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

## 1990–2019

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Environment and Climate Change Canada
Public Inquiries Centre
12th Floor, Fontaine Building
200 Sacré-Coeur Boulevard
Gatineau QC  K1A 0H3
Telephone: 819-938-3860
Toll Free: 1-800-668-6767 (in Canada only)
Email: ec.enviroinfo.ec@canada.ca



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## Readers' Comments Correspondence

Comments regarding the contents of this report should be addressed to:

Director, Pollutant Inventories and Reporting Division

Science and Risk Assessment

Science and Technology Branch

Environment and Climate Change Canada

351 St. Joseph Boulevard, 7th Floor

Gatineau, QC  K1A 0H3

Email: ec.iepa-apei.ec@canada.ca

Telephone: 1-877-877-8375

# 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 1999 | *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 |
| ECCC | Environment and Climate Change Canada |
| 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 |
| LTO | landing and takeoff |
| MOVES | Motor Vehicle Emission Simulator |
| 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 in diameter |
| $PM_{2.5}$ | particulate matter less than or equal to 2.5 microns in diameter |

| | |
|---|---|
| POP | persistent organic pollutant |
| QA | quality assurance |
| QC | quality control |
| RESD | *Report on Energy Supply and Demand in Canada* |
| SOMA | Sulphur Oxides Management Area |
| TPM | total particulate matter |
| UNECE | United Nations Economic Commission for Europe |
| U.S. EPA | United States Environmental Protection Agency |
| 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 |
| w/w | weight by weight (mass fraction) |

# TABLE OF CONTENTS

# LIST OF TABLES

# LIST OF FIGURES

ES

# 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, provincial and 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, and other persistent organic pollutants (POPs). The APEI also reports emissions of additional air pollutants 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. Emission 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 to 2019, as of February 2021. The inventory indicates that emissions of 14 of the 17 reported air pollutants are decreasing compared to historical levels, and specifically indicates that:[1]

- Emissions of $SO_x$ were 0.7 million tonnes in 2019, 52% below the 2010 emission ceiling under the 1999 Gothenburg Protocol and 66% below 2005 levels—Canada is on track to meet its 55% emission reduction commitment from 2005 levels for 2020, as per the amended Gothenburg Protocol.
- Emissions of $NO_x$ were 1.6 million tonnes in 2019, 28% below the 2010 emission ceiling under the 1999 Gothenburg Protocol and 29% below 2005 levels—Canada's emission reduction commitment for $NO_x$ is 35% below 2005 levels by 2020, as per the amended Gothenburg Protocol.
  - The next edition of this report, to be published in 2022, will include data for 2020 and provide an update to Canada's compliance with its 2020 commitments.
- Emissions of non-methane VOCs were 1.7 million tonnes in 2019, 20% below the 2010 emission ceiling under the 1999 Gothenburg Protocol and 27% below 2005 levels—Canada is also on track to meet its 20% emission reduction commitment from 2005 levels for 2020, as per the amended Gothenburg Protocol.
- Emissions of fine particulate matter (particulate matter less than or equal to 2.5 microns in diameter [$PM_{2.5}$]) were 1.6 million tonnes in 2019, 8% below 1990 levels and 25% above 2005 levels.
  - Emissions of $PM_{2.5}$ decreased from most sources with the notable exceptions of dust (not from combustion) sources such as construction operations and unpaved roads.
  - Excluding sources from road dust, construction operations, and crop production, $PM_{2.5}$ emissions in 2019 were 29% lower compared to 2005; therefore, Canada is on track to meet its 25% emission reduction commitment[2] from 2005 levels for 2020, as per the amended Gothenburg Protocol.
- Emissions of Cd, Pb, and Hg in 2019 were 89%, 79% and 81% below the ceilings established under the 1998 Aarhus Protocol on Heavy Metals.
- Emissions of all POPs in 2019 were below the ceilings established under the 1998 Aarhus Protocol on Persistent Organic Pollutants, including the four species of polycyclic aromatic hydrocarbons (PAHs) (72% below), hexachlorobenzene (HCB) (91% below), and dioxins and furans (88% below).
- Emissions of CO in 2019 had decreased by 55% since 1990 and by 30% since 2005.

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

2 This commitment excludes $PM_{2.5}$ emissions from road dust, construction operations, and crop production; focusing on emission sources that have a significant black carbon content.

## Canada's Air Pollution Emission Trends (1990 to 2019)

A few key sources of pollutants account for a significant portion of the downward trends in pollutant emissions in Canada. In particular:

- Non-Ferrous Refining and Smelting is a major contributor to emissions of $SO_x$, Pb, Cd and Hg; emissions of these pollutants from this source have decreased by 95%, 92%, 97% and almost 100%, respectively, over this time period.
- Home Firewood Burning is a major contributor to emissions of $PM_{2.5}$, VOCs, CO and PAHs; emissions of these pollutants from this source have decreased by 43%, 39%, 19% and 4%, respectively, over this time period, in part owing 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 from this source have decreased by 62%, 72% and 98%, respectively, over this time period, as coal-fired power plants have closed down and have been replaced by lower-emission sources such as natural gas power plants.
- Light-Duty Gasoline Trucks and Vehicles are major contributors to emissions of $NO_x$ and PAHs; emissions of these pollutants from these sources have decreased by 58% and 63%, respectively, over this time period.
  - The decrease in emissions is despite a 76% increase in the number of these vehicles on the road, and is due to regulations that have effectively decreased sulphur level in fuels and lowered $NO_x$ and hydrocarbon emissions from engines.
- Transportation associated with the combustion of gasoline[3] is a major contributor to emissions of VOCs and CO; emissions of these pollutants from this source have decreased by 79% and 64%, respectively, over this time period.
  - The decrease in emissions is despite a 64% increase in on-road and off-road spark-ignition engines, and is due to regulations that have effectively decreased sulphur level in fuels and lowered $NO_x$ and hydrocarbon emissions from engines.
- Waste Incineration is a major contributor to emissions of HCB and dioxins and furans; emissions of these pollutants from this source have decreased by 93% and 94%, respectively, over this time period, in part owing to improvements in incineration technologies.

Despite significant decreases in emissions of most pollutants, since 2005 emissions of particulate matter have risen by 49% (TPM), 44% ($PM_{10}$) and 25% ($PM_{2.5}$). 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 $NH_3$, which in 2019 were 20% above 1990 levels although 3% below 2005 levels. The upward trend in $NH_3$ emissions is driven by fertilizer use 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 1999) 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*

3 APEI Transportation categories considered include Light-Duty Gasoline Trucks and Vehicles, as well as Off-Road Gasoline / Liquefied Petroleum Gas (LPG) / Natural Gas (NG) Vehicles and Equipment.

- *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 aluminium, iron, steel and ilmenite, iron ore pellets, potash, base-metals smelting and refining, and pulp and paper.

All regulations and non-regulatory instruments administered under CEPA 1999 are available on the registry[4] and on the Department of Justice's online consolidation of federal acts and regulations.[5]

4 https://www.canada.ca/en/environment-climate-change/services/canadian-environmental-protection-act-registry.html

5 https://laws-lois.justice.gc.ca/eng/regulations/

# 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, mainly by:

- contributing to tracking and quantifying air pollutants in accordance with Canada's domestic and international reporting obligations;
- supporting the development of domestic air quality management strategies, policies and regulations;
- informing Canadians about pollutants that affect their health and the environment; and
- providing 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 pollutant emissions 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, 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 73 sectors and 73 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.

The APEI is compiled from many different data sources. Emissions data reported by individual facilities to ECCC'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.

## 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 CLRTAP 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)
- the 1999 Gothenburg Protocol (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, 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 communication 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. |
| **TRANSPORTATION AND MOBILE EQUIPMENT** | |
| Air Transportation (LTO) | Landing and takeoff (LTO) cycles from piston and turbine aircraft used for commercial and private operations. LTO cycles and cruises modes from piston and turbine aircraft used for military operations. |
| Domestic Air Transportation (Cruise) | Cruise modes from aircraft used for domestic commercial and private operations. |
| International Air Transportation (Cruise) | Cruise modes from aircraft used for international commercial and private operations. |

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

| APEI Source/Sector | Sector Descriptions |
|---|---|
| TRANSPORTATION AND MOBILE EQUIPMENT (cont'd) | |
| Heavy-Duty Diesel Vehicles | Diesel vehicles over 3856 kilograms. |
| Heavy-Duty Gasoline Vehicles | Gasoline vehicles over 3856 kilograms. |
| Heavy-Duty LPG/NG Vehicles | Propane and natural gas vehicles over 3856 kilograms. |
| Light-Duty Diesel Trucks | Diesel trucks under 3856 kilograms. |
| Light-Duty Diesel Vehicles | Diesel vehicles under 3856 kilograms. |
| Light-Duty Gasoline Trucks | Gasoline trucks under 3856 kilograms. |
| Light-Duty Gasoline Vehicles | Gasoline vehicles under 3856 kilograms. |
| Light Duty LPG/NG Trucks | Propane and natural gas trucks under 3856 kilograms. |
| Light Duty LPG/NG Vehicles | Propane and natural gas vehicles under 3856 kilograms. |
| Domestic Marine Navigation, Fishing and Military | Marine vessels engaged in domestic navigation, fishing, or military operations within Canadian waters. |
| International Marine Navigation | Marine vessels engaged in 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, biosolids, 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** | |
| 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, pellets and manufactured logs as fuel for space heating and hot water. Includes emissions from fireplaces, wood stoves and wood-fired boilers. |
| Human | Human respiration, perspiration and dental amalgams. |
| Marine Cargo Handling | Handling, loading and unloading of materials, goods and merchandise 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 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. |

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. More information on the submission to the UNECE can be found in Annex 4.

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 1999) 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 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 refining, and pulp and paper.

All regulations and non-regulatory instruments administered under CEPA 1999 are available on the CEPA 1999 Environmental Registry[1] and on the Department of Justice's online consolidation of federal acts and regulations.[2]

1 https://www.canada.ca/en/environment-climate-change/services/canadian-environmental-protection-act-registry.html.

2 https://laws-lois.justice.gc.ca/eng/regulations/.

# CHAPTER 2

# 2019 EMISSIONS AND TRENDS

This chapter describes the main sources and sectors contributing to the emissions of each pollutant and their historical trends. The descriptions of source categories and sectors are provided in Chapter 1, Table 1–1.

The contribution of each source category to total emissions of air pollutants for 2019 varies by pollutant (Table 2–1),[1] for example:

- Dust, largely from construction operations and unpaved roads, accounts for 62% 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) (54%), and dioxins and furans (D/F) (46%) emissions.
- Ore and Mineral Industries accounts for the largest proportion of lead (Pb) (77%), cadmium (Cd) (54%) and mercury (Hg) (35%) emissions.
- Transportation and Mobile Equipment is the largest emitter of carbon monoxide (CO) (61%) and nitrogen oxides ($NO_x$) (48%).
- Oil and Gas Industry is the largest emitter of volatile organic compounds (VOCs) (39%) and sulphur oxides ($SO_x$) (37%).
- Commercial/Residential/Institutional is a particularly significant source of polycyclic aromatic hydrocarbons (PAHs) (87%).

The last year saw no significant change in the general downward trend in Canada's air pollutant emissions for the time period 1990 to 2019. A few key sources of pollutants account for a significant portion of the downward trends in emissions. In particular:

- The Non-Ferrous Refining and Smelting Industry sector is a major contributor to emissions of $SO_x$, Pb, Cd and Hg; emissions of these pollutants from this source have decreased by 95%, 92%, 97% and almost 100%, respectively, over this time period.



- Home Firewood Burning is a major contributor to emissions of $PM_{2.5}$, VOCs, CO and PAHs; emissions of these pollutants from this source have decreased by 43%, 39%, 19% and 4% respectively, over this time period, in part owing 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 from this source have decreased by 62%, 72% and 98%, respectively, over this time period as coal-fired power plants have closed down and have been replaced by lower-emission sources, such as natural gas power plants.
- Light-Duty Gasoline Trucks and Vehicles are major contributors to emissions of $NO_x$ and PAHs; emissions of these pollutants from these sources have decreased by 58% and 63%, respectively, over this time period.
  - The decrease in emissions is despite a 76% increase in the number of these vehicles on the road, and is due to regulations that have effectively decreased sulphur levels in fuels and lowered $NO_x$ and hydrocarbon emissions from engines.[2]

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

2 See Chapter 1 for list of regulations.

- Transportation associated with the combustion of gasoline[3] is a major contributor to emissions of VOCs and CO; emissions of these pollutants from this source have decreased by 79% and 64%, respectively, over this time period.
  - The decrease in emissions is despite a 64% increase in on-road and off-road spark-ignition engines, and is due to regulations that have effectively decreased sulphur levels in fuels and lowered $NO_x$ and hydrocarbon emissions from engines.
- Waste Incineration is a major contributor to emissions of HCB and dioxins and furans; emissions of these pollutants from this source have decreased by 93% and 94%, respectively, over this time period, in part owing to improvements in incineration technologies.

Despite significant decreases in emissions of most pollutants, since 2005 emissions of PM have risen by 49% (TPM), 44% ($PM_{10}$) and 25% ($PM_{2.5}$). 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 $NH_3$, which in 2019 were 20% above 1990 levels although 3% below 2005 levels. The upward trend in $NH_3$ emissions is driven by fertilizer use and animal production.

The subsequent sections of this chapter identify the important sources of emissions for each substance in 2019 and their varying contribution to total emissions over time (Table 2–2).

The full-time series of national, provincial, and territorial pollutant emissions from 1990 to 2019 are available online on the Government of Canada Open Data Portal.[4]

3 APEI Transportation categories considered include Light-Duty Gasoline Trucks and Vehicles, as well as Off-Road Gasoline / Liquefied Petroleum Gas (LPG) / Natural Gas (NG) Vehicles and Equipment.

4 https://open.canada.ca/data/en/dataset/fa1c88a8-bf78-4fcb-9c1e-2a5534b92131

**Table 2–1 2019 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[a] (kg) | HCB (g) |
| Ore and Mineral Industries | 270 | 110 | 35 | 170 | 80 | 12 | 500 | 1.5 | 85 000 | 2 600 | 1 100 | 8.5 | 540 | 3 500 |
| Oil and Gas Industry | 28 | 18 | 13 | 260 | 480 | 660 | 540 | 2.9 | 490 | 230 | 70 | - | 470 | - |
| Electric Power Generation (Utilities) | 14 | 5.7 | 2.8 | 210 | 120 | 1.2 | 29 | 0.22 | 1 500 | 110 | 570 | 0.96 | 0.0 | 310 |
| Manufacturing | 100 | 41 | 16 | 41 | 67 | 100 | 150 | 11 | 5 300 | 570 | 77 | 3.3 | 150 | 260 |
| Transportation and Mobile Equipment | 47 | 47 | 34 | 6.1 | 780 | 290 | 3 200 | 8.0 | 15 000 | 70 | 56 | 8.7 | 8 400 | - |
| Agriculture | 3 900 | 1 600 | 390 | 5.6 | 3.8 | 120 | 0.98 | 450 | 50 | 91 | 7.2 | 0.062 | 0.33 | - |
| Commercial/Residential/Institutional | 110 | 100 | 100 | 5.7 | 78 | 170 | 700 | 2.4 | 2 200 | 1 100 | 430 | 5.1 | 72 000 | - |
| Incineration and Waste | 6.8 | 3.9 | 2.7 | 2.7 | 4.4 | 18 | 16 | 6.2 | 230 | 41 | 950 | 23 | 680 | 4 700 |
| Paints and Solvents | 0.0 | 0.0 | 0.0 | - | 0.0 | 300 | - | - | - | 0.14 | - | - | - | - |
| Dust | 24 000 | 6 900 | 960 | - | - | - | - | - | - | - | - | - | - | - |
| Fires | 4.9 | 4.0 | 3.2 | 0.0 | 0.67 | 3.2 | 36 | 0.095 | - | - | - | 0.68 | 870 | - |
| **TOTAL** | **29 000** | **8 900** | **1 600** | **700** | **1 600** | **1 700** | **5 100** | **480** | **110 000** | **4 800** | **3 300** | **51** | **83 000** | **8 800** |

Notes:
Totals may not add up due to rounding.
Emissions of pollutants are expressed in either kt, kg, gTEQ or g.
Values in this report have been rounded to two significant digits.
a. PAH includes B(a)p, B(b)f, B(k)f, I(1,2,3-cd)p
0.0 Indicates emissions were truncated due to rounding
- Indicates no emissions

**Table 2–2 2019 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[a] (kg) | HCB (g) |
| **ORE AND MINERAL INDUSTRIES** | **270 000** | **110 000** | **35 000** | **170 000** | **80 000** | **12 000** | **500 000** | **1 500** | **85 000** | **2 600** | **1 100** | **8.5** | **540** | **3 500** |
| Aluminium Industry | 5 300 | 3 800 | 3 100 | 56 000 | 1 100 | 1 900 | 360 000 | - | - | - | 24 | 0.61 | 140 | 35 |
| Alumina (Bauxite Refining) | 68 | 26 | 23 | 0.71 | 220 | 17 | 260 | - | - | - | - | - | - | - |
| Primary Aluminium Smelting and Refining | 5 200 | 3 800 | 3 100 | 56 000 | 910 | 1 800 | 360 000 | - | - | - | 24 | - | 140 | - |
| Secondary Aluminium Production (Includes Recycling) | 5.7 | 5.4 | 4.8 | - | - | - | - | - | - | - | - | 0.61 | - | 35 |
| Asphalt Paving Industry | 36 000 | 7 000 | 1 300 | 620 | 930 | 6 200 | 3 300 | - | 1 000 | 20 | 19 | 0.0 | 11 | - |
| Cement and Concrete Industry | 47 000 | 16 000 | 7 600 | 22 000 | 33 000 | 760 | 24 000 | 490 | 500 | 2.8 | 300 | 1.1 | 0.26 | 790 |
| Cement Manufacturing | 2 700 | 1 300 | 690 | 20 000 | 29 000 | 690 | 15 000 | 490 | 380 | 1.8 | 260 | 1.1 | 0.26 | 790 |
| Concrete Batching and Products | 42 000 | 13 000 | 6 300 | 0.0 | 0.93 | 63 | 0.75 | - | 110 | 1.0 | - | - | - | - |
| Gypsum Product Manufacturing | 110 | 96 | 88 | 0.19 | 230 | 2.2 | 170 | - | - | - | 36 | - | - | - |
| Lime Manufacturing | 2 000 | 1 100 | 530 | 2 400 | 3 500 | 8.6 | 8 700 | - | 4.2 | - | 1.2 | - | - | - |
| Foundries | 6 100 | 5 700 | 5 200 | 48 | 140 | 320 | 49 000 | - | 660 | 26 | - | 0.0 | - | 0.0 |
| Die Casting | 15 | 11 | 8.3 | 0.0 | 0.26 | - | 0.22 | - | 3.8 | - | - | - | - | - |
| Ferrous Foundries | 6 000 | 5 700 | 5 200 | 48 | 140 | 320 | 49 000 | - | 210 | 26 | - | 0.0 | - | 0.0 |
| Non-Ferrous Foundries | 0.77 | 0.72 | 0.72 | - | - | - | - | - | 450 | - | - | - | - | - |

Table 2–2 **2019 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[a] (kg) | HCB (g) |
| Iron and Steel Industry | 6 200 | 3 900 | 2 700 | 19 000 | 10 000 | 870 | 24 000 | 61 | 4 900 | 170 | 520 | 5.3 | 370 | 1 000 |
| Primary (Blast Furnace and DRI) | 5 600 | 3 600 | 2 400 | 18 000 | 8 800 | 650 | 21 000 | 61 | 3 700 | 130 | 220 | 1.4 | 370 | 150 |
| Secondary (Electric Arc Furnaces) | 500 | 360 | 270 | 1 500 | 1 600 | 220 | 3 000 | - | 1 200 | 37 | 300 | 3.9 | 0.57 | 870 |
| Steel Recycling | 7.9 | 5.4 | 3.2 | 0.58 | - | - | 3.2 | - | 17 | - | 3.4 | 0.0 | - | 2.3 |
| Other (Iron and Steel Industry) | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Iron Ore Industry | 13 000 | 4 000 | 1 100 | 11 000 | 11 000 | 330 | 18 000 | - | 3 100 | 53 | 79 | 0.0 | 20 | - |
| Iron Ore Mining | 2 700 | 1 200 | 330 | 160 | 1 600 | 26 | 2 400 | - | 19 | 1.5 | 0.15 | 0.0 | - | - |
| Pelletizing | 10 000 | 2 800 | 790 | 11 000 | 9 800 | 310 | 16 000 | - | 3 100 | 52 | 79 | - | 20 | - |
| Mineral Products Industry | 380 | 310 | 230 | 720 | 210 | 67 | 430 | 180 | - | - | - | - | - | - |
| Clay Products | 9.1 | 7.3 | 3.8 | - | - | - | - | - | - | - | - | - | - | - |
| Brick Products | 80 | 64 | 21 | 76 | 75 | - | 220 | - | - | - | - | - | - | - |
| Other (Mineral Products Industry) | 290 | 240 | 200 | 650 | 130 | 67 | 210 | 180 | - | - | - | - | - | - |
| Mining and Rock Quarrying | 160 000 | 71 000 | 13 000 | 1 700 | 22 000 | 1 300 | 19 000 | 77 | 1 300 | 67 | 110 | 0.0 | 0.0 | 9.8 |
| Coal Mining Industry | 110 000 | 51 000 | 5 700 | 540 | 2 100 | 59 | 4 500 | - | 22 | 2.9 | 2.0 | - | - | - |
| Metal Mining | 23 000 | 9 900 | 3 400 | 850 | 11 000 | 460 | 9 900 | 55 | 1 200 | 61 | 110 | 0.0 | 0.0 | 7.3 |
| Potash | 6 500 | 3 000 | 1 600 | 2.1 | 2 200 | 400 | 1 700 | - | - | - | - | - | - | - |
| Rock, Sand and Gravel | 12 000 | 6 200 | 1 800 | 9.4 | 920 | 17 | 610 | - | 0.0 | - | - | - | - | - |
| Silica Production | 480 | 240 | 24 | - | - | - | - | - | - | - | - | - | - | - |
| Limestone | 48 | 18 | 4.9 | - | 19 | - | - | - | - | - | - | - | - | - |
| Other (Mining and Rock Quarrying) | 1 300 | 760 | 360 | 260 | 6 100 | 370 | 2 100 | 22 | 47 | 3.3 | 2.3 | 0.0 | 0.0 | 2.5 |
| Non-Ferrous Refining and Smelting Industry | 2 100 | 890 | 630 | 61 000 | 1 600 | 110 | 1 500 | 730 | 73 000 | 2 300 | 91 | 1.4 | 0.34 | 1 600 |
| Primary Ni, Cu, Zn, Pb | 2 100 | 880 | 620 | 60 000 | 1 600 | 63 | 1 500 | 670 | 73 000 | 2 300 | 91 | 1.4 | - | 1 600 |
| Secondary Pb, Cu | 10 | 6.0 | 5.4 | 760 | - | 51 | - | - | 180 | - | 0.0 | 0.0 | 0.34 | - |
| Other (Non-Ferrous Refining and Smelting Industry) | 10 | 4.9 | 4.8 | - | 95 | - | - | 61 | - | - | - | - | - | 0.0 |
| **OIL AND GAS INDUSTRY** | **28 000** | **18 000** | **13 000** | **260 000** | **480 000** | **660 000** | **540 000** | **2 900** | **490** | **230** | **70** | **-** | **470** | **-** |
| Downstream Oil and Gas Industry | 3 500 | 2 400 | 1 500 | 48 000 | 15 000 | 26 000 | 14 000 | 46 | 310 | 69 | 46 | - | 14 | - |
| Petroleum Refining | 3 500 | 2 300 | 1 400 | 48 000 | 15 000 | 8 700 | 13 000 | 46 | 310 | 69 | 46 | - | 13 | - |
| Refined Petroleum Products Bulk Storage and Distribution | 25 | 24 | 24 | - | 24 | 17 000 | 170 | 0.0 | - | 0.090 | 0.0 | - | 1.1 | - |
| Refined Petroleum Product Pipelines | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Natural Gas Distribution | 1.8 | 1.8 | 1.8 | 0.47 | 130 | 230 | 98 | - | - | - | - | - | - | - |
| Other (Downstream Oil and Gas Industry) | 1.1 | 0.83 | 0.83 | - | - | - | - | - | - | - | - | - | - | - |
| Upstream Oil and Gas Industry | 24 000 | 16 000 | 11 000 | 210 000 | 470 000 | 630 000 | 530 000 | 2 900 | 180 | 170 | 24 | - | 460 | - |
| Accidents and Equipment Failures | - | - | - | - | - | 110 000 | - | - | - | - | - | - | - | - |
| Disposal and Waste Treatment | 18 | 18 | 18 | 0.0 | 20 | 46 | 57 | 0.26 | - | - | - | - | - | - |
| Heavy Crude Oil Cold Production | 510 | 510 | 510 | 2 000 | 13 000 | 17 000 | 17 000 | 43 | - | - | - | - | - | - |
| Light/Medium Crude Oil Production | 2 800 | 2 800 | 2 800 | 12 000 | 41 000 | 370 000 | 54 000 | 17 | 1.9 | 3.8 | - | - | - | - |
| Natural Gas Production and Processing | 2 600 | 2 600 | 2 600 | 110 000 | 310 000 | 52 000 | 400 000 | 230 | - | - | - | - | - | - |
| Natural Gas Transmission and Storage | 98 | 98 | 98 | 23 | 20 000 | 850 | 6 600 | 0.76 | - | - | - | - | - | - |
| Oil Sands In-Situ Extraction | 1 100 | 1 100 | 1 100 | 21 000 | 38 000 | 12 000 | 27 000 | 920 | - | 70 | 11 | - | - | - |
| Oil Sands Mining, Extraction and Upgrading | 17 000 | 9 000 | 4 000 | 58 000 | 39 000 | 49 000 | 20 000 | 1 700 | 180 | 93 | 13 | - | 460 | - |
| Petroleum Liquids Storage | 29 | 27 | 27 | - | 260 | 7 000 | 180 | - | - | - | - | - | - | - |
| Petroleum Liquids Transportation | 17 | 17 | 13 | 150 | 0.31 | 15 000 | 1.7 | - | - | - | - | - | - | - |
| Well Drilling/Servicing/Testing | 20 | 20 | 20 | 3 400 | 33 | 1 200 | 61 | 0.0 | - | - | - | - | - | - |
| **ELECTRIC POWER GENERATION (UTILITIES)** | **14 000** | **5 700** | **2 800** | **210 000** | **120 000** | **1 200** | **29 000** | **220** | **1 500** | **110** | **570** | **0.96** | **0.0** | **310** |
| Coal | 12 000 | 4 600 | 1 800 | 200 000 | 88 000 | 290 | 11 000 | 55 | 1 000 | 80 | 540 | 0.70 | - | 260 |
| Diesel | 210 | 200 | 190 | 130 | 9 800 | 84 | 2 300 | - | - | - | - | - | - | - |
| Natural Gas | 500 | 380 | 290 | 1 100 | 18 000 | 590 | 10 000 | 100 | 91 | 26 | 2.3 | 0.0 | 0.0 | 45 |
| Waste Materials | 3.3 | 2.4 | 2.1 | - | 180 | - | 140 | - | 0.43 | 0.12 | 0.23 | 0.0 | - | - |
| Other (Electric Power Generation) | 870 | 530 | 460 | 6 500 | 8 800 | 220 | 5 500 | 63 | 390 | 8.5 | 23 | 0.25 | - | 8.1 |
| **MANUFACTURING** | **100 000** | **41 000** | **16 000** | **41 000** | **67 000** | **100 000** | **150 000** | **11 000** | **5 300** | **570** | **77** | **3.3** | **150** | **260** |
| Abrasives Manufacturing | 64 | 26 | 11 | - | - | 16 | - | - | - | - | - | 0.0 | - | - |
| Bakeries | 18 | 16 | 12 | - | - | 5 300 | - | - | - | - | - | - | - | - |
| Biofuel Production | 11 | 6.6 | 2.9 | 6.5 | 13 | 15 | 59 | - | - | - | - | - | - | - |
| Chemicals Industry | 3 000 | 2 100 | 1 400 | 18 000 | 24 000 | 13 000 | 16 000 | 8 700 | 16 | 7.8 | 17 | 0.0 | 24 | - |
| Chemical Manufacturing | 1 600 | 1 200 | 1 000 | 16 000 | 9 000 | 4 500 | 7 900 | 73 | 0.65 | 0.0 | 16 | 0.0 | 24 | - |
| Cleaning Compound Manufacturing | 5.4 | 5.4 | 5.4 | - | 50 | 2 700 | - | 0.0 | - | - | - | - | - | - |
| Fertilizer Production | 990 | 700 | 250 | 900 | 9 000 | 610 | 5 100 | 8 600 | 1.9 | 4.2 | 0.99 | - | - | - |
| Paint and Varnish Manufacturing | 6.7 | 6.1 | 4.0 | - | 3.8 | 390 | 3.1 | 2.1 | 3.9 | 0.0 | - | - | - | - |
| Petrochemical Industry | 220 | 170 | 120 | 850 | 5 200 | 1 500 | 2 300 | 0.0 | 9.1 | 3.6 | 0.43 | - | 0.077 | - |
| Plastics and Synthetic Resins Fabrication | 91 | 60 | 51 | 4.4 | 380 | 2 900 | 330 | 13 | - | - | 0.0 | - | - | - |
| Other (Chemical Industry) | 44 | 27 | 15 | 0.0 | 250 | 340 | 75 | 1.7 | - | - | - | - | - | - |
| Electronics | 0.68 | 0.65 | 0.54 | - | - | 32 | - | 15 | 18 | - | 0.0 | - | - | - |
| Food Preparation | 2 700 | 1 600 | 650 | 390 | 1 700 | 17 000 | 1 200 | 300 | 0.15 | - | - | - | - | - |
| Glass Manufacturing | 190 | 170 | 160 | 580 | 750 | 160 | 290 | - | - | - | - | - | - | - |
| Grain Industry | 67 000 | 19 000 | 3 000 | 330 | 930 | 3 200 | 720 | 6.1 | - | - | - | - | - | - |
| Grain Processing | 66 000 | 19 000 | 2 900 | 330 | 930 | 3 200 | 720 | 5.9 | - | - | - | - | - | - |
| Warehousing and Storage | 770 | 370 | 75 | - | - | - | - | 0.19 | - | - | - | - | - | - |
| Metal Fabrication | 700 | 510 | 430 | 490 | 400 | 4 200 | 1 100 | 27 | 2 800 | 340 | - | 1.9 | - | 190 |
| Plastics Manufacturing | 93 | 74 | 61 | - | 14 | 9 500 | 14 | - | 1.3 | - | - | - | - | - |
| Pulp and Paper Industry | 13 000 | 8 800 | 5 700 | 20 000 | 27 000 | 12 000 | 80 000 | 1 400 | 1 300 | 170 | 48 | 0.94 | 120 | 66 |
| Pulp and Paper Product Manufacturing | 13 000 | 8 800 | 5 700 | 20 000 | 27 000 | 12 000 | 79 000 | 1 400 | 1 300 | 170 | 48 | 0.94 | 120 | 66 |
| Converted Paper Product Manufacturing | 46 | 38 | 32 | 0.060 | 4.8 | 720 | 96 | - | 0.0 | - | - | - | - | - |
| Textiles | 1.3 | 1.3 | 0.99 | 15 | 6.1 | 410 | 0.22 | - | - | - | - | - | - | - |
| Vehicle Manufacturing (Engines, Parts, Assembly, Painting) | 300 | 220 | 180 | 0.0 | 620 | 7 400 | 910 | 6.5 | 85 | - | - | - | 0.0 | - |
| Wood Products | 15 000 | 7 900 | 4 300 | 560 | 11 000 | 27 000 | 53 000 | 630 | 1 100 | 50 | 12 | 0.52 | 5.4 | 0.072 |
| Panel Board Mills | 5 500 | 3 300 | 2 100 | 250 | 5 000 | 11 000 | 17 000 | 230 | 880 | 23 | 4.0 | 0.19 | 2.0 | - |
| Sawmills | 7 900 | 3 600 | 1 600 | 270 | 4 700 | 14 000 | 27 000 | 410 | 210 | 27 | 7.7 | 0.33 | 3.4 | - |
| Other (Wood Products) | 1 300 | 920 | 640 | 43 | 860 | 2 700 | 8 400 | - | - | - | - | - | 0.0 | 0.072 |
| Other (Manufacturing) | 460 | 340 | 260 | 450 | 530 | 2 800 | 520 | 45 | 14 | 0.16 | 0.33 | - | - | - |

