically, it includes the following subsectors: • Accidents and Equipment Failures • Disposal and Waste Treatment • Heavy Crude Oil Cold Production • Light Medium Crude Oil Production • Natural Gas Production and Processing • Oil Sands In-Situ Extraction • Petroleum Liquids Transportation • Well Drilling/Servicing/Testing Emissions from related construction activities, ancillary structures and operations (buildings, offices, etc.), and mobile sources are included under the Construction Operations, Commercial and Institutional Fuel Combustion, and Transportation and Mobile Equipment sources (respectively) of the APEI.
General Inventory Method	Pollutant(s) estimated: TPM, PM_{10}, $PM_{2.5}$, SO_x, NO_x, VOCs, CO, NH_3 Emission estimates are generated using data from comprehensive inventories (EC, 2014; CAPP, 2005a) and are extrapolated (CAPP, 2005b) from 2012 onwards using various provincial-level activity data.
Activity Data	Spills and accidents (AER, 2019a; BCOGC, 2019a; CNLOPB, 2019a; MB, 2019; SKMER, 2019a) Wells drilled (CAPP, 2019) Operating wells (CAPP, 2019, CNLOPB, 2019b,c,d,e,f) Reported volumes of gas flared and vented (AER, 2019b; BC, 2019; BCOGC, 2019b; CNLOPB, 2019g; SKMER, 2019b) Fuel gas volumes (AER, 2019c; BC, 2019; SKMER, 2019b) In-situ bitumen production volumes (AER, 2019d) Non-associated natural gas production volumes (CER, 2019) Crude oil and natural gas production volumes (NBERD, 2019; SKMER, 2019c, d; Statistics Canada, Table 25-10-0014-01, n.d.; Statistics Canada, Table 25-10-0047-01, n.d.; Statistics Canada, Table 25-10-0055-01, n.d.; Statistics Canada, Table 25-10-0063-01, n.d.) Natural gas shrinkage (AER, 2019e; BC, 2019) In addition to the extrapolated estimates, the SO_x estimates for Alberta Natural Gas Processing are adjusted to account for regulations that were developed after the model was originally created. The adjustments are made with both historical provincial data and NPRI data up to 2005. From 2006 onwards, NPRI data for Alberta SO_x emissions from gas plants are used due to the complete facility coverage. NPRI data for the Atlantic provinces are used in place of the model estimates due to the complete facility coverage for the region. Additionally, extrapolated estimates for the Oil Sands In-Situ Extraction facilities are reconciled with NPRI data to eliminate double-counting. NPRI data for Oil Sands Mining, Extraction and Upgrading are used due to the complete facility coverage of the subsector.
Emission Factors (EF)	(EC, 2014)

References for this table can be found on page 84.

Table A2–3 **Estimation Methodologies for Manufacturing**	
For years prior to 2010, there are several source categories for which in-house estimates were developed to use in combination with facility-reported data and historical data from provinces, such as chemical manufacturing (1990–2000) and pulp and paper product manufacturing (1990–2006). Improvement of these estimates is under consideration for future inventories.	
Sector/Subsector	
BAKERIES	
Description	Bakeries release VOCs during the leavening process of industrial baking. Emissions from products leavened by baking powder (used mainly for pastries) are negligible, but VOCs are released when yeast is used for leavening. Yeast is used nearly exclusively in the production of bread and bread-like pastries.
General Inventory Method	Pollutant(s) estimated: VOCs Total quantity of wheat flour available per person is multiplied by population, the fraction of flour use in yeast-leavened baked goods, ratio of product to flour ratio, and an emission factor for VOCs.
Activity Data	Bread production values are estimated using: • National wheat flour available: (Statistics Canada, Table 32-10-0054-01, 2018) • Population data for provinces and territories: (Statistics Canada, Table 051-0001, n.d.) • Fraction of flour use in yeast-leavened baked goods and ratio of product to flour ratio: (Cheminfo Services, 2005)
Emission Factors (EF)	(Cheminfo Services, 2005) EF_{VOC} = 2.35 kg per tonne of baked goods

Table A2–3 **Estimation Methodologies for Manufacturing** (cont'd)

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

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

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

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

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

Table A2–3 **Estimation Methodologies for Manufacturing** (cont'd)	
Sector/Subsector	
SAWMILLS, PANEL BOARD MILLS AND OTHER (WOOD PRODUCTS) (under WOOD PRODUCTS)	
Description	**Sawmills** cover emissions from facilities that typically produce hardwood and softwood lumber from logs. The process of converting wet logs into dry lumber includes debarking, sawing, drying and planing steps, which all release air emissions. **Panel Board Mills** include emissions from several types of mills, all producing hardwood and softwood-based materials. These include: • veneer and plywood mills • waferboard mills, consisting primarily of oriented strand board (OSB) mills • particle board and medium-density fiberboard (MDF) mills **Other Wood Products** encompass emissions from furniture and cabinet manufacturers, wood treating plants, wood pellet mills and masonite manufacturers. The combustion of various fuels for energy production or waste disposal, notably wood residues, natural gas, liquefied petroleum gas (LPG) and fuel oil is a common practice at wood products facilities. Significant amounts of air pollutant emissions result from combustion in this sector.
General Inventory Method	Pollutant(s) estimated: TPM, PM_{10}, $PM_{2.5}$, SO_x, NO_x, VOCs, CO, NH_3, Pb, Cd, Hg, dioxins/furans, B(a)p, B(b)f, B(k)f, I(cd)p **Sawmills and panel board mills** • TPM, PM_{10} and $PM_{2.5}$: Estimation methodology makes use of the NPRI facility-reported data in addition to a number of production and capacity indicators to estimate the PM of the facilities not reporting to the NPRI (Natural Resources Canada, Forest Products Association of Canada and the Composite Panel Association, corporate website information, annual reports, Resource Information Systems Inc. publications, Madison publications and occasional discussion with industry representatives); • All other pollutants: Production rate estimates, hog fuel combustion data, and other fuel use data are used to estimate emissions of the remaining pollutants (Meil et al., 2009; U.S. EPA, 2014). The in-house estimates for panel board mills were carried forward in 2016 based on 2015 mill capacities. Capacity data was available for 2017. 2018 capacity data was extrapolated based on the capacity data from 2015 to 2017. **Other wood products** All pollutants: In-house estimates are not calculated for this subsector. For the whole time series, emissions are from facility data reported to provinces/territories and NPRI facility-reported data.
Activity Data	NPRI 2018 data and data sources for facilities not reporting to the NPRI, including: • *Natural Resources Canada: Status of Energy Use in the Canadian Wood Products sector* (Meil et al., 2009) • Forest Products Association of Canada annual reports (proprietary reports) • Environment and Climate Change Canada's Forestry Products Group • *RISI North American Wood Panels and Engineered Wood Products Capacity Report* (RISI, 2013) • Madison's 2017 Online Lumber Directory (Madison, 2017) • Verbal communications with industry representatives (unpublished)
Emission Factors (EF)	Sawmills: (U.S. EPA, 2012) Plywood manufacturing, particle board, oriented strand board: (U.S. EPA, 1995) Fuel combustion: (Meil et al., 2009; U.S. EPA, 1992; U.S. EPA, 1995; U.S. EPA, 2014)

References for this table can be found on page 85.

Table A2–4 **Estimation Methodologies for Transportation and Mobile Equipment**	
Sector/Subsector	
AIR TRANSPORTATION	
Description	Air Transportation covers emissions from aircraft but not airport support equipment (captured as off-road applications).
General Inventory Method	Pollutant(s) estimated: TPM, PM_{10}, $PM_{2.5}$, SO_x, NO_x, VOCs, CO, NH_3, Pb, B(a)p, B(b)f, B(k)f, I(cd)p Aircraft-specific activity (landing/take-offs) by province/territory is multiplied by pollutant-specific emission factors.
Activity Data	The emission estimates from Air Transportation are calculated using Aircraft Movement Statistics (Statistics Canada, Aircraft Movement Statistics (database), n.d.), a database developed by Statistics Canada based on flight-by-flight data, recorded at airport towers operated by NAV Canada post-1996 and Transport Canada pre-1996. The data are of the highest resolution available and are the only known such aircraft movement data within Canada.
Emission Factors (EF)	For aircraft using turbo aviation fuel, hydrocarbon (HC), CO and NO_x emission factors are taken from the International Civil Aviation Organization (ICAO) databank (ICAO, 2009) for landing/take-offs (LTO) and from the *EMEP/CORINAIR Emission Inventory Guidebook 2006* (EEA, 2006) for the cruise stage. Emission factors are mapped to representative aircraft on the basis of engine characteristics. SO_2 is estimated as a sulphur balance, using data from the *Sulphur in liquid fuels* reports (ECCC, 2017). 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 (ECCC, 2017). The NH_3 emission factor is taken from (Coe et al., 1996). $PM_{2.5}$ is calculated as 69% of PM_{10} as per (U.S. EPA, *Documentation for Aircraft* …, 2005). 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, *Documentation for Aircraft* …, 2005). Emissions of non-standard CACs are estimated as a ratio to PM_{10} or HC/VOCs based on speciation profiles from the U.S. EPA (U.S. EPA, *Documentation for Aircraft* …, 2005).

Table A2–4 **Estimation Methodologies for Transportation and Mobile Equipment** (cont'd)

