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

1990–2021

2023

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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
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
TAN ..... total ammoniacal nitrogen
TPM ..... total particulate matter
UNECE..... United Nations Economic Commission for Europe
U.S. EPA ..... United States Environmental Protection Agency
VKT ..... vehicle kilometres travelled
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)

EXECUTIVE SUMMARY

Canada's Air Pollutant Emissions Inventory (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 (expressed as sulphur dioxides or SO_2), 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),[1] 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 (ECCC)'s National Pollutant Release Inventory (NPRI) 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.

Recent Observed Changes in Canada's Air Pollution Emissions (2019 to 2021)

The most recent years for which data are available for this report, 2020 and 2021, were marked by the COVID-19 pandemic. This coincides with observed emission decreases between the years 2019 and 2020 for almost all pollutants with the exception of NH_3. Between 2020 and 2021, most of the pollutant emissions increased, but remained below their 2019 pre-pandemic levels, except for NH_3 and hexachlorobenzene (HCB) that exceeded their 2019 emission levels in 2021. In contrast to these increases, SO_x, Pb and polycyclic aromatic hydrocarbons (PAHs) emissions continued to decrease between 2020–2021, while VOC emissions remained stable. The categories that were major contributors to emission changes between 2019 and 2020 are similar to those observed between 2019 and 2021 occurring in numerous source categories, most notably:[2]

- Transportation and Mobile Equipment showed decreases of NO_x (-58 kt or -9.5%), VOCs (-36 kt or -14%) and CO (-311 kt or -10%).
  - These reductions are mostly due to a decrease in the vehicle kilometres traveled (VKT) in the light-duty gasoline vehicles and trucks categories between 2019 and 2020.
  - Between 2020 and 2021, the VKT increased but was still below pre-pandemic levels, leading to slight increases in NO_x (9.2 kt or 1.7%) and CO (71 kt or 2.6%).
  - A similar change is noted from the Unpaved Road Dust source, also linked to the VKT, with an emission decrease of $PM_{2.5}$ (59 kt or 14%) between 2019 and 2020 followed by an increase (16 kt or 4.5%) between 2020 and 2021.
- The Oil and Gas Industry contributed to the decrease in SO_x (-5.3 kt or -2.0%) and VOCs emissions (-91 kt or -15%).
  - The overall decreases in SO_x can be explained in part by reductions in total crude oil and natural gas production in 2020, along with decreases in the Petroleum Refining subsector that are mainly due to the closure of the Come-By-Chance refinery in Newfoundland and Labrador.
  - Between 2020 and 2021, there was an increase in SO_x emissions (19 kt or 8.0%) due to overall increases in crude bitumen and natural gas production in 2021, as well as increased flaring at natural gas processing facilities.
  - The VOC reductions result from decreases in venting and fugitive equipment leaks at oil and natural gas production and processing facilities.
- Coal electric power generation saw emission decreases of SO_x (-39 kt or -20%) and Hg (-103 kg or -18%) attributed to a decrease in coal consumption, mostly notable between 2019 and 2020.

1 The Gothenburg Protocol, associated to the CLRTAP, contains an NH_3 emission ceiling for 2010 and a commitment for NH3 emission reduction from 2005, but these apply to Europe only.

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

- Decreases in Ore and Mineral Industries emissions of Pb (-26 t or -26%), Cd (-1.9 t or -41%) and HCB (-1.7 kg or -36%) are in part due to the permanent closure of a non-ferrous metal smelter in December 2019.
    - Between 2020 and 2021, Pb emissions from the Non-Ferrous Refining and Smelting Industry decreased significantly (-20 t or -21%) due in part to a facility shutdown but mainly due to normal operational variations at another facility.
    - Emissions from Cd increased by (0.36 t or 15%) between 2020 and 2021 mostly due to a return to pre-pandemic production levels in the Non-Ferrous Refining and Smelting Industry.
    - Similarly, the return to pre-pandemic production levels in the Iron and Steel and Iron Ore Pelletization sectors contributed to the HCB emission increase (0.18 kg or 6.4%) between 2020 and 2021.

Canada's Air Pollution Emission Trends (1990 to 2021)

This edition of the *Air Pollutant Emissions Inventory Report* summarizes the most recent estimates of air pollutant emissions for 1990 to 2021, as of February 2023. The inventory indicates that emissions of 14 of the 17 reported air pollutants are decreasing compared to historical levels, and a few key sources of pollutants account for a significant portion of the downward trends. In particular:

- Non-Ferrous Refining and Smelting is a major contributor to emissions of Hg, Cd, SO_x, and Pb; emissions of these pollutants from this source have decreased by 99%, 97%, 95% and 93%, respectively, over this time period, in part owing to closure of outdated smelters and implementation of pollution prevention measures.
- 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 46%, 42%, 37% and 32%, respectively, over this time period, owing to a 32% reduction in wood consumption and the adoption of more efficient wood combustion equipment.
- Coal-fired electric power generation is a major contributor to emissions of HCB, Hg and SO_x; emissions of these pollutants from this source have decreased by 98%, 76% and 69%, respectively, over this time period, as emissions control equipment was adopted on some older units, and more recently, 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 89% and 82%, respectively, over this time period.
    - The decrease in emissions is despite a 58% increase in the total VKT of these vehicles, and is primarily due to improved fuel economy and implemented regulations that have effectively lowered NO_x and hydrocarbon emissions from engines.
- Transportation associated with the combustion of gasoline[3] is a major contributor to emissions of CO and VOCs; emissions of these pollutants from this source have decreased by 72% and 68%, respectively, over this time period.
    - The decrease in emissions is despite a 21% increase in the total fuel consumption of on-road light-duty gasoline trucks and vehicles and a 40% increase in the total fuel consumption of off-road gasoline engines, and is primarily due to implemented regulations that have effectively lowered CO and hydrocarbon emissions from engines.
- Waste Incineration is a major contributor to emissions of dioxins and furans and HCB; emissions of these pollutants from this source have decreased by 70% and 36%, 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 38% (TPM), 33% (PM_{10}) and 18% ($PM_{2.5}$). These increases are largely from dust emissions associated with 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 2021 were 25% above 1990 levels, and 1% above 2005 levels. The upward trend in NH_3 emissions is primarily driven by the use of inorganic nitrogen fertilizer.

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.

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.

Canada's Air Pollution Emissions Relative to International Commitments

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)[4] pursuant to the 1979 CLRTAP and its associated protocols. This edition of the Air Pollutant Emissions Inventory Report indicates that:

- Emissions of SO_x were 0.6 million tonnes in 2021, which are 56% below the 2010 emission ceiling under the 1999 Gothenburg Protocol and 69% below 2005 levels; therefore, Canada has met its commitment to reduce emissions of SO_x by 55% from 2005 levels by 2020 and beyond, as per the amended Gothenburg Protocol.
- Emissions of NO_x were 1.3 million tonnes in 2021, which are 41% below the 2010 emission ceiling under the 1999 Gothenburg Protocol and 42% below 2005 levels; therefore, Canada has met its commitment to reduce emissions of NO_x by 35% from 2005 levels by 2020 and beyond, as per the amended Gothenburg Protocol.
- Emissions of non-methane VOCs (NMVOCs) were 1.4 million tonnes in 2020, which are 33% below the 2010 emission ceiling under the 1999 Gothenburg Protocol and 39% below 2005 levels; therefore, Canada has met its commitment to reduce emissions of NMVOC by 20% from 2005 levels by 2020 and beyond, 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 1.5 million tonnes in 2021.
    - Emissions of $PM_{2.5}$ decreased from most sources with the notable exceptions of dust sources (not from combustion) such as construction operations and roads; Canada's emission reduction commitment for $PM_{2.5}$ excludes these two sources along with crop production.
    - In line with Canada's commitment, $PM_{2.5}$ emissions in 2021 were 30% lower compared to 2005 levels; therefore, Canada has met its commitment to reduce emissions of $PM_{2.5}$ by 25% from 2005 levels by 2020 and beyond, as per the amended Gothenburg Protocol.
- Emissions of Cd, Pb, and Hg in 2021 were 89%, 81% and 81% below the ceilings established under the 1998 Aarhus Protocol on Heavy Metals.
- Emissions of all POPs in 2021 were below the ceilings established under the 1998 Aarhus Protocol on Persistent Organic Pollutants, including the four species of PAHs (81% below), HCB (69% below), and dioxins and furans (63% below).

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 related to the 17 APEI pollutants are under the *Canadian Environmental Protection Act, 1999* (CEPA 1999).

A number of greenhouse gas regulations are also expected to achieve significant co-benefit reductions in air pollutants, for example the *Regulations Respecting Reduction in the Release of Methane and Certain Volatile Organic Compounds (Upstream Oil and Gas Sector)*.

Non-regulatory instruments include guidelines, as well as codes of practice, performance agreements, and/or pollution prevention planning notices for various sectors. More information on Canada's air emissions Regulations and non-regulatory measures, including a list of Regulations related to APEI pollutants, can be found in Chapter 1.3.

4 www.ceip.at

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 and 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, provincial, and 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 (PAHs) 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) 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.

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 Pelletizing	Iron ore induration of fired 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. Also includes much smaller non-ferrous refining and smelting sources, such as those from magnesium, cobalt and uranium industry processes.

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

APEI Source/Sector	Sector Descriptions
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 sales and/or private use.
Landfill Gas	Electric power generation from combustion of landfill gas by utilities (both publicly and privately) for commercial sales and/or private use.
Natural Gas	Electric power generation from combustion of natural gas by utilities (both publicly and privately owned) for commercial sales and/or private use.
Diesel	Electric power generation from combustion of diesel by utilities (both publicly and privately owned) for commercial sales and/or private use.
Other (Electric Power Generation)	Electric power generation from other energy sources by utilities (both publicly and privately owned) for commercial sales and/or private use.
MANUFACTURING	
Abrasives Manufacturing	Manufacturing of abrasive grinding wheels, abrasive-coated materials and other abrasive products.
Bakeries	Manufacturing of bakery products, including frozen baked products.
Biofuel Production	Production of ethanol for fuel or oils for biodiesel.
Chemicals Industry	Large number of different product industries including fertilizer manufacturing, plastic resins, paints and varnishes, petrochemicals, inorganic chemicals, and pharmaceuticals. The raw materials, processes used and products produced are in many cases unique to individual plants.
Electronics	Manufacturing of electronics, such as communications equipment, semiconductors and electronic components, navigational and guidance instruments, electric lamp bulbs 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 snacks, 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: production of iron and steel pipes and tubes, cold-rolling steel bars, sheets, strips and other steel shapes; steel wire drawing; copper rolling, drawing, extruding and alloying; forging; and stamping.
Plastics Manufacturing	Manufacturing of: plastic 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 pulp 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; textiles 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 cruise modes cycles from piston and turbine aircraft used for military operations.
Domestic Air Transportation (Cruise)	Cruise modes from aircraft used for domestic commercial and private operations.
Domestic Marine Navigation, Fishing and Military	Marine vessels engaged in domestic navigation, fishing, or military operations within Canadian waters.
International Air Transportation (Cruise)	Cruise modes from aircraft used for international commercial and private operations.
International Marine Navigation	Marine vessels engaged in international navigation within Canadian waters.
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.
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.

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

APEI Source/Sector	Sector Descriptions
AGRICULTURE	
Agricultural Fuel Combustion	Stationary combustion sources in agricultural facilities such as space and water heating and crop drying.
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.
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 food service 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 including dental amalgams, as well as companion animals.
Waste Incineration	Incinerators used to combust municipal, sewage sludge, and other waste types including hazardous and medical 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.
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.

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[1] pollutants: SO_2, NO_x, VOCs, NH_3, PM and black carbon)

1 The Gothenburg Protocol also contains an emission ceiling and a reduction commitment for NH_3, but these apply to Europe only.

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 data to the United Nations Economic Commission for Europe (UNECE) each year by February 15 and submit the APEI Report by March 15. More information on the submission to the UNECE and emission reduction commitments 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 12 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*
- *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 Compression-Ignition (Mobile and Stationary) and Large Spark-Ignition Engine Emission 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*
- *Volatile Organic Compound Concentration Limits for Certain Products 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* and *Regulations Respecting Reduction in the Release of Methane and Certain Volatile Organic Compounds (Upstream Oil and Gas Sector)*.

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.

Additionally, a new International Maritime Organization (IMO) limit, known as "IMO 2020"[2], came into force in 2020. This regulation restricts the amount of sulphur in the fuel oil used by ships travelling outside of specified emission control areas. This new limit was implemented under an amendment to the Annex VI of the International Convention for the Prevention of Pollution from Ships (MARPOL). A set of guidelines for the implementation of the MARPOL regulation was developed by the IMO.

All regulations and non-regulatory instruments administered under CEPA 1999 are available on the environmental registry[3] and on the Department of Justice's online consolidation of federal acts and regulations.[4]

2 https://www.imo.org/en/MediaCentre/HotTopics/Pages/Sulphur-2020.aspx

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

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

CHAPTER 2

2021 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 2021 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 (94%).
- Incineration and Waste accounts for a significant proportion of hexachlorobenzene (HCB) (75%) and dioxins and furans (D/F) emissions (47%).
- Ore and Mineral Industries accounts for the largest proportion of lead (Pb) (78%), cadmium (Cd) (62%) and mercury (Hg) (38%) emissions.
- Transportation and Mobile Equipment is the largest emitter of carbon monoxide (CO) (61%) and nitrogen oxides (NO_x) (42%).
- Oil and Gas Industry is the largest emitter of sulphur oxides (SO_x) (41%) and volatile organic compounds (VOCs) (37%).
- Commercial/Residential/Institutional is a particularly significant source of polycyclic aromatic hydrocarbons (PAHs) (91%).

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

The most recent years for which data are available for this report, 2020 and 2021, were marked by the COVID-19 pandemic. This coincides with observed emission decreases between the years 2019 and 2020 for almost all pollutants except for NH_3. Between 2020 and 2021, most of the pollutant emissions increased, but remained below their 2019 pre-pandemic levels, except for NH_3 and HCB that exceeded their 2019 emission levels in 2021. In contrast to these increases, SO_x, Pb and PAH emissions continued to decrease between 2020 and 2021, while VOC emissions remained stable. Major contributors to emission changes between 2019 and 2021 include:

- Transportation and Mobile Equipment showed decreases of NO_x (-58 kt or -9.5%), VOCs (-36 kt or -14%) and CO (-311 kt or -10%).
  - These reductions are mostly due to a decrease in the vehicle kilometres traveled (VKT) in the light-duty gasoline vehicles and trucks categories between 2019 and 2020.
  - Between 2020 and 2021, the VKT increased but was still below pre-pandemic levels, leading to slight increases in NO_x (9.2 kt or 1.7%) and CO (71 kt or 2.6%).
  - A similar change is noted from the Unpaved Road Dust source, also linked to the VKT, with an emission decrease of $PM_{2.5}$ (59 kt or 14%) between 2019 and 2020 followed by an increase (16 kt or 4.5%) between 2020 and 2021.
- The Oil and Gas Industry contributed to the decrease in SO_x (-5.3 kt or -2.0%) and VOCs emissions (-91 kt or -15%).
  - From 2019 to 2020, the overall decreases in SO_x (-25 kt or -9.2%) can be explained in part by reductions in total crude oil and natural gas production in 2020, along with decreases in the Petroleum Refining subsector that are mainly due to the closure of the Come-By-Chance refinery in Newfoundland and Labrador.
  - Between 2020 and 2021, there was an increase in SO_x emissions (19 kt or 8.0%) due to overall increases in crude bitumen and natural gas production in 2021, as well as increased flaring at natural gas processing facilities.
  - VOC reductions result from decreases in venting and fugitive equipment leaks at oil and natural gas production and processing facilities.
- Coal electric power generation saw emission decreases of SO_x (-39 kt or -20%) and Hg (-103 kg or -18%) attributed to a decrease in coal consumption, mostly notable between 2019 and 2020.
- Decreases in Ore and Mineral Industries emissions of Pb (-26 t or -26%), Cd (-1.9 t or -41%) and HCB (-1.7 kg or -36%) are in part due to the permanent closure of a non-ferrous metal smelter in December 2019.
  - Between 2020 and 2021, Pb emissions from the Non-Ferrous Refining and Smelting Industry decreased significantly (-20 t or -21%) due in part to a facility shutdown but mainly due to normal operational variations at another facility.
  - Emissions from Cd increased by (0.36 t or 15%) between 2020 and 2021 mostly due to a return to pre-pandemic production levels in the Non-Ferrous Refining and Smelting Industry.
  - Similarly, the return to pre-pandemic production levels in the Iron and Steel and Iron Ore Pelletization sectors contributed to the HCB emission increase (0.18 kg or 6.4%) between 2020 and 2021.

This edition of the Air Pollutant Emissions Inventory Report summarizes the most recent estimates of air pollutant emissions for 1990 to 2021, as of February 2023. The inventory indicates that emissions of 14 of the 17 reported air pollutants are decreasing compared to historical levels, and a few key sources of pollutants account for a significant portion of the downward trends. In particular:

- The Non-Ferrous Refining and Smelting Industry sector is a major contributor to emissions of Hg, Cd, SO_x, and Pb; emissions of these pollutants from this source have decreased by 99%, 97%, 95%, and 93%, respectively, over this time period, in part owing to closure of outdated smelters and implementation of pollution prevention measures.
- 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 46%, 42%, 37% and 32% respectively, over this time period, owing to a 32% reduction in wood consumption and the adoption of more efficient wood combustion equipment.
- Coal-fired electric power generation is a major contributor to emissions of HCB, Hg, and SO_x; emissions of these pollutants from this source have decreased by 98%, 76%, and 69%, respectively, over this time period, as emissions control equipment was adopted on some older units, and more recently, 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 89% and 82%, respectively, over this time period.
  - The decrease in emissions is despite a 58% increase in the total VKT of these vehicles, and is primarily due to improved fuel economy and implemented regulations that have effectively lowered NO_x and hydrocarbon emissions from engines.[2]
- Transportation associated with the combustion of gasoline[3] is a major contributor to emissions of CO and VOCs; emissions of these pollutants from this source have decreased by 72% and 68%, respectively, over this time period.
  - The decrease in emissions is despite a 21% increase in the total fuel consumption of on-road light-duty gasoline trucks and vehicles and a 40% increase in the total fuel consumption of off-road gasoline engines, and is primarily due to implemented regulations that have effectively lowered CO and hydrocarbon emissions from engines.
- Waste Incineration is a major contributor to emissions of dioxins and furans and HCB; emissions of these pollutants from this source have decreased by 70% and 36%, 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 38% (TPM), 33% (PM_{10}) and 18% ($PM_{2.5}$). These increases are largely from dust emissions associated with 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 2021 were 25% above 1990 levels, and 1% above 2005 levels. The upward trend in NH_3 emissions is primarily driven by the use of inorganic nitrogen fertilizer.

Important sources of emissions for each substance by category, sector and subsector in 2021 are in Table 2–2. The subsequent sections 2.1 to 2.11 of this chapter identify major source contributions to total emissions over the 1990 to 2021 time period. Emission trends analysis for 2005 to 2021 have also been included for $PM_{2.5}$, SO_x, NO_x, and VOCs in relation to the emission reduction commitments as per the amended Gothenburg Protocol.[4]

The full-time series of national, provincial and territorial pollutant emissions from 1990 to 2021 are available online on the Government of Canada Open Data Portal.[5]

Table 2–1 **Total Air Pollutant Emissions in 2021 for Canada by Category**

Category	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	350	150	38	160	80	12	510	1.5	74 000	2 800	1 200	12	470	3 100
Oil and Gas Industry	33	22	14	260	440	520	540	2.2	520	230	76	-	480	-
Electric Power Generation (Utilities)	13	4.5	2.0	170	100	1.6	38	0.26	1 200	96	500	0.49	6.5	240
Manufacturing	120	48	20	38	67	110	140	11	2 600	230	86	1.8	120	57
Transportation and Mobile Equipment	35	35	26	3.0	560	210	2 800	6.5	14 000	53	70	25	2 300	-
Agriculture	3 600	1 500	360	0.16	2.6	120	1.0	460	20	76	6.0	0.25	0.20	0.49
Commercial/Residential/Institutional	100	97	96	3.8	69	160	550	1.9	1 700	990	410	3.5	48 000	-
Incineration and Waste	6.7	3.9	2.8	1.3	5.3	15	14	5.7	160	38	850	39	690	9 800
Paints and Solvents	0.051	0.050	0.00	-	0.054	260	-	-	-	0.15	-	-	-	-
Dust	22 000	6 400	900	-	-	-	-	-	-	-	-	-	-	-
Fires	4.1	3.5	2.5	0.00	0.52	1.6	27	0.054	-	-	-	0.55	700	-
TOTAL	**27 000**	**8 200**	**1 500**	**640**	**1 300**	**1 400**	**4 600**	**490**	**95 000**	**4 500**	**3 200**	**82**	**52 000**	**13 000**

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.
0.00 Indicates emissions were truncated due to rounding.
- Indicates no emissions.

2 See Chapter 1 for list of 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.

4 For more information on the reporting to the United Nations Economic Commission for Europe (UNECE), Canada's international commitments and related protocols under the Convention on Long-range Transboundary Air Pollution (CLRTAP), refer to Annex 4.

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

Table 2–2 Total Air Pollutant Emissions in 2021 for Canada by Category, 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	**350 000**	**150 000**	**38 000**	**160 000**	**80 000**	**12 000**	**510 000**	**1 500**	**74 000**	**2 800**	**1 200**	**12**	**470**	**3 100**
Aluminium Industry	**6 200**	**4 500**	**3 600**	**59 000**	**1 000**	**2 000**	**380 000**	**-**	**-**	**-**	**18**	**0.53**	**89**	**39**
Alumina (Bauxite Refining)	71	26	23	0.82	250	18	270	-	-	-	-	-	-	-
Primary Aluminium Smelting and Refining	6 000	4 500	3 600	59 000	780	2 000	380 000	-	-	-	18	-	89	-
Secondary Aluminium Production (Includes Recycling)	36	33	32	-	-	-	-	-	-	-	-	0.53	-	39
Asphalt Paving Industry	**35 000**	**6 800**	**1 300**	**580**	**900**	**5 700**	**3 300**	**-**	**1 100**	**20**	**20**	**0.00**	**11**	**-**
Cement and Concrete Industry	**51 000**	**17 000**	**8 300**	**17 000**	**28 000**	**550**	**17 000**	**540**	**200**	**2.5**	**300**	**1.1**	**-**	**840**
Cement Manufacturing	1 900	1 300	750	16 000	24 000	420	16 000	540	77	1.4	270	1.1	-	840
Concrete Batching and Products	47 000	14 000	7 100	0.00	0.76	120	15	-	120	1.1	-	-	-	-
Gypsum Product Manufacturing	94	81	72	0.26	220	1.5	170	-	-	-	33	-	-	-
Lime Manufacturing	1 700	980	420	1 400	3 700	12	980	-	4.1	-	-	-	-	-
Foundries	**5 200**	**4 700**	**4 000**	**2.2**	**84**	**1 200**	**44 000**	**-**	**1 100**	**260**	**0.00**	**0.00**	**-**	**150**
Die Casting	17	12	8.8	0.00	0.53	-	0.45	-	3.8	-	-	-	-	-
Ferrous Foundries	5 100	4 600	4 000	2.2	84	1 100	44 000	-	1 100	260	0.00	0.00	-	150
Non-Ferrous Foundries	17	16	12	-	-	57	-	-	13	-	-	-	-	0.00
Iron and Steel Industry	**6 100**	**3 600**	**2 300**	**14 000**	**9 200**	**690**	**22 000**	**56**	**5 400**	**170**	**480**	**4.4**	**370**	**1 100**
Primary (Blast Furnace and DRI)	5 478	3 178	1 992	12 408	7 314	487	17 860	56	3 330	120	202	1.1	370	150
Secondary (Electric Arc Furnaces)	600	420	300	2 000	1 900	210	3 800	-	1 500	49	270	3.3	0.58	940
Steel Recycling	15	12	8.5	2.1	-	-	31	-	510	-	2.3	0.00	-	4.2
Iron Ore Pelletizing	**8 784**	**2 481**	**626**	**9 724**	**9 520**	**223**	**14 996**	**1.1**	**2 320**	**46**	**79**	**5.1**	**0.30**	**450**
Mineral Products Industry	**520**	**450**	**280**	**790**	**260**	**98**	**600**	**240**	**5.4**	**-**	**-**	**-**	**-**	**-**
Brick Products	129	94	31	102	121	-	372	-	-	-	-	-	-	-
Clay Products	12	9.7	3.5	-	-	-	-	-	-	-	-	-	-	-
Other (Mineral Products Industry)	380	340	250	690	140	98	220	240	5.4	-	-	-	-	-
Mining and Rock Quarrying	**230 000**	**110 000**	**17 000**	**1 700**	**29 000**	**1 500**	**24 000**	**110**	**2 100**	**54**	**120**	**0.16**	**0.00**	**99**
Coal Mining Industry	160 000	78 000	9 000	660	2 500	75	5 400	-	23	1.8	2.1	-	0.00	-
Iron Ore Mining	6 000	2 700	520	270	2 200	9.7	3 100	-	57	5.3	0.16	0.00	-	-
Limestone	940	440	50	-	200	-	140	-	-	-	-	-	-	-
Metal Mining	24 000	9 000	3 200	520	16 000	720	11 000	73	1 900	43	110	0.16	0.00	98
Potash	7 300	3 400	1 900	3.3	2 300	410	1 900	-	0.00	-	-	-	-	-
Rock, Sand and Gravel	37 000	18 000	1 800	9.7	780	-	290	-	0.00	-	-	-	-	-
Silica Production	470	230	23	-	-	-	-	-	-	-	-	-	-	-
Other (Mining and Rock Quarrying)	1 700	870	350	240	5 700	330	1 900	36	72	3.7	1.9	0.00	-	1.8
Non-Ferrous Refining and Smelting Industry	**2 000**	**760**	**530**	**57 000**	**1 300**	**18**	**6 300**	**540**	**62 000**	**2 200**	**190**	**0.20**	**-**	**370**
Primary Ni, Cu, Zn, Pb	1 900	750	520	57 000	1 200	18	6 300	490	61 000	2 200	190	0.18	-	370
Secondary Pb, Cu	9.7	5.6	4.9	500	33	-	-	-	580	0.80	0.00	0.00	-	-
Other (Non-Ferrous Refining and Smelting Industry)	10	5.0	5.0	-	94	-	-	53	0.87	0.12	-	0.00	-	0.00
OIL AND GAS INDUSTRY	**33 000**	**22 000**	**14 000**	**260 000**	**440 000**	**520 000**	**540 000**	**2 200**	**520**	**230**	**76**	**-**	**480**	**-**
Downstream Oil and Gas Industry	**3 300**	**2 200**	**1 300**	**46 000**	**17 000**	**22 000**	**36 000**	**48**	**430**	**74**	**54**	**-**	**14**	**-**
Natural Gas Distribution	1.6	1.4	1.4	0.47	100	240	120	-	-	-	-	-	-	-
Petroleum Refining	3 300	2 200	1 300	46 000	16 000	8 600	36 000	48	430	74	54	-	14	-
Refined Petroleum Products Bulk Storage and Distribution	4.4	4.4	4.4	-	12	14 000	110	-	0.00	-	-	-	0.00	-
Refined Petroleum Product Pipelines	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Other (Downstream Oil and Gas Industry)	1.1	0.83	0.83	-	-	-	-	-	-	-	-	-	-	-
Upstream Oil and Gas Industry	**30 000**	**19 000**	**13 000**	**220 000**	**420 000**	**490 000**	**500 000**	**2 200**	**92**	**150**	**22**	**-**	**470**	**-**
Accidents and Equipment Failures	-	-	-	-	-	50 000	-	-	-	-	-	-	-	-
Disposal and Waste Treatment	29	29	29	0.00	23	50	86	0.20	-	-	-	-	-	-
Heavy Crude Oil Cold Production	540	540	540	1 700	12 000	13 000	16 000	40	-	-	-	-	-	-
Light/Medium Crude Oil Production	2 700	2 700	2 700	20 000	36 000	300 000	48 000	14	0.65	2.0	-	-	-	-
Natural Gas Production and Processing	3 400	3 400	3 400	120 000	300 000	56 000	380 000	230	-	-	-	-	-	-
Natural Gas Transmission and Storage	90	90	90	21	18 000	870	5 700	1.1	-	-	-	-	-	-
Oil Sands In-Situ Extraction	830	810	810	22 000	23 000	3 500	26 000	630	-	65	12	-	-	-
Oil Sands Mining, Extraction and Upgrading	22 000	12 000	5 300	54 000	35 000	46 000	22 000	1 300	91	86	10	-	470	-
Petroleum Liquids Storage	37	36	36	19	290	4 400	100	-	-	-	-	-	-	-
Petroleum Liquids Transportation	16	16	12	130	0.34	15 000	1.9	-	-	-	-	-	-	-
Well Drilling/Servicing/Testing	26	26	26	3 200	35	1 100	77	0.00	-	-	-	-	-	-
ELECTRIC POWER GENERATION (UTILITIES)	**13 000**	**4 500**	**2 000**	**170 000**	**100 000**	**1 600**	**38 000**	**260**	**1 200**	**96**	**500**	**0.49**	**6.5**	**240**
Coal	**12 000**	**3 500**	**1 200**	**160 000**	**67 000**	**280**	**17 000**	**27**	**860**	**71**	**470**	**0.31**	**-**	**190**
Landfill Gas	**8.7**	**7.0**	**7.0**	**7.2**	**100**	**-**	**540**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
Natural Gas	**540**	**400**	**320**	**1 300**	**18 000**	**1 000**	**11 000**	**120**	**62**	**12**	**2.0**	**0.00**	**0.00**	**43**
Diesel	**200**	**190**	**180**	**37**	**9 600**	**71**	**2 000**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
Other (Electric Power Generation)	**690**	**400**	**330**	**8 400**	**7 000**	**200**	**6 800**	**110**	**320**	**12**	**23**	**0.18**	**6.5**	**8.1**
MANUFACTURING	**120 000**	**48 000**	**20 000**	**38 000**	**67 000**	**110 000**	**140 000**	**11 000**	**2 600**	**230**	**86**	**1.8**	**120**	**57**
Abrasives Manufacturing	**68**	**27**	**11**	**-**	**-**	**17**	**-**	**-**	**-**	**-**	**-**	**0.00**	**-**	**-**
Bakeries	**15**	**13**	**9.7**	**-**	**-**	**5 100**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
Biofuel Production	**5.9**	**2.2**	**0.79**	**0.090**	**23**	**17**	**20**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
Chemicals Industry	**3 100**	**2 200**	**1 300**	**18 000**	**24 000**	**15 000**	**15 000**	**8 900**	**35**	**8.0**	**18**	**0.00**	**1.9**	**-**
Chemical Manufacturing	1 400	1 000	840	16 000	8 700	6 600	8 000	58	-	0.00	17	0.00	1.8	-
Cleaning Compound Manufacturing	1.4	1.4	1.4	-	43	-	-	20	-	-	-	-	-	-
Fertilizer Production	1 300	960	270	430	9 600	860	4 900	8 800	1.9	4.2	1.0	-	-	-
Paint and Varnish Manufacturing	7.9	6.9	4.8	-	0.41	370	2.7	2.5	24	0.00	-	-	-	-
Petrochemical Industry	200	160	110	720	4 700	4 800	1 900	0.00	9.2	3.8	0.44	-	0.10	-
Plastics and Synthetic Resins Fabrication	100	72	52	6.0	420	1 900	260	14	-	-	-	0.00	-	-
Other (Chemical Industry)	50	26	13	0.00	160	460	61	3.6	-	-	-	-	-	-
Electronics	**0.68**	**0.65**	**0.54**	**-**	**-**	**35**	**-**	**14**	**10**	**-**	**-**	**-**	**-**	**-**
Food Preparation	**2 300**	**1 500**	**680**	**320**	**1 700**	**18 000**	**1 100**	**200**	**0.31**	**0.68**	**-**	**-**	**-**	**-**
Glass Manufacturing	**220**	**200**	**190**	**550**	**700**	**130**	**290**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
Grain Industry	**79 000**	**22 000**	**4 000**	**320**	**960**	**3 000**	**490**	**5.0**	**-**	**-**	**-**	**-**	**-**	**-**
Grain Processing	78 000	22 000	4 000	320	960	3 000	490	4.7	-	-	-	-	-	-
Warehousing and Storage	910	350	72	-	-	-	-	0.30	-	-	-	-	-	-
Metal Fabrication	**450**	**320**	**270**	**10**	**180**	**2 500**	**540**	**24**	**270**	**3.8**	**4.3**	**0.17**	**-**	**-**
Plastics Manufacturing	**130**	**110**	**86**	**-**	**13**	**10 000**	**12**	**-**	**1.3**	**0.00**	**-**	**-**	**-**	**-**
Pulp and Paper Industry	**11 000**	**7 400**	**5 400**	**18 000**	**25 000**	**12 000**	**63 000**	**1 300**	**1 200**	**170**	**47**	**0.86**	**110**	**57**
Converted Paper Product Manufacturing	63	53	44	0.064	28	800	130	-	-	-	-	-	-	-
Pulp and Paper Product Manufacturing	11 000	7 300	5 300	18 000	25 000	11 000	63 000	1 300	1 200	170	47	0.86	110	57
Textiles	**0.39**	**0.39**	**0.39**	**-**	**-**	**370**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
Vehicle Manufacturing (Engines, Parts, Assembly, Painting)	**310**	**220**	**190**	**0.14**	**470**	**6 400**	**760**	**6.8**	**69**	**0.36**	**-**	**-**	**0.00**	**-**

Table 2–2 **Total Air Pollutant Emissions in 2021 for Canada by Category, Sector and Subsector** (cont'd)

Source	Pollutants													
	TPM (t)	PM10 (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)
Wood Products	**25 000**	**13 000**	**7 300**	**890**	**14 000**	**37 000**	**56 000**	**890**	**980**	**48**	**16**	**0.76**	**8.0**	**0.085**
Panel Board Mills	12 000	6 900	4 200	360	7 700	19 000	40 000	440	810	24	7.7	0.36	3.7	-
Sawmills	12 000	5 100	2 400	510	5 200	14 000	14 000	450	160	24	8.5	0.39	3.8	-
Other (Wood Products)	1 400	1 000	710	22	900	3 300	1 800	-	-	-	-	0.00	0.52	0.085
Other (Manufacturing)	**470**	**340**	**280**	**480**	**550**	**2 800**	**430**	**58**	**37**	**0.14**	**0.00**	**-**	**0.00**	**-**
TRANSPORTATION AND MOBILE EQUIPMENT	**35 000**	**35 000**	**26 000**	**3 000**	**560 000**	**210 000**	**2 800 000**	**6 500**	**14 000**	**53**	**70**	**25**	**2 300**	**-**
Air Transportation (LTO)	**220**	**220**	**210**	**280**	**4 900**	**2 100**	**25 000**	**3.1**	**14 000**	**-**	**-**	**-**	**4.3**	**-**
Domestic Marine Navigation, Fishing and Military	**1 300**	**1 300**	**1 200**	**1 900**	**120 000**	**3 500**	**4 200**	**-**	**130**	**8.1**	**0.13**	**4.5**	**27**	**-**
Heavy-Duty Diesel Vehicles	**4 100**	**4 100**	**3 800**	**110**	**120 000**	**7 800**	**53 000**	**850**	**-**	**-**	**0.29**	**0.42**	**440**	**-**
Heavy-Duty Gasoline Vehicles	**140**	**140**	**130**	**21**	**5 300**	**3 100**	**82 000**	**270**	**-**	**-**	**0.64**	**0.48**	**210**	**-**
Heavy-Duty LPG/NG Vehicles	**2.2**	**2.2**	**2.0**	**1.0**	**110**	**67**	**2 800**	**7.7**	**-**	**-**	**0.00**	**0.00**	**2.6**	**-**
Light-Duty Diesel Trucks	**8.3**	**8.3**	**7.6**	**2.2**	**600**	**360**	**6 200**	**15**	**-**	**-**	**0.00**	**0.00**	**0.67**	**-**
Light-Duty Diesel Vehicles	**3.2**	**3.2**	**2.9**	**1.1**	**190**	**150**	**3 800**	**7.1**	**-**	**-**	**0.00**	**0.00**	**0.43**	**-**
Light-Duty Gasoline Trucks	**890**	**890**	**790**	**250**	**21 000**	**24 000**	**480 000**	**3 000**	**-**	**-**	**15**	**12**	**1 000**	**-**
Light-Duty Gasoline Vehicles	**380**	**380**	**340**	**120**	**10 000**	**18 000**	**320 000**	**1 800**	**-**	**-**	**8.8**	**6.6**	**480**	**-**
Light-Duty LPG/NG Trucks	**0.065**	**0.065**	**0.058**	**0.00**	**6.2**	**2.2**	**40**	**0.15**	**-**	**-**	**0.00**	**0.00**	**0.11**	**-**
Light-Duty LPG/NG Vehicles	**0.00**	**0.00**	**0.00**	**0.00**	**0.11**	**0.00**	**1.1**	**0.00**	**-**	**-**	**0.00**	**0.00**	**0.00**	**-**
Motorcycles	**45**	**45**	**40**	**3.8**	**1 400**	**3 400**	**26 000**	**110**	**-**	**-**	**0.24**	**0.18**	**73**	**-**
Off-Road Diesel Vehicles and Equipment	**12 000**	**12 000**	**11 000**	**120**	**160 000**	**13 000**	**68 000**	**270**	**-**	**-**	**-**	**-**	**-**	**-**
Off-Road Gasoline/LPG/NG Vehicles and Equipment	**6 300**	**6 300**	**5 800**	**53**	**35 000**	**130 000**	**1 700 000**	**160**	**-**	**-**	**-**	**-**	**-**	**-**
Rail Transportation	**1 600**	**1 600**	**1 500**	**47**	**79 000**	**3 300**	**16 000**	**52**	**130**	**45**	**45**	**1.3**	**27**	**-**
Tire Wear and Brake Lining	**8 900**	**8 900**	**1 200**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
AGRICULTURE	**3 600 000**	**1 500 000**	**360 000**	**160**	**2 600**	**120 000**	**1 000**	**460 000**	**20**	**76**	**6.0**	**0.25**	**0.20**	**0.49**
Animal Production	**35 000**	**9 900**	**2 100**	**-**	**-**	**120 000**	**-**	**270 000**	**-**	**-**	**-**	**-**	**-**	**-**
Crop Production	**3 600 000**	**1 500 000**	**360 000**	**-**	**-**	**-**	**-**	**190 000**	**-**	**-**	**-**	**-**	**-**	**-**
Harvesting	270 000	120 000	24 000	-	-	-	-	-	-	-	-	-	-	-
Inorganic Fertilizer Application	13 000	6 200	1 800	-	-	-	-	180 000	-	-	-	-	-	-
Sewage Sludge Application	-	-	-	-	-	-	-	5 500	-	-	-	-	-	-
Tillage Practices	990 000	210 000	99 000	-	-	-	-	-	-	-	-	-	-	-
Wind Erosion	2 300 000	1 100 000	230 000	-	-	-	-	-	-	-	-	-	-	-
Agricultural Fuel Combustion	**400**	**260**	**220**	**160**	**2 600**	**150**	**1 000**	**18**	**20**	**76**	**6.0**	**0.25**	**0.20**	**0.49**
COMMERCIAL/RESIDENTIAL/ INSTITUTIONAL	**100 000**	**97 000**	**96 000**	**3 800**	**69 000**	**160 000**	**550 000**	**1 900**	**1 700**	**990**	**410**	**3.5**	**48 000**	**-**
Commercial and Institutional Fuel Combustion	**2 800**	**2 700**	**2 700**	**750**	**29 000**	**1 500**	**22 000**	**190**	**190**	**490**	**66**	**0.15**	**2.3**	**-**
Commercial Cooking	**17 000**	**17 000**	**16 000**	**-**	**-**	**2 300**	**6 600**	**-**	**-**	**-**	**-**	**-**	**120**	**-**
Construction Fuel Combustion	**180**	**160**	**150**	**290**	**3 000**	**51**	**510**	**50**	**9.3**	**11**	**2.5**	**0.00**	**0.31**	**-**
Home Firewood Burning	**80 000**	**75 000**	**75 000**	**1 200**	**8 700**	**110 000**	**510 000**	**780**	**1 200**	**68**	**18**	**3.1**	**47 000**	**-**
Human	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**640**	**-**	**-**	**1.8**	**-**	**-**	**-**
Marine Cargo Handling	**390**	**160**	**46**	**110**	**22**	**15**	**-**	**-**	**34**	**2.3**	**-**	**-**	**-**	**-**
Residential Fuel Combustion	**2 200**	**2 100**	**2 100**	**1 400**	**28 000**	**1 500**	**11 000**	**270**	**210**	**410**	**67**	**0.20**	**2.6**	**-**
Service Stations	**-**	**-**	**-**	**-**	**-**	**46 000**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
Other (Miscellaneous)	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**250**	**-**	**-**	**-**
INCINERATION AND WASTE	**6 700**	**3 900**	**2 800**	**1 300**	**5 300**	**15 000**	**14 000**	**5 700**	**160**	**38**	**850**	**39**	**690**	**9 800**
Crematoriums	**8.9**	**8.0**	**8.0**	**17**	**190**	**3.0**	**32**	**-**	**7.0**	**1.2**	**630**	**3.9**	**0.00**	**35**
Waste Incineration	**2 300**	**2 300**	**2 200**	**950**	**2 500**	**4 300**	**12 000**	**110**	**64**	**12**	**130**	**35**	**690**	**9 800**
Hazardous Waste Incineration	21	9.7	5.2	210	130	130	36	0.050	3.0	1.0	2.1	0.00	-	1.1
Medical Waste Incineration	6.4	0.00	0.00	0.30	11	0.73	3.3	-	23	3.0	16	15	-	40
Municipal Incineration	76	61	41	230	970	53	190	20	21	1.9	59	0.17	-	4 900
Residential Waste Burning	2 200	2 200	2 200	140	820	4 100	11 000	87	-	-	-	20	690	4 700
Sewage Sludge Incineration	51	13	11	380	520	0.39	190	2.3	17	6.5	55	0.00	0.00	130
Other (Waste Incineration)	3.6	2.6	0.73	0.33	61	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Waste Treatment and Disposal	**4 400**	**1 600**	**520**	**340**	**2 600**	**10 000**	**2 300**	**5 600**	**85**	**24**	**92**	**-**	**0.00**	**-**
Biological Treatment of Waste	12	12	12	16	31	3 200	180	2 100	-	-	-	-	-	-
Landfills	4 300	1 500	430	110	700	6 200	1 700	-	0.00	0.00	70	-	0.00	-
Municipal Wastewater Treatment	84	66	66	210	1 700	740	400	3 500	0.54	0.14	9.9	-	0.00	-
Specialized Waste Treatment and Remediation	8.8	19	13	-	120	250	46	4.3	85	24	12	-	-	-
Waste Sorting and Transfer	-	-	-	-	-	82	-	-	-	-	-	-	-	-
PAINTS AND SOLVENTS	**51**	**50**	**45**	**-**	**54**	**260 000**	**-**	**-**	**-**	**0.15**	**-**	**-**	**-**	**-**
Dry Cleaning	**35**	**35**	**32**	**-**	**29**	**180**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
General Solvent Use	**-**	**-**	**-**	**-**	**-**	**180 000**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
Printing	**8.7**	**7.7**	**7.3**	**-**	**19**	**15 000**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
Surface Coatings	**7.2**	**6.9**	**5.7**	**-**	**6.4**	**62 000**	**-**	**-**	**-**	**0.15**	**-**	**-**	**-**	**-**
DUST	**22 000 000**	**6 400 000**	**900 000**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
Coal Transportation	**1 800**	**900**	**360**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
Construction Operations	**8 500 000**	**2 500 000**	**510 000**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
Mine Tailings	**3 300**	**2 700**	**660**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
Paved Roads	**410 000**	**82 000**	**21 000**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
Unpaved Roads	**14 000 000**	**3 800 000**	**370 000**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
FIRES	**4 100**	**3 500**	**2 500**	**10**	**520**	**1 600**	**27 000**	**54**	**-**	**-**	**-**	**0.55**	**700**	**-**
Prescribed Burning	**3 900**	**3 300**	**2 300**	**10**	**490**	**1 400**	**25 000**	**41**	**-**	**-**	**-**	**0.55**	**700**	**-**
Structural Fires	**230**	**230**	**220**	**-**	**30**	**240**	**1 300**	**14**	**-**	**-**	**-**	**-**	**-**	**-**
GRAND TOTAL	**27 000 000**	**8 200 000**	**1 500 000**	**640 000**	**1 300 000**	**1 400 000**	**4 600 000**	**490 000**	**95 000**	**4 500**	**3 200**	**82**	**52 000**	**13 000**

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.
0.00 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)	210	210	210	980	22 000	1 300	30 000	9.6	16 000	-	-	-	2.1	-
International Air Transportation (Cruise)	310	310	300	1 500	37 000	400	4 000	12	360	-	-	-	0.85	-
International Marine Navigation	1 200	1 100	1 100	2 200	94 000	3 800	3 000	-	160	7.7	0.11	5.3	32	-

Note: Refer to Annex 4.4 for more information on international marine navigation and air transportation reporting emissions.