Table 2–2 **2019 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[a] (kg) | HCB (g) |
| **TRANSPORTATION AND MOBILE EQUIPMENT** | **47 000** | **47 000** | **34 000** | **6 100** | **780 000** | **290 000** | **3 200 000** | **8 000** | **15 000** | **70** | **56** | **8.7** | **8 400** | **-** |
| Air Transportation (LTO) | 300 | 300 | 290 | 620 | 8 500 | 3 000 | 30 000 | 5.0 | 15 000 | - | - | - | 6.2 | - |
| Heavy-Duty Diesel Vehicles | 10 000 | 10 000 | 9 300 | 170 | 260 000 | 18 000 | 68 000 | 790 | - | - | 0.0 | 0.0 | 660 | - |
| Heavy-Duty Gasoline Vehicles | 1 100 | 1 100 | 1 000 | 200 | 38 000 | 13 000 | 420 000 | 340 | - | - | 0.0 | 0.0 | 1 900 | - |
| Heavy-Duty LPG/NG Vehicles | 3.5 | 3.5 | 3.1 | 0.63 | 130 | 63 | 1 400 | 1.9 | - | - | 0.0 | 0.0 | 6.3 | - |
| Light-Duty Diesel Trucks | 23 | 23 | 21 | 4.2 | 2 000 | 1 900 | 22 000 | 20 | - | - | 0.0 | 0.0 | 2.5 | - |
| Light-Duty Diesel Vehicles | 13 | 13 | 12 | 2.9 | 800 | 700 | 8 000 | 16 | - | - | 0.0 | 0.0 | 2.1 | - |
| Light-Duty Gasoline Trucks | 1 600 | 1 600 | 1 400 | 820 | 79 000 | 64 000 | 800 000 | 3 400 | - | - | 0.0 | 0.0 | 3 300 | - |
| Light-Duty Gasoline Vehicles | 1 200 | 1 200 | 1 100 | 510 | 43 000 | 46 000 | 480 000 | 2 800 | - | - | 0.0 | 0.0 | 2 400 | - |
| Light-Duty LPG/NG Trucks | 0.58 | 0.58 | 0.51 | 0.18 | 33 | 29 | 300 | 1.1 | - | - | 0.0 | 0.0 | 1.1 | - |
| Light-Duty LPG/NG Vehicles | 0.0 | 0.0 | 0.0 | 0.0 | 1.1 | 1.3 | 11 | 0.062 | - | - | 0.0 | 0.0 | 0.056 | - |
| Domestic Marine Navigation, Fishing and Military | 1 800 | 1 700 | 1 600 | 3 500 | 69 000 | 3 300 | 7 600 | 110 | 220 | 15 | 0.24 | 7.2 | 43 | - |
| Motorcycles | 25 | 25 | 22 | 4.6 | 700 | 2 100 | 14 000 | 41 | - | - | 0.0 | 0.0 | 41 | - |
| Off-Road Diesel Vehicles and Equipment | 12 000 | 12 000 | 12 000 | 160 | 150 000 | 17 000 | 80 000 | 220 | - | - | - | - | - | - |
| Off-Road Gasoline/LPG/NG Vehicles and Equipment | 4 300 | 4 100 | 3 800 | 84 | 31 000 | 120 000 | 1 200 000 | 92 | - | - | - | - | - | - |
| Rail Transportation | 2 000 | 2 000 | 1 900 | 53 | 95 000 | 4 300 | 19 000 | 58 | 170 | 55 | 55 | 1.4 | 34 | - |
| Tire Wear and Brake Lining | 12 000 | 12 000 | 1 600 | - | - | - | - | - | - | - | - | - | - | - |
| **AGRICULTURE** | **3 900 000** | **1 600 000** | **390 000** | **5 600** | **3 800** | **120 000** | **980** | **450 000** | **50** | **91** | **7.2** | **0.062** | **0.33** | **-** |
| Animal Production | 37 000 | 9 900 | 2 100 | - | - | 120 000 | - | 280 000 | - | - | - | - | - | - |
| Crop Production | 3 800 000 | 1 600 000 | 380 000 | - | - | - | - | 170 000 | - | - | - | - | - | - |
| Harvesting | 260 000 | 120 000 | 24 000 | - | - | - | - | - | - | - | - | - | - | - |
| Inorganic Fertilizer Application | 13 000 | 6 200 | 1 800 | - | - | - | - | 160 000 | - | - | - | - | - | - |
| Sewage Sludge Application | - | - | - | - | - | - | - | 5 200 | - | - | - | - | - | - |
| Tillage Practices | 1 000 000 | 210 000 | 100 000 | - | - | - | - | - | - | - | - | - | - | - |
| Wind Erosion | 2 600 000 | 1 300 000 | 260 000 | - | - | - | - | - | - | - | - | - | - | - |
| Fuel Use | 570 | 410 | 260 | 5 600 | 3 800 | 150 | 980 | 43 | 50 | 91 | 7.2 | 0.062 | 0.33 | - |
| **COMMERCIAL/RESIDENTIAL/INSTITUTIONAL** | **110 000** | **100 000** | **100 000** | **5 700** | **78 000** | **170 000** | **700 000** | **2 400** | **2 200** | **1 100** | **430** | **5.1** | **72 000** | **-** |
| Commercial and Institutional Fuel Combustion | 2 800 | 2 700 | 2 700 | 1 000 | 29 000 | 1 500 | 21 000 | 210 | 220 | 510 | 64 | 0.18 | 2.4 | - |
| Commercial Cooking | 17 000 | 17 000 | 15 000 | - | - | 2 300 | 6 400 | - | - | - | - | - | 110 | - |
| Construction Fuel Combustion | 180 | 160 | 150 | 470 | 2 800 | 47 | 480 | 46 | 7.8 | 10 | 2.4 | 0.0 | 0.24 | - |
| Home Firewood Burning | 84 000 | 79 000 | 79 000 | 1 900 | 13 000 | 110 000 | 660 000 | 1 200 | 1 700 | 100 | 26 | 4.6 | 72 000 | - |
| Human | - | - | - | - | - | - | - | 630 | - | - | 1.8 | - | - | - |
| Marine Cargo Handling | 480 | 220 | 91 | 170 | 38 | - | - | - | 61 | 2.4 | - | - | - | - |
| Residential Fuel Combustion | 2 600 | 2 500 | 2 400 | 2 200 | 33 000 | 1 700 | 13 000 | 330 | 250 | 480 | 78 | 0.24 | 3.1 | - |
| Service Stations | - | - | - | - | - | 51 000 | - | - | - | - | - | - | - | - |
| Other (Miscellaneous) | - | - | - | - | - | - | - | - | - | - | 260 | - | - | - |
| **INCINERATION AND WASTE** | **6 800** | **3 900** | **2 700** | **2 700** | **4 400** | **18 000** | **16 000** | **6 200** | **230** | **41** | **950** | **23** | **680** | **4 700** |
| Crematoriums | 7.8 | 7.8 | 7.8 | 15 | 25 | 2.6 | 20 | - | 6.1 | 1.0 | 300 | 3.5 | 0.0 | 30 |
| Waste Incineration | 2 300 | 2 200 | 2 200 | 2 400 | 2 300 | 4 300 | 14 000 | 150 | 160 | 32 | 540 | 20 | 680 | 4 700 |
| Municipal Incineration | 32 | 22 | 21 | 210 | 750 | 38 | 210 | 19 | 150 | 26 | 28 | 0.059 | - | 58 |
| Residential Waste Burning | 2 200 | 2 200 | 2 200 | 130 | 810 | 4 000 | 11 000 | 86 | - | - | - | 20 | 680 | 4 600 |
| Sewage Sludge Incineration | 120 | 12 | 3.5 | 1 700 | 420 | 150 | 2 000 | 49 | 11 | 5.2 | 27 | 0.0 | - | - |
| Other (Waste Incineration) | 19 | 15 | 13 | 350 | 290 | 100 | 45 | - | 3.2 | 1.1 | 490 | 0.28 | - | 10 |
| Waste Treatment and Disposal | 4 400 | 1 600 | 520 | 230 | 2 100 | 13 000 | 2 300 | 6 100 | 60 | 7.9 | 100 | 0.0 | 0.0 | 0.071 |
| Biological Treatment of Waste | 6.9 | 6.9 | 6.9 | 0.69 | 3.2 | 3 500 | 0.41 | 2 300 | - | - | - | - | - | - |
| Landfills | 4 300 | 1 500 | 430 | 12 | 640 | 8 700 | 1 900 | - | 0.0 | - | 81 | - | 0.0 | - |
| Municipal Wastewater Treatment and Discharge | 85 | 67 | 67 | 210 | 1 400 | 850 | 380 | 3 800 | 2.2 | 0.14 | 15 | - | 0.0 | - |
| Specialized Waste Treatment and Remediation | 29 | 24 | 18 | - | 73 | 300 | 45 | 3.9 | 58 | 7.7 | 8.8 | 0.0 | 0.0 | 0.071 |
| Waste Sorting and Transfer | - | - | - | - | - | 48 | - | - | - | - | - | - | - | - |
| **PAINTS AND SOLVENTS** | **24** | **32** | **24** | **-** | **22** | **300 000** | **-** | **-** | **-** | **0.14** | **-** | **-** | **-** | **-** |
| Dry Cleaning | 14 | 16 | 14 | - | - | 190 | - | - | - | - | - | - | - | - |
| General Solvent Use | - | - | - | - | - | 210 000 | - | - | - | - | - | - | - | - |
| Printing | 8.4 | 8.7 | 8.2 | - | 20 | 24 000 | - | - | - | - | - | - | - | - |
| Surface Coatings | 2.3 | 7.3 | 2.3 | - | 1.9 | 66 000 | - | - | - | 0.14 | - | - | - | - |
| **DUST** | **24 000 000** | **6 900 000** | **960 000** | **-** | **-** | **-** | **-** | **-** | **-** | **-** | **-** | **-** | **-** | **-** |
| Coal Transportation | 1 100 | 560 | 230 | - | - | - | - | - | - | - | - | - | - | - |
| Construction Operations | 8 400 000 | 2 500 000 | 510 000 | - | - | - | - | - | - | - | - | - | - | - |
| Mine Tailings | - | - | 690 | - | - | - | - | - | - | - | - | - | - | - |
| Paved Roads | 450 000 | 89 000 | 23 000 | - | - | - | - | - | - | - | - | - | - | - |
| Unpaved Roads | 16 000 000 | 4 300 000 | 430 000 | - | - | - | - | - | - | - | - | - | - | - |
| **FIRES** | **4 900** | **4 000** | **3 200** | **15** | **670** | **3 200** | **36 000** | **95** | **-** | **-** | **-** | **0.68** | **870** | **-** |
| Prescribed Burning | 4 600 | 3 800 | 3 000 | 15 | 650 | 3 000 | 35 000 | 83 | - | - | - | 0.68 | 870 | - |
| Structural Fires | 210 | 210 | 190 | - | 27 | 210 | 1 200 | 12 | - | - | - | - | - | - |
| **GRAND TOTAL** | **29 000 000** | **8 900 000** | **1 600 000** | **700 000** | **1 600 000** | **1 700 000** | **5 100 000** | **480 000** | **110 000** | **4 800** | **3 300** | **51** | **83 000** | **8 800** |

Notes:

Totals may not add up due to rounding.

a. PAH includes B(a)p, B(b)f, B(k)f, I(1,2,3-cd)p.

0.0 Indicates emissions were truncated due to rounding.

- Indicates no emissions

**Other emissions estimated in the APEI**

| 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[a] (kg) | HCB (g) |
| Domestic Air Transportation (Cruise) | 330 | 330 | 330 | 1 900 | 35 000 | 1 900 | 35 000 | 14 | 18 000 | - | - | - | 3.3 | - |
| International Air Transportation (Cruise) | 650 | 650 | 640 | 4 500 | 80 000 | 1 100 | 9 600 | 28 | 740 | - | - | - | 2.4 | - |
| International Marine Navigation | 2 600 | 2 500 | 2 300 | 5 000 | 110 000 | 4 900 | 11 000 | 170 | 350 | 18 | 0.25 | 12 | 69 | - |

Note: Refer to annex 4.4 for more information.

## 2.1. Particulate Matter Less than or Equal to 2.5 Microns in Diameter

In 2019, approximately 1.6 million tonnes (Mt) of particulate matter less or equal to 2.5 microns in diameters ($PM_{2.5}$) were emitted in Canada (Table 2–3). Dust sources accounted for 62% (959 kt) of total $PM_{2.5}$ emissions, with the most important dust sources being Construction Operations at 33% (507 kt) and Unpaved Roads at 28% (428 kt) of total $PM_{2.5}$ emissions. Agriculture was the second-largest contributor and accounted for 25% (385 kt) of $PM_{2.5}$ emissions, most of which are attributed to Crop Production (25% or 383 kt). In these sectors, PM is largely emitted by non-combustion sources.

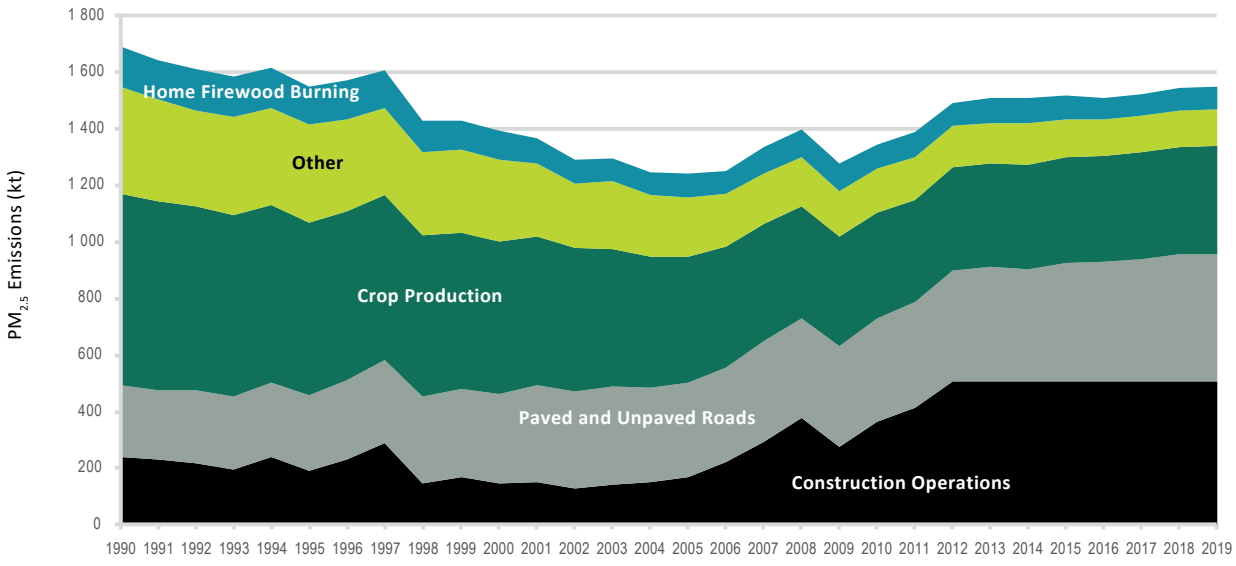
Commercial/Residential/Institutional sources accounted for 6% (100 kt) of total $PM_{2.5}$ emissions in 2019, with the most important contributor being Home Firewood Burning at 5% (79 kt) of total $PM_{2.5}$ emissions. All other Commercial/Residential/Institutional sources accounted for less than 1% 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 from 1990 to 2011 owing to a reduction in summer fallow and the adoption of conservation tillage practices, but have since been offset by an increase in wind erosion emissions 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, that have been replaced with fireplace inserts, furnaces and stoves with improved emission controls and combustion efficiencies. Emissions of dust 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 2019. 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 2019 include:

- Dust: increase of 94% (465 kt), with:
  - Construction Operations: increase of 112% (268 kt)
  - Paved and Unpaved Roads: increase of 77% (196 kt)
- Agriculture: decrease of 43% (293 kt), with:
  - Crop Production: decrease of 43% (293 kt)
- Commercial/Residential/Institutional: decrease of 37% (58 kt), with:
  - Home Firewood Burning: decrease of 43% (60 kt)

Figure 2–1 **Trends in Canadian $PM_{2.5}$ Emissions (1990 to 2019)**



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

| Source | 1990 | 2000 | 2005 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 |
|---|---|---|---|---|---|---|---|---|---|
| | (tonnes) | | | | | | | | |
| **ORE AND MINERAL INDUSTRIES** | **55 000** | **52 000** | **42 000** | **33 000** | **31 000** | **32 000** | **35 000** | **34 000** | **35 000** |
| Aluminium Industry | 5 400 | 4 500 | 5 100 | 3 700 | 3 300 | 3 400 | 3 400 | 3 100 | 3 100 |
| Asphalt Paving Industry | 1 900 | 1 700 | 1 500 | 1 600 | 1 400 | 1 300 | 1 400 | 1 400 | 1 300 |
| Cement and Concrete Industry | 11 000 | 9 600 | 12 000 | 7 600 | 7 600 | 7 100 | 7 300 | 7 700 | 7 600 |
| 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 | 2 500 | 2 400 | 2 200 | 2 500 | 2 600 | 2 700 |
| Iron Ore Industry | 1 600 | 4 500 | 1 700 | 950 | 950 | 1 000 | 940 | 880 | 1 100 |
| Mineral Products Industry | 1 200 | 1 100 | 950 | 370 | 320 | 290 | 230 | 290 | 230 |
| Mining and Rock Quarrying | 8 500 | 9 700 | 6 300 | 8 700 | 8 100 | 9 800 | 12 000 | 12 000 | 13 000 |
| Non-Ferrous Refining and Smelting Industry | 8 800 | 6 000 | 4 100 | 1 900 | 2 100 | 1 700 | 1 300 | 1 000 | 630 |
| **OIL AND GAS INDUSTRY** | **12 000** | **13 000** | **12 000** | **13 000** | **12 000** | **11 000** | **13 000** | **12 000** | **13 000** |
| Downstream Oil and Gas Industry | 5 100 | 4 900 | 4 600 | 1 600 | 1 400 | 1 500 | 1 500 | 1 600 | 1 500 |
| Upstream Oil and Gas Industry | 6 800 | 8 500 | 7 800 | 11 000 | 11 000 | 9 800 | 11 000 | 11 000 | 11 000 |
| **ELECTRIC POWER GENERATION (UTILITIES)** | **48 000** | **23 000** | **8 900** | **3 600** | **3 500** | **3 400** | **3 300** | **3 200** | **2 800** |
| Coal | 46 000 | 20 000 | 5 000 | 2 500 | 2 400 | 2 200 | 2 200 | 2 200 | 1 800 |
| Diesel | 270 | 410 | 400 | 200 | 210 | 220 | 180 | 190 | 190 |
| Natural Gas | 1 200 | 1 900 | 1 700 | 420 | 420 | 390 | 340 | 350 | 290 |
| Waste Materials | 0.41 | 1.6 | 1.0 | 2.1 | 2.3 | 3.0 | 3.1 | 2.3 | 2.1 |
| Other (Electric Power Generation) | 1 300 | 730 | 1 800 | 450 | 450 | 540 | 530 | 460 | 460 |
| **MANUFACTURING** | **120 000** | **79 000** | **45 000** | **19 000** | **18 000** | **17 000** | **17 000** | **17 000** | **16 000** |
| Abrasives Manufacturing | 390 | 210 | 200 | 8.4 | 15 | 14 | 15 | 17 | 11 |
| Bakeries | 0.54 | 0.54 | 0.43 | 1.5 | 7.2 | 7.5 | 6.7 | 10 | 12 |
| Biofuel Production | - | - | - | 5.3 | 4.6 | 5.8 | 6.1 | 3.7 | 2.9 |
| Chemicals Industry | 4 800 | 4 500 | 4 100 | 1 400 | 1 300 | 1 300 | 1 200 | 1 500 | 1 400 |
| Electronics | 120 | 39 | 5.7 | 1.0 | 1.4 | 0.89 | 0.87 | 0.82 | 0.54 |
| Food Preparation | 1 400 | 2 100 | 1 700 | 770 | 740 | 720 | 720 | 660 | 650 |
| Glass Manufacturing | 920 | 1 300 | 1 100 | 150 | 150 | 160 | 130 | 140 | 160 |
| Grain Industry | 2 200 | 2 900 | 2 000 | 2 800 | 2 800 | 2 900 | 3 000 | 3 000 | 3 000 |
| Metal Fabrication | 820 | 1 300 | 900 | 420 | 410 | 410 | 440 | 400 | 430 |
| Plastics Manufacturing | 170 | 180 | 120 | 69 | 53 | 57 | 56 | 61 | 61 |
| Pulp and Paper Industry | 61 000 | 25 000 | 18 000 | 8 400 | 7 600 | 6 900 | 7 200 | 6 800 | 5 700 |
| Textiles | 16 | 23 | 18 | 2.5 | 1.2 | 1.3 | 1.2 | 1.2 | 0.99 |
| Vehicle Manufacturing (Engines, Parts, Assembly, Painting) | 1 700 | 1 600 | 570 | 170 | 180 | 170 | 170 | 200 | 180 |
| Wood Products | 37 000 | 31 000 | 14 000 | 4 400 | 4 700 | 3 800 | 3 600 | 3 800 | 4 300 |
| Other (Manufacturing) | 6 200 | 8 800 | 3 000 | 220 | 190 | 210 | 210 | 200 | 260 |
| **TRANSPORTATION AND MOBILE EQUIPMENT** | **88 000** | **86 000** | **69 000** | **39 000** | **35 000** | **31 000** | **33 000** | **34 000** | **34 000** |
| Air Transportation (LTO) | 430 | 350 | 320 | 280 | 280 | 270 | 280 | 300 | 290 |
| Heavy-Duty Diesel Vehicles | 15 000 | 15 000 | 17 000 | 9 600 | 8 600 | 8 400 | 8 800 | 9 300 | 9 300 |
| Heavy-Duty Gasoline Vehicles | 3 500 | 2 300 | 2 100 | 960 | 920 | 980 | 990 | 1 000 | 1 000 |
| Heavy-Duty LPG/NG Vehicles | 600 | 680 | 160 | 1.4 | 1.2 | 1.8 | 3.3 | 3.3 | 3.1 |
| Light-Duty Diesel Trucks | 13 | 14 | 15 | 12 | 15 | 16 | 19 | 21 | 21 |
| Light-Duty Diesel Vehicles | 49 | 26 | 16 | 13 | 14 | 13 | 13 | 12 | 12 |
| Light-Duty Gasoline Trucks | 2 000 | 2 400 | 1 600 | 1 200 | 1 200 | 1 300 | 1 300 | 1 400 | 1 400 |
| Light-Duty Gasoline Vehicles | 5 000 | 3 600 | 2 200 | 1 200 | 1 100 | 1 100 | 1 100 | 1 100 | 1 100 |
| Light-Duty LPG/NG Trucks | 180 | 83 | 36 | 0.46 | 0.41 | 0.44 | 0.52 | 0.53 | 0.51 |
| Light-Duty LPG/NG Vehicles | 23 | 12 | 5.3 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Domestic Marine Navigation, Fishing and Military | 3 800 | 4 600 | 5 200 | 3 100 | 1 400 | 1 400 | 1 500 | 1 500 | 1 600 |
| Motorcycles | 22 | 21 | 23 | 20 | 20 | 21 | 22 | 22 | 22 |
| Off-Road Diesel Vehicles and Equipment | 41 000 | 42 000 | 29 000 | 14 000 | 13 000 | 10 000 | 11 000 | 12 000 | 12 000 |
| Off-Road Gasoline/LPG/NG Vehicles and Equipment | 13 000 | 10 000 | 6 800 | 4 200 | 4 200 | 3 700 | 3 800 | 3 900 | 3 800 |
| Rail Transportation | 3 600 | 3 400 | 3 300 | 2 300 | 2 000 | 1 800 | 1 900 | 1 900 | 1 900 |
| Tire Wear and Brake Lining | 730 | 1 100 | 1 200 | 1 500 | 1 500 | 1 500 | 1 600 | 1 600 | 1 600 |
| **AGRICULTURE** | **680 000** | **540 000** | **450 000** | **370 000** | **370 000** | **380 000** | **380 000** | **380 000** | **390 000** |
| Animal Production | 1 700 | 2 100 | 2 300 | 2 000 | 2 000 | 2 100 | 2 100 | 2 100 | 2 100 |
| Crop Production | 680 000 | 540 000 | 450 000 | 370 000 | 370 000 | 370 000 | 380 000 | 380 000 | 380 000 |
| Fuel Use | 120 | 140 | 130 | 440 | 390 | 390 | 380 | 360 | 260 |
| **COMMERCIAL/RESIDENTIAL/INSTITUTIONAL** | **160 000** | **120 000** | **110 000** | **110 000** | **100 000** | **99 000** | **98 000** | **100 000** | **100 000** |
| Commercial and Institutional Fuel Combustion | 2 000 | 2 600 | 2 600 | 2 400 | 2 300 | 2 300 | 2 500 | 2 600 | 2 700 |
| Commercial Cooking | 14 000 | 15 000 | 17 000 | 16 000 | 15 000 | 15 000 | 15 000 | 15 000 | 15 000 |
| Construction Fuel Combustion | 180 | 110 | 150 | 130 | 130 | 140 | 140 | 150 | 150 |
| Home Firewood Burning | 140 000 | 100 000 | 84 000 | 89 000 | 85 000 | 79 000 | 77 000 | 80 000 | 79 000 |
| Human | - | - | - | - | - | - | - | - | - |
| Marine Cargo Handling | 180 | 140 | 290 | 84 | 73 | 140 | 110 | 99 | 91 |
| Residential Fuel Combustion | 2 400 | 2 600 | 2 500 | 2 400 | 2 300 | 2 200 | 2 400 | 2 500 | 2 400 |
| Service Stations | - | - | - | - | - | - | - | - | - |
| Other (Miscellaneous) | - | - | - | - | - | - | - | - | - |
| **INCINERATION AND WASTE** | **4 600** | **4 200** | **3 900** | **2 500** | **2 600** | **2 600** | **2 600** | **2 700** | **2 700** |
| Crematoriums | 2.6 | 3.6 | 4.6 | 6.7 | 6.8 | 7.2 | 7.5 | 7.8 | 7.8 |
| Waste Incineration | 3 900 | 3 500 | 3 100 | 2 000 | 2 100 | 2 100 | 2 200 | 2 200 | 2 200 |
| Waste Treatment and Disposal | 650 | 650 | 720 | 490 | 520 | 500 | 470 | 500 | 520 |
| **PAINTS AND SOLVENTS** | **3.7** | **7.1** | **25** | **11** | **15** | **16** | **23** | **23** | **24** |
| Dry Cleaning | 0.32 | 0.32 | 1.2 | 4.9 | 6.1 | 4.5 | 14 | 13 | 14 |
| General Solvent Use | - | - | - | - | - | - | - | - | - |
| Printing | 3.0 | 6.4 | 23 | 5.4 | 8.2 | 9.8 | 7.4 | 7.3 | 8.2 |
| Surface Coatings | 0.37 | 0.37 | 0.94 | 0.63 | 1.0 | 1.5 | 1.5 | 2.4 | 2.3 |
| **DUST** | **490 000** | **460 000** | **500 000** | **910 000** | **930 000** | **930 000** | **940 000** | **960 000** | **960 000** |
| Coal Transportation | 320 | 300 | 240 | 300 | 230 | 250 | 220 | 220 | 230 |
| 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 | 530 | 620 | 580 | 660 | 690 | 690 |
| Paved Roads | 24 000 | 19 000 | 19 000 | 21 000 | 22 000 | 22 000 | 22 000 | 23 000 | 23 000 |
| Unpaved Roads | 230 000 | 290 000 | 310 000 | 380 000 | 400 000 | 400 000 | 410 000 | 430 000 | 430 000 |
| **FIRES** | **36 000** | **6 900** | **4 500** | **12 000** | **10 000** | **9 100** | **4 800** | **2 900** | **3 200** |
| Prescribed Burning | 36 000 | 6 600 | 4 200 | 12 000 | 10 000 | 8 900 | 4 600 | 2 700 | 3 000 |
| Structural Fires | 350 | 280 | 260 | 200 | 190 | 190 | 190 | 200 | 190 |
| **GRAND TOTAL** | **1 700 000** | **1 400 000** | **1 200 000** | **1 500 000** | **1 500 000** | **1 500 000** | **1 500 000** | **1 500 000** | **1 600 000** |

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

**Other emissions estimated in the APEI**

| Source | 1990 | 2000 | 2005 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 |
|---|---|---|---|---|---|---|---|---|---|
| Domestic Air Transportation (Cruise) | 370 | 480 | 330 | 280 | 280 | 280 | 300 | 320 | 330 |
| International Air Transportation (Cruise) | 520 | 580 | 570 | 470 | 480 | 500 | 540 | 620 | 640 |
| International Marine Navigation | 6 000 | 8 700 | 10 000 | 6 500 | 2 300 | 2 300 | 2 300 | 2 300 | 2 300 |

Note: Refer to Annex 4.4 for more information.

## 2.2. Sulphur Oxides

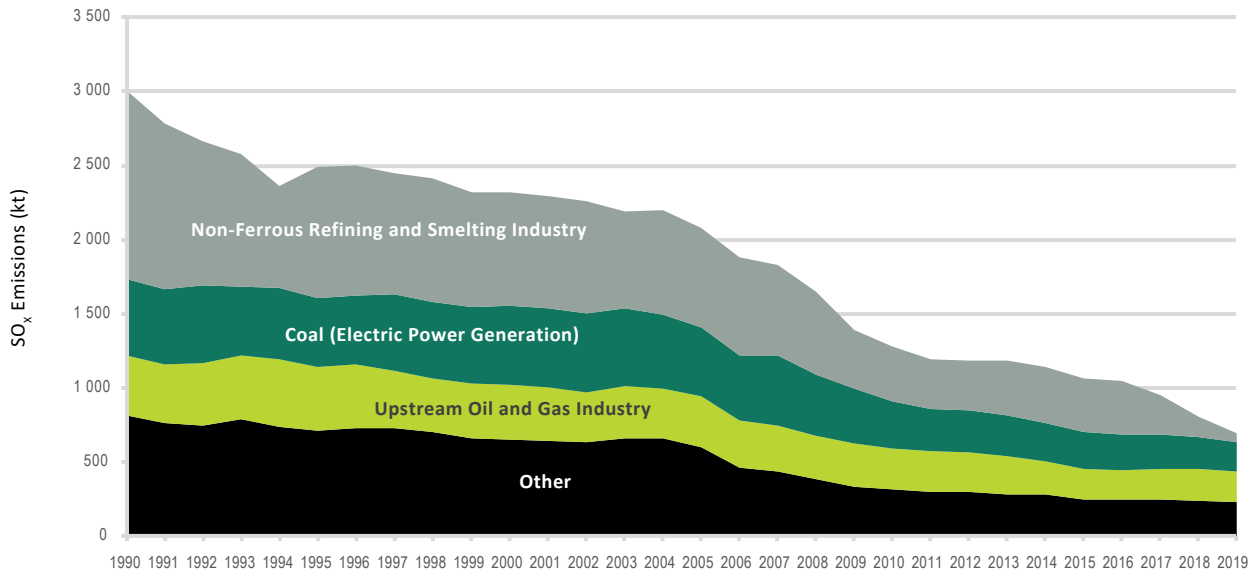
In 2019, 699 kt of sulphur oxides ($SO_x$) were emitted in Canada (Table 2–4). Oil and Gas Industry were one of the largest contributors, accounting for 37% (259 kt) of national emissions. Approximately 81% (211 kt) of the emissions from this source were attributed to the Upstream Oil and Gas Industry sector. Electric Power Generation (Utilities) was the second-largest source of $SO_x$, accounting for 29% (205 kt) of total $SO_x$ emissions, almost entirely attributed to coal-fired electricity generation at 28% (198 kt). Ore and Mineral Industries also accounted for 25% (173 kt) of total $SO_x$ emissions. The remaining 9% of $SO_x$ emissions were distributed across multiple sources.

Overall, $SO_x$ emissions decreased by 77% (2.3 Mt) between 1990 and 2019 (Figure 2–2). Reductions in emissions from the Ore and Mineral Industries, and in particular the Non-Ferrous Refining and Smelting Industry sector, were the largest driver of this downward trend, particularly in the early 1990s, and again from 2008 to 2019. The decrease since 2008 can be attributed to the preparation and implementation of pollution prevention plans by facilities, the installation of new technology or processes at facilities, the closure of four major smelters in Manitoba, Ontario, Quebec and New Brunswick, and facilities achieving Base Level Industrial Emissions Requirements (BLIERs) through environmental performance agreements (ECCC, 2017; ECCC 2018). Emissions from Electric Power Generation (Utilities) decreased significantly from 2003 to 2019, primarily owing to the closure of, or improvements to, generating stations burning heavy fuel oil. Improvements consisted of installing 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 Production and Processing, attributed to better emission control technologies.

The most significant decreases in $SO_x$ emissions from 1990 to 2019 include:

- Ore and Mineral Industries: decrease of 88% (1.3 Mt), with:
  - Non-Ferrous Refining and Smelting Industry: decrease of 95% (1.2 Mt)
- Electric Power Generation (Utilities): decrease of 67% (413 kt), with:
  - Coal: decrease of 62% (317 kt)
- Oil and Gas Industry: decrease of 51% (272 kt), with:
  - Upstream Oil and Gas Industry: decrease of 48% (191 kt)

Figure 2–2 **Trends in Canadian $SO_x$ Emissions (1990 to 2019)**



## Table 2–4 National Summary of Annual $SO_x$ Emissions

| Source | 1990 | 2000 | 2005 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 |
|---|---|---|---|---|---|---|---|---|---|
| | (tonnes) | | | | | | | | |
| **ORE AND MINERAL INDUSTRIES** | **1 500 000** | **910 000** | **860 000** | **490 000** | **480 000** | **480 000** | **390 000** | **260 000** | **170 000** |
| Aluminium Industry | 31 000 | 48 000 | 63 000 | 55 000 | 57 000 | 64 000 | 66 000 | 62 000 | 56 000 |
| Asphalt Paving Industry | 730 | 640 | 710 | 660 | 570 | 610 | 690 | 690 | 620 |
| Cement and Concrete Industry | 48 000 | 45 000 | 54 000 | 20 000 | 23 000 | 24 000 | 23 000 | 25 000 | 22 000 |
| Foundries | 1 300 | 910 | 720 | 48 | 48 | 49 | 48 | 48 | 48 |
| Iron and Steel Industry | 36 000 | 29 000 | 30 000 | 24 000 | 22 000 | 17 000 | 18 000 | 19 000 | 19 000 |
| Iron Ore Industry | 59 000 | 17 000 | 19 000 | 10 000 | 12 000 | 13 000 | 12 000 | 9 800 | 11 000 |
| Mineral Products Industry | 1 300 | 820 | 1 800 | 1 600 | 1 400 | 1 500 | 850 | 750 | 720 |
| Mining and Rock Quarrying | 32 000 | 9 500 | 11 000 | 2 300 | 2 100 | 1 900 | 2 300 | 1 800 | 1 700 |
| Non-Ferrous Refining and Smelting Industry | 1 300 000 | 760 000 | 680 000 | 370 000 | 360 000 | 360 000 | 270 000 | 140 000 | 61 000 |
| **OIL AND GAS INDUSTRY** | **530 000** | **500 000** | **450 000** | **280 000** | **260 000** | **250 000** | **260 000** | **260 000** | **260 000** |
| Downstream Oil and Gas Industry | 130 000 | 140 000 | 110 000 | 52 000 | 44 000 | 50 000 | 47 000 | 48 000 | 48 000 |
| Upstream Oil and Gas Industry | 400 000 | 370 000 | 340 000 | 230 000 | 210 000 | 200 000 | 210 000 | 220 000 | 210 000 |
| **ELECTRIC POWER GENERATION (UTILITIES)** | **620 000** | **620 000** | **520 000** | **270 000** | **250 000** | **250 000** | **250 000** | **220 000** | **210 000** |
| Coal | 510 000 | 530 000 | 460 000 | 260 000 | 240 000 | 240 000 | 240 000 | 210 000 | 200 000 |
| Diesel | 430 | 440 | 330 | 39 | 160 | 73 | 74 | 120 | 130 |
| Natural Gas | 29 000 | 21 000 | 19 000 | 2 400 | 2 100 | 1 800 | 1 100 | 1 400 | 1 100 |
| Waste Materials | 0.76 | 1.4 | - | - | - | - | - | - | - |
| Other (Electric Power Generation) | 74 000 | 63 000 | 41 000 | 7 000 | 7 700 | 8 200 | 8 300 | 6 800 | 6 500 |
| **MANUFACTURING** | **230 000** | **160 000** | **150 000** | **53 000** | **49 000** | **45 000** | **42 000** | **45 000** | **41 000** |
| Abrasives Manufacturing | 4 000 | 860 | 860 | - | - | - | - | - | - |
| Bakeries | 0.053 | 0.052 | 0.16 | 0.0 | 0.0 | 0.0 | 0.0 | - | - |
| Biofuel Production | - | - | - | 0.33 | - | - | - | 2.3 | 6.5 |
| Chemicals Industry | 38 000 | 31 000 | 36 000 | 21 000 | 23 000 | 21 000 | 18 000 | 20 000 | 18 000 |
| Electronics | 1 700 | 3 000 | 3 000 | - | - | 0.0 | - | - | - |
| Food Preparation | 3 500 | 4 800 | 6 000 | 610 | 370 | 280 | 370 | 420 | 390 |
| Glass Manufacturing | 2 300 | 2 800 | 2 500 | 600 | 630 | 610 | 590 | 600 | 580 |
| Grain Industry | 230 | 210 | 370 | 470 | 510 | 530 | 490 | 340 | 330 |
| Metal Fabrication | 2 300 | 2 700 | 2 000 | 580 | 700 | 540 | 550 | 560 | 490 |
| Plastics Manufacturing | 470 | 27 | 3.9 | 0.0 | - | - | 0.0 | 0.0 | - |
| Pulp and Paper Industry | 140 000 | 78 000 | 66 000 | 29 000 | 24 000 | 21 000 | 22 000 | 22 000 | 20 000 |
| Textiles | 380 | 390 | 320 | 22 | 17 | 21 | 19 | 19 | 15 |
| Vehicle Manufacturing (Engines, Parts, Assembly, Painting) | 2 300 | 2 100 | 990 | 0.64 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Wood Products | 3 300 | 3 400 | 3 000 | 640 | 590 | 600 | 600 | 530 | 560 |
| Other (Manufacturing) | 29 000 | 25 000 | 24 000 | 650 | 350 | 400 | 360 | 340 | 450 |
| **TRANSPORTATION AND MOBILE EQUIPMENT** | **93 000** | **87 000** | **63 000** | **29 000** | **6 800** | **6 700** | **7 200** | **7 400** | **6 100** |
| Air Transportation (LTO) | 810 | 850 | 930 | 630 | 480 | 490 | 690 | 650 | 620 |
| Heavy-Duty Diesel Vehicles | 15 000 | 6 700 | 6 100 | 160 | 160 | 150 | 160 | 170 | 170 |
| Heavy-Duty Gasoline Vehicles | 970 | 2 000 | 150 | 180 | 180 | 190 | 190 | 190 | 200 |
| Heavy-Duty LPG/NG Vehicles | 240 | 1 300 | 9.5 | 0.32 | 0.38 | 0.45 | 0.65 | 0.65 | 0.63 |
| Light-Duty Diesel Trucks | 170 | 78 | 52 | 2.2 | 2.8 | 3.2 | 3.8 | 4.2 | 4.2 |
| Light-Duty Diesel Vehicles | 570 | 130 | 110 | 3.2 | 3.3 | 3.1 | 3.1 | 3.0 | 2.9 |
| Light-Duty Gasoline Trucks | 3 200 | 6 400 | 510 | 670 | 700 | 740 | 760 | 790 | 820 |
| Light-Duty Gasoline Vehicles | 7 300 | 8 400 | 560 | 540 | 540 | 550 | 530 | 520 | 510 |
| Light-Duty LPG/NG Trucks | 190 | 180 | 10 | 0.16 | 0.14 | 0.16 | 0.18 | 0.19 | 0.18 |
| Light-Duty LPG/NG Vehicles | 23 | 28 | 1.4 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Domestic Marine Navigation, Fishing and Military | 30 000 | 38 000 | 42 000 | 26 000 | 4 400 | 4 300 | 4 600 | 4 700 | 3 500 |
| Motorcycles | 15 | 25 | 2.8 | 4.0 | 4.2 | 4.4 | 4.5 | 4.6 | 4.6 |
| Off-Road Diesel Vehicles and Equipment | 28 000 | 17 000 | 6 700 | 150 | 150 | 130 | 150 | 160 | 160 |
| Off-Road Gasoline/LPG/NG Vehicles and Equipment | 1 400 | 1 500 | 83 | 78 | 80 | 80 | 83 | 85 | 84 |
| Rail Transportation | 5 700 | 5 400 | 5 000 | 51 | 48 | 45 | 51 | 52 | 53 |
| Tire Wear and Brake Lining | - | - | - | - | - | - | - | - | - |
| **AGRICULTURE** | **2 200** | **1 500** | **2 900** | **9 300** | **6 900** | **6 400** | **6 400** | **6 000** | **5 600** |
| Animal Production | - | - | - | - | - | - | - | - | - |
| Crop Production | - | - | - | - | - | - | - | - | - |
| Fuel Use | 2 200 | 1 500 | 2 900 | 9 300 | 6 900 | 6 400 | 6 400 | 6 000 | 5 600 |
| **COMMERCIAL/RESIDENTIAL/INSTITUTIONAL** | **50 000** | **35 000** | **35 000** | **8 900** | **7 800** | **6 100** | **6 000** | **5 600** | **5 700** |
| Commercial and Institutional Fuel Combustion | 19 000 | 19 000 | 21 000 | 3 300 | 2 400 | 1 500 | 1 500 | 970 | 1 000 |
| Commercial Cooking | - | - | - | - | - | - | - | - | - |
| Construction Fuel Combustion | 1 900 | 620 | 1 400 | 520 | 620 | 420 | 440 | 410 | 470 |
| Home Firewood Burning | 1 800 | 1 500 | 1 300 | 1 800 | 1 700 | 1 700 | 1 700 | 1 800 | 1 900 |
| Human | - | - | - | - | - | - | - | - | - |
| Marine Cargo Handling | 0.0 | 0.0 | - | 140 | 88 | 91 | 120 | 97 | 170 |
| Residential Fuel Combustion | 28 000 | 14 000 | 11 000 | 3 200 | 3 000 | 2 500 | 2 300 | 2 400 | 2 200 |
| Service Stations | - | - | - | - | - | - | - | - | - |
| Other (Miscellaneous) | - | - | - | - | - | - | - | - | - |
| **INCINERATION AND WASTE** | **2 700** | **2 800** | **2 800** | **2 500** | **3 000** | **2 700** | **2 800** | **2 600** | **2 700** |
| Crematoriums | 5.0 | 7.0 | 8.9 | 13 | 13 | 14 | 14 | 15 | 15 |
| Waste Incineration | 2 200 | 2 400 | 2 400 | 2 300 | 2 600 | 2 500 | 2 500 | 2 400 | 2 400 |
| Waste Treatment and Disposal | 440 | 400 | 420 | 210 | 380 | 220 | 220 | 220 | 230 |
| **PAINTS AND SOLVENTS** | **2.1** | **1.5** | **0.62** | **-** | **-** | **-** | **-** | **-** | **-** |
| Dry Cleaning | 0.0 | 0.0 | - | - | - | - | - | - | - |
| General Solvent Use | - | - | - | - | - | - | - | - | - |
| Printing | 2.0 | 1.5 | 0.62 | - | - | - | - | - | - |
| Surface Coatings | 0.0 | 0.0 | - | - | - | - | - | - | - |
| **DUST** | **-** | **-** | **-** | **-** | **-** | **-** | **-** | **-** | **-** |
| Coal Transportation | - | - | - | - | - | - | - | - | - |
| Construction Operations | - | - | - | - | - | - | - | - | - |
| Mine Tailings | - | - | - | - | - | - | - | - | - |
| Paved Roads | - | - | - | - | - | - | - | - | - |
| Unpaved Roads | - | - | - | - | - | - | - | - | - |
| **FIRES** | **180** | **28** | **18** | **53** | **41** | **34** | **20** | **12** | **15** |
| Prescribed Burning | 180 | 28 | 18 | 53 | 41 | 34 | 20 | 12 | 15 |
| Structural Fires | - | - | - | - | - | - | - | - | - |
| **GRAND TOTAL** | **3 000 000** | **2 300 000** | **2 100 000** | **1 100 000** | **1 100 000** | **1 000 000** | **960 000** | **810 000** | **700 000** |

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

**Other emissions estimated in the APEI**

| Source | 1990 | 2000 | 2005 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 |
|---|---|---|---|---|---|---|---|---|---|
| Domestic Air Transportation (Cruise) | 2 200 | 2 300 | 2 500 | 1 900 | 1 500 | 1 400 | 2 200 | 2 000 | 1 900 |
| International Air Transportation (Cruise) | 2 400 | 3 600 | 4 300 | 3 200 | 2 900 | 3 300 | 5 300 | 5 000 | 4 500 |
| International Marine Navigation | 50 000 | 73 000 | 85 000 | 58 000 | 5 300 | 5 500 | 5 700 | 5 900 | 5 000 |

Note: Refer to Annex 4.4 for more information.