Sector/Subsector	
MARINE TRANSPORTATION	
Description	Marine Transportation covers emissions from commercial marine vessels, but not recreational marine engines (captured as off-road applications).
General Inventory Method	Pollutant(s) estimated: TPM, PM_{10}, $PM_{2.5}$, SO_x, NO_x, VOCs, CO, NH_3, Pb, Cd, Hg, dioxins/furans, B(a)p, B(b)f, B(k)f, I(1,2,3-cd)p Vessel-specific activity (movements) is multiplied by pollutant-specific emission factors.
Activity Data	The main source of data is from the Marine Emission Inventory Tool (MEIT) (ECCC, MEIT 2015, 2018; ECCC, MEIT V.4.3.1, 2016) which provides emissions for NO_x, CO, HC, SO_2, TPM, PM_{10}, $PM_{2.5}$ and NH_3. MEIT provides data for 1980, 1985, 1987, 1990, 1995, 2000, 2005, 2010, 2015 and forecast for 2020.
Emission Factors (EF)	NO_x, CO, HC, SO_2, TPM, PM_{10}, $PM_{2.5}$ and NH_3 are taken directly from MEIT. B(a)p, B(b)f, B(k)f, I(1,2,3-cd)p, Pb, Cd, Hg, dioxins/furans are estimated as ratios of PM based on speciation profiles from the *Documentation for the Commercial Marine Vessel Component of the National Emissions Inventory Methodology* (U.S. EPA, 2009). The correlation factor for HC to VOCs is taken from *Emission Factors for Locomotives* document (U.S. EPA, 2009).
ON-ROAD VEHICLES	
Description	On-road Vehicles include: Heavy-duty Diesel Vehicles, Heavy-duty Gasoline Vehicles, Light-duty Diesel Trucks, Light-duty Diesel Vehicles, Light-duty Gasoline Trucks, Light-duty Gasoline Vehicles, Propane and Natural Gas Vehicles, Motorcycles, and Tire Wear and Brake Lining.
General Inventory Method	Pollutant(s) estimated: TPM, PM_{10}, $PM_{2.5}$, SO_x, NO_x, VOCs, CO, NH_3, Pb, Cd, Hg, dioxins/furans, B(a)p, B(b)f, B(k)f, I(cd)p Vehicle-specific activity (vehicle kilometres travelled) is multiplied by pollutant-specific emission factors in the MOVES model (version MOVES2014 was used for this submission). Refuelling VOC emissions are included under Service Stations.
Activity Data	Data on the vehicle fleet (counts), defined by fuel type, model-year and gross vehicle weight rating, originate from (DAC, 2017) and (Polk & Co, 2017) for light- and heavy-duty vehicles, respectively. Motorcycle populations originate from the publication Road motor vehicle, trailer and snowmobile registration (registrations) (Statistics Canada, Table 405-0001 , n.d.; Statistics Canada, Table 405-0004, n.d.). The *Annual Industry Statistics* report (MMIC, 2013) is used to estimate the age distribution of motorcycles by model year which is applied to motorcycle populations obtained from Statistics Canada. The actual activity level is vehicle kilometres travelled (VKT). To arrive at estimates of VKT, vehicle counts are multiplied by mileage accumulation rates from Stewart-Brown Associates (Stewart-Brown Associates, 2012).
Emission Factors (EF)	Emission factors for on-road vehicles are embedded in the MOVES model. More information on MOVES is available online at www.epa.gov/otaq/models/moves/, in the U.S. EPA user guides (U.S. EPA, 2012; U.S. EPA, 2014) and in U.S. EPA technical guidance document (U.S. EPA, 2010).
OFF-ROAD VEHICLES AND EQUIPMENT	
Description	Off-road Vehicles and Equipment consists of Off-road Diesel Vehicles and Equipment and Off-road gasoline/LPG/NG Vehicles and Equipment.
General Inventory Method	Pollutant(s) estimated: TPM, PM_{10}, $PM_{2.5}$, SO_x, NO_x, VOCs, CO, NH_3 Application-specific activity (hours-of-use, load factor) is multiplied by pollutant-specific emission factors in the NONROAD model.
Activity Data	Data on the applications (vehicle/engine counts, load factor, hours-of-use), defined by fuel type, model year and source classification code, originate from (EC, 2011). The hours-of-use parameter was updated in 2018 for select equipment types. For example, snowmobile hours of use is now distinct by stroke type (ECCC, *Off-road Equipment Analysis—Snowmobiles,* 2018). Construction equipment populations used in oil sands mining operations are now sourced from The Parker Bay Company (ECCC, *Off-road Equipment Analysis—Oil Sands Mining Equipment*, 2018).
Emission Factors (EF)	Emission factors for off-road applications are embedded in the NONROAD model. For this iteration of the APEI, NONROAD version 2012C was used. This version is based on the U.S. EPA's NONROAD2008, and modified by Environment and Climate Change Canada to exploit detailed activity data. Model operation is conducted following the user guide for NONROAD2005/2008 (U.S. EPA, *User's Guide for the Final NONROAD2005 Model*, 2005), given that the functionality of the models is the same. More information on the NONROAD model is available online (http://www.epa.gov/otaq/nonrdmdl.htm).
RAIL TRANSPORTATION	
Description	Rail Transportation covers emissions from the fuel consumed by locomotive engines.
General Inventory Method	Pollutant(s) estimated: TPM, PM_{10}, $PM_{2.5}$, SO_x, NO_x, VOCs, CO, NH_3, Pb, Cd, Hg, dioxins/furans, B(a)p, B(b)f, B(k)f, I(cd)p Railway activity (fuel consumption) is multiplied by pollutant-specific emission factors.
Activity Data	Fuel consumption data: (Statistics Canada, RESD, n.d.)
Emission Factors (EF)	HC, CO, SO_2, PM_{10} and NO_x emission factors are taken from the *Locomotive Emissions Monitoring Program 2011* report (Railway Association of Canada, 2013) and the *Locomotive Emissions Monitoring Program 2016* report (Railway Association of Canada, 2019). The correlation factor for HC to VOCs and TPM to PM_{10} is taken from Emission Factors for Locomotives document (U.S. EPA, 2009). $PM_{2.5}$, NH_3, Pb, Cd, Hg, B(a)p, B(b)f, B(k)f, I(cd)p are estimated as ratios to PM_{10} or VOCs, based on speciation profiles from are taken from the *Documentation for Locomotive Component of the National Emissions Inventory Methodology* (U.S. EPA, 2011). The dioxin/furan emission factor (0.54 ng/L) is taken from the *An inventory of sources and environmental releases of dioxin-like compounds in the United States for the years 1987, 1995, and 2000* report (U.S. EPA, 2006).

References for this table can be found on page 86.

Table A2–5 **Estimation Methodologies for Agriculture**

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

Table A2–5 **Estimation Methodologies for Agriculture** (cont'd)

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

Table A2–5 **Estimation Methodologies for Agriculture** (cont'd)

Sector/Subsector	
INORGANIC FERTILIZER APPLICATION (under CROP PRODUCTION)	
Description	Fertilizer Application includes emissions emitted when synthetic nitrogen fertilizers are applied for annual and perennial crop production.
General Inventory Method	Pollutant(s) estimated: TPM, PM_{10}, $PM_{2.5}$, NH_3 **Ammonia** The method is a simplified version of the approach adopted by (Sheppard et al., *Monthly ammonia emissions …*, 2010) for application on an annual time step. The methodology uses a regression model developed by (Bouwman et al., 2002) and derived NH_3 emission factors, taking into account the most important parameters influencing emissions from synthetic nitrogen fertilizer application, based on a meta-analysis of scientific literature. **Particulates** Methodology is under review.
Activity Data	Data on the types of nitrogen fertilizer used on farms are published by Statistics Canada (Statistics Canada, Table 32-10-0038-01, n.d.) Areas of seeded annual and perennial crops: (Statistics Canada, Table 32-10-0359-01, n.d.) Soil properties, including pH and cation exchange capacity, are included in calculations using soil polygon information from a national-scale spatial database (http://sis.agr.gc.ca/cansis/nsdb/slc/index.html) describing the types of soils associated with landforms.
Emission Factors (EF)	Ammonia emission factors are calculated using the multiple linear regression equation from (Bouwman et al., 2002). The approach uses different regression parameters for synthetic nitrogen fertilizer types, method of nitrogen application, crop type, and soil pH and cation exchange capacity. A matrix of emission factors for each combination of these conditions occurring across Canada is derived. The average provincial and national emission factors are weighted averages of the relative proportion of each combination of fertilizer type and fertilizer application practice on different soil types in different ecodistricts across the country. TPM, PM_{10} and $PM_{2.5}$ methodology is under review.
SEWAGE SLUDGE APPLICATION (under CROP PRODUCTION)	
Description	Sewage sludge application (i.e. biosolids) includes ammonia emitted when sewage sludge is land-applied on agricultural soils for annual and perennial crop production.
General Inventory Method	Pollutant(s) estimated: NH_3 **Ammonia** The methodology is aligned with reporting of ammonia losses from land application of sewage sludge in the NIR. In contrast to the 2016 EMEP/EEA simplified Tier 1 methodology for estimating per capita emissions from sewage sludge, use of the NIR methodology allows consistency among pollutant estimates. The methodology takes into account population change, but also captures trends in provincial land-application rates and regulations as well as characteristics of the material, such as N content.
Activity Data	Data on the production and management of biosolids were derived from an Environment and Climate Change Canada commissioned report (Cheminfo Services Inc. 2017). The dataset was generated through a combination of telephone surveys and reports by the municipal wastewater treatment services from 33 Census Metropolitan Areas and from municipal and provincial environmental departments/ministries across Canada. This survey was representative of 63% of the Canadian population on wastewater treatment plants (WWTP) located in Canadian Metropolitan Areas (CMAs). It did not include PEI and Canadian territories. The data was compiled at five-year intervals (1990–2015). Some gaps and inconsistencies owing to a lack of complete management information and changes in provincial regulations on biosolids were acknowledged, nevertheless, this data is the only known source for a quantitative estimate of biosolids available at a National scale. The timeseries of biosolid production data was produced through a series of analytical steps. First, a provincial-level per capita model was constructed to establish a "baseline biosolid production". Production was assumed to be directly proportional to the population of a geographical area. Different spatially scaled roll-ups of Statistics Canada population estimates were evaluated for best-fit of the data including: CMA populations, aggregated CMA populations, and provincial populations. Regression analysis indicated that the provincial population based model was the most accurate based on the strength of the correlation coefficients. The data generated using this approach were not significantly different from the years for which data was reported by Cheminfo Services Inc. (2017). Therefore, the smoothed annual provincial biosolid production was derived using the linear model. For PEI, annual estimates for biosolid production were developed based on expert opinion and using a national average per capita figure (22.5 kg /person/year). This analysis created a complete series of biosolid production at a provincial scale. Secondly, the regional rates of land application of biosolids (dry tonnes) were derived using the proportions reported in ChemInfo Services Inc. (2017) adjusted for federal, provincial and municipal regulations and restrictions. At the federal level, the regulations imposed by the CCME were applied. Later the provincial restrictions based on the nutrient content of the biosolid and any restrictions on the frequency of biosolid application to lands were incorporated. Biosolids are typically subject to various digestion and decomposition methods in wastewater treatment plants (WWTP) prior to land application. These methods have significant implications on the nutrient content of the biosolids and therefore influence the emission potential when land applied. Accordingly, as the final step, a combination of survey results and literature analyses were used to identify the major digestion processes and estimates from Dad et al. (2018) was used to establish the nutrient content of the biosolids.
Emission Factors (EF)	The default loss factors for organic nitrogen from the 2006 IPCC guidelines were used to quantify ammonia emissions.

Table A2–5 **Estimation Methodologies for Agriculture** (cont'd)