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

In 2021, approximately 1.5 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% (904 kt) of total $PM_{2.5}$ emissions, with the most important dust sources being Construction Operations at 35% (508 kt) and Unpaved Roads at 26% (374 kt) of total $PM_{2.5}$ emissions. Agriculture was the second-largest contributor and accounted for 24% (358 kt) of $PM_{2.5}$ emissions, almost all of which are attributed to Crop Production (24% or 355 kt). In these sectors, PM is largely emitted by non-combustion sources.

Commercial/Residential/Institutional sources accounted for 6.6% (96 kt) of total $PM_{2.5}$ emissions in 2021, with the most important contributor being Home Firewood Burning at 5.2% (75 kt) of total $PM_{2.5}$ emissions. All other Commercial/Residential/Institutional sources accounted for less than 1.4% of total $PM_{2.5}$ emissions.

Overall, emissions of $PM_{2.5}$ decreased from 1990 to 2009, gradually increased from 2009 to 2019, decreased significantly between 2019 to 2020, and slightly increased between 2020 and 2021 (Figure 2–1). Emissions in 2021 were 12% below 1990 levels. The downward trend between 1990 to 2009 was influenced predominantly by decreasing emissions from Crop Production. 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, and were offset by an increase in wind erosion emissions resulting from increased production of pulse crops until 2016 when the proportion of pulse crops began to decrease relative to other less emission intensive crops. To a lesser extent, the 1990 to 2009 $PM_{2.5}$ emissions decrease was also influenced by decreased emissions from Home Firewood Burning. This decrease is due to the reduction in the use of conventional fireplaces and wood stoves, which 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, but experienced a decrease of 59 kt (14%) between 2019 and 2020, coinciding with the first year of the COVID-19 pandemic. Between 2020 and 2021 emissions of $PM_{2.5}$ from Unpaved Roads increased by 16 kt (4.5%).These emission changes are linked to a decrease and then, increase in the vehicle kilometres traveled (VKT). Overall $PM_{2.5}$ emissions including those from Unpaved Roads were still below 2019 pre-pandemic emission levels in 2021. The trend in $PM_{2.5}$ emissions from roads is driven predominantly by the use of unpaved roads in Alberta, Saskatchewan, Manitoba and Ontario.

Furthermore, emissions of $PM_{2.5}$ were 18% above 2005 levels. Emissions decreased from most sources with the notable exceptions of dust sources (not from combustion) such as construction operations and unpaved roads. Excluding sources from road dust, construction operations, and crop production, $PM_{2.5}$ emissions in 2021 were 30% lower compared to 2005 levels. The emission sources that contributed to the trends between 2005 and 2021 were mainly an increase in Dust sources, but also decreases in Agriculture and Transportation and Mobile Equipment. The Dust emissions increase between 2005 to 2021 is linked to more vehicles driven on Unpaved Roads, as noted previously, as well as an increase in Construction Operations. The Agriculture decrease is associated with a decrease in the proportion of pulse crops in recent years relative to less emission intensive crops. The Transportation and Mobile Equipment decrease is primarily due to implemented regulations that have effectively lowered PM emission rates from diesel engines.

The most significant changes in $PM_{2.5}$ emissions from 1990 to 2021 include:

- Dust: increase of 83% (411 kt), with:
  - Construction Operations: increase of 113% (269 kt)
  - Paved and Unpaved Roads: increase of 56% (141 kt)
- Agriculture: decrease of 47% (316 kt), with:
  - Crop Production: decrease of 47% (317 kt)
- Commercial/Residential/Institutional: decrease of 39% (62 kt), with:
  - Home Firewood Burning: decrease of 46% (64 kt)

The most significant changes in $PM_{2.5}$ emissions from 2005 to 2021 include:

- Dust: increase of 80% (401 kt), with:
  - Construction Operations: increase of 199% (338 kt)
  - Paved and Unpaved Roads: increase of 19% (63 kt)
- Agriculture: decrease of 21% (93 kt), with:
  - Crop Production: decrease of 21% (92 kt)
- Transportation and Mobile Equipment: decrease of 60% (39 kt), with:
  - Heavy-Duty Diesel Vehicles: decrease of 80% (15 kt)
  - Off-Road Diesel Vehicles and Equipment: decrease of 52% (12 kt)

Figure 2–1 **Trends in Canadian $PM_{2.5}$ Emissions (1990 to 2021)**

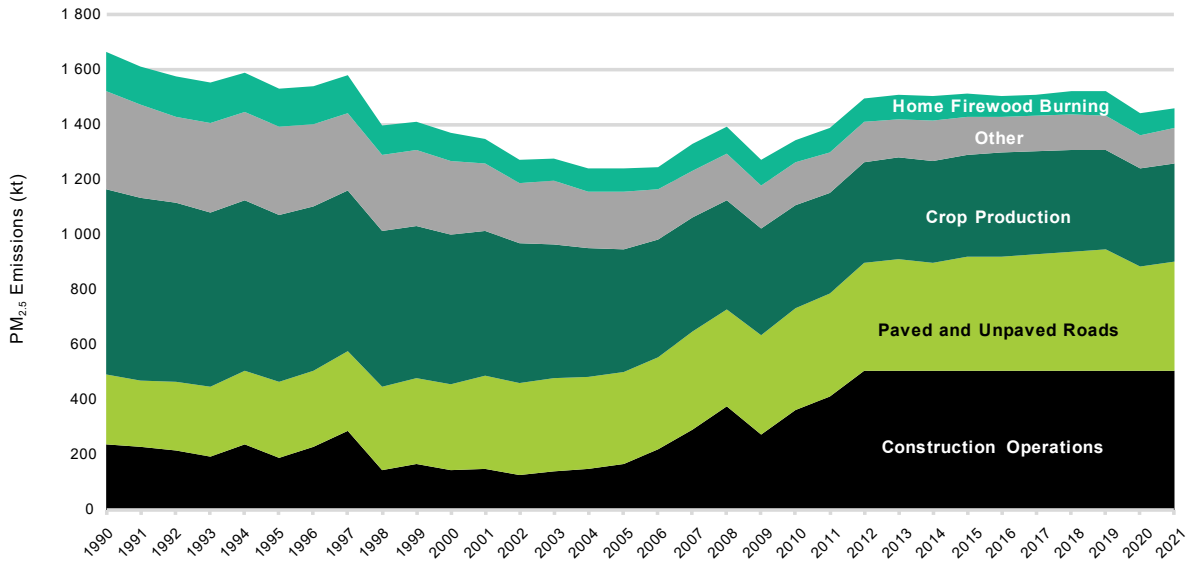


Table 2–3 National Summary of Annual $PM_{2.5}$ Emissions

Source	1990	2000	2005	2016	2017	2018	2019	2020	2021
					(tonnes)				
ORE AND MINERAL INDUSTRIES	**54 000**	**51 000**	**41 000**	**31 000**	**35 000**	**34 000**	**34 000**	**33 000**	**38 000**
Aluminium Industry	5 400	4 600	5 200	3 500	3 400	3 200	3 200	3 500	3 600
Asphalt Paving Industry	1 900	1 700	1 500	1 300	1 400	1 400	1 300	1 300	1 300
Cement and Concrete Industry	11 000	9 700	12 000	7 200	8 000	8 000	7 800	7 100	8 300
Foundries	4 600	4 300	4 500	4 100	4 200	4 200	4 000	3 700	4 000
Iron and Steel Industry	11 000	9 700	5 200	2 200	2 500	2 700	2 700	2 100	2 300
Iron Ore Pelletizing	650	3 900	1 200	900	790	690	790	680	630
Mineral Products Industry	1 300	1 200	960	290	230	290	230	230	280
Mining and Rock Quarrying	9 600	10 000	6 900	10 000	13 000	13 000	13 000	14 000	17 000
Non-Ferrous Refining and Smelting Industry	8 600	5 600	4 100	1 700	1 300	1 000	650	570	530
OIL AND GAS INDUSTRY	**12 000**	**14 000**	**12 000**	**11 000**	**12 000**	**12 000**	**12 000**	**12 000**	**14 000**
Downstream Oil and Gas Industry	5 100	4 900	4 600	1 500	1 500	1 600	1 500	1 500	1 300
Upstream Oil and Gas Industry	6 800	8 800	7 900	9 200	11 000	10 000	10 000	11 000	13 000
ELECTRIC POWER GENERATION (UTILITIES)	**49 000**	**23 000**	**9 100**	**3 400**	**3 300**	**3 200**	**2 800**	**2 400**	**2 000**
Coal	46 000	20 000	5 000	2 200	2 200	2 200	1 800	1 500	1 200
Landfill Gas	0.41	1.6	5.3	15	15	12	11	9.5	7.0
Natural Gas	1 300	2 100	1 900	390	340	350	300	300	320
Diesel	280	410	400	220	180	200	200	180	180
Other (Electric Power Generation)	1 300	720	1 800	540	520	440	450	420	330
MANUFACTURING	**110 000**	**75 000**	**45 000**	**17 000**	**17 000**	**17 000**	**16 000**	**16 000**	**20 000**
Abrasives Manufacturing	390	210	200	14	15	17	11	11	11
Bakeries	0.54	0.54	0.43	7.5	6.7	10	12	11	9.7
Biofuel Production	-	-	-	5.8	6.1	3.7	2.9	1.5	0.79
Chemicals Industry	4 800	4 500	4 100	1 300	1 200	1 500	1 400	1 300	1 300
Electronics	130	39	5.7	0.89	0.87	0.82	0.54	0.57	0.54
Food Preparation	1 400	2 100	1 700	720	720	660	660	680	680
Glass Manufacturing	950	1 300	1 100	160	130	140	160	160	190
Grain Industry	2 200	2 900	2 000	3 400	3 500	3 500	2 600	3 000	4 000
Metal Fabrication	180	270	360	260	280	250	260	250	270
Plastics Manufacturing	150	170	120	57	56	61	76	87	86
Pulp and Paper Industry	61 000	25 000	18 000	6 900	7 200	6 800	6 300	6 100	5 400
Textiles	16	23	18	1.3	1.2	1.2	0.99	0.34	0.39
Vehicle Manufacturing (Engines, Parts, Assembly, Painting)	1 700	1 600	650	210	210	240	230	170	190
Wood Products	35 000	28 000	14 000	3 800	3 600	3 800	4 300	4 300	7 300
Other (Manufacturing)	6 300	8 900	3 000	210	210	200	260	240	280
TRANSPORTATION AND MOBILE EQUIPMENT	**70 000**	**72 000**	**65 000**	**33 000**	**33 000**	**32 000**	**30 000**	**26 000**	**26 000**
Air Transportation (LTO)	430	350	320	270	280	300	290	180	210
Domestic Marine Navigation, Fishing and Military	4 200	5 100	5 800	1 100	1 200	1 100	1 100	1 000	1 200
Heavy-Duty Diesel Vehicles	19 000	18 000	19 000	6 100	5 200	4 900	4 300	3 800	3 800
Heavy-Duty Gasoline Vehicles	760	510	370	160	150	150	150	130	130
Heavy-Duty LPG/NG Vehicles	170	8.4	3.3	1.2	1.4	1.5	1.7	1.7	2.0
Light-Duty Diesel Trucks	42	39	31	7.3	7.1	7.8	8.0	7.0	7.6
Light-Duty Diesel Vehicles	36	19	15	4.5	4.2	4.1	3.6	2.6	2.9
Light-Duty Gasoline Trucks	1 400	1 400	1 100	640	670	740	810	730	790
Light-Duty Gasoline Vehicles	2 900	1 900	1 200	430	400	420	420	340	340
Light-Duty LPG/NG Trucks	3.9	0.27	0.16	0.16	0.11	0.15	0.12	0.066	0.058
Light-Duty LPG/NG Vehicles	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Motorcycles	21	22	25	45	45	47	49	40	40
Off-Road Diesel Vehicles and Equipment	34 000	30 000	24 000	15 000	15 000	15 000	14 000	12 000	11 000
Off-Road Gasoline/LPG/NG Vehicles and Equipment	3 500	9 300	9 300	6 700	6 400	6 200	6 200	5 600	5 800
Rail Transportation	3 600	3 400	3 300	1 700	1 800	2 000	1 800	1 600	1 500
Tire Wear and Brake Lining	720	940	1 000	1 200	1 200	1 300	1 300	1 100	1 200
AGRICULTURE	**670 000**	**540 000**	**450 000**	**380 000**	**370 000**	**370 000**	**370 000**	**360 000**	**360 000**
Animal Production	1 700	2 100	2 300	2 100	2 100	2 100	2 100	2 100	2 100
Crop Production	670 000	540 000	450 000	380 000	370 000	370 000	360 000	360 000	360 000
Agricultural Fuel Combustion	120	140	130	290	280	260	260	230	220
COMMERCIAL/RESIDENTIAL/INSTITUTIONAL	**160 000**	**120 000**	**110 000**	**99 000**	**98 000**	**110 000**	**110 000**	**100 000**	**96 000**
Commercial and Institutional Fuel Combustion	2 000	2 600	2 600	2 400	2 600	2 700	2 900	2 800	2 700
Commercial Cooking	14 000	15 000	17 000	15 000	15 000	15 000	15 000	16 000	16 000
Construction Fuel Combustion	180	110	150	140	140	140	150	150	150
Home Firewood Burning	140 000	100 000	84 000	79 000	77 000	85 000	86 000	79 000	75 000
Human	-	-	-	-	-	-	-	-	-
Marine Cargo Handling	190	140	110	85	87	81	76	48	46
Residential Fuel Combustion	2 400	2 600	2 500	2 200	2 300	2 400	2 300	2 200	2 100
Service Stations	-	-	-	-	-	-	-	-	-
Other (Miscellaneous)	-	-	-	-	-	-	-	-	-
INCINERATION AND WASTE	**3 500**	**3 700**	**3 400**	**2 600**	**2 600**	**2 700**	**2 700**	**2 800**	**2 800**
Crematoriums	2.3	3.3	4.2	6.4	6.8	7.1	7.2	7.9	8.0
Waste Incineration	3 000	3 100	2 800	2 100	2 200	2 200	2 200	2 200	2 200
Waste Treatment and Disposal	540	580	620	440	450	470	500	520	520
PAINTS AND SOLVENTS	**3.7**	**7.1**	**25**	**16**	**23**	**23**	**43**	**41**	**45**
Dry Cleaning	0.32	0.32	1.2	4.5	14	13	32	28	32
General Solvent Use	-	-	-	-	-	-	-	-	-
Printing	3.0	6.4	23	9.8	7.4	7.3	8.2	8.0	7.3
Surface Coatings	0.37	0.37	0.94	1.5	1.5	2.4	2.3	4.9	5.7
DUST	**490 000**	**460 000**	**500 000**	**920 000**	**930 000**	**940 000**	**950 000**	**890 000**	**900 000**
Coal Transportation	320	300	240	250	220	220	230	200	360
Construction Operations	240 000	150 000	170 000	510 000	510 000	510 000	510 000	510 000	510 000
Mine Tailings	200	280	260	480	540	560	540	610	660
Paved Roads	24 000	19 000	19 000	22 000	21 000	22 000	23 000	20 000	21 000
Unpaved Roads	230 000	290 000	310 000	390 000	400 000	410 000	420 000	360 000	370 000
FIRES	**36 000**	**6 900**	**4 500**	**9 100**	**4 800**	**2 900**	**3 200**	**2 500**	**2 500**
Prescribed Burning	36 000	6 600	4 200	8 900	4 600	2 700	3 000	2 300	2 300
Structural Fires	350	280	260	190	190	200	190	200	220
GRAND TOTAL	**1 700 000**	**1 400 000**	**1 200 000**	**1 500 000**	**1 500 000**	**1 500 000**	**1 500 000**	**1 400 000**	**1 500 000**

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

Other Emissions Estimated in the APEI

Source	1990	2000	2005	2016	2017	2018	2019	2020	2021
Domestic Air Transportation (Cruise)	370	480	330	280	300	320	330	180	210
International Air Transportation (Cruise)	520	580	570	500	540	620	640	290	300
International Marine Navigation	5 500	8 200	9 500	1 500	1 500	1 600	1 300	980	1 100

Note: Refer to Annex 4.4 for more information on international marine navigation and air transportation reporting emissions.

2.2. Sulphur Oxides

In 2021, 641 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 41% (264 kt) of national emissions. Approximately 83% (218 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 26% (169 kt) of total SO_x emissions, mostly attributable to coal-electric power generation at 25% (159 kt) of the national total. Ore and Mineral Industries also accounted for 25% (161 kt) of total SO_x emissions.

Overall, SO_x emissions decreased by 79% (2.4 Mt) between 1990 and 2021 (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 2021. 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, 2018a).

Emissions from Electric Power Generation (Utilities) decreased significantly from 2003 to 2021, primarily owing to the adoption of emissions control equipment on older coal units, and more recently, closure of coal-fired power plants. Between 2019 and 2021, coal-electric power generation saw a SO_x emission decrease of 20% (39 kt) attributable to a decrease in coal consumption, mostly notably between 2019 and 2020. Installation of pollution control equipment, switching to low sulphur heavy fuel oil and closure of generating stations burning heavy fuel oil also contributed 15% of the reduction in emissions between 2003 and 2021.

SO_x emissions from the Oil and Gas Industry exhibited an overall downward trend since the mid 1990s. Emissions from the Upstream Oil and Gas Industry have gradually declined throughout the time series due to implementation of better emission control technologies, particularly in the Oil Sands Mining, Extraction and Upgrading and Natural Gas Production and Processing subsectors. Despite improved emissions controls SO_x emissions from the Upstream Oil and Gas Industry gradually increased between 2016 and 2021. This recent trend is driven by a 28% increase in crude bitumen production, as well as increased flaring at natural gas production and processing facilities as part of growing efforts to reduce methane emissions from venting. From 2020 to 2021 the Oil and Gas Industry experienced an 8.0% increase (19 kt) in SO_x emissions. This includes a 25% (9.2 kt) increase in Petroleum Refining emissions as crude oil and crude bitumen charged to refineries increased as well as increases in crude bitumen production and flaring at natural gas processing facilities.

Emissions of SO_x were 69% below 2005 levels. The main emission sources that contributed to these trends and the explanations for those decreases are similar to the ones between 1990 and 2021 that were previously explained.

The most significant changes in SO_x emissions from 1990 to 2021 include:

- Ore and Mineral Industries: decrease of 89% (1.3 Mt), with:
  - Non-Ferrous Refining and Smelting Industry: decrease of 95% (1.2 Mt)
- Electric Power Generation (Utilities): decrease of 73% (449 kt), with:
  - Coal: decrease of 69% (356 kt)
- Oil and Gas Industry: decrease of 51% (273 kt), with:
  - Upstream Oil and Gas Industry: decrease of 46% (189 kt)

The most significant changes in SO_x emissions from 2005 to 2021 include:

- Ore and Mineral Industries: decrease of 81% (698 kt), with:
  - Non-Ferrous Refining and Smelting Industry: decrease of 92% (619 kt)
- Electric Power Generation (Utilities): decrease of 68% (353 kt), with:
  - Coal: decrease of 66% (303 kt)
- Oil and Gas Industry: decrease of 43% (200 kt), with:
  - Upstream Oil and Gas Industry: decrease of 38% (132 kt)

Figure 2–2 **Trends in Canadian SO_x Emissions (1990 to 2021)**

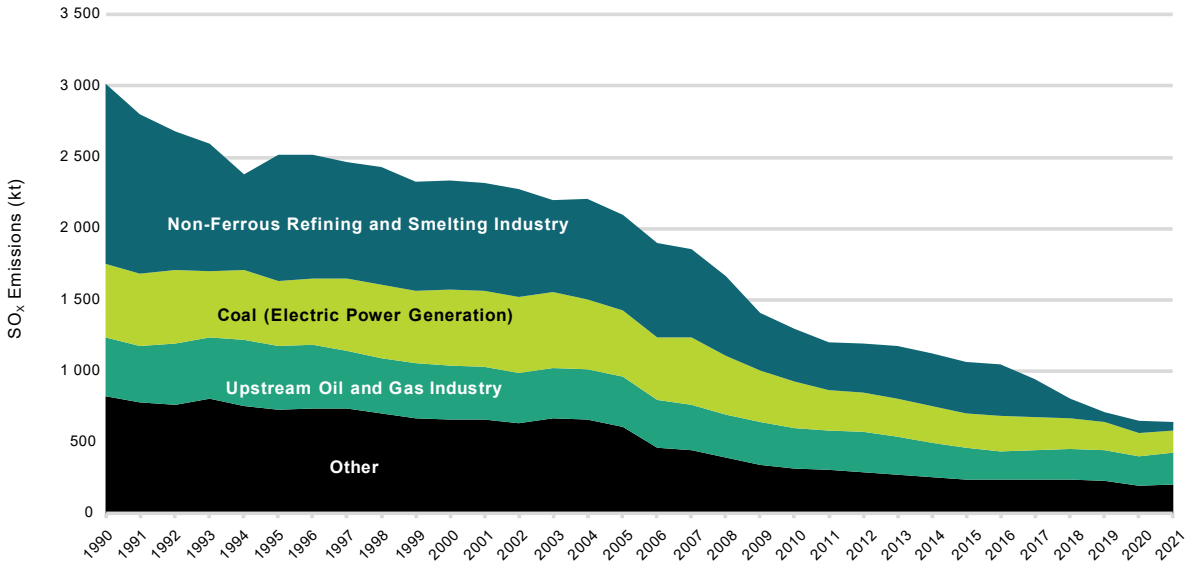


Table 2–4 National Summary of Annual SO_x Emissions

Source	1990	2000	2005	2016	2017	2018	2019	2020	2021
					(tonnes)				
ORE AND MINERAL INDUSTRIES	**1 500 000**	**920 000**	**860 000**	**480 000**	**390 000**	**260 000**	**180 000**	**190 000**	**160 000**
Aluminium Industry	31 000	48 000	63 000	64 000	66 000	61 000	57 000	62 000	59 000
Asphalt Paving Industry	730	640	710	610	690	690	620	560	580
Cement and Concrete Industry	48 000	45 000	54 000	24 000	23 000	25 000	23 000	19 000	17 000
Foundries	1 800	1 900	1 700	23	22	23	22	21	2.2
Iron and Steel Industry	37 000	30 000	31 000	18 000	19 000	20 000	20 000	15 000	14 000
Iron Ore Pelletizing	15 000	16 000	18 000	12 000	12 000	9 700	11 000	10 000	9 700
Mineral Products Industry	1 500	1 100	2 100	1 500	850	750	720	690	790
Mining and Rock Quarrying	83 000	15 000	12 000	2 600	2 400	1 900	1 900	2 100	1 700
Non-Ferrous Refining and Smelting Industry	1 300 000	760 000	680 000	360 000	270 000	140 000	70 000	85 000	57 000
OIL AND GAS INDUSTRY	**540 000**	**520 000**	**460 000**	**250 000**	**260 000**	**270 000**	**270 000**	**240 000**	**260 000**
Downstream Oil and Gas Industry	130 000	140 000	110 000	50 000	48 000	53 000	53 000	37 000	46 000
Upstream Oil and Gas Industry	410 000	380 000	350 000	200 000	210 000	220 000	220 000	210 000	220 000
ELECTRIC POWER GENERATION (UTILITIES)	**620 000**	**620 000**	**520 000**	**250 000**	**250 000**	**220 000**	**210 000**	**170 000**	**170 000**
Coal	510 000	530 000	460 000	240 000	240 000	210 000	200 000	160 000	160 000
Landfill Gas	0.76	15	-	120	100	92	88	11	7.2
Natural Gas	29 000	21 000	19 000	1 800	1 100	1 400	1 100	770	1 300
Diesel	430	440	330	73	9.4	37	37	37	37
Other (Electric Power Generation)	74 000	63 000	41 000	8 000	8 200	6 700	6 400	6 600	8 400
MANUFACTURING	**220 000**	**150 000**	**140 000**	**44 000**	**42 000**	**44 000**	**41 000**	**35 000**	**38 000**
Abrasives Manufacturing	4 000	860	860	-	-	-	-	-	-
Bakeries	0.053	0.052	0.16	0.00	0.00	-	-	-	-
Biofuel Production	-	-	-	-	-	2.3	6.5	5.1	0.090
Chemicals Industry	38 000	31 000	36 000	21 000	18 000	20 000	18 000	15 000	18 000
Electronics	1 700	3 000	3 000	0.00	-	-	-	-	-
Food Preparation	3 500	4 800	6 000	280	370	420	390	320	320
Glass Manufacturing	2 300	2 800	2 500	610	590	600	580	580	550
Grain Industry	230	210	370	530	490	340	330	200	320
Metal Fabrication	150	190	37	8.1	7.1	4.4	2.0	2.5	10
Plastics Manufacturing	340	24	3.9	-	0.00	0.00	-	-	-
Pulp and Paper Industry	140 000	78 000	66 000	21 000	22 000	22 000	20 000	18 000	18 000
Textiles	380	390	320	21	19	19	15	0.00	-
Vehicle Manufacturing (Engines, Parts, Assembly, Painting)	1 200	1 200	1 100	0.00	0.00	0.058	0.060	0.00	0.14
Wood Products	3 200	3 300	3 000	600	600	530	560	480	890
Other (Manufacturing)	30 000	27 000	24 000	400	360	340	450	140	480
TRANSPORTATION AND MOBILE EQUIPMENT	**98 000**	**92 000**	**71 000**	**7 400**	**6 800**	**6 500**	**6 700**	**2 800**	**3 000**
Air Transportation (LTO)	810	850	930	490	690	650	620	260	280
Domestic Marine Navigation, Fishing and Military	38 000	47 000	54 000	5 500	4 700	4 300	4 600	1 800	1 900
Heavy-Duty Diesel Vehicles	18 000	6 500	5 700	130	130	130	120	100	110
Heavy-Duty Gasoline Vehicles	740	850	61	50	47	53	49	21	21
Heavy-Duty LPG/NG Vehicles	100	4.8	0.20	0.65	0.93	1.1	1.4	0.97	1.0
Light-Duty Diesel Trucks	970	260	120	1.9	2.2	2.3	2.4	1.9	2.2
Light-Duty Diesel Vehicles	450	100	120	2.4	2.3	2.1	1.8	1.1	1.1
Light-Duty Gasoline Trucks	3 900	6 900	520	580	560	650	620	240	250
Light-Duty Gasoline Vehicles	7 800	8 500	540	390	360	410	370	120	120
Light-Duty LPG/NG Trucks	9.7	1.5	0.079	0.00	0.00	0.00	0.00	0.00	0.00
Light-Duty LPG/NG Vehicles	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Motorcycles	40	63	6.2	9.6	9.3	11	11	3.8	3.8
Off-Road Diesel Vehicles and Equipment	20 000	13 000	4 000	120	130	130	130	120	120
Off-Road Gasoline/LPG/NG Vehicles and Equipment	1 200	2 000	140	130	120	130	120	50	53
Rail Transportation	5 700	5 400	5 000	44	50	51	51	48	47
Tire Wear and Brake Lining	-	-	-	-	-	-	-	-	-
AGRICULTURE	**2 200**	**1 500**	**2 900**	**370**	**300**	**240**	**220**	**190**	**160**
Animal Production	-	-	-	-	-	-	-	-	-
Crop Production	-	-	-	-	-	-	-	-	-
Agricultural Fuel Combustion	2 200	1 500	2 900	370	300	240	220	190	160
COMMERCIAL/RESIDENTIAL/INSTITUTIONAL	**50 000**	**35 000**	**35 000**	**5 000**	**5 100**	**4 600**	**4 500**	**4 200**	**3 800**
Commercial and Institutional Fuel Combustion	19 000	19 000	21 000	1 100	1 200	860	930	780	750
Commercial Cooking	-	-	-	-	-	-	-	-	-
Construction Fuel Combustion	1 900	620	1 400	390	310	250	270	500	290
Home Firewood Burning	1 800	1 500	1 300	1 700	1 700	1 600	1 400	1 300	1 200
Human	-	-	-	-	-	-	-	-	-
Marine Cargo Handling	0.00	0.00	-	91	120	97	170	83	110
Residential Fuel Combustion	28 000	14 000	11 000	1 700	1 700	1 800	1 700	1 600	1 400
Service Stations	-	-	-	-	-	-	-	-	-
Other (Miscellaneous)	-	-	-	-	-	-	-	-	-
INCINERATION AND WASTE	**1 100**	**1 400**	**1 300**	**1 400**	**1 300**	**1 400**	**1 300**	**1 500**	**1 300**
Crematoriums	5.0	7.0	8.9	14	14	15	15	17	17
Waste Incineration	790	1 100	930	1 100	1 100	1 100	1 000	1 200	950
Waste Treatment and Disposal	350	300	310	220	220	240	250	350	340
PAINTS AND SOLVENTS	**2.1**	**1.5**	**0.62**	**-**	**-**	**-**	**-**	**-**	**-**
Dry Cleaning	0.00	0.00	-	-	-	-	-	-	-
General Solvent Use	-	-	-	-	-	-	-	-	-
Printing	2.0	1.5	0.62	-	-	-	-	-	-
Surface Coatings	0.00	0.00	-	-	-	-	-	-	-
DUST	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
Coal Transportation	-	-	-	-	-	-	-	-	-
Construction Operations	-	-	-	-	-	-	-	-	-
Mine Tailings	-	-	-	-	-	-	-	-	-
Paved Roads	-	-	-	-	-	-	-	-	-
Unpaved Roads	-	-	-	-	-	-	-	-	-
FIRES	**180**	**28**	**18**	**34**	**20**	**12**	**15**	**11**	**10**
Prescribed Burning	180	28	18	34	20	12	15	11	10
Structural Fires	-	-	-	-	-	-	-	-	-
GRAND TOTAL	**3 000 000**	**2 300 000**	**2 100 000**	**1 000 000**	**950 000**	**810 000**	**710 000**	**650 000**	**640 000**

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

Other Emissions Estimated in the APEI

Source	1990	2000	2005	2016	2017	2018	2019	2020	2021
Domestic Air Transportation (Cruise)	2 200	2 300	2 500	1 400	2 200	2 000	1 900	820	980
International Air Transportation (Cruise)	2 400	3 600	4 300	3 300	5 300	5 000	4 500	1 500	1 500
International Marine Navigation	42 000	63 000	73 000	4 100	4 000	4 000	3 100	2 100	2 200

Note: Refer to Annex 4.4 for more information on international marine navigation and air transportation reporting emissions.

2.3. Nitrogen Oxides

Approximately 1.3 Mt of nitrogen oxides (NO_x) were released in Canada in 2021 (Table 2–5). Transportation and Mobile Equipment was the largest contributor, accounting for 42% (556 kt) of total NO_x emissions. Within this source category, Off-Road Diesel Vehicles and Equipment, Heavy-Duty Diesel Vehicles, and Domestic Marine Navigation, Fishing and Military sectors were the largest emitters, collectively contributing 30% (399 kt) of total NO_x emissions. The Oil and Gas Industry accounted for 33% (439 kt) of total NO_x emissions in 2021, with the Upstream Oil and Gas Industry sector accounting for nearly all of the Oil and Gas Industry total (96% or 423 kt). Electric Power Generation (Utilities) contributed 7.7% (101 kt) of total NO_x emissions, with coal-fired generation contributing 5.1% (67 kt) of the national total. The remaining 17% of NO_x emissions were distributed across multiple sources.

In 2021, national NO_x emissions were 41% (931 kt) below 1990 levels and 42% (945 kt) below 2005 levels (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.[6] NO_x emissions from Heavy-Duty Diesel Vehicles generally increased from 1990 through 1997, before generally decreasing until 2021. NO_x emissions from Off-Road Diesel Vehicles and Equipment generally increased from 1990 through 2000, before generally decreasing until 2021. Between 2019 and 2021, Transportation and Mobile Equipment showed an emission decrease of NO_x (58 kt or 9.5%). This change is mostly due to a decrease in the VKT in the Light-Duty Gasoline Vehicles and Trucks categories between 2019 and 2020. Between 2020 and 2021, the VKT increased but was still below pre-pandemic levels, leading to a slight increase in the Transportation and Mobile Equipment NO_x emissions (9.2 kt or 1.7%).

Within Electric Power Generation (Utilities), coal-electric power generation contributed to the downward trend across the time series, with a gradual decrease in emissions from 1998 to 2021. This decrease can be attributed to coal-fired power plants that have closed down and have been replaced by lower-emission sources such as natural gas power plants.

The Oil and Gas Industry experienced an increase in emissions since 1990. This increase is attributed to expansion and growth in the industry. Between 2019 and 2021, most major contributors to NO_x emissions experienced decreases. Notably, the Upstream Oil and Gas Industry saw a significant decrease between 2019 and 2020, and a slight decrease between 2020 and 2021, resulting in an overall decrease of 29 kt (6.5%) over this two-year period. This can be attributed to a 10% reduction in reported fuel gas consumption from 2019 to 2021.