## 2.3. Nitrogen Oxides

Approximately 1.6 Mt of nitrogen oxides ($NO_x$) were released in Canada in 2019 (Table 2–5). Transportation and Mobile Equipment was the largest contributor, accounting for 48% (778 kt) of total $NO_x$ emissions. Within this source category, Heavy-Duty Diesel Vehicles, Off-Road Diesel Vehicles and Equipment and Rail Transportation were the largest emitters, collectively contributing 31% (506 kt) of total $NO_x$ emissions. Oil and Gas Industry accounted for 30% (481 kt) of total $NO_x$ emissions in 2019, with the Upstream Oil and Gas Industry sector accounting for nearly all of the Oil and Gas Industry total (466 kt). Electric Power Generation (Utilities) contributed 8% (125 kt) of total $NO_x$ emissions, with coal-fired generation contributing 5% (88 kt) of the national total. The remaining 14% of $NO_x$ emissions were distributed across multiple sources.

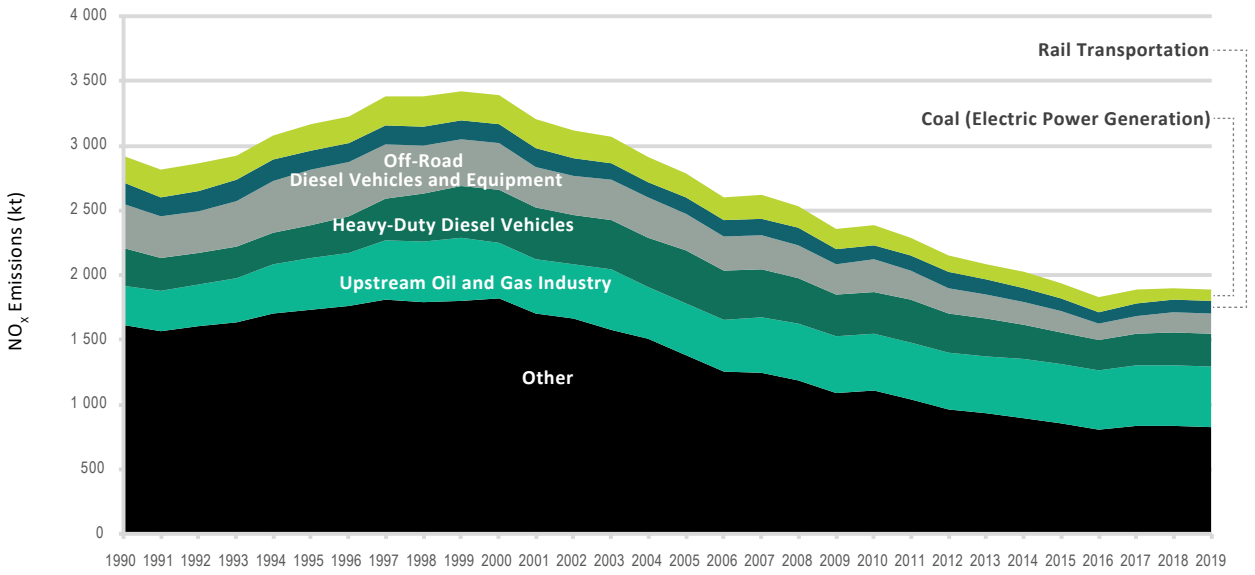
From 1990 to 2019, national $NO_x$ emissions decreased by 29% (657 kt) (Figure 2–3). A significant driver of this trend was the decrease in emissions from Light-Duty Gasoline Trucks and Vehicles, as a result of increasingly stringent vehicle regulations that have effectively lowered $NO_x$ and hydrocarbon emissions from engines.[5] Emissions from Heavy-Duty Diesel Vehicles and Off-Road Diesel Vehicles and Equipment 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 2019. Finally, Upstream Oil and Gas Industry and Domestic Marine Navigation, Fishing and Military 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 2019 include:

- Transportation and Mobile Equipment: decrease of 40% (511 kt), with:
  - Off-Road Diesel Vehicles and Equipment: decrease of 54% (180 kt)
  - Light-Duty Gasoline Trucks and Vehicles: decrease of 58% (170 kt)
  - Rail Transportation: decrease of 42% (70 kt)
- Electric Power Generation (Utilities): decrease of 51% (132 kt), with:
  - Coal: decrease of 57% (118 kt)
- Oil and Gas Industry: increase of 39% (135 kt), with:
  - Upstream Oil and Gas Industry: increase of 50% (155 kt)
  - Downstream Oil and Gas Industry: decrease of 56% (20 kt)

5 See Chapter 1 for list of regulations.

Figure 2–3 **Trends in Canadian $NO_x$ Emissions (1990 to 2019)**



## Table 2–5 National Summary of Annual $NO_X$ Emissions

| Source | 1990 | 2000 | 2005 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 |
|---|---|---|---|---|---|---|---|---|---|
| | (tonnes) | | | | | | | | |
| **ORE AND MINERAL INDUSTRIES** | **100 000** | **99 000** | **110 000** | **82 000** | **82 000** | **77 000** | **86 000** | **82 000** | **80 000** |
| Aluminium Industry | 1 600 | 1 400 | 2 000 | 1 100 | 1 100 | 1 200 | 1 200 | 1 200 | 1 100 |
| Asphalt Paving Industry | 1 200 | 1 100 | 1 200 | 1 200 | 930 | 890 | 960 | 980 | 930 |
| Cement and Concrete Industry | 43 000 | 45 000 | 54 000 | 31 000 | 35 000 | 32 000 | 34 000 | 36 000 | 33 000 |
| Foundries | 490 | 640 | 540 | 140 | 140 | 140 | 140 | 140 | 140 |
| Iron and Steel Industry | 19 000 | 16 000 | 13 000 | 12 000 | 11 000 | 11 000 | 11 000 | 11 000 | 10 000 |
| Iron Ore Industry | 10 000 | 10 000 | 9 800 | 12 000 | 12 000 | 11 000 | 12 000 | 9 900 | 11 000 |
| Mineral Products Industry | 1 300 | 560 | 1 100 | 310 | 290 | 300 | 290 | 240 | 210 |
| Mining and Rock Quarrying | 24 000 | 20 000 | 23 000 | 23 000 | 20 000 | 19 000 | 25 000 | 22 000 | 22 000 |
| Non-Ferrous Refining and Smelting Industry | 4 300 | 3 800 | 1 800 | 1 600 | 1 600 | 1 900 | 1 800 | 1 600 | 1 600 |
| **OIL AND GAS INDUSTRY** | **350 000** | **460 000** | **430 000** | **480 000** | **480 000** | **470 000** | **480 000** | **490 000** | **480 000** |
| Downstream Oil and Gas Industry | 35 000 | 30 000 | 31 000 | 17 000 | 17 000 | 17 000 | 17 000 | 16 000 | 15 000 |
| Upstream Oil and Gas Industry | 310 000 | 430 000 | 400 000 | 460 000 | 460 000 | 450 000 | 460 000 | 470 000 | 470 000 |
| **ELECTRIC POWER GENERATION (UTILITIES)** | **260 000** | **330 000** | **250 000** | **170 000** | **150 000** | **150 000** | **150 000** | **130 000** | **120 000** |
| Coal | 210 000 | 230 000 | 190 000 | 130 000 | 110 000 | 120 000 | 110 000 | 92 000 | 88 000 |
| Diesel | 3 100 | 8 300 | 8 500 | 9 200 | 9 900 | 9 100 | 8 900 | 9 700 | 9 800 |
| Natural Gas | 20 000 | 65 000 | 38 000 | 19 000 | 17 000 | 16 000 | 16 000 | 18 000 | 18 000 |
| Waste Materials | 45 | 200 | 68 | 94 | 110 | 220 | 260 | 200 | 180 |
| Other (Electric Power Generation) | 28 000 | 28 000 | 21 000 | 10 000 | 10 000 | 10 000 | 9 600 | 9 000 | 8 800 |
| **MANUFACTURING** | **190 000** | **170 000** | **140 000** | **69 000** | **69 000** | **68 000** | **69 000** | **69 000** | **67 000** |
| Abrasives Manufacturing | 240 | 90 | 74 | - | - | - | - | - | - |
| Bakeries | 4.1 | 4.0 | - | 1.0 | 0.89 | 0.89 | 0.95 | - | - |
| Biofuel Production | - | - | - | 41 | 18 | 16 | 18 | 33 | 13 |
| Chemicals Industry | 41 000 | 47 000 | 37 000 | 22 000 | 23 000 | 23 000 | 23 000 | 25 000 | 24 000 |
| Electronics | 150 | 160 | 71 | - | - | 0.0 | - | - | - |
| Food Preparation | 2 400 | 2 900 | 3 300 | 1 700 | 1 800 | 1 700 | 1 900 | 1 900 | 1 700 |
| Glass Manufacturing | 7 000 | 7 400 | 6 100 | 890 | 920 | 780 | 780 | 770 | 750 |
| Grain Industry | 1 400 | 1 300 | 990 | 1 000 | 780 | 760 | 1 100 | 820 | 930 |
| Metal Fabrication | 5 900 | 9 000 | 1 200 | 360 | 470 | 490 | 420 | 470 | 400 |
| Plastics Manufacturing | 880 | 810 | 100 | 0.91 | 9.4 | 11 | 13 | 18 | 14 |
| Pulp and Paper Industry | 72 000 | 49 000 | 45 000 | 30 000 | 30 000 | 29 000 | 29 000 | 28 000 | 27 000 |
| Textiles | 120 | 170 | 110 | 33 | 8.2 | 7.8 | 7.8 | 7.7 | 6.1 |
| Vehicle Manufacturing (Engines, Parts, Assembly, Painting) | 2 500 | 3 500 | 1 500 | 610 | 650 | 610 | 600 | 660 | 620 |
| Wood Products | 18 000 | 22 000 | 19 000 | 12 000 | 11 000 | 12 000 | 11 000 | 11 000 | 11 000 |
| Other (Manufacturing) | 33 000 | 30 000 | 22 000 | 580 | 480 | 510 | 560 | 680 | 530 |
| **TRANSPORTATION AND MOBILE EQUIPMENT** | **1 300 000** | **1 600 000** | **1 200 000** | **800 000** | **750 000** | **710 000** | **740 000** | **770 000** | **780 000** |
| Air Transportation (LTO) | 5 700 | 6 800 | 6 800 | 6 700 | 7 100 | 7 300 | 7 600 | 8 500 | 8 500 |
| Heavy-Duty Diesel Vehicles | 290 000 | 410 000 | 410 000 | 260 000 | 240 000 | 230 000 | 240 000 | 260 000 | 260 000 |
| Heavy-Duty Gasoline Vehicles | 60 000 | 82 000 | 60 000 | 37 000 | 35 000 | 37 000 | 37 000 | 38 000 | 38 000 |
| Heavy-Duty LPG/NG Vehicles | 15 000 | 34 000 | 4 500 | 59 | 61 | 80 | 140 | 140 | 130 |
| Light-Duty Diesel Trucks | 790 | 1 500 | 2 100 | 1 300 | 1 400 | 1 600 | 1 800 | 2 000 | 2 000 |
| Light-Duty Diesel Vehicles | 2 200 | 2 200 | 1 200 | 940 | 920 | 860 | 860 | 830 | 800 |
| Light-Duty Gasoline Trucks | 97 000 | 190 000 | 130 000 | 70 000 | 68 000 | 72 000 | 74 000 | 77 000 | 79 000 |
| Light-Duty Gasoline Vehicles | 200 000 | 220 000 | 120 000 | 50 000 | 46 000 | 46 000 | 45 000 | 44 000 | 43 000 |
| Light-Duty LPG/NG Trucks | 7 500 | 5 900 | 2 900 | 31 | 27 | 29 | 34 | 34 | 33 |
| Light-Duty LPG/NG Vehicles | 820 | 740 | 280 | 0.81 | 0.73 | 0.89 | 1.2 | 1.2 | 1.1 |
| Domestic Marine Navigation, Fishing and Military | 59 000 | 70 000 | 77 000 | 62 000 | 60 000 | 60 000 | 62 000 | 65 000 | 69 000 |
| Motorcycles | 320 | 440 | 530 | 620 | 640 | 680 | 700 | 700 | 700 |
| Off-Road Diesel Vehicles and Equipment | 330 000 | 360 000 | 280 000 | 170 000 | 170 000 | 130 000 | 140 000 | 150 000 | 150 000 |
| Off-Road Gasoline/LPG/NG Vehicles and Equipment | 53 000 | 37 000 | 28 000 | 30 000 | 30 000 | 29 000 | 30 000 | 31 000 | 31 000 |
| Rail Transportation | 160 000 | 150 000 | 130 000 | 110 000 | 98 000 | 88 000 | 93 000 | 95 000 | 95 000 |
| Tire Wear and Brake Lining | - | - | - | - | - | - | - | - | - |
| **AGRICULTURE** | **2 100** | **2 200** | **2 100** | **4 600** | **4 100** | **4 200** | **4 200** | **4 100** | **3 800** |
| Animal Production | - | - | - | - | - | - | - | - | - |
| Crop Production | - | - | - | - | - | - | - | - | - |
| Fuel Use | 2 100 | 2 200 | 2 100 | 4 600 | 4 100 | 4 200 | 4 200 | 4 100 | 3 800 |
| **COMMERCIAL/RESIDENTIAL/INSTITUTIONAL** | **74 000** | **78 000** | **77 000** | **74 000** | **72 000** | **70 000** | **74 000** | **76 000** | **78 000** |
| Commercial and Institutional Fuel Combustion | 23 000 | 30 000 | 30 000 | 27 000 | 26 000 | 26 000 | 28 000 | 28 000 | 29 000 |
| Commercial Cooking | - | - | - | - | - | - | - | - | - |
| Construction Fuel Combustion | 3 900 | 2 000 | 2 700 | 2 500 | 2 500 | 2 600 | 2 700 | 2 800 | 2 800 |
| Home Firewood Burning | 13 000 | 11 000 | 9 300 | 12 000 | 12 000 | 12 000 | 12 000 | 13 000 | 13 000 |
| Human | - | - | - | - | - | - | - | - | - |
| Marine Cargo Handling | 0.20 | 0.059 | - | 31 | 26 | 24 | 28 | 26 | 38 |
| Residential Fuel Combustion | 35 000 | 35 000 | 35 000 | 32 000 | 31 000 | 30 000 | 32 000 | 33 000 | 33 000 |
| Service Stations | - | - | - | - | - | - | - | - | - |
| Other (Miscellaneous) | - | - | - | - | - | - | - | - | - |
| **INCINERATION AND WASTE** | **7 700** | **7 500** | **8 900** | **4 100** | **4 200** | **4 200** | **5 200** | **4 400** | **4 400** |
| Crematoriums | 8.1 | 11 | 15 | 21 | 21 | 22 | 24 | 24 | 25 |
| Waste Incineration | 2 300 | 2 400 | 3 900 | 2 300 | 2 300 | 2 300 | 2 400 | 2 200 | 2 300 |
| Waste Treatment and Disposal | 5 400 | 5 100 | 5 000 | 1 800 | 1 900 | 1 900 | 2 800 | 2 100 | 2 100 |
| **PAINTS AND SOLVENTS** | **110** | **120** | **130** | **23** | **23** | **23** | **17** | **15** | **22** |
| Dry Cleaning | 1.1 | 1.6 | - | - | - | - | - | - | - |
| General Solvent Use | - | - | - | - | - | - | - | - | - |
| Printing | 110 | 120 | 130 | 23 | 23 | 23 | 17 | 15 | 20 |
| Surface Coatings | 0.12 | 0.12 | - | - | - | - | - | - | 1.9 |
| **DUST** | **-** | **-** | **-** | **-** | **-** | **-** | **-** | **-** | **-** |
| Coal Transportation | - | - | - | - | - | - | - | - | - |
| Construction Operations | - | - | - | - | - | - | - | - | - |
| Mine Tailings | - | - | - | - | - | - | - | - | - |
| Paved Roads | - | - | - | - | - | - | - | - | - |
| Unpaved Roads | - | - | - | - | - | - | - | - | - |
| **FIRES** | **7 500** | **1 400** | **890** | **2 600** | **2 000** | **1 700** | **990** | **600** | **670** |
| Prescribed Burning | 7 400 | 1 400 | 850 | 2 600 | 2 000 | 1 600 | 970 | 570 | 650 |
| Structural Fires | 49 | 39 | 36 | 28 | 27 | 27 | 27 | 28 | 27 |
| **GRAND TOTAL** | **2 300 000** | **2 700 000** | **2 300 000** | **1 700 000** | **1 600 000** | **1 600 000** | **1 600 000** | **1 600 000** | **1 600 000** |

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

**Other emissions estimated in the APEI**

| Source | 1990 | 2000 | 2005 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 |
|---|---|---|---|---|---|---|---|---|---|
| Domestic Air Transportation (Cruise) | 28 000 | 26 000 | 27 000 | 30 000 | 30 000 | 31 000 | 33 000 | 35 000 | 35 000 |
| International Air Transportation (Cruise) | 23 000 | 39 000 | 44 000 | 54 000 | 56 000 | 61 000 | 68 000 | 78 000 | 80 000 |
| International Marine Navigation | 81 000 | 120 000 | 130 000 | 120 000 | 120 000 | 120 000 | 110 000 | 110 000 | 110 000 |

Note: Refer to Annex 4.4 for more information.

## 2.4. Volatile Organic Compounds

In 2019, approximately 1.7 Mt of volatile organic compounds (VOCs) were released in Canada (Table 2–6). Oil and Gas Industry was the largest contributor at 39% (659 kt) of total emissions (with the Upstream Oil and Gas Industry sector emitting 38% (633 kt) of total VOCs). Paints and Solvents were the next-largest contributor, accounting for 18% (303 kt) of emissions, with General Solvent Use accounting for 13% (213 kt) of the national total. Transportation and Mobile Equipment sources accounted for 17% (289 kt) of emissions, with the Off-Road Gasoline / Liquefied Petroleum Gas (LPG) / Natural Gas (NG) Vehicles and Equipment sector contributing 7% (117 kt) of the national total.

Commercial/Residential/Institutional sources represented 10% (171 kt) of VOC emissions, attributed mainly to Home Firewood Burning (7% or 114 kt). The other contributing VOC sources are Agriculture, Manufacturing and Incineration and Waste. Of these, agricultural sources accounted for 7% (116 kt) of emissions and manufacturing sources represented 6% (102 kt) of total VOC emissions.

Between 1990 and 2019, VOC emissions decreased by 42% (1.2 Mt) (Figure 2–4). The most significant driver of this trend is a decrease in emissions from the Off-Road Gasoline/LPG/NG Vehicles and Equipment sector, due to increasingly stringent regulations on these spark-ignition engines.[6] The consistent decrease in emissions from Light-Duty Gasoline Vehicles and Trucks throughout the time series also contributed to this trend.

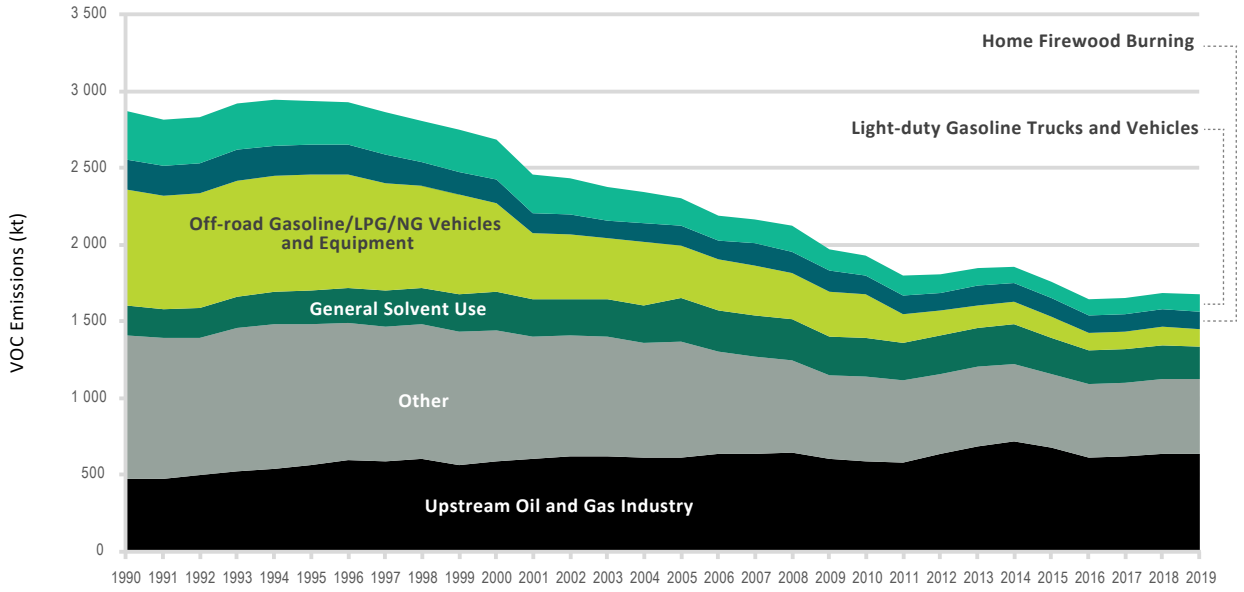
Although emissions from most sources decreased, Oil and Gas Industry experienced an overall increase in emissions between 1990 and 2019. VOC emissions from the Downstream Oil and Gas Industry sector declined overall from 1990 to 2006, with emissions remaining relatively stable after that time, but the Upstream Oil and Gas Industry sector experienced increased emissions, which were more pronounced from 2013 to 2015. In 2019, VOC emissions from Upstream Oil and Gas Industry declined compared to 2014, owing to a 35% decrease in the number of oil spills (AER, 2020a; BCOGC, 2020; CNLOPB, 2020; MB, 2020; SK MER, 2020a), as well as a 22% reduction in reported volumes of vented gas from crude oil batteries (AER, 2020b; SK MER, 2020b).

The most significant changes in VOC emissions from 1990 to 2019 include:

- Transportation and Mobile Equipment: decrease of 76% (916 kt), with:
  - Off-Road Gasoline/LPG/NG Vehicles and Equipment: decrease of 85% (647 kt)
  - Light-Duty Gasoline Vehicles and Trucks: decrease of 66% (209 kt)
- Oil and Gas Industry: increase of 10% (60 kt), with:
  - Upstream Oil and Gas Industry: increase of 34% (162 kt)
  - Downstream Oil and Gas Industry: decrease of 80% (101 kt)

6 See Chapter 1 for list of regulations.

Figure 2–4 **Trends in Canadian Volatile Organic Compound Emissions (1990 to 2019)**



## Table 2–6 National Summary of Annual Volatile Organic Compound Emissions

| Source | 1990 | 2000 | 2005 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 |
|---|---|---|---|---|---|---|---|---|---|
| | (tonnes) | | | | | | | | |
| **ORE AND MINERAL INDUSTRIES** | **19 000** | **20 000** | **16 000** | **13 000** | **12 000** | **11 000** | **11 000** | **12 000** | **12 000** |
| Aluminium Industry | 710 | 1 100 | 1 200 | 970 | 930 | 950 | 950 | 1 700 | 1 900 |
| Asphalt Paving Industry | 6 600 | 6 400 | 6 100 | 8 500 | 6 600 | 6 300 | 6 400 | 6 400 | 6 200 |
| Cement and Concrete Industry | 590 | 630 | 1 200 | 410 | 400 | 440 | 690 | 760 | 760 |
| Foundries | 1 700 | 1 100 | 920 | 450 | 380 | 360 | 310 | 350 | 320 |
| Iron and Steel Industry | 5 800 | 4 200 | 2 000 | 1 100 | 870 | 820 | 820 | 1 200 | 870 |
| Iron Ore Industry | 570 | 3 200 | 1 600 | 320 | 300 | 410 | 280 | 270 | 330 |
| Mineral Products Industry | 170 | 320 | 200 | 120 | 110 | 140 | 72 | 110 | 67 |
| Mining and Rock Quarrying | 3 000 | 2 600 | 2 300 | 1 600 | 1 900 | 1 400 | 1 300 | 1 400 | 1 300 |
| Non-Ferrous Refining and Smelting Industry | 330 | 37 | 52 | 66 | 67 | 65 | 69 | 79 | 110 |
| **OIL AND GAS INDUSTRY** | **600 000** | **670 000** | **680 000** | **740 000** | **700 000** | **640 000** | **650 000** | **660 000** | **660 000** |
| Downstream Oil and Gas Industry | 130 000 | 85 000 | 66 000 | 24 000 | 24 000 | 24 000 | 26 000 | 27 000 | 26 000 |
| Upstream Oil and Gas Industry | 470 000 | 580 000 | 610 000 | 710 000 | 670 000 | 610 000 | 620 000 | 630 000 | 630 000 |
| **ELECTRIC POWER GENERATION (UTILITIES)** | **2 500** | **3 600** | **3 300** | **1 700** | **1 600** | **1 600** | **1 300** | **1 200** | **1 200** |
| Coal | 1 300 | 950 | 1 300 | 450 | 410 | 410 | 380 | 210 | 290 |
| Diesel | 77 | 280 | 220 | 46 | 84 | 55 | 53 | 68 | 84 |
| Natural Gas | 480 | 1 600 | 1 500 | 900 | 910 | 890 | 630 | 610 | 590 |
| Waste Materials | 0.70 | 3.0 | - | 11 | 13 | 9.1 | - | - | - |
| Other (Electric Power Generation) | 630 | 770 | 350 | 270 | 220 | 200 | 290 | 280 | 220 |
| **MANUFACTURING** | **260 000** | **260 000** | **190 000** | **110 000** | **110 000** | **100 000** | **100 000** | **100 000** | **100 000** |
| Abrasives Manufacturing | 1 500 | 590 | 610 | 59 | 18 | 20 | 17 | 18 | 16 |
| Bakeries | 4 000 | 4 700 | 5 100 | 4 800 | 4 800 | 4 900 | 4 800 | 5 000 | 5 300 |
| Biofuel Production | - | - | - | 400 | 100 | 42 | 46 | 43 | 15 |
| Chemicals Industry | 47 000 | 36 000 | 26 000 | 12 000 | 10 000 | 9 800 | 9 200 | 13 000 | 13 000 |
| Electronics | 1 300 | 540 | 380 | 53 | 49 | 39 | 33 | 24 | 32 |
| Food Preparation | 10 000 | 13 000 | 15 000 | 15 000 | 15 000 | 15 000 | 14 000 | 17 000 | 17 000 |
| Glass Manufacturing | 2 000 | 2 300 | 630 | 240 | 200 | 190 | 200 | 160 | 160 |
| Grain Industry | 2 200 | 2 300 | 2 200 | 3 000 | 3 000 | 2 500 | 2 200 | 2 200 | 3 200 |
| Metal Fabrication | 9 100 | 14 000 | 12 000 | 4 200 | 4 400 | 3 700 | 4 100 | 4 400 | 4 200 |
| Plastics Manufacturing | 14 000 | 16 000 | 15 000 | 10 000 | 11 000 | 10 000 | 10 000 | 10 000 | 9 500 |
| Pulp and Paper Industry | 27 000 | 24 000 | 23 000 | 14 000 | 13 000 | 13 000 | 13 000 | 13 000 | 12 000 |
| Textiles | 870 | 1 500 | 850 | 570 | 470 | 490 | 880 | 510 | 410 |
| Vehicle Manufacturing (Engines, Parts, Assembly, Painting) | 22 000 | 23 000 | 16 000 | 8 200 | 8 400 | 9 300 | 8 300 | 7 800 | 7 400 |
| Wood Products | 110 000 | 98 000 | 64 000 | 36 000 | 33 000 | 32 000 | 30 000 | 29 000 | 27 000 |
| Other (Manufacturing) | 11 000 | 21 000 | 7 900 | 2 800 | 2 800 | 2 700 | 2 900 | 2 600 | 2 800 |
| **TRANSPORTATION AND MOBILE EQUIPMENT** | **1 200 000** | **970 000** | **630 000** | **310 000** | **300 000** | **280 000** | **290 000** | **290 000** | **290 000** |
| Air Transportation (LTO) | 5 500 | 3 100 | 2 500 | 2 700 | 2 800 | 2 700 | 2 800 | 3 000 | 3 000 |
| Heavy-Duty Diesel Vehicles | 10 000 | 18 000 | 24 000 | 18 000 | 17 000 | 16 000 | 17 000 | 18 000 | 18 000 |
| Heavy-Duty Gasoline Vehicles | 24 000 | 28 000 | 22 000 | 12 000 | 12 000 | 12 000 | 12 000 | 13 000 | 13 000 |
| Heavy-Duty LPG/NG Vehicles | 7 100 | 12 000 | 2 300 | 26 | 26 | 36 | 68 | 68 | 63 |
| Light-Duty Diesel Trucks | 770 | 1 000 | 1 600 | 1 200 | 1 300 | 1 400 | 1 700 | 1 800 | 1 900 |
| Light-Duty Diesel Vehicles | 2 200 | 1 500 | 920 | 780 | 800 | 750 | 750 | 730 | 700 |
| Light-Duty Gasoline Trucks | 90 000 | 110 000 | 82 000 | 55 000 | 55 000 | 58 000 | 60 000 | 62 000 | 64 000 |
| Light-Duty Gasoline Vehicles | 230 000 | 150 000 | 95 000 | 50 000 | 49 000 | 49 000 | 48 000 | 47 000 | 46 000 |
| Light-Duty LPG/NG Trucks | 8 100 | 3 700 | 1 900 | 26 | 24 | 25 | 30 | 30 | 29 |
| Light-Duty LPG/NG Vehicles | 1 100 | 540 | 230 | 0.85 | 0.82 | 1.0 | 1.3 | 1.3 | 1.3 |
| Domestic Marine Navigation, Fishing and Military | 2 700 | 3 100 | 3 500 | 2 400 | 2 200 | 2 200 | 2 300 | 2 500 | 3 300 |
| Motorcycles | 1 600 | 1 700 | 1 800 | 1 800 | 1 900 | 2 000 | 2 000 | 2 000 | 2 100 |
| Off-Road Diesel Vehicles and Equipment | 53 000 | 53 000 | 37 000 | 19 000 | 18 000 | 15 000 | 16 000 | 17 000 | 17 000 |
| Off-Road Gasoline/LPG/NG Vehicles and Equipment | 760 000 | 580 000 | 350 000 | 140 000 | 140 000 | 110 000 | 120 000 | 120 000 | 120 000 |
| Rail Transportation | 6 700 | 6 200 | 6 100 | 5 100 | 4 500 | 3 800 | 4 200 | 4 300 | 4 300 |
| Tire Wear and Brake Lining | - | - | - | - | - | - | - | - | - |
| **AGRICULTURE** | **100 000** | **120 000** | **130 000** | **120 000** | **110 000** | **110 000** | **120 000** | **120 000** | **120 000** |
| Animal Production | 100 000 | 120 000 | 130 000 | 120 000 | 110 000 | 110 000 | 120 000 | 120 000 | 120 000 |
| Crop Production | - | - | - | - | - | - | - | - | - |
| Fuel Use | 81 | 91 | 82 | 200 | 190 | 200 | 190 | 190 | 150 |
| **COMMERCIAL/RESIDENTIAL/INSTITUTIONAL** | **260 000** | **230 000** | **200 000** | **180 000** | **180 000** | **170 000** | **170 000** | **170 000** | **170 000** |
| Commercial and Institutional Fuel Combustion | 1 000 | 1 400 | 1 400 | 1 300 | 1 300 | 1 300 | 1 400 | 1 400 | 1 500 |
| Commercial Cooking | 2 000 | 2 300 | 2 500 | 2 400 | 2 200 | 2 300 | 2 300 | 2 300 | 2 300 |
| Construction Fuel Combustion | 71 | 34 | 41 | 43 | 42 | 44 | 46 | 47 | 47 |
| Home Firewood Burning | 190 000 | 150 000 | 130 000 | 130 000 | 120 000 | 110 000 | 110 000 | 110 000 | 110 000 |
| Human | - | - | - | - | - | - | - | - | - |
| Marine Cargo Handling | 0.34 | 0.92 | 1.9 | - | - | - | - | - | - |
| Residential Fuel Combustion | 1 500 | 1 700 | 1 700 | 1 700 | 1 600 | 1 600 | 1 700 | 1 700 | 1 700 |
| Service Stations | 72 000 | 74 000 | 65 000 | 49 000 | 50 000 | 51 000 | 51 000 | 51 000 | 51 000 |
| Other (Miscellaneous) | - | - | - | - | - | - | - | - | - |
| **INCINERATION AND WASTE** | **19 000** | **21 000** | **21 000** | **16 000** | **16 000** | **17 000** | **17 000** | **17 000** | **18 000** |
| Crematoriums | 0.87 | 1.2 | 1.6 | 2.3 | 2.3 | 2.4 | 2.5 | 2.6 | 2.6 |
| Waste Incineration | 8 700 | 7 500 | 7 700 | 4 200 | 4 200 | 4 400 | 4 400 | 4 300 | 4 300 |
| Waste Treatment and Disposal | 10 000 | 13 000 | 13 000 | 12 000 | 12 000 | 12 000 | 12 000 | 13 000 | 13 000 |
| **PAINTS AND SOLVENTS** | **360 000** | **400 000** | **440 000** | **360 000** | **330 000** | **310 000** | **310 000** | **310 000** | **300 000** |
| Dry Cleaning | 740 | 790 | 220 | 270 | 190 | 200 | 200 | 190 | 190 |
| General Solvent Use | 190 000 | 260 000 | 280 000 | 260 000 | 240 000 | 230 000 | 220 000 | 220 000 | 210 000 |
| Printing | 37 000 | 48 000 | 55 000 | 24 000 | 24 000 | 22 000 | 22 000 | 24 000 | 24 000 |
| Surface Coatings | 130 000 | 89 000 | 100 000 | 74 000 | 64 000 | 62 000 | 63 000 | 67 000 | 66 000 |
| **DUST** | **-** | **-** | **-** | **-** | **-** | **-** | **-** | **-** | **-** |
| Coal Transportation | - | - | - | - | - | - | - | - | - |
| Construction Operations | - | - | - | - | - | - | - | - | - |
| Mine Tailings | - | - | - | - | - | - | - | - | - |
| Paved Roads | - | - | - | - | - | - | - | - | - |
| Unpaved Roads | - | - | - | - | - | - | - | - | - |
| **FIRES** | **41 000** | **4 200** | **3 400** | **8 100** | **5 900** | **4 900** | **2 900** | **1 800** | **3 200** |
| Prescribed Burning | 40 000 | 3 900 | 3 100 | 7 900 | 5 700 | 4 700 | 2 700 | 1 600 | 3 000 |
| Structural Fires | 390 | 310 | 280 | 220 | 210 | 210 | 210 | 220 | 210 |
| **GRAND TOTAL** | **2 900 000** | **2 700 000** | **2 300 000** | **1 900 000** | **1 800 000** | **1 600 000** | **1 700 000** | **1 700 000** | **1 700 000** |

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

**Other emissions estimated in the APEI**

| Source | 1990 | 2000 | 2005 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 |
|---|---|---|---|---|---|---|---|---|---|
| Domestic Air Transportation (Cruise) | 3 900 | 2 900 | 2 300 | 1 700 | 1 800 | 1 800 | 1 900 | 1 800 | 1 900 |
| International Air Transportation (Cruise) | 1 500 | 1 400 | 1 100 | 930 | 940 | 950 | 1 000 | 1 100 | 1 100 |
| International Marine Navigation | 3 100 | 4 400 | 5 200 | 4 700 | 4 600 | 4 500 | 4 400 | 4 500 | 4 900 |

Note: Refer to Annex 4.4 for more information.