Sector/Subsector	
HARVESTING (under CROP PRODUCTION)	
Description	Agricultural harvest activities entrain particulate matter into the air. Particulate matter generated from agricultural harvesting, also known as grain dust, includes grain and dry plant particles, moulds, pollen and spores, silica, bacteria, fungi, insects, and possibly pesticide residues. These emissions are generated by vehicles traveling over the soil or by the processing of plant materials by agricultural equipment.
General Inventory Method	Pollutant(s) estimated: TPM, PM_{10}, $PM_{2.5}$ Particulate matter emissions from agricultural harvest operations are computed by multiplying an emission factor and an activity factor relating emissions to the area harvested.
Activity Data	Activity data for PM emission estimates from crop harvesting rely on a combination of data from the Census of Agriculture and area estimates based on Earth Observation data. Activity data on areas of major field crops at an ecodistrict level from 1990 to 2017 are consistent with the data reported in the Agriculture and the Cropland remaining Cropland category of the Land Use, Land-Use Change and Forestry sector for the *National Inventory Report 1990–2017: Greenhouse Gas Sources and Sinks in Canada* (ECCC, 2019).
Emission Factors (EF)	There are no emission factors for agricultural harvest in Canada. The PM_{10} emission factors proposed by the California Air Resources Board (CARB, 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 & Qiu Guowang, 2012).
TILLAGE PRACTICES (under CROP PRODUCTION)	
Description	Tillage practices produce PM emissions from mechanical disturbances such as seeding, seed bed preparation and cultivation.
General Inventory Method	Pollutant(s) estimated: TPM, PM_{10}, $PM_{2.5}$ Agricultural tillage is the common method used by farmers to prepare land for seeding and weed control. Particulate matter emissions are generated from airborne soil particles during tillage operations due to the mechanical disturbance of the soil surface. Particulate matter emissions from agricultural tillage operations are proportional to the area tilled. They are also dependent on the type of tillage practice as well as the number of tillage events per year. The calculations are described in more detail (Pattey & Qiu Guowang, 2012). The number of tillage events per year is dependent on tillage practices. There are fewer tillage events per year for conservation tillage compared to conventional tillage. Therefore, a reduction in particulate matter emissions from reduced tillage and no-till is observed.
Activity Data	Activity data for PM emission estimates from tillage practices rely mainly on a combination of data from the Census of Agriculture and area estimates based on Earth Observation analyses. Activity data on areas of major field crops, including summerfallow, and on tillage practices at an ecodistrict level from 1990 to 2016 are consistent with the data reported in the Cropland Remaining Cropland category of the Land Use, Land-use Change and Forestry sector for the *National Inventory Report 1990–2017: Greenhouse Gas Sources and Sinks in Canada* (ECCC, 2019). Information on the number of tillage events per year for crop type and tillage practices is taken from soil cover indicators (Huffman et al., 2012).
Emission Factors (EF)	Emission factors for tillage practices are calculated using the method described in (U.S. EPA, 1985).
WIND EROSION (under CROP PRODUCTION)	
Description	Wind erosion occurs when wind blows across exposed agricultural land, resulting in PM emissions from the entrained particles.
General Inventory Method	Pollutant(s) estimated: TPM, PM_{10}, $PM_{2.5}$ Wind erosion emissions from agricultural lands are calculated by multiplying the cultivated cropland area by an emission factor.
Activity Data	Activity data for PM emission estimates from wind erosion rely mainly on a combination of data from the Census of Agriculture and area estimates based on Earth Observation. Activity data on areas of major field crops, including summerfallow, and on tillage practices at an ecodistrict level from 1990 to 2016 are consistent with the data reported in the Cropland Remaining Cropland category of the Land Use, Land-Use Change and Forestry sector for the *National Inventory Report 1990–2017: Greenhouse Gas Sources and Sinks in Canada* (ECCC, 2019).
Emission Factors (EF)	The PM emission factor for wind erosion is calculated using the wind erosion equation (Woodruff & Siddoway, 1965) but considers the impact of soil and crop cover on PM emissions (Huffman et al., 2012). The emission factor for windblown PM emissions from agricultural lands is calculated using the methodology described in (Pattey & Qiu Guowang, 2012).
FUEL USE	
Description	Fuel Use includes emissions resulting primarily from combustion sources used for space/water heating and crop drying.
General Inventory Method	Pollutant(s) estimated: TPM, PM_{10}, $PM_{2.5}$, SO_x, NO_x, VOCs, CO, NH_3, Pb, Cd, Hg, dioxins/furans, B(a)p, B(b)f, B(k)f, I(cd)p Emissions are calculated for 10 types of fuel: natural gas, natural gas liquids, kerosene and stove oils, light fuel oil, heavy fuel oil, Canadian bituminous coal, sub-bituminous coal, lignite coal, anthracite coal, and imported coal. Total usage by fuel type and province/territory is multiplied by pollutant-specific emission factors.
Activity Data	(Statistics Canada, RESD, n.d.)
Emission Factors (EF)	TPM, PM_{10}, $PM_{2.5}$, SO_x, NO_x, VOCs, CO: (U.S. EPA, 1998) (Emission factors are chosen to represent the typical type of combustion equipment for each fuel type.) TPM, PM_{10}, $PM_{2.5}$, SO_x, NO_x, VOCs, CO for natural gas fuel: (U.S. EPA, 2004) 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; U.S. EPA, 2003; U.S. EPA, 2004) (Emission factors are selected to represent the typical type of combustion equipment for each fuel type.)

References for this table can be found on page 87.

Table A2–6 **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 Cigarette Smoking is being considered for removal from future inventories. If you have any questions, please contact us at ec.iepa-apei.ec@canada.ca or 1-877-877-8375.
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, Table 051-0001, 1991–2018
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 & Boyle, 2002) Dioxins/furans: (U.S. EPA, Exposure and Human …, 2004) B(a)p, B(b)f, B(b)k: (Ding et al., 2005)
COMMERCIAL AND INSTITUTIONAL FUEL COMBUSTION, CONSTRUCTION FUEL COMBUSTION AND RESIDENTIAL FUEL COMBUSTION	
Description	Commercial and Institutional Fuel Combustion, Construction Fuel Combustion and Residential Fuel Combustion include emissions resulting primarily from external combustion sources used for space/water heating and material heating. Commercial establishments, health and educational institutions, government/public administration facilities, and residences all fall under these categories, in addition to construction sites.
General Inventory Method	Pollutant(s) estimated: TPM, PM_{10}, $PM_{2.5}$, SO_x, NO_x, VOCs, CO, NH_3, Pb, Cd, Hg, dioxins/furans, B(a)p, B(b)f, B(k)f, I(cd)p Emissions are calculated for 10 types of fuel: natural gas, natural gas liquids, kerosene and stove oils, light fuel oil, heavy fuel oil, Canadian bituminous coal, sub-bituminous coal, lignite coal, anthracite coal, and imported coal. Total usage by fuel type and province/territory is multiplied by pollutant-specific emission factors.
Activity Data	(Statistics Canada, RESD, n.d.)
Emission Factors (EF)	TPM, PM_{10}, $PM_{2.5}$, SO_x, NO_x, 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}, $PM_{2.5}$, SO_x, NO_x, VOCs, CO for natural gas fuel: (U.S. EPA, WebFIRE. Factor Information …, 2004) 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; U.S. EPA, 2003; U.S. EPA, WebFIRE. Factor Information …, 2004) (Emission factors are selected to represent the typical type of combustion equipment for each fuel type.)
COMMERCIAL COOKING	
Description	Commercial Cooking includes emissions from cooking meat and french fries in commercial operations that are classified under five foodservice types: ethnic, fast food, family, seafood, and steak and BBQ. The types of meat considered include beef steak, hamburger, poultry with skin, poultry without skin, pork, seafood and other. Five types of commercial cooking equipment are taken into account including: chain driven charbroilers, underfired charbroilers, deep-fat fryers, flat griddles and clamshell griddles. The commercial operations inventoried are defined as all commercial foodservice points of distribution that are open to the public, offer prepared meals and snacks for consumption on/off-premises, and operate in a fixed location.
General Inventory Method	Pollutant(s) estimated: TPM, PM_{10}, $PM_{2.5}$, VOCs, CO, B(a)p **Commercial meat cooking (1999 to 2018)** 1. determine the number of restaurants in each province/territory that were classified as ethnic, fast food, family, seafood, steak and BBQ 2. determine 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. apply 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)** 1999 emission estimates were back-casted to 1990 using the gross domestic product (GDP) for NAICS [72]: Accommodation and Food Services (Statistics Canada, Table 379-0019 , n.d.) **Commercial cooking of french fries** The annual national consumption rate of frozen fries was multiplied by the annual provincial/territorial population and by a VOC-specific emission factor.

Table A2–6 **Estimation Methodologies for Commercial/Residential/Institutional** (cont'd)

Sector/Subsector	
Activity Data	**Commercial meat cooking (1999 to 2018 only)** Activity data were estimated using: • annual restaurant census for Canada: ReCount Database (The NPD Group Inc., 2017) • statistics on the prevalence of commercial cooking equipment, for the five restaurant types (E.H. Pechan & Associates Inc., 2003) • statistics on the average number of pounds of meat cooked on each type of equipment per week for the seven types of meat (E.H. Pechan & Associates Inc., 2003) **Commercial cooking of french fries** Activity data were estimated using: • provincial/territorial population data (Statistics Canada, Table 051-0001, n.d.) • annual Canadian consumption rates of frozen fries (USDA FAS, 2015) • assumed 80% of french fries were purchased in restaurants (E.H. Pechan & Associates Inc., 2003)
Emission Factors (EF)	Commercial meat cooking: TPM, PM_{10}, $PM_{2.5}$, VOCs, CO, B(a)p: (E.H. Pechan & Associates Inc., 2003) Commercial cooking of french fries: VOCs: (E.H. Pechan & Associates Inc., 2003)
HOME FIREWOOD BURNING	
Description	Home Firewood Burning encompasses emissions from wood burned in urban and rural homes for primary and supplementary heating, as well as for aesthetics and hot water, in both main and secondary residences. This covers household wood-burning devices such as wood-burning fireplaces, wood stoves, pellet stoves, outdoor boilers and a variety of other devices used in limited quantities, such as wood-fired cooking stoves.
General Inventory Method	Pollutant(s) estimated: TPM, PM_{10}, $PM_{2.5}$, SO_x, NO_x, VOCs, CO, NH_3, Pb, Cd, Hg, dioxins/furans, B(a)p, B(b)f, B(k)f, I(cd)p The quantity of wood burned by device type and province is multiplied by pollutant-specific emission factors by device type.
Activity Data	Activity data from (Canadian Facts, 1997; Canadian Facts, 2006; TNS Canada, 2012) are converted from volume to mass utilizing the reported wood species burnt. Wood consumption is interpolated and extrapolated from the three points (1996, 2006 and 2012) to the time series using statistical information on household wood-burning devices from (Statistics Canada, 1997; Statistics Canada, 2010; Tracey, 2016).
Emission Factors (EF)	TPM, PM_{10}, $PM_{2.5}$, SO_x, NO_x, VOCs, CO, NH_3: (Gulland, 2000) Pb, Cd, Hg, B(a)p, B(b)f, B(k)f: (U.S. EPA, 1995) Dioxins/furans: (EC, 2000)
HUMAN	
Description	Sources of ammonia emissions in the Human sector include respiration, perspiration, pharmaceutical use and infant-diapered waste. Infant Diapered Waste is being considered for removal from future inventories. If you have any questions, please contact us at ec.iepa-apei.ec@canada.ca or 1-877-877-8375.
General Inventory Method	Pollutant(s) estimated: NH_3 and Hg **Respiration and perspiration** Annual population data by province/territory are multiplied by an NH_3 emission factor. **Infant-diapered waste** An annual estimate of the population aged 0-3 years by province/territory is multiplied by an NH_3 emission factor.
Activity Data	**Respiration and perspiration** Population data: (Statistics Canada, Table 051-0001, n.d.) Infant-diapered waste: Number of children aged 0-3 years by province/territory: (Statistics Canada, Table 051-0001, n.d.).
Emission Factors (EF)	Respiration and perspiration and Infant-diapered waste: NH_3: (Roe et al., 2004).
SERVICE STATIONS	
Description	Service Stations estimates covers fugitive VOC emissions from fuel transfers and storage from refined petroleum products retail, as well as fugitive emissions from the refuelling of on- and off-road vehicles. Off-road refuelling emissions include all non-vehicle gasoline usage (lawn mowers, snow blowers, etc.).
General Inventory Method	Pollutant(s) estimated: VOCs **Refined petroleum products retail** Emissions are calculated using gasoline usage data multiplied by emission factors for underground tank filling and breathing. For British Columbia and Ontario, emissions from service stations are broken down into regulated versus unregulated areas. An emission control efficiency of 50% is applied to the filling of underground storage tanks in regulated areas in British Columbia and Ontario. The rest of the country is assumed to have no control efficiency. **Off-road refuelling** Off-road refuelling emissions are calculated using off-road gasoline usage data multiplied by an emission factor for uncontrolled vehicle refuelling. **On-road refuelling** On-road refuelling estimates are produced using the MOVES model. This year's estimates were made using $MOVES_{2014}$. Vehicle-specific activity (vehicle kilometres travelled) is multiplied by pollutant-specific emission factors.