The most significant changes in NO_x emissions from 1990 to 2021 include:

- Transportation and Mobile Equipment: decrease of 56% (713 kt), with:
  - Light-Duty Gasoline Trucks and Vehicles: decrease of 89% (244 kt)
  - Heavy-Duty Diesel Vehicles: decrease of 62% (202 kt)
  - Off-Road Diesel Vehicles and Equipment: decrease of 48% (147 kt)
- Electric Power Generation (Utilities): decrease of 61% (156 kt), with:
  - Coal: decrease of 68% (139 kt)
- Oil and Gas Industry: increase of 28% (95 kt), with:
  - Upstream Oil and Gas Industry: increase of 37% (114 kt)

The most significant changes in NO_x emissions from 2005 to 2021 include:

- Transportation and Mobile Equipment: decrease of 56% (696 kt), with:
  - Heavy-Duty Diesel Vehicles: decrease of 69% (274 kt)
  - Light-Duty Gasoline Trucks and Vehicles: decrease of 89% (244 kt)
  - Off-Road Diesel Vehicles and Equipment: decrease of 45% (131 kt)
- Electric Power Generation (Utilities): decrease of 60% (152 kt), with:
  - Coal: decrease of 64% (119 kt)

6 See Chapter 1 for list of regulations.

Figure 2–3 **Trends in Canadian NO_x Emissions (1990 to 2021)**

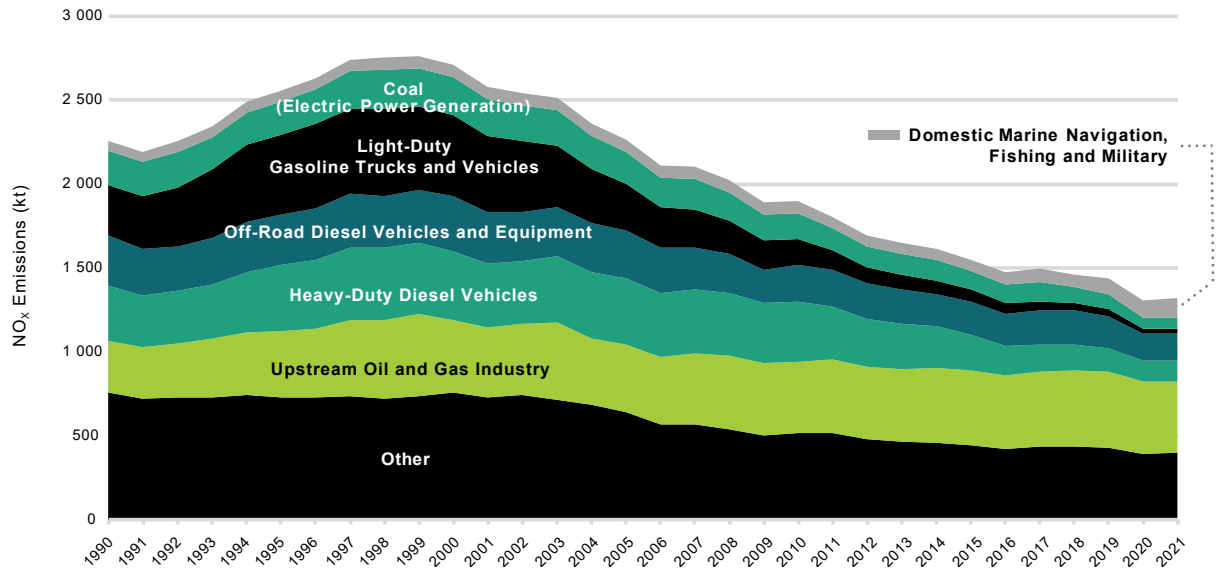


Table 2–5 National Summary of Annual NO_X Emissions

Source	1990	2000	2005	2016	2017	2018	2019	2020	2021
					(tonnes)				
ORE AND MINERAL INDUSTRIES	**110 000**	**100 000**	**110 000**	**78 000**	**86 000**	**82 000**	**81 000**	**74 000**	**80 000**
Aluminium Industry	1 600	1 400	2 100	1 200	1 200	1 200	1 100	1 100	1 000
Asphalt Paving Industry	1 200	1 100	1 200	890	960	980	930	880	900
Cement and Concrete Industry	42 000	45 000	54 000	32 000	34 000	35 000	31 000	27 000	28 000
Foundries	720	1 000	640	96	93	90	83	78	84
Iron and Steel Industry	19 000	16 000	14 000	11 000	11 000	11 000	11 000	8 600	9 200
Iron Ore Pelletizing	5 200	5 100	9 500	10 000	10 000	8 500	9 800	9 300	9 500
Mineral Products Industry	1 500	670	1 100	300	290	240	210	220	260
Mining and Rock Quarrying	29 000	26 000	24 000	20 000	27 000	23 000	25 000	25 000	29 000
Non-Ferrous Refining and Smelting Industry	4 200	3 700	1 800	1 900	1 800	1 700	1 900	1 500	1 300
OIL AND GAS INDUSTRY	**340 000**	**460 000**	**430 000**	**460 000**	**460 000**	**470 000**	**470 000**	**440 000**	**440 000**
Downstream Oil and Gas Industry	35 000	30 000	31 000	17 000	17 000	17 000	16 000	17 000	17 000
Upstream Oil and Gas Industry	310 000	430 000	400 000	440 000	450 000	450 000	450 000	430 000	420 000
ELECTRIC POWER GENERATION (UTILITIES)	**260 000**	**330 000**	**250 000**	**150 000**	**140 000**	**130 000**	**120 000**	**100 000**	**100 000**
Coal	210 000	230 000	190 000	120 000	110 000	92 000	88 000	66 000	67 000
Landfill Gas	45	400	300	200	220	150	140	130	100
Natural Gas	20 000	65 000	38 000	16 000	16 000	18 000	18 000	18 000	18 000
Diesel	3 200	8 500	8 500	9 100	8 900	9 800	9 900	9 800	9 600
Other (Electric Power Generation)	27 000	27 000	21 000	10 000	9 600	8 900	8 800	8 100	7 000
MANUFACTURING	**190 000**	**170 000**	**140 000**	**68 000**	**69 000**	**69 000**	**67 000**	**63 000**	**67 000**
Abrasives Manufacturing	240	90	74	-	-	-	-	-	-
Bakeries	4.1	4.0	-	0.89	0.95	-	-	-	-
Biofuel Production	-	-	-	16	18	33	13	33	23
Chemicals Industry	41 000	47 000	37 000	23 000	23 000	25 000	24 000	24 000	24 000
Electronics	160	160	72	0.00	-	-	-	-	-
Food Preparation	2 400	2 800	3 300	1 700	1 900	1 900	1 700	1 700	1 700
Glass Manufacturing	7 100	7 400	6 200	780	780	770	750	750	700
Grain Industry	1 400	1 300	990	760	1 100	820	930	430	960
Metal Fabrication	5 100	7 700	400	220	170	220	190	200	180
Plastics Manufacturing	820	770	98	11	13	18	15	12	13
Pulp and Paper Industry	72 000	49 000	45 000	29 000	29 000	28 000	27 000	25 000	25 000
Textiles	120	170	110	7.8	7.8	7.7	6.1	0.20	-
Vehicle Manufacturing (Engines, Parts, Assembly, Painting)	2 700	3 800	1 900	650	630	680	620	470	470
Wood Products	18 000	22 000	19 000	12 000	11 000	11 000	11 000	10 000	14 000
Other (Manufacturing)	34 000	31 000	22 000	510	420	540	540	380	550
TRANSPORTATION AND MOBILE EQUIPMENT	**1 300 000**	**1 600 000**	**1 300 000**	**640 000**	**650 000**	**630 000**	**610 000**	**550 000**	**560 000**
Air Transportation (LTO)	5 700	6 800	6 800	7 300	7 600	8 500	8 500	4 600	4 900
Domestic Marine Navigation, Fishing and Military	60 000	71 000	79 000	67 000	83 000	73 000	92 000	100 000	120 000
Heavy-Duty Diesel Vehicles	330 000	410 000	400 000	180 000	160 000	160 000	140 000	120 000	120 000
Heavy-Duty Gasoline Vehicles	37 000	35 000	25 000	11 000	9 600	9 100	7 600	5 700	5 300
Heavy-Duty LPG/NG Vehicles	6 700	340	140	97	100	100	110	100	110
Light-Duty Diesel Trucks	3 600	7 500	5 800	830	680	670	630	550	600
Light-Duty Diesel Vehicles	1 900	2 300	1 700	350	320	300	260	180	190
Light-Duty Gasoline Trucks	110 000	230 000	150 000	38 000	33 000	31 000	28 000	22 000	21 000
Light-Duty Gasoline Vehicles	190 000	250 000	120 000	23 000	20 000	18 000	16 000	11 000	10 000
Light-Duty LPG/NG Trucks	290	50	25	11	8.1	10	9.3	5.1	6.2
Light-Duty LPG/NG Vehicles	0.95	0.69	0.20	0.26	0.24	0.13	0.19	0.090	0.11
Motorcycles	660	970	980	1 600	1 600	1 700	1 700	1 400	1 400
Off-Road Diesel Vehicles and Equipment	300 000	330 000	290 000	190 000	200 000	200 000	190 000	160 000	160 000
Off-Road Gasoline/LPG/NG Vehicles and Equipment	62 000	62 000	46 000	37 000	36 000	36 000	36 000	34 000	35 000
Rail Transportation	160 000	150 000	130 000	86 000	91 000	90 000	90 000	80 000	79 000
Tire Wear and Brake Lining	-	-	-	-	-	-	-	-	-
AGRICULTURE	**2 100**	**2 200**	**2 100**	**2 900**	**2 800**	**2 800**	**2 900**	**2 600**	**2 600**
Animal Production	-	-	-	-	-	-	-	-	-
Crop Production	-	-	-	-	-	-	-	-	-
Agricultural Fuel Combustion	2 100	2 200	2 100	2 900	2 800	2 800	2 900	2 600	2 600
COMMERCIAL/RESIDENTIAL/INSTITUTIONAL	**74 000**	**78 000**	**76 000**	**71 000**	**74 000**	**75 000**	**75 000**	**71 000**	**69 000**
Commercial and Institutional Fuel Combustion	23 000	30 000	30 000	27 000	29 000	29 000	31 000	30 000	29 000
Commercial Cooking	-	-	-	-	-	-	-	-	-
Construction Fuel Combustion	3 900	2 000	2 700	2 600	2 700	2 800	3 000	3 000	3 000
Home Firewood Burning	13 000	11 000	9 300	12 000	12 000	11 000	10 000	9 100	8 700
Human	-	-	-	-	-	-	-	-	-
Marine Cargo Handling	0.20	0.059	-	24	28	26	38	18	22
Residential Fuel Combustion	35 000	35 000	35 000	30 000	31 000	32 000	31 000	29 000	28 000
Service Stations	-	-	-	-	-	-	-	-	-
Other (Miscellaneous)	-	-	-	-	-	-	-	-	-
INCINERATION AND WASTE	**7 100**	**7 000**	**8 400**	**4 500**	**5 700**	**4 900**	**5 100**	**5 900**	**5 300**
Crematoriums	55	78	99	150	160	170	170	190	190
Waste Incineration	2 700	2 800	3 600	2 600	2 800	2 600	2 600	2 500	2 500
Waste Treatment and Disposal	4 300	4 100	4 700	1 800	2 700	2 200	2 300	3 200	2 600
PAINTS AND SOLVENTS	**110**	**120**	**130**	**23**	**17**	**15**	**51**	**59**	**54**
Dry Cleaning	1.1	1.6	-	-	-	-	29	33	29
General Solvent Use	-	-	-	-	-	-	-	-	-
Printing	110	120	130	23	17	15	20	19	19
Surface Coatings	0.12	0.12	-	-	-	-	1.9	6.4	6.4
DUST	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
Coal Transportation	-	-	-	-	-	-	-	-	-
Construction Operations	-	-	-	-	-	-	-	-	-
Mine Tailings	-	-	-	-	-	-	-	-	-
Paved Roads	-	-	-	-	-	-	-	-	-
Unpaved Roads	-	-	-	-	-	-	-	-	-
FIRES	**7 500**	**1 400**	**890**	**1 700**	**990**	**600**	**670**	**530**	**520**
Prescribed Burning	7 400	1 400	850	1 600	970	570	650	500	490
Structural Fires	49	39	36	27	27	28	27	28	30
GRAND TOTAL	**2 300 000**	**2 700 000**	**2 300 000**	**1 500 000**	**1 500 000**	**1 500 000**	**1 400 000**	**1 300 000**	**1 300 000**

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

Other Emissions Estimated in the APEI

Source	1990	2000	2005	2016	2017	2018	2019	2020	2021
Domestic Air Transportation (Cruise)	28 000	26 000	27 000	31 000	33 000	35 000	36 000	19 000	22 000
International Air Transportation (Cruise)	23 000	39 000	44 000	61 000	68 000	78 000	80 000	36 000	37 000
International Marine Navigation	80 000	120 000	130 000	120 000	120 000	120 000	100 000	87 000	94 000

Note: Refer to Annex 4.4 for more information on international marine navigation and air transportation reporting emissions.

2.4. Volatile Organic Compounds

In 2021, approximately 1.4 Mt of volatile organic compounds (VOCs) were released in Canada (Table 2–6). Oil and Gas Industry was the largest contributor at 37% (516 kt) of total emissions with the Upstream Oil and Gas Industry sector emitting 35% (493 kt) of the national total. Paints and Solvents were the next-largest contributor, accounting for 18% (257 kt) of emissions, with General Solvent Use accounting for 13% (180 kt) of the national total. Transportation and Mobile Equipment sources accounted for 15% (210 kt) of emissions, with the Off-Road Gasoline / Liquefied Petroleum Gas (LPG) / Natural Gas (NG) Vehicles and Equipment sector contributing 9.4% (131 kt) of the national total.

Commercial/Residential/Institutional sources represented 11% (160 kt) of VOC emissions, attributed mainly to Home Firewood Burning (7.7% or 108 kt). The other significant contributing VOC sources were Agriculture and Manufacturing, with 8.3% (116 kt) and 8.0% (112 kt) of total VOC emissions, respectively.

Between 1990 and 2021, VOC emissions decreased by 39% (894 kt) (Figure 2–4). The most significant drivers of this trend are decreases in emissions from the Light-Duty Gasoline Vehicles and Trucks and Off-Road Gasoline/ LPG/NG Vehicles and Equipment sector. These decreases are due to increasingly stringent regulations on these spark-ignition engines that have effectively lowered hydrocarbon emissions.[7] Transportation and Mobile Equipment also showed a decrease of VOCs (-36 kt or -14%) between the years 2019 and 2021. This decrease is mostly due to a decrease in the VKT in the Light-Duty Gasoline Vehicles and Trucks categories.

Another driver to the downward VOC emissions trend between 1990 and 2021 is the Manufacturing category. The largest contributors to this decrease were from Wood Products and Chemicals Industry, although almost all sectors observed a declining VOC emissions trend from 1990 to 2021. The decrease in emissions from Wood Products can be attributed in part to facilities closing and decreased production of lumber and panel boards. The decrease in emissions from the Chemicals Industry can be attributed in part to facilities closing, the decreased production of solvent-based paints and varnishes and in part to the installation of solvent recovery units and the implementation of Leak Detection and Repair (LDAR) programs.

The Oil and Gas Industry also experienced a decrease in emissions between 1990 and 2021. VOC emissions from the Downstream Oil and Gas Industry decreased by 82% (105 kt) over the time series as emission controls improved and five petroleum refineries closed or were converted to terminal facilities. Conversely, the Upstream Oil and Gas Industry experienced increased emissions due to growth in the sector, which were most pronounced from 2013 to 2015. The Upstream Oil and Gas Industry experienced a significant decrease of 15% (89 kt) between 2019 and 2021, primarily due to the 14% (84 kt) difference between 2019 and 2020. This VOC decrease results from reductions in venting, storage losses, and equipment leaks at oil and natural gas production and processing facilities. The majority of this decrease is due to a combination of factors that coincided in 2020, including the COVID-19 pandemic. The economic impact of the pandemic resulted in a drastic drop in the price of oil and contraction of the industry as marginal wells were shut in. As a result, there was a 5% reduction in total crude oil production and a 2% reduction in natural gas production in 2020. Additionally, federal and provincial regulations to reduce fugitive CH_4 and VOC emissions from oil and gas operations came into effect in 2020 (ECCC, 2018b; AB, 2018; BC, 2021; SK, 2020), and definitions for vent gas volumes were changed in updated reporting requirements in Alberta, Saskatchewan, and British Columbia.[8]

Emissions of VOCs were 39% (889 kt) below 2005 levels. The main drivers of this downward trend are similar to those between 1990 and 2021. Of note is a significant decrease in Paints and Solvents, with decreases in General Solvent Use and Printing between 2005 and 2021. The decrease in General Solvent Use can be associated with decline in emissions from solvents in manufacturing as well as from private households. The decrease in Printing VOCs emissions is due to lower emissions in the printing manufacturing and assembly subsector.

7 See Chapter 1 for list of regulations.

8 Effective January 1, 2020, updated requirements for the reporting of vent gas volumes in Alberta and Saskatchewan came into effect. Similar changes in British Columbia became effective July 1, 2020. New sources (e.g., venting from pneumatics, compressor seals, etc.), not previously required to be included in reported vent gas volumes, are now reported in the total vented volume. In order to avoid double counting, emissions from these sources are no longer estimated separately for each province, with the exception of pneumatics in Alberta. For Alberta, the availability of Alberta OneStop data delineated by source has allowed ECCC to partly address the changes in the updated requirements. In each case, the updated requirements result in a methodological inconsistency between 2019 and 2020. The methodological inconsistency introduced as a result of the changes to provincial reporting guidelines is a priority and is being actively investigated.

The most significant changes in VOC emissions from 1990 to 2021 include:

- Transportation and Mobile Equipment: decrease of 67% (427 kt), with:
  - Light-Duty Gasoline Vehicles and Trucks: decrease of 86% (253 kt)
  - Off-Road Gasoline/LPG/NG Vehicles and Equipment: decrease of 48% (120 kt)
- Manufacturing: decrease of 56% (145 kt), with:
  - Wood products: decrease of 66% (70 kt)
  - Chemicals Industry: decrease of 68% (32 kt)
- Oil and Gas Industry: decrease of 14% (84 kt), with:
  - Upstream Oil and Gas Industry: increase of 5% (21 kt)
  - Downstream Oil and Gas Industry: decrease of 82% (105 kt)

The most significant changes in VOC emissions from 2005 to 2021 include:

- Transportation and Mobile Equipment: decrease of 68% (446 kt), with:
  - Off-Road Gasoline/LPG/NG Vehicles and Equipment: decrease of 68% (277 kt)
  - Light-Duty Gasoline Vehicles and Trucks: decrease of 74% (117 kt)
- Paints and Solvents: decrease of 42% (184 kt), with:
  - General Solvent Use: decrease of 36% (100 kt)
  - Printing: decrease of 74% (42 kt)
- Oil and Gas Industry: decrease of 20% (128 kt), with:
  - Upstream Oil and Gas Industry: decrease of 15% (84 kt)
  - Downstream Oil and Gas Industry: decrease of 66% (43 kt)

Figure 2–4 **Trends in Canadian Volatile Organic Compound Emissions (1990 to 2021)**

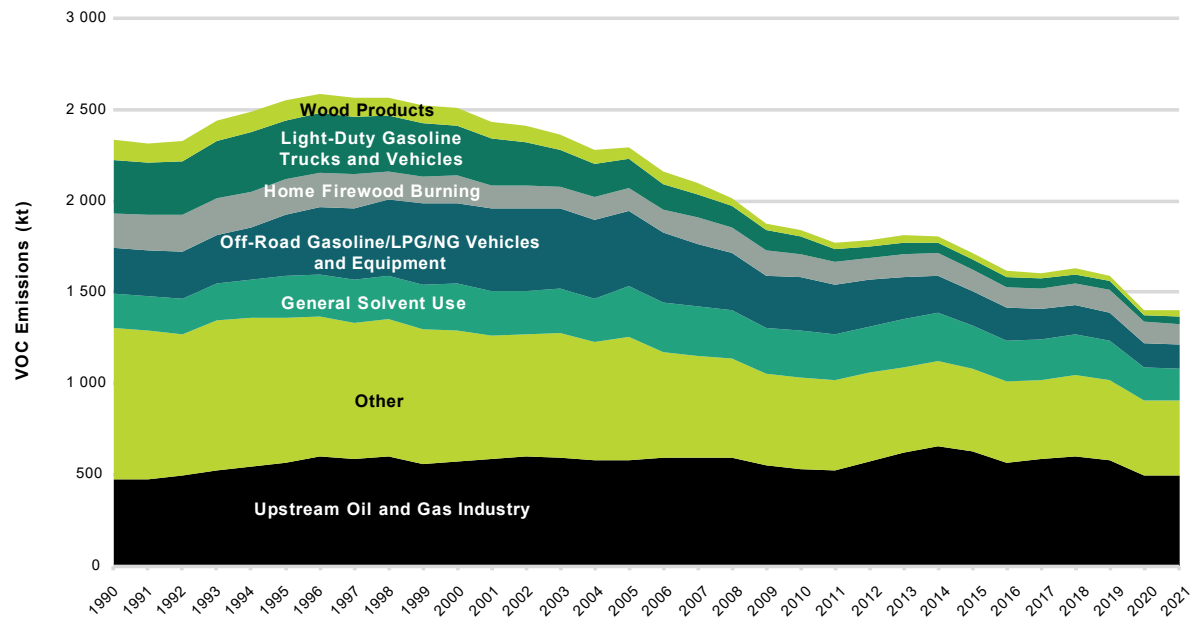


Table 2–6 National Summary of Annual Volatile Organic Compound Emissions

Source	1990	2000	2005	2016	2017	2018	2019	2020	2021
					(tonnes)				
ORE AND MINERAL INDUSTRIES	**21 000**	**21 000**	**17 000**	**11 000**	**12 000**	**13 000**	**13 000**	**12 000**	**12 000**
Aluminium Industry	710	1 100	1 200	950	950	1 700	1 900	2 000	2 000
Asphalt Paving Industry	6 600	6 400	6 100	6 300	6 400	6 400	6 200	5 800	5 700
Cement and Concrete Industry	580	630	1 200	440	690	760	760	590	550
Foundries	1 900	1 600	1 400	630	980	1 100	1 100	1 400	1 200
Iron and Steel Industry	6 700	5 300	2 400	820	920	1 000	840	640	690
Iron Ore Pelletizing	21	3 200	1 600	400	240	240	310	290	220
Mineral Products Industry	610	320	200	140	72	110	67	85	98
Mining and Rock Quarrying	3 500	2 600	2 400	1 400	1 400	1 400	1 400	1 500	1 500
Non-Ferrous Refining and Smelting Industry	330	38	740	65	69	79	110	82	18
OIL AND GAS INDUSTRY	**600 000**	**660 000**	**640 000**	**590 000**	**610 000**	**630 000**	**610 000**	**520 000**	**520 000**
Downstream Oil and Gas Industry	130 000	85 000	66 000	24 000	26 000	26 000	24 000	22 000	22 000
Upstream Oil and Gas Industry	470 000	570 000	580 000	570 000	580 000	600 000	580 000	500 000	490 000
ELECTRIC POWER GENERATION (UTILITIES)	**2 500**	**3 600**	**3 300**	**1 600**	**1 300**	**1 200**	**1 200**	**1 400**	**1 600**
Coal	1 300	950	1 300	410	380	280	290	240	280
Landfill Gas	0.70	3.0	-	9.1	-	-	-	-	-
Natural Gas	480	1 600	1 500	890	630	620	590	820	1 000
Diesel	77	280	220	55	53	68	84	77	71
Other (Electric Power Generation)	630	770	350	200	290	280	220	220	200
MANUFACTURING	**260 000**	**250 000**	**190 000**	**100 000**	**100 000**	**110 000**	**100 000**	**97 000**	**110 000**
Abrasives Manufacturing	1 500	590	610	20	17	18	16	14	17
Bakeries	4 000	4 700	5 100	4 900	4 800	5 000	5 300	5 300	5 100
Biofuel Production	-	-	-	42	46	43	15	16	17
Chemicals Industry	47 000	36 000	26 000	9 900	9 200	16 000	14 000	12 000	15 000
Electronics	1 300	600	410	39	33	24	32	43	35
Food Preparation	10 000	13 000	15 000	15 000	15 000	17 000	17 000	18 000	18 000
Glass Manufacturing	2 000	2 300	630	190	200	160	160	150	130
Grain Industry	2 200	2 300	2 200	2 500	2 200	2 400	3 200	3 500	3 000
Metal Fabrication	5 100	9 500	8 300	2 600	2 500	2 800	2 700	2 300	2 500
Plastics Manufacturing	13 000	15 000	15 000	10 000	10 000	10 000	10 000	9 300	10 000
Pulp and Paper Industry	27 000	24 000	23 000	13 000	13 000	13 000	12 000	12 000	12 000
Textiles	870	1 500	850	490	880	510	410	290	370
Vehicle Manufacturing (Engines, Parts, Assembly, Painting)	24 000	24 000	18 000	10 000	9 100	8 500	8 300	6 600	6 400
Wood Products	110 000	98 000	64 000	32 000	30 000	29 000	27 000	25 000	37 000
Other (Manufacturing)	12 000	23 000	8 300	2 700	2 900	2 600	2 800	2 500	2 800
TRANSPORTATION AND MOBILE EQUIPMENT	**640 000**	**810 000**	**660 000**	**280 000**	**270 000**	**260 000**	**250 000**	**210 000**	**210 000**
Air Transportation (LTO)	5 500	3 100	2 500	2 700	2 800	3 000	3 000	1 900	2 100
Domestic Marine Navigation, Fishing and Military	2 700	3 200	3 500	2 600	2 700	2 800	3 500	3 100	3 500
Heavy-Duty Diesel Vehicles	10 000	19 000	26 000	12 000	10 000	9 800	8 800	7 700	7 800
Heavy-Duty Gasoline Vehicles	17 000	17 000	12 000	4 600	4 300	4 100	3 800	3 200	3 100
Heavy-Duty LPG/NG Vehicles	2 700	130	49	36	42	47	54	57	67
Light-Duty Diesel Trucks	2 700	4 100	3 000	500	460	480	450	390	360
Light-Duty Diesel Vehicles	1 700	1 300	960	330	320	300	260	180	150
Light-Duty Gasoline Trucks	96 000	120 000	74 000	28 000	26 000	27 000	26 000	23 000	24 000
Light-Duty Gasoline Vehicles	200 000	150 000	85 000	26 000	25 000	24 000	23 000	18 000	18 000
Light-Duty LPG/NG Trucks	230	21	9.3	5.3	3.9	5.1	3.4	1.9	2.2
Light-Duty LPG/NG Vehicles	0.84	0.31	0.091	0.18	0.16	0.083	0.13	0.00	0.00
Motorcycles	2 700	3 200	3 000	3 600	3 600	3 700	3 800	3 400	3 400
Off-Road Diesel Vehicles and Equipment	40 000	40 000	32 000	18 000	19 000	18 000	17 000	14 000	13 000
Off-Road Gasoline/LPG/NG Vehicles and Equipment	250 000	440 000	410 000	180 000	170 000	160 000	150 000	130 000	130 000
Rail Transportation	6 700	6 200	6 100	3 700	4 100	4 300	3 800	3 400	3 300
Tire Wear and Brake Lining	-	-	-	-	-	-	-	-	-
AGRICULTURE	**100 000**	**120 000**	**130 000**	**110 000**	**110 000**	**120 000**	**120 000**	**120 000**	**120 000**
Animal Production	100 000	120 000	130 000	110 000	110 000	120 000	120 000	120 000	120 000
Crop Production	-	-	-	-	-	-	-	-	-
Agricultural Fuel Combustion	81	91	82	170	160	160	160	150	150
COMMERCIAL/RESIDENTIAL/INSTITUTIONAL	**260 000**	**230 000**	**200 000**	**170 000**	**170 000**	**180 000**	**180 000**	**160 000**	**160 000**
Commercial and Institutional Fuel Combustion	1 000	1 400	1 400	1 400	1 500	1 500	1 600	1 500	1 500
Commercial Cooking	2 000	2 300	2 500	2 300	2 300	2 300	2 300	2 300	2 300
Construction Fuel Combustion	71	34	41	44	46	47	53	51	51
Home Firewood Burning	190 000	150 000	130 000	110 000	110 000	120 000	120 000	110 000	110 000
Human	-	-	-	-	-	-	-	-	-
Marine Cargo Handling	0.34	0.92	1.9	-	-	-	-	-	15
Residential Fuel Combustion	1 500	1 700	1 700	1 600	1 600	1 700	1 600	1 500	1 500
Service Stations	70 000	71 000	65 000	52 000	51 000	51 000	50 000	44 000	46 000
Other (Miscellaneous)	-	-	-	-	-	-	-	-	-
INCINERATION AND WASTE	**12 000**	**15 000**	**15 000**	**14 000**	**14 000**	**15 000**	**15 000**	**15 000**	**15 000**
Crematoriums	0.87	1.2	1.6	2.4	2.5	2.7	2.7	3.0	3.0
Waste Incineration	4 300	4 500	4 600	4 300	4 300	4 200	4 200	4 200	4 300
Waste Treatment and Disposal	7 900	10 000	10 000	10 000	9 800	10 000	11 000	10 000	10 000
PAINTS AND SOLVENTS	**360 000**	**400 000**	**440 000**	**320 000**	**310 000**	**310 000**	**300 000**	**260 000**	**260 000**
Dry Cleaning	740	790	220	200	200	190	190	180	180
General Solvent Use	190 000	260 000	280 000	230 000	220 000	220 000	210 000	180 000	180 000
Printing	37 000	48 000	57 000	24 000	24 000	23 000	22 000	17 000	15 000
Surface Coatings	130 000	89 000	100 000	65 000	66 000	66 000	65 000	58 000	62 000
DUST	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
Coal Transportation	-	-	-	-	-	-	-	-	-
Construction Operations	-	-	-	-	-	-	-	-	-
Mine Tailings	-	-	-	-	-	-	-	-	-
Paved Roads	-	-	-	-	-	-	-	-	-
Unpaved Roads	-	-	-	-	-	-	-	-	-
FIRES	**41 000**	**4 200**	**3 400**	**4 900**	**2 900**	**1 800**	**3 200**	**2 100**	**1 600**
Prescribed Burning	40 000	3 900	3 100	4 700	2 700	1 600	3 000	1 800	1 400
Structural Fires	390	310	280	210	210	220	210	220	240
GRAND TOTAL	**2 300 000**	**2 500 000**	**2 300 000**	**1 600 000**	**1 600 000**	**1 600 000**	**1 600 000**	**1 400 000**	**1 400 000**

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

Other Emissions Estimated in the APEI

Source	1990	2000	2005	2016	2017	2018	2019	2020	2021
Domestic Air Transportation (Cruise)	3 900	2 900	2 300	1 800	1 900	1 800	1 900	1 100	1 300
International Air Transportation (Cruise)	1 500	1 400	1 100	950	1 000	1 100	1 100	430	400
International Marine Navigation	3 000	4 400	5 100	4 700	4 700	4 900	4 100	3 500	3 800

Note: Refer to Annex 4.4 for more information on international marine navigation and air transportation reporting emissions.

2.5. Carbon Monoxide

In 2021, approximately 4.6 Mt of carbon monoxide (CO) were released in Canada (Table 2–7). Transportation and Mobile Equipment accounted for 61% (2.8 Mt) of total emissions, with the Off-Road Gasoline/LPG/NG Vehicles and Equipment sector contributing 37% (1.7 Mt) and the Light-Duty Gasoline Trucks and Vehicles sectors contributing 17% (800 kt) of total CO emissions. The next-largest contributors are Commercial/Residential/Institutional sources, which in 2021 accounted for 12% (551 kt) of emissions, almost all owing to contributions from Home Firewood Burning at 11% (511 kt) of total CO emissions. The Upstream Oil and Gas Industry and Aluminium Industry sectors were the largest-emitting industrial contributors, accounting for 11% (500 kt) and 8.3% (380 kt) of CO emissions, respectively.

Between 1990 and 2021, CO emissions decreased by 65% (8.5 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.[9] Transportation and Mobile Equipment CO emissions experienced a decrease of 12% (382 kt) between 2019 and 2020, but emissions increased by 2.6% (71 kt) between 2020 and 2021. This change is mostly due to a significant decrease between 2019 and 2020 followed by an increase between 2020 and 2021 in the VKT in the Light-Duty Gasoline Vehicles and Trucks categories. Transportation and Mobile Equipment CO emissions in 2021 are still notably below 2019 emission levels.

Emissions from Wood Products manufacturing declined from 1993 to 2015 due to the removal of incinerators at sawmill and panel board mill facilities that incinerated hog fuel, and have remained relatively stable since 2015. Furthermore, emissions from Prescribed Burning, within the Fires category, have decreased considerably over the time series, which can be explained by the reduced use of this practice compared to 1990.

Finally, the Upstream Oil and Gas Industry sector experienced an increase in CO emissions across the time series, but experienced a decrease between 2019 and 2020 and remained stable between 2020 and 2021. The increase between 1990 and 2021 is attributed to expansion and growth in the oil and gas industry. The 23 kt (4.5%) decrease between the years 2019 and 2021 can be attributed to a 10% reduction in reported fuel gas consumption over this two-year period.

The most significant changes in CO emissions from 1990 to 2021 include:

- Transportation and Mobile Equipment: decrease of 71% (6.9 Mt), with:
  - Light-Duty Gasoline Trucks and Vehicles: decrease of 86% (4.7 Mt)
  - Off-Road Gasoline/LPG/NG Vehicles and Equipment: decrease of 50% (1.7 Mt)
- Manufacturing: decrease of 90% (1.2 Mt)
  - Wood Products: decrease of 95% (1.0 Mt)
- Fires: decrease of 94% (416 kt), with:
  - Prescribed Burning: decrease of 94% (416 kt)
- Oil and Gas Industry: increase of 61% (202 kt), with:
  - Upstream Oil and Gas Industry: increase of 64% (195 kt)

9 See Chapter 1 for list of regulations.

Figure 2–5 **Trends in Canadian CO Emissions (1990 to 2021)**

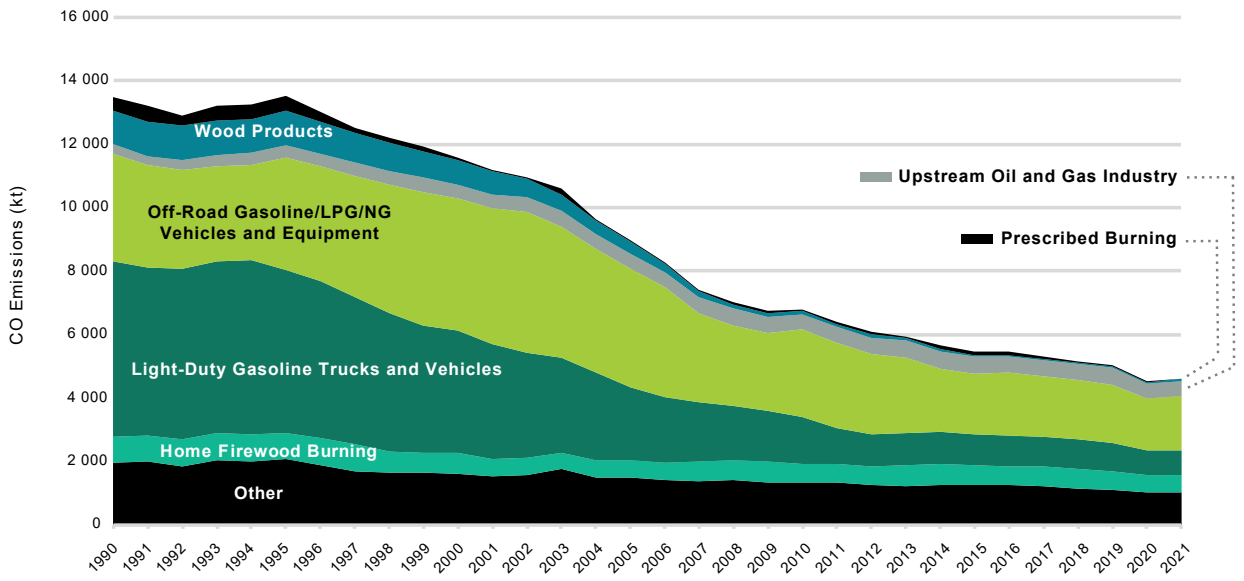


Table 2–7 National Summary of Annual CO Emissions

Source	1990	2000	2005	2016	2017	2018	2019	2020	2021
					(tonnes)				
ORE AND MINERAL INDUSTRIES	**390 000**	**400 000**	**510 000**	**560 000**	**590 000**	**530 000**	**510 000**	**510 000**	**510 000**
Aluminium Industry	240 000	250 000	310 000	420 000	430 000	380 000	360 000	390 000	380 000
Asphalt Paving Industry	4 200	4 200	4 500	3 100	3 400	3 500	3 600	3 200	3 300
Cement and Concrete Industry	15 000	22 000	27 000	13 000	16 000	16 000	24 000	17 000	17 000
Foundries	50 000	47 000	49 000	47 000	49 000	48 000	43 000	42 000	44 000
Iron and Steel Industry	44 000	48 000	64 000	21 000	27 000	28 000	24 000	21 000	22 000
Iron Ore Pelletizing	810	9 600	23 000	16 000	16 000	14 000	16 000	15 000	15 000
Mineral Products Industry	4 800	4 300	3 700	660	610	550	430	460	600
Mining and Rock Quarrying	31 000	14 000	11 000	17 000	28 000	21 000	21 000	22 000	24 000
Non-Ferrous Refining and Smelting Industry	280	370	13 000	17 000	15 000	15 000	16 000	5 800	6 300
OIL AND GAS INDUSTRY	**330 000**	**440 000**	**490 000**	**530 000**	**550 000**	**560 000**	**540 000**	**510 000**	**540 000**
Downstream Oil and Gas Industry	29 000	23 000	21 000	16 000	21 000	30 000	14 000	14 000	36 000
Upstream Oil and Gas Industry	300 000	420 000	470 000	520 000	530 000	530 000	520 000	500 000	500 000
ELECTRIC POWER GENERATION (UTILITIES)	**50 000**	**43 000**	**52 000**	**38 000**	**42 000**	**36 000**	**30 000**	**30 000**	**38 000**
Coal	41 000	18 000	25 000	16 000	19 000	15 000	11 000	8 800	17 000
Landfill Gas	82	400	410	720	750	620	520	610	540
Natural Gas	4 400	17 000	17 000	12 000	14 000	12 000	10 000	13 000	11 000
Diesel	380	1 300	1 300	1 400	1 500	1 800	2 300	2 100	2 000
Other (Electric Power Generation)	4 400	7 200	8 300	7 400	7 300	5 700	5 400	5 700	6 800
MANUFACTURING	**1 300 000**	**1 000 000**	**530 000**	**130 000**	**140 000**	**140 000**	**150 000**	**120 000**	**140 000**
Abrasives Manufacturing	610	240	240	-	-	-	-	-	-
Bakeries	5.9	5.8	1.2	0.30	0.32	-	-	-	-
Biofuel Production	-	-	-	-	-	14	59	28	20
Chemicals Industry	27 000	30 000	18 000	15 000	16 000	14 000	16 000	13 000	15 000
Electronics	32	46	19	0.26	-	-	-	-	-
Food Preparation	1 200	1 400	1 600	1 200	1 300	1 300	1 200	960	1 100
Glass Manufacturing	490	600	1 100	280	300	300	290	280	290
Grain Industry	1 900	2 700	290	380	420	640	720	410	490
Metal Fabrication	5 100	5 100	4 400	420	410	480	520	450	540
Plastics Manufacturing	190	320	200	10	11	13	14	14	12
Pulp and Paper Industry	180 000	150 000	98 000	73 000	78 000	82 000	80 000	68 000	63 000
Textiles	45	78	53	0.071	0.069	0.097	0.22	0.16	-
Vehicle Manufacturing (Engines, Parts, Assembly, Painting)	5 800	5 500	3 900	1 100	1 100	1 100	1 100	700	760
Wood Products	1 100 000	790 000	390 000	43 000	40 000	35 000	46 000	37 000	56 000
Other (Manufacturing)	32 000	61 000	11 000	610	550	540	520	420	430
TRANSPORTATION AND MOBILE EQUIPMENT	**9 700 000**	**8 800 000**	**6 700 000**	**3 300 000**	**3 200 000**	**3 200 000**	**3 100 000**	**2 700 000**	**2 800 000**
Air Transportation (LTO)	30 000	23 000	21 000	28 000	27 000	27 000	30 000	22 000	25 000
Domestic Marine Navigation, Fishing and Military	5 800	6 800	7 600	2 600	3 100	2 900	3 600	3 700	4 200
Heavy-Duty Diesel Vehicles	42 000	80 000	110 000	63 000	60 000	61 000	57 000	51 000	53 000
Heavy-Duty Gasoline Vehicles	290 000	320 000	260 000	120 000	110 000	100 000	97 000	86 000	82 000
Heavy-Duty LPG/NG Vehicles	61 000	2 600	990	1 200	1 600	1 800	2 300	2 400	2 800
Light-Duty Diesel Trucks	51 000	47 000	36 000	7 100	6 600	6 900	6 300	5 500	6 200
Light-Duty Diesel Vehicles	23 000	14 000	10 000	5 700	5 700	5 600	5 000	3 400	3 800
Light-Duty Gasoline Trucks	2 200 000	1 900 000	1 200 000	540 000	520 000	530 000	520 000	460 000	480 000
Light-Duty Gasoline Vehicles	3 300 000	2 000 000	1 100 000	440 000	410 000	410 000	400 000	320 000	320 000
Light-Duty LPG/NG Trucks	5 800	390	190	120	88	120	70	38	40
Light-Duty LPG/NG Vehicles	17	5.4	1.6	3.6	3.2	2.1	2.5	0.97	1.1
Motorcycles	30 000	38 000	33 000	30 000	30 000	31 000	32 000	27 000	26 000
Off-Road Diesel Vehicles and Equipment	180 000	190 000	150 000	91 000	96 000	93 000	86 000	72 000	68 000
Off-Road Gasoline/LPG/NG Vehicles and Equipment	3 400 000	4 200 000	3 700 000	2 000 000	1 900 000	1 900 000	1 800 000	1 600 000	1 700 000
Rail Transportation	16 000	15 000	15 000	15 000	18 000	18 000	18 000	17 000	16 000
Tire Wear and Brake Lining	-	-	-	-	-	-	-	-	-
AGRICULTURE	**630**	**690**	**520**	**1 200**	**1 200**	**1 100**	**1 100**	**1 000**	**1 000**
Animal Production	-	-	-	-	-	-	-	-	-
Crop Production	-	-	-	-	-	-	-	-	-
Agricultural Fuel Combustion	630	690	520	1 200	1 200	1 100	1 100	1 000	1 000
COMMERCIAL/RESIDENTIAL/INSTITUTIONAL	**850 000**	**690 000**	**600 000**	**650 000**	**650 000**	**660 000**	**630 000**	**580 000**	**550 000**
Commercial and Institutional Fuel Combustion	15 000	19 000	19 000	19 000	21 000	22 000	23 000	22 000	22 000
Commercial Cooking	5 700	6 400	7 100	6 300	6 400	6 400	6 400	6 500	6 600
Construction Fuel Combustion	670	360	460	450	460	480	510	500	510
Home Firewood Burning	810 000	650 000	560 000	610 000	610 000	620 000	590 000	530 000	510 000
Human	-	-	-	-	-	-	-	-	-
Marine Cargo Handling	0.16	0.050	-	-	-	-	-	-	-
Residential Fuel Combustion	13 000	13 000	13 000	12 000	12 000	13 000	12 000	11 000	11 000
Service Stations	-	-	-	-	-	-	-	-	-
Other (Miscellaneous)	-	-	-	-	-	-	-	-	-
INCINERATION AND WASTE	**14 000**	**14 000**	**16 000**	**14 000**	**14 000**	**15 000**	**14 000**	**15 000**	**14 000**
Crematoriums	9.4	13	17	26	27	29	29	32	32
Waste Incineration	13 000	14 000	13 000	11 000	11 000	11 000	12 000	12 000	12 000
Waste Treatment and Disposal	1 100	570	2 900	2 400	2 400	3 600	2 500	2 500	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**	**120 000**	**52 000**	**30 000**	**36 000**	**26 000**	**27 000**
Prescribed Burning	440 000	76 000	51 000	120 000	51 000	29 000	35 000	25 000	25 000
Structural Fires	2 100	1 700	1 500	1 100	1 200	1 200	1 200	1 200	1 300
GRAND TOTAL	**13 000 000**	**12 000 000**	**8 900 000**	**5 400 000**	**5 200 000**	**5 100 000**	**5 000 000**	**4 500 000**	**4 600 000**

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

Other Emissions Estimated in the APEI

Source	1990	2000	2005	2016	2017	2018	2019	2020	2021
Domestic Air Transportation (Cruise)	110 000	77 000	72 000	39 000	38 000	32 000	35 000	25 000	30 000
International Air Transportation (Cruise)	12 000	9 900	8 400	8 500	9 000	9 400	9 700	4 000	4 000
International Marine Navigation	6 800	9 900	11 000	3 800	3 800	4 000	3 200	2 700	3 000

Note: Refer to Annex 4.4 for more information on international marine navigation and air transportation reporting emissions.

2.6. Ammonia

In 2021, approximately 493 kt of ammonia (NH_3) were released in Canada (Table 2–8). NH_3 emissions originated primarily from Agriculture, which accounted for 94% (463 kt) of total emissions. All other sources combined accounted for only 6% of emissions.

From 1990 to 2021, an exception to the general downward trends of air pollutant emissions is Canada's NH_3 emissions increase of 25% (98 kt) (Figure 2–6). NH_3 emissions peaked in 2004 and have since fluctuated. This trend is driven by emissions from animal production and the increasing use of inorganic nitrogen fertilizers in crop production. Animal Production, which accounts for the majority of emissions throughout the time series, experienced a steady increase in emissions from 1990 to 2005, followed by a sharp decrease from 2006 to 2011, and has since declined slowly. Emissions from Crop Production, however, have been steadily increasing since 2005, and now account for 39% of NH_3 emissions.

Emissions from Wood Products manufacturing declined significantly from 1995 to 2010 and have since fluctuated, with an observed increase of 55% (0.31 kt) between 2020 and 2021.The decrease is due to the removal of incinerators at sawmill and panel board mill facilities that incinerated hog fuel and the increase observed from 2020 to 2021 can be attributed to a return to pre-pandemic production levels. Emissions from Pulp and Paper declined from 1990 to 2021 due to facility closures and decreased production.