## 2.5. Carbon Monoxide

In 2019, approximately 5.1 Mt of carbon monoxide (CO) were released in Canada (Table 2–7). Transportation and Mobile Equipment accounted for 61% (3.2 Mt) of total emissions, with the Light-Duty Gasoline Trucks and Vehicles sectors contributing 25% (1.3 Mt) and the Off-Road Gasoline/LPG/NG Vehicles and Equipment sector contributing 23% (1.2 Mt) of total CO emissions. The next-largest contributors are Commercial/Residential/Institutional sources, which in 2019 also accounted for 14% (701 kt) of emissions, mostly owing to contributions from Home Firewood Burning at 13% (660 kt) of total CO emissions. The Upstream Oil and Gas Industry and Aluminium Industry sectors were the largest-emitting industrial contributors, accounting for 10% (526 kt) and 7% (361 kt) of CO emissions, respectively.

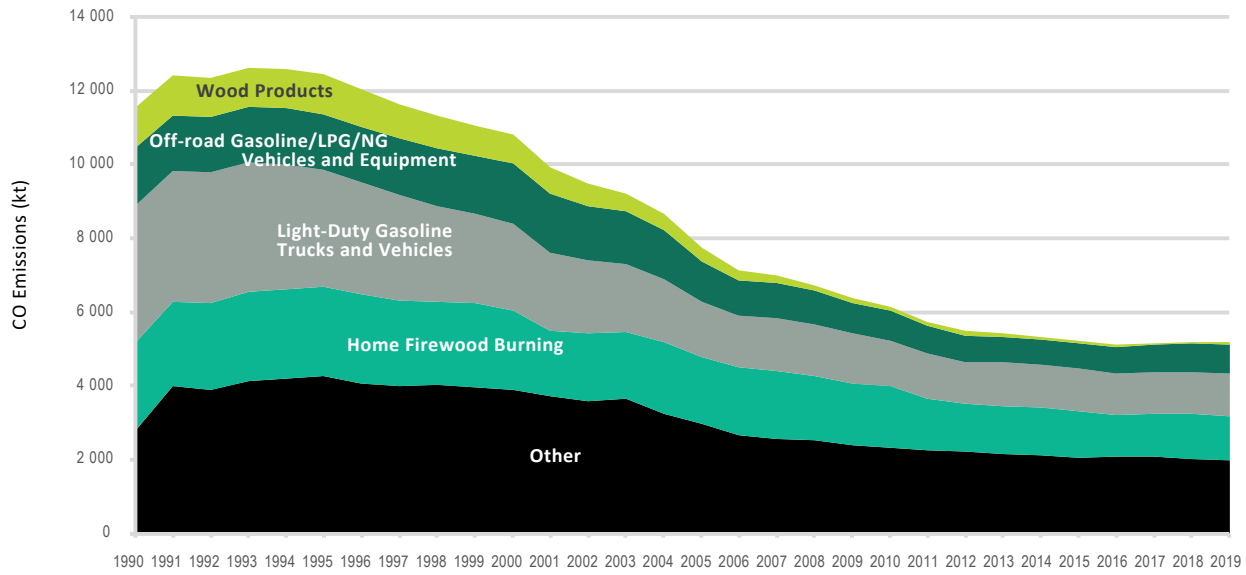
Between 1990 and 2019, CO emissions decreased by 55% (6.4 Mt) (Figure 2–5). Of the many contributors to the overall decrease in emissions, two in particular—Light-Duty Gasoline Trucks and Vehicles, and Off-Road Gasoline/LPG/NG Vehicles and Equipment (spark ignition engines)—had the largest impact on emission reductions. The decreasing emission trend in these sectors is due to increasingly stringent engine and vehicle regulations.[7] Emissions from Wood Products manufacturing declined from 1995 to 2019 due to the removal of incinerators at sawmill and panel board mill facilities that incinerated hog fuel. Furthermore, emissions from Home Firewood Burning gradually decreased across the time series, resulting from improved combustion efficiency in modern fireplace inserts, stoves and fireplaces (ECCC, 2020). Finally, the Upstream Oil and Gas Industry sector experienced an increase in CO emissions across the time series. This increase is attributed to expansion and growth in the oil and gas industry.

The most significant changes in CO emissions from 1990 to 2019 include:

- Transportation and Mobile Equipment: decrease of 61% (4.9 Mt), with:
  - Light-Duty Gasoline Trucks and Vehicles: decrease of 71% (3.2 Mt)
  - Off-Road Gasoline/LPG/NG Vehicles and Equipment: decrease of 49% (1.2 Mt)
- Manufacturing: decrease of 89% (1.2 Mt)
  - Wood Products: decrease of 95% (1.0 Mt)
- Commercial/Residential/Institutional: decrease of 17% (145 kt), with:
  - Home Firewood Burning: decrease of 19% (152 kt)
- Oil and Gas Industry: increase of 61% (204 kt), with:
  - Upstream Oil and Gas Industry: increase of 72% (220 kt)

7 See Chapter 1 for list of regulations.

Figure 2–5 **Trends in Canadian CO Emissions (1990 to 2019)**



## Table 2–7 National Summary of Annual CO Emissions

| Source | 1990 | 2000 | 2005 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 |
|---|---|---|---|---|---|---|---|---|---|
| | (tonnes) | | | | | | | | |
| **ORE AND MINERAL INDUSTRIES** | **390 000** | **400 000** | **500 000** | **510 000** | **510 000** | **560 000** | **590 000** | **530 000** | **500 000** |
| Aluminium Industry | 240 000 | 250 000 | 310 000 | 380 000 | 380 000 | 420 000 | 430 000 | 380 000 | 360 000 |
| Asphalt Paving Industry | 4 200 | 4 200 | 4 500 | 4 000 | 3 300 | 3 100 | 3 400 | 3 500 | 3 300 |
| Cement and Concrete Industry | 16 000 | 23 000 | 27 000 | 12 000 | 10 000 | 13 000 | 16 000 | 16 000 | 24 000 |
| 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 | 24 000 | 21 000 | 21 000 | 27 000 | 28 000 | 24 000 |
| Iron Ore Industry | 18 000 | 9 600 | 23 000 | 20 000 | 20 000 | 18 000 | 19 000 | 16 000 | 18 000 |
| Mineral Products Industry | 3 900 | 3 400 | 3 200 | 580 | 640 | 660 | 610 | 550 | 430 |
| Mining and Rock Quarrying | 14 000 | 14 000 | 10 000 | 15 000 | 13 000 | 14 000 | 26 000 | 19 000 | 19 000 |
| Non-Ferrous Refining and Smelting Industry | 280 | 360 | 13 000 | 13 000 | 13 000 | 17 000 | 15 000 | 15 000 | 1 500 |
| **OIL AND GAS INDUSTRY** | **340 000** | **440 000** | **490 000** | **550 000** | **560 000** | **540 000** | **550 000** | **570 000** | **540 000** |
| Downstream Oil and Gas Industry | 29 000 | 23 000 | 21 000 | 16 000 | 22 000 | 16 000 | 21 000 | 29 000 | 14 000 |
| Upstream Oil and Gas Industry | 310 000 | 420 000 | 470 000 | 530 000 | 540 000 | 520 000 | 530 000 | 540 000 | 530 000 |
| **ELECTRIC POWER GENERATION (UTILITIES)** | **50 000** | **43 000** | **52 000** | **40 000** | **40 000** | **38 000** | **42 000** | **36 000** | **29 000** |
| Coal | 41 000 | 18 000 | 25 000 | 15 000 | 16 000 | 16 000 | 19 000 | 15 000 | 11 000 |
| Diesel | 370 | 1 200 | 1 300 | 1 400 | 1 600 | 1 400 | 1 500 | 1 800 | 2 300 |
| Natural Gas | 4 400 | 17 000 | 17 000 | 15 000 | 15 000 | 12 000 | 14 000 | 12 000 | 10 000 |
| Waste Materials | 82 | 390 | 200 | 340 | 230 | 270 | 330 | 230 | 140 |
| Other (Electric Power Generation) | 4 400 | 7 200 | 8 500 | 7 900 | 7 200 | 7 900 | 7 700 | 6 100 | 5 500 |
| **MANUFACTURING** | **1 300 000** | **1 100 000** | **530 000** | **160 000** | **140 000** | **140 000** | **140 000** | **140 000** | **150 000** |
| Abrasives Manufacturing | 610 | 240 | 240 | - | - | - | - | - | - |
| Bakeries | 5.9 | 5.8 | 1.2 | 0.34 | 0.30 | 0.30 | 0.32 | - | - |
| Biofuel Production | - | - | - | - | - | - | - | 14 | 59 |
| Chemicals Industry | 27 000 | 30 000 | 18 000 | 15 000 | 15 000 | 16 000 | 16 000 | 14 000 | 16 000 |
| Electronics | 27 | 40 | 18 | - | - | 0.26 | - | - | - |
| Food Preparation | 1 200 | 1 400 | 1 600 | 980 | 1 200 | 1 200 | 1 300 | 1 300 | 1 200 |
| Glass Manufacturing | 490 | 570 | 690 | 280 | 300 | 280 | 300 | 300 | 290 |
| Grain Industry | 1 900 | 2 700 | 290 | 390 | 370 | 390 | 420 | 330 | 720 |
| Metal Fabrication | 8 800 | 8 700 | 7 700 | 1 900 | 1 200 | 1 100 | 1 200 | 1 300 | 1 100 |
| Plastics Manufacturing | 220 | 350 | 220 | 0.33 | 9.3 | 10 | 11 | 13 | 14 |
| Pulp and Paper Industry | 180 000 | 150 000 | 98 000 | 64 000 | 69 000 | 73 000 | 78 000 | 82 000 | 80 000 |
| Textiles | 45 | 78 | 53 | 0.063 | 0.069 | 0.071 | 0.069 | 0.097 | 0.22 |
| Vehicle Manufacturing (Engines, Parts, Assembly, Painting) | 3 800 | 4 000 | 2 900 | 930 | 750 | 880 | 920 | 930 | 910 |
| Wood Products | 1 100 000 | 790 000 | 390 000 | 73 000 | 51 000 | 43 000 | 40 000 | 35 000 | 53 000 |
| Other (Manufacturing) | 31 000 | 61 000 | 11 000 | 540 | 560 | 610 | 550 | 540 | 520 |
| **TRANSPORTATION AND MOBILE EQUIPMENT** | **8 100 000** | **7 300 000** | **5 100 000** | **3 100 000** | **3 100 000** | **3 000 000** | **3 100 000** | **3 100 000** | **3 200 000** |
| Air Transportation (LTO) | 30 000 | 23 000 | 21 000 | 25 000 | 27 000 | 28 000 | 27 000 | 27 000 | 30 000 |
| Heavy-Duty Diesel Vehicles | 34 000 | 63 000 | 91 000 | 70 000 | 63 000 | 61 000 | 65 000 | 68 000 | 68 000 |
| Heavy-Duty Gasoline Vehicles | 590 000 | 1 100 000 | 830 000 | 410 000 | 380 000 | 400 000 | 410 000 | 420 000 | 420 000 |
| Heavy-Duty LPG/NG Vehicles | 130 000 | 310 000 | 67 000 | 630 | 640 | 860 | 1 500 | 1 500 | 1 400 |
| Light-Duty Diesel Trucks | 13 000 | 15 000 | 20 000 | 13 000 | 16 000 | 17 000 | 20 000 | 22 000 | 22 000 |
| Light-Duty Diesel Vehicles | 29 000 | 17 000 | 9 300 | 8 700 | 9 200 | 8 600 | 8 600 | 8 300 | 8 000 |
| Light-Duty Gasoline Trucks | 1 600 000 | 1 600 000 | 1 100 000 | 680 000 | 690 000 | 730 000 | 750 000 | 780 000 | 800 000 |
| Light-Duty Gasoline Vehicles | 2 900 000 | 1 700 000 | 950 000 | 520 000 | 510 000 | 520 000 | 500 000 | 490 000 | 480 000 |
| Light-Duty LPG/NG Trucks | 140 000 | 54 000 | 24 000 | 270 | 240 | 260 | 310 | 310 | 300 |
| Light-Duty LPG/NG Vehicles | 14 000 | 6 000 | 2 300 | 7.7 | 7.3 | 8.9 | 12 | 12 | 11 |
| Domestic Marine Navigation, Fishing and Military | 5 700 | 6 700 | 7 400 | 5 700 | 5 400 | 5 600 | 5 800 | 6 200 | 7 600 |
| Motorcycles | 12 000 | 14 000 | 15 000 | 13 000 | 13 000 | 13 000 | 14 000 | 14 000 | 14 000 |
| Off-Road Diesel Vehicles and Equipment | 220 000 | 240 000 | 170 000 | 93 000 | 88 000 | 69 000 | 75 000 | 81 000 | 80 000 |
| Off-Road Gasoline/LPG/NG Vehicles and Equipment | 2 400 000 | 2 100 000 | 1 800 000 | 1 300 000 | 1 300 000 | 1 100 000 | 1 200 000 | 1 200 000 | 1 200 000 |
| Rail Transportation | 16 000 | 15 000 | 15 000 | 18 000 | 17 000 | 16 000 | 18 000 | 18 000 | 19 000 |
| Tire Wear and Brake Lining | - | - | - | - | - | - | - | - | - |
| **AGRICULTURE** | **630** | **690** | **520** | **1 400** | **1 300** | **1 300** | **1 300** | **1 300** | **980** |
| Animal Production | - | - | - | - | - | - | - | - | - |
| Crop Production | - | - | - | - | - | - | - | - | - |
| Fuel Use | 630 | 690 | 520 | 1 400 | 1 300 | 1 300 | 1 300 | 1 300 | 980 |
| **COMMERCIAL/RESIDENTIAL/INSTITUTIONAL** | **850 000** | **690 000** | **600 000** | **700 000** | **680 000** | **650 000** | **650 000** | **690 000** | **700 000** |
| Commercial and Institutional Fuel Combustion | 15 000 | 19 000 | 19 000 | 19 000 | 18 000 | 18 000 | 20 000 | 21 000 | 21 000 |
| Commercial Cooking | 5 700 | 6 400 | 7 100 | 6 700 | 6 300 | 6 300 | 6 400 | 6 400 | 6 400 |
| Construction Fuel Combustion | 670 | 360 | 460 | 440 | 440 | 450 | 460 | 480 | 480 |
| Home Firewood Burning | 810 000 | 650 000 | 560 000 | 660 000 | 640 000 | 610 000 | 610 000 | 650 000 | 660 000 |
| Human | - | - | - | - | - | - | - | - | - |
| Marine Cargo Handling | 0.16 | 0.050 | - | - | - | - | - | - | - |
| Residential Fuel Combustion | 13 000 | 13 000 | 13 000 | 13 000 | 12 000 | 12 000 | 13 000 | 13 000 | 13 000 |
| Service Stations | - | - | - | - | - | - | - | - | - |
| Other (Miscellaneous) | - | - | - | - | - | - | - | - | - |
| **INCINERATION AND WASTE** | **42 000** | **26 000** | **24 000** | **15 000** | **15 000** | **15 000** | **16 000** | **17 000** | **16 000** |
| Crematoriums | 6.7 | 9.4 | 12 | 17 | 18 | 19 | 20 | 20 | 20 |
| Waste Incineration | 39 000 | 23 000 | 20 000 | 13 000 | 13 000 | 13 000 | 13 000 | 13 000 | 14 000 |
| Waste Treatment and Disposal | 3 300 | 2 800 | 3 700 | 2 700 | 2 600 | 2 400 | 2 400 | 3 500 | 2 300 |
| **PAINTS AND SOLVENTS** | **23** | **73** | **20** | **-** | **-** | **-** | **-** | **-** | **-** |
| Dry Cleaning | 0.95 | 0.81 | - | - | - | - | - | - | - |
| General Solvent Use | - | - | - | - | - | - | - | - | - |
| Printing | 22 | 72 | 20 | - | - | - | - | - | - |
| Surface Coatings | 0.10 | 0.10 | - | - | - | - | - | - | - |
| **DUST** | **-** | **-** | **-** | **-** | **-** | **-** | **-** | **-** | **-** |
| Coal Transportation | - | - | - | - | - | - | - | - | - |
| Construction Operations | - | - | - | - | - | - | - | - | - |
| Mine Tailings | - | - | - | - | - | - | - | - | - |
| Paved Roads | - | - | - | - | - | - | - | - | - |
| Unpaved Roads | - | - | - | - | - | - | - | - | - |
| **FIRES** | **440 000** | **78 000** | **52 000** | **140 000** | **130 000** | **120 000** | **52 000** | **30 000** | **36 000** |
| Prescribed Burning | 440 000 | 76 000 | 51 000 | 140 000 | 130 000 | 120 000 | 51 000 | 29 000 | 35 000 |
| Structural Fires | 2 100 | 1 700 | 1 500 | 1 200 | 1 100 | 1 100 | 1 200 | 1 200 | 1 200 |
| **GRAND TOTAL** | **12 000 000** | **10 000 000** | **7 400 000** | **5 300 000** | **5 200 000** | **5 100 000** | **5 100 000** | **5 100 000** | **5 100 000** |

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

**Other emissions estimated in the APEI**

| Source | 1990 | 2000 | 2005 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 |
|---|---|---|---|---|---|---|---|---|---|
| Domestic Air Transportation (Cruise) | 110 000 | 77 000 | 72 000 | 35 000 | 38 000 | 39 000 | 38 000 | 32 000 | 35 000 |
| International Air Transportation (Cruise) | 12 000 | 9 900 | 8 400 | 7 800 | 8 100 | 8 500 | 9 000 | 9 400 | 9 600 |
| International Marine Navigation | 6 900 | 10 000 | 12 000 | 11 000 | 11 000 | 11 000 | 10 000 | 10 000 | 11 000 |

Note: Refer to Annex 4.4 for more information.

## 2.6. **Ammonia**

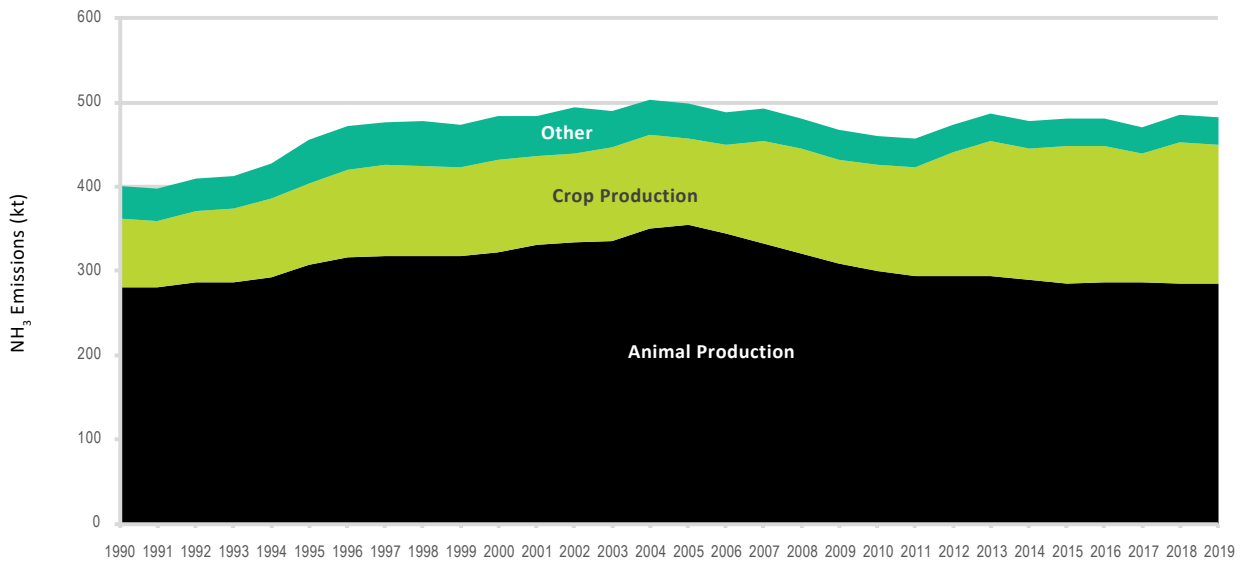
In 2019, approximately 483 kt of ammonia ($NH_3$) were released in Canada (Table 2–8). $NH_3$ emissions originated primarily from Agriculture, which accounted for 93% (450 kt) of total emissions. All other sources combined accounted for only 7% of emissions.

From 1990 to 2019, Canada's $NH_3$ emissions increased by 20% (81 kt) (Figure 2–6); $NH_3$ emissions peaked in 2004 and have since fluctuated. This trend is driven by emissions from the Animal Production sector and the 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 2012, 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 2019 include:

- Agriculture: increase of 24% (87 kt), with:
  - Crop Production: increase of 103% (84 kt)
  - Animal Production: increase of 1% (3.4 kt)
- Other sources, dominated by Manufacturing, Transportation and Mobile Equipment and Oil and Gas Industry:
  - Manufacturing: decrease of 44% (8.9 kt)
  - Transportation and Mobile Equipment and Oil and Gas Industry: increase of 79% (4.8 kt)

Figure 2–6 **Trends in Canadian $NH_3$ Emissions (1990 to 2019)**



## Table 2–8 National Summary of Annual $NH_3$ Emissions

| Source | 1990 | 2000 | 2005 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 |
|---|---|---|---|---|---|---|---|---|---|
| | (tonnes) | | | | | | | | |
| **ORE AND MINERAL INDUSTRIES** | **1 800** | **2 200** | **1 200** | **1 300** | **1 200** | **1 200** | **1 300** | **1 500** | **1 500** |
| Aluminium Industry | 29 | 34 | 13 | - | - | - | - | - | - |
| Asphalt Paving Industry | 0.59 | 1.2 | 1.2 | - | - | - | - | - | - |
| Cement and Concrete Industry | 600 | 630 | 340 | 440 | 480 | 360 | 380 | 480 | 490 |
| Foundries | 12 | 13 | 8.5 | - | - | - | - | - | - |
| Iron and Steel Industry | 180 | 230 | 86 | 89 | 59 | 56 | 55 | 58 | 61 |
| Iron Ore Industry | 160 | 160 | 23 | - | - | - | - | - | - |
| Mineral Products Industry | 83 | 100 | 96 | 430 | 330 | 400 | 290 | 250 | 180 |
| Mining and Rock Quarrying | 510 | 540 | 82 | 67 | 52 | 97 | 83 | 120 | 77 |
| Non-Ferrous Refining and Smelting Industry | 210 | 460 | 520 | 310 | 290 | 330 | 470 | 580 | 730 |
| **OIL AND GAS INDUSTRY** | **650** | **1 800** | **2 500** | **2 700** | **2 200** | **2 400** | **2 600** | **2 600** | **2 900** |
| Downstream Oil and Gas Industry | 360 | 250 | 110 | 78 | 68 | 55 | 58 | 92 | 46 |
| Upstream Oil and Gas Industry | 290 | 1 500 | 2 400 | 2 600 | 2 100 | 2 300 | 2 600 | 2 500 | 2 900 |
| **ELECTRIC POWER GENERATION (UTILITIES)** | **710** | **1 400** | **990** | **760** | **380** | **350** | **240** | **230** | **220** |
| Coal | 62 | 110 | 530 | 610 | 170 | 170 | 170 | 130 | 55 |
| Diesel | 3.7 | 6.0 | 2.8 | - | - | - | - | - | - |
| Natural Gas | 270 | 700 | 180 | 95 | 130 | 100 | 7.0 | 35 | 100 |
| Waste Materials | 0.26 | 1.7 | - | - | 5.3 | 11 | 12 | 10 | - |
| Other (Electric Power Generation) | 380 | 620 | 280 | 62 | 70 | 62 | 45 | 56 | 63 |
| **MANUFACTURING** | **20 000** | **25 000** | **17 000** | **11 000** | **12 000** | **12 000** | **11 000** | **12 000** | **11 000** |
| Abrasives Manufacturing | 0.76 | 0.76 | 0.12 | - | - | - | - | - | - |
| Bakeries | 0.11 | 0.11 | - | - | 0.34 | - | - | - | - |
| Biofuel Production | - | - | - | - | - | - | - | - | - |
| Chemicals Industry | 9 800 | 15 000 | 11 000 | 8 500 | 9 000 | 9 300 | 8 500 | 9 300 | 8 700 |
| Electronics | 31 | 78 | 57 | 17 | 19 | 18 | 16 | 16 | 15 |
| Food Preparation | 180 | 330 | 300 | 270 | 240 | 220 | 250 | 240 | 300 |
| Glass Manufacturing | 88 | 110 | 120 | - | - | - | - | - | - |
| Grain Industry | 6.2 | 6.7 | 0.84 | 7.6 | 5.0 | 5.7 | 5.5 | 4.9 | 6.1 |
| Metal Fabrication | 93 | 210 | 40 | 2.4 | 25 | 25 | 27 | 27 | 27 |
| Plastics Manufacturing | 31 | 32 | 4.8 | - | - | - | - | - | - |
| Pulp and Paper Industry | 4 400 | 3 600 | 2 600 | 1 600 | 1 600 | 1 700 | 1 700 | 1 600 | 1 400 |
| Textiles | 13 | 28 | 16 | - | - | - | - | - | - |
| Vehicle Manufacturing (Engines, Parts, Assembly, Painting) | 73 | 180 | 47 | - | 2.3 | 2.2 | 6.5 | 6.5 | 6.5 |
| Wood Products | 4 800 | 4 800 | 2 600 | 800 | 780 | 780 | 710 | 700 | 630 |
| Other (Manufacturing) | 500 | 360 | 180 | 22 | 32 | 30 | 18 | 40 | 45 |
| **TRANSPORTATION AND MOBILE EQUIPMENT** | **5 400** | **11 000** | **11 000** | **7 600** | **7 500** | **7 700** | **7 700** | **7 900** | **8 000** |
| Air Transportation (LTO) | 4.4 | 4.5 | 4.3 | 4.2 | 4.3 | 4.4 | 4.5 | 4.9 | 5.0 |
| Heavy-Duty Diesel Vehicles | 210 | 390 | 560 | 750 | 730 | 710 | 750 | 790 | 790 |
| Heavy-Duty Gasoline Vehicles | 160 | 250 | 270 | 310 | 310 | 330 | 330 | 340 | 340 |
| Heavy-Duty LPG/NG Vehicles | 55 | 170 | 21 | 0.88 | 1.1 | 1.3 | 2.0 | 2.0 | 1.9 |
| Light-Duty Diesel Trucks | 2.4 | 4.6 | 4.6 | 10 | 13 | 15 | 18 | 20 | 20 |
| Light-Duty Diesel Vehicles | 10 | 11 | 11 | 17 | 18 | 17 | 17 | 16 | 16 |
| Light-Duty Gasoline Trucks | 1 100 | 3 700 | 3 700 | 2 900 | 2 900 | 3 100 | 3 200 | 3 300 | 3 400 |
| Light-Duty Gasoline Vehicles | 3 300 | 6 300 | 5 600 | 3 200 | 3 000 | 3 000 | 3 000 | 2 900 | 2 800 |
| Light-Duty LPG/NG Trucks | 77 | 110 | 82 | 0.96 | 0.85 | 0.93 | 1.1 | 1.1 | 1.1 |
| Light-Duty LPG/NG Vehicles | 14 | 21 | 14 | 0.0 | 0.0 | 0.0 | 0.064 | 0.064 | 0.062 |
| Domestic Marine Navigation, Fishing and Military | 68 | 81 | 91 | 86 | 86 | 88 | 92 | 98 | 110 |
| Motorcycles | 4.4 | 7.0 | 12 | 35 | 37 | 39 | 40 | 41 | 41 |
| Off-Road Diesel Vehicles and Equipment | 170 | 210 | 200 | 190 | 200 | 180 | 200 | 220 | 220 |
| Off-Road Gasoline/LPG/NG Vehicles and Equipment | 170 | 130 | 91 | 88 | 89 | 88 | 92 | 94 | 92 |
| Rail Transportation | 51 | 48 | 48 | 56 | 53 | 49 | 56 | 58 | 58 |
| Tire Wear and Brake Lining | - | - | - | - | - | - | - | - | - |
| **AGRICULTURE** | **360 000** | **430 000** | **460 000** | **450 000** | **450 000** | **450 000** | **440 000** | **450 000** | **450 000** |
| Animal Production | 280 000 | 320 000 | 350 000 | 290 000 | 290 000 | 290 000 | 290 000 | 290 000 | 280 000 |
| Crop Production | 82 000 | 110 000 | 100 000 | 160 000 | 160 000 | 160 000 | 150 000 | 170 000 | 170 000 |
| Fuel Use | 44 | 41 | 28 | 52 | 45 | 45 | 45 | 44 | 43 |
| **COMMERCIAL/RESIDENTIAL/INSTITUTIONAL** | **2 700** | **2 400** | **2 300** | **2 300** | **2 300** | **2 200** | **2 200** | **2 300** | **2 400** |
| Commercial and Institutional Fuel Combustion | 310 | 340 | 320 | 220 | 210 | 200 | 200 | 200 | 210 |
| Commercial Cooking | - | - | - | - | - | - | - | - | - |
| Construction Fuel Combustion | 70 | 38 | 50 | 44 | 44 | 44 | 45 | 46 | 46 |
| Home Firewood Burning | 1 100 | 960 | 840 | 1 100 | 1 100 | 1 000 | 1 100 | 1 100 | 1 200 |
| Human | 470 | 520 | 540 | 600 | 600 | 610 | 610 | 620 | 630 |
| Marine Cargo Handling | 0.0 | - | - | - | - | - | - | - | - |
| Residential Fuel Combustion | 690 | 560 | 530 | 370 | 360 | 340 | 330 | 340 | 330 |
| Service Stations | - | - | - | - | - | - | - | - | - |
| Other (Miscellaneous) | - | - | - | - | - | - | - | - | - |
| **INCINERATION AND WASTE** | **6 200** | **7 200** | **6 700** | **6 400** | **6 300** | **6 500** | **6 000** | **6 100** | **6 200** |
| Crematoriums | - | - | - | - | - | - | - | - | - |
| Waste Incineration | 190 | 210 | 330 | 150 | 150 | 150 | 150 | 150 | 150 |
| Waste Treatment and Disposal | 6 000 | 6 900 | 6 300 | 6 300 | 6 100 | 6 400 | 5 900 | 5 900 | 6 100 |
| **PAINTS AND SOLVENTS** | **14** | **14** | **0.88** | **-** | **-** | **-** | **-** | **-** | **-** |
| Dry Cleaning | 0.0 | 0.0 | - | - | - | - | - | - | - |
| General Solvent Use | - | - | - | - | - | - | - | - | - |
| Printing | 14 | 14 | 0.88 | - | - | - | - | - | - |
| Surface Coatings | 0.080 | 0.080 | - | - | - | - | - | - | - |
| **DUST** | **-** | **-** | **-** | **-** | **-** | **-** | **-** | **-** | **-** |
| Coal Transportation | - | - | - | - | - | - | - | - | - |
| Construction Operations | - | - | - | - | - | - | - | - | - |
| Mine Tailings | - | - | - | - | - | - | - | - | - |
| Paved Roads | - | - | - | - | - | - | - | - | - |
| Unpaved Roads | - | - | - | - | - | - | - | - | - |
| **FIRES** | **1 100** | **130** | **100** | **240** | **180** | **150** | **93** | **60** | **95** |
| Prescribed Burning | 1 100 | 110 | 88 | 230 | 170 | 140 | 81 | 48 | 83 |
| Structural Fires | 22 | 17 | 16 | 13 | 12 | 12 | 12 | 12 | 12 |
| **GRAND TOTAL** | **400 000** | **480 000** | **500 000** | **480 000** | **480 000** | **480 000** | **470 000** | **490 000** | **480 000** |

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

**Other emissions estimated in the APEI**

| Source | 1990 | 2000 | 2005 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 |
|---|---|---|---|---|---|---|---|---|---|
| Domestic Air Transportation (Cruise) | 15 | 14 | 14 | 13 | 13 | 13 | 14 | 14 | 14 |
| International Air Transportation (Cruise) | 10 | 17 | 18 | 20 | 21 | 22 | 24 | 27 | 28 |
| International Marine Navigation | 94 | 140 | 160 | 160 | 160 | 160 | 150 | 150 | 170 |

Note: Refer to Annex 4.4 for more information.

## 2.7. **Lead**

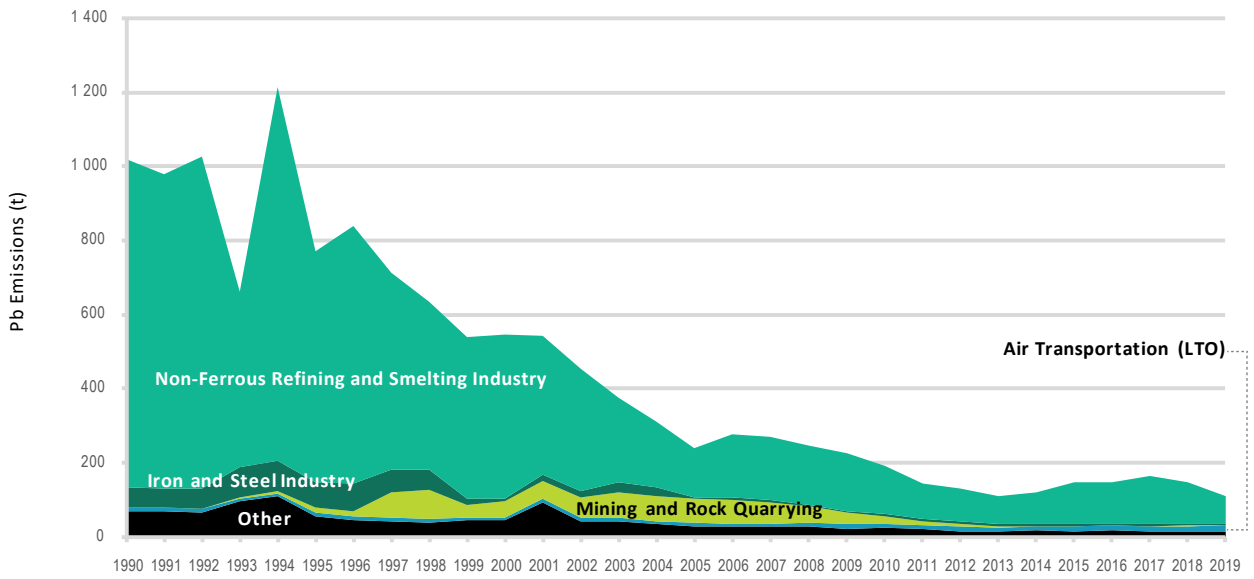
In 2019, approximately 110 tonnes (t) of lead (Pb) were emitted in Canada (Table 2–9). Ore and Mineral Industries was the largest contributor at 77% (85 t) of emissions, with the Non-Ferrous Refining and Smelting Industry sector accounting for the largest share at 67% (73 t) of total Pb emissions. Transportation and Mobile Equipment was the second-largest contributor at 14% (15 t) of total emissions, almost all of which was from Air Transportation (Landing and Takeoff [LTO]) with 13 % (15 t).

Overall, Pb emissions decreased by 89% (911 t) from 1990 to 2019 (Figure 2–7). This decreasing trend is attributable partly to the closure of outdated smelters and partly to the implementation, since 2005, of pollution prevention plans and facilities achieving Base Level Industrial Emission Requirements (BLIERs) for particulate matters through environmental performance agreements (ECCC, 2017; ECCC, 2018). Although, since 2013, Pb emissions attributed to the Non-Ferrous Refining and Smelting Industry sector have fluctuated, in general the trend is decreasing. It should also be noted that even though BLIERs were written with focus on particulate matters, reduction of Pb emissions over the years has been an additional positive outcome. Manufacturing has contributed to the decreasing trend, with the Metal Fabrication and Chemicals Industry sectors as the largest drivers. Reduced production of lead-containing products has partly contributed to decreases in emissions from the Metal Fabrication sector over the time series. The downward trend of Chemicals Industry sector emissions is attributable partly to the closure of a tetraethyl lead production facility and partly to reduced production of lead-based paint and coatings.