Table A2–6 **Estimation Methodologies for Commercial/Residential/Institutional** (cont'd)

Sector/Subsector	
Activity Data	Refined petroleum products retail: Gross sales of gasoline for motor vehicles: (Statistics Canada, Table 23-10-0066-01, n.d.). Off-road refuelling: Off-road gasoline usage data (ECCC, 2019). On-road refuelling: Data on the vehicle fleet (counts), defined by fuel type, model-year and gross vehicle weight rating, originate from DesRosiers Automotive Consultants (DAC, 2017) and R. L. Polk & Co. (2017) for light- and heavy-duty vehicles, respectively. Motorcycle populations originate from the Road motor vehicle, trailer and snowmobile registration database (Statistics Canada, Table 405-0001, n.d.). The Annual Industry Statistics report (MMIC, 2013) is used to estimate the age distribution of motorcycles by model year which is applied to motorcycle populations obtained from Statistics Canada. The actual activity level is vehicle kilometres travelled (VKT). To arrive at estimates of VKT, vehicle counts are multiplied by mileage accumulation rates from Stewart-Brown Associates (Stewart-Brown Associates, 2012).
Emission Factors (EF)	Refined petroleum products retail and off-road refuelling: Evaporative emissions from gasoline service station operations (U.S. EPA, 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, 2012; U.S. EPA, 2014) and in the U.S. EPA technical guidance document (U.S. EPA, 2010).

References for this table can be found on page 88.

Table A2–7 **Estimation Methodologies for Incineration and Waste**

Sector/Subsector	
CREMATORIUMS	
Description	Crematoriums cover emissions from the combustion of caskets and human bodies. The combustion of fuel associated with the operation of a crematorium furnace or crematory fire is excluded from the sector. Fuel combustion emissions from cremations are captured under the Commercial and Institutional Fuel Combustion sector. In-house estimates do not cover animal cremation, as these emissions are reported through the NPRI.
General Inventory Method	Pollutant(s) estimated: TPM, PM_{10}, $PM_{2.5}$, SO_x, NO_x, CO, Pb, Cd, Hg, dioxins/furans, B(a)p, B(b)f, B(k)f, I(cd)p, HCB Number of human cremations per year by province/territory is multiplied by pollutant-specific emission factors.
Activity Data	Activity data for the years 2002 to 2018 is obtained from annual reports produced by the Cremation Association of North America (CANA). The *CANA Annual Statistics Report 2012: Executive Summary* (CANA, 2013) covers 2002 to 2007 and the CANA Annual Statistics Report (CANA, 2019) includes data from 2008 to 2018. Given the unavailability of data for some years, emission estimates are calculated using linear interpolation for all provinces/territories for the year 2001 to 2002, and as well as Quebec for the years 2002 to 2007.
Emission Factors (EF)	TPM, PM_{10}, $PM_{2.5}$: (U.S. EPA, 2014) VOCs, HCB: (EEA, 2013) SO_x, NO_x, CO: (EEA, 2009) Hg, Cd, Pb: (U.S. EPA, 2014) Dioxins/furans: (U.S. EPA, 2014) B(a)p, B(b)f, B(b)k, I(cd)p: (U.S. EPA, 2014) An average weight per body and casing of approximately 150 lbs. is assumed.
SEWAGE SLUDGE INCINERATION (under WASTE INCINERATION)	
Description	Sewage Sludge Incineration involves the incineration of sewage sludge from wastewater treatment facilities.
General Inventory Method	Pollutant(s) estimated: TPM, PM_{10}, $PM_{2.5}$, SO_x, NO_x, VOCs, CO, NH_3, Pb, Cd, Hg, dioxins/furans, B(a)p, B(b)f, B(k)f, I(cd)p The volume of sewage sludge is multiplied by default emission factors.
Activity Data	Activity data is developed based on Environment and Climate Change Canada surveys (ECCC, 2018).
Emission Factors (EF)	TPM, PM_{10}, $PM_{2.5}$, Cd, Pb, Hg, D/F, NO_x, SO_x, NH_3, CO, VOC: (EEA, EMEP/EEA, 2016)
MUNICIPAL INCINERATION (under WASTE INCINERATION)	
Description	Municipal Incineration involves the incineration of domestic waste, as well as non-hazardous and industrial waste.
General Inventory Method	Pollutant(s) estimated: TPM, PM_{10}, $PM_{2.5}$, Cd, CO, dioxins/furans, HCB, Hg, NH_3, NO_x, Pb, SO_x, VOCs Methodology under review.
Activity Data	Methodology under review.
Emission Factors (EF)	Methodology under review.

Table A2–7 **Estimation Methodologies for Incineration and Waste** (cont'd)	
Sector/Subsector	
LANDFILLS (under WASTE TREATMENT AND DISPOSAL)	
Description	Landfills include emissions from bulk non-hazardous waste disposed of in landfills across Canada. Materials deposited into landfills are covered daily with soil to prevent scattering of litter by wind, scavenging by animals, and odours. As a result, PM emissions are due to wind erosion, the movement of heavy vehicles and the dumping of waste. VOC emissions are emitted as a small component of landfill gas (LFG) generated by the anaerobic decomposition of organic waste within the landfill.
General Inventory Method	Pollutant(s) estimated: TPM, PM_{10}, $PM_{2.5}$, VOCs The quantity of waste landfilled for each province/territory is multiplied by PM emission factors to determine the amount of PM released. VOC emissions are calculated as a concentration of the total fugitive landfill gas released, derived from CH_4 emissions.
Activity Data	The tonnage of waste landfilled is calculated on the basis of the total amount of waste disposed by province as reported by Statistics Canada (Statistics Canada, n.d.), the amount of waste exported out of the province, and the amount of waste incinerated. Landfilled waste is assumed to be any disposed waste that is not exported or incinerated. Where landfill data is available directly from provincial sources, it is integrated into the activity data set. The provincial CH_4 emissions calculated for Canada's NIR are used to estimate VOC emissions for the APEI. CH_4 emissions are calculated using a First Order Decay model, as described in the NIR.
Emission Factors (EF)	TPM: (BCMELP, 1997) PM_{10}, $PM_{2.5}$: (GVRD & FVRD, 2003). The EF_{PM10} is calculated using a distribution percentage of 8% of the EF_{TPM}. The $EF_{PM2.5}$ is calculated using a distribution percentage of 2% of the EF_{TPM}. VOCs: (U.S. EPA, 1995). The default concentration of VOC in landfill gas is 835 ppmv.
RESIDENTIAL WASTE BURNING (under WASTE INCINERATION)	
Description	Emissions from Residential Waste Burning are related to on-site burning of residential waste materials in backyard barrels or to open-pit burning in rural areas.
General Inventory Method	Pollutant(s) estimated: TPM, PM_{10}, $PM_{2.5}$, SO_x, NO_x, VOCs, CO, NH_3, dioxins/furans, B(a)p, B(b)f, B(k)f, I(cd)p, HCB Methodology under review.
Activity Data	Methodology under review.
Emission Factors (EF)	Methodology under review.

References for this table can be found on page 90.

Table A2–8 **Estimation Methodologies for Paints and Solvents**	
Sector/Subsector	
DRY CLEANING, GENERAL SOLVENT USE, PRINTING AND SURFACE COATINGS	
Description	Dry Cleaning includes emissions from companies that provide dry cleaning of fabric and leather items. General Solvent Use consists of emissions from a broad range of applications occurring in residential, commercial, industrial and institutional settings. Industrial applications include uses such as degreasing, adhesives and sealants, aerosols, blowing agents and resin manufacturing. The use of consumer and commercial products, pesticides and personal care products is also included under General Solvent Use. Printing covers emissions from the manufacturing or use of printing inks. The sector consists of flexographic, gravure, letterpress, lithographic and other printing. Surface Coatings encompasses emissions from a broad range of applications and industries, including individuals and companies engaged in the manufacturing or use of paints and coatings.
General Inventory Method	Pollutant(s) estimated: VOCs The analysis methodology used is largely a "top-down" national mass balance approach that involves gathering statistical activity data on the production, distribution, end-use patterns and disposal of VOC-containing products and then building relationships between stages. More detailed data on solvent quantities and practices are collected from a subset of solvent and formulated product users, producers and distributors in Canada.
Activity Data	Solvent use quantities (1990 to 2004): Cheminfo Services, 2007 Solvent use quantities (2005 to 2018): Cheminfo Services, 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 2015–2018 were developed based on historical base year national total solvent use and macroeconomic growth and solvent growth ratios (Cheminfo Services, 2016b). Macroeconomic growth data (GDP by NAICS): Statistics Canada, n.d.
Emission Factors (EF)	The estimated use of emission control technologies is applied in each solvent application area. More specifically, emissions are calculated by taking the estimated quantity of solvent used in an application area multiplied by the estimated percentage of uncontrolled VOCs or: $$E_{VOCs} = Quantity_{solventused} \times (100\% - \%\ VOCs_{Controlled})$$ where E_{VOCs} is the emission estimate of VOCs. If there is no estimated use of control technologies, then 100% of the solvent VOCs is assumed to evaporate. Only a small portion of the estimated VOC emissions is reduced by the application of control technologies. Control efficiencies are applied (as percentages) in the following applications: flexographic, rotogravure and lithographic printing, aircraft coatings, automotive original equipment manufacture (OEM) coatings, metal can manufacturing, metal coil coating, metal furniture manufacturing, adhesives and sealants, and resin manufacturing (Cheminfo Services, 2016a).

References for this table can be found on page 91.

Table A2–9 **Estimation Methodologies for Dust**

Sector/Subsector	
COAL TRANSPORTATION	
Description	Coal Transportation includes PM emissions resulting from the transportation of coal by open-top rail, truck or barge. Most of the coal mined in Canada is carried to trans-shipment terminals (ports, for export) or to end use facilities by unit trains. Coal imported into Canada is predominantly shipped in lake and ocean vessels—some imported coal is landed directly at the end use facility; some is transported inland from import terminals by train or truck. Coal imported from central and western United States is generally transported by rail to end use facilities. Trucks are typically only used for coal shipment over shorter distances, whether to rail load-out (where it is shipped by rail the rest of the journey), or directly to the end-user / trans-shipment (port) terminals (Cope and Bhattacharyya, 2001). Load-in and load-out losses, including transportation within the mine-site and to mine-mouth facilities, are estimated and reported by mine facilities to the NPRI as part of fugitive emissions. Emissions from fuel combustion during coal transport (diesel, gasoline or oil) are inventoried separately as part of the Transportation and Mobile Equipment source category.
General Inventory Method	Pollutant(s) estimated: TPM, PM_{10}, $PM_{2.5}$ Emissions are estimated for each source-destination rail, truck or barge transportation route and summed by province. Emission factors for TPM for each rail or truck transportation route (source-destination) are derived from the distance travelled, the emission control/dust-mitigation effectiveness, and moisture (precipitation) along the route. For each province that a route crosses, the route emissions attributed to that province are determined from the proportion of the province-segment of the route to total route length. The PM_{10} and $PM_{2.5}$ emissions are calculated from the total particulate matter emissions based on a scaling factor. The mass of coal transported along each route is determined on the basis of either mine production of marketable coal (for mine to port or mine to end-user) or coal demand by end-user (for imported coal to end users). Coal mine production sent to multiple destinations is proportioned on the basis of documented coal shipping volumes to each destination, reported coal demand for coal-users, or estimates from (Cope & Bhattacharyya, 2001). Where no information was available, the coal production was proportioned to the various destinations on the basis of the distance between the mine and the destination.
Activity Data	Coal mine production and coal-user demand: (Statistics Canada, Table 135-0002, n.d.; Statistics Canada, Table 25-10-0048-01, n.d.; Statistics Canada, RESD, n.d.; Cope & Bhattacharyya, 2001) Monthly climate summaries: (ECCC, 2017) Rail Transportation Network: (NRCan, n.d.) (1:1M scale used) Mine Locations: (BC MINEFILE, 2017; AER, 2015), environmental assessment reports, and in-house remote-sensing.
Emission Factors (EF)	(Cope & Bhattacharyya, 2001)
CONSTRUCTION OPERATIONS	
Description	Construction Operations include PM emissions primarily resulting from soil disturbance on construction sites. The amount of soil disturbance is related to the surface area and duration of a construction project. The geographic region, type of construction (residential, industrial-commercial-institutional [ICI], engineering) and soil characteristics are all considered.
General Inventory Method	Pollutant(s) estimated: TPM, PM_{10}, $PM_{2.5}$ **Residential construction** Emission factors (SNC-Lavalin Environment, 2005) are applied to the number of housing starts, the average lengths of construction (duration) and buildings-to-hectares conversion factors, by province/territory and dwelling type. The number of houses with basements, average basement area and depth (volume of earth moved) are also considered. Emission factors are corrected for soil texture using average provincial soil silt contents weighted by the areas of highest residential construction or average territorial level soil silt contents. Thornthwaite's precipitation-evaporation (PE) index by province/territory is used to correct the emission factors for soil moisture. **ICI and engineering construction** Methodology under review The in-house estimates for ICI were last calculated for 2012 and were carried forward to 2018.
Activity Data	**Residential construction** Dwelling starts: (Statistics Canada, Table 027-0009, n.d.; CMHC, 2017) Average lengths of construction: (CMHC, 2017) Buildings to hectares conversion factors: (SNC-Lavalin Environment, 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.