The most significant changes in NH_3 emissions from 1990 to 2021 include:

- Agriculture: increase of 30% (107 kt), with:
  - Crop Production: increase of 133% (108 kt)
  - Animal Production: decrease of 0.46% (1.3 kt)
- Manufacturing: decrease of 43% (8.6 kt):
  - Wood Products: decrease of 81% (3.9 kt)
  - Pulp and Paper: decrease of 70% (3.1 kt)

Figure 2–6 **Trends in Canadian NH_3 Emissions (1990 to 2021)**

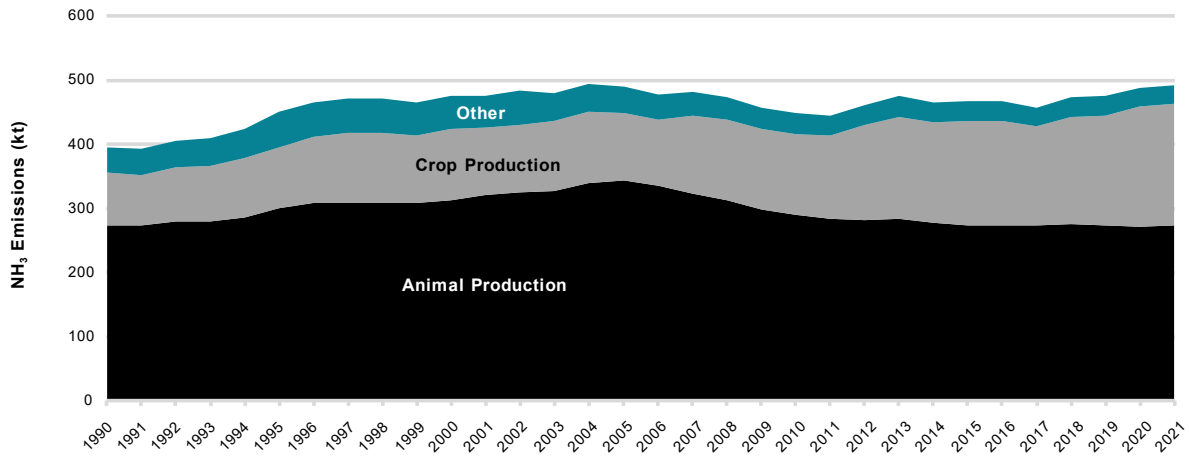


Table 2–8 National Summary of Annual NH_3 Emissions

Source	1990	2000	2005	2016	2017	2018	2019	2020	2021
					(tonnes)				
ORE AND MINERAL INDUSTRIES	**1 800**	**2 200**	**1 200**	**1 200**	**1 300**	**1 500**	**1 500**	**1 400**	**1 500**
Aluminium Industry	29	34	13	-	-	-	-	-	-
Asphalt Paving Industry	3.2	3.8	3.9	-	-	-	-	-	-
Cement and Concrete Industry	600	630	340	360	380	480	490	510	540
Foundries	16	19	10	-	-	-	-	-	-
Iron and Steel Industry	200	250	110	56	55	58	57	56	56
Iron Ore Pelletizing	150	150	18	-	-	-	-	1.1	1.1
Mineral Products Industry	84	100	99	400	290	250	180	210	240
Mining and Rock Quarrying	520	550	86	97	83	120	77	92	110
Non-Ferrous Refining and Smelting Industry	210	460	520	330	470	580	730	510	540
OIL AND GAS INDUSTRY	**560**	**1 600**	**2 200**	**1 600**	**1 800**	**1 800**	**2 200**	**1 700**	**2 200**
Downstream Oil and Gas Industry	360	250	110	55	58	92	46	39	48
Upstream Oil and Gas Industry	200	1 400	2 100	1 500	1 700	1 700	2 100	1 700	2 200
ELECTRIC POWER GENERATION (UTILITIES)	**710**	**1 400**	**990**	**340**	**230**	**220**	**220**	**220**	**260**
Coal	62	110	530	170	170	130	55	34	27
Landfill Gas	0.40	2.7	-	-	-	-	-	-	-
Natural Gas	270	700	180	100	7.0	35	100	130	120
Diesel	3.7	6.0	2.8	-	-	-	-	-	-
Other (Electric Power Generation)	380	620	280	62	45	56	62	56	110
MANUFACTURING	**20 000**	**25 000**	**17 000**	**12 000**	**11 000**	**12 000**	**11 000**	**12 000**	**11 000**
Abrasives Manufacturing	0.76	0.76	0.12	-	-	-	-	-	-
Bakeries	0.11	0.11	-	-	-	-	-	-	-
Biofuel Production	-	-	-	-	-	-	-	-	-
Chemicals Industry	9 800	15 000	11 000	9 300	8 500	9 300	8 700	9 800	8 900
Electronics	32	78	57	18	16	16	15	13	14
Food Preparation	180	330	300	210	230	220	230	230	200
Glass Manufacturing	89	110	120	-	-	-	-	-	-
Grain Industry	6.2	6.7	0.84	5.7	5.5	4.9	6.1	2.0	5.0
Metal Fabrication	15	49	4.8	25	27	27	27	26	24
Plastics Manufacturing	29	31	3.7	-	-	-	-	-	-
Pulp and Paper Industry	4 400	3 600	2 600	1 700	1 700	1 600	1 500	1 300	1 300
Textiles	13	28	16	-	-	-	-	-	-
Vehicle Manufacturing (Engines, Parts, Assembly, Painting)	72	200	44	2.2	6.5	6.5	6.5	6.5	6.8
Wood Products	4 800	4 800	2 600	780	710	700	630	570	890
Other (Manufacturing)	510	370	140	46	34	57	63	50	58
TRANSPORTATION AND MOBILE EQUIPMENT	**5 900**	**12 000**	**11 000**	**7 300**	**7 200**	**7 300**	**7 400**	**6 200**	**6 500**
Air Transportation (LTO)	4.4	4.5	4.3	4.4	4.5	4.9	5.0	2.9	3.1
Domestic Marine Navigation, Fishing and Military	-	-	-	-	-	-	-	-	-
Heavy-Duty Diesel Vehicles	310	580	770	850	870	910	900	780	850
Heavy-Duty Gasoline Vehicles	300	370	410	310	300	300	290	270	270
Heavy-Duty LPG/NG Vehicles	35	1.9	1.0	3.1	4.5	5.3	6.8	7.1	7.7
Light-Duty Diesel Trucks	15	17	11	11	13	15	16	13	15
Light-Duty Diesel Vehicles	8.9	9.1	13	14	13	13	11	6.8	7.1
Light-Duty Gasoline Trucks	1 400	4 100	3 900	2 900	3 000	3 100	3 200	2 700	3 000
Light-Duty Gasoline Vehicles	3 400	6 600	5 500	2 600	2 400	2 400	2 300	1 800	1 800
Light-Duty LPG/NG Trucks	3.1	0.91	0.62	0.14	0.11	0.14	0.12	0.061	0.15
Light-Duty LPG/NG Vehicles	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Motorcycles	11	19	27	130	130	130	140	110	110
Off-Road Diesel Vehicles and Equipment	150	210	210	240	280	300	300	270	270
Off-Road Gasoline/LPG/NG Vehicles and Equipment	110	160	160	160	160	160	160	150	160
Rail Transportation	51	48	48	48	55	56	56	52	52
Tire Wear and Brake Lining	-	-	-	-	-	-	-	-	-
AGRICULTURE	**360 000**	**420 000**	**450 000**	**440 000**	**430 000**	**440 000**	**440 000**	**460 000**	**460 000**
Animal Production	270 000	310 000	340 000	270 000	270 000	280 000	270 000	270 000	270 000
Crop Production	82 000	110 000	100 000	160 000	150 000	170 000	170 000	190 000	190 000
Agricultural Fuel Combustion	44	41	28	23	22	23	22	20	18
COMMERCIAL/RESIDENTIAL/INSTITUTIONAL	**2 700**	**2 400**	**2 300**	**2 200**	**2 200**	**2 200**	**2 100**	**2 000**	**1 900**
Commercial and Institutional Fuel Combustion	310	340	310	200	200	200	210	200	190
Commercial Cooking	-	-	-	-	-	-	-	-	-
Construction Fuel Combustion	70	38	50	44	45	46	50	49	50
Home Firewood Burning	1 100	960	840	1 000	1 100	1 000	900	820	780
Human	470	520	540	610	610	620	630	640	640
Marine Cargo Handling	0.00	-	-	-	-	-	-	-	-
Residential Fuel Combustion	690	560	530	340	320	330	320	290	270
Service Stations	-	-	-	-	-	-	-	-	-
Other (Miscellaneous)	-	-	-	-	-	-	-	-	-
INCINERATION AND WASTE	**6 100**	**6 200**	**6 100**	**6 300**	**5 700**	**5 800**	**5 900**	**5 900**	**5 700**
Crematoriums	-	-	-	-	-	-	-	-	-
Waste Incineration	65	70	80	98	110	100	100	110	110
Waste Treatment and Disposal	6 000	6 100	6 100	6 200	5 600	5 700	5 800	5 800	5 600
PAINTS AND SOLVENTS	**14**	**14**	**0.88**	**-**	**-**	**-**	**-**	**-**	**-**
Dry Cleaning	0.00	0.00	-	-	-	-	-	-	-
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**	**150**	**93**	**60**	**95**	**65**	**54**
Prescribed Burning	1 100	110	88	140	81	48	83	52	41
Structural Fires	22	17	16	12	12	12	12	12	14
GRAND TOTAL	**390 000**	**480 000**	**490 000**	**470 000**	**460 000**	**470 000**	**480 000**	**490 000**	**490 000**

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

Other Emissions Estimated in the APEI

Source	1990	2000	2005	2016	2017	2018	2019	2020	2021
Domestic Air Transportation (Cruise)	15	14	14	13	14	14	14	8.0	9.6
International Air Transportation (Cruise)	10	17	18	22	24	27	28	12	12
International Marine Navigation	-	-	-	-	-	-	-	-	-

Note: Refer to Annex 4.4 for more information on international marine navigation and air transportation reporting emissions.

2.7. Lead

In 2021, approximately 95 tonnes (t) of lead (Pb) were emitted in Canada (Table 2–9). Ore and Mineral Industries were the largest contributor at 78% (74 t) of emissions, with the Non-Ferrous Refining and Smelting Industry sector accounting for the largest share at 65% (62 t) of total Pb emissions. Transportation and Mobile Equipment was the second-largest contributor at 15% (14 t) of total emissions, almost all of which came from the Air Transportation (Landing and Takeoff [LTO]) sector.

Overall, Pb emissions decreased by 91% (928 t) from 1990 to 2021 (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 BLIERs for particulate matters through environmental performance agreements (ECCC, 2017, 2018a). 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. Between 2019 and 2020, Ore and Mineral Industries Pb emissions decreased by 5.3% (4.6 t) and continued to decrease between 2020 and 2021 by an additional 21% (20 t). The change between 2020 and 2021 is particularly notable in the Non-Ferrous Refining and Smelting Industry with a decrease of 25% (20 t). These reductions are in part due to the permanent closure of a non-ferrous metal smelter in December 2019, but mainly due to normal operational variations at another facility.

The Iron and Steel Industry reduced its emissions of Pb by 90% (50 t), which is associated with effective emission controls on coke ovens and coke by-product plants (EC, 2001). 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 2021 include:

- Ore and Mineral Industries: decrease of 92% (875 t), with:
  - Non-Ferrous Refining and Smelting Industry: decrease of 93% (824 t)
  - Iron and Steel Industry: decrease of 90% (50 t)
- Manufacturing: decrease of 94% (40 t), with:
  - Metal Fabrication: decrease of 98% (16 t)
  - Chemicals Industry: decrease of almost 100% (12 t)

Figure 2–7 **Trends in Canadian Pb Emissions (1990 to 2021)**

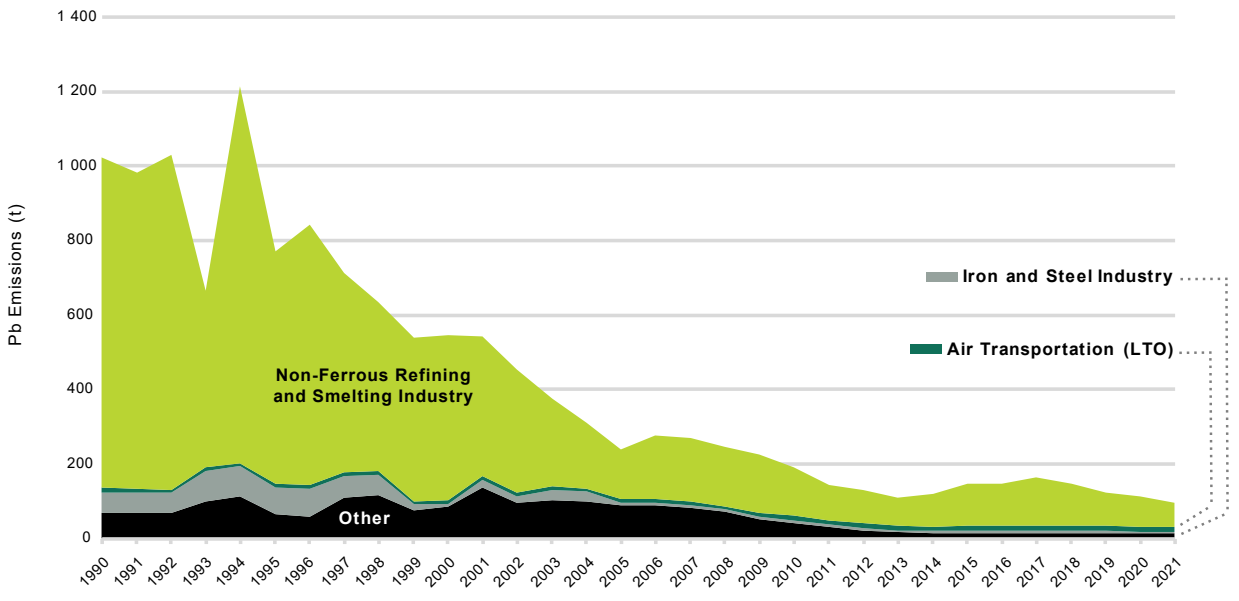


Table 2–9 National Summary of Annual Pb Emissions

Source	1990	2000	2005	2016	2017	2018	2019	2020	2021
					(kg)				
ORE AND MINERAL INDUSTRIES	**950 000**	**500 000**	**220 000**	**130 000**	**140 000**	**130 000**	**100 000**	**94 000**	**74 000**
Aluminium Industry	120	100	-	-	-	-	-	-	-
Asphalt Paving Industry	1 400	1 200	1 200	1 000	1 000	1 000	1 000	1 000	1 100
Cement and Concrete Industry	550	610	950	700	580	400	500	190	200
Foundries	4 800	7 600	8 900	1 300	1 100	1 200	1 800	1 800	1 100
Iron and Steel Industry	55 000	8 300	5 700	5 200	5 100	6 200	4 900	4 800	5 400
Iron Ore Pelletizing	-	-	-	3 300	3 800	2 900	3 100	2 400	2 300
Mineral Products Industry	1 500	440	0.19	15	-	-	-	2.7	5.4
Mining and Rock Quarrying	-	42 000	65 000	1 100	1 200	1 600	2 300	1 400	2 100
Non-Ferrous Refining and Smelting Industry	890 000	440 000	130 000	110 000	130 000	110 000	87 000	82 000	62 000
OIL AND GAS INDUSTRY	**340**	**300**	**720**	**580**	**520**	**570**	**420**	**550**	**520**
Downstream Oil and Gas Industry	200	81	450	380	350	400	240	340	430
Upstream Oil and Gas Industry	140	220	260	200	160	170	180	210	92
ELECTRIC POWER GENERATION (UTILITIES)	**11 000**	**15 000**	**1 900**	**1 400**	**1 700**	**1 300**	**1 500**	**1 200**	**1 200**
Coal	8 300	11 000	1 300	770	1 100	810	1 000	770	860
Landfill Gas	-	-	-	-	-	-	-	-	-
Natural Gas	430	530	72	86	91	83	91	83	62
Diesel	-	-	-	-	-	-	-	-	-
Other (Electric Power Generation)	2 600	3 200	590	560	540	380	390	360	320
MANUFACTURING	**43 000**	**14 000**	**7 400**	**3 800**	**2 500**	**4 000**	**3 000**	**2 500**	**2 600**
Abrasives Manufacturing	-	-	-	-	-	-	-	-	-
Bakeries	-	-	-	-	-	-	-	-	-
Biofuel Production	-	-	-	-	-	-	-	-	-
Chemicals Industry	12 000	300	1 800	45	59	30	16	61	35
Electronics	2 000	710	96	19	22	23	18	13	10
Food Preparation	-	-	-	-	-	-	0.15	0.24	0.31
Glass Manufacturing	25	27	25	0.00	-	-	-	-	-
Grain Industry	-	-	-	-	-	-	-	-	-
Metal Fabrication	16 000	5 200	760	550	580	480	440	430	270
Plastics Manufacturing	76	46	21	4.8	1.3	1.3	1.3	1.3	1.3
Pulp and Paper Industry	2 100	840	2 400	2 800	1 300	1 500	1 400	1 300	1 200
Textiles	-	0.38	0.00	-	-	-	-	-	-
Vehicle Manufacturing (Engines, Parts, Assembly, Painting)	7 200	3 800	790	71	74	67	88	52	69
Wood Products	3 500	2 500	1 400	330	390	1 900	1 100	610	980
Other (Manufacturing)	0.42	200	98	39	9.3	6.7	14	31	37
TRANSPORTATION AND MOBILE EQUIPMENT	**14 000**	**10 000**	**9 600**	**14 000**	**14 000**	**12 000**	**15 000**	**13 000**	**14 000**
Air Transportation (LTO)	13 000	9 400	8 900	14 000	13 000	12 000	15 000	12 000	14 000
Domestic Marine Navigation, Fishing and Military	350	400	440	130	130	130	150	120	130
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	-	-	-	-	-	-	-	-	-
Motorcycles	-	-	-	-	-	-	-	-	-
Off-Road Diesel Vehicles and Equipment	-	-	-	-	-	-	-	-	-
Off-Road Gasoline/LPG/NG Vehicles and Equipment	-	-	-	-	-	-	-	-	-
Rail Transportation	310	290	280	150	160	170	150	140	130
Tire Wear and Brake Lining	-	-	-	-	-	-	-	-	-
AGRICULTURE	**30**	**30**	**26**	**31**	**30**	**27**	**26**	**23**	**20**
Animal Production	-	-	-	-	-	-	-	-	-
Crop Production	-	-	-	-	-	-	-	-	-
Agricultural Fuel Combustion	30	30	26	31	30	27	26	23	20
COMMERCIAL/RESIDENTIAL/INSTITUTIONAL	**4 600**	**3 200**	**3 300**	**2 100**	**2 100**	**2 100**	**1 900**	**1 800**	**1 700**
Commercial and Institutional Fuel Combustion	250	290	420	250	240	220	230	250	190
Commercial Cooking	-	-	-	-	-	-	-	-	-
Construction Fuel Combustion	10	4.9	11	6.7	7.1	7.2	7.9	9.7	9.3
Home Firewood Burning	1 900	1 500	1 300	1 500	1 500	1 500	1 400	1 300	1 200
Human	-	-	-	-	-	-	-	-	-
Marine Cargo Handling	2 000	970	1 200	41	51	50	61	37	34
Residential Fuel Combustion	490	410	390	260	250	260	240	220	210
Service Stations	-	-	-	-	-	-	-	-	-
Other (Miscellaneous)	-	-	-	-	-	-	-	-	-
INCINERATION AND WASTE	**380**	**370**	**390**	**160**	**150**	**170**	**150**	**120**	**160**
Crematoriums	2.0	2.8	3.6	5.6	5.9	6.2	6.2	6.8	7.0
Waste Incineration	380	370	320	70	72	79	88	71	64
Waste Treatment and Disposal	-	-	60	79	68	87	59	38	85
PAINTS AND SOLVENTS	**-**	**16**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
Dry Cleaning	-	-	-	-	-	-	-	-	-
General Solvent Use	-	-	-	-	-	-	-	-	-
Printing	-	-	-	-	-	-	-	-	-
Surface Coatings	-	16	-	-	-	-	-	-	-
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**	**150 000**	**160 000**	**150 000**	**120 000**	**110 000**	**95 000**

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

Other Emissions Estimated in the APEI

Source	1990	2000	2005	2016	2017	2018	2019	2020	2021
Domestic Air Transportation (Cruise)	66 000	43 000	40 000	20 000	20 000	15 000	18 000	14 000	16 000
International Air Transportation (Cruise)	3 300	1 600	890	820	720	590	740	270	360
International Marine Navigation	250	340	390	220	220	230	190	150	160

Note: Refer to Annex 4.4 for more information on international marine navigation and air transportation reporting emissions.

2.8. Cadmium

Approximately 4.5 t of cadmium (Cd) were emitted in Canada in 2021 (Table 2–10). Ore and Mineral Industries accounted for 62% (2.8 t) of national emissions, with the Non-Ferrous Refining and Smelting Industry sector contributing 49% (2.2 t) of the national total. Commercial/Residential/Institutional fuel combustion sources contributed 22% (0.99 t) and Manufacturing to 5.3% (0.23 t) of total Cd emissions.

From 1990 to 2021, national Cd emissions decreased by 94% (77 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 BLIERs for particulate matter through Environmental Performance Agreements (ECCC, 2017, 2018a). 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. Between 2019 and 2020, Ore and Mineral Industries showed a decrease in Cd emissions of 48% (2.2 t) associated in part due to the permanent closure of a non-ferrous metal smelter in December 2019. Between 2020 and 2021, Ore and Mineral Industries showed an increase in Cd emissions of 15% (0.36 t), mostly due to a return to pre-pandemic production levels in the Non-Ferrous Refining and Smelting Industry.

The most significant changes in Cd emissions from 1990 to 2021 include:

- Ore and Mineral Industries: decrease of 96% (76 t), with:
  - Non-Ferrous Refining and Smelting Industry: decrease of 97% (76 t)

Figure 2–8 **Trends in Canadian Cd Emissions (1990 to 2021)**

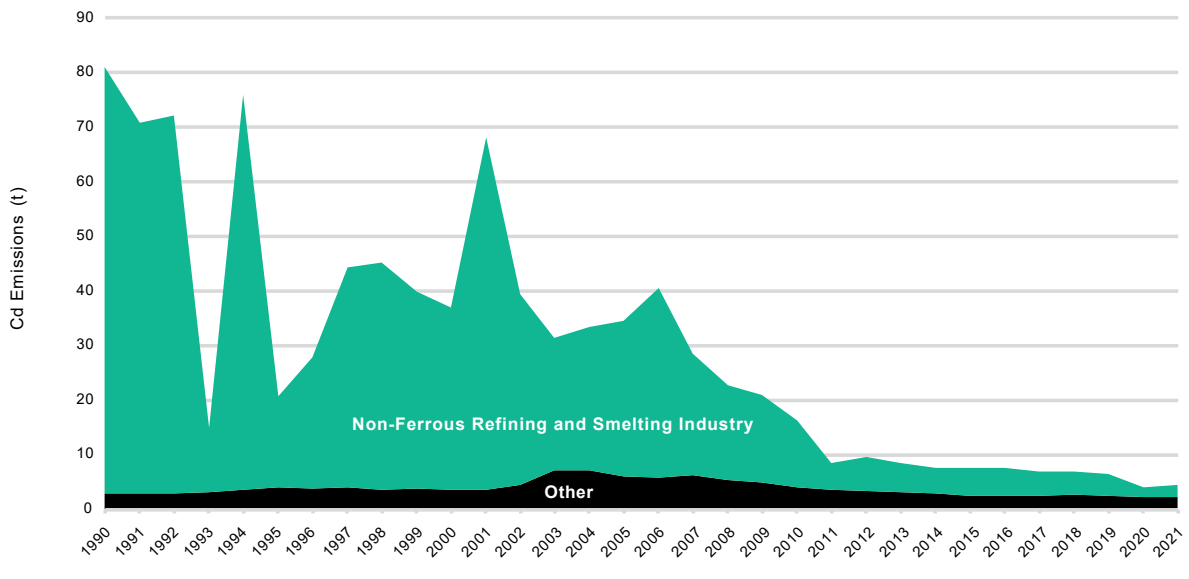


Table 2–10 National Summary of Annual Cd Emissions

Source	1990	2000	2005	2016	2017	2018	2019	2020	2021
					(kg)				
ORE AND MINERAL INDUSTRIES	**79 000**	**34 000**	**32 000**	**5 800**	**5 000**	**5 000**	**4 600**	**2 400**	**2 800**
Aluminium Industry	1.2	2.1	-	-	-	-	-	-	-
Asphalt Paving Industry	26	24	25	19	20	20	20	19	20
Cement and Concrete Industry	46	46	44	12	9.5	9.6	2.8	6.2	2.5
Foundries	50	57	310	310	310	320	370	310	260
Iron and Steel Industry	160	180	310	210	200	230	170	150	170
Iron Ore Pelletizing	-	-	-	82	83	48	52	48	46
Mineral Products Industry	25	24	-	-	-	-	-	-	-
Mining and Rock Quarrying	-	550	2 900	52	54	100	70	59	54
Non-Ferrous Refining and Smelting Industry	78 000	34 000	29 000	5 100	4 300	4 200	4 000	1 800	2 200
OIL AND GAS INDUSTRY	**130**	**190**	**190**	**220**	**250**	**260**	**230**	**230**	**230**
Downstream Oil and Gas Industry	110	150	130	95	98	95	69	66	74
Upstream Oil and Gas Industry	25	38	61	120	150	160	170	160	150
ELECTRIC POWER GENERATION (UTILITIES)	**130**	**130**	**250**	**160**	**120**	**97**	**110**	**99**	**96**
Coal	87	91	170	100	78	62	80	65	71
Landfill Gas	-	-	-	-	-	-	-	-	-
Natural Gas	29	30	56	35	27	24	26	24	12
Diesel	-	-	-	-	-	-	-	-	-
Other (Electric Power Generation)	14	14	27	25	16	11	8.8	10	12
MANUFACTURING	**1 000**	**860**	**600**	**290**	**270**	**280**	**230**	**210**	**230**
Abrasives Manufacturing	-	-	-	-	-	-	-	-	-
Bakeries	-	-	-	-	-	-	-	-	-
Biofuel Production	-	-	-	-	-	-	-	-	-
Chemicals Industry	140	130	11	8.1	7.8	8.2	7.8	8.4	8.0
Electronics	0.26	0.28	-	-	-	-	-	-	-
Food Preparation	-	-	-	-	-	-	-	-	0.68
Glass Manufacturing	1.3	2.5	1.9	-	-	-	-	-	-
Grain Industry	-	-	-	-	-	-	-	-	-
Metal Fabrication	270	250	7.5	1.5	1.6	1.7	1.7	3.9	3.8
Plastics Manufacturing	5.2	5.7	3.6	-	-	-	0.00	0.00	0.00
Pulp and Paper Industry	370	190	320	210	200	200	170	160	170
Textiles	-	-	-	-	-	-	-	-	-
Vehicle Manufacturing (Engines, Parts, Assembly, Painting)	110	160	1.3	0.69	0.68	0.69	0.75	0.34	0.36
Wood Products	130	130	110	63	59	77	50	40	48
Other (Manufacturing)	0.00	0.00	140	0.060	0.13	0.11	0.16	0.14	0.14
TRANSPORTATION AND MOBILE EQUIPMENT	**170**	**190**	**200**	**61**	**64**	**67**	**62**	**52**	**53**
Air Transportation (LTO)	-	-	-	-	-	-	-	-	-
Domestic Marine Navigation, Fishing and Military	70	91	100	12	11	11	11	7.3	8.1
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	-	-	-	-	-	-	-	-	-
Motorcycles	-	-	-	-	-	-	-	-	-
Off-Road Diesel Vehicles and Equipment	-	-	-	-	-	-	-	-	-
Off-Road Gasoline/LPG/NG Vehicles and Equipment	-	-	-	-	-	-	-	-	-
Rail Transportation	100	98	95	49	53	56	51	45	45
Tire Wear and Brake Lining	-	-	-	-	-	-	-	-	-
AGRICULTURE	**51**	**54**	**64**	**82**	**82**	**80**	**84**	**75**	**76**
Animal Production	-	-	-	-	-	-	-	-	-
Crop Production	-	-	-	-	-	-	-	-	-
Agricultural Fuel Combustion	51	54	64	82	82	80	84	75	76
COMMERCIAL/RESIDENTIAL/INSTITUTIONAL	**1 000**	**1 100**	**1 100**	**1 000**	**1 100**	**1 100**	**1 100**	**1 000**	**990**
Commercial and Institutional Fuel Combustion	340	510	470	490	510	510	540	500	490
Commercial Cooking	-	-	-	-	-	-	-	-	-
Construction Fuel Combustion	11	7.0	10	9.1	9.2	9.9	10	10	11
Home Firewood Burning	100	84	73	91	92	88	78	72	68
Human	-	-	-	-	-	-	-	-	-
Marine Cargo Handling	-	-	47	2.2	2.3	2.5	2.4	2.2	2.3
Residential Fuel Combustion	540	500	500	450	460	460	450	420	410
Service Stations	-	-	-	-	-	-	-	-	-
Other (Miscellaneous)	-	-	-	-	-	-	-	-	-
INCINERATION AND WASTE	**76**	**89**	**39**	**14**	**15**	**23**	**25**	**38**	**38**
Crematoriums	0.34	0.47	0.61	0.93	0.99	1.0	1.0	1.1	1.2
Waste Incineration	76	89	36	11	11	15	16	29	12
Waste Treatment and Disposal	-	-	2.5	2.3	3.0	7.2	7.9	8.2	24
PAINTS AND SOLVENTS	**-**	**-**	**0.00**	**0.10**	**0.14**	**0.14**	**0.14**	**0.14**	**0.15**
Dry Cleaning	-	-	-	-	-	-	-	-	-
General Solvent Use	-	-	-	-	-	-	-	-	-
Printing	-	-	0.00	-	-	-	-	-	-
Surface Coatings	-	-	-	0.10	0.14	0.14	0.14	0.14	0.15
DUST	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
Coal Transportation	-	-	-	-	-	-	-	-	-
Construction Operations	-	-	-	-	-	-	-	-	-
Mine Tailings	-	-	-	-	-	-	-	-	-
Paved Roads	-	-	-	-	-	-	-	-	-
Unpaved Roads	-	-	-	-	-	-	-	-	-
FIRES	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
Prescribed Burning	-	-	-	-	-	-	-	-	-
Structural Fires	-	-	-	-	-	-	-	-	-
GRAND TOTAL	**81 000**	**37 000**	**35 000**	**7 600**	**6 800**	**6 900**	**6 500**	**4 100**	**4 500**

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

Other Emissions Estimated in the APEI

Source	1990	2000	2005	2016	2017	2018	2019	2020	2021
Domestic Air Transportation (Cruise)	-	-	-	-	-	-	-	-	-
International Air Transportation (Cruise)	-	-	-	-	-	-	-	-	-
International Marine Navigation	120	190	210	12	12	13	9.6	7.2	7.7

Note: Refer to Annex 4.4 for more information on international marine navigation and air transportation reporting emissions.

2.9. Mercury

Approximately 3.2 t of mercury (Hg) were emitted in Canada in 2021 (Table 2–11). Ore and Mineral Industries accounted for 38% (1.2 t) of Hg emissions in 2021, with the Iron and Steel Industry sector contributing 15% (0.48 t) of the national total. Incineration and Waste sources accounted for 27% (0.85 t) of Hg emissions in 2021, with Crematoriums being the largest contributor at 20% (0.63 t). Electric Power Generation (Utilities) accounted for 16% (0.50 t) of 2021 emissions, most of which were emitted from coal-powered electric generation with 15% (0.47 t) of the annual total.

Between 1990 and 2021, Hg emissions decreased by 91% (30 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 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, 2018a).

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. Coal electric power generation experienced a significant Hg emissions decrease of 16% (95 kg) between 2019 and 2020 and an additional decrease of 1.6% (7.7 kg) between 2020 and 2021, both attributed to plant closures and a decrease in coal consumption. For the Incineration and Waste source category, decreases in emissions from 1990 to 2021 resulted from a reduction of Hg emissions reported by incineration facilities as well as a result of a reduction in 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 2021 include:

- Ore and Mineral Industry: decrease of 95% (25 t), with:
  - Non-Ferrous Refining and Smelting Industry: decrease of 99% (25 t)
- Electric Power Generation (Utilities): decrease of 78% (1.7 t), with:
  - Coal: decrease of 76% (1.5 t)
- Incineration and Waste: decrease of 67% (1.7 t), with:
  - Waste Incineration: decrease of 92% (1.4 t)
  - Waste Treatment and Disposal: decrease of 89% (0.73 t)

Figure 2–9 **Trends in Canadian Hg Emissions (1990 to 2021)**

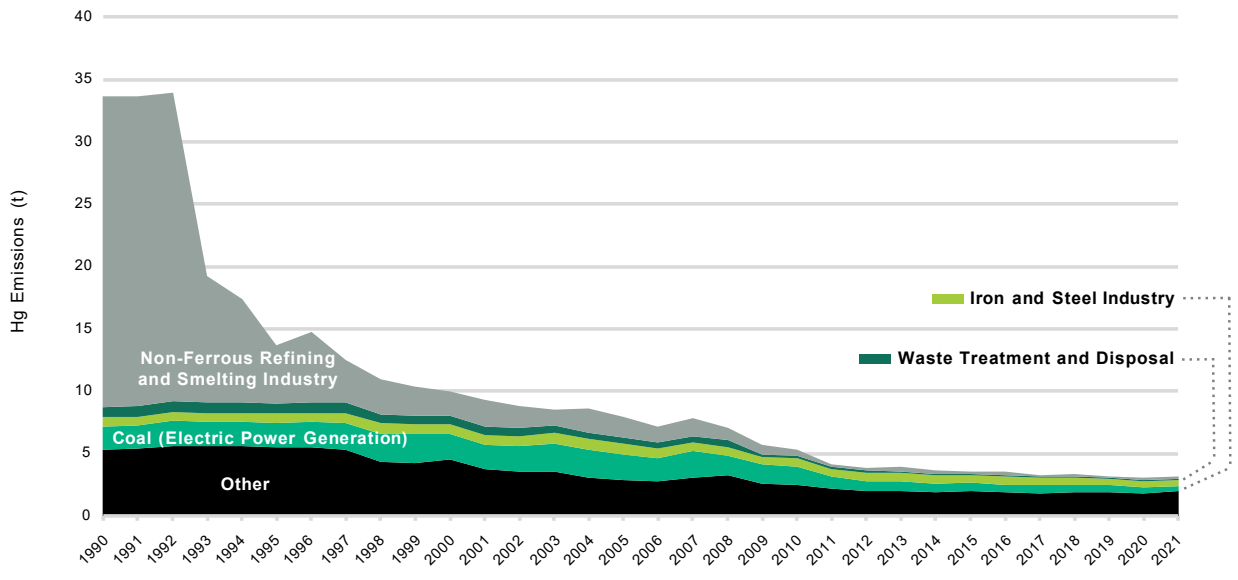


Table 2–11 National Summary of Annual Hg Emissions

Source	1990	2000	2005	2016	2017	2018	2019	2020	2021
					(tonnes)				
ORE AND MINERAL INDUSTRIES	**26 000**	**3 400**	**2 900**	**1 400**	**1 200**	**1 300**	**1 200**	**1 100**	**1 200**
Aluminium Industry	18	31	43	21	22	24	24	21	18
Asphalt Paving Industry	24	22	22	19	20	19	19	18	20
Cement and Concrete Industry	460	390	210	340	330	300	300	240	300
Foundries	210	120	4.3	-	-	-	-	-	0.00
Iron and Steel Industry	710	800	860	680	610	600	520	490	480
Iron Ore Pelletizing	60	60	50	71	70	73	79	73	79
Mineral Products Industry	-	-	-	-	-	-	-	-	-
Mining and Rock Quarrying	22	17	29	16	19	110	110	110	120
Non-Ferrous Refining and Smelting Industry	25 000	1 900	1 700	220	140	200	120	160	190
OIL AND GAS INDUSTRY	**120**	**61**	**83**	**81**	**70**	**74**	**70**	**68**	**76**
Downstream Oil and Gas Industry	110	26	46	53	47	50	46	42	54
Upstream Oil and Gas Industry	3.0	36	38	28	22	24	24	26	22
ELECTRIC POWER GENERATION (UTILITIES)	**2 200**	**2 000**	**2 200**	**670**	**630**	**610**	**600**	**500**	**500**
Coal	1 900	2 000	2 000	630	610	590	580	480	470
Landfill Gas	-	-	-	-	-	-	-	-	-
Natural Gas	12	22	27	11	0.00	2.1	2.3	2.5	2.0
Diesel	-	-	-	-	-	-	-	-	-
Other (Electric Power Generation)	290	62	91	30	17	22	23	22	23
MANUFACTURING	**1 100**	**1 400**	**500**	**120**	**100**	**110**	**77**	**76**	**86**
Abrasives Manufacturing	-	-	-	-	-	-	-	-	-
Bakeries	-	-	-	-	-	-	-	-	-
Biofuel Production	-	-	-	-	-	-	-	-	-
Chemicals Industry	170	82	45	17	17	18	17	14	18
Electronics	400	760	60	15	11	7.8	0.00	0.00	-
Food Preparation	0.14	0.14	0.30	-	-	-	-	-	-
Glass Manufacturing	28	28	21	-	-	-	-	-	-
Grain Industry	-	-	-	-	-	-	-	-	-
Metal Fabrication	16	17	16	-	-	-	-	3.1	4.3
Plastics Manufacturing	0.00	0.00	-	-	-	-	-	-	-
Pulp and Paper Industry	98	130	58	71	58	59	48	48	47
Textiles	-	-	-	-	-	-	-	-	-
Vehicle Manufacturing (Engines, Parts, Assembly, Painting)	0.00	0.00	0.00	-	-	-	-	-	-
Wood Products	260	190	89	16	13	25	12	11	16
Other (Manufacturing)	120	170	210	-	0.00	0.56	0.33	-	0.00
TRANSPORTATION AND MOBILE EQUIPMENT	**120**	**120**	**120**	**76**	**80**	**85**	**80**	**69**	**70**
Air Transportation (LTO)	-	-	-	-	-	-	-	-	-
Domestic Marine Navigation, Fishing and Military	1.5	2.0	2.3	0.22	0.20	0.19	0.19	0.12	0.13
Heavy-Duty Diesel Vehicles	0.11	0.20	0.26	0.29	0.30	0.31	0.31	0.26	0.29
Heavy-Duty Gasoline Vehicles	0.64	0.79	0.87	0.72	0.71	0.70	0.69	0.63	0.64
Heavy-Duty LPG/NG Vehicles	0.086	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Light-Duty Diesel Trucks	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Light-Duty Diesel Vehicles	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Light-Duty Gasoline Trucks	4.3	7.4	8.6	13	14	15	16	14	15
Light-Duty Gasoline Vehicles	11	12	12	12	12	12	12	9.0	8.8
Light-Duty LPG/NG Trucks	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Light-Duty LPG/NG Vehicles	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Motorcycles	0.076	0.10	0.14	0.28	0.29	0.29	0.30	0.25	0.24
Off-Road Diesel Vehicles and Equipment	-	-	-	-	-	-	-	-	-
Off-Road Gasoline/LPG/NG Vehicles and Equipment	-	-	-	-	-	-	-	-	-
Rail Transportation	100	98	95	49	53	56	51	45	45
Tire Wear and Brake Lining	-	-	-	-	-	-	-	-	-
AGRICULTURE	**2.8**	**3.4**	**3.2**	**7.3**	**7.0**	**6.7**	**6.7**	**6.1**	**6.0**
Animal Production	-	-	-	-	-	-	-	-	-
Crop Production	-	-	-	-	-	-	-	-	-
Agricultural Fuel Combustion	2.8	3.4	3.2	7.3	7.0	6.7	6.7	6.1	6.0
COMMERCIAL/RESIDENTIAL/INSTITUTIONAL	**1 100**	**780**	**740**	**470**	**460**	**460**	**440**	**420**	**410**
Commercial and Institutional Fuel Combustion	47	62	63	58	63	66	69	67	66
Commercial Cooking	-	-	-	-	-	-	-	-	-
Construction Fuel Combustion	2.6	1.7	2.6	2.2	2.2	2.4	2.4	2.5	2.5
Home Firewood Burning	28	23	20	24	24	23	21	19	18
Human	110	24	18	1.8	1.8	1.8	1.8	1.8	1.8
Marine Cargo Handling	-	-	2.8	-	-	-	-	-	-
Residential Fuel Combustion	64	76	75	70	72	76	74	69	67
Service Stations	-	-	-	-	-	-	-	-	-
Other (Miscellaneous)	820	590	560	320	300	290	270	260	250
INCINERATION AND WASTE	**2 600**	**2 200**	**1 400**	**730**	**730**	**730**	**750**	**800**	**850**
Crematoriums	180	260	330	500	530	560	570	620	630
Waste Incineration	1 600	1 300	600	120	94	81	91	91	130
Waste Treatment and Disposal	820	680	490	110	100	91	90	87	92
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**	**7 900**	**3 500**	**3 300**	**3 400**	**3 200**	**3 000**	**3 200**

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

Other Emissions Estimated in the APEI

Source	1990	2000	2005	2016	2017	2018	2019	2020	2021
Domestic Air Transportation (Cruise)	-	-	-	-	-	-	-	-	-
International Air Transportation (Cruise)	-	-	-	-	-	-	-	-	-
International Marine Navigation	2.8	4.2	4.9	0.18	0.19	0.20	0.14	0.10	0.11

Note: Refer to Annex 4.4 for more information on international marine navigation and air transportation reporting emissions.

2.10. Dioxins and Furans

In 2021, emissions of dioxins and furans (D/F) in Canada totalled approximately 82 grams of toxicity equivalent (gTEQ) (Table 2–12). The Incineration and Waste source accounted for the largest share of these emissions at 47% (39 gTEQ), with Waste Incineration accounting for 43% (35 gTEQ) of the national total. Transportation and Mobile Equipment contributed 31% (25 gTEQ) of 2021 dioxins and furans emissions, 22% (18 gTEQ) of which are attributed to Light-Duty Gasoline Trucks and Vehicles. Ore and Mineral Industries accounted for 14% (12 gTEQ) of 2021 dioxins and furans emissions with Iron Ore Pelletizing being the largest sector contributing to this source with 6.2% (5.1 gTEQ) of total dioxins and furans emissions followed by the Iron and Steel Industry sector with 5.4% (4.4 gTEQ) of national emissions. The Commercial/Residential/Institutional source category was also a notable contributor at 4.2% (3.5 gTEQ) of 2021 dioxins and furans emissions of which the majority of it is attributed to the Home Firewood Burning sector with 3.8% (3.1 gTEQ) of the national total.