The most significant changes in Pb emissions from 1990 to 2019 include:

- Ore and Mineral Industries: decrease of 91% (860 t), with:
  - Non-Ferrous Refining and Smelting Industry: decrease of 92% (813 t)
  - Iron and Steel Industry: decrease of 91% (49 t)
- Manufacturing: decrease of 89% (43 t), with:
  - Metal Fabrication: decrease of 90% (25 t)
  - Chemicals Industry: decrease of almost 100% (12 t)

Figure 2–7 **Trends in Canadian Pb Emissions (1990 to 2019)**



## Table 2–9 National Summary of Annual Pb Emissions

| Source | 1990 | 2000 | 2005 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 |
|---|---|---|---|---|---|---|---|---|---|
| | (kg) | | | | | | | | |
| **ORE AND MINERAL INDUSTRIES** | **940 000** | **500 000** | **210 000** | **97 000** | **120 000** | **120 000** | **140 000** | **120 000** | **85 000** |
| Aluminium Industry | 84 | 84 | - | - | - | - | - | - | - |
| Asphalt Paving Industry | 1 400 | 1 200 | 1 200 | 1 100 | 1 100 | 1 000 | 1 000 | 1 000 | 1 000 |
| Cement and Concrete Industry | 550 | 610 | 960 | 600 | 870 | 700 | 570 | 400 | 500 |
| Foundries | 2 000 | 6 600 | 1 600 | 190 | 210 | 200 | 170 | 210 | 660 |
| Iron and Steel Industry | 54 000 | 8 000 | 5 700 | 6 100 | 5 500 | 5 200 | 5 100 | 6 200 | 4 900 |
| Iron Ore Industry | - | - | - | 2 700 | 2 600 | 3 300 | 3 800 | 2 900 | 3 100 |
| Mineral Products Industry | - | - | 0.19 | - | - | 15 | - | - | - |
| Mining and Rock Quarrying | - | 42 000 | 65 000 | 900 | 980 | 1 100 | 1 200 | 1 800 | 1 300 |
| Non-Ferrous Refining and Smelting Industry | 890 000 | 440 000 | 130 000 | 85 000 | 110 000 | 110 000 | 130 000 | 110 000 | 73 000 |
| **OIL AND GAS INDUSTRY** | **340** | **300** | **720** | **670** | **510** | **580** | **520** | **570** | **490** |
| Downstream Oil and Gas Industry | 200 | 81 | 450 | 300 | 320 | 380 | 350 | 400 | 310 |
| Upstream Oil and Gas Industry | 140 | 220 | 260 | 370 | 190 | 200 | 160 | 170 | 180 |
| **ELECTRIC POWER GENERATION (UTILITIES)** | **11 000** | **15 000** | **1 900** | **1 800** | **1 500** | **1 400** | **1 700** | **1 300** | **1 500** |
| Coal | 8 300 | 11 000 | 1 300 | 1 200 | 820 | 770 | 1 100 | 810 | 1 000 |
| Diesel | - | - | - | - | - | - | - | - | - |
| Natural Gas | 430 | 530 | 72 | 93 | 97 | 86 | 91 | 83 | 91 |
| Waste Materials | - | - | - | - | 0.44 | 0.37 | 0.35 | 0.36 | 0.43 |
| Other (Electric Power Generation) | 2 600 | 3 200 | 590 | 490 | 530 | 560 | 540 | 380 | 390 |
| **MANUFACTURING** | **48 000** | **16 000** | **17 000** | **6 500** | **5 900** | **6 500** | **3 700** | **6 800** | **5 300** |
| Abrasives Manufacturing | - | - | - | - | - | - | - | - | - |
| Bakeries | - | - | - | - | - | - | - | - | - |
| Biofuel Production | - | - | - | - | - | - | - | - | - |
| Chemicals Industry | 12 000 | 300 | 1 800 | 82 | 120 | 45 | 59 | 30 | 16 |
| Electronics | 2 000 | 710 | 96 | 18 | 17 | 19 | 22 | 23 | 18 |
| Food Preparation | - | - | - | - | - | - | - | - | 0.15 |
| Glass Manufacturing | 22 | 7.4 | 25 | 0.0 | 0.0 | 0.0 | - | - | - |
| Grain Industry | - | - | - | - | - | - | - | - | - |
| Metal Fabrication | 28 000 | 9 200 | 10 000 | 3 600 | 1 900 | 3 200 | 1 800 | 3 300 | 2 800 |
| Plastics Manufacturing | 76 | 46 | 21 | 4.7 | 4.8 | 4.8 | 1.3 | 1.3 | 1.3 |
| Pulp and Paper Industry | 2 100 | 840 | 2 400 | 2 200 | 3 400 | 2 800 | 1 300 | 1 500 | 1 300 |
| Textiles | - | 0.38 | 0.0 | - | - | - | - | - | - |
| Vehicle Manufacturing (Engines, Parts, Assembly, Painting) | 960 | 2 400 | 770 | 68 | 68 | 66 | 69 | 64 | 85 |
| Wood Products | 3 500 | 2 500 | 1 400 | 530 | 330 | 330 | 390 | 1 900 | 1 100 |
| Other (Manufacturing) | - | 220 | 98 | 32 | 25 | 39 | 9.3 | 6.7 | 14 |
| **TRANSPORTATION AND MOBILE EQUIPMENT** | **14 000** | **10 000** | **9 600** | **11 000** | **13 000** | **14 000** | **14 000** | **13 000** | **15 000** |
| Air Transportation (LTO) | 13 000 | 9 400 | 8 900 | 11 000 | 13 000 | 14 000 | 13 000 | 12 000 | 15 000 |
| 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 | - | - | - | - | - | - | - | - | - |
| Domestic Marine Navigation, Fishing and Military | 340 | 380 | 420 | 370 | 170 | 170 | 180 | 190 | 220 |
| Motorcycles | - | - | - | - | - | - | - | - | - |
| Off-Road Diesel Vehicles and Equipment | - | - | - | - | - | - | - | - | - |
| Off-Road Gasoline/LPG/NG Vehicles and Equipment | - | - | - | - | - | - | - | - | - |
| Rail Transportation | 310 | 290 | 290 | 200 | 170 | 150 | 160 | 170 | 170 |
| Tire Wear and Brake Lining | - | - | - | - | - | - | - | - | - |
| **AGRICULTURE** | **30** | **30** | **26** | **84** | **70** | **68** | **67** | **62** | **50** |
| Animal Production | - | - | - | - | - | - | - | - | - |
| Crop Production | - | - | - | - | - | - | - | - | - |
| Fuel Use | 30 | 30 | 26 | 84 | 70 | 68 | 67 | 62 | 50 |
| **COMMERCIAL/RESIDENTIAL/INSTITUTIONAL** | **2 600** | **3 200** | **3 300** | **2 200** | **2 200** | **2 100** | **2 100** | **2 200** | **2 200** |
| Commercial and Institutional Fuel Combustion | 250 | 290 | 420 | 230 | 250 | 240 | 240 | 210 | 220 |
| Commercial Cooking | - | - | - | - | - | - | - | - | - |
| Construction Fuel Combustion | 10 | 4.9 | 11 | 7.3 | 7.7 | 6.7 | 7.1 | 7.2 | 7.8 |
| Home Firewood Burning | 1 900 | 1 500 | 1 300 | 1 700 | 1 600 | 1 500 | 1 500 | 1 700 | 1 700 |
| Human | - | - | - | - | - | - | - | - | - |
| Marine Cargo Handling | - | 970 | 1 200 | 20 | 9.8 | 41 | 51 | 50 | 61 |
| Residential Fuel Combustion | 490 | 410 | 390 | 290 | 270 | 260 | 250 | 260 | 250 |
| Service Stations | - | - | - | - | - | - | - | - | - |
| Other (Miscellaneous) | - | - | - | - | - | - | - | - | - |
| **INCINERATION AND WASTE** | **210** | **150** | **390** | **210** | **190** | **250** | **240** | **250** | **230** |
| Crematoriums | 2.0 | 2.8 | 3.6 | 5.2 | 5.3 | 5.6 | 5.9 | 6.1 | 6.1 |
| Waste Incineration | 200 | 150 | 300 | 180 | 170 | 160 | 160 | 160 | 160 |
| Waste Treatment and Disposal | - | - | 85 | 22 | 12 | 80 | 69 | 88 | 60 |
| **PAINTS AND SOLVENTS** | **-** | **-** | **-** | **0.0** | **-** | **-** | **-** | **-** | **-** |
| Dry Cleaning | - | - | - | - | - | - | - | - | - |
| General Solvent Use | - | - | - | - | - | - | - | - | - |
| Printing | - | - | - | - | - | - | - | - | - |
| Surface Coatings | - | - | - | 0.0 | - | - | - | - | - |
| **DUST** | **-** | **-** | **-** | **-** | **-** | **-** | **-** | **-** | **-** |
| Coal Transportation | - | - | - | - | - | - | - | - | - |
| Construction Operations | - | - | - | - | - | - | - | - | - |
| Mine Tailings | - | - | - | - | - | - | - | - | - |
| Paved Roads | - | - | - | - | - | - | - | - | - |
| Unpaved Roads | - | - | - | - | - | - | - | - | - |
| **FIRES** | **-** | **-** | **-** | **-** | **-** | **-** | **-** | **-** | **-** |
| Prescribed Burning | - | - | - | - | - | - | - | - | - |
| Structural Fires | - | - | - | - | - | - | - | - | - |
| **GRAND TOTAL** | **1 000 000** | **550 000** | **240 000** | **120 000** | **150 000** | **150 000** | **160 000** | **150 000** | **110 000** |

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

**Other emissions estimated in the APEI**

| Source | 1990 | 2000 | 2005 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 |
|---|---|---|---|---|---|---|---|---|---|
| Domestic Air Transportation (Cruise) | 66 000 | 43 000 | 40 000 | 17 000 | 20 000 | 20 000 | 20 000 | 15 000 | 18 000 |
| International Air Transportation (Cruise) | 3 300 | 1 600 | 890 | 730 | 750 | 820 | 720 | 590 | 740 |
| International Marine Navigation | 260 | 360 | 410 | 780 | 340 | 330 | 320 | 320 | 350 |

Note: Refer to Annex 4.4 for more information.

## 2.8. **Cadmium**

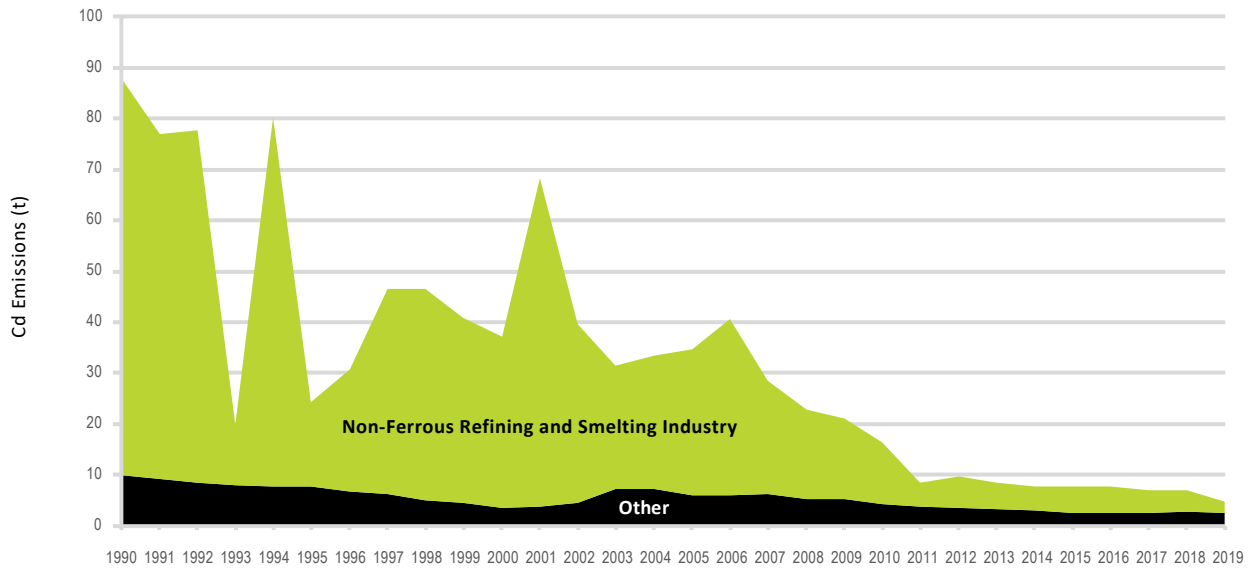
Approximately 4.8 t of cadmium (Cd) were emitted in Canada in 2019 (Table 2–10). Ore and Mineral Industries accounted for 54% (2.6 t) of national emissions, with the Non-Ferrous Refining and Smelting Industry sector contributing 47% (2.3 t) of the total. Commercial/Residential/Institutional fuel combustion sources contributed 23% (1.1 t) of total Cd emissions.

From 1990 to 2019, national Cd emissions decreased by 95% (83 t) (Figure 2–8). This trend is almost entirely driven by the Non-Ferrous Refining and Smelting Industry sector. Emissions from this industry fluctuated greatly between 1990 and 2006, but decreased steadily from 2007 onward. As with Pb emissions, reductions in Cd emissions coincide with the closure of outdated smelters, the implementation of pollution prevention plans and facilities achieving Base Level Industrial Emission Requirements (BLIERs) for particulate matter through Environmental Performance Agreements (ECCC, 2017; ECCC, 2018). Even though BLIERs were written with focus on particulate matters, reduction of Cd emissions over the years has been an additional positive outcome. Fluctuations in emissions prior to 2010 are almost entirely driven by emissions from a single smelter in Manitoba that is now closed.

The most significant changes in Cd emissions from 1990 to 2019 include:

- Ore and Mineral Industries: decrease of 97% (76 t), with:
  - Non-Ferrous Refining and Smelting Industry: decrease of 97% (76 t)

Figure 2–8 **Trends in Canadian Cd Emissions (1990 to 2019)**



## Table 2–10 National Summary of Annual Cd Emissions

| Source | 1990 | 2000 | 2005 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 |
|---|---|---|---|---|---|---|---|---|---|
| | (kg) | | | | | | | | |
| **ORE AND MINERAL INDUSTRIES** | **79 000** | **34 000** | **32 000** | **5 400** | **5 400** | **5 500** | **4 700** | **4 700** | **2 600** |
| Aluminium Industry | 0.67 | 0.98 | - | - | - | - | - | - | - |
| Asphalt Paving Industry | 26 | 24 | 25 | 23 | 20 | 19 | 20 | 20 | 20 |
| Cement and Concrete Industry | 46 | 46 | 44 | 13 | 14 | 12 | 9.4 | 9.6 | 2.8 |
| Foundries | 1.8 | 2.3 | 26 | 62 | 21 | 0.75 | 21 | 21 | 26 |
| Iron and Steel Industry | 150 | 160 | 310 | 300 | 220 | 210 | 200 | 230 | 170 |
| Iron Ore Industry | - | - | - | 88 | 83 | 82 | 84 | 49 | 53 |
| Mineral Products Industry | - | - | - | - | - | - | - | - | - |
| Mining and Rock Quarrying | - | 550 | 2 900 | 330 | 50 | 52 | 54 | 130 | 67 |
| Non-Ferrous Refining and Smelting Industry | 78 000 | 34 000 | 29 000 | 4 600 | 5 000 | 5 100 | 4 300 | 4 200 | 2 300 |
| **OIL AND GAS INDUSTRY** | **130** | **190** | **190** | **210** | **220** | **220** | **250** | **260** | **230** |
| Downstream Oil and Gas Industry | 110 | 150 | 130 | 110 | 94 | 95 | 98 | 95 | 69 |
| Upstream Oil and Gas Industry | 25 | 38 | 61 | 110 | 130 | 120 | 150 | 160 | 170 |
| **ELECTRIC POWER GENERATION (UTILITIES)** | **130** | **130** | **250** | **160** | **140** | **160** | **120** | **98** | **110** |
| Coal | 87 | 91 | 170 | 94 | 43 | 100 | 79 | 63 | 80 |
| Diesel | - | - | - | - | - | - | - | - | - |
| Natural Gas | 29 | 30 | 56 | 43 | 52 | 35 | 27 | 24 | 26 |
| Waste Materials | - | - | - | - | 0.11 | 0.090 | 0.080 | 0.090 | 0.12 |
| Other (Electric Power Generation) | 14 | 14 | 27 | 27 | 45 | 25 | 15 | 11 | 8.5 |
| **MANUFACTURING** | **1 100** | **960** | **940** | **590** | **580** | **600** | **560** | **590** | **570** |
| Abrasives Manufacturing | - | - | - | - | - | - | - | - | - |
| Bakeries | - | - | - | - | - | - | - | - | - |
| Biofuel Production | - | - | - | - | - | - | - | - | - |
| Chemicals Industry | 140 | 130 | 71 | 7.3 | 7.9 | 8.1 | 7.8 | 8.2 | 7.8 |
| Electronics | - | - | - | - | - | - | - | - | - |
| Food Preparation | - | - | - | - | - | - | - | - | - |
| Glass Manufacturing | 1.3 | 1.4 | 1.9 | - | - | - | - | - | - |
| Grain Industry | - | - | - | - | - | - | - | - | - |
| Metal Fabrication | 470 | 420 | 290 | 330 | 320 | 310 | 290 | 310 | 340 |
| Plastics Manufacturing | 5.2 | 5.7 | 3.6 | - | - | - | - | - | - |
| Pulp and Paper Industry | 370 | 190 | 320 | 200 | 200 | 210 | 200 | 200 | 170 |
| Textiles | - | - | - | - | - | - | - | - | - |
| Vehicle Manufacturing (Engines, Parts, Assembly, Painting) | 1.5 | 89 | 1.1 | - | - | - | 0.0 | - | - |
| Wood Products | 130 | 130 | 110 | 58 | 51 | 63 | 59 | 77 | 50 |
| Other (Manufacturing) | - | - | 140 | 0.68 | 0.063 | 0.060 | 0.13 | 0.11 | 0.16 |
| **TRANSPORTATION AND MOBILE EQUIPMENT** | **160** | **180** | **180** | **100** | **72** | **66** | **70** | **72** | **70** |
| Air Transportation (LTO) | - | - | - | - | - | - | - | - | - |
| 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 | - | - | - | - | - | - | - | - | - |
| Domestic Marine Navigation, Fishing and Military | 61 | 79 | 90 | 37 | 16 | 16 | 16 | 17 | 15 |
| Motorcycles | - | - | - | - | - | - | - | - | - |
| Off-Road Diesel Vehicles and Equipment | - | - | - | - | - | - | - | - | - |
| Off-Road Gasoline/LPG/NG Vehicles and Equipment | - | - | - | - | - | - | - | - | - |
| Rail Transportation | 100 | 98 | 95 | 66 | 57 | 51 | 54 | 55 | 55 |
| Tire Wear and Brake Lining | - | - | - | - | - | - | - | - | - |
| **AGRICULTURE** | **51** | **54** | **64** | **87** | **84** | **92** | **92** | **89** | **91** |
| Animal Production | - | - | - | - | - | - | - | - | - |
| Crop Production | - | - | - | - | - | - | - | - | - |
| Fuel Use | 51 | 54 | 64 | 87 | 84 | 92 | 92 | 89 | 91 |
| **COMMERCIAL/RESIDENTIAL/INSTITUTIONAL** | **1 000** | **1 100** | **1 100** | **1 100** | **1 000** | **1 000** | **1 100** | **1 100** | **1 100** |
| Commercial and Institutional Fuel Combustion | 340 | 510 | 480 | 480 | 470 | 480 | 480 | 480 | 510 |
| Commercial Cooking | - | - | - | - | - | - | - | - | - |
| Construction Fuel Combustion | 11 | 7.0 | 10 | 8.9 | 8.9 | 9.1 | 9.2 | 9.9 | 10 |
| Home Firewood Burning | 100 | 84 | 73 | 97 | 96 | 91 | 92 | 99 | 100 |
| Human | - | - | - | - | - | - | - | - | - |
| Marine Cargo Handling | - | - | 47 | 1.2 | 0.50 | 2.2 | 2.3 | 2.5 | 2.4 |
| Residential Fuel Combustion | 540 | 500 | 500 | 460 | 460 | 450 | 470 | 470 | 480 |
| Service Stations | - | - | - | - | - | - | - | - | - |
| Other (Miscellaneous) | - | - | - | - | - | - | - | - | - |
| **INCINERATION AND WASTE** | **7 000** | **200** | **47** | **36** | **36** | **34** | **36** | **40** | **41** |
| Crematoriums | 0.34 | 0.48 | 0.61 | 0.87 | 0.89 | 0.93 | 0.99 | 1.0 | 1.0 |
| Waste Incineration | 7 000 | 200 | 44 | 33 | 32 | 31 | 32 | 32 | 32 |
| Waste Treatment and Disposal | - | - | 2.5 | 2.0 | 3.5 | 2.3 | 3.0 | 7.2 | 7.9 |
| **PAINTS AND SOLVENTS** | **-** | **-** | **0.0** | **0.12** | **0.14** | **0.10** | **0.14** | **0.14** | **0.14** |
| Dry Cleaning | - | - | - | - | - | - | - | - | - |
| General Solvent Use | - | - | - | - | - | - | - | - | - |
| Printing | - | - | 0.0 | - | - | - | - | - | - |
| Surface Coatings | - | - | - | 0.12 | 0.14 | 0.10 | 0.14 | 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** | **7 600** | **7 600** | **7 700** | **6 900** | **6 900** | **4 800** |

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

**Other emissions estimated in the APEI**

| Source | 1990 | 2000 | 2005 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 |
|---|---|---|---|---|---|---|---|---|---|
| Domestic Air Transportation (Cruise) | - | - | - | - | - | - | - | - | - |
| International Air Transportation (Cruise) | - | - | - | - | - | - | - | - | - |
| International Marine Navigation | 130 | 200 | 230 | 75 | 18 | 18 | 19 | 20 | 18 |

Note: Refer to Annex 4.4 for more information.

## 2.9. **Mercury**

Approximately 3.3 t of mercury (Hg) were emitted in Canada in 2019 (Table 2–11). Ore and Mineral Industries accounted for 35% (1.1 t) of Hg emissions in 2019, with the Iron and Steel Industry sector contributing 16% (0.52 t) of the annual total. Incineration and Waste sources accounted for 29% (0.95 t) of Hg emissions in 2019, with Waste Incineration being the largest contributor at 16% (0.55 t). Electric Power Generation (Utilities) also accounted for 17% (0.57 t) of 2019 emissions, most of which were emitted from coal-powered electric generation (16% of annual total, 0.55 t).

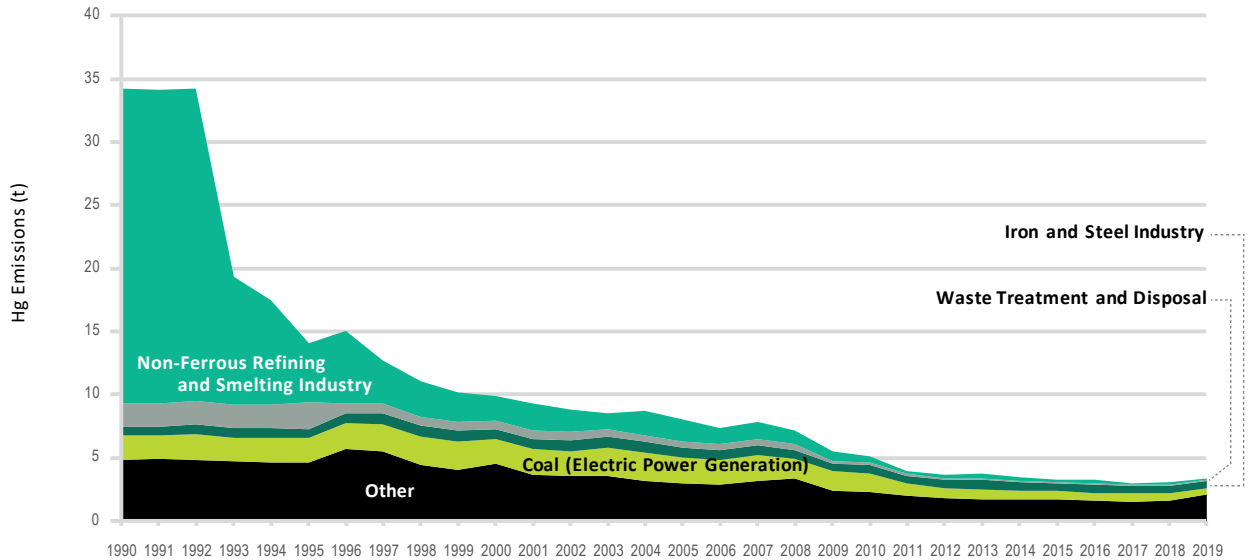
Between 1990 and 2019, Hg emissions decreased by 90% (31 t) (Figure 2–9). This decrease in emissions is mainly due to a large drop in emissions from the Non-Ferrous Refining and Smelting Industry sector. As with Pb and Cd emissions, reductions in Hg emissions coincide with the closure of outdated smelters, the implementation of pollution prevention plans, achieving Base Level Industrial Emissions Requirements (BLIERs) for particulate matter through Environmental Performance Agreements, increased emission control measures, such as changing feedstocks, improved particulate matter emission controls and fuel switching (ECCC, 2017; ECCC 2018).

Emission reductions from Electric Power Generation (Utilities) are largely due to the closure of coal-fired electricity generation facilities and from the addition of Hg controls to plants. For the Incineration and Waste source category, 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 2019 include:

- Ore and Mineral Industry: decrease of 96% (25 t), with:
  - Non-Ferrous Refining and Smelting Industry: decrease of almost 100% (25 t)
- Incineration and Waste: decrease of 71% (2.3 t), with:
  - Waste Treatment and Disposal: decrease of 94% (1.7 t)
- Electric Power Generation (Utilities): decrease of 75% (1.7 t), with:
  - Coal: decrease of 72% (1.4 t)

Figure 2–9 **Trends in Canadian Hg Emissions (1990 to 2019)**



## Table 2–11 National Summary of Annual Hg Emissions

| Source | 1990 | 2000 | 2005 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | (kg) | | | | |
| **ORE AND MINERAL INDUSTRIES** | **26 000** | **3 400** | **2 900** | **1 400** | **1 300** | **1 400** | **1 200** | **1 300** | **1 100** |
| Aluminium Industry | 18 | 31 | 43 | 19 | 21 | 21 | 22 | 24 | 24 |
| Asphalt Paving Industry | 24 | 22 | 22 | 23 | 20 | 19 | 20 | 19 | 19 |
| Cement and Concrete Industry | 460 | 390 | 210 | 300 | 380 | 340 | 330 | 300 | 300 |
| Foundries | 210 | 120 | 4.2 | - | - | - | - | - | - |
| Iron and Steel Industry | 710 | 800 | 860 | 680 | 640 | 680 | 610 | 600 | 520 |
| Iron Ore Industry | 60 | 60 | 50 | 74 | 72 | 72 | 70 | 73 | 79 |
| Mineral Products Industry | - | - | - | - | - | - | - | - | - |
| Mining and Rock Quarrying | 12 | 12 | 29 | 20 | 20 | 16 | 19 | 110 | 110 |
| Non-Ferrous Refining and Smelting Industry | 25 000 | 1 900 | 1 700 | 290 | 180 | 220 | 140 | 200 | 91 |
| **OIL AND GAS INDUSTRY** | **120** | **61** | **83** | **89** | **74** | **81** | **70** | **74** | **70** |
| Downstream Oil and Gas Industry | 110 | 26 | 46 | 46 | 49 | 53 | 47 | 50 | 46 |
| Upstream Oil and Gas Industry | 3.0 | 36 | 38 | 44 | 25 | 28 | 22 | 24 | 24 |
| **ELECTRIC POWER GENERATION (UTILITIES)** | **2 200** | **2 000** | **2 200** | **710** | **730** | **670** | **630** | **610** | **570** |
| Coal | 1 900 | 2 000 | 2 000 | 660 | 680 | 630 | 610 | 590 | 540 |
| Diesel | - | - | - | - | - | - | - | - | - |
| Natural Gas | 12 | 22 | 27 | 19 | 26 | 11 | 0.0 | 2.1 | 2.3 |
| Waste Materials | - | - | 0.0 | 0.11 | 0.92 | 0.49 | 0.12 | 0.32 | 0.23 |
| Other (Electric Power Generation) | 290 | 62 | 91 | 28 | 26 | 30 | 17 | 22 | 23 |
| **MANUFACTURING** | **1 100** | **1 400** | **510** | **99** | **110** | **120** | **100** | **110** | **77** |
| Abrasives Manufacturing | - | - | - | - | - | - | - | - | - |
| Bakeries | - | - | - | - | - | - | - | - | - |
| Biofuel Production | - | - | - | - | - | - | - | - | - |
| Chemicals Industry | 170 | 82 | 58 | 18 | 15 | 17 | 17 | 18 | 17 |
| Electronics | 400 | 760 | 60 | 3.5 | 4.3 | 15 | 11 | 7.8 | 0.0 |
| Food Preparation | 0.14 | 0.14 | 0.30 | - | - | - | - | - | - |
| Glass Manufacturing | 28 | 28 | 21 | - | - | - | - | - | - |
| Grain Industry | - | - | - | - | - | - | - | - | - |
| Metal Fabrication | 16 | 17 | 17 | - | - | - | - | - | - |
| Plastics Manufacturing | 0.0 | 0.0 | - | - | - | - | - | - | - |
| Pulp and Paper Industry | 98 | 130 | 58 | 60 | 70 | 71 | 58 | 59 | 48 |
| Textiles | - | - | - | - | - | - | - | - | - |
| Vehicle Manufacturing (Engines, Parts, Assembly, Painting) | 0.0 | 0.0 | 0.0 | - | - | - | - | - | - |
| Wood Products | 260 | 190 | 89 | 18 | 17 | 16 | 13 | 25 | 12 |
| Other (Manufacturing) | 120 | 170 | 210 | - | - | - | 0.0 | 0.56 | 0.33 |
| **TRANSPORTATION AND MOBILE EQUIPMENT** | **100** | **99** | **97** | **67** | **57** | **51** | **54** | **55** | **56** |
| Air Transportation (LTO) | - | - | - | - | - | - | - | - | - |
| Heavy-Duty Diesel Vehicles | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Heavy-Duty Gasoline Vehicles | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Heavy-Duty LPG/NG Vehicles | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Light-Duty Diesel Trucks | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Light-Duty Diesel Vehicles | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Light-Duty Gasoline Trucks | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Light-Duty Gasoline Vehicles | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Light-Duty LPG/NG Trucks | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Light-Duty LPG/NG Vehicles | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Domestic Marine Navigation, Fishing and Military | 1.3 | 1.7 | 1.9 | 0.70 | 0.29 | 0.29 | 0.30 | 0.31 | 0.24 |
| Motorcycles | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Off-Road Diesel Vehicles and Equipment | - | - | - | - | - | - | - | - | - |
| Off-Road Gasoline/LPG/NG Vehicles and Equipment | - | - | - | - | - | - | - | - | - |
| Rail Transportation | 100 | 98 | 95 | 66 | 57 | 51 | 54 | 55 | 55 |
| Tire Wear and Brake Lining | - | - | - | - | - | - | - | - | - |
| **AGRICULTURE** | **2.8** | **3.4** | **3.2** | **11** | **10** | **10** | **9.8** | **9.4** | **7.2** |
| Animal Production | - | - | - | - | - | - | - | - | - |
| Crop Production | - | - | - | - | - | - | - | - | - |
| Fuel Use | 2.8 | 3.4 | 3.2 | 11 | 10 | 10 | 9.8 | 9.4 | 7.2 |
| **COMMERCIAL/RESIDENTIAL/INSTITUTIONAL** | **990** | **780** | **740** | **550** | **500** | **470** | **460** | **460** | **430** |
| Commercial and Institutional Fuel Combustion | 47 | 62 | 63 | 58 | 55 | 55 | 61 | 63 | 64 |
| Commercial Cooking | - | - | - | - | - | - | - | - | - |
| Construction Fuel Combustion | 2.6 | 1.7 | 2.6 | 2.1 | 2.2 | 2.2 | 2.2 | 2.4 | 2.4 |
| Home Firewood Burning | 28 | 23 | 20 | 25 | 25 | 24 | 24 | 26 | 26 |
| Human | 23 | 24 | 18 | 5.2 | 3.5 | 1.8 | 1.8 | 1.8 | 1.8 |
| Marine Cargo Handling | - | - | 2.8 | - | - | - | - | - | - |
| Residential Fuel Combustion | 64 | 76 | 75 | 75 | 73 | 70 | 75 | 78 | 78 |
| Service Stations | - | - | - | - | - | - | - | - | - |
| Other (Miscellaneous) | 820 | 590 | 560 | 380 | 340 | 310 | 300 | 280 | 260 |
| **INCINERATION AND WASTE** | **3 200** | **2 200** | **1 500** | **530** | **470** | **470** | **470** | **460** | **950** |
| Crematoriums | 100 | 140 | 180 | 260 | 260 | 280 | 290 | 300 | 300 |
| Waste Incineration | 1 300 | 1 300 | 840 | 140 | 85 | 82 | 73 | 66 | 540 |
| Waste Treatment and Disposal | 1 800 | 690 | 490 | 130 | 120 | 110 | 110 | 94 | 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** | **8 000** | **3 400** | **3 300** | **3 200** | **3 000** | **3 100** | **3 300** |

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

**Other emissions estimated in the APEI**

| Source | 1990 | 2000 | 2005 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 |
|---|---|---|---|---|---|---|---|---|---|
| Domestic Air Transportation (Cruise) | - | - | - | - | - | - | - | - | - |
| International Air Transportation (Cruise) | - | - | - | - | - | - | - | - | - |
| International Marine Navigation | 3.0 | 4.5 | 5.2 | 1.4 | 0.27 | 0.28 | 0.30 | 0.31 | 0.25 |

Note: Refer to Annex 4.4 for more information.

## 2.10. Dioxins and Furans

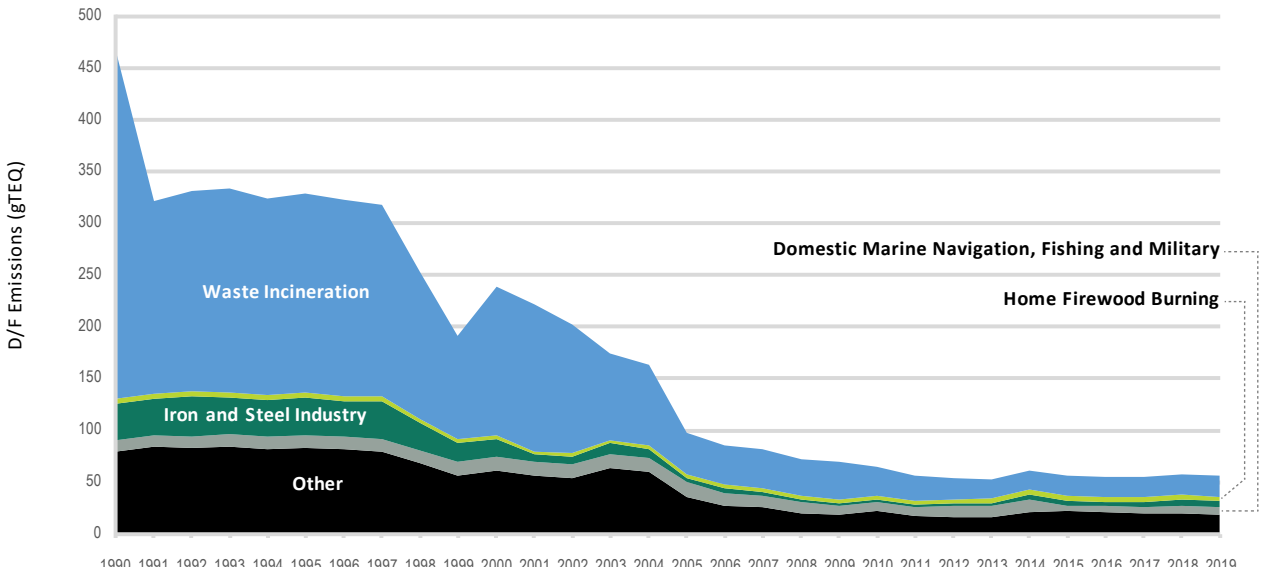
In 2019, emissions of dioxins and furans (D/F) in Canada totalled approximately 51 grams of toxicity equivalent (gTEQ) (Table 2–12). The Incineration and Waste source accounted for the largest share of these emissions at 46% (23 gTEQ), with Waste Incineration accounting for 39% (20 gTEQ). Transportation and Mobile Equipment contributed 17% (8.7 gTEQ) of 2019 dioxins and furans emissions, 14% (7.2 gTEQ) of which are attributed to Domestic Marine Navigation, Fishing and Military. Ore and Mineral Industries collectively accounted for 17% (8.5 gTEQ) of 2019 dioxins and furans emissions with Iron and Steel Industry being the largest contributor to this source. The Commercial/Residential/Institutional source category was also a significant contributor at 10% (5.1 gTEQ) of 2019 dioxins and furans emissions of which the majority of it is attributed to the Home Firewood Burning sector.

Between 1990 and 2019, dioxins and furans emissions decreased by 88% (385 gTEQ) (Figure 2–10). This decrease is due to large reductions in emissions from Waste Incineration. This reduction is due to improvements in incineration technologies and closure of smaller batch incinerators.