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

Table A2–9 **Estimation Methodologies for Dust** (cont'd)

Sector/Subsector	
MINE TAILINGS	
Description	Mine Tailings covers emissions of particulates resulting primarily from wind erosion of mine tailings 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, though not universal practice to keep the solids in the tailings pond submerged, even when the mine is inactive or closed. If the solids are no longer submerged, fugitive particulate emissions occur through wind dispersion.
General Inventory Method	Pollutant(s) estimated: TPM, PM_{10}, $PM_{2.5}$ The particulate matter dust emissions are estimated by applying an emission factor to the area of exposed mine tailings. The emission factor is from Evans and Cooper (1980), which is loosely based on wind soil-loss equations. A term to account for snow cover was added to the original equation. $EF_{TPM} = 1.33C \times A \times S$ where C is a weather correction factor, A is the area of mine tailings in acres, and S is (365 – n_days_with_snow_cover) / 365 The emission factor is for total particulate matter (TPM), with the smaller particulate matter size fractions determined as ratios of total particulate matter: $PM_{10} = 0.8 \times TPM$ $PM_{2.5} = 0.2 \times TPM$ The weather correction factor C, is calculated from the equation: $C = 0.345(V_{30})^3 / PE^2$ where V_{30} is the average annual wind speed at 30 ft elevation (miles per hour) PE is the Thornthwaite Precipitation-Evaporation index, calculated as $PE = 115 \sum [P / (T\text{-}10)]^{(10/9)}$ (sum of monthly) where P is precipitation in inches, T is the temperature in Fahrenheit or 28.4 °F, whichever is greater. The weather correction factor, C, is determined for each province, by year using monthly surface wind speed (CCMP, n.d), precipitation (CRU 4.03, 2019) and temperature (CRU 4.03, 2019). All data sources ranged from spatial resolution of 0.25x0.25 to 1x1 degree latitude/longitude resolution. The snow cover correction is applied as a single provincial value (full time-series data was not available). Days with snow cover taken as the mean number of days with snow cover greater than 5cm. Snow cover data was obtained from Canadian Meteorological Centre (CMC, 2019) Daily Snow Depth Analysis, using 2000 to 2018 data, except years with missing data (2003–5, and 2008). The mine tailings areas were measured via a remote sensing classification of mine-disturbance areas throughout the country. Mine disturbance areas were classified from Landsat-5 and Sentinel 1, and Sentinel 2 imagery for the years 1990, 2000, 2010, and 2018, using supervised random forest classification, processed using Google Earth Engine (Fuentes et al., 2020). Tailings areas are taken as one third of total mine disturbance areas, with further 'within-mine' classification and mapping planned as a future improvement. The classification of mine disturbance areas was restricted to a search area consisting of a 3km buffer around known mine sites (existing or abandoned) identified in various ancillary data sources at any time between 1977 and 2016. Ancillary data sources used were: Murray et al. (1977), Natural Resources Canada, Map 900A, Producing Mines, 48th ed. (1996) to 66th ed. (2016), Parsons et al. (2012), Natural Resources Canada (NRCan), CanVec ManMade vector data (NRcan, n.d.), filtered for "Industrial Waste", which includes tailings. The mine-disturbance areas were manually refined and corrected in "challenging" regions for the automated classification, such as mountainous areas, badlands and high-arctic regions.
Activity Data	Fuentes et al. (2019).
Emission Factors (EF)	Evans and Cooper (1980) with addition of term to account for snow cover.

Table A2–9 **Estimation Methodologies for Dust** (cont'd)

Sector/Subsector	
PAVED AND UNPAVED ROADS	
Description	Emissions from the Paved Roads sector originate from primary (road abrasion) and secondary (re-suspended) PM emissions. Emissions from unpaved roads originate from suspended or re-suspended silt from the road surface.
General Inventory Method	Pollutant(s) estimated: TPM, PM_{10}, $PM_{2.5}$ Road abrasion, or **primary** paved road emissions, are produced by multiplying the total vehicle kilometres travelled for each province/territory by pollutant-specific emission factors. The methodology for **secondary (re-suspended)** emissions is based on the US EPA AP-42 methods. Paved road emissions follow the AP-42 Section 13.2.1, 2011 update (U.S. EPA, 2011). Unpaved roads estimation methods follows the AP-42 Section 13.2.2, 2006 update methods for publicly accessible roads (U.S. EPA, 2006). In both cases, Canadian-specific traffic distribution model was used to determine traffic volume by road class, and regional distribution of traffic for application of weather correction parameters. Unpaved roads also includes facility reported emissions occurring on private roads and parking lots. The road dust emissions are nominally the application of an emission factor to the vehicle kilometers travelled (VKT). The emission factor calculation differs for paved an unpaved roads. For paved roads, the emission factor is a function of the silt load—which in turn is a function of annual average daily traffic volume (AADT), the average vehicle fleet weight, and weather corrections for wet-days, winter silt load adjustments (to account for grit application) and snow cover. For unpaved roads, the emission factor is a function of road surface silt content, mean vehicle speeds, and surface material moisture content, a correction to remove 1980's vehicle tailpipe, tire-wear and break wear emissions (which were included in the original model parameterization), and weather corrections for snow and frozen road surfaces. Speeds on unpaved roads were estimated to be 70km/hr for highway, 60 km/hr for collectors, 50km/hr for arterial roads and resource and recreation roads, and 40 km/hr for local roads. The average fleet weight for Canada was estimated to be 2.676 tonnes. The silt content of unpaved roads was taken as 3.9% (AP-42 section 13.2.2, 2006 update default value). Silt loads were taken from the AP-42 table 13.2.1-2. Silt Load (sL) is a function of Average Annual Daily Traffic Volume (AADT), with adjustments for winter grit application (winter baseline multiplier).

AADT	sL Baseline	sL Winter Multiplier	Units
<500	0.6	4	g/m^2
500–5000	0.2	3	g/m^2
5000–10000	0.06	2	g/m^2
>10000	0.03	1	g/m^2

	In order to determine the number of roads having traffic volumes (AADT) within the various silt load ranges and to apply regional weather correction parameters the regional distribution of VKT is also required. The Natural Resources Canada road network was used, with roads reclassified into a subset of classes (paved/unpaved resources and recreation, local, collector, arterial, highway, freeway, and winter roads. Winter roads being neither paved nor unpaved and assumed to be a non-source of dust. Freeways are only paved). Traffic counts from provinces and municipalities from across Canada were gathered by ECCC and spatially matched to the road network (approximately 500,000 data-points). Roads and census population (1991-2016 census years) were summarized by census subdivision using census geography vintages/versions from the 1996, 2006, and 2016 census' (Statistics Canada 1996, 1996b, 2006, 2006b, 2016, 2016b). The ratios of mean traffic volume by road class modelled against regional population density to a baseline of paved local roads was used to distribute the estimated total VKT in Canada to each road class in each census subdivision, by year (geography and population varying by census year). See Table A2–4 Estimation Methodologies for Transportation and Mobile Equipment for VKT estimation methods). Weather parameters (soil moisture) and corrections (precipitation, winter multipliers) were applied on a monthly time-scale at the census subdivision level. The frost days and wet days were obtained from Climate Research Unit (CRU 4.03, 2019), 0.5x0.5 degree spatial resolution, monthly. Soil moisture was from NOAA Climate Prediction Center (NOAA n.d.), 0.5x0.5 degree spatial resolution, monthly. Winter silt load multipliers were applied, by census subdivision, for any month that the subdivision had more than 15 days with mean temperature below zero. It is assumed that no dust is (re)suspended from paved or unpaved roads on days with precipitation. The emission factor was adjusted using the factor: $$Precip\_Cor = (n\_Days\_per\_Month - Precipitation\_Days) / n\_Days\_per\_Month$$ For unpaved roads, soil moisture was taken as the mean surface soil moisture content of the census subdivision, or 6.515% (the AP-42 2006 update, section 13.2.2 default value), if weather data was not available.
Activity Data	See General Inventory Method. The same method used to calculate VKT for Transportation and Mobile Equipment sources was used to estimate VKT for the primary and secondary emissions.
Emission Factors (EF)	Primary—(EEA, EMEP/EEA, 2013) Secondary—Methodology under review.

References for this table can be found on page 91.

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

Sector/Subsector	
PRESCRIBED BURNING	
Description	Prescribed Burning includes emissions from controlled fires used for land management treatments. Prescribed burning is used to reduce logging residues, manage forest production, control insects and minimize potential for destructive wildfires. The practice of prescribed burning is carried out by the logging industry and forestry officials to manage Crown lands. This sector excludes the burning of agricultural residues.
General Inventory Method	Pollutant(s) estimated: TPM, PM_{10}, $PM_{2.5}$, SO_x, NO_x, VOCs, CO, NH_3, dioxins/furans, B(a)p, B(b)f, B(k)f, I(cd)p Total annual mass of forest debris burned by fire and by province/territory is multiplied by pollutant-specific emission factors.
Activity Data	The total number of hectares burned in each province/territory per year (CIFFC, 2019; PCA, 2019; 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, 1995). British Columbia: (GVRD & FVRD, 2003; BCMWLAP, 2004) Dioxins/furans, B(b)f, B(k)f: (Lemieux et al., 2004), B(a)p, I(cd)p: (Johnson et al., 1992)
STRUCTURAL FIRES	
Description	Structural Fires cover emissions from vehicle fires (such as fires from cars, trains and airplanes) and buildings fires. Structural fires emit large quantities of pollutants due to rapid but incomplete combustion. This sector includes only emissions estimated in-house.
General Inventory Method	Pollutant(s) estimated: TPM, PM_{10}, $PM_{2.5}$, NO_x, VOCs, CO, NH_3 Tonnes of structures burned per year, by province/territory, are multiplied by pollutant-specific emission factors.
Activity Data	The Secretary/Treasurer of the Council of Canadian Fire Marshals and Fire Commissioners[2] (CCMFC) and the following members of the CCMFC are contacted to obtain the number of annual structural fires in their jurisdictions: • Government of Nunavut[3] (carried forward) • Fire and Emergency Services, Newfoundland and Labrador[4] (carried forward) • Office of the Fire Marshal and Emergency Management (Ontario)[5] (carried forward) • Office of the Fire Commissioner (Manitoba)[6] (carried forward) • Emergency Management and Fire Safety Branch (Saskatchewan)[7] (carried forward) • Canadian Forces Fire Marshal[8] (2016 data) • Office of Public Safety (Prince Edward Island)[9] (carried forward) • Yukon Government[10] (2016 data) • Department of Labour and Advanced Education (Nova Scotia)[11] (2016 data) • Department of Municipal and Community Affairs (Government of the Northwest Territories)[12] (2016 data) • Department of Public Safety (New Brunswick)[13] (2016 data) • Office of the Fire Commissioner (Alberta)[14] (2016 data) • Emergency Management British Columbia[15] (2016 data) • Ministère de la Sécurité publique[16] (carried forward) Number of structure fires in each province/territory is multiplied by a loading factor to convert the number of fires into tonnes of structure burned (EIIP, 2001). Loading factor = 1.04 t of structure burned/fire Given the unavailability of activity data, emission estimates for 2001, 2002 and 2004 are calculated using linear interpolation.
Emission Factors (EF)	TPM, PM_{10}, $PM_{2.5}$, NO_x, VOCs, CO: (GVRD & FVRD, 2003) NH_3: (Battye et al., 1994)

References for this table can be found on page 92.