Between 1990 and 2021, dioxins and furans emissions decreased by 63% (142 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. Ore and Mineral Industries also contributed to the overall dioxins and furans emissions decrease, associated with effective emission controls on coke ovens and coke by-product plants in the Iron and Steel Industry (EC, 2001).

The most significant changes in dioxins and furans emissions from 1990 to 2021 include:

- Incineration and Waste: decrease of 67% (78 gTEQ), with:
  - Waste Incineration: decrease of 70% (81 gTEQ)
- Ore and Mineral Industries: decrease of 75% (34 gTEQ), with:
  - Iron and Steel Industry: decrease of 87% (31 gTEQ)

Figure 2–10 **Trends in Canadian Dioxins and Furans Emissions (1990 to 2021)**

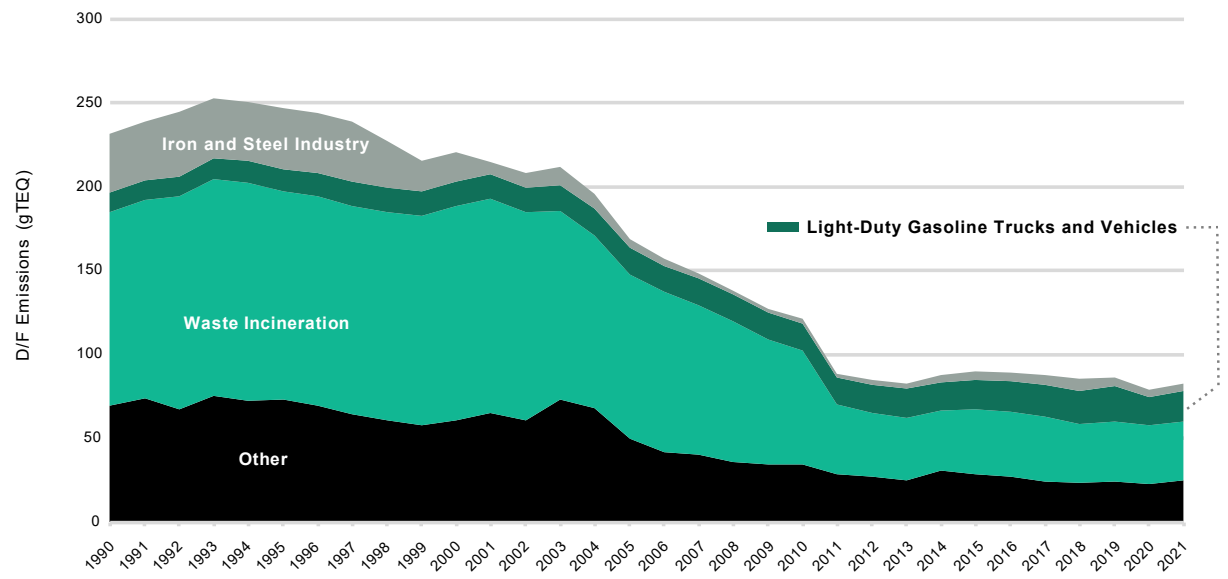


Table 2–12 National Summary of Annual Dioxins and Furans Emissions

Source	1990	2000	2005	2016	2017	2018	2019	2020	2021
					(gTEQ)				
ORE AND MINERAL INDUSTRIES	**46**	**33**	**14**	**6.9**	**7.5**	**10**	**10**	**9.8**	**12**
Aluminium Industry	2.8	6.6	0.95	1.1	1.1	0.98	2.2	1.4	0.53
Asphalt Paving Industry	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Cement and Concrete Industry	3.0	1.8	2.6	0.61	0.22	1.6	1.1	1.0	1.1
Foundries	0.42	2.0	3.0	0.12	0.12	0.10	0.092	0.082	0.00
Iron and Steel Industry	35	18	5.0	4.7	5.6	7.1	5.3	4.2	4.4
Iron Ore Pelletizing	-	-	-	-	-	-	-	2.4	5.1
Mineral Products Industry	1.0	1.4	0.81	-	-	-	-	-	-
Mining and Rock Quarrying	-	-	0.50	0.00	0.00	0.00	0.00	0.00	0.16
Non-Ferrous Refining and Smelting Industry	3.4	3.4	1.2	0.41	0.44	0.42	1.5	0.67	0.20
OIL AND GAS INDUSTRY	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
Downstream Oil and Gas Industry	-	-	-	-	-	-	-	-	-
Upstream Oil and Gas Industry	-	-	-	-	-	-	-	-	-
ELECTRIC POWER GENERATION (UTILITIES)	**3.0**	**6.2**	**5.5**	**2.7**	**2.2**	**1.3**	**0.95**	**0.59**	**0.49**
Coal	2.3	3.1	3.9	1.9	1.6	0.74	0.70	0.45	0.31
Landfill Gas	0.00	-	-	-	-	-	-	-	-
Natural Gas	0.46	1.0	1.2	0.00	0.00	0.00	0.00	0.00	0.00
Diesel	-	-	-	-	-	-	-	-	-
Other (Electric Power Generation)	0.23	2.1	0.43	0.75	0.60	0.52	0.25	0.14	0.18
MANUFACTURING	**19**	**13**	**8.1**	**3.4**	**2.3**	**2.0**	**1.7**	**1.4**	**1.8**
Abrasives Manufacturing	-	-	0.051	0.00	0.00	0.00	0.00	0.00	0.00
Bakeries	-	-	-	-	-	-	-	-	-
Biofuel Production	-	-	-	-	-	-	-	-	-
Chemicals Industry	2.2	0.10	0.00	0.31	0.33	0.00	0.00	0.00	0.00
Electronics	0.00	0.00	-	-	-	-	-	-	-
Food Preparation	-	-	0.065	-	-	-	-	-	-
Glass Manufacturing	0.00	0.00	-	-	-	-	-	-	-
Grain Industry	-	-	-	-	-	-	-	-	-
Metal Fabrication	2.4	2.5	-	0.31	0.30	0.31	0.17	0.14	0.17
Plastics Manufacturing	0.00	0.00	-	-	-	-	-	-	-
Pulp and Paper Industry	11	5.2	4.9	2.1	1.1	1.1	0.95	0.80	0.86
Textiles	-	-	-	-	-	-	-	-	-
Vehicle Manufacturing (Engines, Parts, Assembly, Painting)	1.2	2.3	0.44	-	-	-	-	-	-
Wood Products	1.8	2.6	2.5	0.64	0.59	0.58	0.52	0.47	0.76
Other (Manufacturing)	0.00	0.00	0.12	-	-	-	-	-	-
TRANSPORTATION AND MOBILE EQUIPMENT	**26**	**31**	**33**	**26**	**27**	**27**	**29**	**24**	**25**
Air Transportation (LTO)	-	-	-	-	-	-	-	-	-
Domestic Marine Navigation, Fishing and Military	12	13	15	4.5	4.4	4.5	5.0	3.9	4.5
Heavy-Duty Diesel Vehicles	0.37	0.67	0.88	0.47	0.46	0.46	0.44	0.39	0.42
Heavy-Duty Gasoline Vehicles	0.48	0.60	0.66	0.54	0.53	0.53	0.52	0.48	0.48
Heavy-Duty LPG/NG Vehicles	0.065	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Light-Duty Diesel Trucks	0.065	0.072	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Light-Duty Diesel Vehicles	0.00	0.00	0.057	0.00	0.00	0.00	0.00	0.00	0.00
Light-Duty Gasoline Trucks	3.2	5.6	6.5	10	11	11	12	11	12
Light-Duty Gasoline Vehicles	8.3	9.1	9.0	8.8	8.7	8.8	8.8	6.8	6.6
Light-Duty LPG/NG Trucks	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Light-Duty LPG/NG Vehicles	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Motorcycles	0.058	0.077	0.11	0.21	0.22	0.22	0.23	0.19	0.18
Off-Road Diesel Vehicles and Equipment	-	-	-	-	-	-	-	-	-
Off-Road Gasoline/LPG/NG Vehicles and Equipment	-	-	-	-	-	-	-	-	-
Rail Transportation	1.2	1.2	1.2	1.2	1.3	1.4	1.4	1.3	1.3
Tire Wear and Brake Lining	-	-	-	-	-	-	-	-	-
AGRICULTURE	**0.058**	**0.054**	**0.00**	**0.55**	**0.53**	**0.42**	**0.40**	**0.31**	**0.25**
Animal Production	-	-	-	-	-	-	-	-	-
Crop Production	-	-	-	-	-	-	-	-	-
Agricultural Fuel Combustion	0.058	0.054	0.00	0.55	0.53	0.42	0.40	0.31	0.25
COMMERCIAL/RESIDENTIAL/INSTITUTIONAL	**6.4**	**5.4**	**4.8**	**4.8**	**4.7**	**4.5**	**4.0**	**3.7**	**3.5**
Commercial and Institutional Fuel Combustion	0.37	0.37	0.32	0.27	0.24	0.18	0.17	0.15	0.15
Commercial Cooking	-	-	-	-	-	-	-	-	-
Construction Fuel Combustion	0.068	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Home Firewood Burning	4.6	3.8	3.3	4.1	4.2	4.0	3.6	3.3	3.1
Human	-	-	-	-	-	-	-	-	-
Marine Cargo Handling	-	-	-	-	-	-	-	-	-
Residential Fuel Combustion	1.5	1.2	1.1	0.39	0.26	0.26	0.24	0.21	0.20
Service Stations	-	-	-	-	-	-	-	-	-
Other (Miscellaneous)	-	-	-	-	-	-	-	-	-
INCINERATION AND WASTE	**120**	**130**	**100**	**41**	**42**	**39**	**39**	**39**	**39**
Crematoriums	1.1	1.6	2.1	3.2	3.3	3.5	3.5	3.9	3.9
Waste Incineration	120	130	98	38	39	35	35	35	35
Waste Treatment and Disposal	-	0.57	0.66	-	-	-	-	-	-
PAINTS AND SOLVENTS	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
Dry Cleaning	-	-	-	-	-	-	-	-	-
General Solvent Use	-	-	-	-	-	-	-	-	-
Printing	-	-	-	-	-	-	-	-	-
Surface Coatings	-	-	-	-	-	-	-	-	-
DUST	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
Coal Transportation	-	-	-	-	-	-	-	-	-
Construction Operations	-	-	-	-	-	-	-	-	-
Mine Tailings	-	-	-	-	-	-	-	-	-
Paved Roads	-	-	-	-	-	-	-	-	-
Unpaved Roads	-	-	-	-	-	-	-	-	-
FIRES	**7.6**	**1.5**	**0.92**	**1.8**	**1.1**	**0.64**	**0.68**	**0.54**	**0.55**
Prescribed Burning	7.6	1.5	0.92	1.8	1.1	0.64	0.68	0.54	0.55
Structural Fires	-	-	-	-	-	-	-	-	-
GRAND TOTAL	**220**	**220**	**170**	**87**	**87**	**85**	**85**	**79**	**82**

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

Other Emissions Estimated in the APEI

Source	1990	2000	2005	2016	2017	2018	2019	2020	2021
Domestic Air Transportation (Cruise)	-	-	-	-	-	-	-	-	-
International Air Transportation (Cruise)	-	-	-	-	-	-	-	-	-
International Marine Navigation	8.2	11	13	7.5	7.3	7.6	6.4	4.9	5.3

Note: Refer to Annex 4.4 for more information on international marine navigation and air transportation reporting emissions.

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(cd)p). The analysis presented here is based on the aggregate total of all four substances. In 2021, 52 t of PAHs were emitted in Canada (Table 2–13), with 91% (48 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, with 91% (47 t) of total 2021 emissions. Transportation and Mobile Equipment was the next largest source, contributing 4.3% (2.3 t) of PAH emissions in 2021.

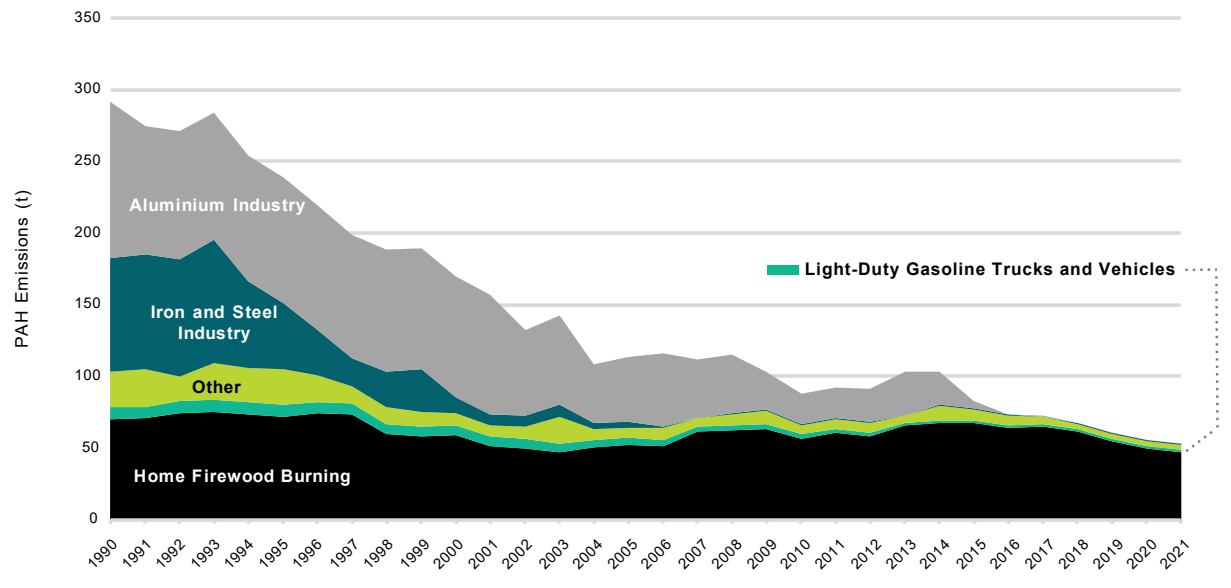
From 1990 to 2021, PAH emissions decreased by 81% (230 t) (Figure 2–11), primarily owing to emission reductions in the Aluminium Industry and Iron and Steel Industry sectors of almost 100% each (109 t and 79 t, respectively). Emissions from Aluminium Industry experienced a large drop in PAH emissions 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 2021. Reductions here are a result of effective emission controls on coke ovens and coke by-product plants (EC, 2001).

Within Commercial/Residential/Institutional sources, Home Firewood Burning contributed to the downward trend across the 1990-2021 time series. Emissions increased from 1990 to 1997, fluctuated until 2014 and have since then constantly decreased, resulting in an overall decrease in emissions of 32% (22 t). This decrease is owed to a 32% reduction in wood consumption and the adoption of more efficient wood combustion equipment. PAH emissions from Transportation and Mobile Equipment have decreased across the time series owing to increasingly stringent engine and vehicle regulations.[10]

The most significant changes in PAH emissions from 1990 to 2021 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)
- Commercial/Residential/Institutional sources: decrease of 32% (22 t)
  - Home Firewood Burning: decrease of 32% (22 t)
- Transportation and Mobile Equipment: decrease of 81% (10 t), with:
  - Light-Duty Gasoline Trucks and Vehicles: decrease of 82% (6.9 t)

Figure 2–11 **Trends in Canadian Polycyclic Aromatic Hydrocarbons Emissions (1990 to 2021)**



10 See Chapter 1 for list of regulations.

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

Source	1990	2000	2005	2016	2017	2018	2019	2020	2021
					(kg)				
ORE AND MINERAL INDUSTRIES	**190 000**	**95 000**	**50 000**	**690**	**550**	**620**	**540**	**470**	**470**
Aluminium Industry	110 000	84 000	45 000	100	130	190	140	83	89
Asphalt Paving Industry	14	14	15	11	12	12	11	11	11
Cement and Concrete Industry	17	13	19	0.23	0.62	0.34	0.26	0.18	-
Foundries	0.11	0.14	-	-	-	-	-	-	-
Iron and Steel Industry	80 000	11 000	4 600	440	390	400	370	370	370
Iron Ore Pelletizing	-	-	-	20	21	18	20	8.6	0.30
Mineral Products Industry	0.058	0.059	8.3	-	-	-	-	-	-
Mining and Rock Quarrying	-	-	-	110	0.00	0.00	0.00	0.00	0.00
Non-Ferrous Refining and Smelting Industry	1.9	2.8	0.33	0.30	0.33	0.33	0.34	0.20	-
OIL AND GAS INDUSTRY	**150**	**95**	**46**	**20**	**18**	**22**	**470**	**470**	**480**
Downstream Oil and Gas Industry	150	92	43	14	13	14	14	12	14
Upstream Oil and Gas Industry	2.3	3.3	2.3	5.8	4.5	7.9	450	460	470
ELECTRIC POWER GENERATION (UTILITIES)	**370**	**360**	**240**	**6.8**	**6.5**	**0.00**	**0.00**	**0.00**	**6.5**
Coal	240	240	240	-	-	-	-	-	-
Landfill Gas	-	-	-	-	-	-	-	-	-
Natural Gas	2.9	2.3	0.23	0.00	0.00	0.00	0.00	0.00	0.00
Diesel	-	-	-	-	-	-	-	-	-
Other (Electric Power Generation)	130	110	-	6.8	6.5	-	-	-	6.5
MANUFACTURING	**320**	**310**	**290**	**120**	**140**	**130**	**150**	**160**	**120**
Abrasives Manufacturing	-	-	-	-	-	-	-	-	-
Bakeries	-	-	-	-	-	-	-	-	-
Biofuel Production	-	-	-	-	-	-	-	-	-
Chemicals Industry	0.60	24	29	25	25	24	24	23	1.9
Electronics	0.00	0.00	-	-	-	-	-	-	-
Food Preparation	-	-	-	-	-	-	-	-	-
Glass Manufacturing	0.00	0.00	-	-	-	-	-	-	-
Grain Industry	-	-	-	-	-	-	-	-	-
Metal Fabrication	0.62	0.62	-	-	-	-	-	-	-
Plastics Manufacturing	0.00	0.00	-	-	-	-	-	-	-
Pulp and Paper Industry	110	130	190	89	110	100	120	130	110
Textiles	-	-	-	-	-	-	-	-	-
Vehicle Manufacturing (Engines, Parts, Assembly, Painting)	0.26	0.42	-	0.00	0.00	0.00	0.00	0.00	0.00
Wood Products	210	150	72	7.9	6.0	6.0	5.4	4.8	8.0
Other (Manufacturing)	0.00	0.00	2.2	-	-	-	-	-	0.00
TRANSPORTATION AND MOBILE EQUIPMENT	**12 000**	**10 000**	**7 800**	**2 900**	**2 700**	**2 700**	**2 600**	**2 300**	**2 300**
Air Transportation (LTO)	12	6.8	5.4	5.7	5.8	6.2	6.2	3.9	4.3
Domestic Marine Navigation, Fishing and Military	71	80	88	27	26	27	30	23	27
Heavy-Duty Diesel Vehicles	2 100	2 200	2 400	750	630	590	510	450	440
Heavy-Duty Gasoline Vehicles	1 300	880	660	290	260	260	250	230	210
Heavy-Duty LPG/NG Vehicles	260	11	3.9	1.6	1.7	2.0	2.2	2.2	2.6
Light-Duty Diesel Trucks	8.4	9.9	7.8	1.3	1.0	0.98	0.91	0.78	0.67
Light-Duty Diesel Vehicles	7.3	5.0	3.9	0.75	0.63	0.59	0.50	0.42	0.43
Light-Duty Gasoline Trucks	2 700	3 000	2 200	1 000	1 000	1 100	1 100	960	1 000
Light-Duty Gasoline Vehicles	5 700	3 800	2 400	730	660	650	630	500	480
Light-Duty LPG/NG Trucks	7.8	0.58	0.33	0.29	0.20	0.27	0.21	0.12	0.11
Light-Duty LPG/NG Vehicles	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Motorcycles	47	50	53	82	84	87	90	73	73
Off-Road Diesel Vehicles and Equipment	-	-	-	-	-	-	-	-	-
Off-Road Gasoline/LPG/NG Vehicles and Equipment	-	-	-	-	-	-	-	-	-
Rail Transportation	63	59	58	30	32	34	31	27	27
Tire Wear and Brake Lining	-	-	-	-	-	-	-	-	-
AGRICULTURE	**0.32**	**0.31**	**0.21**	**0.23**	**0.22**	**0.23**	**0.23**	**0.21**	**0.20**
Animal Production	-	-	-	-	-	-	-	-	-
Crop Production	-	-	-	-	-	-	-	-	-
Agricultural Fuel Combustion	0.32	0.31	0.21	0.23	0.22	0.23	0.23	0.21	0.20
COMMERCIAL/RESIDENTIAL/INSTITUTIONAL	**70 000**	**59 000**	**53 000**	**64 000**	**65 000**	**62 000**	**54 000**	**50 000**	**48 000**
Commercial and Institutional Fuel Combustion	2.6	3.1	2.9	2.3	2.3	2.4	2.5	2.3	2.3
Commercial Cooking	100	110	120	110	110	110	110	110	120
Construction Fuel Combustion	0.45	0.19	0.41	0.22	0.23	0.22	0.25	0.33	0.31
Home Firewood Burning	70 000	59 000	52 000	64 000	65 000	62 000	54 000	50 000	47 000
Human	-	-	-	-	-	-	-	-	-
Marine Cargo Handling	-	-	-	-	-	-	-	-	-
Residential Fuel Combustion	5.3	4.6	4.3	3.1	3.0	3.1	3.0	2.7	2.6
Service Stations	-	-	-	-	-	-	-	-	-
Other (Miscellaneous)	-	-	-	-	-	-	-	-	-
INCINERATION AND WASTE	**490**	**530**	**610**	**660**	**660**	**670**	**680**	**690**	**690**
Crematoriums	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Waste Incineration	490	530	610	660	660	670	680	690	690
Waste Treatment and Disposal	-	-	-	0.00	0.00	0.00	0.00	0.00	0.00
PAINTS AND SOLVENTS	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
Dry Cleaning	-	-	-	-	-	-	-	-	-
General Solvent Use	-	-	-	-	-	-	-	-	-
Printing	-	-	-	-	-	-	-	-	-
Surface Coatings	-	-	-	-	-	-	-	-	-
DUST	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
Coal Transportation	-	-	-	-	-	-	-	-	-
Construction Operations	-	-	-	-	-	-	-	-	-
Mine Tailings	-	-	-	-	-	-	-	-	-
Paved Roads	-	-	-	-	-	-	-	-	-
Unpaved Roads	-	-	-	-	-	-	-	-	-
FIRES	**9 800**	**2 000**	**1 200**	**2 400**	**1 400**	**820**	**870**	**700**	**700**
Prescribed Burning	9 800	2 000	1 200	2 400	1 400	820	870	700	700
Structural Fires	-	-	-	-	-	-	-	-	-
GRAND TOTAL	**280 000**	**170 000**	**110 000**	**71 000**	**71 000**	**67 000**	**60 000**	**55 000**	**52 000**

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

Other Emissions Estimated in the APEI

Source	1990	2000	2005	2016	2017	2018	2019	2020	2021
Domestic Air Transportation (Cruise)	5.5	4.4	3.1	3.0	3.1	3.3	3.3	1.9	2.1
International Air Transportation (Cruise)	3.1	3.0	2.3	2.1	2.2	2.3	2.4	0.93	0.85
International Marine Navigation	49	68	79	45	44	46	38	30	32

Note: Refer to Annex 4.4 for more information on international marine navigation and air transportation reporting emissions.

2.12. Hexachlorobenzene

In 2021, approximately 13 kg of hexachlorobenzene (HCB) were emitted in Canada (Table 2–14). Waste Incineration was the largest contributor in 2021 with 74% (9.8 kg) of total HCB emissions. Ore and Mineral Industries was the second-largest contributor, with 23% (3.1 kg) of total emissions, attributed to the Iron and Steel Industry sector, which represented 8.3% (1.1 kg) of the national total. Within the same category, the Cement and Concrete Industry and Iron Ore Pelletizing sectors contributed to 6.4% (0.84 kg) and 3.4% (0.45 kg), respectively, of the total HCB emissions.

Overall, HCB emissions decreased by 69% (29 kg) from 1990 to 2021. HCB emissions decreased between 1990 and 2014 and have fluctuated since 2014 (Figure 2–12). Emission reductions were also observed in the Electric Power Generation (Utilities) category between 1990 and 2021 as a result of reduced HCB emissions reported at several coal plants, as well as plant closures. The overall national HCB decrease is also partly 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). Between 2019 and 2020, Ore and Mineral Industries experienced a decrease in HCB emissions of 39% (1.9 kg), mostly due to a decrease in Non-Ferrous Refining and Smelting Industry of 73% (2.0 kg), in part owed to the permanent closure of a non-ferrous metal smelter in December 2019. Although Ore and Mineral Industries experienced a significant decrease during the first year of the COVID-19 pandemic, there was an increase of 6.4% (183 g) between 2020 and 2021, mostly due to the return to pre-pandemic production levels in the Iron and Steel and Iron Ore Pelletizing sectors.

The most significant changes in HCB emissions from 1990 to 2021 include:

- Electric Power Generation (Utilities): decrease of 98% (11 kg), with:
  - Coal (Electric Power Generation): decrease of 98% (10 kg)
- Incineration and Waste: decrease of 36% (5.5 kg), with:
  - Waste Incineration: decrease of 36% (5.5 kg)

Figure 2–12 **Trends in Canadian HCB Emissions (1990 to 2021)**

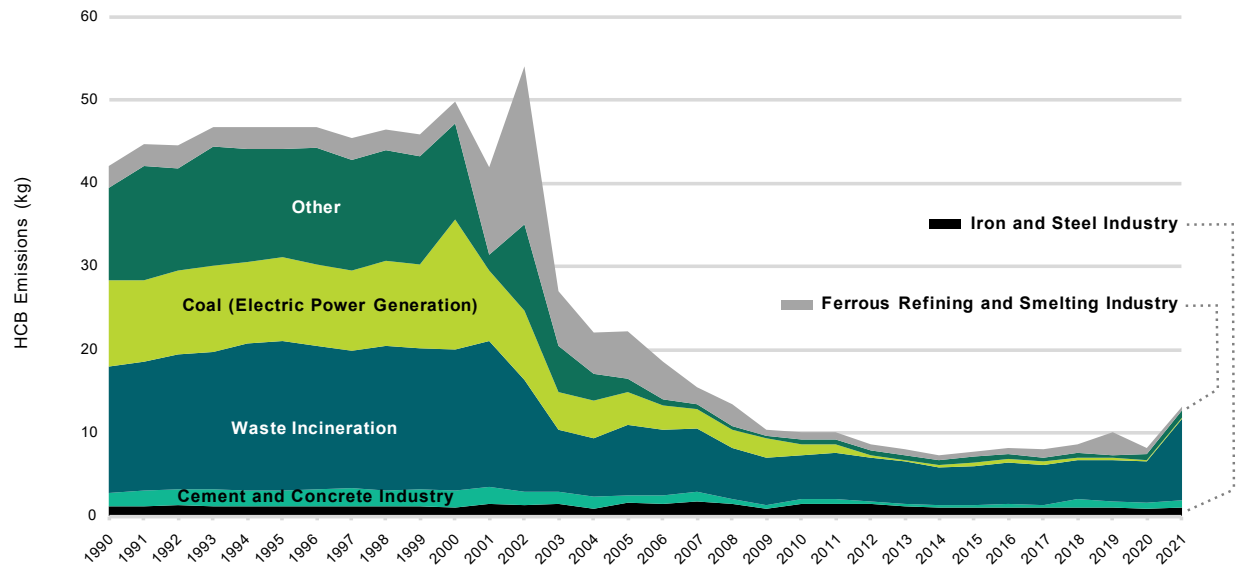


Table 2–14 National Summary of Annual HCB Emissions

Source	1990	2000	2005	2016	2017 (g)	2018	2019	2020	2021
ORE AND MINERAL INDUSTRIES	**5 600**	**5 900**	**8 100**	**2 500**	**2 700**	**3 400**	**4 700**	**2 900**	**3 100**
Aluminium Industry	0.52	1.3	-	89	90	89	90	81	39
Asphalt Paving Industry	-	-	-	-	-	-	-	-	-
Cement and Concrete Industry	1 600	2 100	880	410	300	900	790	770	840
Foundries	47	62	-	160	190	180	140	110	150
Iron and Steel Industry	1 200	1 000	1 600	1 000	1 100	1 100	1 000	890	1 100
Iron Ore Pelletizing	-	-	-	-	-	-	-	280	450
Mineral Products Industry	25	27	-	-	-	-	-	-	-
Mining and Rock Quarrying	-	-	44	12	7.5	6.5	9.8	9.7	99
Non-Ferrous Refining and Smelting Industry	2 700	2 600	5 600	830	1 000	1 100	2 700	720	370
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**	**570**	**460**	**400**	**310**	**240**	**240**
Coal	10 000	16 000	3 900	430	360	300	260	200	190
Landfill Gas	4.8	-	-	-	-	-	-	-	-
Natural Gas	640	1 300	170	120	84	81	45	35	43
Diesel	-	-	-	-	-	-	-	-	-
Other (Electric Power Generation)	-	190	-	17	16	17	8.1	4.1	8.1
MANUFACTURING	**10 000**	**9 800**	**1 400**	**85**	**110**	**100**	**67**	**67**	**57**
Abrasives Manufacturing	-	-	-	-	-	-	-	-	-
Bakeries	-	-	-	-	-	-	-	-	-
Biofuel Production	-	-	-	-	-	-	-	-	-
Chemicals Industry	680	330	480	-	-	-	-	2.8	-
Electronics	0.25	0.32	-	-	-	-	-	-	-
Food Preparation	-	2.9	3.0	-	-	-	-	-	-
Glass Manufacturing	0.059	1.2	-	-	-	-	-	-	-
Grain Industry	-	-	-	-	-	-	-	-	-
Metal Fabrication	260	280	-	-	-	-	-	-	-
Plastics Manufacturing	0.00	0.00	0.00	-	-	-	-	-	-
Pulp and Paper Industry	140	180	310	85	110	100	67	64	57
Textiles	-	-	-	-	-	-	-	-	-
Vehicle Manufacturing (Engines, Parts, Assembly, Painting)	8 900	8 400	-	-	-	-	-	-	-
Wood Products	340	580	620	0.11	0.088	0.090	0.072	0.086	0.085
Other (Manufacturing)	0.00	0.00	-	-	-	-	-	-	-
TRANSPORTATION AND MOBILE EQUIPMENT	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
Air Transportation (LTO)	-	-	-	-	-	-	-	-	-
Domestic Marine Navigation, Fishing and Military	-	-	-	-	-	-	-	-	-
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	-	-	-	-	-	-	-	-	-
Motorcycles	-	-	-	-	-	-	-	-	-
Off-Road Diesel Vehicles and Equipment	-	-	-	-	-	-	-	-	-
Off-Road Gasoline/LPG/NG Vehicles and Equipment	-	-	-	-	-	-	-	-	-
Rail Transportation	-	-	-	-	-	-	-	-	-
Tire Wear and Brake Lining	-	-	-	-	-	-	-	-	-
AGRICULTURE	**-**	**-**	**-**	**1.1**	**1.0**	**0.82**	**0.78**	**0.60**	**0.49**
Animal Production	-	-	-	-	-	-	-	-	-
Crop Production	-	-	-	-	-	-	-	-	-
Agricultural Fuel Combustion	-	-	-	1.1	1.0	0.82	0.78	0.60	0.49
COMMERCIAL/RESIDENTIAL/INSTITUTIONAL	**1.6**	**4.4**	**1.3**	**0.23**	**-**	**-**	**-**	**-**	**-**
Commercial and Institutional Fuel Combustion	0.11	3.0	0.00	-	-	-	-	-	-
Commercial Cooking	-	-	-	-	-	-	-	-	-
Construction Fuel Combustion	-	-	-	-	-	-	-	-	-
Home Firewood Burning	-	-	-	-	-	-	-	-	-
Human	-	-	-	-	-	-	-	-	-
Marine Cargo Handling	-	-	-	-	-	-	-	-	-
Residential Fuel Combustion	1.5	1.4	1.3	0.23	-	-	-	-	-
Service Stations	-	-	-	-	-	-	-	-	-
Other (Miscellaneous)	-	-	-	-	-	-	-	-	-
INCINERATION AND WASTE	**15 000**	**17 000**	**8 500**	**5 100**	**4 900**	**4 800**	**4 900**	**5 000**	**9 800**
Crematoriums	10	14	18	28	29	31	31	34	35
Waste Incineration	15 000	17 000	8 500	5 000	4 800	4 800	4 900	4 900	9 800
Waste Treatment and Disposal	-	81	39	-	-	-	-	-	-
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	**42 000**	**50 000**	**22 000**	**8 300**	**8 100**	**8 700**	**10 000**	**8 200**	**13 000**

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

Other Emissions Estimated in the APEI

Source	1990	2000	2005	2016	2017	2018	2019	2020	2021
Domestic Air Transportation (Cruise)	-	-	-	-	-	-	-	-	-
International Air Transportation (Cruise)	-	-	-	-	-	-	-	-	-
International Marine Navigation	-	-	-	-	-	-	-	-	-

Note: Refer to Annex 4.4 for more information on international marine navigation and air transportation reporting emissions.

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 (section 3.6) is performed throughout the inventory development process. Every year, the whole time series (from 1990 to the latest year) is estimated and continuous improvement often results in revisions to previously published estimates, called recalculations (section 3.7).

Facility-Reported Emissions

As a first step, 17 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 most facility-reported emissions used in the air pollutant emissions 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 which are 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 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), relational databases (MS Access and SQL server), using computational scripts (R and Python), and may include spatial data quantified using geographic information systems software (GIS-ArcGIS and QGIS).

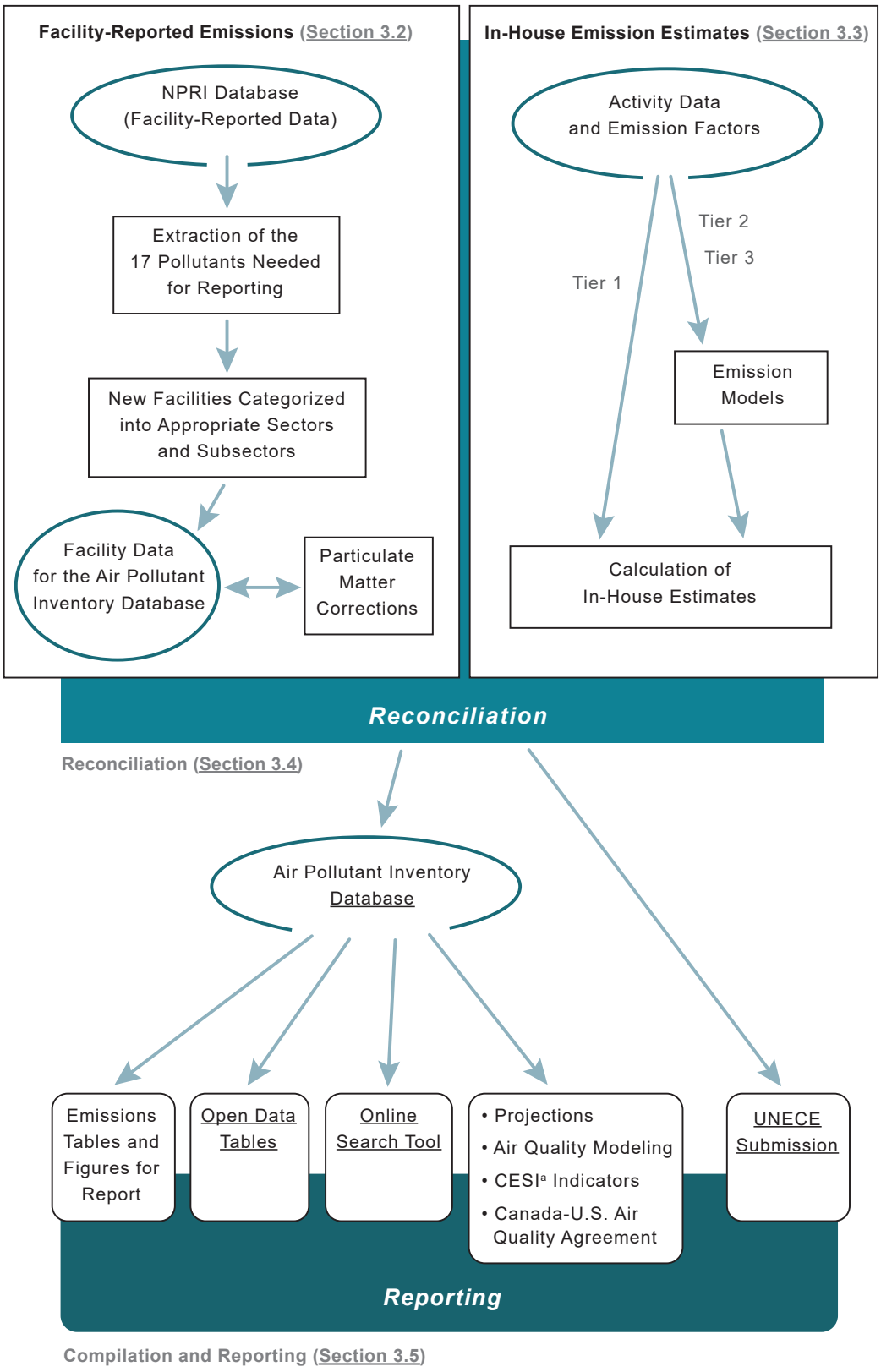
More information on in-house estimates can be found in section 3.3.

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 through 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. The origin of the emissions 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 2021, reconciliation was performed for 29 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. CESI = Canadian Environmental Sustainability Indicators

Table 3–1 **Origin of 2021 Air Pollutant Emissions Estimates by Inventory Category**

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	☑	☑	2021
Cement and Concrete Industry			
Cement Manufacturing	☑		
Concrete Batching and Products	☑	☑	2021
Gypsum Product Manufacturing	☑		
Lime Manufacturing	☑		
Foundries			
Die Casting	☑		
Ferrous Foundries	☑	☑	2021
Non-Ferrous Foundries	☑		
Iron and Steel Industry			
Primary (Blast Furnace and DRI)	☑		
Secondary (Electric Arc Furnaces)	☑	☑	2021 (Hg in Products)
Steel Recycling	☑	☑	2021 (Hg in Products)
Iron Ore Pelletizing	☑		
Mineral Products Industry			
Brick Products	☑		
Clay Products	☑		
Other (Mineral Products Industry)	☑		
Mining and Rock Quarrying			
Coal Mining Industry	☑		
Iron Ore Mining	☑		
Limestone	☑		
Metal Mining	☑		
Potash	☑		
Rock, Sand and Gravel	☑	☑	2021
Silica Production		☑	2020
Other (Mining and Rock Quarrying)	☑		
Non-Ferrous Refining and Smelting Industry			
Primary Ni, Cu, Zn, Pb	☑		
Secondary Pb, Cu	☑		
Other (Non-Ferrous Refining and Smelting Industry)	☑		
OIL AND GAS INDUSTRY			
Downstream Oil and Gas Industry			
Natural Gas Distribution	☑	☑	2021
Petroleum Refining	☑		
Refined Petroleum Products Bulk Storage and Distribution	☑	☑	2021
Refined Petroleum Product Pipelines	☑		
Other (Downstream Oil and Gas Industry)	☑		
Upstream Oil and Gas Industry			
Accidents and Equipment Failures		☑	2021
Disposal and Waste Treatment		☑	2021
Heavy Crude Oil Cold Production		☑	2021
Light/Medium Crude Oil Productionc	☑	☑	2021
Natural Gas Production and Processing[d]	☑	☑	2021
Natural Gas Transmission and Storage	☑	☑	2021
Oil Sands In-Situ Extraction	☑		
Oil Sands Mining, Extraction and Upgrading	☑		
Petroleum Liquids Storage	☑		
Petroleum Liquids Transportation		☑	2021
Well Drilling/Servicing/Testing		☑	2021
ELECTRIC POWER GENERATION (UTILITIES)			
Coal	☑		
Diesel	☑		
Natural Gas	☑		
Other (Electric Power Generation)	☑		
MANUFACTURING			
Abrasives Manufacturing	☑		
Bakeries	☑	☑	2021
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	☑	☑	2021 (Hg in Products)
Food Preparation	☑		
Glass Manufacturing	☑		
Grain Industry			
Grain Processing	☑	☑	2021
Warehousing and Storage	☑		2021
Metal Fabrication	☑		
Plastics Manufacturing	☑		
Pulp and Paper Industry			
Converted Paper Product Manufacturing	☑		
Pulp and Paper Product Manufacturing	☑		
Textiles	☑		

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

Air Pollutant Emissions Inventory Categories	Facility-Reported Data[a]	In-House Estimates[b]	Activity Data Used for in-House Estimates
Vehicle Manufacture (Engines, Parts, Assembly, Painting)	☑		
Wood Products[e]			
Panel Board Mills	☑	☑	2021
Sawmills	☑	☑	2021
Other (Wood Products)	☑		
Other (Manufacturing)	☑		
TRANSPORTATION AND MOBILE EQUIPMENT			
Air Transportation (LTO)		☑	2021
Domestic Marine Navigation, Fishing and Military		☑	2021
Heavy-Duty Diesel Vehicles		☑	2021
Heavy-Duty Gasoline Vehicles		☑	2021
Heavy-Duty LPG/NG Vehicles		☑	2021
Light-Duty Diesel Trucks		☑	2021
Light-Duty Diesel Vehicles		☑	2021
Light-Duty Gasoline Trucks		☑	2021
Light-Duty Gasoline Vehicles		☑	2021
Light-Duty LPG/NG Trucks		☑	2021
Light-Duty LPG/NG Vehicles		☑	2021
Motorcycles		☑	2021
Off-Road Diesel Vehicles and Equipment		☑	2021
Off-Road Gasoline/LPG/NG Vehicles and Equipment		☑	2021
Rail Transportation		☑	2021
Tire Wear and Brake Lining		☑	2021
AGRICULTURE			
Agricultural Fuel Combustion	☑	☑	2021
Animal Production		☑	2021
Crop Production			
Harvesting		☑	2021
Inorganic Fertilizer Application		☑	2021
Sewage Sludge Application		☑	2021
Tillage Practices		☑	2021
Wind Erosion		☑	2021
COMMERCIAL/RESIDENTIAL/INSTITUTIONAL			
Commercial and Institutional Fuel Combustion	☑	☑	2021
Commercial Cooking		☑	2021
Construction Fuel Combustion		☑	2021
Home Firewood Burning		☑	2019
Human		☑	2021
Marine Cargo Handling	☑		
Residential Fuel Combustion		☑	2021
Service Stations		☑	2021
Other (Miscellaneous)[f]		☑	2021
INCINERATION AND WASTE			
Crematoriums	☑	☑	2021
Waste Incineration			
Hazardous Waste Incineration	☑	☑	2021
Medical Waste Incineration	☑	☑	2021
Municipal Incineration	☑	☑	2021
Residential Waste Burning[g]		☑	2021
Sewage Sludge Incineration	☑	☑	2021
Other (Waste Incineration)	☑		
Waste Treatment and Disposal			
Biological Treatment of Waste	☑	☑	2018-2020 (based on availability)
Landfills	☑	☑	2021
Municipal Wastewater Treatment	☑		
Specialized Waste Treatment and Remediation	☑		
Waste Sorting and Transfer	☑		
PAINTS AND SOLVENTS			
Dry Cleaning	☑	☑	2021
General Solvent Use		☑	2021
Printing	☑	☑	2021
Surface Coatings	☑	☑	2021
DUST			
Coal Transportation		☑	2021
Construction Operations		☑	2021
Mine Tailings		☑	2018
Paved Roads		☑	2021
Unpaved Roads	☑	☑	2021
FIRES			
Prescribed Burning		☑	2021
Structural Fires		☑	2021
MERCURY IN PRODUCTS[h]		☑	2021

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]
- online Search Tool[3]
- input to other products, such as air pollutant emissions projections,[4] air quality modeling, Canadian Environmental Sustainability Indicators,[5] and reports under the Canada-U.S. Air Quality Agreement[6]
- Canada's submission to the United Nations Economic Commission for Europe (UNECE) under the Convention on 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 all the 17 pollutants included in the APEI for industrial and commercial facilities since 2002. For some pollutants, the data collection began earlier. It started as early as 1993 for the three heavy metals (Pd, Cd and Hg), in 1995 for ammonia and in 2000 for polycyclic aromatic hydrocarbons [PAHs], dioxins and furans and hexachlorobenze [HCB]. Prior to 2002, facility-level emissions for the criteria air contaminants (CACs) were collected and compiled by provincial, territorial and regional environmental authorities across Canada and provided to ECCC for inclusion in the APEI.