The most significant changes in dioxins and furans emissions from 1990 to 2019 include:

- Incineration and Waste: decrease of 93% (318 gTEQ), with:
  - Waste Incineration: decrease of 94% (320 gTEQ)

Figure 2–10 **Trends in Canadian Dioxins and Furans Emissions (1990 to 2019)**



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

| Source | 1990 | 2000 | 2005 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 |
|---|---|---|---|---|---|---|---|---|---|
| | (gTEQ) | | | | | | | | |
| **ORE AND MINERAL INDUSTRIES** | **45** | **28** | **9.2** | **7.4** | **7.9** | **6.3** | **6.8** | **9.7** | **8.5** |
| Aluminium Industry | 2.8 | 4.1 | - | 0.67 | 0.63 | 0.58 | 0.56 | 0.58 | 0.61 |
| Asphalt Paving Industry | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Cement and Concrete Industry | 3.0 | 1.8 | 2.6 | 1.9 | 1.6 | 0.61 | 0.22 | 1.6 | 1.1 |
| Foundries | - | 0.072 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Iron and Steel Industry | 35 | 17 | 4.0 | 4.4 | 5.2 | 4.7 | 5.6 | 7.1 | 5.3 |
| Iron Ore Industry | - | - | - | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Mineral Products Industry | 0.81 | 1.2 | 0.81 | - | - | - | - | - | - |
| Mining and Rock Quarrying | - | - | 0.50 | 0.0 | 0.086 | 0.0 | 0.0 | 0.0 | 0.0 |
| Non-Ferrous Refining and Smelting Industry | 3.4 | 3.4 | 1.3 | 0.29 | 0.38 | 0.41 | 0.44 | 0.42 | 1.4 |
| **OIL AND GAS INDUSTRY** | **-** | **-** | **-** | **-** | **-** | **-** | **-** | **-** | **-** |
| Downstream Oil and Gas Industry | - | - | - | - | - | - | - | - | - |
| Upstream Oil and Gas Industry | - | - | - | - | - | - | - | - | - |
| **ELECTRIC POWER GENERATION (UTILITIES)** | **3.0** | **6.2** | **5.5** | **2.0** | **1.9** | **2.9** | **2.2** | **1.5** | **0.96** |
| Coal | 2.3 | 3.1 | 3.9 | 1.8 | 1.6 | 1.9 | 1.6 | 0.95 | 0.70 |
| Diesel | - | - | - | - | - | - | - | - | - |
| Natural Gas | 0.46 | 1.0 | 1.2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Waste Materials | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.16 | 0.0 | 0.0 | 0.0 |
| Other (Electric Power Generation) | 0.23 | 2.1 | 0.43 | 0.19 | 0.19 | 0.75 | 0.60 | 0.52 | 0.25 |
| **MANUFACTURING** | **20** | **18** | **13** | **3.0** | **2.9** | **4.0** | **3.2** | **2.5** | **3.3** |
| Abrasives Manufacturing | - | - | 0.051 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Bakeries | - | - | - | - | - | - | - | - | - |
| Biofuel Production | - | - | - | - | - | - | - | - | - |
| Chemicals Industry | 2.2 | 0.10 | 0.067 | 0.27 | 0.26 | 0.31 | 0.33 | 0.0 | 0.0 |
| Electronics | - | - | - | - | - | - | - | - | - |
| Food Preparation | - | - | 0.065 | - | - | - | - | - | - |
| Glass Manufacturing | - | - | - | - | - | - | - | - | - |
| Grain Industry | - | - | - | - | - | - | - | - | - |
| Metal Fabrication | 4.1 | 8.2 | 5.0 | 0.90 | 0.87 | 0.92 | 0.92 | 0.81 | 1.9 |
| Plastics Manufacturing | - | - | - | - | - | - | - | - | - |
| Pulp and Paper Industry | 11 | 5.2 | 4.9 | 1.1 | 1.1 | 2.1 | 1.3 | 1.1 | 0.94 |
| Textiles | - | - | - | - | - | - | - | - | - |
| Vehicle Manufacturing (Engines, Parts, Assembly, Painting) | 0.30 | 1.5 | 0.44 | - | - | - | - | - | - |
| Wood Products | 1.8 | 2.7 | 2.5 | 0.66 | 0.64 | 0.64 | 0.59 | 0.58 | 0.52 |
| Other (Manufacturing) | - | - | 0.12 | - | - | - | - | - | - |
| **TRANSPORTATION AND MOBILE EQUIPMENT** | **13** | **14** | **15** | **14** | **7.0** | **7.0** | **7.4** | **7.8** | **8.7** |
| Air Transportation (LTO) | - | - | - | - | - | - | - | - | - |
| Heavy-Duty Diesel Vehicles | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Heavy-Duty Gasoline Vehicles | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Heavy-Duty LPG/NG Vehicles | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Light-Duty Diesel Trucks | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Light-Duty Diesel Vehicles | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Light-Duty Gasoline Trucks | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Light-Duty Gasoline Vehicles | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Light-Duty LPG/NG Trucks | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Light-Duty LPG/NG Vehicles | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Domestic Marine Navigation, Fishing and Military | 11 | 13 | 14 | 12 | 5.7 | 5.8 | 6.1 | 6.4 | 7.2 |
| Motorcycles | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Off-Road Diesel Vehicles and Equipment | - | - | - | - | - | - | - | - | - |
| Off-Road Gasoline/LPG/NG Vehicles and Equipment | - | - | - | - | - | - | - | - | - |
| Rail Transportation | 1.2 | 1.2 | 1.2 | 1.4 | 1.3 | 1.2 | 1.4 | 1.4 | 1.4 |
| Tire Wear and Brake Lining | - | - | - | - | - | - | - | - | - |
| **AGRICULTURE** | **0.058** | **0.054** | **0.0** | **0.64** | **0.59** | **0.58** | **0.56** | **0.45** | **0.062** |
| Animal Production | - | - | - | - | - | - | - | - | - |
| Crop Production | - | - | - | - | - | - | - | - | - |
| Fuel Use | 0.058 | 0.054 | 0.0 | 0.64 | 0.59 | 0.58 | 0.56 | 0.45 | 0.062 |
| **COMMERCIAL/RESIDENTIAL/INSTITUTIONAL** | **6.4** | **5.4** | **4.8** | **5.5** | **6.1** | **4.8** | **4.7** | **5.0** | **5.1** |
| Commercial and Institutional Fuel Combustion | 0.37 | 0.37 | 0.33 | 0.45 | 1.3 | 0.27 | 0.23 | 0.17 | 0.18 |
| Commercial Cooking | - | - | - | - | - | - | - | - | - |
| Construction Fuel Combustion | 0.068 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Home Firewood Burning | 4.6 | 3.8 | 3.3 | 4.4 | 4.3 | 4.1 | 4.2 | 4.5 | 4.6 |
| Human | - | - | - | - | - | - | - | - | - |
| Marine Cargo Handling | - | - | - | - | - | - | - | - | - |
| Residential Fuel Combustion | 1.5 | 1.2 | 1.1 | 0.58 | 0.44 | 0.39 | 0.26 | 0.26 | 0.24 |
| Service Stations | - | - | - | - | - | - | - | - | - |
| Other (Miscellaneous) | - | - | - | - | - | - | - | - | - |
| **INCINERATION AND WASTE** | **340** | **150** | **45** | **21** | **23** | **22** | **23** | **23** | **23** |
| Crematoriums | 1.1 | 1.6 | 2.1 | 2.9 | 3.0 | 3.2 | 3.3 | 3.4 | 3.5 |
| Waste Incineration | 340 | 140 | 41 | 18 | 20 | 19 | 20 | 19 | 20 |
| Waste Treatment and Disposal | - | 3.8 | 1.9 | - | - | - | - | - | 0.0 |
| **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** | **2.8** | **2.2** | **1.8** | **1.1** | **0.64** | **0.68** |
| Prescribed Burning | 7.6 | 1.5 | 0.92 | 2.8 | 2.2 | 1.8 | 1.1 | 0.64 | 0.68 |
| Structural Fires | - | - | - | - | - | - | - | - | - |
| **GRAND TOTAL** | **440** | **220** | **94** | **56** | **51** | **50** | **49** | **50** | **51** |

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

**Other emissions estimated in the APEI**

| Source | 1990 | 2000 | 2005 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 |
|---|---|---|---|---|---|---|---|---|---|
| Domestic Air Transportation (Cruise) | - | - | - | - | - | - | - | - | - |
| International Air Transportation (Cruise) | - | - | - | - | - | - | - | - | - |
| International Marine Navigation | 8.7 | 12 | 14 | 26 | 11 | 11 | 11 | 11 | 12 |

Note: Refer to Annex 4.4 for more information.

## 2.11. Polycyclic Aromatic Hydrocarbons

The APEI reports emissions of four polycyclic aromatic hydrocarbons (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 2019, 83 t of PAHs were emitted in Canada (Table 2–13), with 87% (72 t) attributed to Commercial/Residential/Institutional sources. This is almost entirely due to Home Firewood Burning, this sector being the largest contributor to PAH emissions since 2004. Transportation and Mobile Equipment was the next largest source, contributing 10% (8.4 t) of PAH emissions in 2019.

From 1990 to 2019, PAH emissions decreased by 72% (211 t) (Figure 2–11), primarily owing to emission reductions in the Aluminium Industry and Iron and Steel Industry sectors. Emissions from Aluminium Industry experienced a large drop in PAH emissions from 2008 to 2016 owing to process improvements and the progressive phase-out of old Söderberg aluminium production technologies (ECCC, 2014).

Emissions of these four types of PAHs from Iron and Steel Industry dropped significantly earlier in the time series, from 1993 to 2006, and emissions remained small through 2019. Reductions here are a result of effective emission controls on coke ovens and coke by-product plants (EC, 2001).

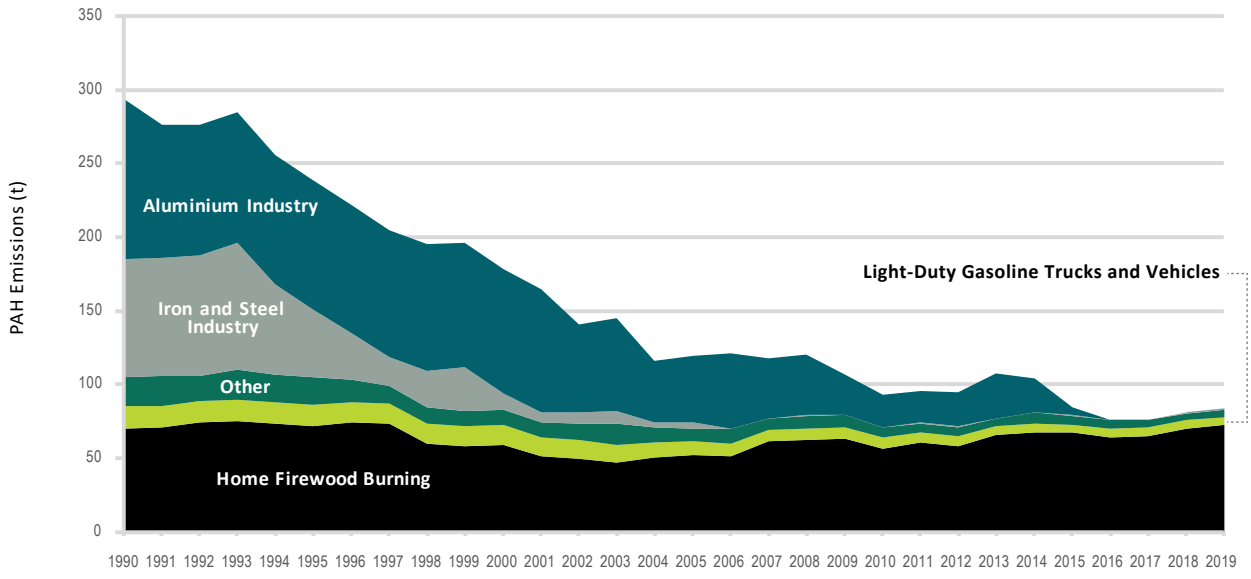
PAH emissions from Transportation and Mobile Equipment have decreased across the time series owing to increasingly stringent engine and vehicle regulations.[8]

The most significant changes in PAH emissions from 1990 to 2019 include:

- Ore and Mineral Industries: decrease of almost 100% (188 t), with:
  - Aluminium Industry: decrease of almost 100% (109 t)
  - Iron and Steel Industry: decrease of almost 100% (79 t)
- Transportation and Mobile Equipment: decrease of 65% (16 t), with:
  - Light-Duty Gasoline Trucks and Vehicles: decrease of 63% (9.7 t)

8 See Chapter 1 for list of regulations.

Figure 2–11 **Trends in Canadian Polycyclic Aromatic Hydrocarbons Emissions (1990 to 2019)**



## Table 2–13 National Summary of Annual Polycyclic Aromatic Hydrocarbons Emissions

| Source | 1990 | 2000 | 2005 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 |
|---|---|---|---|---|---|---|---|---|---|
| | (kg) | | | | | | | | |
| **ORE AND MINERAL INDUSTRIES** | **190 000** | **95 000** | **50 000** | **24 000** | **5 400** | **690** | **550** | **620** | **540** |
| Aluminium Industry | 110 000 | 84 000 | 45 000 | 23 000 | 4 900 | 100 | 130 | 190 | 140 |
| Asphalt Paving Industry | 14 | 14 | 15 | 13 | 12 | 11 | 12 | 12 | 11 |
| Cement and Concrete Industry | 17 | 13 | 19 | 3.1 | 2.8 | 0.23 | 0.62 | 0.34 | 0.26 |
| Foundries | - | - | - | - | - | - | - | - | - |
| Iron and Steel Industry | 80 000 | 11 000 | 4 600 | 400 | 400 | 440 | 390 | 400 | 370 |
| Iron Ore Industry | - | - | - | 19 | 20 | 20 | 21 | 18 | 20 |
| Mineral Products Industry | - | - | - | - | - | - | - | - | - |
| Mining and Rock Quarrying | - | - | - | 250 | 110 | 110 | 0.0 | 0.0 | 0.0 |
| Non-Ferrous Refining and Smelting Industry | 1.9 | 2.8 | 0.69 | 0.31 | 0.32 | 0.30 | 0.33 | 0.33 | 0.34 |
| **OIL AND GAS INDUSTRY** | **150** | **95** | **46** | **25** | **24** | **20** | **18** | **22** | **470** |
| Downstream Oil and Gas Industry | 150 | 92 | 43 | 16 | 19 | 14 | 13 | 14 | 14 |
| Upstream Oil and Gas Industry | 2.3 | 3.3 | 2.3 | 9.8 | 4.8 | 5.8 | 4.5 | 7.9 | 460 |
| **ELECTRIC POWER GENERATION (UTILITIES)** | **370** | **360** | **240** | **6.4** | **6.1** | **6.8** | **6.5** | **0.0** | **0.0** |
| Coal | 240 | 240 | 240 | - | - | - | - | - | - |
| Diesel | - | - | - | - | - | - | - | - | - |
| Natural Gas | 2.9 | 2.3 | 0.23 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Waste Materials | - | - | - | - | - | - | - | - | - |
| Other (Electric Power Generation) | 130 | 110 | - | 6.4 | 6.0 | 6.8 | 6.5 | - | - |
| **MANUFACTURING** | **320** | **310** | **300** | **170** | **130** | **120** | **140** | **130** | **150** |
| Abrasives Manufacturing | - | - | - | - | - | - | - | - | - |
| Bakeries | - | - | - | - | - | - | - | - | - |
| Biofuel Production | - | - | - | - | - | - | - | - | - |
| Chemicals Industry | 0.60 | 24 | 30 | 24 | 25 | 25 | 25 | 24 | 24 |
| Electronics | - | - | - | - | - | - | - | - | - |
| Food Preparation | - | - | - | - | - | - | - | - | - |
| Glass Manufacturing | 0.0 | 0.0 | - | - | - | - | - | - | - |
| Grain Industry | - | - | - | - | - | - | - | - | - |
| Metal Fabrication | 1.1 | 1.1 | 8.3 | - | - | - | - | - | - |
| Plastics Manufacturing | - | - | - | - | - | - | - | - | - |
| Pulp and Paper Industry | 110 | 130 | 190 | 130 | 100 | 89 | 110 | 100 | 120 |
| Textiles | - | - | - | - | - | - | - | - | - |
| Vehicle Manufacturing (Engines, Parts, Assembly, Painting) | 0.0 | 0.23 | - | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Wood Products | 210 | 150 | 72 | 9.8 | 8.6 | 7.9 | 6.0 | 6.0 | 5.4 |
| Other (Manufacturing) | - | - | 2.2 | - | - | - | - | - | - |
| **TRANSPORTATION AND MOBILE EQUIPMENT** | **24 000** | **20 000** | **15 000** | **8 200** | **7 800** | **8 100** | **8 200** | **8 300** | **8 400** |
| Air Transportation (LTO) | 12 | 6.8 | 5.4 | 5.8 | 5.8 | 5.7 | 5.8 | 6.2 | 6.2 |
| Heavy-Duty Diesel Vehicles | 910 | 990 | 1 200 | 690 | 610 | 600 | 630 | 660 | 660 |
| Heavy-Duty Gasoline Vehicles | 6 200 | 4 300 | 4 200 | 1 900 | 1 800 | 1 900 | 1 900 | 1 900 | 1 900 |
| Heavy-Duty LPG/NG Vehicles | 1 100 | 1 300 | 330 | 2.8 | 2.5 | 3.5 | 6.7 | 6.7 | 6.3 |
| Light-Duty Diesel Trucks | 2.1 | 2.7 | 2.8 | 1.7 | 1.8 | 2.0 | 2.3 | 2.5 | 2.5 |
| Light-Duty Diesel Vehicles | 7.8 | 5.4 | 3.4 | 2.5 | 2.4 | 2.2 | 2.2 | 2.1 | 2.1 |
| Light-Duty Gasoline Trucks | 4 500 | 5 400 | 3 800 | 2 800 | 2 800 | 3 000 | 3 000 | 3 100 | 3 300 |
| Light-Duty Gasoline Vehicles | 11 000 | 7 600 | 5 000 | 2 700 | 2 500 | 2 500 | 2 500 | 2 400 | 2 400 |
| Light-Duty LPG/NG Trucks | 380 | 170 | 80 | 0.95 | 0.85 | 0.93 | 1.1 | 1.1 | 1.1 |
| Light-Duty LPG/NG Vehicles | 47 | 25 | 12 | 0.0 | 0.0 | 0.0 | 0.058 | 0.058 | 0.056 |
| Domestic Marine Navigation, Fishing and Military | 68 | 77 | 84 | 74 | 34 | 35 | 36 | 39 | 43 |
| Motorcycles | 39 | 38 | 42 | 37 | 37 | 40 | 41 | 41 | 41 |
| Off-Road Diesel Vehicles and Equipment | - | - | - | - | - | - | - | - | - |
| Off-Road Gasoline/LPG/NG Vehicles and Equipment | - | - | - | - | - | - | - | - | - |
| Rail Transportation | 63 | 59 | 58 | 40 | 34 | 31 | 33 | 33 | 34 |
| Tire Wear and Brake Lining | - | - | - | - | - | - | - | - | - |
| **AGRICULTURE** | **0.32** | **0.31** | **0.21** | **0.38** | **0.34** | **0.35** | **0.35** | **0.35** | **0.33** |
| Animal Production | - | - | - | - | - | - | - | - | - |
| Crop Production | - | - | - | - | - | - | - | - | - |
| Fuel Use | 0.32 | 0.31 | 0.21 | 0.38 | 0.34 | 0.35 | 0.35 | 0.35 | 0.33 |
| **COMMERCIAL/RESIDENTIAL/INSTITUTIONAL** | **70 000** | **59 000** | **53 000** | **68 000** | **67 000** | **64 000** | **65 000** | **70 000** | **72 000** |
| Commercial and Institutional Fuel Combustion | 2.6 | 3.1 | 3.0 | 2.4 | 2.3 | 2.2 | 2.3 | 2.3 | 2.4 |
| Commercial Cooking | 100 | 110 | 120 | 120 | 110 | 110 | 110 | 110 | 110 |
| Construction Fuel Combustion | 0.45 | 0.19 | 0.41 | 0.26 | 0.28 | 0.22 | 0.23 | 0.22 | 0.24 |
| Home Firewood Burning | 70 000 | 59 000 | 52 000 | 68 000 | 67 000 | 64 000 | 65 000 | 70 000 | 72 000 |
| Human | - | - | - | - | - | - | - | - | - |
| Marine Cargo Handling | - | - | - | - | - | - | - | - | - |
| Residential Fuel Combustion | 5.3 | 4.6 | 4.3 | 3.3 | 3.3 | 3.1 | 3.1 | 3.2 | 3.1 |
| Service Stations | - | - | - | - | - | - | - | - | - |
| Other (Miscellaneous) | - | - | - | - | - | - | - | - | - |
| **INCINERATION AND WASTE** | **490** | **530** | **610** | **630** | **640** | **660** | **660** | **670** | **680** |
| Crematoriums | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Waste Incineration | 490 | 530 | 610 | 630 | 640 | 660 | 660 | 670 | 680 |
| Waste Treatment and Disposal | - | - | - | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| **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** | **3 600** | **2 900** | **2 400** | **1 400** | **820** | **870** |
| Prescribed Burning | 9 800 | 2 000 | 1 200 | 3 600 | 2 900 | 2 400 | 1 400 | 820 | 870 |
| Structural Fires | - | - | - | - | - | - | - | - | - |
| **GRAND TOTAL** | **290 000** | **180 000** | **120 000** | **100 000** | **84 000** | **76 000** | **76 000** | **81 000** | **83 000** |

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

**Other emissions estimated in the APEI**

| Source | 1990 | 2000 | 2005 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 |
|---|---|---|---|---|---|---|---|---|---|
| Domestic Air Transportation (Cruise) | 5.5 | 4.4 | 3.1 | 3.0 | 3.0 | 3.0 | 3.1 | 3.3 | 3.3 |
| International Air Transportation (Cruise) | 3.1 | 3.0 | 2.3 | 2.0 | 2.0 | 2.1 | 2.2 | 2.3 | 2.4 |
| International Marine Navigation | 52 | 72 | 83 | 160 | 68 | 67 | 65 | 65 | 69 |

Note: Refer to Annex 4.4 for more information.

## 2.12. **Hexachlorobenzene**

In 2019, approximately 8.8 kg of hexachlorobenzene (HCB) were emitted in Canada (Table 2–14). Waste Incineration was the largest contributor in 2019 with 54% (4.7 kg) of total HCB emissions. Ore and Mineral Industries was the second-largest contributor, with 40% (3.5 kg) of total emissions, largely attributed to the Non-Ferrous Refining and Smelting Industry sector, which represented 19% (1.6 kg) of the national total.

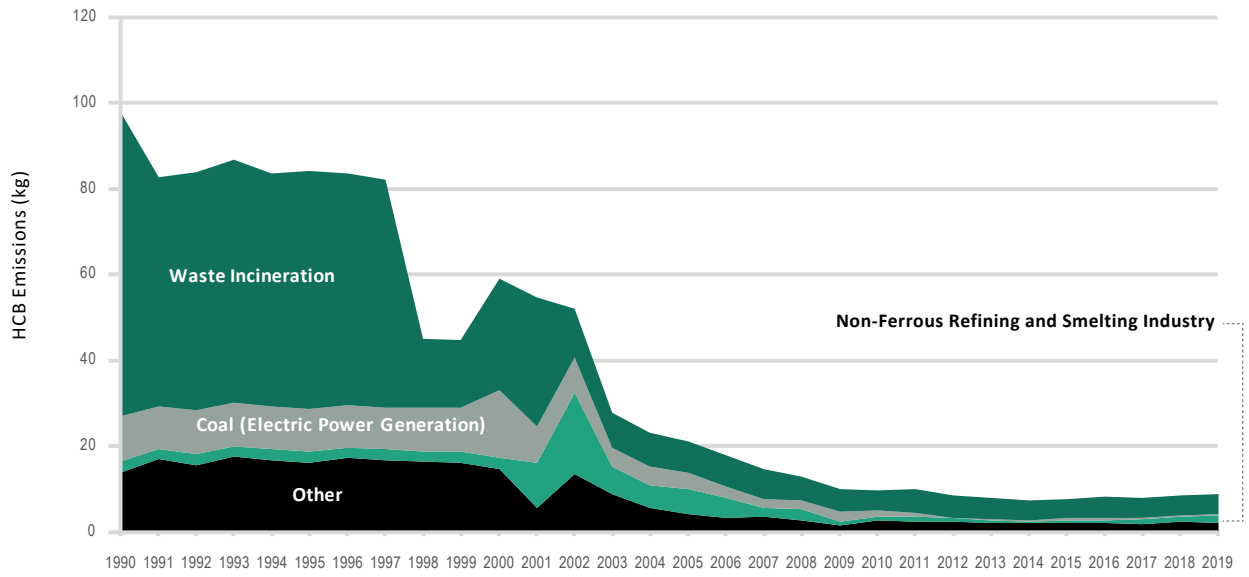
Overall, HCB emissions decreased by 91% (89 kg) from 1990 to 2019. HCB emissions decreased between 1990 and 2014 and have remained stable since 2014 (Figure 2–12). Most of the decrease is due to a drop in emissions from Waste Incineration since 1998, specifically as a result of a decline in the use of batch incinerators for municipal waste incineration. For example, the use of conical burners has declined steadily in Newfoundland and Labrador (Newfoundland Municipal Affairs and Environment, 2017). Emission reductions were also observed as a result of the phasing out of coal electricity generation in Ontario between 2000 and 2014.[9]

The most significant changes in HCB emissions from 1990 to 2019 include:

- Incineration and Waste: decrease of 93% (67 kg), with:
  - Waste Incineration: decrease of 93% (67 kg)
- Electric Power Generation (Utilities): decrease of 97% (11 kg), with:
  - Coal (Electric Power Generation): decrease of 98% (10 kg)

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

Figure 2–12 **Trends in Canadian HCB Emissions (1990 to 2019)**



## Table 2–14 National Summary of Annual HCB Emissions

| Source | 1990 | 2000 | 2005 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 |
|---|---|---|---|---|---|---|---|---|---|
| | (g) | | | | | | | | |
| **ORE AND MINERAL INDUSTRIES** | **5 500** | **5 700** | **8 100** | **2 000** | **2 200** | **2 300** | **2 400** | **3 100** | **3 500** |
| Aluminium Industry | - | - | - | 35 | 35 | 35 | 35 | 35 | 35 |
| Asphalt Paving Industry | - | - | - | - | - | - | - | - | - |
| Cement and Concrete Industry | 1 600 | 2 100 | 880 | 280 | 290 | 410 | 300 | 900 | 790 |
| Foundries | - | - | - | 29 | 23 | 24 | 6.0 | 0.0 | 0.0 |
| Iron and Steel Industry | 1 100 | 980 | 1 500 | 1 100 | 1 100 | 1 000 | 1 100 | 1 100 | 1 000 |
| Iron Ore Industry | - | - | - | - | - | - | - | - | - |
| Mineral Products Industry | - | - | - | - | - | - | - | - | - |
| Mining and Rock Quarrying | - | - | 44 | 12 | 17 | 12 | 7.5 | 6.5 | 9.8 |
| Non-Ferrous Refining and Smelting Industry | 2 700 | 2 600 | 5 600 | 530 | 700 | 830 | 1 000 | 1 100 | 1 600 |
| **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** | **400** | **600** | **570** | **460** | **400** | **310** |
| Coal | 10 000 | 16 000 | 3 900 | 240 | 430 | 430 | 360 | 300 | 260 |
| Diesel | - | - | - | - | - | - | - | - | - |
| Natural Gas | 640 | 1 300 | 170 | 140 | 150 | 120 | 84 | 81 | 45 |
| Waste Materials | 4.8 | - | - | - | - | - | - | - | - |
| Other (Electric Power Generation) | - | 190 | - | 23 | 16 | 17 | 16 | 17 | 8.1 |
| **MANUFACTURING** | **10 000** | **9 900** | **1 500** | **360** | **350** | **270** | **350** | **330** | **260** |
| Abrasives Manufacturing | - | - | - | - | - | - | - | - | - |
| Bakeries | - | - | - | - | - | - | - | - | - |
| Biofuel Production | - | - | - | - | - | - | - | - | - |
| Chemicals Industry | 680 | 330 | 480 | - | - | - | - | - | - |
| Electronics | - | - | - | - | - | - | - | - | - |
| Food Preparation | - | 2.9 | 3.0 | - | - | - | - | - | - |
| Glass Manufacturing | - | - | - | - | - | - | - | - | - |
| Grain Industry | - | - | - | - | - | - | - | - | - |
| Metal Fabrication | 460 | 480 | 52 | 290 | 210 | 190 | 240 | 230 | 190 |
| Plastics Manufacturing | - | - | 0.0 | - | - | - | - | - | - |
| Pulp and Paper Industry | 140 | 180 | 310 | 71 | 140 | 85 | 110 | 100 | 66 |
| Textiles | - | - | - | - | - | - | - | - | - |
| Vehicle Manufacturing (Engines, Parts, Assembly, Painting) | 8 800 | 8 400 | - | - | - | - | - | - | - |
| Wood Products | 340 | 580 | 620 | 0.26 | 0.11 | 0.11 | 0.088 | 0.090 | 0.072 |
| Other (Manufacturing) | - | - | - | - | - | - | - | - | - |
| **TRANSPORTATION AND MOBILE EQUIPMENT** | **-** | **-** | **-** | **-** | **-** | **-** | **-** | **-** | **-** |
| Air Transportation (LTO) | - | - | - | - | - | - | - | - | - |
| 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 | - | - | - | - | - | - | - | - | - |
| Domestic Marine Navigation, Fishing and Military | - | - | - | - | - | - | - | - | - |
| 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** | **1.1** | **1.1** | **1.0** | **0.82** | **-** |
| Animal Production | - | - | - | - | - | - | - | - | - |
| Crop Production | - | - | - | - | - | - | - | - | - |
| Fuel Use | - | - | - | 1.2 | 1.1 | 1.1 | 1.0 | 0.82 | - |
| **COMMERCIAL/RESIDENTIAL/INSTITUTIONAL** | **1.6** | **4.4** | **1.3** | **0.58** | **0.31** | **0.23** | **-** | **-** | **-** |
| Commercial and Institutional Fuel Combustion | 0.11 | 3.0 | 0.0 | - | - | - | - | - | - |
| Commercial Cooking | - | - | - | - | - | - | - | - | - |
| Construction Fuel Combustion | - | - | - | - | - | - | - | - | - |
| Home Firewood Burning | - | - | - | - | - | - | - | - | - |
| Human | - | - | - | - | - | - | - | - | - |
| Marine Cargo Handling | - | - | - | - | - | - | - | - | - |
| Residential Fuel Combustion | 1.5 | 1.4 | 1.3 | 0.58 | 0.31 | 0.23 | - | - | - |
| Service Stations | - | - | - | - | - | - | - | - | - |
| Other (Miscellaneous) | - | - | - | - | - | - | - | - | - |
| **INCINERATION AND WASTE** | **71 000** | **26 000** | **7 300** | **4 500** | **4 600** | **4 900** | **4 700** | **4 700** | **4 700** |
| Crematoriums | 10 | 14 | 18 | 26 | 27 | 28 | 29 | 30 | 30 |
| Waste Incineration | 71 000 | 26 000 | 7 200 | 4 500 | 4 500 | 4 900 | 4 700 | 4 600 | 4 700 |
| Waste Treatment and Disposal | - | 230 | 96 | 0.47 | 0.080 | 0.082 | 0.084 | 0.22 | 0.071 |
| **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** | **59 000** | **21 000** | **7 200** | **7 700** | **8 100** | **7 900** | **8 500** | **8 800** |

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

**Other emissions estimated in the APEI**

| Source | 1990 | 2000 | 2005 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 |
|---|---|---|---|---|---|---|---|---|---|
| Domestic Air Transportation (Cruise) | - | - | - | - | - | - | - | - | - |
| International Air Transportation (Cruise) | - | - | - | - | - | - | - | - | - |
| International Marine Navigation | - | - | - | - | - | - | - | - | - |

Note: Refer to Annex 4.4 for more information.

# 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
- 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 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 is presented in Figure 3–1. It consists of categorizing facility-reported data (section 3.2), calculating in-house estimates (section 3.3), and 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 (section 3.5). Quality control is performed throughout inventory development (section 3.6), and continuous improvement often results in revisions to previously published estimates (section 3.7).

### 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 facility-reported emissions needed for the air pollutant inventory report.

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).

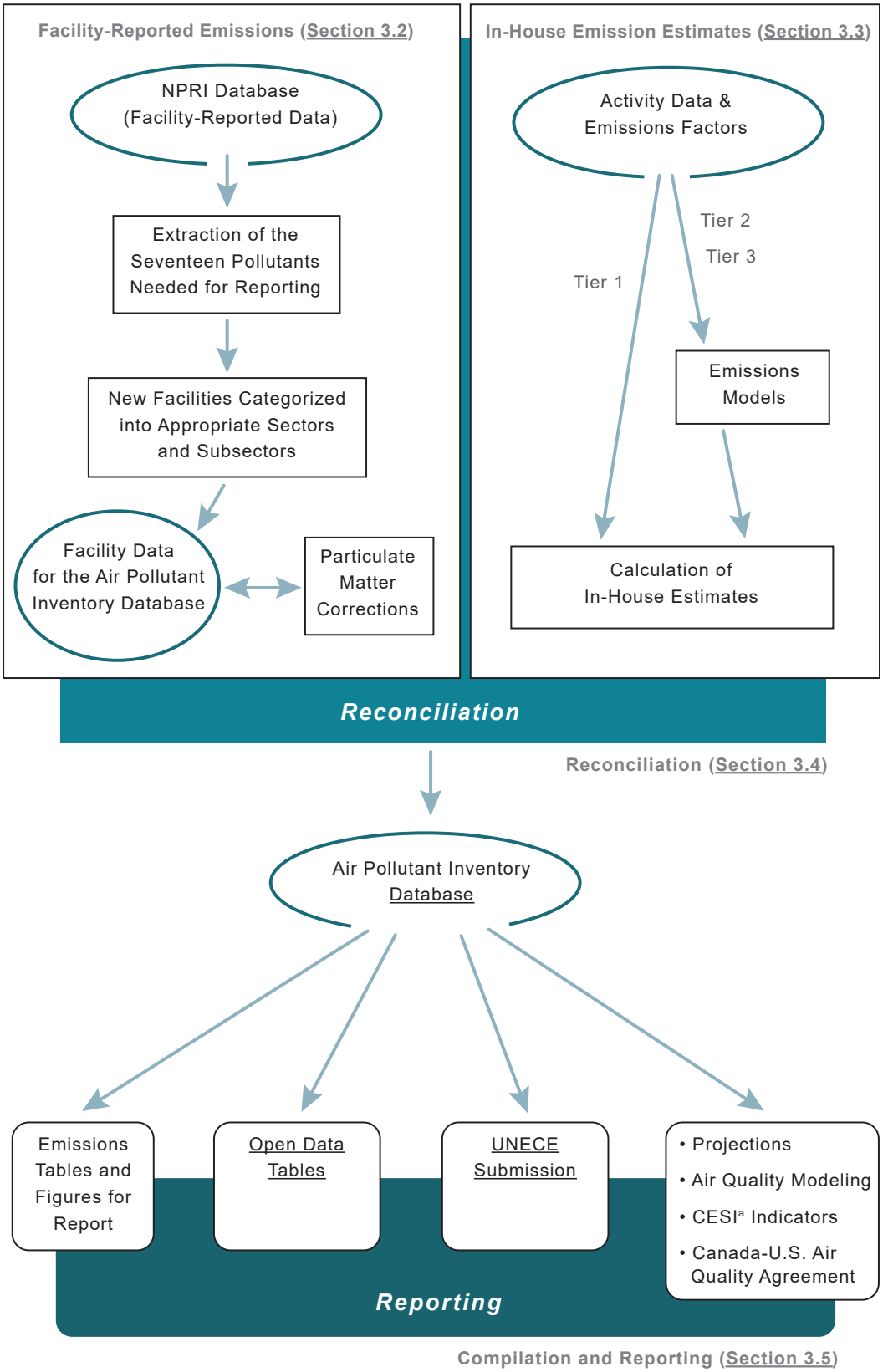
More information on in-house estimates can be found in section 3.3.