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

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

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

5 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).

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

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

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

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

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

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

12 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).

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

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

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

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

Table A2–11 **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 lamps • non-fluorescent lamps • measurement and control devices • thermometers • thermostats • tire balancers Emissions from the above devices impact the following sectors/subsectors: • Iron and Steel Industry—Secondary (Electric Arc Furnaces) • Iron and Steel Industry—Steel Recycling • Electronics • Other (Manufacturing) • Human Respiration (Miscellaneous Other) • Municipal Incineration • Landfills • Residential Waste Burning • Municipal Wastewater Treatment and Discharge
General Inventory Method	Pollutant(s) estimated: Hg Mercury emissions from 1990 to 2008 are estimated based on the model *Substance Flow Analysis of Mercury in Products* originally developed by the Minnesota Pollution Control Agency, modified by ToxEcology Environmental. In 2018, the methodology was updated by ChemInfo Services with specific interest in 2009 forward. However, at that time work was also done for time series consistency which impacted emissions from 1990 to 2008 at the national level. (Barr Engineering, 2001; ToxEcology, 2007; ToxEcology, 2009; Cheminfo Services, 2018). The current update focuses on provincial distribution from 1990 forward and modifying aspects of the fluorescent and non-fluorescent lamp models from 2009 forward. The Mercury in Products models use a lifecycle approach which considers releases from manufacturing, in-service breakage, recycling, transportation and storage of items sent to disposal as well as the ultimate disposal point for each product. The update completed by ChemInfo Services in 2018 allocated emissions to provinces and territories based on product type from 2009 forward. Prior to this update, emissions were not allocated based on product type. This year emissions from 1990 to 2008 were re-distributed based on product type for time series consistency. In addition, emissions were re-allocated for the open burning, sewage sludge incineration and municipal incineration sectors from 1990 forward to better reflect the provinces in which these practises take place. Lastly, activity data inputs for both fluorescent and non-fluorescent lamps were updated based on newly available data that was not provided at the time of the last update.
Activity Data	ToxEcology, 2007; ToxEcology, 2009; Cheminfo Services, 2018.
Emission Factors (EF)	A modified version of the model, entitled *Substance Flow Analysis of Mercury in Products* by (Barr Engineering, 2001) used with updates from (ToxEcology, 2007; Cheminfo Services, 2018). The model includes partitioning factors to the various streams from manufacture through final disposal, including emission factors at every point along the way.

References for this table can be found on page 93.

ANNEX 3

RECALCULATIONS

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

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

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

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

The following in-house emissions estimates were recalculated for the 2020 edition of the APEI. Brief descriptions of the recalculations and the impacts on emission levels are provided in Table A3–1 to Table A3–11.

- Ore and Mineral Industries: Secondary (Electric Arc Furnaces) under Iron and Steel Industry
- Oil and Gas Industry: Natural Gas Distribution; Accidents and Equipment Failures; Disposal and Waste Treatment; Heavy Crude Oil Cold Production; Light/Medium Crude Oil Production; Natural Gas Production and Processing; Natural Gas Transmission and Storage; Oil Sands In-Situ Extraction; Petroleum Liquids Storage; Petroleum Liquids Transportation; Well Drilling/Servicing/Testing
- Manufacturing: Bakeries; Wood Products
- Transportation and Mobile Equipment: Air Transportation; Marine Transportation;
- Agriculture: Animal Production; Crop Production; Fuel Use
- Commercial/Residential/Institutional: Commercial and Institutional Fuel Combustion; Construction Fuel Combustion; Residential Fuel Combustion; Service Stations
- Incineration and Waste: Waste Incineration
- Mercury in Products
- Dust: Paved and Unpaved Roads; Mine Tailings
- Solvents: Dry Cleaning, General Solvent Use; Printing, Surface Coatings
- Silica Production

For the purpose of Table A3–1 to Table A3–11, the term "significant" refers to changes greater than ±10% in emission levels.

Annex 3 Tables:

Table A3–1 Recalculations for Ore and Mineral Industries

Sector	Pollutant(s)	Description	Impact on Emissions
SECONDARY (ELECTRIC ARC FURNACES) (under IRON AND STEEL INDUSTRY)			
	Hg	Recalculations of Hg occurred due to changes in Hg in Products model and the detection of an error in the reconciliation of values throughout the time series.	This resulted in changes to emissions at the national level from 1990 through 2017 for Hg. The differences ranged from -0.16 tonnes to +0.20 t or -62% to +516% (largest difference was for the year 2008).

Table A3–2 Recalculations for Oil and Gas Industry

Sector	Pollutant(s)	Description	Impact on Emissions
NATURAL GAS DISTRIBUTION (under DOWNSTREAM OIL AND GAS INDUSTRY)			
	TPM, PM_{10}, $PM_{2.5}$, SO_x, NO_x, VOCs, CO	Recalculations of TPM and PM_{10} occurred from 2003 through 2013 as a result of improved allocation of NPRI data to the Oil and Gas Industry subsectors and corrections to the distribution of particulate matter emissions. Recalculations for all pollutants occurred in 2016 and 2017 as a result of updated activity data (Statistics Canada, 2019).	This resulted in changes to emissions at the national level from 2003 through 2017 for PM_{10} (largest difference in 2005: +12.8 t, 57.3%), from 2009 through 2017 for TPM (largest difference in 2010: -0.2 t, -16.2%). All other pollutants had recalculations in 2016 and 2017 and did not result in emissions changes greater than ±10%.
ACCIDENTS AND EQUIPMENT FAILURES (under UPSTREAM OIL AND GAS INDUSTRY)			
	VOCs	Recalculations occurred from 2013 through 2017 as a result of updated activity data. ([CNLOPB] Canada Newfoundland and Labrador Offshore Petroleum Board, 2019; [SKMER] Saskatchewan Ministry of Energy and Resources, 2019; [CAPP] Canadian Association of Petroleum Producers, 2019).	The recalculations did not result in changes greater than ±10% in any of the impacted years.
DISPOSAL AND WASTE TREATMENT (under UPSTREAM OIL AND GAS INDUSTRY)			
	VOCs, CO, NO_x, $PM_{2.5}$, PM_{10}, TPM	Recalculations occurred from 1990 through 2010 as a result of methodological changes to flaring emission estimates.	The recalculations resulted in changes to emissions at the national level from 1990 through 2010 for: VOCs (largest difference in 1992: +8.7 t, +76%), CO (largest difference in 1992: +93.6 t, +5293%), NO_x (largest difference in 1992: +17.2 t, +422%), and $PM_{2.5}$, PM_{10}, and TPM (largest difference in 1992: +33.5 t, +25223%).
HEAVY CRUDE OIL COLD PRODUCTION (under UPSTREAM OIL AND GAS INDUSTRY)			
	VOCs, SO_x, $PM_{2.5}$, PM_{10}, TPM	Recalculations occurred from 1990 through 1999 as a result of methodological changes to flaring emission estimates.	The recalculations resulted in changes to emissions at the national level from 1990 through 1999 for: SO_x (largest difference in 1997: -122.8 t, -20.2%), and $PM_{2.5}$, PM_{10}, and TPM (largest difference in 1997: -179.7 t, -17.7%). The recalculations did not result in changes greater than ±10% for any other pollutants.
LIGHT MEDIUM CRUDE OIL PRODUCTION (under UPSTREAM OIL AND GAS INDUSTRY)			
	TPM, PM_{10}, $PM_{2.5}$, SO_x, NO_x, VOCs, CO, NH_3	Recalculations occurred from 1990 through 2017, as a result of updated flaring activity data (CNLOPB. Personal communication (email from CNLOPB to S. Smyth [Pollutant Inventories and Reporting Division (PIRD), ECCC] dated 2019 October 11); [BCOGC] British Columbia Oil and Gas Commission. Personal communication (email from BCOGC to S. Smyth [PIRD, ECCC] dated 2019 October 10) and methodological changes to flaring emission estimates.	The recalculations resulted in changes to emissions at the national level from 1990 through 2017 for SO_x (largest difference in 1997: -4153.0 t, -21.0%). For all other pollutants, this recalculation did not result in changes greater than ±10%.
NATURAL GAS PRODUCTION AND PROCESSING (under UPSTREAM OIL AND GAS INDUSTRY)			
	CO, NO_x, VOCs, SO_x, TPM, PM_{10}, $PM_{2.5}$	Recalculations occurred from 1990 through 2017 as a result of updated flaring activity data (BCOGC. Personal communication (email from BCOGC to S. Smyth [PIRD, ECCC] dated 2019 October 10) and methodological changes to flaring emission estimates.	This resulted in changes to emissions at the national level from 1990 through 2017 for TPM, PM_{10}, and $PM_{2.5}$ (largest difference in 1997: -315.7 t, -12.3%). The recalculations did not result in changes greater than ±10% for any of the other pollutants.
NATURAL GAS TRANSMISSION AND STORAGE (under UPSTREAM OIL AND GAS INDUSTRY)			
	TPM, PM_{10}, $PM_{2.5}$, SO_x, NO_x, VOCs, CO	Recalculations occurred from 2002 through 2017 as a result of corrections to the distribution of particulate matter emissions, and improved allocation of NPRI data to Oil and Gas Industry subsectors. Recalculations for all pollutants occurred in 2017 as a result of updated activity data. (Statistics Canada, 2019).	This resulted in changes to emissions at the national level in 2012 for SO_x (difference of -63.2 t, -26.7%), from 2002 through 2017 for PM_{10} (largest difference in 2015: -18.2 t, -17.4%) and TPM (largest difference in 2011: -83.3 t, -46.9%). For all other pollutants, this recalculation did not result in an emissions change of greater than ±10%.
OIL SANDS IN-SITU EXTRACTION (under UPSTREAM OIL AND GAS INDUSTRY)			
	TPM, PM_{10}, $PM_{2.5}$, SO_x, NO_x, VOCs, CO	Recalculations occurred from 1990 through 2017 as a result of corrections to the distribution of particulate matter emissions and methodological changes to flaring emission estimates.	This resulted in changes to emissions at the national level from 1990 through 2017 for TPM (largest difference in 1997: -73.7 t, -14.3%), from 1990 through 2016 for PM_{10} (largest difference in 1997: -72.0 t, -14.0%) and $PM_{2.5}$ (largest difference in 1997: -73.7 t, -14.3%). For all other pollutants, this recalculation did not result in an emissions change of greater than ±10%.