Facility-reported data from the NPRI are used in the APEI without modification, 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.[7]

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. Some facilities may be required to report emissions of certain pollutants only. 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 were primarily provided by provinces and territories. 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 the use of 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 and territories 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 some provincial governments on selected sources that are not reported to the NPRI.

The NPRI groups substances into five parts, as 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)

1 www.canada.ca/apei

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

3 https://pollution-waste.canada.ca/air-emission-inventory

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

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

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

7 www.canada.ca/NPRI

Table 3–2 shows the 17 air pollutants reported in the APEI and their NPRI reporting thresholds. No VOC data collected under Part 5 are used in the APEI.

In 2021, 6 160 facilities reported releases to air of one or more APEI pollutants to the NPRI. Since 1993, nearly 20 000 facilities have reported at least one of the seventeen APEI pollutants. Over the years, many facilities have fallen below the emissions reporting threshold or have ended operations and no longer report to the NPRI program. There may also be times, for example for oil and gas facilities, that facilities have changed ownership. The new owner would not necessarily reuse the same number used to identify the facility in the NPRI reporting system by the previous owner. The end result would look like the opening of a new facility and the closing and an old facility. Therefore, the total true number of facilities over time could be somewhat less than 20 000. Using the 2021 NPRI database, with data available as of September 29, 2022, 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.

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. Additional research and verifications on facility's operations are then performed to confirm or correct the classification into the appropriate APEI sector or subsector. The assigned classification is used for subsequent reporting years, as long as the facility does not change operations.

NPRI reporting facilities may not report all three PM size fractions: TPM, PM_{10} and $PM_{2.5}$. For cases where only one or two of the three PM size fractions are 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 emissions data for most sectors, 2002–2017 facility-reported emissions data or detailed studies for other sectors, or derived from NPRI toolbox guidance (e.g., unpaved roads). Where ratios were calculated using facility-reported data, the ratio for each facility is calculated and then averaged by sector. The resulting distributions are presented in Table 3–3.

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
Iron Ore Pelletizing	**0.480**	**0.212**	**0.410**
Mineral Products Industry			
Brick Products	0.757	0.230	0.323
Clay Products	0.802	0.094	0.484
Other (Mineral Products Industry)	0.762	0.545	0.665
Mining and Rock Quarrying			
Coal Mining Industry	0.368	0.064	0.147
Iron Ore Mining	0.513	0.191	0.432
Limestone	0.46	0.165	0.397
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	–	–	–
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			
Natural Gas Distribution[a]	1.000	1.000	1.000
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
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
Landfill Gas	0.734	0.54	0.76
Natural Gas	0.909	0.663	0.902
Other (Electric Power Generation)	0.735	0.608	0.924
MANUFACTURING			
Abrasives Manufacturing	**0.415**	**0.231**	**0.669**
Bakeries	**0.861**	**0.744**	**0.760**
Biofuel Production	**–**	**–**	**–**
Chemicals Industry			
Chemical Manufacturing	0.737	0.595	0.754
Cleaning Compound Manufacturing	1.000	1.000	1.000
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**	**0.590**	**0.771**
Plastics Manufacturing	**0.731**	**0.474**	**0.817**
Pulp and Paper Industry			
Converted Paper Product Manufacturing	0.805	0.64	0.773
Pulp and Paper Product Manufacturing	0.737	0.56	0.757
Textiles	**1**	**1**	**0.759**

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
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**
Drinking Water[c]	**1.000**	**1.000**	**0.968**
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)	–	–	–
Domestic Marine Navigation, Fishing and Military	–	–	–
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	–	–	–
Motorcycles	–	–	–
Off-Road Diesel Vehicles and Equipment	–	–	–
Off-Road Gasoline/LPG/CNG Vehicles and Equipment	–	–	–
Rail Transportation	–	–	–
Tire Wear and Brake Lining	–	–	–
AGRICULTURAL FUEL COMBUSTION			
Agricultural Fuel Combustion	**0.646**	**0.503**	**0.749**
Animal Production	–	–	–
Crop Production	–	–	–
Harvesting	–	–	–
Inorganic Fertilizer Application	–	–	–
Sewage Sludge Application	–	–	–
Tillage Practices	–	–	–
Wind Erosion	–	–	–
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			
Hazardous Waste Incineration	–	–	–
Medical 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			
Biological Treatment of Waste	1.000	1.000	1.000
Landfills	0.778	0.603	0.743
Municipal Wastewater Treatment	1.000	1.000	0.968
Specialized Waste Treatment and Remediation	0.818	0.790	0.953
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	**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; Drinking Water; 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.

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

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

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

$PM_{10}\ ratio$	=	Ratio of the sector's PM_{10} emissions to TPM emissions
$PM_{10}\ emissions$	=	PM_{10} emissions for the sector
$TPM\ emissions$	=	Total particulate matter emissions for the sector

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

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

$PM_{2.5}\ ratio$	=	Ratio of the sector's $PM_{2.5}$ emissions to its TPM emissions
$PM_{2.5}\ emissions$	=	$PM_{2.5}$ emissions for the sector
$TPM\ emissions$	=	Total particulate matter emissions for the sector

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

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

$PM_{2.5}/PM_{10}\ ratio$	=	Ratio of the sector's $PM_{2.5}$ emissions to its 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 industrial air pollution data in Canada. Sectors with significant sources of facility-reported data (e.g., petroleum 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 the 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 provide 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 subsectors that have limited coverage in the NPRI because many facilities do not meet the reporting thresholds (e.g., Natural Gas Production and Processing, Light/Medium Crude Oil Production, Sawmills, Ferrous Foundries, etc.).

Other sources of air pollutants, such as Residential Fuel Combustion, Transportation and Mobile Equipment 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, such as the burning of agricultural wastes and demolition activities in the construction industry.

In-house estimates are calculated using information such as production data and activity data, using various estimation methodologies, emission models and emission factors[8]. Depending on the source, there are three methodological tiers that represent varying levels of complexity: Tier 1 is the simplest; Tier 2, the intermediate; and Tier 3, the most demanding in terms of complexity and data requirements. Tier 2 and 3 methods are referred to 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 such that they represent typical process conditions, and they tend to be technology independent. UNECE provides Tier 1 methods for all sources and substances that countries that have ratified the protocols of the Convention on Long-range Transboundary Air Pollution are required to report. Tier 2 methods use the same or similar activity data as Tier 1 methods, but apply country-specific emission factors, which need to be developed using country-specific information. Tier 3 methods go beyond the previous two methods and may include using facility-level data, specific information on the types of technologies being used at facilities, pollution abatement equipment, and/or sophisticated models. It is a good practice to use higher tier methods for categories that are large contributors 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 calculated at the provincial, territorial and national level. Table 3–1 illustrates the complete list of sectors and subsectors of the APEI for which emissions are based on in-house estimates and provides the activity data year on which the 2021 in-house estimate is based.

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

3.4. Reconciliation

In several sectors, such as the Upstream Oil and Gas Industry, estimation of total emissions involves combining estimates provided by facilities with estimates developed in-house by ECCC. To prevent double counting of emissions and to confirm that the APEI includes all emissions, a comparison and reconciliation of emission estimates from various sources is performed for each pollutant, industry sector and geographical region, as appropriate.

3.4.1. General Procedures

The approach for reconciling facility-reported data and in-house estimates for a specific pollutant is as follows:

- For most industrial sectors, the NPRI facility-reported data capture all facilities' emissions, which means that no in-house estimates are required (i.e., InHouseEstimateREC = 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 2021, reconciliation was performed for the Asphalt Paving Industry.
- If the total of the in-house estimates is greater than or equal to the total facility-reported data, the reconciled in-house estimate is equal to the total of the in-house estimates minus the total of the facility-report data, as outlined in Equation 3–4.

Equation 3–4

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

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

- 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 0, as outlined in Equation 3–5.

Equation 3–5

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

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

8 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)."

Some points to consider:

- In general, InHouseEstimateREC represents non-reporting facilities (including smaller facilities or emissions from reporting facilities that do not meet reporting requirements).
- In cases where InHouseEstimateREC = 0 (Equation 3–5), facility-reported data are considered to reflect all the sector emitting sources.

There are sectors where the typical reconciliation approach is not used. Sections 3.4.2, 3.4.3, 3.4.4 and 3.4.5 provide information on reconciliation approaches that are unique in nature.

3.4.2. Wood Products

Particulate matter emissions (TPM, PM_{10} and $PM_{2.5}$) from the Sawmills and Panel Board Mills subsectors (Wood Products sector) were not reconciled using the procedure described in section 3.4.1. Rather, NPRI facility-reported data from these subsectors 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 and territorial level according to the standard procedure and equations outlined in section 3.4.1.

3.4.3. Wastewater Treatment and Sewage Sludge Incineration

Most sewage sludge incineration occurs at municipal wastewater treatment plants, rather than at distinct incineration facilities. Facility-reported data is presently only reported as a single category whereas for APEI reporting, wastewater treatment and sewage sludge incineration are categorized under distinct subsectors. Therefore, to reflect the emissions associated with sewage incineration at wastewater treatment sites, some emissions are transferred from the wastewater treatment category to the sewage sludge incineration category. For such facilities, it is assumed that all stack emissions are related to incineration while other types of releases remain classified under the wastewater treatment subsector.

3.4.4. 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 include a variety of sources (solvent use as well as processes, fuel combustion, road dust, etc.) grouped under the same NAICS. Given the complexity of the solvent sectors, reconciliation of in-house estimates with facility-reported data from the NPRI requires that the following steps be performed by a specially designed database application (Cheminfo Services, 2019):

1. allocation of the solvent use in-house estimates to the 4-digit NAICS level from the NPRI
2. allocation of the NPRI VOC inventory totals at the 4-digit NAICS level to “Process” and “Solvent” type emissions
3. subtraction of 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.

3.4.5. 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. Reconciliation of Hg air emissions from mercury in products with NPRI 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 remain unchanged (Equation 3–6 and Equation 3–7):

Equation 3–6

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

Equation 3–7

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

This is done at the provincial and territorial level by year.

3.5. Compilation and Reporting

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

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 subsector level, while phase 3 is performed on the final database of reconciled and compiled emissions, including NFR tables. See Figure 3–2 for a visual representation of the different quality control check points.

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. This phase is divided into two parts.

First, high level completeness tests are completed on NPRI data before sharing facility data with sectoral experts. This step involves comparison with the previous year's dataset and identify any significant changes. High level checks on the number of facilities reporting, number of records included in the database, number of new facilities and total emissions by pollutants by year are performed to ensure sufficient completeness before proceeding to more detailed analysis and quality control (refer to 3.6.1.a in Figure 3–2).

Once the initial checks are satisfied, the facility-reported dataset is prepared and shared with sectoral experts for more specific and in depth quality control. The quality control process is adapted where necessary such that category-specific or sector-specific quality control procedures are applied, as appropriate (refer to 3.6.1.b in Figure 3–2). A key part of the quality control process is identifying missing NPRI facility reporters and assessing new reporters to ensure that the correct data are captured and allocated to the appropriate sectors and subsectors.

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.

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.

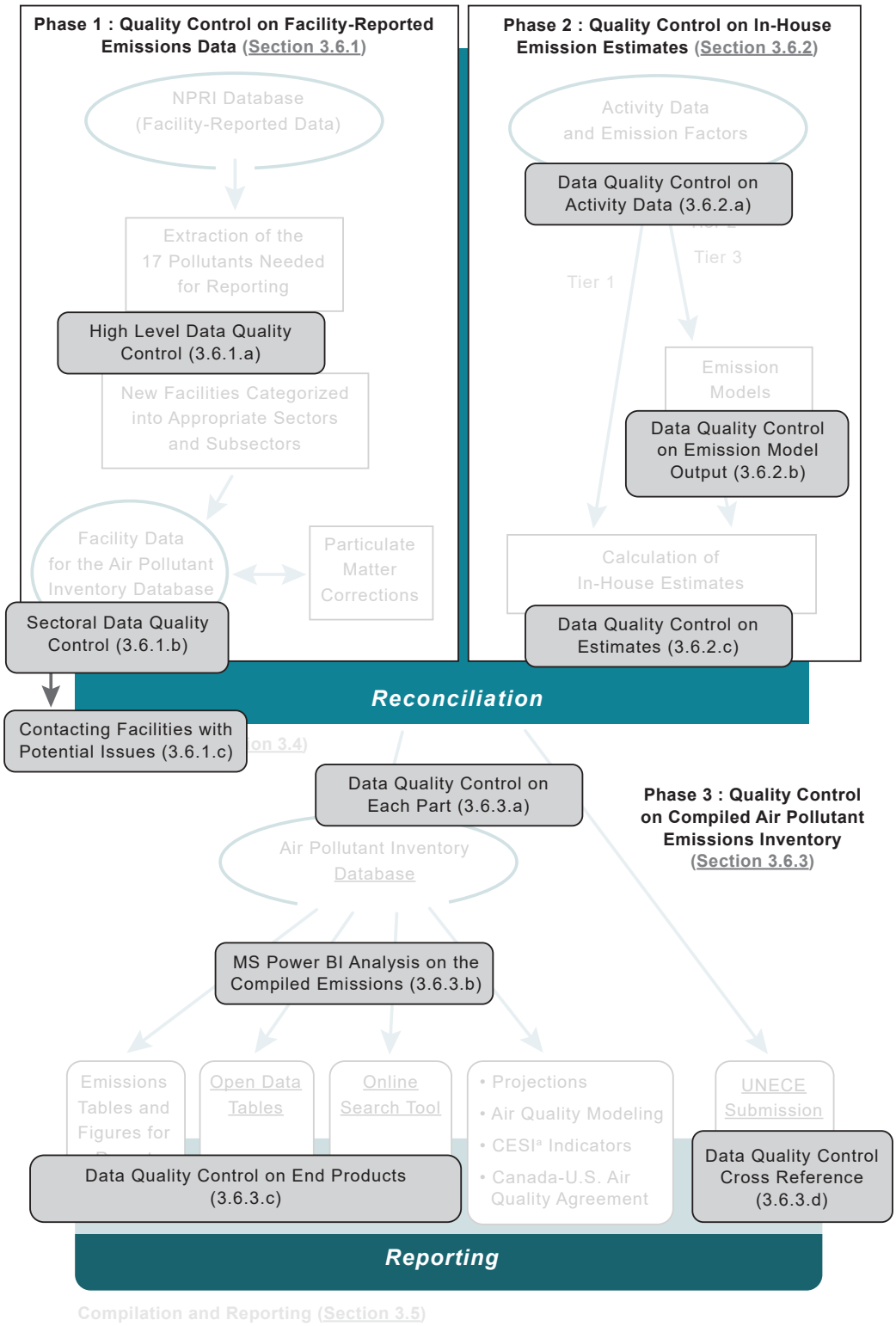
In addition to identifying missing NPRI facilities and outliers, the quality control review includes analysis of:

- the impact of first-year reporting;
- substances that are no longer reported, inconsistently reported, or that have never been reported by a facility that conducts activities that are expected to be emissive;
- 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.

Finally, quality control checks are also performed on facility information. These checks include facility identification numbers and geographical information (i.e., city, province and territory, address and latitude and longitude).

Once the review of the facility data is complete, facilities are contacted to resolve identified issues with significant impacts. Identification, facility follow-up and resolution of such issues are conducted at the earliest stage of the quality control review. Where unresolved issues persist, any updates to the data will be reflected in the next inventory edition (refer to 3.6.1.c in Figure 3–2).

Figure 3–2 **Quality Control Check Points**



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 to ensure quality, accuracy and consistency. The following are verified:

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

Activity data (refer to 3.6.2.a in Figure 3–2) and emission estimates are reviewed by multiple sector experts to identify outliers, similar to the review of facility reported data. Potential outliers are defined as sector level activity data and emissions that:

- have large year-over-year changes;
- have changed significantly since the previous reporting year.

Emissions estimates (refer to 3.6.2.b in Figure 3–2) are further compared against other metrics for the sectors, such as: heating degree days, electricity generation, population, or gross domestic product. These comparisons are used to confirm general trends identified. Additional information is gathered from industry associations or news releases related to temporary shut-downs, plant closures, and re-tooling of facilities which is used to confirm trends.

Best-available emission factors are chosen by sector experts to reflect Canadian conditions for the various sectors. For example, emission factors for residential firewood burning are currently taken from the US EPA as their technology is also used in Canada.

Prior to implementation, in-house models are rigorously tested to ensure activity data and emission factors are correctly applied, unit conversions are consistent throughout and resulting emissions estimates are in the appropriate sector (refer to 3.6.2.c in Figure 3–2).

3.6.3. Phase 3: Compiled Air Pollutant Emissions Inventory

Phase 3 includes all tests performed immediately prior to compiling the estimates as well as the analysis of the results and different products once they have been compiled in a final database. Before integrating the emissions estimates from all sources, automated quality control tests are done on each individual part. The tests performed include checking for duplicates, ensuring that all sources are considered and all mandatory fields are filled according to the standards, and verifying units. The purpose of the tests is to ensure the quality of the compiled data (refer to 3.6.3.a in Figure 3–2).

Once all estimates have been compiled, trend analysis graphics and recalculations graphics are produced to analyze the consistency of the estimates. Data visualization tools, such as Microsoft Power BI, are also used to perform trend and recalculation analysis and to identify any abnormal gaps. Data are analyzed at different levels. They are analyzed by pollutant, by source, sector or sub-sectors. Gaps can be identified either from their impact on the overall contribution to the national trend or from their impact on the category itself. Trends are also analyzed by province and territory. Any significant changes from year to year and any recalculated emissions are identified and explained (refer to 3.6.3.b in Figure 3–2).

Quality control is also performed on all other APEI products, including the data tables presented in this report as well as data published online (refer to 3.6.3.c in Figure 3–2). At this stage, the quality control tests mainly consist of verifying that totals (for different layers of disaggregation, different years and different pollutants) match the compiled estimates. The various end products are also compared against each others as an additional quality control step.

As a last step, quality control tests are made on the NFR tables (refer to 3.6.3.d in Figure 3–2). Some tests are automated and are run on the compiled tables that will be submitted to the UNECE. They include verifying totals for each pollutant and each year and comparing those values with what is reported in this report. A completeness test is also run to make sure every cell has a value, either a numerical value or a notation key. Other quality control checks are also made by sectoral experts and are, in some cases, cross referenced with the sector-level estimates. For more information on the NFR tables, refer to Annex 4.

3.7. Recalculations

Emissions 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 from the base year (1990) to ensure a consistent and comparable trend in emissions. Recalculations of previously reported emission estimates are common for in-house estimates and can also occur with facility-reported emissions data. More information on recalculations is provided in Annex 3.

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 airborne solid and liquid particles of various origins that remain suspended in air for any length of time. PM can be emitted directly into the atmosphere or formed secondarily from precursor gases as a result of physical and chemical transformations. 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. The size of PM particles influences the extent of environmental and health damage caused.

Total Particulate Matter (TPM)

TPM includes any airborne 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 airborne 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 airborne 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, such as motor vehicles and vegetation burning, but can also come from industrial processes 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.

Both SO_2 in its untransformed state, and the acid and sulphate transformation products of SO_2, can have adverse effects on human health or the environment. SO_2 oxidation into sulphuric acid is the main ingredient of acid rain, which can damage crops, forests, buildings and materials, and contribute to acidification of ecosystems. When sulphate is combined with other compounds in the atmosphere, such as NH_3, it becomes an important contributor to $PM_{2.5}$. It is also one of the principal precursors to PM_{10}.

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 emitted during combustion quickly oxidizes to NO_2 in the atmosphere. NO_2 dissolves in water vapour in the air to form acids, and interacts with other gases and particles in the air to form particles known as nitrates and other products that may be harmful to respiratory systems of humans and their environment. Nitric acid (HNO_3) can cause damage to vegetation, buildings and materials, and contribute to acidification of ecosystems. 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. When nitrate is combined with other compounds in the atmosphere, such as NH_3, it also becomes

an important contributor to the formation of $PM_{2.5}$. NO_x originate from both anthropogenic and natural sources. The main anthropogenic sources are from combustion in transportation, electric power generation as well as the upstream oil and gas industry. The main natural sources are forest fires, lightning and soil microbial activity.

Volatile Organic Compounds (VOCs)

VOCs are gases or vapors organic compounds containing one or more carbon atoms that evaporate readily to the atmosphere and react photochemically to form ground-level ozone, and $PM_{2.5}$, leading to smog. VOCs originate from anthropogenic and natural sources. Besides biogenic sources (e.g., vegetation), other major sources include combustion and evaporation processes related to the upstream oil and gas industry, general solvent use, mobile sources, and other miscellaneous sources.[1] VOCs may condense in the atmosphere, contributing to ambient PM formation and acid rain. A number of individual VOCs, such as benzene and dichloromethane, have been assessed to be toxic under CEPA 1999, while other VOCs (e.g., formaldehyde and benzene) are carcinogenic. The term Non-methane volatile organic compounds (NMVOCs) is equivalent to VOCs in this report.

Carbon Monoxide (CO)

CO is a colourless, odourless, and tasteless poisonous 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 incomplete combustion of hydrocarbon-based fuels, primarily from mobile sources. The wood industry, residential wood heating, and forest fires represent lesser but significant 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 colourless and corrosive gas that originates mostly from anthropogenic sources. Major sources of NH_3 emissions include agricultural livestock, waste management, agricultural fertilizer use and synthetic fertilizer manufacturing. NH_3 has been identified as one of the principal precursors to $PM_{2.5}$.

A1.2. Selected Heavy Metals

Lead (Pb)

Pb is a toxic metallic element, which occurs naturally in the Earth's crust. Pb is used in plumbing, gasoline, paint, and pewter manufacturing. 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. Small amounts of lead can be hazardous to human health.

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), stationary fuel combustion, transportation, solid waste disposal, and sewage sludge application. Major sources from natural processes include weathering and erosion of cadmium-bearing rocks, as well as forest fires and volcanic emissions.

Mercury (Hg)

Despite its toxic nature, 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 come from various sectors such as iron and steel production, electric power generation from combustion of coal, waste incineration and various commercial, residential and institutional uses. Hg can exist in several forms depending on the surrounding conditions.

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.

A1.3. Persistent Organic Pollutants

Dioxins and Furans

Dioxins and furans are a family of anthropogenic toxic compounds that are found in very small amounts in the environment, including air, water, and soil. 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 municipal and residential waste. Other major sources include the production of cement and concrete industry, the production of iron and steel, electrical power generation and home firewood burning. Natural sources of dioxins and furans are forest fire and volcanic eruptions.

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, aluminum smelters and transportation. Forest fires are the most important natural source of PAHs in Canada.

In this report, 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 information on PAHs.

Hexachlorobenzene (HCB)

HCB is carcinogenic. It has not been used commercially in Canada since 1972 (Environment and Climate Change Canada [ECCC], 2017), although it is released to the environment in trace amounts as a by-product from the manufacture and use of chlorinated solvents and pesticides, through long-range transport and deposition. HCB has been prohibited globally under the Stockholm Convention and the Protocol on Persistent Organic Pollutants under the CLRTAP. 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 use 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 emissions for civil and international aviation, railways and navigation are estimated using detailed vehicle movement statistics coupled with fuel consumption, engine information, and emission rates by vehicle types.

Table A2–1 through Table 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.

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	Emissions from the Asphalt Paving Industry consist of those 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 includes both permanent or portable hot-mix asphalt installations.
General Inventory Method	Pollutant(s) estimated: TPM, PM_{10}, $PM_{2.5}$, SO_x, NO_x, VOCs, CO, Pb, Cd, Hg, dioxins/furans, B[a]p, B[b]f, B[k]f, I(cd)p Total use of asphalt by province and territory is multiplied by pollutant-specific emission factors.
Activity Data	Cutback and emulsion asphalt data are used to calculate volatile organic compound (VOC) emissions from the paving process: SNC/GECO Canada Inc. and Ontario Research Foundation (1981) Asphalt use 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 and I(cd)p: Senes Consultants (2008) 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. 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 plant stores, convey, measure and discharge these constituents into trucks for transport to a construction site or process, for use in the manufacturing of concrete pipes, concrete blocks, etc.
General Inventory Method	Pollutant(s) estimated: TPM, PM_{10}, $PM_{2.5}$, Pb, Cd Provincial and territorial cement distribution ratios are calculated based on the provincial and territorial population data, and data on the distribution of cement consumption by province and territory. To obtain the total use of concrete by province and territory, the provincial and territorial cement distribution ratios are multiplied by the national domestic consumption of Portland cement and the ratio of concrete produced from Portland cement. National domestic consumption of Portland cement is the sum of the production and imports of Portland cement, minus the exports of Portland cement. Due to the discontinuation of the Annual survey of cement (Table-16-10-0009-01) by Statistics Canada in 2018, to estimate 2019-2021 Portland cement production, the Portland cement-to-clinker ratio is multiplied by the annual clinker production of each of these years. The total use of concrete by province and territory is then multiplied by pollutant-specific emission factors to obtain emission estimates.
Activity Data	Cement consumption distribution for the provinces: CANMET (1993) Portland Cement import and export data: Statistics Canada (2022) Clinker production data: Environment and Climate Change Canada (ECCC) (2022) 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) Emission factors for TPM, PM_{10} and $PM_{2.5}$ emitted by loading mixers and loading trucks: (U.S. EPA, 2006) PM_{10} and $PM_{2.5}$ emission factors for sand and aggregate transfer are derived from a weighted combination of TPM emission factors, using information from the U.S. EPA's PM Calculator database (using SCC 30501101): $PM_{10} = 0.51 \times EF_{TPM}$ $PM_{2.5} = 0.15 \times EF_{TPMTPM}$
FERROUS FOUNDRIES (under FOUNDRIES)	
Description	Ferrous Foundries include facilities that produce castings of various types of ferro-alloys and small iron and steel foundries not associated with integrated iron and steel facilities. The types of foundries found in Canada include open ferrous, electric arc and induction foundries.
General Inventory Method	Pollutant(s) estimated: TPM, PM_{10}, $PM_{2.5}$, SO_x, NO_x, VOCs, CO Total production from grey iron or steel foundries by province and territory are multiplied by pollutant-specific emission factors, which are based on the type of foundry. The in-house estimates were last calculated for 2011 and were carried forward to 2021, for all provinces and territories, except for Quebec. Work is ongoing to update activity data for the province of Ontario, which is Canada's major producer of castings from iron and steel foundries.
Activity Data	Production for the province of Québec for 1990-2021 was provided by Direction générale de la réglementation carbone et des données d'émission, Ministère de l'Environnement et de la Lutte contre les changements climatiques (MELCC, 2022).
Emission Factors (EF)	Emissions factors were updated as per the U.S. EPA, AP-42, Chapter 12 (U.S. EPA, 1998).
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, and excludes those from off-road equipment which are reported under Transportation. This model also excludes emissions from the combustion of fuels used in this process. Stone processing is categorized into three activities, depending on the size of stone required: crushed stone, pulverized stone and building stone. Sand and gravel deposits are quarried, classified and stockpiled. Processing is accomplished by crushing, screening, washing, blending and stockpiling materials according to product specifications. Products are used for road construction, as an aggregate for asphalt and concrete, and for other construction purposes such as fill and mortar sand. Sand is also used in the glassmaking, foundry and abrasive industries.
General Inventory Method	Pollutant(s) estimated: TPM, PM_{10}, $PM_{2.5}$ Total quantity of rock, sand and gravel produced by province and territory is multiplied by pollutant-specific emission factors.
Activity Data	Annual Statistics of Mineral Production: NRCan (2021)
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 consists of 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 the material is ground to very fine particle sizes. Dry or wet screening and air classification may be carried out to achieve the desired size distribution. Both wet and dry methods of dust control are used, and baghouses are commonly used.
General Inventory Method	Pollutant(s) estimated: TPM, PM_{10}, $PM_{2.5}$ Total quantity of silica produced by province and territory is multiplied by pollutant-specific emission factors.
Activity Data	Annual Statistics of Mineral Production: NRCan (2021) Confidential provincial production values are estimated using employment distributions: Statistics Canada (n.d.[c])
Emission Factors (EF)	TPM, PM_{10}, $PM_{2.5}$: EEA (2019)
Note: References for this table can be found on page 93.	

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 volatile organic compound (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 the large above-ground tanks, tank trucks, or railcars. In addition, the subsector includes emissions that result from the evaporation of fuels spilled during transfer operations. Only fugitive VOC emissions from bulk plants are estimated in-house.
General Inventory Method	Pollutant(s) estimated: VOCs Emissions are calculated using the gross sales of gasoline for on-road motor vehicles multiplied by emission factors developed by Tecsult Inc (2006).
Activity Data	Gross sales of gasoline for motor vehicles: Statistics Canada (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. 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 Air Pollutant Emissions Inventory (APEI).
General Inventory Method	Pollutant(s) estimated: TPM, PM_{10}, $PM_{2.5}$, SO_x, NO_x, VOCs, CO, NH_3 Emission estimates are generated using data from comprehensive inventories (EC, 2014; CAPP, 2005a) and extrapolated (CAPP, 2005b) from 2012 onwards based on pipeline length.
Activity Data	Gas Pipeline Distance, by province: Statistics Canada (2022) Natural gas injections to storage and withdrawals from storage: Statistics Canada (n.d.[b])
Emission Factors (EF)	EC (2014)
NATURAL GAS TRANSMISSION AND STORAGE (under UPSTREAM OIL AND GAS INDUSTRY)	
Description	Natural Gas Transmission includes emissions from all infrastructure used to transport pipeline quality natural gas to local distribution companies. This sector consists of large diameter pipelines, compressor stations and metering facilities. Natural Gas Storage includes emissions from all infrastructure used to store natural gas produced during off-peak times (i.e., summer) for delivery during peak demand periods (i.e., winter). Gas is stored in spent production fields, aquifers or salt caverns with facilities consisting of piping, meters, compressor stations and dehydrators. Emissions from midstream services (e.g., straddle plants) and gas plants are included under Natural Gas Production and Processing. Emissions from related construction activities, ancillary structures and operations (buildings, offices, etc.) and mobile sources are included under the Construction Operations, Commercial and Institutional Fuel Combustion, and Transportation and Mobile Equipment sources (respectively) of the APEI.
General Inventory Method	Pollutant(s) estimated: TPM, PM_{10}, $PM_{2.5}$, SO_x, NO_x, VOCs, CO, NH_3 Emission estimates are generated using data from comprehensive inventories (EC, 2014; CAPP, 2005a) and extrapolated (CAPP, 2005b) from 2012 onwards. Natural gas transmission emissions are extrapolated based on pipeline length, while natural gas storage emissions are extrapolated based on annual volumes of gas injected and withdrawn.
Activity Data	Gas Pipeline Distance, by province: Statistics Canada (2022) 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 (UOG) Industry includes emissions from all infrastructure used to locate, extract, produce, process/treat and transport natural gas, crude oil (light/medium oil, heavy oil, crude bitumen), liquefied petroleum gas (LPG) and condensate to market. It also includes emissions from onshore and offshore facilities, as well as drilling and exploration, conventional oil and gas production, open pit mining and in situ oil sands production, natural gas processing and oil transmission. Specifically, it includes the following subsectors: • Accidents and Equipment Failures • Disposal and Waste Treatment • Heavy Crude Oil Cold Production • Light/Medium Crude Oil Production • Natural Gas Production and Processing • Oil Sands In-Situ Extraction • Petroleum Liquids Transportation • Well Drilling/Servicing/Testing Emissions from related construction activities, ancillary structures and operations (buildings, offices, etc.), and mobile sources are included under the Construction Operations, Commercial and Institutional Fuel Combustion, and Transportation and Mobile Equipment sources (respectively) of the APEI.
General Inventory Method	Pollutant(s) estimated: TPM, PM_{10}, $PM_{2.5}$, SO_x, NO_x, VOCs, CO, NH_3 Emission estimates are generated using data from comprehensive UOG inventories (EC, 2014; CAPP, 2005a) and are extrapolated (CAPP, 2005b) from 2012 onwards using various provincial-level activity data. Alberta reported venting and flaring emissions are calculated directly (i.e., not extrapolated) for the years 2010 to 2021 using monthly conventional volumetric data (Petrinex, 2022a) and detailed gas composition data for each township in Alberta (Tyner and Johnson, 2020). In 2021, vent volumes from Alberta's OneStop program (AEP, 2022) are used in place of Petrinex data. Saskatchewan reported venting and flaring emissions are calculated directly for the years 1990 to 2021 using reported vent and flare volumes (SKMER, 1990–2008, 2009–2011; Petrinex, 2022b) and detailed gas composition data by five production classes[1] provided by the Saskatchewan Ministry of Energy and Resources (SKMER, 2021). Alberta and British Columbia VOC emissions from surface casing vent flow (SCVF) are calculated directly for 1990 to 2021 from provincial SCVF incidence reports (AER, 2021e; BCOGC, 2021c). Reports for each detected SCVF are linked to provincial oil and gas well information (AER, 2021f; BCOGC, 2021d, 2021e), which provides key dates and characteristics of the wells where SCVF has occurred. Location information for wells in Alberta allows specific township-level gas composition data (Tyner and Johnson, 2020) to be applied to SCVF releases, while the composition of SCVF releases in British Columbia is derived from representative Alberta data. This information is combined to estimate the magnitude and duration of these releases, then annual emissions are aggregated and allocated to the appropriate Upstream Oil and Gas subsector. British Columbia, Alberta, Saskatchewan and Manitoba VOC emissions from pneumatic devices (controllers and pumps), compressor seals and fugitive equipment leaks are estimated in the Fugitive Emissions Model (FEM) (ECCC, 2021) for the Heavy Crude Oil Cold Production, Light/Medium Crude Oil Production, and Natural Gas Production and Processing subsectors. The FEM uses annual counts of active facilities and wells, gas composition data, component level emission factors, average number of components per facility type and other source parameters. Effective January 1, 2020, in Saskatchewan and Alberta and June 22, 2020, in British Columbia, guidelines and definitions changed for fuel, flare and vent gas reporting to Petrinex. For example, previously unreported vent gas from compressor seals and glycol dehydrators is now included in vent gas volumes, and vent gas from pneumatics (previously reported as fuel gas) is now included in vent gas. As these sources are included in vent volumes from 2020 onwards, careful attention is required to ensure no double-counting of emissions from these sources occurs. Additionally, starting in 2020, Alberta publishes source delineated vent volumes by facility subtype collected through the OneStop reporting program (AEP, 2022). Emissions from pneumatic devices, compressor seals and equipment leaks emissions are estimated by province and year as follows:

Emissions Source	British Columbia	Alberta	Saskatchewan	Manitoba
Pneumatic devices	1990–2020: FEM 2021: Petrinex reported venting	1990–2021: FEM	1990–2019: FEM 2020–2021: Petrinex reported venting	1990–2021: FEM
Compressor seals	1990–2020: FEM 2021: Petrinex reported venting	1990–2021: FEM 2020–2021: OneStop reported venting	1990–2019: FEM 2020–2021: Petrinex reported venting	1990–2021: FEM
Fugitive equipment leaks	1990–2021: FEM	1990–2021: FEM	1990–2021: FEM	1990–2021: FEM
Glycol dehydrator off-gas	1990–2020: UOG inventories 2021: Petrinex reported venting	1990–2019: UOG inventories 2020–2021: OneStop reported venting	1990–2019: UOG inventories 2020–2021: Petrinex reported venting	1990–2021: FEM

1 Saskatchewan is divided into four oil and gas production areas: I − Lloydminster, II − Kindersley, III − Swift Current and IV − Estevan. Each production area is assigned one production class (i.e., heavy/non-heavy) except Kindersley which has two production classes: heavy and non-heavy.

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

Sector/Subsector	
UPSTREAM OIL AND GAS INDUSTRY (cont'd)	
Activity Data	Spills and accidents: AER (2022a), BCOGC (2022a), CNLOPB (2022a), MB NRND (2022), and SKMER (2022) Wells drilled: CAPP (2022) Operating wells: CAPP (2022) and CNLOPB (1997–, 2002–, 2005–, 2010–, 2017–) Reported volumes of gas flared and vented: AER (2022b), BC (2019), BCOGC (2020, 2022b), CNLOPB (2022b), Petrinex (2022a, 2022b) and SKMER (1990–2008, 2009–2011) Fuel gas volumes: AER (2003–), BC (2019), BCOGC (2022b) and SKMER (1990–2008, 2009–2011, 2012– [a]) In-situ bitumen production volumes: AER (2022c) Non-associated natural gas production volumes: CER (2022) Crude oil and natural gas production volumes: NBERD (2022), SKMER (2012– [b], 2012– [c]) and Statistics Canada (n.d.[c], n.d.[d], n.d.[e], n.d.[f]) Natural gas shrinkage: AER (2022d) and BC (2022b) Alberta and Saskatchewan monthly conventional volumetric data: Petrinex (2022a, 2022b) Alberta and British Columbia SCVF: AER (2022e), BCOGC (2022c, 2022d, 2022e), and Petrinex (2022c) 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 using 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), ECCC (2021) Alberta flaring emissions from 2010 to 2021 are calculated using the monthly conventional volumetric data (Petrinex, 2022a) and emission factors calculated from the detailed gas composition data (Tyner and Johnson, 2020) by Alberta township. Similarly, Saskatchewan flaring emissions from 1990 to 2021 are calculated using flare volumes by production class (SKMER, 1990–2008, 2009–2011; Petrinex, 2022b) and EFs calculated from gas composition data (SKMER, 2021). The flaring SO_2 emission factors are calculated as shown in Equation A2–2.1. Equation A2–2.1: $$EF_{SO2,i} = \sum_j \frac{y_{i,j} \cdot n_{s,j} \cdot MW_{SO2}}{V_{STP}} \cdot g_c$$ where: $EF_{SO2,i}$ = volume-weighted SO_2 emission factor for area i (g/m^3) $y_{i,j}$ = mole fraction of component j in area i $n_{s,j}$ = number of sulphur atoms per molecule of component j MW_{SO2} = molecular weight of SO_2 (g/mol) = 64.066 g/mol V_{STP} = volume of gas at standard conditions (101.325 kPa and 15°C) = 23.6444813 m^3/kmol g_c = constant of proportionality = 1000 mol/kmol The VOC emission factor is calculated as shown in Equation A2–2.2. Equation A2–2.2: $$EF_{i,j} = \sum_j \frac{y_{i,j} \cdot MW_j \cdot (1 - CE)}{V_{STP}} \cdot g_c$$ where: $EF_{i,j}$ = emission factor for area i and VOC component j (g/m^3) MW_j = molecular weight of VOC component j (g/mol) CE = combustion efficiency = 0.98 (EC, 2014)0

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:

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

where:

$EF_{i,j}$ = emission factor for area *i* and pollutant *j* (g/m^3)

ER_j = flaring emission rate for pollutant *j* (g/MJ)

HHV_i = higher heating value for area *i* (MJ/m^3)

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%	

Reported venting emissions for Alberta from 2010 to 2021 and Saskatchewan from 1990 to 2021 are calculated using the vented volumes and detailed gas composition data as shown in Equation A2–2.4.