### Reconciliation

The next step in the compilation process is eliminating 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 2019, reconciliation was performed for about 27 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 2021 Air Pollutant Emissions Inventory Origin

| Air Pollutant Emissions Inventory Categories | 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** | ☑ | ☑ | 2019 |
| **Cement and Concrete Industry** | | | |
| Cement Manufacturing | ☑ | | |
| Concrete Batching and Products | ☑ | ☑ | 2019 |
| 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) | ☑ | ☑ | 2019 (Hg in Products) |
| Steel Recycling | ☑ | ☑ | 2019 (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 | ☑ | ☑ | 2019 |
| Silica Production | | ☑ | 2019 |
| 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 | ☑ | ☑ | 2019 |
| Other (Downstream Oil and Gas Industry) | ☑ | | |
| **Upstream Oil and Gas Industry** | | | |
| Accidents and Equipment Failures | | ☑ | 2019 |
| Disposal and Waste Treatment | | ☑ | 2019 |
| Heavy Crude Oil Cold Production | | ☑ | 2019 |
| Light/Medium Crude Oil Production[c] | ☑ | ☑ | 2019 |
| Natural Gas Production and Processing[d] | ☑ | ☑ | 2019 |
| Natural Gas Transmission and Storage | ☑ | ☑ | 2019 |
| Oil Sands In-Situ Extraction | ☑ | ☑ | 2019 |
| Oil Sands Mining, Extraction and Upgrading | ☑ | | |
| Petroleum Liquids Storage | ☑ | | |
| Petroleum Liquids Transportation | | ☑ | 2019 |
| Well Drilling/Servicing/Testing | | ☑ | 2019 |
| **ELECTRIC POWER GENERATION (UTILITIES)** | | | |
| **Coal** | ☑ | | |
| **Diesel** | ☑ | | |
| **Natural Gas** | ☑ | | |
| **Waste Materials** | ☑ | | |
| **Other (Electric Power Generation)** | ☑ | | |
| **MANUFACTURING** | | | |
| **Abrasives Manufacturing** | ☑ | | |
| **Bakeries** | ☑ | ☑ | 2019 |
| **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** | ☑ | ☑ | 2019 (Hg in Products) |
| **Food Preparation** | ☑ | | |
| **Glass Manufacturing** | ☑ | | |
| **Grain Industry** | | | |
| Grain Processing | ☑ | ☑ | 2019 |
| Warehousing and Storage | ☑ | | 2019 |
| **Metal Fabrication** | ☑ | | |
| **Plastics Manufacturing** | ☑ | | |
| **Pulp and Paper Industry** | | | |
| Pulp and Paper Product Manufacturing | ☑ | | |
| Converted Paper Product Manufacturing | ☑ | | |

Table 3–1 **2021 Air Pollutant Emissions Inventory Origin** (cont'd)

| Air Pollutant Emissions Inventory Categories | 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 | ☑ | ☑ | 2019 |
| Sawmills | ☑ | ☑ | 2019 |
| Other (Wood Products) | ☑ | | |
| **Other (Manufacturing)** | ☑ | | |
| **TRANSPORTATION AND MOBILE EQUIPMENT** | | | |
| **Air Transportation (LTO)** | | ☑ | 2019 |
| **Heavy-Duty Diesel Vehicles** | | ☑ | 2019 |
| **Heavy-Duty Gasoline Vehicles** | | ☑ | 2019 |
| **Heavy-Duty LPG/NG Vehicles** | | ☑ | 2019 |
| **Light-Duty Diesel Trucks** | | ☑ | 2019 |
| **Light-Duty Diesel Vehicles** | | ☑ | 2019 |
| **Light-Duty Gasoline Trucks** | | ☑ | 2019 |
| **Light-Duty Gasoline Vehicles** | | ☑ | 2019 |
| **Light-Duty LPG/NG Trucks** | | ☑ | 2019 |
| **Light-Duty LPG/NG Vehicles** | | ☑ | 2019 |
| **Domestic Marine Navigation, Fishing and Military** | | ☑ | 2018 |
| **Motorcycles** | | ☑ | 2019 |
| **Off-Road Diesel Vehicles and Equipment** | | ☑ | 2019 |
| **Off-Road Gasoline/LPG/NG Vehicles and Equipment** | | ☑ | 2019 |
| **Rail Transportation** | | ☑ | 2019 |
| **Tire Wear and Brake Lining** | | ☑ | 2019 |
| **AGRICULTURE** | | | |
| **Animal Production** | | ☑ | 2019 |
| **Crop Production** | | | |
| Harvesting | | ☑ | 2019 |
| Inorganic Fertilizer Application | | ☑ | 2019 |
| Sewage Sludge Application | | ☑ | 2019 |
| Tillage Practices | | ☑ | 2019 |
| Wind Erosion | | ☑ | 2019 |
| **Fuel Use** | ☑ | ☑ | 2019 |
| **COMMERCIAL/RESIDENTIAL/INSTITUTIONAL** | | | |
| **Commercial and Institutional Fuel Combustion** | ☑ | ☑ | 2019 |
| **Commercial Cooking** | | ☑ | 2018 |
| **Construction Fuel Combustion** | | ☑ | 2019 |
| **Home Firewood Burning** | | ☑ | 2017 |
| **Human** | | ☑ | 2019 |
| **Marine Cargo Handling** | ☑ | | |
| **Residential Fuel Combustion** | | ☑ | 2019 |
| **Service Stations** | | ☑ | 2019 |
| **Other (Miscellaneous)[f]** | | ☑ | 2008 |
| **INCINERATION AND WASTE** | | | |
| **Crematoriums** | ☑ | ☑ | 2019 |
| **Waste Incineration** | | | |
| Municipal Incineration | ☑ | ☑ | 2019 |
| Residential Waste Burning[g] | | ☑ | 2019 |
| Sewage Sludge Incineration | | ☑ | 2019 |
| Other (Waste Incineration) | ☑ | | |
| **Waste Treatment and Disposal** | | | |
| Landfills | ☑ | ☑ | 2019 |
| Municipal Wastewater Treatment and Discharge | ☑ | | |
| Specialized Waste Treatment and Remediation | ☑ | | |
| Biological Treatment of Waste | ☑ | ☑ | 2019 |
| Waste Sorting and Transfer | ☑ | | |
| **PAINTS AND SOLVENTS** | | | |
| **Dry Cleaning** | ☑ | ☑ | 2019 |
| **General Solvent Use** | | ☑ | 2019 |
| **Printing** | ☑ | ☑ | 2019 |
| **Surface Coatings** | ☑ | ☑ | 2019 |
| **DUST** | | | |
| **Coal Transportation** | | ☑ | 2019 |
| **Construction Operations** | | ☑ | 2012 |
| **Mine Tailings** | | ☑ | 2018 |
| **Paved Roads** | | ☑ | 2018 |
| **Unpaved Roads** | ☑ | ☑ | 2018 |
| **FIRES** | | | |
| **Prescribed Burning** | | ☑ | 2019 |
| **Structural Fires** | | ☑ | 2017 |
| | | | |
| **Mercury in Products[h]** | | ☑ | 2019 |

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. 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.

g. 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.

h. 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 Products emissions continue to be estimated and reported under these sectors.

## Compilation and Reporting

The final steps in the development process involve 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[1]
- open data emissions tables published on open.canada.ca[2]
- input to other products, such as air pollutant emissions projections, air quality modeling, Canadian Environmental Sustainability Indicators,[3] and reports under the Canada-U.S. Air Quality Agreement[4]
- Canada's submission to the United Nations Economic Commission for Europe (UNECE) under the Convention of Long-range Transboundary Air Pollution (Annex 4)

More information on compilation and reporting is available in section 3.5.

# 3.2. Facility-Reported Emissions Data

Facility-reported emissions data generally refer 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 18 000 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 ECCC 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 particulate matter (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 ECCC's website in the National Pollutant Release Inventory section.[5]

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 owing 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 to 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 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 for 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. No VOC data collected under Part 5 is used in the APEI.

In 2019, approximately 5760 facilities reported releases to air of one or more APEI pollutants to the NPRI.

Using the 2019 NPRI database, with data available as of November 19, 2020, 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 3.6 was applied to the NPRI data to identify outliers or missing substance reports.

1 canada.ca/apei

2 https://open.canada.ca/data/en/dataset/fa1c88a8-bf78-4fcb-9c1e-2a5534b92131

3 https://www.canada.ca/en/environment-climate-change/services/environmental-indicators/air-pollutant-emissions.html

4 https://www.canada.ca/en/environment-climate-change/corporate/international-affairs/partnerships-countries-regions/north-america/canada-united-states-air-quality.html

5 www.canada.ca/NPRI

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, are used to assign preliminary APEI sector and subsector classifications. Then, additional research and verification are performed to confirm or correct the classification. The assigned classification is then used for subsequent reporting years, as long as the facility does not change operations.

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 2006–2016 facility-reported PM emission data for most sectors and 2002–2017 facility-reported emission data for certain other sectors. 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 |

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**

| Air Pollutant Emissions Inventory Categories | $PM_{10}$ 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)

| Air Pollutant Emissions Inventory Categories | $PM_{10}$ 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 (LTO)** | – | – | – |
| **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** | – | – | – |
| **Domestic Marine Navigation, Fishing and Military** | – | – | – |
| **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** | | | |
| **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:

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

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

a. Adapted from EC (2014).

b. Adapted from ECCC (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).

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.

## 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 do 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 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.[6] Depending on the sources, there are three estimation levels (tiers) that represent methodological complexity: Tier 1 is the simple (most basic) method; Tier 2, the intermediate; and Tier 3, the most demanding in terms of complexity and data requirements. Tiers 2 and 3 are referred as higher tier methods and are considered more accurate. Tier 1 methods typically apply a simple linear relation between activity data and emission factors. The default Tier 1 emission factors are chosen in way that they represent typical process conditions—they tend to be technology independent. The United Nations Economic Commission for Europe (UNECE) provides Tier 1 methods for all the source and substances which the countries that have ratified Convention protocols need to report. Tier 2 methods use the same or similar activity data to Tier 1 methods, but apply country-specific emission factors; country-specific emission factors need to be developed, using country-specific information. Tier 3 methods go beyond the above; these may include using facility level data and/or sophisticated models. It is a good practice to use higher tier methods for categories that are contributing more to total emissions.

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
- 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 2019 in-house estimate is based.

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

6 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)."

## 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. $\text{InHouseEstimate}_{\text{REC}} = 0$).
  - However, certain industrial sectors still have an in-house estimate component and require reconciliation.
- In general, reconciliation procedures were performed for sector/subsectors that had both in-house estimates and facility-reported data (Table 3–1).
  - For example, for 2019, 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 :

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

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

- If the total in-house estimate quantity is less than or equal to the total of the facility-reported data for the source, the reconciled in-house estimate is equal to zero, as outlined in Equation 3–5.

Equation 3–5 :

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

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

Some points to consider:

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

Mercury (Hg) 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 or other facility-reported data involves a review and characterization of the source of the Hg air emissions included in the facility-reported estimate. This is to ensure that the Hg emissions estimated through the life-cycle approach are not duplicated in the facility-reported data. In situations where overlap exists, either the area source emissions from mercury in products are removed from reporting in the APEI or a proportion method is applied. The proportion method only changes the mercury in product emissions, while the point source emissions remained unchanged (Equation 3–6 and Equation 3–7):

Equation 3–6 :

$$\text{Proportion} = \frac{(\text{Sum Mercury in Product Emissions} - \text{Sum Point Source Emissions})}{\text{Sum Mercury in Product Emissions}}$$

Equation 3–7 :

$$\text{Final Emissions for Mercury in Products} = \text{Sum of Mercury in Product Emissions} \times \text{Proportion}$$

This is done at the provinces/territories level by year.

## 3.5. Compilation and Reporting

The time interval between when emissions data from industries are received and the submission to the UNECE is relatively short. Tools used to compile emissions, fill the UNECE Nomenclature for Reporting (NFR) tables templates, perform quality control tests as well as to generate the different tables and figures for this report are automated as much as possible to allow quick compilation, efficient corrections as well as to reduce the possibility of errors.

APEI data are also used for other initiatives such as Canadian Environmental Sustainability Indicators, emissions projections, air quality modeling as well as other agreements like the Canada-U.S. Air Quality Agreement (Figure 3–1).

## 3.6. 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.

### 3.6.1. 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 identifying missing NPRI facility reports/reporters and assessing new reports/reporters, to ensure that the correct data are captured.

Identifying outliers (i.e. reports that significantly depart from comparable NPRI facility-reported data) is critically important to ensuring 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.

### 3.6.2. 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 verifications and quality control checks are undertaken on the in-house emission estimates of the current year to ensure quality, accuracy and consistency. The following are verified:

- activity data
- emission factors
- unit conversions
- emission calculations

### 3.6.3. Phase 3: Compiled Air Pollutant Emissions Inventory

Phase 3 includes all the tests performed just before compiling all estimates together and once the estimates are reconciled and compiled in a final database. First, before integrating the emissions estimates from all sources together, automated quality control tests are done on each individual part. The tests performed includes checking for duplicates, making sure all sources are considered and all mandatory fields are filled, verifying units and other tests. Those tests are to insure the quality of the compiled database.

Finally, once all estimates have been compiled together, trend analysis graphics and recalculations graphics are produced to analyse the accuracy of the estimates. Data visualisation tools such as Microsoft Power BI are also used for trend analysis and identify any abnormal gaps. Any significant changes from year to year and any recalculated emissions are identified and explained.

## 3.7. 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 emissions 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). These pollutants are identified in the *Canadian Environmental Protection Act, 1999* (CEPA 1999) and the 1979 Convention on Long-range Transboundary Air Pollution (CLRTAP) and associated protocols ratified by Canada. The APEI also reports some 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) that impact air quality as well. Chapter 2 summarizes the air emissions of these air pollutants grouped into 12 families 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.

### Total Particulate Matter (TPM)

TPM includes any PM with a diameter less than 100 microns. It includes $PM_{10}$ and $PM_{2.5}$.

### 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. It includes $PM_{2.5}$.

### 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. Emissions of $PM_{2.5}$ and its precursor gases originate typically from combustion processes—motor vehicles, industrial processes, vegetative burning and crop production.

### 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 PM). $SO_2$ 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). In this report, $NO_x$ 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. 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, leading to smog.[1] VOCs may condense in the atmosphere to contribute to ambient PM formation and acid rain. 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. Ambient CO concentrations are much higher in urban areas due to the larger number of human sources.

### Ammonia ($NH_3$)

$NH_3$ is a corrosive gas that originates from anthropogenic sources: major sources of $NH_3$ emissions include agricultural livestock, agricultural fertilizer use and synthetic fertilizer manufacturing. $NH_3$ has been identified as one of the principal precursors to $PM_{2.5}$.

1 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 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 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 has unique properties 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. Emissions of Hg in the atmosphere comes from various sectors: iron and steel production, electric power generation from combustion of coal, waste incineration and various commercial, residential and institutional uses.

## A1.3. Persistent Organic Compounds

### Dioxins and Furans (D/F)

Dioxins and furans are a family of anthropogenic 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 environment from natural and anthropogenic sources. Some PAHs are genotoxic and induce mutations that initiate cancer. The largest anthropogenic sources of PAHs released to the atmosphere are home firewood burning as well as transportation and mobile equipment sources.

In this report, 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. The National Pollutant Release Inventory (NPRI) facility-reported data are available for additional PAHs.

### Hexachlorobenzene (HCB)

HCB is a persistent organic pollutant. It is also carcinogenic. 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, 2019).

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.

Tables 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:<br>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<br>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. and Ontario Research Foundation (1981)<br>Asphalt usage data from construction: Statistics Canada (n.d.[a]) |
| 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)<br>VOCs from paving: SNC/GECO Canada Inc. and 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.<br>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:<br>TPM, $PM_{10}$, $PM_{2.5}$, Pb, Cd<br>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.<br>The national domestic consumption of cement in 2019 is assumed to stay at 2018 level. |
| Activity Data | Cement consumption distribution for the provinces: CANMET (1993)<br>Cement production and export data: Statistics Canada (2018)<br>Population data for the provinces/territories: Statistics Canada (n.d.[b]) |
| Emission Factors (EF) | TPM, $PM_{10}$, $PM_{2.5}$, Pb, Cd: U.S. EPA (1998), U.S. EPA (2010)<br>Emission factors for TPM, $PM_{10}$ and $PM_{2.5}$ emitted by loading mixers and loading trucks: (U.S. EPA, 2006)<br>$PM_{10}$ 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):<br>$EF_{PM10} = 0.51 \times EF_{TPM}$<br>$EF_{PM2.5} = 0.15 \times EF_{TPM}$ |
| **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:<br>TPM, $PM_{10}$, $PM_{2.5}$, $SO_x$, $NO_x$, VOCs, CO<br>Methodology under review.<br>The in-house estimates were last calculated for 2011 and were carried forward to 2019. |
| 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.<br>Stone processing is categorized into three activities, depending on the size of stone required: crushed stone, pulverized stone and building stone.<br>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:<br>TPM, $PM_{10}$, $PM_{2.5}$<br>Total quantity of rock, sand and gravel produced by province/territory is multiplied by pollutant-specific emission factors. |
| Activity Data | Annual Statistics of Mineral Production: NRCan (2020) |
| Emission Factors (EF) | TPM, $PM_{10}$, $PM_{2.5}$: EEA (2019) |

| 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:<br>TPM, $PM_{10}$, $PM_{2.5}$<br>Total quantity of silica produced by province/territory is multiplied by pollutant-specific emission factors. |
| Activity Data | Annual Statistics of Mineral Production: NRCan (2020)<br>Confidential provincial production values are estimated with employment distributions: Statistics Canada (n.d.[c]) |
| Emission Factors (EF) | TPM, $PM_{10}$, $PM_{2.5}$: EEA (2019) |

References for this table can be found on page 86.

| 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.<br>Only fugitive VOC emissions from bulk plants are estimated in-house. |
| General Inventory Method | Pollutant(s) estimated:<br>VOCs<br>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 (n.d.[a]) |
| 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.<br>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:<br>TPM, $PM_{10}$, $PM_{2.5}$, $SO_x$, $NO_x$, VOCs, CO, $NH_3$<br>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 (2020) |
| 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.<br>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:<br>TPM, $PM_{10}$, $PM_{2.5}$, $SO_x$, $NO_x$, VOCs, CO, $NH_3$<br>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 (2020)<br>Natural gas injections to storage and withdrawals from storage: Statistics Canada (n.d.[b]) |
| 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:<br>• Accidents and Equipment Failures<br>• Disposal and Waste Treatment<br>• Heavy Crude Oil Cold Production<br>• Light Medium Crude Oil Production<br>• Natural Gas Production and Processing<br>• Oil Sands In-Situ Extraction<br>• Petroleum Liquids Transportation<br>• Well Drilling/Servicing/Testing<br>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:<br>TPM, $PM_{10}$, $PM_{2.5}$, $SO_x$, $NO_x$, VOCs, CO, $NH_3$<br>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.<br>Alberta reported venting and flaring emissions are calculated directly (i.e. not extrapolated) for the years 2010 to 2019 using monthly conventional volumetric data (Petrinex, 2020) and detailed gas composition data for each township in Alberta (Tyner and Johnson, 2020). |
| Activity Data | Spills and accidents: AER (2020a), BCOGC (2020a), CNLOPB (2020a), MB (2020), and SKMER (2020a)<br>Wells drilled: CAPP (2020)<br>Operating wells: CAPP (2020) and CNLOPB (2020b, 2020c, 2020d, 2020e, 2020f)<br>Reported volumes of gas flared and vented: AER (2020b), BC (2019), BCOGC (2019, 2020b), CNLOPB, (2020g), and SKMER (2020b)<br>Fuel gas volumes: AER (2020c), BC (2019), BCOGC (2020b) and SKMER (2020b)<br>In-situ bitumen production volumes: AER (2020d)<br>Non-associated natural gas production volumes: CER (2020)<br>Crude oil and natural gas production volumes: NBERD (2020), SKMER (2020c, 2020d) and Statistics Canada (n.d.[c], n.d.[d], n.d.[e], n.d.[f])<br>Natural gas shrinkage: AER (2020e) and BC (2020)<br>Alberta monthly conventional volumetric data: Petrinex (2020)<br>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 National Pollutant Release Inventory (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)<br>Alberta flaring emissions from 2010 to 2019 are calculated using the monthly conventional volumetric data (Petrinex 2020) and emission factors calculated from the detailed gas composition data (Tyner and Johnson, 2020). The flaring $SO_2$ emission factor is calculated as shown in Equation A2–2.1.<br>Equation A2–2.1:<br>$$EF_{SO2,i} = \sum_j \frac{y_{i,j} \cdot n_{s,j} \cdot MW_{SO2}}{V_{STP}} \cdot g_c$$<br>$EF_{SO2,i}$ = volume-weighted $SO_2$ emission factor for township i ($g/m^3$)<br>$y_{i,j}$ = mole fraction of component j in township i<br>$n_{s,j}$ = number of sulphur atoms per molecule of component j<br>$MW_{SO2}$ = molecular weight of $SO_2$ (g/mol) = 64.066 g/mol<br>$V_{STP}$ = volume of gas at standard conditions (101.325 kPa and 15°C) = 23.6444813 $m^3$/kmol<br>$g_c$ = constant of proportionality = 1000 mol/kmol<br>The VOC emission factor is calculated as shown in Equation A2–2.2.<br>Equation A2–2.2:<br>$$EF_{i,j} = \sum_j \frac{y_{i,j} \cdot MW_j \cdot (1 - CE)}{V_{STP}} \cdot g_c$$<br>$EF_{i,j}$ = emission factor for township i and VOC component j ($g/m^3$)<br>$MW_j$ = molecular weight of VOC component j (g/mol)<br>$CE$ = combustion efficiency = 0.98 (EC, 2014) |

## Table A2–2 Estimation Methodologies for the Oil and Gas Industry (cont'd)

| Sector/Subsector | |
|---|---|
| **UPSTREAM OIL AND GAS INDUSTRY (cont'd)** | |
| Emission Factors (EF) (cont'd) | Flaring emission factors for $NO_x$, CO, $PM_{2.5}$, $PM_{10}$ and TPM are calculated using Equation A2–2.3. |

Equation A2–2.3:

$$EF_{i,j} = ER_j \cdot HHV_i$$

$EF_{i,j}$ = emission factor for township i and pollutant j (g/m³)
$ER_j$ = flaring emission rate for pollutant j (g/MJ)
$HHV_i$ = higher heating value for township i (MJ/m³)

The flaring emission rates for $NO_x$, CO, $PM_{2.5}$, $PM_{10}$ and TPM are as follows:

| Pollutant | Emission Rate (g/MJ) | Uncertainty | Source |
|---|---|---|---|
| $NO_x$ | 0.0292 | ±50% | EC (2014) |
| CO | 0.1591 | -55% to +181% | |
| TPM, $PM_{10}$, $PM_{2.5}$ | 0.057 | ±50% | |

Lastly, reported venting emissions for Alberta from 2010 to 2019 are calculated using the summarized township vented volumes and township gas composition data as shown in Equation A2–2.4.

Equation A2–2.4:

$$Emis_{i,j} = y_{i,j} \cdot Vol_i \cdot \rho_j$$

$Emis_{i,j}$ = vented emissions of component j in township i (kilotonnes)
$y_{i,j}$ = mole fraction of component j in township i
$Vol_i$ = volume of gas vented in township i ($10^3$ m³)
$\rho_j$ = density of component j at standard conditions (101.325 kPa and 15°C) (kg/m³)

References for this table can be found on page 87.

## 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:<br>VOCs<br>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:<br>• national wheat flour available: Statistics Canada (2020)<br>• population data for provinces and territories: Statistics Canada (n.d.)<br>• 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)<br>$EF_{VOC}$ = 2.36 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:<br>**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).<br>**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).<br>**Terminal elevators** dry, clean, blend and store grain for shipment.<br>**Transfer elevators** generally perform the same function as terminal elevators. |
| General Inventory Method | Pollutant(s) estimated:<br>TPM, $PM_{10}$, $PM_{2.5}$<br>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:<br>$$Grain\ throughputs = (PY - W52) - (PY - W22) + (CY - W22)$$<br>**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).<br>The division of grains between Western Canada and Eastern Canada is performed based on the Total Canadian grain (Statistics Canada, 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.<br>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.<br>$$Emission = Activity\ level \times (1 - Control\ Efficiency) \times Emission\ factor \times Handling\ ratio$$<br>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.<br>**Panel Board Mills** include emissions from several types of mills, all producing hardwood and softwood-based materials. These include:<br>• veneer and plywood mills<br>• waferboard mills, consisting primarily of oriented strand board (OSB) mills<br>• particle board and medium-density fiberboard (MDF) mills<br>**Other Wood Products** encompass emissions from furniture and cabinet manufacturers, wood treating plants, wood pellet mills and masonite manufacturers.<br>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:<br>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<br>**Sawmills and Panel Board Mills**<br>• 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);<br>• 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).<br>The in-house estimates for sawmills and panel board mills were carried forward in 2016 based on 2015 mill capacities. Capacity data was available for 2017. The 2018 capacity data was updated based on 2019 data. Capacity data was available for 2019.<br>**Other Wood Products**<br>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 2019 data and data sources for facilities not reporting to the NPRI, including:<br>• *Natural Resources Canada: Status of Energy Use in the Canadian Wood Products sector* (Meil et al., 2009)<br>• *The State of Canada's Forests Annual Report 2019* (NRCan, Canadian Forest Service, 2020)<br>• Forest Products Association of Canada annual reports (proprietary reports)<br>• Environment and Climate Change Canada's Forestry Products Group<br>• *RISI North American Wood Panels and Engineered Wood Products Capacity Report* (RISI, 2019)<br>• Madison's 2017 Online Lumber Directory (Madison, 2017)<br>• Verbal communications with industry representatives (unpublished) |
| Emission Factors (EF) | Sawmills: U.S. EPA (2012)<br>Plywood manufacturing, particle board, oriented strand board: U.S. EPA (1995)<br>Fuel combustion: Meil et al. (2009) and U.S. EPA (1992, 1995, 2014) |

References for this table can be found on page 88.

Table A2–4 **Estimation Methodologies for Transportation and Mobile Equipment**

| Sector/Subsector | |
|---|---|
| **AIR TRANSPORTATION (LTO)** | |
| Description | Air Transportation (landing and takeoffs [LTO]) covers emissions from aircraft but not airport support equipment (captured as off-road applications). |
| General Inventory Method | Pollutant(s) estimated:<br>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<br>Aircraft-specific activity (LTO) 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, n.d.[a]), 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) Engine Databank (ICAO, 2019) for LTO and derived from the *Master emissions calculator 2019* spreadsheet from Annex 5 of the *EMEP/EEA air pollutant emissions inventory guidebook 2019* (EEA, 2019) 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 database* (ECCC, 2020a). The $NH_3$ emission factor is taken from (Coe et al., 1996). Emissions of $PM_{10}$ for jet engines during the 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 turboprop/turboshaft engines the emissions of $PM_{10}$ are derived from the *Documentation for aircraft, commercial marine vessel, locomotive, and other non-road components of the national emissions inventory* (U.S. EPA, 2005a). All PM from aircraft using turbo aviation fuel is considered to be less than $PM_{10}$ therefore, TPM is equal to $PM_{10}$. Emissions of $PM_{10}$ for jet engines during the cruise are derived from the *Master emissions calculator 2019* spreadsheet from Annex 5 of the *EMEP/EEA air pollutant emissions inventory guidebook 2019* (EEA, 2019). Emissions of $PM_{10}$ for turboprop/turboshaft engines during the cruise are derived from the *Aircraft Particulate Matter Emission Estimation through all Phases of Flight* (Eurocontrol, 2005) *and AERO$_2$k Global Aviation Emissions Inventories for 2002 and 2025* (Eyers et al., 2004). The $PM_{2.5}$, B(a)p, B(b)f, B(k)f and I(cd)p emission factors are taken from the *Documentation for aircraft, commercial marine vessel, locomotive, and other non-road components of the national emissions inventory* (U.S. EPA, 2005a). The VOC emission factor is taken from *Procedures for Emission Inventory Preparation Volume IV Mobile Sources* (U.S. EPA, 1992), which relates VOCs to total HC.<br>For aircraft using aviation gasoline, HC, CO, $PM_{10}$ and $NO_x$ emission factors are taken from the Federal Office of Civil Aviation (FOCA, 2007) for LTO and derived from the *Master emissions calculator 2019* spreadsheet from Annex 5 of the *EMEP/EEA air pollutant emissions inventory guidebook 2019* (EEA, 2019) for the cruise stage. $SO_2$ is estimated as a sulphur balance, using data from the *Sulphur in liquid fuels database* (ECCC, 2020a). The $NH_3$ emission factor is taken from (Coe et al., 1996). All PM from aircraft using turbo aviation fuel is considered to be less than $PM_{10}$ therefore, TPM is equal to $PM_{10}$. $PM_{2.5}$, B(a)p, B(b)f, B(k)f and I(cd)p emission factors are taken from the *Documentation for aircraft, commercial marine vessel, locomotive, and other non-road components of the national emissions inventory* (U.S. EPA, 2005a). The VOC emission factor is taken from *Procedures for Emission Inventory Preparation Volume IV Mobile Sources* (U.S. EPA, 1992), which relates VOCs to total HC. The emission factor for lead is based on an expert review[1] of the CGSB specification from the *Ontario Alkyl Lead Inventory Study* (Patriache and Campbell, 1999). |
| **DOMESTIC MARINE NAVIGATION, FISHING AND MILITARY** | |
| Description | Domestic Marine Navigation, Fishing and Military covers emissions from commercial marine vessels, but not recreational marine engines (captured as off-road applications). |
| General Inventory Method | Pollutant(s) estimated:<br>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<br>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, 2016, 2019, 2020b, 2020c, 2020d, 2020e) 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, 2016, 2017, 2018 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:<br>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<br>Vehicle-specific activity (vehicle kilometres travelled) is multiplied by pollutant-specific emission factors in the MOVES model (version MOVES2014 was used for this submission).<br>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, n.d.[b], n.d.[c]). 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 (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, 2014) and in U.S. EPA technical guidance document (U.S. EPA, 2010). |

1 Niemi, D. (2012). Personal communication (email from Niemi D to Inventories Expert, Environment and Climate Change Canada, dated November 22, 2012). Pollutant Inventories and Reporting Division, Environment and Climate Change Canada. Gatineau (QC).

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

| Sector/Subsector | |
|---|---|
| **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:<br>TPM, $PM_{10}$, $PM_{2.5}$, $SO_x$, $NO_x$, VOCs, CO, $NH_3$<br>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, 2018a). Construction equipment populations used in oil sands mining operations are now sourced from The Parker Bay Company (ECCC, 2018b). |
| 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 $NONROAD_{2008}$, and modified by Environment and Climate Change Canada to exploit detailed activity data. Model operation is conducted following the user guide for $NONROAD_{2005}$/2008 (U.S. EPA, 2005b), given that the functionality of the models is the same.<br>More information on the NONROAD model is available online. |
| **RAIL TRANSPORTATION** | |
| Description | Rail Transportation covers emissions from the fuel consumed by locomotive engines. |
| General Inventory Method | Pollutant(s) estimated:<br>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<br>Railway activity (fuel consumption) is multiplied by pollutant-specific emission factors. |
| Activity Data | Fuel consumption data: Statistics Canada (n.d.[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 2017* Report (Railway Association of Canada, 2020). 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 dioxins and furans emission factor (0.54 ng/L) is taken from the A*n 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 89.

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.<br>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.<br>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.<br>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:<br>TPM, $PM_{10}$, $PM_{2.5}$, $NH_3$, NMVOCs<br>**Ammonia ($NH_3$)**<br>The methodologies for ammonia emissions were developed by Environment and Climate Change Canada (ECCC) in collaboration with Agriculture and Agri-Food Canada (AAFC) through a national research project: the National Agri-Environmental Standards Initiative (NAESI).<br>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 a few publications (Sheppard and Bittman, 2010; Sheppard and Bittman, 2012; Sheppard et al., 2007a; Sheppard et al., 2007b; Sheppard et al., 2009a; Sheppard et al., 2009b; Sheppard et al., 2010; Sheppard et al., 2011a; Sheppard et al., 2011b; Chai et al., 2016).<br>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.<br>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). |

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

| Sector/Subsector | |
|---|---|
| ANIMAL PRODUCTION (cont'd) | |
| General Inventory Method (cont'd) | **Particulate Matter (TPM, $PM_{10}$, $PM_{2.5}$)**<br>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, 2002), but uses country-specific emission factors. Methodologies are published in Pattey and Qiu Guowang (2012) and Pattey et al. (2015).<br>**Non-Methane Volatile Organic Compounds (NMVOCs)**<br>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, 2013).<br>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 1990-2018: Greenhouse Gas Sources and Sinks in Canada*, as described in Annex 3.4 of Part II of the NIR (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, n.d.[a], n.d.[b], n.d.[c], n.d.[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.<br>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.<br>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, n.d.[e]). Rabbit populations were taken from responses to the COA as provided on the AAFC Red Meat Market website (AAFC, 2016). |
| Emission Factors (EF) | **Ammonia**<br>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.<br>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.<br>Animal populations are reassigned to a matrix of animal housing and manure management systems based on their relative proportion in the overall farm population.<br>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, 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.<br>The models employed to calculate $NH_3$ emissions from beef and swine production are described in Sheppard and Bittman (2010, 2012) and Sheppard et al. (2010).<br>Dairy cattle:<br>Ammonia emissions are calculated according to Sheppard et al. (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: 1990–2018, 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).<br>Ammonia emission factors from Sheppard et al. (2011a) are expressed as fractions of total N using calculated TAN fractions (Chai et al., 2016) to produce ammonia N loss factors by ecoregion for housing and manure storage, manure application, and manure deposited on pasture, range, and paddock.<br>Manure management storage information was derived from Sheppard et al. (2011b) to identify proportions of manure excreted on pasture and in exercise yards and information on the 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, n.d.[f]) and the 2005 Livestock Farm Practices Survey (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.<br>Emissions from manure applied to agricultural soils were consistent with Sheppard et al. (2010) as modified according to Chai et al., 2016.<br>Swine:<br>Ammonia emissions are calculated according to Sheppard et al. (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: 1990–2018, Greenhouse Gas Sources and Sinks in Canada* (ECCC, 2020). 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.<br>Ammonia emission factors from Sheppard et al. (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.<br>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. |

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

| Sector/Subsector | |
|---|---|
| ANIMAL PRODUCTION **(**cont'd**)** | |
| Emission Factors (EF) (cont'd) | **Particulate Matter**<br>Total particulate matter (TPM) emission factors for poultry are taken from Van Heyst (2005) and Van Heyst and Roumeliotis (2007). Emission factors for cattle and swine are average values from Takai et al. (1998) and Seedorf (2004). In the case of $PM_{10}$ and $PM_{2.5}$, emissions are estimated from TPM emission factors multiplied by 0.45 and 0.1 to produce $PM_{10}$ and $PM_{2.5}$ emission factors, respectively.<br>Average animal weights are used to convert emission factors in the form of g $d^{-1}$ $AU^{-1}$ to units of kg $head^{-1}$ $year^{-1}$.<br>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: 1990–2018, Greenhouse Gas Sources and Sinks in Canada* (ECCC, 2020). All other animal weights were consistent with values used to estimate nitrogen excretion in (ECCC, 2020).<br>Currently no emissions are estimated for mink, fox, wild boars, deer, elk or rabbit.<br>**Non-Methane Volatile Organic Compounds (NMVOCs)**<br>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, 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 (Boardi et al., 2004).<br>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). |
| **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:<br>TPM, $PM_{10}$, $PM_{2.5}$, $NH_3$<br>**Ammonia**<br>The method is a simplified version of the approach adopted by Sheppard et al. (2010) for application on an annual time step.<br>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.<br>**Particulates**<br>Methodology is under review. |
| Activity Data | Data on the types of nitrogen fertilizer used on farms are published by Statistics Canada (n.d.[g])<br>Areas of seeded annual and perennial crops: Statistics Canada (n.d.[h])<br>Soil properties, including pH and cation exchange capacity, are included in calculations using soil polygon information from a national-scale spatial database describing the types of soils associated with landforms. |
| 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.<br>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.<br>TPM, $PM_{10}$ and $PM_{2.5}$ methodology is under review. |

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

| Sector/Subsector | |
|---|---|
| **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:<br>$NH_3$<br>**Ammonia**<br>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 Prince Edward Island (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.<br>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.<br>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.<br>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. |
| **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:<br>TPM, $PM_{10}$, $PM_{2.5}$<br>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 2018 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 1990–2018: Greenhouse Gas Sources and Sinks in Canada* (ECCC, 2020). |
| 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 and 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:<br>TPM, $PM_{10}$, $PM_{2.5}$<br>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.<br>Particulate matter emissions from agricultural tillage operations are proportional to the area tilled. They are also dependent on the type of tillage practice as well as the number of tillage events per year. The calculations are described in more detail in Pattey and Qiu Guowang (2012).<br>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 2018 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 1990–2018: Greenhouse Gas Sources and Sinks in Canada* (ECCC, 2020). Information on the number of tillage events per year for crop type and tillage practices is taken from soil cover indicators (Huffman et al., 2012). |
| Emission Factors (EF) | Emission factors for tillage practices are calculated using the method described in U.S. EPA (1985). |

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

| Sector/Subsector | |
|---|---|
| **WIND EROSION (**under CROP PRODUCTION**)** | |
| Description | Wind erosion occurs when wind blows across exposed agricultural land, resulting in PM emissions from the entrained particles. |
| General Inventory Method | Pollutant(s) estimated:<br>TPM, $PM_{10}$, $PM_{2.5}$<br>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 2018 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 1990–2018: Greenhouse Gas Sources and Sinks in Canada* (ECCC, 2020). |
| Emission Factors (EF) | The PM emission factor for wind erosion is calculated using the wind erosion equation (Woodruff and Siddoway, 1965) but considers the impact of soil and crop cover on PM emissions (Huffman et al., 2012). The emission factor for windblown PM emissions from agricultural lands is calculated using the methodology described in Pattey and Qiu 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:<br>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<br>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.<br>Total usage by fuel type and province/territory is multiplied by pollutant-specific emission factors. |
| Activity Data | Statistics Canada (n.d.[i]) |
| Emission Factors (EF) | TPM, $PM_{10}$, $PM_{2.5}$, $SO_x$, $NO_x$, VOCs, CO: U.S. EPA (1998)<br>(Emission factors are chosen to represent the typical type of combustion equipment for each fuel type)<br>TPM, $PM_{10}$, $PM_{2.5}$, $SO_x$, $NO_x$, VOCs, CO for natural gas fuel: U.S. EPA (2004)<br>Sulphur contents of liquid fuels: EC (2010)<br>Sulphur contents of coal: CEA (2002)<br>$NH_3$: Battye et al. (1994) and Coe et al. (1996)<br>Pb, Cd, Hg, dioxins/furans, B(a)p, B(b)f, B(k)f: CARB (2005) and U.S. EPA (1998, 2003, 2004)<br>(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 90.