Table A3–2 Recalculations for Oil and Gas Industry (cont'd)

Sector	Pollutant(s)	Description	Impact on Emissions
PETROLEUM LIQUIDS STORAGE (under UPSTREAM OIL AND GAS INDUSTRY)			
	VOCs, TPM, PM_{10}, $PM_{2.5}$, CO, NO_x, Pb, Cd, B(a)p, B(p)f, HCB, B(k)f, I(1,2,3-cd)p	Recalculations occurred from 2002 through 2017 as a result of updates to the reported NPRI data and improved allocation of NPRI data to the Oil and Gas Industry subsectors. Unsubstantiated air toxic emissions legacy data was removed for the year 2004.	The recalculations resulted in changes to emissions from 2012 through 2017 for VOCs (largest difference in 2013: +909.0 t, +14.5%) and PM_{10} (largest difference in 2012: +11.2 t, +62.6%), from 2004 through 2017 for TPM (largest difference in 2012: +44.1 t, +88.8%), from 2003 through 2017 for $PM_{2.5}$ (largest difference in 2009: +3.0 t, +20.9%). From 2002 through 2012 for CO and from 2006 through 2010 for NO_x, emissions were previously zero. Data removal resulted in emissions in 2004 becoming zero for Pb, Cd, HCB, and PAHs.
PETROLEUM LIQUIDS TRANSPORTATION (under UPSTREAM OIL AND GAS INDUSTRY)			
	TPM, PM_{10}, $PM_{2.5}$, NO_x, VOCs, CO	Recalculations occurred from 1990 through 2010 as a result of updated flaring activity data. (BCOGC. Personal communication [email from BCOGC to S. Smyth (PIRD, ECCC) dated 2019 October 10]) and corrections to the distribution of particulate matter emissions.	This resulted in changes to emissions at the national level from 1990 through 2004 for $PM_{2.5}$ (largest difference in 2001: +5.3 t, +39.6%), PM_{10} (largest difference in 2001: +5.3 t, +31.2%), CO (largest difference in 2001: +14.9 t, 628%), and NO_x (largest difference in 2001: +2.7 t, 628%. Emissions changed from 1990 through 2010 for TPM (largest difference in 2001: +5.3 t, +32.0%). This recalculation did not result in an emissions change of greater than ±10% for VOCs.
OIL SANDS MINING, EXTRACTION AND UPGRADING (under UPSTREAM OIL AND GAS INDUSTRY)			
	TPM, $PM_{2.5}$	Recalculations occurred from 2002 through 2017 as a result of corrections to the distribution of particulate matter emissions.	This resulted in changes to emissions at the national level in 2002 for $PM_{2.5}$ (difference of -389.5 t, -19.9%). This recalculation did not result in an emissions change of greater than ±10% for TPM.
WELL DRILLING/SERVICING/TESTING (under UPSTREAM OIL AND GAS INDUSTRY)			
	TPM, PM_{10}, $PM_{2.5}$, CO, NO_x	Updated flaring activity data for Well Drilling (BCOGC. Personal communication [email from BCOGC to S. Smyth (PIRD, ECCC) dated 2019 October 10]) resulted in recalculations for the years 2012 to 2017, while methodological changes to Well Testing flaring emission estimates resulted in recalculations between 1996 and 2017.	These recalculations resulted in changes to emissions from 1996 through 2017 for $PM_{2.5}$, PM_{10}, and TPM (largest difference in 2017: -114.5 t, -44.0%), CO (largest difference in 2017: -319.7 t, -43.5%), and NO_x (largest difference in 2017: -58.7 t, -35.9%).

Table A3–3 Recalculations for Manufacturing

Sector	Pollutant(s)	Description	Impact on Emissions
BAKERIES			
	VOCs	Updated population and bakeries activity data were used for 1990–2017 estimates.	The recalculations resulted in minor changes in emissions for 2001–2017 for VOCs (largest difference in 2017: +58 t or +1%; for the other years, i.e. 2001 to 2016, differences were < ±0.69 t or ±0.01%).
WOOD PRODUCTS			
	TPM, PM_{10}, $PM_{2.5}$, SO_x, NO_x, VOCs, CO, NH_3, Pb, Cd, Hg, dioxins/furans, B(a)p, B(b)f, B(k)f, I(cd)p	The recalculations were done using updated facility data reported to provinces and NPRI facility-reported data from 1990 to 2017.	The recalculations resulted in changes in emission levels (> ±10%) for $PM_{2.5}$ for 2006, 2011 to 2013 and 2016 to 2017; NO_x for 2004; VOCs from 2002 to 2017;Cd from 2011 to 2013; dioxins/furans for 2002 and from 2004 to 2006; HCB for 2007 and 2013; Hg from 2012 to 2013; and SO_x from 1990 to 2005 and 2009.

Table A3–4 Recalculations for Transportation and Mobile Equipment

Sector	Pollutant(s)	Fuel	Description	Impact on Emissions
AIR TRANSPORTATION				
	B(a)p, B(b)f, B(k)f, I(cd)p, CO, NH_3, Pb, TPM, PM_{10}, $PM_{2.5}$, VOCs, NO_x, SO_x	Aviation Turbo Fuel, Aviation Gasoline	Civil emissions from the cruise segment of each flight were removed from the report total in order to conform with the national total reported in the NFR table. The percent of sulphur in each fuel type was updated with the most recent data.	The overall air transportation emissions are not significantly impacted. The change in reporting for 1990 resulted in significant changes in the emissions of TPM (-54% or -389 t), PM_{10} (-54% or -389 t), $PM_{2.5}$ (-59% or -379 t), SO_x (-85% or -4490 t), VOCs (-46% or -2390 t), CO (-14% or -8540 t), NO_x (-87% or -45 kilotonne), NH_3 (-83% or -24 t), Pb (-70% or -54.4 t), B(a)p (-29% or -0.60 kilogram), B(b)f (-33% or -1.17 kg), B(k)f (-33% or -1.17 kg), and I(cd)p (-36% or -1.27 kg). The change in reporting for 2017 resulted in significant changes in the emissions of TPM (-64% or -640 t), PM_{10} (-64% or -640 t), $PM_{2.5}$ (-69% or -632 t), SO_x (-93% or -6170 t), VOCs (-63% or -3860 t), CO (-23% or -11.7 kt), NO_x (-92% or -74 kt), NH_3 (-88% or -35 t), Pb (-37% or -11.8 t), B(a)p (-59% or -0.92 kg), B(b)f (-62% or -1.81 kg), B(k)f (-62% or -1.81 kg), and I(cd)p (-64% or -1.96 kg).
MARINE TRANSPORTATION				
	B(a)p, B(b)f, B(k)f, I(cd)p, TPM, PM_{10}, $PM_{2.5}$, SO_x, NO_x, VOCs, CO, NH_3, Pb, Cd, Hg, D/F	Heavy Fuel Oil, Diesel Fuel Oil	Provincial estimates were redeveloped based on port origin/destination pairs.	The recalculations will only impact the emissions of individual provinces and not the national total.

Table A3–5 Recalculations for Agriculture

Sector	Pollutant(s)	Description	Impact on emissions
ANIMAL PRODUCTION			
	NH_3	Corrections were made to the nitrogen excretion rates of minor animal categories (fox, mink, rabbit), and adjustments to the ecodistrict distribution of animals.	The changes resulted in minor recalculations for all years.
CROP PRODUCTION			
	NH_3	Recalculations are due to: A methodology for estimating ammonia emissions from land-applied sewage sludge (i.e. biosolids), was added as a new subcategory of crop production.	Emission for this new source were 2.6 kt in 1990, 3.7 kt in 2005, and 5.1 kt in 2017.
	NH_3	Corrections to inorganic N fertilizer data for years 2013–2017.	Emissions of NH_3 decreased by 11.3 kt (-7%) in 2017, but recalculations were minor in other years.
FUEL USE			
	TPM, PM_{10}, $PM_{2.5}$, SO_x, NO_x, VOCs, CO, NH_3, Pb, Cd, Hg, dioxins/ furans, B(a)p, B(b)f, B(k)f, I(cd)p, HCB	The activity data have been updated to a more recent edition of the RESD.	The recalculations did not result in changes in emission levels for any of the pollutants in 1990. For the year 2017, pollutant emissions changed by less than ±10%.

Table A3–6 Recalculations for Commercial/Residential/Institutional

Sector	Pollutant(s)	Description	Impact on Emissions
COMMERCIAL AND INSTITUTIONAL FUEL COMBUSTION			
	TPM, PM_{10}, $PM_{2.5}$, SO_x, NO_x, VOCs, CO, NH_3, Pb, Cd, Hg, dioxins/furans, B(a)p, B(b)f, B(k)f, I(cd)p, HCB	The activity data have been updated to a more recent edition of the RESD.	The recalculations did not result in changes in emission levels for any of the pollutants in 1990. For the year 2017, pollutant emissions changed by less than ±10%.
CONSTRUCTION FUEL COMBUSTION			
	TPM, PM_{10}, $PM_{2.5}$, SO_x, NO_x, VOCs, CO, NH_3, Pb, Cd, Hg, dioxins/furans, B(a)p, B(b)f, B(k)f, I(cd)p, HCB	The activity data have been updated to a more recent edition of the RESD.	The recalculations did not result in changes in emission levels of greater than 10% for any of the pollutants in 1990. For the year 2017, pollutant emissions changed by less than ±10%.
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.	The recalculations did not result in changes in emission levels for any of the pollutants in 1990. For the year 2017, HCB changed by 100%. The remaining pollutant emissions changed by less than ±10% in 2017.
SERVICE STATIONS			
	VOCs	The activity data has been updated to a more recent version of the source data.	At the national level, recalculations did not result in changes of emissions levels greater than 3% over the entire time series. For the year 2017, VOCs changed by less than 0.1% (23 tonnes).

Table A3–7 Recalculations for Incineration and Waste Sources

Sector	Pollutant(s)	Description	Impact on Emissions
WASTE INCINERATION			
	Cd, CO, D/F, Hg, NH_3, NO_x, Pb, PM_{10}, $PM_{2.5}$, SO_x, TPM, VOCs	Changes affecting estimates are a result of updating incineration activity data for the complete 1990–2018 time series using information collected in the ECCC waste incineration surveys, the re-classification of several incinerators into the Other Incineration subcategory, and the removal of the in-house model for the Industrial, Commercial, and Institutional incineration sector in favor of using facility data. In addition, the mercury in products model was implemented for the sewage sludge incineration sector resulting in an increase in mercury emissions.	At a national level, the recalculations for 1990–2017 years ranged from -45% to +87% for mercury emissions, 0% to +365% for HCB emissions and -80% to -32% for lead emissions.

Table A3–8 Recalculations for Mercury in Products

Sector	Pollutant(s)	Description	Impact on Emissions
ORE AND MINERAL INDUSTRIES, MANUFACTURING AND COMMERCIAL/RESIDENTIAL/INSTITUTIONAL, INCINERATION AND WASTE			
	Hg	The estimation methodologies for mercury in products have been updated from 2009 forward for two product types, namely fluorescent and non-fluorescent lamps. In addition, distribution of emissions to provinces and territories from 1990 to 2008 have been re-allocated based on product type for time series consistency with the update done by ChemInfo Services in 2018. Distribution of emissions to the provinces and territories for open burning, sewage sludge incineration and municipal incineration have been updated for the full time series to better reflect the provinces that use these practices. Recalculations for municipal incineration also occurred. Please note that mercury in products Hg emissions are reconciled with point source emissions before publication.	At the national level the recalculations resulted in a 0% to 10% change for 1990 and a 0% to 40% for 2017.