Equation A2–2.4:

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

where:

$Emis_{i,j}$ = vented emissions of component *j* in area *i* (kt)

$y_{i,j}$ = mole fraction of component *j* in area *i*

Vol_i = volume of gas vented in area *i* (10^3 m^3)

ρ_j = density of component *j* at standard conditions (101.325 kPa and 15°C) (kg/m^3)

Lastly, VOC emissions from SCVF in Alberta and British Columbia are determined using reported total gas release rates. In cases where SCVF is reported without a gas flow rate, average flow rates are applied based on well location and SCVF characteristics. The product of the total gas flow rate and the estimated duration gives the volume of gas released, which is then used to calculate VOC emissions using Equation A2–2.4.

Note: References for this table can be found on page 93.

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 volatile organic compounds (VOC) during the leavening process of industrial baking. Emissions from products leavened by baking powder (used mainly for pastries) are negligible, but VOCs are released when yeast is used for leavening. Yeast is used nearly exclusively in the production of bread and bread-like pastries.
General Inventory Method	Pollutant(s) estimated: VOCs Total quantity of wheat flour available per person is multiplied by population, the fraction of flour use in yeast-leavened baked goods, the ratio of product to flour, and an emission factor for VOCs emitted per t of product.
Activity Data	Bread production values are estimated using: • national wheat flour available: Statistics Canada (2022) • population data for provinces and territories: Statistics Canada (2022) • fraction of flour use in yeast-leavened baked goods and ratio of product to flour: Cheminfo Services (2005)
Emission Factors (EF)	Cheminfo Services (2005) EFVOC = 2.36 kg per t of baked goods produced

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 Air Pollutant Emissions Inventory (APEI): Primary elevators receive grain by truck from producers for either storage or forwarding. These elevators sometimes clean or dry grain before it is transported to terminal or process elevators (U.S. EPA, 1985). Process elevators are grain processing plants or mills. While elevator unloading, conveying and storing operations are performed at these locations, direct manufacturing or processing of grain for use in other products are also carried out (U.S. EPA, 1985). Terminal elevators dry, clean, blend and store grain for shipment. Transfer elevators generally perform the same function as terminal elevators.
General Inventory Method	Pollutant(s) estimated: TPM, PM_{10}, $PM_{2.5}$ Total grain production by province and territory is multiplied by process-specific emission factors for primary elevators, process elevators, transfer elevators and terminal elevators. Calculated emissions are reconciled with facility-reported data emissions reported through the National Pollutant Release Inventory (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 weeks 21-22 (W22) from current year (CY). PY-W52 represents grain throughput from August and July and PY-W22 represents throughputs from August to December of the previous year (CGC, 2017). The current calendar year's estimate of grain throughput is calculated as: $$Grain\ throughputs = (PY\text{-}W52) - (PY\text{-}W22) + (CY\text{-}W22)$$ Estimation of grain distribution among provinces: The CGC does not report primary delivery data from Eastern provinces (NS, NB, PE). Consequently, grains that are delivered to primary elevators outside of Western provinces are assumed to be consistent with the grain deliveries in Ontario (ON). The division of grains between Western Canada and Eastern Canada is performed based on the total Canadian grain (Statistics Canada, 2017). However, the sum of each grain type shows the annual receipts in Western Canada as one value (there is no breakdown by province), and therefore, two assumptions are made in order to estimate provincial grain receipts. First, it is assumed that all grains received by ON primary elevators are transferred to process elevators in ON (including inter-provincial transfers). Second, the portion of receipts shared by each province is calculated based on the provincial proportions from the 1995 Criteria Air Contaminants (CAC) inventory. This inventory also provides the provincial distribution for transfer elevators. All grains from process elevators in ON are subsequently transported to terminal elevators, while transfer elevators in Ontario receive and ship grains from Western provinces. Unlike process elevators, terminal elevators are only located at four ports in three provinces: BC (Vancouver, Prince Rupert), ON (Thunder Bay), MB (Churchill). With receipts and shipment data for 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)	Emissions 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 for all processes in each elevator. Accordingly, the total Canadian TPM, PM_{10} and $PM_{2.5}$ annual emissions is the sum of emissions from all processes involved in the four elevators. The emission factors and parameters are listed in the following section. $$Emission = Activity\ level \times (1 - Control\ Efficiency) \times Emission\ factor \times Handling\ ratio$$ All emission factors and parameters are identical in all provinces (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 the National Pollutant Release Inventory and they serve as the most reliable estimate of emission values. Thus, the AS and PS estimates are subjected to a reconciliation procedure before submission to the inventory. When cumulative AS values for a province were found to be lower than the cumulative PS value for the same province, the AS value was replaced by the 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 planning steps, which all release air emissions. **Panel Board Mills** include emissions from several types of mills, all producing hardwood and softwood-based materials. These include: • veneer and plywood mills • waferboard mills, consisting primarily of oriented strand board (OSB) mills • particle board and medium-density fiberboard (MDF) mills **Other Wood Products** encompass emissions from furniture and cabinet manufacturers, wood treating plants, wood pellet mills and masonite manufacturers. The combustion of various fuels for energy production or waste disposal, notably wood residues, natural gas, liquefied petroleum gas (LPG) and fuel oil is a common practice at wood products facilities. Significant amounts of air pollutant emissions result from combustion in this sector.
General Inventory Method	Pollutant(s) estimated: TPM, PM_{10}, $PM_{2.5}$, SO_x, NO_x, VOCs, CO, NH_3, Pb, Cd, Hg, dioxins/furans, B[a]p, B[b]f, B[k]f, I(cd)p **Sawmills and Panel Board Mills** • TPM, PM_{10} and $PM_{2.5}$: Estimation methodology makes use of the NPRI facility-reported data in addition to a number of production and capacity indicators to estimate the PM levels of facilities not reporting to the NPRI (Natural Resources Canada, Forest Products Association of Canada and the Composite Panel Association, corporate website information, annual reports, Resource Information Systems Inc. publications, Madison publications and occasional discussion with industry representatives). • All other pollutants: Production rate estimates, hog fuel combustion data, and other fuel use data are used to estimate emissions of the remaining pollutants (Meil et al., 2009; U.S. EPA, 2014). The in-house estimates for sawmills and panel board mills were carried forward in 2016 based on 2015 mill capacities. Capacity data were available for 2017. The 2018 capacity data were updated based on 2019 data. Capacity data were available for 2019, 2020 and 2021. **Other Wood Products** **All pollutants:** In-house estimates are not calculated for this subsector. For the whole time series, emissions are from facility data reported to provinces/territories and NPRI facility-reported data.
Activity Data	NPRI 2021 data and data sources for facilities not reporting to the NPRI, including: • *Natural Resources Canada: Status of Energy Use in the Canadian Wood Products sector* (Meil et al., 2009) • *The State of Canada's Forests Annual Report 2020* (NRCan, Canadian Forest Service, 2021) • Forest Products Association of Canada annual reports (proprietary reports) • Environment and Climate Change Canada's Forestry Products Group • *RISI North American Wood Panels and Engineered Wood Products Capacity Report* (RISI, 2020) • Madison's 2021 Online Lumber Directory (Madison, 2021) • Verbal communications with industry representatives (unpublished)
Emission Factors (EF)	Sawmills: U.S. EPA (2012) Plywood manufacturing, particle board, oriented strand board: U.S. EPA (1995) Fuel combustion: Meil et al. (2009) and U.S. EPA (1992, 1995, 2014)

Note: References for this table can be found on page 95.

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: TPM, PM_{10}, $PM_{2.5}$, SO_x, NO_x, VOCs, CO, NH_3, Pb, B[a]p, B[b]f, B[k]f, I(cd)p Aircraft-specific activity (LTO) by province and territory is multiplied by pollutant-specific emission factors.
Activity Data	The emission estimates for 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 by Transport Canada pre-1996. The data are of the highest resolution available and are the only known 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 publication entitled *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 or equal to 10 microns in diameter and, therefore, TPM is equal to PM_{10}. Emissions of PM_{10} for jet engines during 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 cruise are derived from the *Aircraft Particulate Matter Emission Estimation Through all Phases of Flight* (Eurocontrol, 2005) and *AERO2k 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. 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 gasoline is considered to be less than or equal to 10 microns in diameter and, 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 Pb is based on an expert review[2] 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: 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(1,2,3-cd)p Vessel-specific activity (movements) is multiplied by pollutant-specific emission factors.
Activity Data	The main source of data is the Marine Emission Inventory Tool (MEIT) (ECCC, 2016, 2022) which provides emissions for NO_x, CO, HC, SO_2, TPM, PM_{10} and $PM_{2.5}$. MEIT provides data for 1980, 1985, 1987, 1990, 1995, 2000, 2005, 2010, 2015, 2016, 2017, 2018, 2019 and 2020. 2021 data is based on Statistics Canada's vessel movement data published in the Statistical Addendum for the Transportation in Canada Report (Transport Canada, 2022).
Emission Factors (EF)	NO_x, CO, HC, SO_2, TPM, PM_{10} and $PM_{2.5}$ 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, 2009a). The correlation factor for HC to VOCs is taken from the *Emission Factors for Locomotives* document (U.S. EPA, 2009b).
ON-ROAD VEHICLES	
Description	On-Road Vehicles include Heavy-Duty Diesel Vehicles, Heavy-Duty Gasoline Vehicles, Light-Duty Diesel Trucks, Light-Duty Diesel Vehicles, Light-Duty Gasoline Trucks, Light-Duty Gasoline Vehicles, Propane and Natural Gas Vehicles, Motorcycles, and Tire Wear and Brake Lining.
General Inventory Method	Pollutant(s) estimated: TPM, PM_{10}, $PM_{2.5}$, SO_x, NO_x, VOCs, CO, NH_3, Pb, Cd, Hg, dioxins/furans, B[a]p, B[b]f, B[k]f, I(cd)p Vehicle-specific activity (vehicle kilometres travelled) is multiplied by pollutant-specific emission factors in the MOtor Vehicle Emission Simulator (MOVES) model (version MOVES3 was used for this submission). Refuelling VOC emissions are included under Service Stations.
Activity Data	Data on the vehicle fleet (counts) are based on road motor vehicle annual registration datasets from Statistics Canada (Statistics Canada 2015; Statistics Canada 2020). The distribution of those vehicles into the various classes were determined from light-duty vehicle population obtained from DesRosiers Automotive Consultants Inc and heavy-duty vehicle population data obtained from R.L Polk & Company. The activity level is represented by vehicle kilometres travelled (VKT). To arrive at estimates of VKT, vehicle counts are multiplied by kilometre accumulation rates obtained from the publication by 550572 BC Ltd (2021). For light-duty vehicles, VKT for calendar year 2020 and 2021 was adjusted using the *Light Vehicle Survey* (DAC, 2022).
Emission Factors (EF)	Emission factors for on-road vehicles are embedded in the MOVES model. More information on MOVES is available from the U.S. EPA user guides and technical reports online at https://www.epa.gov/moves (U.S. EPA, 2022).

2 Saskatchewan is divided into four oil and gas production areas: I − Lloydminster, II − Kindersley, III − Swift Current and IV − Estevan. Each production area is assigned one production class (i.e., heavy/non-heavy) except Kindersley which has two production classes: heavy and non-heavy.

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 consist of Off-Road Diesel Vehicles and Equipment and Off-Road Gasoline/LPG/NG Vehicles and Equipment
General Inventory Method	Pollutant(s) estimated: TPM, PM_{10}, $PM_{2.5}$, SO_x, NO_x, VOCs, CO, NH_3 Application-specific activity (hours-of-use, load factor) is multiplied by pollutant-specific emission factors in the NONROAD model. Refuelling VOC emissions are included under Service Stations.
Activity Data	Off-Road vehicle and equipment counts are sourced from Power Systems Research (PSR) data. PSR is an independent supplier of data which maintains PartsLink, a comprehensive database that includes off-road vehicles and equipment used in Canada with information such as year of manufacture, engine fuel and engine size. Construction equipment populations used in oil sands mining operations are sourced from The Parker Bay Company (ECCC, 2018b). Data on the operating parameters of off-road vehicles and equipment (load factor and hours-of-use), are largely sourced by an off-road study conducted in 2011 (Environ, 2011). The hours-of-use parameter was updated in 2018 for select equipment types. For example, snowmobile hours of use is now broken down by stroke type (ECCC, 2018a).
Emission Factors (EF)	Emission factors for off-road applications are embedded in the NONROAD model, which have recently been updated for off-road diesel vehicles and equipment compliant with regulatory Tier 4 exhaust standards (U.S. EPA, 2018). For this iteration of the APEI, NONROAD version 2012C. This version is based on the U.S. EPA's NONROAD2008, and modified by Environment and Climate Change Canada to exploit detailed activity data. The model is operated according to the user guide for NONROAD2005/2008 (U.S. EPA, 2005b), given that the functionality of the models is the same. 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: TPM, PM_{10}, $PM_{2.5}$, SO_x, NO_x, VOCs, CO, NH_3, Pb, Cd, Hg, dioxins/furans, B[a]p, B[b]f, B[k]f, I(cd)p Railway activity (fuel consumption) is multiplied by pollutant-specific emission factors.
Activity Data	Data on provincial fuel consumption is obtained from the publications *Railway industry diesel fuel consumption* (Statistics Canada, n.d.[e]) and *Railway industry diesel fuel consumption by Area* (Statistics Canada, n.d.[f]). National fuel demand for the railway industry is obtained in the publication *Report on Energy Supply and Demand* (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 Report 2020* (Railway Association of Canada, 2022). The correlation factor for HC to VOCs and TPM to PM_{10} is taken from the Emission Factors for Locomotives document (U.S. EPA, 2009b). $PM_{2.5}$, NH_3, Pb, Cd, Hg, B[a]p, B[b]f, B[k]f, I(cd)p are estimated in relation to PM_{10} or VOCs, based on speciation profiles 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 report entitled *An inventory of sources and environmental releases of dioxin-like compounds in the United States for the years 1987, 1995, and 2000* (U.S. EPA, 2006).

Note: References for this table can be found on page 96.

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

Sector/Subsector	
AGRICULTURAL FUEL COMBUSTION	
Description	Agricultural Fuel Combustion covers emissions resulting primarily from combustion sources used for space/water heating and crop drying.
General Inventory Method	Pollutant(s) estimated: TPM, PM_{10}, $PM_{2.5}$, SO_x, NO_x, VOCs, CO, NH_3, Pb, Cd, Hg, dioxins/furans, B[a]p, B[b]f, B[k]f, I(cd)p Emissions are calculated for 10 types of fuel: natural gas, natural gas liquids, kerosene and stove oils, light fuel oil, heavy fuel oil, Canadian bituminous coal, sub-bituminous coal, lignite coal, anthracite coal, and imported coal. Total usage by fuel type and province and 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) (Emission factors are chosen to represent the typical type of combustion equipment for each fuel type) TPM, PM_{10}, $PM_{2.5}$, SO_x, NO_x, VOCs, CO for natural gas fuel: U.S. EPA (2004) Sulphur contents of liquid fuels: EC (2010) Sulphur contents of coal: CEA (2002) NH_3: Battye et al. (1994) and Coe et al. (1996) Pb, Cd, Hg, dioxins/furans, B[a]p, B[b]f, B[k]f: CARB (2005) and U.S. EPA (1998, 2003, 2004) (Emission factors are selected to represent the typical type of combustion equipment for each fuel type)
ANIMAL PRODUCTION	
Description	Animal Production covers emissions from the volatilization of NH_3 from nitrogen (N) in manure, particulate matter (PM) that is released from feeding and housing, and volatile organic compounds (VOCs) that are released during livestock feeding, housing and manure management. Ammonia volatilization is a chemical process that occurs when manure is excreted or stored without a cover. Once excreted, manure moves through a number of stages until it is eventually cycled back to farm fields. Ammonia volatilization occurs at each stage of this cycle, including animal housing, transport to long-term storage, storage, and application of manure to the field. Livestock production results in primary PM emissions from the aerial transport of feed particles, feather fragments, fecal material, skin debris or dander, animal wastes, mould spores, bacteria, fungi, litter fragments, etc. Ventilation systems are required in livestock buildings for air exchange and, as a result, a portion of the PM in confined livestock buildings is emitted into the atmosphere via the ventilation system. VOC emissions from livestock production are the result of biological processes that partially breakdown feed, especially silage, during storage and digestion. Emissions from excreted manure also occur during all stages of the manure management cycle. Sites of emission therefore include silage stores, livestock housing, manure stores and agricultural fields on which manure is applied or that are used for grazing.
General Inventory Method	Pollutant(s) estimated: TPM, PM_{10}, $PM_{2.5}$, NH_3, VOCs **Ammonia** The methodologies for NH_3 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). 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, 2007b, 2009a, 2009b, 2010, 2011a, 2011b; Chai and al., 2016). For dairy and swine, the methodology used to estimate NH_3 emissions has been updated to make it compatible with the current methodology used for the estimation of greenhouse gases (GHG) (see Annex 3.4 of the National Inventory Report [NIR]). Although the specific emission factors used in estimating NH_3 emissions have not been modified, the total emissions per head have changed as a result of changes in rates of N excretion per animal and the proportions of manure stored in different manure systems over time. Methodologies for minor animals, such as horses, goats, fur-bearing animals (mink, fox), wild boars, deer, elk, rabbit and poultry, were taken from Battye et al. (1994). **Nitric Oxide (NO)** The Tier 1 methodology from the 2019 *EMEP/EEA Air Pollutant Emission Inventory Guidebook* (EEA, 2019) for estimating nitric oxide emissions associated with manure management was implemented for all livestock with an available emission factor. **Particulate Matter (TPM, PM_{10}, $PM_{2.5}$)** The methodologies for PM emissions from livestock production are developed by AAFC for publication in the National Agri-Environmental Health Analysis and Reporting Program (NAHARP) report, 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 (2012) and Pattey et al. (2015). **Volatile Organic Compounds (VOCs)** For all livestock except dairy cattle, the methodology for estimating VOC emissions was based on the Tier 1 methodology outlined in the 2013 *EMEP/EEA Air Pollutant Emission Inventory Guidebook* (EEA, 2013). Emissions from 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 NIR, as described in Annex 3.4 of Part II (canada.ca/ghg-inventory).
Activity Data	Annual cattle, sheep and swine populations are calculated as the simple mean of semi-annual or quarterly surveys, 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. 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 during census years. Where populations for certain alternative livestock animal categories were not available in the COA, values were held constant or extrapolated back to zero. The breeding mink and fox population estimates were taken from an annual Statistics Canada survey titled Supply and Disposition of Mink and Fox on Fur Farms (Statistics Canada, n.d.[e]). Rabbit populations were taken from responses to the COA as provided on the AAFC Red Meat Market website (AAFC, 2016).

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

Sector/Subsector	
ANIMAL PRODUCTION (cont'd)	
Emission Factors (EF)	**Ammonia** Non-dairy cattle and poultry ammonia emission factors are a weighted average of a variety of different emission fractions associated with the stages of the manure and animal production cycle. The input to the emission factor equation originates from a combination of the Livestock Farm Practices Survey (LFPS), which defines feed distribution to and consumption by animals throughout the year, and generic parameters derived from scientific literature or expert opinion. This information is distributed spatially across Canada by ecoregion. Animal populations are reassigned to a matrix of animal housing and manure management systems based on their relative proportion in the overall farm population. The fractions of NH_3 emitted at each step in the manure cycle are taken in part from the *EMEP/CORINAIR Emission Inventory Guidebook* (EEA, 2002) and in part from Canadian studies. The resulting weighted emission factors are applied to populations of animal subcategories taken from census data at the ecoregion spatial scale. The models employed to calculate NH_3 emissions from beef and swine production are described in Sheppard and Bittman (2010, 2012) and Sheppard et al. (2010). **Dairy cattle:** Ammonia emissions are calculated according to Sheppard et al. (2010), with modifications according to Chai et al. (2016), based on the activity data and methodology outlined for Agriculture in the NIR (ECCC, 2022). Total N excretion for dairy cattle is calculated according to the Tier 2 methodology as described in the IPCC 2006 Guidelines (IPCC, 2006). Ammonia emission factors from Sheppard et al. (2011a) are expressed as fractions of total N using calculated total ammoniacal nitrogen (TAN) (Chai et al., 2016) to produce ammonia N loss factors by ecoregion for housing and manure storage, manure application, and manure deposited on pasture, range, and paddock. Manure management storage information was derived from Sheppard et al. (2011b) to identify proportions of manure excreted on pasture and in exercise yards and information on the 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. Emissions from manure applied to agricultural soils were consistent with Sheppard et al. (2010) as modified according to Chai et al., 2016. **Swine:** 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 NIR (ECCC, 2022). Total N excretion for swine is calculated according to the Tier 1 methodology described in the 2006 IPCC Guidelines (IPCC, 2006), and modified to use a country-specific animal mass time series for market swine as described in Annex 3.4 of the NIR. Ammonia emission factors from Sheppard et al. (2010) are expressed as fractions of total N using calculated TAN fractions (Chai et al., 2016) to produce ammonia N loss factors by ecoregion for housing and manure storage, and manure application to agricultural soils. Manure management storage information on the quantity of manure stored as liquid and solid manure was drawn from a series of Farm Management Surveys for years 1995, 2005, 2006 and 2011. A time series of manure storage was developed on the basis of relationships between liquid storage and farm size to account for changes in manure storage between 1990 and the present. **Nitric Oxide (NO)** Tier 1 emission factors were taken from Table 3.3 of the *EMEP/EEA Air Pollutant Emission Inventory Guidebook* 2019 (EEA, 2019), for each livestock category and manure management system. In cases where multiple emission factors were provided for different manure storage systems, the emission factors were weighted based on the proportion of manure handled in each system, using the same provincial time series of manure management practices used for other manure management methodologies. **Particulate Matter** Total particulate matter (TPM) emission factors for poultry are taken from Van Heyst (2005) and Van Heyst and Roumeliotis (2007). Emission factors for cattle and swine are average values from Takai et al. (1998) and Seedorf (2004). In the case of PM_{10} and $PM_{2.5}$, emissions are estimated from TPM emission factors multiplied by 0.45 and 0.1 to produce PM_{10} and $PM_{2.5}$ emission factors, respectively. Average animal weights are used to convert emission factors in the form of g d^{-1} AU^{-1} to units of kg $head^{-1}$ $year^{-1}$. The emission factors for cattle are also assigned to the other animal types by assuming that the emission factors per animal unit for sheep, goats, bison, llamas, alpacas and horses are the same as those for cattle. Average body weight of cattle are consistent with information provided by Boadi et al. (2004) and with weight corrections for cattle according to the methodology outlined in the NIR (ECCC, 2022). All other animal weights were consistent with values used to estimate N excretion in ECCC (2022). Currently no emissions are estimated for mink, fox, wild boars, deer, elk or rabbit. **Volatile Organic Compounds (VOCs)** 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 used, except for beef cattle in feedlots where the silage emission factor was used. A weighted emission factor for beef cattle was calculated using the fraction of time spent during each stage of production according to Boadi et al. (2004). For dairy cattle, emission factors were calculated for six separate sources of emissions as described in the EMEP/EEA tier 2 methodology. Gross energy intake, silage content of feed, and fraction of time spent in barns, were all calculated based on country-specific data compiled in order to estimate GHG emissions (see Annex 3.4 of the NIR). In the EMEP/EEA tier 2 methodology, NH_3 emissions are used as a proxy to estimate the proportion of VOC emissions that occur in housing and manure storage and during manure application. The proportions were derived from NH_3 emissions from the Canadian Ammonia Model, which was modified to account for the shift in manure management practices in the dairy sector (see ammonia methodology).

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

Sector/Subsector	
INORGANIC FERTILIZER APPLICATION (under CROP PRODUCTION)	
Description	Fertilizer Application includes emissions resulting from the application of synthetic N fertilizers for annual and perennial crop production.
General Inventory Method	Pollutant(s) estimated: TPM, PM_{10}, $PM_{2.5}$, NH_3 **Ammonia** The method is a simplified version of the approach adopted by Sheppard et al. (2010) for application on an annual time step. The methodology uses a regression model developed by Bouwman et al. (2002) with derived NH_3 emission factors, and takes into account the most important parameters influencing emissions from synthetic N fertilizer application, based on a meta-analysis of scientific literature. **Particulates** Methodology is under review.
Activity Data	Data on the types of N fertilizer used on farms are published by Statistics Canada (n.d.[g]) Areas of seeded annual and perennial crops: Statistics Canada (n.d.[h]) Soil properties, including pH and cation exchange capacity, are included in calculations using soil polygon information from a national-scale spatial database describing the types of soils associated with landforms.
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 N fertilizer types, method of N application, crop type, and soil pH and cation exchange capacity. A matrix of emission factors is derived for each combination of these conditions occurring across Canada. The average provincial and national emission factors are weighted averages of the relative proportion of each combination of fertilizer type and fertilizer application practice on different soil types in different ecodistricts across the country. TPM, PM_{10} and $PM_{2.5}$ methodology is under review.
SEWAGE SLUDGE APPLICATION (under CROP PRODUCTION)	
Description	Sewage sludge application (i.e. biosolids) includes NH_3 emitted when sewage sludge is land-applied on agricultural soils for annual and perennial crop production.
General Inventory Method	Pollutant(s) estimated: NH_3 **Ammonia** The methodology is aligned with reporting of NH_3 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, the 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 were compiled at five-year intervals (1990–2015). Although there were some gaps and inconsistencies owing to a lack of complete management information and changes in provincial regulations on biosolids, this is the only known source of data for a quantitative estimate of biosolids available at the national scale. The time series of biosolid production data was produced through a series of analytical steps. First, a provincial-level per capita model was constructed to establish "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 were reported by Cheminfo Services Inc. (2017). Therefore, the smoothed annual provincial biosolid production was derived using the linear model. For PEI, annual estimates for biosolid production were developed based on expert opinion and using a national average per capita figure (22.5 kg /person/year). This analysis created a complete series of biosolid production at a provincial scale. Secondly, the regional rates of land application of biosolids (dry tonnes) were derived using the proportions reported in Cheminfo Services Inc. (2017) adjusted for federal, provincial and municipal regulations and restrictions. At the federal level, the regulations imposed by the Canadian Council of Ministers of the Environment (CCME) were applied. Later the provincial restrictions based on the nutrient content of the biosolids and any restrictions on the frequency of biosolid application to lands were incorporated. Biosolids are typically subjected to various digestion and decomposition methods in wastewater treatment plants (WWTP) prior to land application. These methods have significant implications for the nutrient content of the biosolids and therefore influence the potential for emission 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 factor (FracGASm) for organic N from the 2019 refinement to the 2006 IPCC guidelines was used to quantify NH_3 emissions (IPCC, 2019).
HARVESTING (under CROP PRODUCTION)	
Description	Agricultural harvest activities entrain PM into the air. PM 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 travelling over the soil or by the processing of plant materials by agricultural equipment.
General Inventory Method	Pollutant(s) estimated: TPM, PM_{10}, $PM_{2.5}$ PM 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 2020 are consistent with the data reported in the Agriculture and the Cropland Remaining Cropland category of the Land Use, Land-use Change and Forestry (LULUCF) sector for the NIR (ECCC, 2022).

Table A2–5 **Estimation Methodologies for Agriculture** (cont'd)	
Sector/Subsector	
HARVESTING (under CROP PRODUCTION) (cont'd)	
Emission Factors (EF)	There are no emission factors for agricultural harvests in Canada. The PM_{10} emission factors proposed by the California Air Resources Board (CARB, 2003) are used to calculate PM emissions from crop harvests. Where not available from CARB (2003), the specific emission factors for some crops are based on an approximation from the closest representation (Pattey and Qiu, 2012).
TILLAGE PRACTICES (under CROP PRODUCTION)	
Description	Tillage practices produce PM emissions from mechanical disturbances such as seeding, seed bed preparation and cultivation.
General Inventory Method	Pollutant(s) estimated: TPM, PM_{10}, $PM_{2.5}$ Agricultural tillage is the common method used by farmers to prepare land for seeding and weed control. Particulate matter emissions are generated from airborne soil particles during tillage operations due to the mechanical disturbance of the soil surface. Particulate matter emissions from agricultural tillage operations are proportional to the area tilled. They are also dependent on the type of tillage practice as well as the number of tillage events per year. The calculations are described in more detail in Pattey and Qiu (2012). The number of tillage events per year is dependent on tillage practices. There are fewer tillage events per year for conservation tillage compared to conventional tillage. Therefore, PM emissions from reduced tillage and no-till are lower.
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 LULUCF sector for the NIR (ECCC, 2022). Information on the number of tillage events per year for crop type and tillage practices is taken from soil cover indicators (Huffman et al., 2012).
Emission Factors (EF)	Emission factors for tillage practices are calculated using the method described in U.S. EPA (1985).
WIND EROSION (under CROP PRODUCTION)	
Description	Wind erosion occurs when wind blows across exposed agricultural land, resulting in PM emissions from the entrained particles.
General Inventory Method	Pollutant(s) estimated: TPM, PM_{10}, $PM_{2.5}$ Wind erosion emissions from agricultural lands are calculated by multiplying the cultivated cropland area by an emission factor.
Activity Data	Activity data for PM emission estimates from wind erosion rely mainly on a combination of data from the Census of Agriculture and area estimates based on Earth Observation. Activity data on areas of major field crops, including summerfallow, and on tillage practices at an ecodistrict level from 1990 to 2018 are consistent with the data reported in the Cropland Remaining Cropland category of the LULUCF sector for the NIR (ECCC, 2022).
Emission Factors (EF)	The PM emission factor for wind erosion is calculated using the wind erosion equation (Woodruff and Siddoway, 1965) but considers the impact of soil and crop cover on PM emissions (Huffman et al., 2012). The emission factor for windblown PM emissions from agricultural lands is calculated using the methodology described in Pattey and Qiu (2012).

Note: References for this table can be found on page 97.

Table A2–6 **Estimation Methodologies for Commercial/Residential/Institutional Sources**	
Sector/Subsector	
COMMERCIAL AND INSTITUTIONAL FUEL COMBUSTION, CONSTRUCTION FUEL COMBUSTION AND RESIDENTIAL FUEL COMBUSTION	
Description	Commercial and Institutional Fuel Combustion, Construction Fuel Combustion and Residential Fuel Combustion include emissions resulting primarily from external combustion sources used for space/water heating and material heating. Commercial establishments, health and educational institutions, government/public administration facilities, and residences all fall under these categories, in addition to construction sites.
General Inventory Method	Pollutant(s) estimated: TPM, PM_{10}, $PM_{2.5}$, SO_x, NO_x, VOCs, CO, NH_3, Pb, Cd, Hg, dioxins/furans, B[a]p, B[b]f, B[k]f, I(cd)p Emissions are calculated for 10 types of fuel: natural gas, natural gas liquids, kerosene and stove oils, light fuel oil, heavy fuel oil, Canadian bituminous coal, sub-bituminous coal, lignite coal, anthracite coal, and imported coal. Total usage by fuel type, and province and 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) (Emission factors are chosen to represent the typical type of combustion equipment for each fuel type.) TPM, PM_{10}, $PM_{2.5}$, SO_x, NO_x, VOCs, CO for natural gas fuel: U.S. EPA (2004) Sulphur contents of liquid fuels: EC (2010) Sulphur contents of coal: CEA (2002) NH_3: Battye et al. (1994) and Coe et al. (1996) Pb, Cd, Hg, dioxins/furans, B[a]p, B[b]f, B[k]f: CARB (2005) and U.S. EPA (1998, 2003, 2004) (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 Sources** (cont'd)

Sector/Subsector	
COMMERCIAL COOKING	
Description	Commercial Cooking includes emissions from cooking meat and french fries in commercial operations that are classified according to five foodservice types: ethnic, fast food, family, seafood, and steak and BBQ. The types of meat considered include beef steak, hamburger, poultry with skin, poultry without skin, pork, seafood and other. Five types of commercial cooking equipment are taken into account including chain driven charbroilers, underfired charbroilers, deep-fat fryers, flat griddles and clamshell griddles. The commercial operations inventoried are defined as all commercial food service points of distribution that are open to the public, offer prepared meals and snacks for consumption on/off-premises, and operate in a fixed location.
General Inventory Method	Pollutant(s) estimated: TPM, PM_{10}, $PM_{2.5}$, VOCs, CO, B(a)p **Commercial meat cooking (1999 to present)** 1. Determine the number of restaurants in each province and territory that were classified as ethnic, fast food, family, seafood, steak and BBQ. 2. Determine the fraction of restaurants with commercial cooking equipment (i.e. chain driven charbroilers, underfired charbroilers, deep-fat fryers, flat griddles and clamshell griddles), the average number of units of each type of equipment per restaurant, and the average amount of food cooked (i.e. steak, hamburger, poultry with skin, poultry without skin, pork, seafood and other) on each type of equipment. 3. Apply pollutant-specific emission factors to each type of food for each type of commercial cooking equipment to get the final emission estimates. **Commercial meat cooking (1990 to 1998)** 1999 emission estimates were back-casted to 1990 using the gross domestic product (GDP) for NAICS [72]: Accommodation and Food Services (Statistics Canada, n.d.[b]). **Commercial cooking of french fries** The annual national consumption rate of frozen fries was multiplied by the annual provincial and territorial population and by a VOC-specific emission factor.
Activity Data	**Commercial meat cooking (1999 to present only)** Activity data were estimated using: • annual restaurant census for Canada: ReCount Database (The NPD Group Inc., 2017) • statistics on the prevalence of commercial cooking equipment, for the five restaurant types (E.H. Pechan & Associates Inc., 2003) • statistics on the average number of pounds of meat cooked on each type of equipment per week for the seven types of meat (E.H. Pechan & Associates Inc., 2003) **Commercial cooking of french fries** • Activity data were estimated using: • provincial and territorial population data (Statistics Canada, n.d.[c]) • annual Canadian consumption rates of frozen fries (USDA FAS, 2015) • assumed 80% of french fries were purchased in restaurants (E.H. Pechan & Associates Inc., 2003)
Emission Factors (EF)	Commercial meat cooking: TPM, PM_{10}, $PM_{2.5}$, VOCs, CO, B(a)p: E.H. Pechan & Associates Inc. (2003) Commercial cooking of french fries: VOCs: E.H. Pechan & Associates Inc. (2003)
HOME FIREWOOD BURNING	
Description	Home Firewood Burning encompasses emissions from wood, 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: TPM, PM_{10}, $PM_{2.5}$, SO_x, NO_x, VOCs, CO, NH_3, Pb, Cd, Hg, dioxins/furans, B[a]p, B[b]f, B[k]f, I(cd)p The quantity of wood burned by device type and province is multiplied by pollutant-specific emission factors by device type.
Activity Data	Activity data for wood from (Statistics Canada, 1997, 2003, 2007, 2015, 2017, 2019) are converted from volume to mass using 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) and Statistics Canada (2017) are used based on the reported mass. 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) Pb, Cd, Hg, B[a]p, B[b]f, B[k]f: U.S. EPA (1995) Dioxins/furans: EC (2000)
HUMAN	
Description	Ammonia and Hg emissions from respiration and perspiration.
General Inventory Method	Pollutant(s) estimated: NH_3 and Hg **Respiration and perspiration** Annual population data by province and territory are multiplied by an NH_3 emission factor. Mass balance of Hg from dental amalgams (see Table A2–11)
Activity Data	**Respiration and perspiration** Population data: (n.d.[c])
Emission Factors (EF)	**Respiration and perspiration** NH_3: Roe et al. (2004)

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

Sector/Subsector	
SERVICE STATIONS	
Description	Service Stations estimates covers fugitive VOC emissions from fuel transfers and storage from refined petroleum products retail, as well as fugitive emissions from the refuelling of on- and off-road vehicles. Off-road refuelling emissions include all non-vehicle gasoline usage (lawnmowers, snow blowers, etc.).
General Inventory Method	Pollutant(s) estimated: VOCs **Refined petroleum products retail** Emissions are calculated using gasoline usage data multiplied by emission factors for underground tank filling and breathing. For British Columbia and Ontario, emissions from service stations are broken down into regulated versus unregulated areas. An emission control efficiency of 50% is applied to the filling of underground storage tanks in regulated areas in British Columbia and Ontario. The rest of the country is assumed to have no control efficiency. **Off-road refuelling** Off-road refuelling emissions are calculated using off-road gasoline usage data multiplied by an emission factor for uncontrolled vehicle refuelling. **On-road refuelling** On-road refuelling estimates are produced using the MOVES model. This year's estimates were made using MOVES3. 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]). **Off-road refuelling** Off-Road vehicle and equipment counts are sourced from Power Systems Research (PSR) data. PSR is an independent supplier of data which maintains PartsLink, a comprehensive database that includes off-road vehicles and equipment used in Canada with information such as year of manufacture, engine fuel and engine size. Data on the operating parameters of off-road vehicles and equipment (load factor and hours-of-use), are largely sourced by an off-road study conducted in 2011 (Environ, 2011). The hours-of-use parameter was updated in 2018 for select equipment types. For example, snowmobile hours of use is now broken down by stroke type (ECCC, 2018). **On-road refuelling** Data on the vehicle fleet (counts) are based on road motor vehicle annual registration datasets from Statistics Canada (Statistics Canada 2015; Statistics Canada 2020). The distribution of those vehicles into the various classes were determined from light-duty vehicle population obtained from DesRosiers Automotive Consultants Inc and heavy-duty vehicle population data obtained from R.L Polk & Company. To arrive at estimates of VKT, vehicle counts are multiplied by mileage accumulation rates d from 550572 BC Ltd (550572 BC Ltd, 2021). For light-duty vehicles, VKT for calendar year 2020 and 2021 were adjusted using the *Light Vehicle Survey* (DAC, 2022).
Emission Factors (EF)	**Refined petroleum products retail** Emission factors for refined petroleum products consist of those associated with submerged filling of underground tanks as well as the breathing and emptying of underground tanks (U.S EPA, 2008). **Off-road refuelling** Emission factor for off-road refueling is associated with uncontrolled displacement losses during vehicle refueling operations (U.S. EPA, 2008). **On-road refuelling** Emission factors for on-road vehicles are embedded in the MOVES model. More information on MOVES is available online at www.epa.gov/otaq/models/moves/, in the U.S. EPA user guides (U.S. EPA, 2012, 2014) and in the U.S. EPA technical guidance document (U.S. EPA, 2010).

Note: References for this table can be found on page 99.

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

Sector/Subsector	
CREMATORIUMS	
Description	Crematoriums cover emissions from the combustion of caskets and human bodies. The combustion of fuel associated with the operation of a crematorium furnace or crematory fire is excluded from the sector. Fuel combustion emissions from cremations are captured under Commercial and Institutional Fuel Combustion. In-house estimates do not cover animal cremation, as these emissions are reported through the National Pollutant Release Inventory (NPRI).
General Inventory Method	Pollutant(s) estimated: TPM, PM_{10}, $PM_{2.5}$, SO_x, NO_x, CO, Pb, Cd, Hg, dioxins/furans, B[a]p, B[b]f, B[k]f, I(cd)p, HCB Number of human cremations per year by province and territory is multiplied by pollutant-specific emission factors. Mercury (Hg) from dental amalgams comes from the Hg in Products model (see Table A2–11)
Activity Data	Activity data for the years 2002 to 2021 are 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, 2022) includes data from 2008 to 2021. Given the unavailability of data for some years, emission estimates are calculated using linear interpolation for all provinces/territories for the years 2001 to 2002, and for Quebec for the years 2002 to 2007.
Emission Factors (EF)	TPM, PM_{10}, $PM_{2.5}$: U.S. EPA (2014) VOCs, HCB: EEA (2013) SO_x, NO_x, CO: EEA (2009) Hg: Reindl (2012) Cd, Pb: U.S. EPA (2014) Dioxins/furans: U.S. EPA (2014) B[a]p, B[b]f, B[k]f, I(cd)p: U.S. EPA (2014) An average weight per body and casing of approximately 150 lbs. is assumed.
WASTE INCINERATION	
Description	Incineration of municipal solid waste, sewage sludge, hazardous waste, clinical waste and other incineration.
General Inventory Method	Pollutant(s) estimated: TPM, PM_{10}, $PM_{2.5}$, SO_x, NO_x, VOCs, CO, NH_3, Pb, Cd, Hg, dioxins/furans, B[a]p, B[b]f, B[k]f, I(cd)p Where NPRI facility data is not available, the volume of incinerated waste is multiplied by technology-specific or default emission factors.
Activity Data	Activity data is developed based on Environment and Climate Change Canada (ECCC) surveys (ECCC, 2022) as well as (EC, 2003).
Emission Factors (EF)	EEA (2019)
RESIDENTIAL WASTE BURNING (under WASTE INCINERATION)	
Description	Emissions from Residential Waste Burning are related to on-site burning of residential waste materials in backyard barrels or to open-pit burning in rural areas.
General Inventory Method	Pollutant(s) estimated: TPM, PM_{10}, $PM_{2.5}$, SO_x, NO_x, VOCs, CO, NH_3, dioxins/furans, B[a]p, B[b]f, B[k]f, I(cd)p, HCB 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 of 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 factors from Table 2.5-1 of U.S. EPA (1992). NH_3 comes from Greater Vancouver Regional District (GVRD): BCMELP (2003). Dioxins and furans use an emission factor of 72.8 ng 1-TEQW/kg of residential waste (Gartner Lee Limited, 2003)
LANDFILLS (under WASTE TREATMENT AND DISPOSAL)	
Description	Landfills include emissions from bulk non-hazardous waste disposed of in landfills across Canada. Materials deposited in landfills are covered daily with soil to prevent scattering of litter by wind, scavenging by animals, and odours. Dust (PM) emissions occur due to wind erosion, the movement of heavy vehicles and the dumping of waste. 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 CH_4.
General Inventory Method	Pollutant(s) estimated: TPM, PM_{10}, $PM_{2.5}$, VOCs The quantity of waste landfilled for each province and territory is multiplied by PM emission factors to determine the amount of PM released. 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. All landfill data available directly from provincial and territorial sources are integrated into the activity dataset. The provincial CH_4 emissions calculated for Canada's National Inventory Report (NIR) are used to estimate VOC emissions for the APEI. CH_4 emissions are calculated using a first order decay model, as described in the NIR.
Emission Factors (EF)	TPM: BCMELP (1997) PM_{10}, $PM_{2.5}$: GVRD and FVRD (2003). The EF_{PM10} is calculated using a distribution percentage of 8% of the EF_{TPM}. The $EF_{PM2.5}$ is calculated using a distribution percentage of 2% of the EF_{TPM}. VOCs: U.S. EPA (1995). The default concentration of VOC in landfill gas is 835 ppmv.