Table A2–6 **Estimation Methodologies for Commercial/Residential/Institutional**

| Sector/Subsector | |
|---|---|
| **COMMERCIAL AND INSTITUTIONAL FUEL COMBUSTION, CONSTRUCTION FUEL COMBUSTION AND RESIDENTIAL FUEL COMBUSTION** | |
| Description | Commercial and Institutional Fuel Combustion, Construction Fuel Combustion and Residential Fuel Combustion include emissions resulting primarily from external combustion sources used for space/water heating and material heating. Commercial establishments, health and educational institutions, government/public administration facilities, and residences all fall under these categories, in addition to construction sites. |
| General Inventory Method | Pollutant(s) estimated:<br>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<br>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.<br>Total usage by fuel type and province/territory is multiplied by pollutant-specific emission factors. |
| Activity Data | Statistics Canada (n.d.[a]) |
| Emission Factors (EF) | TPM, $PM_{10}$, $PM_{2.5}$, $SO_x$, $NO_x$, VOCs, CO: U.S. EPA (1998)<br>(Emission factors are chosen to represent the typical type of combustion equipment for each fuel type.)<br>TPM, $PM_{10}$, $PM_{2.5}$, $SO_x$, $NO_x$, VOCs, CO for natural gas fuel: U.S. EPA (2004)<br>Sulphur contents of liquid fuels: EC (2010)<br>Sulphur contents of coal: CEA (2002)<br>$NH_3$: Battye et al. (1994) and Coe et al. (1996)<br>Pb, Cd, Hg, dioxins/furans, B(a)p, B(b)f, B(k)f: CARB (2005) and U.S. EPA (1998, 2003, 2004)<br>(Emission factors are selected to represent the typical type of combustion equipment for each fuel type) |

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

| Sector/Subsector | |
|---|---|
| **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.<br>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:<br>TPM, $PM_{10}$, $PM_{2.5}$, VOCs, CO, B(a)p<br>**Commercial meat cooking (1999 to present)**<br>1. determine the number of restaurants in each province/territory that were classified as ethnic, fast food, family, seafood, steak and BBQ<br>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<br>3. apply pollutant-specific emission factors to each type of food for each type of commercial cooking equipment to get the final emission estimates<br>**Commercial meat cooking (1990 to 1998)**<br>1999 emission estimates were back-casted to 1990 using the gross domestic product (GDP) for NAICS [72]: Accommodation and Food Services (Statistics Canada, n.d.[b]).<br>**Commercial cooking of french fries**<br>The annual national consumption rate of frozen fries was multiplied by the annual provincial/territorial population and by a VOC-specific emission factor. |
| Activity Data | **Commercial meat cooking (1999 to present only)**<br>Activity data were estimated using:<br>• annual restaurant census for Canada: ReCount Database (The NPD Group Inc., 2017)<br>• statistics on the prevalence of commercial cooking equipment, for the five restaurant types (E.H. Pechan & Associates Inc., 2003)<br>• 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)<br>**Commercial cooking of french fries**<br>Activity data were estimated using:<br>• provincial/territorial population data (Statistics Canada, n.d.[c])<br>• annual Canadian consumption rates of frozen fries (USDA FAS, 2015)<br>• assumed 80% of french fries were purchased in restaurants (E.H. Pechan & Associates Inc., 2003) |
| Emission Factors (EF) | Commercial meat cooking:<br>TPM, $PM_{10}$, $PM_{2.5}$, VOCs, CO, B(a)p: E.H. Pechan & Associates Inc. (2003)<br>Commercial cooking of french fries:<br>VOCs: E.H. Pechan & Associates Inc. (2003) |
| **HOME FIREWOOD BURNING** | |
| Description | Home Firewood Burning encompasses emissions from wood, pellets and manufactured logs 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:<br>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<br>The quantity of wood burned by device type and province is multiplied by pollutant-specific emission factors by device type. |
| Activity Data | Activity data for wood from (Statistics Canada, 1997, 2003, 2007, 2015, 2017) are converted from volume to mass utilizing the reported wood species burnt based on the reconciliation unit, and the moisture content. Activity data for pellets and manufactured logs from (Canadian Facts, 1997, 2006; TNS Canada, 2012; Statistics Canada, 2017) are used on the reported mass basis. Wood consumption is interpolated and extrapolated to the time series using pro-rated heating degree days in relation to the survey years (Kay, 2020). |
| Emission Factors (EF) | TPM, $PM_{10}$, $PM_{2.5}$, $SO_x$, $NO_x$, VOCs, CO, $NH_3$: Gulland (2000)<br>Pb, Cd, Hg, B(a)p, B(b)f, B(k)f: U.S. EPA (1995)<br>Dioxins/furans: EC (2000) |

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

| Sector/Subsector | |
|---|---|
| **HUMAN** | |
| Description | Ammonia and Mercury emissions from respiration and perspiration. |
| General Inventory Method | Pollutant(s) estimated:<br>$NH_3$ and Hg<br>**Respiration and perspiration**<br>Annual population data by province/territory are multiplied by an $NH_3$ emission factor.<br>Mass balance of mercury from dental amalgams (see Table A2–11) |
| Activity Data | **Respiration and perspiration**<br>Population data: Statistics Canada (n.d.[c]) |
| Emission Factors (EF) | Respiration and perspiration:<br>$NH_3$: 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.<br>Off-road refuelling emissions include all non-vehicle gasoline usage (lawn mowers, snow blowers, etc.). |
| General Inventory Method | Pollutant(s) estimated:<br>VOCs<br>**Refined petroleum products retail**<br>Emissions are calculated using gasoline usage data multiplied by emission factors for underground tank filling and breathing.<br>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.<br>**Off-road refuelling**<br>Off-road refuelling emissions are calculated using off-road gasoline usage data multiplied by an emission factor for uncontrolled vehicle refuelling.<br>**On-road refuelling**<br>On-road refuelling estimates are produced using the MOVES model. This year's estimates were made using $MOVES_{2014}$. Vehicle-specific activity (vehicle kilometres travelled) is multiplied by pollutant-specific emission factors. |
| Activity Data | Refined petroleum products retail: Gross sales of gasoline for motor vehicles: Statistics Canada (n.d.[d]).<br>Off-road refuelling: Off-road gasoline usage data from ECCC (2020)<br>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.<br>Motorcycle populations originate from the Road motor vehicle, trailer and snowmobile registration database (Statistics Canada, n.d.[e]). 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)<br>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, 2014) and in the U.S. EPAs technical guidance document (U.S. EPA, 2010). |

References for this table can be found on page 92.

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

| Sector/Subsector | |
|---|---|
| **CREMATORIUMS** | |
| Description | Crematoriums cover emissions from the combustion of caskets and human bodies.<br>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:<br>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<br>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 2019 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, 2020) includes data from 2008 to 2019. 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)<br>VOCs, HCB: EEA (2013)<br>$SO_x$, $NO_x$, CO: EEA (2009)<br>Hg, Cd, Pb: U.S. EPA (2014)<br>Dioxins/furans: U.S. EPA (2014)<br>B(a)p, B(b)f, B(b)k, I(cd)p: U.S. EPA (2014)<br>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:<br>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<br>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, 2020). |
| Emission Factors (EF) | TPM, $PM_{10}$, $PM_{2.5}$, Cd, Pb, Hg, D/F, $NO_x$, $SO_x$, $NH_3$, CO, VOC: 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:<br>TPM, $PM_{10}$, $PM_{2.5}$, Cd, CO, dioxins/furans, HCB, Hg, $NH_3$, $NO_x$, Pb, $SO_x$, VOCs<br>Methodology under review; however, the majority of emissions since 2012 are sourced from the NPRI. |
| Activity Data | Methodology under review. |
| Emission Factors (EF) | Methodology under review. |
| **LANDFILLS** (under WASTE TREATMENT AND DISPOSAL) | |
| Description | Landfills include emissions from bulk non-hazardous waste disposed of in landfills across Canada. Materials deposited into landfills are covered daily with soil to prevent scattering of litter by wind, scavenging by animals, and odours. Dust (particulate matter) emissions occur due to wind erosion, the movement of heavy vehicles and the dumping of waste.<br>VOC emissions are emitted as a component of landfill gas (LFG) generated by the anaerobic decomposition of organic waste within the landfill, mostly in the form of methane. |
| General Inventory Method | Pollutant(s) estimated:<br>TPM, $PM_{10}$, $PM_{2.5}$, VOCs<br>The quantity of waste landfilled for each province/territory is multiplied by PM emission factors to determine the amount of PM released.<br>VOC emissions are calculated from the total $CH_4$ in landfill gas released, as calculated in Canada's NIR. |
| 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.<br>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)<br>$PM_{10}$, $PM_{2.5}$: GVRD and 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 $EF_{TPM}$.<br>VOCs: U.S. EPA (1995). The default concentration of VOC in landfill gas is 835 ppmv. |

Table A2–7 **Estimation Methodologies for Incineration and Waste** (cont'd)

| Sector/Subsector | |
|---|---|
| **RESIDENTIAL WASTE BURNING** (under WASTE INCINERATION) | |
| Description | Emissions from Residential Waste Burning are related to on-site burning of residential waste materials in backyard barrels or to open-pit burning in rural areas. |
| General Inventory Method | Pollutant(s) estimated:<br>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<br>The quantity of residential waste burned in either barrels or open pits is combined with the appropriate emission factors for the applicable pollutants. |
| Activity Data | The quantity of residential waste burned in either open pits or barrels is calculated by combining the residential waste generation rate, rural population, and percent of rural population burning their waste, the percent of waste that is burned, and the percent of the population using either barrels or open pits. The residential waste generation rate is calculated by taking the total amount of waste that is disposed and adding back in the waste that is diverted from disposal. |
| Emission Factors (EF) | TPM, $PM_{10}$, $PM_{2.5}$, $SO_x$, $NO_x$, VOC, CO are default emission factor from Table 2.5-1 of U.S. EPA (1992).<br>$NH_3$ comes from Greater Vancouver Regional District (GVRD): BCMELP (2003).<br>Dioxins and furans use an emission factor of 72.8 ng 1-TEQW/kg of residential waste (Gartner Lee Limited, 2003). |
| **COMPOSTING** (under BIOLOGICAL TREATMENT OF WASTE) | |
| Description | Emissions from Composting are related to on-site process emissions from municipal and commercial facilities. Home composting is not accounted for in our inventory due to lack of available data at this time. |
| General Inventory Method | Pollutant(s) estimated:<br>$NH_3$, VOCs |
| Activity Data | Municipal and commercial facility level inventory compiled from industry surveys, annual reports or facility based websites (ECCC, 2020). |
| Emission Factors (EF) | The California Air Resources Board Methodology (CARB) for Composting Facilities is applied and modified for Canadian use (CARB, 2015). Only emissions from the composting process are estimated, storage and stockpiling emissions are not accounted due to lack of available data.<br>The CARB Method provides emission factors for green and food waste as well as green waste co-composted with biosolids or manure. The assumptions for the green waste and food waste emission factor is that only 15% of food waste is co-composted with green waste. This emission factor applies to facilities that accept any volume of food waste and/or paper waste. According to the San Joaquin Method (used in the development of the CARB method), there is no stand alone food waste emission factor available. The co-compost green waste and biosolids or manure emission factor is used in the absence of green waste when woodier type yard wastes such as branches are co-composted with biosolids/manure.<br>An average of the control efficiencies published by the CARB method are combined to meet the level of detail available for Canadian facilities control use. CARB suggests that fully enclosed systems (e.g., in-vessel systems) and indoor facilities can achieve 80% or more emissions reductions; emission reduction rates are adapted to reflect the information available in Canada. |

References for this table can be found on page 94.

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.<br>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.<br>Printing covers emissions from the manufacturing or use of printing inks. The sector consists of flexographic, gravure, letterpress, lithographic and other printing.<br>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:<br>VOCs<br>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)<br>Solvent use quantities (2005 to 2014): Cheminfo Services (2016)<br>Solvent use quantities (2015 to 2019): Cheminfo Services (2019)<br>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.<br>Projected estimates of national total solvent use for the year 2019 was developed based on historical base year national total solvent use and macroeconomic growth and solvent growth ratios (Cheminfo Services, 2019).<br>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:<br>$E_{VOCs} = Quantity_{solventused} \times (100\% - \%\ VOC_{Controlled})$<br>where Evocs is the emission estimate of VOCs.<br>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, 2019). |

References for this table can be found on page 94.

| 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.<br><br>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).<br><br>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:<br>TPM, $PM_{10}$, $PM_{2.5}$<br><br>Emissions are estimated for each source-destination rail, truck or barge transportation route and summed by province.<br><br>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.<br><br>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 and 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, n.d.[a], n.d.[b], n.d.[c]; Cope and Bhattacharyya, 2001) and company websites (accessed 2017).<br><br>Monthly climate summaries: ECCC (2017)<br><br>Rail Transportation Network: NRCan (n.d.) (1:1M scale used)<br><br>Mine Locations: BC MINEFILE (2017) and AER (2015), environmental assessment reports, and in-house remote-sensing. |
| Emission Factors (EF) | Cope and Bhattacharyya (2001) |
| **CONSTRUCTION OPERATIONS** | |
| Description | Construction Operations include PM emissions primarily resulting from soil disturbance on construction sites. The amount of soil disturbance is related to the surface area and duration of a construction project. The geographic region, type of construction (residential, industrial-commercial-institutional [ICI], engineering) and soil characteristics are all considered. |
| General Inventory Method | Pollutant(s) estimated:<br>TPM, $PM_{10}$, $PM_{2.5}$<br><br>**Residential construction**<br><br>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.<br><br>**ICI and engineering construction**<br><br>Methodology under review<br><br>The in-house estimates for ICI were last calculated for 2012 and were carried forward to 2018. |
| Activity Data | **Residential construction**<br><br>Dwelling starts: Statistics Canada (n.d.[d]) and CMHC (2020)<br><br>Average lengths of construction: CMHC (2017)<br><br>Buildings to hectares conversion factors: SNC-Lavalin Environment (2005)<br><br>Average basement area and depth: SNC-Lavalin Environment (2005)<br><br>Number of homes with basements: SNC-Lavalin Environment (2005)<br><br>**ICI and engineering construction**<br><br>Methodology under review |
| Emission Factors (EF) | **Residential construction**<br><br>TPM, $PM_{10}$, $PM_{2.5}$: SNC-Lavalin Environment (2005)<br><br>Correction factors:<br>% silt content[2]<br><br>Precipitation-Evaporation (PE) Index: SNC-Lavalin Environment (2005)<br><br>**ICI and engineering construction**<br><br>Methodology under review |

2 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.<br>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. Dust may also emanate from silt fractions within exposed substrate and coarse waste materials, through wind dispersion. |
| General Inventory Method | Pollutant(s) estimated:<br>TPM, $PM_{10}$, $PM_{2.5}$<br>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.<br>$EF_{TPM} = 1.33C \times A \times S$<br>where C is a weather correction factor,<br>A is the area of mine tailings in acres, and<br>S is (365 – n_days_with_snow_cover) / 365<br>The emission factor is for total particulate matter (TPM), with the smaller particulate matter size fractions determined as ratios of total particulate matter:<br>$PM_{10} = 0.8 \times TPM$<br>$PM_{2.5} = 0.2 \times TPM$<br>The weather correction factor C, is calculated from the equation:<br>$C = 0.345(V_{30})^3 / PE^2$<br>where $V_{30}$ is the average annual wind speed at 30 ft elevation (miles per hour), and<br>PE is the Thornthwaite Precipitation-Evaporation index, calculated as<br>$PE = 115 \sum [ P / (T\text{-}10) ]^{(10/9)}$ (sum of monthly)<br>where P is precipitation in inches, T is the temperature in Fahrenheit or 28.4 °F, whichever is greater<br>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.<br>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).<br>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.<br>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.<br>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. (2020) |
| 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:<br>TPM, $PM_{10}$, $PM_{2.5}$<br><br>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.<br><br>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.<br><br>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.<br><br>Speeds on unpaved roads were estimated to be 70 km/hr for highway, 60 km/hr for collectors, 50 km/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).<br><br>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 1996a, 1996b, 2006a, 2006b, 2016a, 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).<br><br>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.<br><br>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:<br><br>$Precip\_Cor = (n\_Days\_per\_Month - Precipitation\_Days) / n\_Days\_per\_Month$<br><br>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 (2013)<br><br>Secondary – Methodology under review |

References for this table can be found on page 95.

| 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:<br>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<br>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, $NH_3$:<br>All provinces/territories (except British Columbia): U.S. EPA (1995)<br>British Columbia: GVRD and FVRD (2003), BCMWLAP (2004)<br>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:<br>TPM, $PM_{10}$, $PM_{2.5}$, $NO_x$, VOCs, CO, $NH_3$<br>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[3] (CCMFC) and the following members of the CCMFC are contacted to obtain the number of annual structural fires in their jurisdictions:<br>• Government of Nunavut[4] (carried forward)<br>• Fire and Emergency Services, Newfoundland and Labrador[5] (carried forward)<br>• Office of the Fire Marshal and Emergency Management (Ontario)[6] (carried forward)<br>• Office of the Fire Commissioner (Manitoba)[7] (carried forward)<br>• Emergency Management and Fire Safety Branch (Saskatchewan)[8] (carried forward)<br>• Canadian Forces Fire Marshal[9] (2016 data)<br>• Office of Public Safety (Prince Edward Island)[10] (carried forward)<br>• Yukon Government[11] (2016 data)<br>• Department of Labour and Advanced Education (Nova Scotia)[12] (2016 data)<br>• Department of Municipal and Community Affairs (Government of the Northwest Territories)[13] (2016 data)<br>• Department of Public Safety (New Brunswick)[14] (2016 data)<br>• Office of the Fire Commissioner (Alberta)[15] (2016 data)<br>• Emergency Management British Columbia[16] (2016 data)<br>• Ministère de la Sécurité publique[17] (carried forward)<br>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).<br>Loading factor = 1.04 t of structure burned/fire<br>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 and FVRD (2003)<br>$NH_3$: Battye et al. (1994) |

References for this table can be found on page 96.

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

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

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

6 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).

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

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

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

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

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

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

13 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).

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

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

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

17 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:<br>• automotive switches<br>• switches and relays<br>• batteries<br>• dental amalgams<br>• fluorescent lamps<br>• non-fluorescent lamps<br>• measurement and control devices<br>• thermometers<br>• thermostats<br>• tire balancers<br>Emissions from the above devices impact the following sectors/subsectors:<br>• Iron and Steel Industry – Secondary (Electric Arc Furnaces)<br>• Iron and Steel Industry– Steel Recycling<br>• Electronics<br>• Other (Manufacturing)<br>• Human Respiration (Miscellaneous Other)<br>• Municipal Incineration<br>• Landfills<br>• Residential Waste Burning<br>• Municipal Wastewater Treatment and Discharge |
| General Inventory Method | Pollutant(s) estimated:<br>Hg<br>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; 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.<br>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, 2009) and 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) and 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 96.

# 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 the:

- 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, n.d.[a]).

The following in-house emissions estimates were recalculated for the 2021 edition of the APEI. Brief descriptions of the recalculations and the impacts on emission levels are provided in Table A3–1 to Table A3–10.

- Ore and Mineral Industries: Silica Production
- Oil and Gas Industry: Natural Gas Distribution; Accidents and Equipment Failures; 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; Oil Sands Mining, Extraction and Upgrading; Petroleum Liquids Transportation
- Manufacturing: Bakeries; Wood Products
- Transportation and Mobile Equipment: Air Transportation (landing and takeoff [LTO]); Domestic Marine Navigation, Fishing and Military
- Agriculture: Animal Production; Crop Production; Fuel Use
- Commercial/Residential/Institutional: Commercial and Institutional Fuel Combustion; Construction Fuel Combustion; Home Firewood Burning; Human; Residential Fuel Combustion; Cigarette Smoking
- Incineration and Waste: Residential Waste Burning; Composting; Landfills
- Paints and Solvents: Dry Cleaning; General Solvent Use; Printing; Surface Coatings
- Fires: Prescribed Burning
- Mercury in Products

For the purpose of Table A3–1 to Table A3–10, 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 |
|---|---|---|---|
| **SILICA PRODUCTION** (under MINING AND ROCK QUARRYING) | | | |
| | 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. For this submission, the missing data was estimated based on an employment distribution using data from Statistics Canada under the non-metallic mineral mining and quarrying sector. | These changes ranged from ±0.0001% to ±42.9%. The most notable years being 1995, 2005, 2011, and 2016 showing changes greater than ±10%, as well as 2010 and 2018 showing increases of 20.9% and 42.9% respectively. |

## 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) | | | |
| | $NO_x$, VOCs, CO | Recalculations occurred because of updated activity data for pipeline lengths in 2018 (Statistics Canada, 2020). | The recalculations did not result in changes greater than ±10% at the national level in 2018. |
| **ACCIDENTS AND EQUIPMENT FAILURES** (under UPSTREAM OIL AND GAS INDUSTRY) | | | |
| | VOCs | Recalculations occurred due to updated activity data for Surface Casing Vent Flow and Gas Migration from 2014 through 2018. (MB, 2020; CAPP, 2020) | The recalculations did not result in changes greater than ±10% in any of the impacted years. |
| **HEAVY CRUDE OIL COLD PRODUCTION** (under UPSTREAM OIL AND GAS INDUSTRY) | | | |
| | CO, $NO_x$, VOCs, $SO_x$, $PM_{2.5}$, $PM_{10}$, TPM | Recalculations occurred as a result of methodological changes to flaring and venting emissions estimates from 2010 through 2018. | The recalculations resulted in significant changes to emissions at the national level from 2010 through 2018 for VOCs (largest difference in 2012: -7245 t, -23.7%), and $PM_{2.5}$, $PM_{10}$, and TPM (largest differences all +195 t, +27.7% in 2017). 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 | Recalculations occurred as a result of methodological changes to flaring and venting emissions estimates from 2010 through 2018. | The recalculations resulted in changes to emissions at the national level from 2010 through 2018 for $SO_x$ (largest difference in 2015: +2286 t, +20.5%). 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 as a result of methodological changes to flaring and venting emissions estimates from 2010 through 2018. Changes were also made to non-associated gas production activity data from 2010 through 2018 (Petrinex, 2020). | Combined, these recalculations did not result in changes greater than ±10% for any of the pollutants. |
| **NATURAL GAS TRANSMISSION AND STORAGE** (under UPSTREAM OIL AND GAS INDUSTRY) | | | |
| | TPM, $PM_{10}$, $PM_{2.5}$, $SO_x$, $NO_x$, VOCs, CO | Recalculations occurred in 2017 and 2018 because of updated activity data. (Statistics Canada, 2020; Statistics Canada, n.d.[b]) | For all 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 as a result of methodological changes to flaring and venting emissions estimates from 2010 through 2018. | This resulted in changes to emissions at the national level from 2010 through 2018 for VOCs (largest difference in 2010: -927 t, -15.1%). For all other pollutants, this recalculation did not result in an emissions change of greater than ±10%. |
| **OIL SANDS MINING, EXTRACTION AND UPGRADING** (under UPSTREAM OIL AND GAS INDUSTRY) | | | |
| | TPM, $PM_{10}$, $PM_{2.5}$, VOCs | Recalculations occurred because NPRI reported data was updated for one large facility for 2018. | Recalculations resulted in slight increases in 2018 estimates, but none greater than 10%. |
| **PETROLEUM LIQUIDS TRANSPORTATION** (under UPSTREAM OIL AND GAS INDUSTRY) | | | |
| | TPM, $PM_{10}$, $PM_{2.5}$, VOCs, $SO_x$ | Recalculations occurred from 2012 through 2018 because of updated activity data in the RESD (Statistics Canada, n.d.[a]). Further updates were made as corrections to the distribution of particulate matter emissions from 2006 through 2018. | As a result of these recalculations, national level VOC emissions in the affected years increased by less than 10%, while $SO_x$ emissions increased (largest difference in 2018: +14.7 t, 11.4%). From 2006 through 2010, recalculations resulted in decreases for TPM, $PM_{10}$ of less than 10%. From 2011 through 2018, recalculations resulted in increases for TPM, $PM_{10}$, and $PM_{2.5}$, but none greater than 10%. |

## Table A3–3 Recalculations for Manufacturing

| Sector | Pollutant(s) | Description | Impact on Emissions |
|---|---|---|---|
| **BAKERIES** | | | |
| | VOCs | Updated population and bakeries activity data were used for 1990–2018 estimates. | The recalculations resulted in minor changes in emissions for 2017 and 2018 for VOCs (difference in 2017: +2.3 t or +0.05%; difference in 2018: +150 t or 3%). |
| **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 | Updated NPRI facility-reported data and production capacity data were used for 2018. | The recalculations resulted in changes in emission levels greater than 20% for $PM_{2.5}$, $PM_{10}$ and TPM and smaller than ±5% for $SO_x$, $NO_x$, VOCs, CO, $NH_3$, Pb, Cd, Hg, dioxins/furans, B(a)p, B(b)f, B(k)f and I(cd)p for 2018. |

## Table A3–4 Recalculations for Transportation and Mobile Equipment

| Sector | Pollutant(s) | Fuel | Description | Impact on Emissions |
|---|---|---|---|---|
| **AIR TRANSPORTATION (LTO)** | | | | |
| | 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 | The aviation model was updated for the 2021 inventory. Previously, data sources were updated to include new/current information. Also, aerodromes and aircraft were further defined included additional information.<br>Finally, the emissions are now calculated by flight mode (taxi in/out, takeoff, climb-out, climb, cruise, descent and landing). In order to calculate emissions at this level of details, some emission factors were adjusted to account for each mode. | The recalculations resulted in significant changes for the whole time series.<br>For 1990, the recalculations resulted in significant changes in the emissions of:<br>TPM (+32% or +106 t)<br>$PM_{10}$ (+32% or +106 t)<br>$PM_{2.5}$ (+64% or +169 t)<br>$SO_x$ (+2% or +17 t)<br>VOCs (+98% or +2704 t)<br>CO (-40% or -20.5 kt)<br>$NO_x$ (-14% or -923 t)<br>$NH_3$ (-12% or -0.6 t)<br>Pb (-44% or -10 t)<br>B(a)p (+10% or +0.14 kg)<br>B(b)f (+48% or +1.12 kg)<br>B(k)f (+48% or +1.12 kg)<br>I(cd)p (+65% or +1.45 kg)<br>For 2018, the recalculations resulted in significant changes in the emissions of:<br>TPM (-14% or -50 t)<br>$PM_{10}$ (-14% or -50 t)<br>$PM_{2.5}$ (+5% or +15 t)<br>$SO_x$ (+24% or +126 t)<br>VOCs (+36% or +784 t)<br>CO (-26% or -9270 t)<br>$NO_x$ (+15% or +1133 t)<br>$NH_3$ (-1% or -29 kg)<br>Pb (-31% or -6 t)<br>B(a)p (-30% or -0.21 kg)<br>B(b)f (+54% or +0.66 kg)<br>B(k)f (+54% or +0.66 kg)<br>I(cd)p (+60% or +0.75 kg) |
| **DOMESTIC MARINE NAVIGATION, FISHING AND MILITARY** | | | | |
| | 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, dioxins/furans | Heavy Fuel Oil, Diesel Fuel Oil | Updated vessel activity data was incorporated into the marine model. The Marine Emissions Inventory Tool (MEIT) updated their 2015 model and produced data for the 2016, 2017, 2018 calendar years.<br>Provincial estimates were redeveloped based on 2015, 2016, 2017 and 2018 port origin/destination pairs.<br>Emissions associated with international navigation were removed from the report total in order to conform to the national total reported in the NFR tables. | The overall marine values were not significantly impacted from 1990 to 2014. The updated MEIT models resulted in significant changes from 2015 to 2018.<br>The redevelopment port origin/destination pairs had a significant impact on provincial estimates for the whole time series.<br>The change in reporting for 1990 resulted in significant changes in the emissions of:<br>TPM (-61% or -6726 t)<br>$PM_{10}$ (-61% or -6457 t)<br>$PM_{2.5}$ (-61% or -5940 t)<br>$SO_x$ (-63% or -50.2 kt)<br>VOCs (-53% or -3046 t)<br>CO (-55% or -6914 t)<br>$NO_x$ (-58% or -80.7 kt)<br>$NH_3$ (-58% or -94 t)<br>dioxins/furans (-43% or -9 gTEQ)<br>Pb (-43% or -257 kg)<br>Cd (-69% or -113 kg)<br>Hg (-70% or -3 kg)<br>B(a)p (-43% or -9 kg)<br>B(b)f (-43% or -17 kg)<br>B(k)f (-43% or -9 kg)<br>I(cd)p (-43% or -17 kg)<br>The change in reporting for 2018 resulted in significant changes in the emissions of:<br>TPM (-62% or -2308 t)<br>$PM_{10}$ (-62% or -2731 t)<br>$PM_{2.5}$ (-62% or -2512 t)<br>$SO_x$ (-37% or -2822 t)<br>VOCs (-72% or -6308 t)<br>CO (-69% or -13.6 kt)<br>$NO_x$ (-66% or -126 kt)<br>$NH_3$ (-66% or -190 t)<br>dioxins/furans (-68% or -13 gTEQ)<br>Pb (-68% or -404 kg)<br>Cd (-47% or -15 kg)<br>Hg (-34% or -0.2 kg)<br>B(a)p (-68% or -13 kg)<br>B(b)f (-68% or -27 kg)<br>B(k)f (-68% or -13 kg)<br>I(cd)p (-68% or -27 kg) |

## Table A3–5 Recalculations for Agriculture

| Sector | Pollutant(s) | Description | Impact on emissions |
|---|---|---|---|
| **ANIMAL PRODUCTION** | | | |
| | $NH_3$, VOCs | Recalculations are due to minor modifications in the spatial distribution of animal populations among ecodistricts. | The changes resulted in minor recalculations for all years since 1990. |
| **CROP PRODUCTION** | | | |
| | $NH_3$, TPM, $PM_{10}$, $PM_{2.5}$ | Recalculations are due to minor modifications in the spatial distribution of crops and inorganic nitrogen fertilizers among ecodistricts. | The changes resulted in minor recalculations for all years since 1990. |
| **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.<br>For the year 2018, pollutant emissions changed by less than ±10%. |

## Table A3–6 Recalculations for Commercial/Residential/Institutional Sources

| 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.<br>For the year 2018, 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.<br>For the year 2018, pollutant emissions changed by less than ±10%. |
| **HOME FIREWOOD BURNING** | | | |
| | 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 based on a switch to survey data from Statistic Canada from the Households and the Environment Survey. | The recalculations resulted in decreases in emissions of 46–50% for all pollutants for 1990.<br>For the year 2018, pollutant emissions decreased between 7% and 50%. |
| **HUMAN** | | | |
| | $NH_3$ | The estimation methodologies for Human include perspiration and respiration as well as Infant Diapered Waste. The Infant Diapered Waste emissions are based on an area source model that has been removed from our inventory as of the 2021 publication cycle. | At the national level, the recalculations resulted in a decline of 5% for 1990, 3% for 2005 and 3% for 2018. |
| **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.<br>For the year 2018, HCB changed by +100%. The remaining pollutant emissions changed by less than ±10% in 2018. |
| **CIGARETTE SMOKING** | | | |
| | Hg, $PM_{2.5}$, $PM_{10}$, TPM, VOCs, CO, Cd, Pb, dioxins/furans, B(a)p, B(b)f, B(k)f | This sector is based on an area source model that has been removed from our inventory as of the 2021 publication cycle. | The sector is no longer estimated. |

## Table A3–7 Recalculations for Incineration and Waste Sources

| Sector | Pollutant(s) | Description | Impact on Emissions |
|---|---|---|---|
| **RESIDENTIAL WASTE BURNING** (under WASTE INCINERATION) | | | |
| | B(a)p, B(b)f, B(k)f, CO, dioxins/furans, HCB, I(cd)p, $NH_3$, $NO_x$, $PM_{10}$, $PM_{2.5}$, $SO_x$, TPM, VOCs | Changes affecting estimates are a result of updating waste generation per capita data for the complete 1990–2019 time series, as well as the correction of errors. | At a national level, the recalculations for 1990–2019 years ranged in a reduction of 26% in 1990, 11% in 2005, and under 6% for 2018 for all pollutants. |
| **COMPOSTING** (under WASTE TREATMENT AND DISPOSAL AND BIOLOGICAL TREATMENT OF WASTE) | | | |
| | $NH_3$, VOCs | A new area source model for composting in Canada had been implemented for this inventory. In the past, Biological Treatment of Waste only included NPRI data. The area source model included emissions estimates for $NH_3$ and VOCs from 1990 forward. | At the national level, the recalculations resulted in a 100% increase for $NH_3$ for the entire time series, as it was not reported under this sector in the past. For VOCs, a 100% increase was seen for 1990 and 2005, as it was not reported in last year's inventory. For 2018, there was also a 100% increase for VOCs as the reported emissions in last year's inventory were only 0.01 t for this pollutant compared to 3312 t reported in this inventory. |
| **LANDFILLS** (under WASTE TREATMENT AND DISPOSAL) | | | |
| | VOCs | The VOC estimates from landfills are derived from methane emissions (converted to hexane equivalents). Decay rate parameters in the landfill decay model have been corrected. The model has also been updated to estimate decay based on material-specific parameters for degradable carbon content, the amount that does decay and the decay rates. Corrections have also been made to the quantity of waste disposed in the 1990's. | The corrections and model updates resulted in a methane emission estimates 132% higher for 1990 and 173% higher for 2018 than previously estimated for landfills. As a result, the VOCs emissions also increase by the same amount, relative to previous estimates (132% to 173%). |

## Table A3–8 Recalculations for Paints and Solvents

| Sector | Pollutant(s) | Description | Impact on Emissions |
|---|---|---|---|
| **DRY CLEANING, GENERAL SOLVENT USE, PRINTING AND SURFACE COATINGS** | | | |
| | VOCs, Cd, CO, $NH_3$, $NO_x$, Pb, $PM_{10}$, $PM_{2.5}$, TPM | The area source model was updated from 2015 forward for VOC related emissions, and a recalculation of point source emissions was applied to the earlier portion of the time series. | At the national level, the changes to VOCs ranged from 10% to 33% between 2015 to 2018, where the update to the area source model was applied. For the recalculation of point source data which included Cd, CO, $NH_3$, $NO_x$, Pb, $PM_{10}$, $PM_{2.5}$, TPM and VOCs, an increase of 0% to 100% was noted in 1990, an increase of 0% to 94% in 2005 and no change was noted for 2018 (with the exclusion of VOCs discussed above). |

## Table A3–9 Recalculations for Fires

| Sector | Pollutant(s) | Description | Impact on Emissions |
|---|---|---|---|
| **PRESCRIBED BURNING** | | | |
| | 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 | Recalculations occurred in 2018 as a result of the correction of burned areas in all provinces and territories for that year. | At the national level, the recalculations resulted in an increase in emissions in 2018 of 20% to 25%, for all pollutants. |

## Table A3–10 Recalculations for Mercury in Products

| Sector | Pollutant(s) | Description | Impact on Emissions |
|---|---|---|---|
| **MERCURY IN PRODUCTS** | | | |
| | Hg | There were recalculations from 2016 or 2017 forward for product types: dental amalgams, switches and relays (automotive switches not included), and non-fluorescent lamps based on new data that became available for this inventory. Please note that Mercury in Products Hg emissions are reconciled before publication. | At the national level, the recalculations resulted in less than or equal to a 5% decrease from 2016 forward. |

# 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)[1] pursuant to the 1979 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 to 2019, as of February 2021. The inventory indicates that emissions of 14 of the 17 reported air pollutants are decreasing compared to historical levels, and specifically indicates that:

- Emissions of sulphur oxides ($SO_x$) were 0.7 million tonnes in 2019, 52% below the 2010 emission ceiling under the 1999 Gothenburg Protocol and 66% below 2005 levels—Canada is on track to meet its 55% emission reduction commitment from 2005 levels for 2020, as per the amended Gothenburg Protocol.
- Emissions of $NO_x$ were 1.6 million tonnes in 2019, 28% below the 2010 emission ceiling under the 1999 Gothenburg Protocol and 29% below 2005 levels—Canada's emission reduction commitment for $NO_x$ is 35% below 2005 levels by 2020, as per the amended Gothenburg Protocol.
  - The next edition of this report, to be published in 2022, will include data for 2020 and provide an update to Canada's compliance with its 2020 commitments.
- Emissions of non-methane volatile organic compounds (NMVOCs) were 1.7 million tonnes in 2019, 20% below the 2010 emission ceiling under the 1999 Gothenburg Protocol and 27% below 2005 levels—Canada is also on track to meet its 20% emission reduction commitment from 2005 levels for 2020, as per the amended Gothenburg Protocol.

1 www.ceip.at

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 55% 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% from 1980 levels |
| $NO_x$ | 1999 Gothenburg Protocol (as amended in 2012) | Reduction of $NO_x$ emissions by 35% 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 20% 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 25% 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 |
| Dioxins and furans | 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 |

- Emissions of fine particulate matter (particulate matter less than or equal to 2.5 microns in diameter [$PM_{2.5}$]) were 1.6 million tonnes in 2019, 8% below 1990 levels and 25% above 2005 levels.
  - Emissions of $PM_{2.5}$ decreased from most sources with the notable exceptions of dust (not from combustion) sources such as construction operations and unpaved roads.
  - Excluding sources from road dust, construction operations, and crop production, $PM_{2.5}$ emissions in 2019 were 29% lower compared to 2005; therefore Canada is on track to meet its 25% emission reduction commitment[2] from 2005 levels for 2020, as per the amended Gothenburg Protocol.
- Emissions of cadmium (Cd), lead (Pb), and mercury (Hg) in 2019 were 89%, 79% and 81% below the ceilings established under the 1998 Aarhus Protocol on Heavy Metals.
- Emissions of all persistent organic pollutants (POPs) in 2019 were below the ceilings established under the 1998 Aarhus Protocol on Persistent Organic Pollutants, including the four species of polycyclic aromatic hydrocarbons (PAHs) (72% below), hexachlorobenzene (HCB) (91% below), and dioxins and furans (88% below).
- Emissions of carbon monoxide (CO) in 2019 had decreased by 55% since 1990 and by 30% since 2005.

2 This commitment excludes $PM_{2.5}$ emissions from road dust, construction operations, and crop production; focusing on emission sources that have a significant black carbon content.

Despite significant decreases in emissions of most pollutants, since 2005 emissions of particulate matter have risen by 49% (TPM), 44% ($PM_{10}$) and 25% ($PM_{2.5}$). 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 $NH_3$, which in 2019 were 20% above 1990 levels although 3% below 2005 levels. The upward trend in $NH_3$ emissions is driven by fertilizer use 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

Table A4–2 Excerpt from United Nations Economic Commission for Europe Nomenclature for Reporting Template for 2021

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

| NFR aggregation for gridding and LPS[a] (GNFR)[b] | 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:
a. LPS = large point source
b. GNFR = gridded nomenclature for reporting

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.

## 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 volatile organic compounds (VOCs) 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 Navigation and Air 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.

The NFR table has five categories for marine: 1A3dii – National navigation (shipping), 1A4ciii – Agriculture/Forestry/Fishing: National fishing, 1A3di(i) – International maritime navigation, 1A3di(ii) – International inland waterways, and 1A5b – Other, Mobile (including military, land based and recreational boats). The APEI report includes all emissions occurring from domestic marine navigation (1A3dii), fishing vessels (1A4ciii) and military vessels (1A5b) in one category as those categories contribute to Canada's national total. International marine navigation (excluding fishing and military operations) are reported in a separate table in the APEI report and the NFR table, as those emissions do not contribute to Canada's national total. This is consistent with international reporting requirements. No values are reported under 1A3di(ii) – International inland waterways.

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). The APEI report includes all emissions occurring from civil LTO cycles—1A3ai(i) and 1A3aii(i)—and military flights (1A5b) in one category as those categories contribute to Canada's national total. The emissions attributed to the cruise phase for civil flights are reported separately in the APEI report and the NFR table, as those emissions do not contribute to Canada's national total. This is consistent with international reporting requirements.

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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## Chapter 2


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