Table A3–9 Recalculations for Dust

Sector	Pollutant(s)	Description	Impact on Emissions
MINE TAILINGS DUST			
	TPM, PM_{10}, $PM_{2.5}$	The activity data has been completely recalculated. Originally derived from Murray et. al. (1977), tailings areas are now determined mapping of mine disturbance areas for 1990, 2000, 2010 and 2018 using supervised classification of landsat-5, Landat-8 and Sentinel satellite imagery (Fuentes et al., 2019). The emission factors calculations have been corrected: an error in the Thornthwaite P-E index in the original source (Evans and Cooper, 1980) and a unit error in calculations have been corrected. The emission factor climate correction factor, C, has been updated to include annually and provincially resolved climate correction factors (formerly static eastern/western Canada). The emission factor calculations also now include a correction for snow cover.	1990: TPM changed from 58 000 to 1300 t, PM_{10} changed from 4600 to 1100 t, $PM_{2.5}$ changed from 1200 to 270 t (decreases of 41% to 97%, varying by pollutant). 2016: TPM changed from 32 000 to 2900 t, PM_{10} changed from 2600 t to 2300 $PM_{2.5}$ changed from 700 to 580 t (decreases of 17% to 90%, varying by pollutant).
PAVED ROADS			
	TPM, PM_{10}, $PM_{2.5}$	Previously, the emissions were last estimated for 2002 and were carried forward to 2017. The method used up to 2002 was based on the 1995 version of the US EPA AP-42 road dust model (Section 13.2.1 of U.S. EPA, 1995). The method has been updated to the most recent AP-42 model, the 2011 update (Section 13.2.1 of U.S. EPA, 2011), which includes the removal of tailpipe, break-wear and tire-wear emissions from the road dust model. The application of silt-load factors based on traffic volumes of different road types, see Annex 2.2 for a further description of the update.	1990: TPM changed from 2 982 000 t to 495 000 t (83% decrease), PM_{10} changed from 470 000 to 95 034 (80% decrease), $PM_{2.5}$ changed from 112 000 to 22 992 (7% decrease). 2017: TPM changed from 2 982 000 t to 412 109 t (86% decrease). PM_{10} changed from 572 000 t to 79 104 (86% decrease), $PM_{2.5}$ changed from 137 000 t to 19 138 (86% decrease).
UNPAVED ROADS			
	TPM, PM_{10}, $PM_{2.5}$	See Paved Roads for a description of the method change. The contribution of dust from unpaved private roads and private parking areas remains unchanged—it is the reported values from the NPRI.	1990: TPM changed from 5 999 000 to 8 181 421 t (27% increase). PM_{10} changed from 1 902 000 to 2 312 132 t (18% increase). $PM_{2.5}$ changed from 283 000 to 230 197 t (19% decrease). 2017: TPM changed from 7 935 000 to 8 181 421 t (3% increase). PM_{10} changed from 2 489 000 to 4 070 851 t (64% increase). $PM_{2.5}$ changed from 364 000 to 405 329 t (11% increase).

Table A3–10 Recalculations for Solvent Related Sectors

Sector	Pollutant(s)	Description	Impact on Emissions
GENERAL SOLVENT USE, PRINTING, SURFACE COATINGS AND DRY CLEANING			
	VOCs	Facilities under the NPRI were reviewed and re-distributed as needed by sector in 2019 for the APEI, from 2005 forward.	At the national level the recalculation did not result in more than ±10% change in 2005. A 16% increase was observed for 2017.

Table A3–11 Recalculations for Silica Production

Sector	Pollutant(s)	Description	Impact on Emissions
SILICA PRODUCTION			
	TPM, PM_{10}, $PM_{2.5}$	The activity data that is used to estimate emissions for this sector is provided in part from Natural Resources Canada. In some cases, the data is suppressed for provinces or territories due to confidentiality reasons. In the past, the missing data was estimated by using employment sector data from Statistics Canada. For this submission, the missing data was estimated based on a population distribution for the full time series to reduce the complexity of this estimation methodology.	At the national level the recalculations did not result in a significant change.

ANNEX 4

SUBMISSION TO THE UNITED NATIONS ECONOMIC COMMISSION FOR EUROPE

A4.1. 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) (www.ceip.at) pursuant to the Convention on Long-range Transboundary Air Pollution (CLRTAP) and its associated protocols. Table A4–1 lists the atmospheric pollutants for which annual emissions are reported to the UNECE, along with the corresponding protocols under CLRTAP.

This edition of the Canada's Air Pollutant Emissions Inventory (APEI) Report summarizes the most recent estimates of air pollutant emissions for 1990–2018 as of February 2020. The inventory indicates that 14 of the 17 reported air pollutants show decreases compared to historical levels, and specifically indicate that:

- Emissions of sulphur oxides (SO_x) were 0.8 million tonnes in 2018, 44% below the emission ceiling of 1.45 million tonnes established under the 1999 Gothenburg Protocol to Abate Acidification, Eutrophication and Ground-level Ozone.
- Emissions of nitrogen oxides (NO_x) were 1.8 million tonnes in 2018, 21% below the emission ceiling of 2.25 million tonnes established under the 1999 Gothenburg Protocol.
- In 2018, emissions of non-methane volatile organic compounds (VOCs) were 9% below the emission ceiling of 2.1 million tonnes established under the 1999 Gothenburg Protocol.
- In 2018, emissions of cadmium (Cd), lead (Pb), mercury (Hg) were 82%, 63% and 82% below the ceilings established under the 1998 Aarhus Protocol on Heavy Metals.
- In 2018, emissions of all persistent organic pollutants (POPs) were below the ceilings established under the 1998 Aarhus Protocol on Persistent Organic Pollutants, including the four species of polycyclic aromatic hydrocarbons (PAHs) (69% below), hexachlorobenzene (HCB) (91% below), and D/F (84% below).

Table A4–1 **Pollutant Emissions Reported to the United Nations Economic Commission for Europe and Related Protocols under the Convention on Long-range Transboundary Air Pollution**

Pollutant	Relevant protocols under the CLRTAP	Protocol obligation
SO_x	1999 Gothenburg Protocol (as amended in 2012)	Reduction of SO_2 emissions by 63% from 2005 levels by 2020
	1999 Gothenburg Protocol	2010 emissions ceiling of 1.45 million tonnes
	1994 Oslo Protocol	Maintain SO_x emissions (excluding natural sources) in the regional Sulphur Oxides Management Area (SOMA) below 1.8 million tonnes
	1985 Helsinki Protocol	Reduction of SO_x emissions by at least 30 percent from 1980 levels
NO_x	1999 Gothenburg Protocol (as amended in 2012)	Reduction of NO_x emissions by 41% from 2005 levels by 2020
	1999 Gothenburg Protocol	2010 emissions ceiling of 2.25 million tonnes
	1988 Sofia Protocol	Stabilize (not exceed) 1987 NO_x level
VOCs	1999 Gothenburg Protocol (as amended in 2012)	Reduction of VOC emissions by 19% from 2005 levels by 2020
	1999 Gothenburg Protocol	2010 emissions ceiling of 2.1 million tonnes
$PM_{2.5}$	1999 Gothenburg Protocol (as amended in 2012)	Reduction of $PM_{2.5}$ emissions by 26% from 2005 levels by 2020 (excluding road dust, construction operations, and crop production)
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

- Carbon monoxide (CO) decreased by 54% from 1990 to 2018.
- Fine particulate emissions (particulate matter less than or equal to 2.5 microns in diameter [$PM_{2.5}$]) decreased from most sources with the notable exceptions of dust from construction operations and unpaved roads.
  - Total $PM_{2.5}$ emissions in 2018 were 11% below 1990 levels, although emissions have increased since 2009.

Despite significant decreases since 1990, emissions of some pollutants, including Pb and $PM_{2.5}$ have begun to rise again in recent years.

In addition, a 39% increase in total particulate matter (TPM) and 30% increase in coarse particulate matter (PM_{10}) emissions since 1990 contrast with the general trends described above. Another exception to the general downward trends is the steady increase in emissions of ammonia (NH_3), which were 21% above 1990 levels in 2018; the upward trend in ammonia emissions is driven by fertilizer application and animal production.

Irrespective of the downward trends observed in Canadian emissions, air quality issues may still arise when emissions sources are spatially concentrated. While the APEI provides valuable information on emissions within Canada, it does not distinguish localized sources of emissions within the provincial and territorial level aggregations.

A4.2. Overview of the United Nations Economic Commission for Europe Reporting Template

The UNECE Nomenclature for Reporting (NFR) categories correspond to the sectors described in the EMEP/EEA Air Pollutant Emission Inventory Guidebook 2019 (EEA, 2019). In addition to providing technical guidance for developing inventory methodologies, the 2019 EMEP/EEA guidebook includes instructions for attributing sectoral emissions to NFR codes.

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

Table A4–2 illustrates the structure of the UNECE reporting template. The template in its entirety can be found on the CEIP website.

Table A4–2 **Excerpt from United Nations Economic Commission for Europe Nomenclature for Reporting Template for 2019**

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

NFR aggregation for gridding and LPS[1] (GNFR)[2]	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 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)											

Notes:
1. LPS = large point source
2. GNFR = gridded nomenclature for reporting

A4.3. Mapping of Air Pollutant Emission Inventory Emissions to the United Nations Economic Commission for Europe's Nomenclature for Reporting Categories

The mapping of APEI sector emissions to UNECE NFR categories involves dividing the sector emissions into their combustion and process components. Whereas certain sectors contribute solely a process component (in the case of road dust) or combustion component (in the case of mobile sources), the majority of sectoral emissions are distributed over both components. This is accomplished using a split ratio, which, apart from a small number of exceptions, is assigned to a particular subsector and pollutant. For example, in the alumina production sector, all Hg, CO, sulphur dioxide (SO_2) and VOC emissions are attributed to combustion activities, while the remaining pollutants are attributed to both the bauxite refining process and combustion activities (Table A4–3).

A4.4. Reporting International Marine and Aviation Transportation Emissions

The APEI reports marine and aviation differently than NFR tables. While the overall total of emissions for these sectors are the same, the allocation into different categories are different.

Marine values in this report include all emissions occurring in one category since they occur within Canadian waters (i.e. 200 nautical mile from Canada's coastline). However, in the NFR table fishing operations are reported under 1A4ciii—Agriculture/Forestry/Fishing: National fishing and, military operations are reported under 1A5b—Other, Mobile (including military, land based and recreational boats). All other marine activity is reported under 1A3dii—National navigation (shipping) regardless if it is a domestic or international voyage. No values are reported under 1A3di(ii)—International inland waterways and 1A3di(i)—International maritime navigation.

Similarly, the NFR table has five categories for aviation: 1a3ai(i)—International aviation landing/take-offs (LTO) (civil), 1A3ai(ii)—International aviation cruise (civil), 1A3aii(i)—Domestic aviation LTO (civil), 1A3aii(ii)—Domestic aviation cruise (civil), and 1A5b—Other, Mobile (including military, land based and recreational boats). Only the civil LTO cycles (1A3ai(i) and 1A3aii(i)) and military flights (1A5b) are included in this report. The emissions attributed to the cruise phase for civil flights are reported in the NFR table as memo items.

Table A4–3 **Example of Air Pollutant Emission Inventory Subsector mapping to a United Nations Economic Commission for Europe's Nomenclature for Reporting Category**

	UNECE NFR category			Split ratios (w/w)	
APEI subsector	Combustion	Process	Pollutant	Combustion	Process
Alumina (bauxite refining)	1A2b: Stationary combustion in manufacturing industries and construction: Non-ferrous metals	2C3: Aluminium production	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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