Table A2–7 **Estimation Methodologies for Incineration and Waste** (cont'd)	
Sector/Subsector	
COMPOSTING (under BIOLOGICAL TREATMENT OF WASTE, under WASTE TREATMENT AND DISPOSAL)	
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 the lack of available data at this time.
General Inventory Method	Pollutant(s) estimated: 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 (CARB) methodology 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 a lack of available data in Canada. The CARB method provides emission factors for green and food waste as well as green waste co-composted with biosolids or manure. For the green waste and food waste emission factor, the CARB method assumes that only 15% of food waste is co-composted with green waste. However, in Canada this emission factor has been applied 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 CARB method emission factor for co-composting of green waste and biosolids or manure is used for any type of yard waste such as brown wastes. This emission factor is also applied to composting facilities that use food and paper waste with biosolids or manure and yard waste. This is done as the method does not provide an option for mixtures of all waste types together at this time. The control efficiencies published by CARB are averaged and used 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 an emissions reduction level of 80% or more; emission reduction rates are adapted to reflect the information available in Canada.
Note: References for this table can be found on page 101.	

Table A2–8 **Estimation Methodologies for Paints and Solvents**	
Sector	
DRY CLEANING, GENERAL SOLVENT USE, PRINTING AND SURFACE COATINGS	
Description	Dry Cleaning includes emissions from companies that provide dry cleaning of fabric and leather items. General Solvent Use consists of emissions from a broad range of applications occurring in residential, commercial, industrial and institutional settings. Industrial applications include uses such as degreasing, adhesives and sealants, aerosols, blowing agents and resin manufacturing. The use of consumer and commercial products, pesticides and personal care products is also included under General Solvent Use. Printing covers emissions from the manufacturing or use of printing inks. The sector consists of flexographic, gravure, letterpress, lithographic and other types of printing. Surface Coatings encompasses emissions from a broad range of applications and industries, including individuals and companies engaged in the manufacturing or use of paints and coatings.
General Inventory Method	Pollutant(s) estimated: VOCs The analysis methodology used is largely a "top-down" national mass balance approach that involves gathering statistical activity data on the production, distribution, end-use patterns and disposal of VOC-containing products and then building relationships between stages. More detailed data on solvent quantities and practices are collected from a subset of solvent and formulated product users, producers and distributors in Canada.
Activity Data	Solvent use quantities (1990 to 2004): Cheminfo Services (2007) Solvent use quantities (2005 to 2014): Cheminfo Services (2016) Solvent use quantities (2015 to 2020): Cheminfo Services (2019) Domestic consumption is determined using a national mass balance approach. Information on production, trade and inventory changes is obtained from various literature sources, Statistics Canada and interviews with a subset of solvent producers and distributors. Projected estimates of the national total solvent use for the years 2019 to 2021 were developed based on historical base year national total solvent use and macroeconomic growth and solvent growth ratios (Cheminfo Services, 2019). 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 and multiplying it by the estimated percentage of uncontrolled VOCs or: $$E_{VOCs} = Quantity_{solventused} \times (100\% - \%\ VOC_{Controlled})$$ where E_{VOCs} is the emission estimate of VOCs. If there is no estimate for use of control technologies, 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) to the following: 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).
Note: References for this table can be found on page 102.	

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

Sector	
COAL TRANSPORTATION	
Description	Coal Transportation includes PM emissions resulting from the transportation of coal by open-top rail, truck or barge. Most of the coal mined in Canada is carried to transshipment 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 / transshipment (port) terminals (Cope and Bhattacharyya, 2001). Load-in and load-out losses, including transportation within the mine site and to mine-mouth facilities, are estimated and reported by mine facilities to the NPRI as part of fugitive emissions. Emissions from fuel combustion during coal transport (diesel, gasoline or oil) are inventoried separately as part of the Transportation and Mobile Equipment source category.
General Inventory Method	Pollutant(s) estimated: TPM, PM_{10}, $PM_{2.5}$ Emissions are estimated for each source-destination rail, truck or barge transportation route and summed by province. Emission factors for TPM for each rail or truck transportation route (source-destination) are derived from the distance travelled, the emission control/dust-mitigation effectiveness, and moisture (precipitation) along the route. For each province that a route crosses, the route emissions attributed to that province are determined from the proportion of the province-segment of the route to total route length. The PM_{10} and $PM_{2.5}$ emissions are calculated from the TPM emissions using a scaling factor. The mass of coal transported along each route is determined on the basis of either mine production of marketable coal (for mine to port or mine to end-user) or coal demand by end-user (for imported coal to end-users). Coal mine production sent to multiple destinations is proportioned on the basis of documented coal shipping volumes to each destination, reported coal demand for coal-users, or estimates from Cope and Bhattacharyya (2001). Where no information was available, 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). Monthly climate summaries: ECCC (2017) Rail Transportation Network: NRCan (n.d.[a]) (1:1 M scale used) 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 depends on the surface area and duration of a construction project. The geographic region, type of construction (residential, industrial-commercial-institutional [ICI], engineering) and soil characteristics are all considered.
General Inventory Method	Pollutant(s) estimated: TPM, PM_{10}, $PM_{2.5}$ **Residential construction** Emission factors (SNC-Lavalin Environment, 2005) are applied to the number of housing starts, the average lengths of construction (duration) and buildings-to-hectares conversion factors, by province and territory and dwelling type. The number of houses with basements and 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. The Thornthwaite precipitation-evaporation (PE) index by province and territory is used to correct the emission factors for soil moisture. **ICI and engineering construction** Methodology under review The in-house estimates for ICI were last calculated for 2012 and were carried forward to 2020.
Activity Data	**Residential construction** Dwelling starts: Statistics Canada (n.d.[d]) and CMHC (2020) Average lengths of construction: CMHC (2017) Buildings to hectares conversion factors: SNC-Lavalin Environment (2005) Average basement area and depth: SNC-Lavalin Environment (2005) Number of homes with basements: SNC-Lavalin Environment (2005) **ICI and engineering construction** Methodology under review
Emission Factors (EF)	**Residential construction** TPM, PM_{10}, $PM_{2.5}$: SNC-Lavalin Environment (2005) Correction factors: % silt content[3] Precipitation-Evaporation (PE) Index: SNC-Lavalin Environment (2005) ICI and engineering construction Methodology under review.

3 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 (AFOLU) Section, Pollutant Inventories and Reporting Division, Environment and Climate Change Canada.

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

Sector	
MINE TAILINGS	
Description	Mine Tailings covers emissions of particulates resulting primarily from wind erosion of mine tailings located on active and inactive mine sites. Concentrators used for mining produce both a finely-milled concentrate rich in the desired metal(s) and a solids-laden mine tailings stream. This slurry is sent to a tailings pond where the solids settle out of suspension and the supernatant solution is either recycled back into the process or discharged as effluent. It is a 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. Wind may disperse dust from silt fractions within exposed substrate and coarse waste materials.
General Inventory Method	Pollutant(s) estimated: TPM, PM_{10}, $PM_{2.5}$ Particulate matter dust emissions are estimated by applying an emission factor to the area of exposed mine tailings. The emission factor, taken from Evans and Cooper (1980), is loosely based on wind soil-loss equations. A term to account for snow cover was added to the original equation. $$EF_{TPM} = 1.33C \times A \times S$$ where C is a weather correction factor, A is the area of mine tailings in acres, and S is (365 – n_days_with_snow_cover) / 365 The emission factor is for TPM, with the smaller PM size fractions determined as ratios of TPM: $$PM_{10} = 0.8 \times TPM,\ PM_{2.5} = 0.2 \times TPM$$ The weather correction factor C is calculated from the equation: $$C = 0.345(V_{30})^3 / PE^2$$ where V_{30} is the average annual wind speed at 30 ft. elevation (miles per hour), and PE is the Thornthwaite precipitation-evaporation index, calculated as $$PE = 115 \sum [\ P / (T\text{-}10)\ ]^{(10/9)}\ (sum\ of\ monthly)$$ where P is precipitation in inches and T is the temperature in Fahrenheit or 28.4 °F, whichever is greater. The weather correction factor, C, is determined for each province, by year using monthly surface wind speed (CCMP, n.d), precipitation (CRU 4.03, 2019) and temperature (CRU 4.03, 2019). All data sources ranged from spatial resolution of 0.25 × 0.25 to 1 × 1 degree latitude/longitude resolution. The snow cover correction is applied as a single provincial value (full time-series data were not available). Days with snow cover taken as the mean number of days with snow cover greater than 5 cm. Snow cover data were obtained from the Canadian Meteorological Centre (CMC, n.d.) daily snow depth analysis, using 2000 to 2020 data, except years with missing data (2003 to 2005, and 2008). The mine tailings areas were measured via a remote sensing classification of mine disturbance areas throughout the country. Mine disturbance areas were classified from Landsat-5 and Sentinel 1, and Sentinel 2 imagery for the years 1990, 2000, 2010, and 2018, using supervised random forest classification, processed using Google Earth Engine (Fuentes et al., 2020). Tailings areas are taken as one third of total mine disturbance areas, with further "within-mine" classification and mapping planned as a future improvement. The classification of mine disturbance areas was restricted to a search area consisting of a 3 km 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 (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.[b]), filtered for "Industrial Waste," which includes tailings. The mine disturbance areas were manually refined and corrected in "challenging" regions for the automated classification, such as mountainous areas, badlands and high-arctic regions.
Activity Data	Fuentes et al. (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	
PAVED AND UNPAVED ROADS	
Description	Emissions from Paved Roads originate from primary (road abrasion) and secondary (resuspended) PM emissions. Emissions from unpaved roads originate from suspended or resuspended silt from the road surface.
General Inventory Method	Pollutant(s) estimated: TPM, PM_{10}, $PM_{2.5}$ Road abrasion, or **primary** paved road emissions, are produced by multiplying the total vehicle kilometres travelled for each province and territory by pollutant-specific emission factors. The methodology for **secondary (resuspended)** emissions is based on the U.S. 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 follow the AP-42 Section 13.2.2, 2006 update methods for publicly accessible roads (U.S. EPA, 2006). In both cases, a 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 include facility-reported emissions occurring on private roads and parking lots. The road dust emissions are nominally the application of an emission factor to the vehicle kilometers travelled (VKT). The emission factor calculation differs for paved and 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), 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 1980s vehicle tailpipe, tire-wear and break wear emissions (which were included in the original model parameterization), and weather corrections for snow and frozen road surfaces. Speeds on unpaved roads were estimated to be 70 km/hr for highways, 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 t. The silt content of unpaved roads was taken as 3.9% (AP-42 section 13.2.2, 2006 update default value). Silt loads were taken from the AP-42 Table 13.2.1-2. Silt load (sL) is a function of average annual daily traffic volume (AADT), with adjustments for winter grit application (winter baseline multiplier).

AADT	sL Baseline	sL Winter Multiplier	Units
<500	0.6	4	g/m^2
500 – 5 000	0.2	3	g/m^2
5 000 – 10 000	0.06	2	g/m^2
>10 000	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, collectors, arterial, highways, freeways, and winter roads). Winter roads are considered neither paved nor unpaved and are assumed to be not a source of dust. Freeways are only paved. Traffic counts from provinces and municipalities across Canada were collected by ECCC and spatially matched to the road network (approximately 500,000 data points). Roads and census population (1991 to 2016 census years) were summarized by census subdivision using census geography vintages/versions from the 1996, 2006, and 2016 censuses (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). 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), 0.5 × 0.5 degree spatial resolution, monthly. Soil moisture was from the NOAA Climate Prediction Center (NOAA, n.d.), 0.5 × 0.5 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 a mean temperature below zero. It is assumed that no dust is (re)suspended from paved or unpaved roads on days with precipitation. The emission factor was adjusted using the factor: $$Precip\_Cor = (n\_Days\_per\_Month - Precipitation\_Days) / n\_Days\_per\_Month$$ For unpaved roads, soil moisture was taken as the mean surface soil moisture content of the census subdivision, or 6.515% (the AP-42 2006 update, section 13.2.2 default value), if weather data were not available.
Activity Data	See General Inventory Method. The method used to calculate VKT for Transportation and Mobile Equipment sources was used to estimate VKT for primary and secondary emissions.
Emission Factors (EF)	Primary – EEA (2013) Secondary – Methodology under review

Note: References for this table can be found on page 102.

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

Sector	
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. This treatment is carried out by the logging industry and forestry officials to manage Crown lands. This sector excludes the burning of agricultural residues.
General Inventory Method	Pollutant(s) estimated: TPM, PM_{10}, $PM_{2.5}$, SO_x, NO_x, VOCs, CO, NH_3, dioxins/furans, B[a]p, B[b]f, B[k]f, I(cd)p Total annual mass of forest debris burned by fire and by province and territory is multiplied by pollutant-specific emission factors.
Activity Data	The total number of hectares burned in each province and territory per year (CIFFC, 2021; PCA, 2021; NFD, 2016) is multiplied by a conversion factor for each province and territory (EC, 1992) to convert the area burned into the mass of forest debris burned. Pollutant and province-specific emission factors are then applied to the mass of forest debris to determine the release of pollutants from the burn.
Emission Factors (EF)	TPM, PM_{10}, $PM_{2.5}$, SO_x, NO_x, VOCs, CO, NH_3: All provinces/territories (except British Columbia): U.S. EPA (1995) British Columbia: GVRD and FVRD (2003), BCMWLAP (2004) Dioxins/furans, B(b)f, B(k)f: Lemieux et al. (2004), B(a)p, I(cd)p: Johnson et al. (1992)
STRUCTURAL FIRES	
Description	Structural Fires cover emissions from vehicle fires (such as fires from cars, trains and airplanes) and buildings fires. Structural fires emit large quantities of pollutants due to rapid but incomplete combustion. This sector includes only emissions estimated in-house.
General Inventory Method	Pollutant(s) estimated: TPM, PM_{10}, $PM_{2.5}$, NO_x, VOCs, CO, NH_3 Tonnes of structures burned per year, by province and territory, are multiplied by pollutant-specific emission factors.
Activity Data	The Secretary/Treasurer of the Council of Canadian Fire Marshals and Fire Commissioners (CCMFC) and the following members of the CCMFC are contacted annually to obtain the number of annual structural fires in their jurisdictions: • Government of Nunavut • Fire and Emergency Services, Newfoundland and Labrador • Office of the Fire Marshal and Emergency Management (Ontario) • Office of the Fire Commissioner (Manitoba) • Emergency Management and Fire Safety Branch (Saskatchewan) • Canadian Forces Fire Marshal • Office of Public Safety (Prince Edward Island) • Yukon Government • Department of Labour and Advanced Education (Nova Scotia) • Department of Municipal and Community Affairs (Government of the Northwest Territories) • Department of Public Safety (New Brunswick) • Office of the Fire Commissioner (Alberta) • Emergency Management British Columbia • Quebec Ministère de la Sécurité publique Number of structure fires in each province and territory is multiplied by a loading factor to convert the number of fires into tonnes of structure burned (EIIP, 2001). Loading factor = 1.04 t of structure burned/fire Where activity data is unavailable, emission estimates for are calculated using linear interpolation/extrapolation.
Emission Factors (EF)	TPM, PM_{10}, $PM_{2.5}$, NO_x, VOCs, CO: GVRD and FVRD (2003) NH_3: Battye et al. (1994)

Note: References for this table can be found on page 103.

Table A2–11 **Estimation Methodology for Mercury in Products**

Sector/Subsector	
MERCURY IN PRODUCTS	
Description	Mercury in Products covers emissions from products throughout their life cycle, from manufacture to final disposition. The following products are included: • automotive switches • switches and relays • batteries • dental amalgams • fluorescent lamps • non-fluorescent lamps • measurement and control devices • thermometers • thermostats • tire balancers Emissions from the above devices impact the following sectors/subsectors: • Iron and Steel Industry – Secondary (Electric Arc Furnaces) • Iron and Steel Industry – Steel Recycling • Electronics • Other (Manufacturing) • Human Respiration (Miscellaneous Other) • Municipal Incineration • Landfills • Residential Waste Burning • Municipal Wastewater Treatment and Discharge
General Inventory Method	Pollutant(s) estimated: Hg Mercury emissions from 1990 to 2008 are estimated based on the model *Substance Flow Analysis of Mercury in Products* originally developed by the Minnesota Pollution Control Agency and modified by ToxEcology Environmental. In 2018, the methodology was updated by Cheminfo Services with a specific focus on 2009 forward. However, at that time, work was also done to support time series consistency, which affected emissions from 1990 to 2008 at the national level (Barr Engineering, 2001; ToxEcology, 2007; 2009; Cheminfo Services, 2018). The current update focuses on provincial and territorial distribution from 1990 forward and modifies aspects related to the fluorescent and non-fluorescent lamp models from 2009 forward. The Mercury-in-Products models use a lifecycle approach which considers releases from manufacturing, in-service breakage, recycling, transportation and storage of items sent to disposal as well as the ultimate disposal point for each product. The update completed by Cheminfo Services in 2018 allocated emissions to provinces and territories based on product type from 2009 forward. Prior to this update, emissions were not allocated based on product type. This inventory year emissions from 1990 to 2008 were redistributed based on product type for time series consistency. In addition, emissions were reallocated for the open burning, sewage sludge incineration and municipal incineration sectors from 1990 forward to better link these practices to the provinces where they take place. Lastly, activity data inputs for both fluorescent and non-fluorescent lamps were updated based on data that was not available 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) was used in conjunction with updates from ToxEcology (2007) and Cheminfo Services (2018). The model includes partitioning factors for the various streams from manufacture through final disposal, including emission factors at every point along the way.

Note: References for this table can be found on page 104.

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;
- reallocation 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. Table 3-1 in Chapter 3 shows which sources are estimated using facility reported data and/or in-house methods. 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 Combustion and Construction Fuel Combustion sources 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 2023 edition of the APEI. Brief descriptions of the recalculations and the impacts on emission levels are provided in Table A3–1 to Table A3–7.

- Ore and Mineral Industries: Concrete Batching and Products; Foundries
- Oil and Gas Industry: Accidents and Equipment Failures; Heavy Crude Oil Cold Production; Light/Medium Crude Oil Production; Natural Gas Distribution; 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
- Transportation and Mobile Equipment: Domestic Marine Navigation, Fishing and Military; On-Road Vehicles; Off-Road Vehicles and Equipment
- Agriculture: Agricultural Fuel Combustion; Animal Production; Crop Production
- Commercial/Residential/Institutional sources: Commercial and Institutional Fuel Combustion; Construction Fuel Combustion; Home Firewood Burning; Residential Fuel Combustion; Service Stations
- Incineration and Waste: Landfills

Further refinements and recalculations to the emissions estimates are anticipated for subsequent editions of the APEI. For the 2024 edition, it is expected that significant recalculations will be completed for the waste incineration sector due to methodology updates to open burning of waste. These recalculations will primarily affect the emissions estimates for hexachlorobenzene (HCB) and dioxins and furans (D/F) emissions, as waste incineration accounts for a significant proportion of overall emissions for these pollutants. Please contact apei-iepa@ec.gc.ca for more information on this methodological update.

In Table A3–1 to Table A3–7, the term "significant" refers to changes greater than ±10% in emission levels.

Table A3–1 Recalculations for Ore and Mineral Industries

Sector	Pollutant(s)	Description	Impact on Emissions
CONCRETE BATCHING AND PRODUCTS (under CEMENT AND CONCRETE INDUSTRY)			
	CO, NO_X	Concrete Batching and Products emission estimates were recalculated due to updated facility-reported data from the NPRI, as well as updated activity and population data across the time series.	Recalculations resulted in changes at the subsector level, including a decrease of 29.4 t CO (-94%) in 2010, an increase of 48.5 t NO_x (+2976%) in 2017, and an increase of 26.4 t CO (+3110%) in 2017. By sector, the impact ranges from -0.20% (-29 tonnes) for CO in 2010 to +0.16% (+26 tonnes) for NO_x in 2017, and the impact at the national level was less than 0.01% for both pollutants and all years.
FOUNDRIES			
	TPM, PM_{10}, $PM_{2.5}$, NO_x, and CO	Recalculations occurred due to a correction in the premise of what technology is used at foundries in the province of Quebec. This change impacts years 2019 and 2020.	The recalculations resulted in minor decreases of less than 0.1% per year for all pollutants at the national level. At the Foundries sectoral level, emissions decreased in 2019 for CO -4180 t, -9.6%; NO_x -5.6 t, -6.7%; TPM -12.5 t, -0.3%; PM_{10} -2.6 t, -0.06% and $PM_{2.5}$ -117 t, -2.9%. In 2020, the decreases were, CO -2438 t, -5.9%; NO_x -5.6 t, -7.2%; TPM -24.4 t, -0.5%; PM_{10} -13.4 t, -0.3% and $PM_{2.5}$ -71.8 t, -1.9%

Table A3–2 Recalculations for Oil and Gas Industry

Sector	Pollutant(s)	Description	Impact on Emissions
ACCIDENTS AND EQUIPMENT FAILURES (under UPSTREAM OIL AND GAS INDUSTRY)			
	VOCs	Recalculations occurred due to the reallocation of surface casing vent flow emissions in Alberta and British Columbia from the oil and gas production sectors where they occurred to accidents and equipment failures in order to maintain consistency between all provinces and territories.	The recalculations resulted in significant changes in VOCs at the national level from 1990 through 2020. Emissions attributed to this sector increased in each year, with the largest difference in 2018: +13 887 t, +35.6%.
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 reported venting emissions estimates from 2013 through 2020, and to unreported venting emissions in 2020. Minor activity data updates resulted in changes for fuel combustion emissions in 2019 and 2020. Surface casing vent flow emissions in Alberta were reallocated to accidents and equipment failures from this sector, resulting in further changes from 1990 through 2020.	The recalculations resulted in significant changes to emissions at the national level in 2016 for SO_x (+202 t, 10.6%), $PM_{2.5}$, PM_{10}, and TPM (for each: +69 t, +14.7%). VOC emissions decreased each year from 1990 through 2020, with the largest change in 2018 (-766 t, -4.8%). For all other pollutants, these recalculations resulted in changes of less than ±10% at the national level.
LIGHT/MEDIUM CRUDE OIL PRODUCTION (under UPSTREAM OIL AND GAS INDUSTRY)			
	TPM, PM_{10}, $PM_{2.5}$, SO_x, NO_x, VOCs, CO, NH_3	Recalculations occurred as a result of methodological changes to flaring and reported venting emissions estimates from 2013 through 2020, in addition to unreported venting and glycol dehydrator estimates in 2020. Minor activity data updates resulted in changes for fuel combustion emissions in 2019 and 2020. Surface casing vent flow emissions in Alberta and British Columbia were reallocated to accidents and equipment failures from this sector, resulting in further changes from 1990 through 2020.	For all pollutants, these recalculations resulted in changes of less than ±10% at the national level. From 2013 to 2020, changes to $PM_{2.5}$, PM_{10}, and TPM emissions included both increases and decreases, with the largest change in 2018 (for each: -68 t, -2.4%). VOC emissions decreased from 1990 through 2020 (largest difference in 2017: -7820 t, -2.0%). The recalculations resulted in changes of less than ±1% for all other pollutants.
NATURAL GAS DISTRIBUTION (under DOWNSTREAM OIL AND GAS INDUSTRY)			
	CO, NO_x, VOCs, SO_x, $PM_{2.5}$, PM_{10}, TPM	Recalculations occurred because of updated activity data for distribution pipeline lengths from 2015 through 2020 (Statistics Canada, 2022).	For all pollutants, these recalculations resulted in changes of less than ±10% at the national level.

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

Sector	Pollutant(s)	Description	Impact on Emissions
NATURAL GAS PRODUCTION AND PROCESSING (under UPSTREAM OIL AND GAS INDUSTRY)			
	CO, NO_x, VOCs, SO_x, TPM, PM_{10}, $PM_{2.5}$, NH_3	Recalculations occurred as a result of methodological changes to flaring and reported venting emissions estimates from 2013 through 2020, in addition to unreported venting and glycol dehydrator estimates in 2020. Minor activity data updates resulted in changes for fuel combustion and unreported venting emissions in 2019 and 2020. Surface casing vent flow emissions in Alberta and British Columbia were reallocated to accidents and equipment failures from this sector, resulting in further changes from 1990 through 2020.	These recalculations resulted in changes to emissions at the national level from 1990 through 2020 for VOCs (largest difference in 2020: -13 225 t, -20.1%). In 2020, changes resulted in increases for CO (+10 879 t, +2.9%), NO_x (+8918 t, +3.1%), SO_x (+799 t, +0.7%), TPM, PM_{10}, and $PM_{2.5}$ (for each: +214 t, +7.3%), and NH_3 (+13 t, +5.9%) emissions estimates. In earlier years for all other pollutants, these recalculations did not result in changes greater than ±10%.
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 because of updated activity data for transmission pipeline lengths from 2015 through 2020 (Statistics Canada, 2022).	Recalculations resulted in changes at the national level, with minor (<1%) increases in 2015 followed by decreases from 2016 to 2020 for SO_x emissions (largest difference in 2019: -3 t, -13.3%), and for $PM_{2.5}$, PM_{10}, and TPM emissions (largest differences for each in 2020: -10 t, -10.4%). CO emissions decreased in each year from 2015 to 2020 (largest difference in 2020: -490 t, -7.8%). For all other pollutants, this recalculation did not result in changes 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, NH_3	Recalculations occurred from 1990 through 2020 as a result of a methodological update. As a result of this update, only NPRI reported data are included in emissions estimates, and in-house estimates for all other emissions sources are no longer included for this sector.	Recalculations resulted in significant changes to emissions at the national level from 1990 through 2020, with decreases for CO (largest difference in 2014: -5621 t, -26.2%), for NO_x (largest difference in 2017: -17 100 t, -43.2%), for VOCs (largest difference in 2018: -8783 t, -77.0%), for TPM (largest difference in 2015: -377 t, -45.5%), for PM_{10} (largest difference in 2017: -379 t, -41.8%), for $PM_{2.5}$ (largest difference in 2015: -380 t, -45.9%), and for NH_3 (largest difference in 2017: -871 t, -93.7%). SO_x emissions increased from 1990 to 2003 (largest increase in 2001: +2387 t, +137.6%), and decreased from 2004 to 2020 (largest decrease in 2015: -9841 t, -54.9%).
OIL SANDS MINING, EXTRACTION AND UPGRADING (under UPSTREAM OIL AND GAS INDUSTRY)			
	CO, NO_x, SO_x, TPM, PM_{10}, $PM_{2.5}$, VOCs	Recalculations occurred because NPRI reported data was updated for certain facilities for 2019 and 2020, as well as the reallocation of one NPRI facility from the Upgrading subsector to the Petroleum Refining sector.	For all pollutants, these recalculations resulted in changes of less than ±10% nationally.
PETROLEUM LIQUIDS TRANSPORTATION (under UPSTREAM OIL AND GAS INDUSTRY)			
	CO, NO_x, SO_x, TPM, PM_{10}, $PM_{2.5}$, VOCs	Recalculations occurred in 2020 because of updated activity data (Petrinex, 2022; Statistics Canada, n.d.[a]).	This recalculation did not result in an emissions change of greater than ±10%.

Table A3–3 **Recalculations for Manufacturing**

Sector/ Subsector	Pollutant(s)	Description	Impact on Emissions
BAKERIES			
	VOCs	Recalculations occurred due to revisions to wheat flour activity data (Statistics Canada, n.d.[c]) for 2019 and 2020 and revised population data (Statistics Canada, n.d.[d]) for 2020.	These recalculations resulted in minor decreases to VOC emissions in 2019 and 2020, with a maximum change of -53 t (-1.0%) at the sector level in 2020.

Table A3–4 Recalculations for Transportation and Mobile Equipment

Sector	Pollutant(s)	Fuel(s)	Description	Impact on Emissions
DOMESTIC MARINE NAVIGATION, FISHING AND MILITARY				
	B(a)p, B(b)f, B(k)f, I(cd)p, Cd, CO, D/F, Hg, NH_3, NO_x, Pb, TPM, PM_{10}, $PM_{2.5}$, SO_x VOCs	Diesel Fuel Oil, Heavy Fuel Oil	Updated vessel activity data was incorporated into the marine model. The Marine Emissions Inventory Tool (MEIT) updated their 2015, 2016, 2017 and 2018 model. Also new data was produced data for the 2019 and 2020 calendar years. Provincial estimates were redeveloped based on 2015 to 2020 port origin/destination pairs.	The recalculations resulted in changes from 1990 to 2020. Pollutant emissions changes fluctuated between -58% and 65%. For 1990, the recalculations resulted in changes in the emissions of: TPM (+11% or +470 t); Pb (+4% or +14 kg) PM_{10} (+11% or +451 t); Cd (+16% or +10 kg) $PM_{2.5}$ (+11% or +413 t); Hg (+18% or +0.2 kg) SO_x (+26% or +7930 t); D/F (+4% or +0.5 gTEQ) VOCs (+1% or +19 t); B(a)p (+4% or +0.5 kg) CO (+2% or +113 t); B(b)f (+4% or +0.5 kg) NO_x (+1% or +643 t); B(k)f (+4% or +1 kg) NH_3 was removed; I(cd)p (+4% or +1 kg) For 2005, the recalculations resulted in changes in the emissions of: TPM (+12% or +686 t); Pb (+5% or +21 kg) PM_{10} (+12% or +658 t); Cd (+16% or +14 kg) $PM_{2.5}$ (+12% or +604 t); Hg (+17% or +0.3 kg) SO_x (+28% or +11,738 t); D/F (+5% or +0.7 gTEQ) VOCs (+1% or +33 t); B(a)p (+5% or +0.7 kg) CO (+3% or +191 t); B(b)f (+5% or +0.7 kg) NO_x (+1% or +1115 t); B(k)f (+5% or +1.4 kg) NH_3 was removed; I(cd)p (+5% or +1.4 kg) For 2020, the recalculations resulted in changes in the emissions of: TPM (-25% or -396 t); Pb (-44% or -91 kg) PM_{10} (-380% or -380 t); Cd (-31% or -3 kg) $PM_{2.5}$ (-25% or -352 t); Hg (-22% or -0.03 kg) SO_x (+4% or +65 t); D/F (-44% or -3 gTEQ) VOCs (-12% or -403 t); B(a)p (-44% or -3 kg) CO (-53% or -4158 t); B(b)f (-44% or -3 kg) NO_x (65% or +40,687 t); B(k)f (-44% or -6 kg) NH_3 was removed; I(cd)p (-44% or -6 kg)
ON-ROAD VEHICLES				
	B(a)p, B(b)f, B(k)f, I(cd)p, CO, D/F, Hg, NH_3, NO_x, TPM, PM_{10}, $PM_{2.5}$, SO_x, VOCs	Diesel Fuel Oil, Motor Gasoline, Liquid Petroleum Gas, Natural Gas	Estimates for on-road vehicles, comprised of light-duty vehicles, light-duty trucks, heavy-duty vehicles, motorcycles and tire wear and brake lining, were recalculated for all reporting years. Recalculations at the on-road vehicle level were most impacted by corrections to diesel fuel oil consumption determined from the RESD in addition to the adoption of the on-road vehicle emissions model, MOVES3. Other updates that impacted on-road vehicle estimates, but to a lesser degree include: • Updated method to allocate fuel reported in the RESD between on-road vehicles and off-road vehicles/equipment. • Updates to on-road vehicle population estimates. • Updates to on-road vehicle kilometer accumulation rates. • Updates to off-road vehicle/equipment populations.	For 1990, the results of these recalculations, for select pollutants are: • $PM_{2.5}$ = -1.8 kt (-6.8%) • SO_x = +4.6 kt (+17%) • NO_x = +1.5 kt (+0.2%) • VOCs = -42 kt (-11%) • CO = +0.6 Mt (+11%) For 2005, the results of these recalculations, for select pollutants are: • $PM_{2.5}$ = -1.6 kt (-6.7%) • SO_x = -0.4 kt (-5.9%) • NO_x = -22 kt (-3.0%) • VOCs = -29 kt (-13%) • CO = -0.3 Mt (-11%) For 2020, the results of these recalculations, for select pollutants are: • $PM_{2.5}$ = -7.0 kt (-53%) • SO_x = -0.2 kt (-33%) • NO_x = -0.2 Mt (-54%) • VOCs = -67 kt (-55%) • CO = -0.6 Mt (-40%)

Table A3–4 **Recalculations for Transportation and Mobile Equipment** (cont'd)

Sector	Pollutant(s)	Fuel(s)	Description	Impact on Emissions
OFF-ROAD VEHICLES AND EQUIPMENT				
	CO, NH_3, NO_x, TPM, PM_{10}, $PM_{2.5}$, SO_x, VOCs	Diesel Fuel Oil, Motor Gasoline, Liquid Petroleum Gas, Natural Gas	Estimates for off-road vehicles and equipment, were recalculated for all reporting years. Recalculations at the off-road vehicles and equipment level were most impacted by corrections to diesel fuel oil consumption determined from the RESD in addition to an updated method to allocate fuel reported in the RESD between on-road vehicles and off-road vehicles/equipment. Other updates that impacted off-road vehicles and equipment estimates, but to a lesser degree include: • Updates to off-road vehicle/equipment populations. • Updates to on-road vehicle population estimates. • Updates to on-road vehicle kilometer accumulation rates. • Updates to emission rates for off-road diesel engines compliant with Tier 4 exhaust standards.	For 1990, the results of these recalculations, for select pollutants are: • $PM_{2.5}$ = -17 kt (-31%) • SO_x = -7.9 kt (-27%) • NO_x = -21 kt (-5.5%) • VOCs = -0.5 Mt (-64%) • CO = +1.0 Mt (+38%) For 2005, the results of these recalculations, for select pollutants are: • $PM_{2.5}$ = -2.8 kt (-7.9%) • SO_x = -2.6 kt (-39%) • NO_x = +24 kt (+7.7%) • VOCs = +57 kt (+15%) • CO = +1.9 Mt (+96%) For 2020, the results of these recalculations, for select pollutants are: • $PM_{2.5}$ = +3.2 kt (+23%) • SO_x = -26 t (-14%) • NO_x = +22 kt (+13%) • VOCs = +25 kt (+20%) • CO = +0.5 Mt (+38%)

Table A3–5 **Recalculations for Agriculture**

Sector	Pollutant(s)	Description	Impact on Emissions
AGRICULTURAL 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	Recalculations are due to activity data updated to a more recent edition of the RESD.	The recalculations did not result in changes in emission levels for any of the pollutants in 1990. For the year 2020, significant pollutant emissions recalculations were: D/F: 0.36 kt (13%) HCB: 0.08 kt (15%) SO_x: -82.6 kt (-30%) Other pollutant emissions changed less than ±10%.
ANIMAL PRODUCTION			
	TPM, PM_{10}, $PM_{2.5}$	Recalculations are primarily due to the integration of the 2021 census of agriculture including crop areas and other parameters based on the census. Other changes are due to minor activity data updates and error corrections.	The changes were minor in years 1990 and 2005, increasing emissions by <0.1%. In 2020, TPM emissions decreased by 0.8 kt (-2.3%), PM_{10} emissions increased by 0.03 kt (+0.3%), and $PM_{2.5}$ emissions increased by 0.01 kt (+0.7%)
	VOCs	Recalculations occurred from the integration of the 2021 census of agriculture including animal populations derived from the census. Minor changes resulted from small updates to activity data based on annual surveys, and from spatial reallocation of cattle populations and as a consequence weighting of emission factors.	The changes decreased emissions by <1 tonne (<0.1%) for years 1990 and 2005, and by 0.19 kt (-0.2%) in 2020.
CROP PRODUCTION			
	NH_3	The largest recalculations were in the most recent years and due to the integration of activity data from the 2021 census of agriculture. Minor changes resulted from other minor activity data updates and error corrections.	The changes decreased emissions by <0.1% in 1990 and 2005, and increased emissions by 1.4 kt (+0.8%) in 2020.
	TPM, PM_{10}, $PM_{2.5}$	Recalculations are primarily due to the integration of updated activity data based on the 2021 census of agriculture, influencing the weighting of PM emission factors.	The changes had a minor impact to emissions in years 1990 and 2005 (<0.1%). In 2020, TPM emissions increased by 123 kt (+3.5%), PM_{10} emissions by 40 kt (+2.7%), and $PM_{2.5}$ emissions by 12 kt (+3.6%).

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	Recalculations occur between 1999 and 2020. Recalculations are due to activity data updated to a more recent edition of the RESD.	The recalculations did not result in changes in emission levels for any of the pollutants in 1990. For the year 2020, pollutant emissions changed by less than ±10%, with the exception of Pb which showed an 19% increase.
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	Recalculations are due to activity data updated to a more recent edition of the RESD.	The recalculations did not result in changes in emission levels for any of the pollutants in 1990. For the year 2020, 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	Recalculations are due to updated heating degree data used to estimate firewood consumption for years where activity data is not available.	The recalculations did not result in changes in emission levels for any of the pollutants in 1990. For the year 2020, pollutant emissions changed by less than ±10%.
RESIDENTIAL FUEL COMBUSTION			
	TPM, PM_{10}, $PM_{2.5}$, SO_x, NO_x, VOCs, CO, NH_3, Pb, Cd, Hg, dioxins/furans, B(a)p, B(b)f, B(k)f, I(cd)p, HCB	Recalculations are due to activity data updated to a more recent edition of the RESD; which had updates to this source back to 2010.	The recalculations did not result in changes in emission levels for any of the pollutants in 1990. For the year 2020, pollutant emissions changed by less than ±10%.
SERVICE STATIONS			
	VOCs	Recalculations occurred for all reporting years as a result of updates to on-road vehicle and off-road vehicle and equipment estimates. More information on those updates can be found in Table A3–4.	The recalculations did not result in significant changes to emissions estimates. Changes made were less than ±5%.

Table A3–7 Recalculations for Incineration and Waste Sources

Sector	Pollutant(s)	Description	Impact on Emissions
LANDFILLS (under WASTE TREATMENT AND DISPOSAL)			
	VOCs	The VOC estimates from landfills are derived from estimates of landfill gas generated. Recalculations are primarily due to an update of the model parameters used to calculate landfill gas emissions.	The corrections resulted in VOC emission estimates to become 18% lower for 1990 and 22% lower for 2020 than previously estimated for landfills.

SUBMISSION TO THE UNITED NATIONS ECONOMIC COMMISSION FOR EUROPE

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.

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 and beyond
	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 and beyond
	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 and beyond
	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 and beyond (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

1 www.ceip.at

A4.1. Canada's Air Pollution Emissions Relative to International Commitments

This edition of the Canada's Air Pollutant Emissions Inventory (APEI) indicates that:

- Emissions of sulphur oxides (SO_x) were 0.6 million tonnes in 2021, which are 56% below the 2010 emission ceiling under the 1999 Gothenburg Protocol and 69% below 2005 levels; therefore, Canada has met its commitment to reduce emissions of SO_x by 55% from 2005 levels by 2020 and beyond, as per the amended Gothenburg Protocol.
- Emissions of nitrogen oxides (NO_x) were 1.3 million tonnes in 2021, which are 41% below the 2010 emission ceiling under the 1999 Gothenburg Protocol and 42% below 2005 levels; therefore, Canada has met its commitment to reduce emissions of NO_x by 35% from 2005 levels by 2020 and beyond, as per the amended Gothenburg Protocol.
- Emissions of non-methane volatile organic compounds (NMVOCs[2]) were 1.4 million tonnes in 2021, which are 33% below the 2010 emission ceiling under the 1999 Gothenburg Protocol and 39% below 2005 levels; therefore, Canada has met its commitment to reduce emissions of NMVOCs by 20% from 2005 levels by 2020 and beyond, 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 1.5 million tonnes in 2021.
  - Emissions of $PM_{2.5}$ decreased from most sources with the notable exceptions of dust sources (not from combustion) such as construction operations and roads; Canada's emission reduction commitment[3] for $PM_{2.5}$ excludes these two sources along with crop production.
  - In line with Canada's commitment, $PM_{2.5}$ emissions in 2021 were 30% lower compared to 2005 levels; therefore, Canada has met its commitment to reduce emissions of $PM_{2.5}$ by 25% from 2005 levels by 2020 and beyond, as per the amended Gothenburg Protocol.
- Emissions of cadmium (Cd), lead (Pb), and mercury (Hg) in 2021 were 89%, 81% and 81% below the ceilings established under the 1998 Aarhus Protocol on Heavy Metals.
- Emissions of all persistent organic pollutants (POPs) in 2021 were below the ceilings established under the 1998 Aarhus Protocol on Persistent Organic Pollutants, including the four species of polycyclic aromatic hydrocarbons (PAHs) (81% below), hexachlorobenzene (HCB) (69% below), and dioxins and furans (63% below).

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

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

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

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

Table A4–2 illustrates the structure of the UNECE reporting template. The template, last revised November 18, 2019, can be found in its entirety on the CEIP website.

2 Please see Annex 1 within this report for more information on NMVOCs.

3 This commitment focuses on emission sources of $PM_{2.5}$ from combustion, and therefore, that have a significant black carbon content. *Canada's Black Carbon Inventory Report* can be found at www.canada.ca/black-carbon.

Table A4–2 **Excerpt from United Nations Economic Commission for Europe Nomenclature for Reporting Template for 2023**

Annex 1: National sector emissions: Main pollutants, particulate matter, heavy metals and persistent organic pollutants													
NFR aggregation for gridding and LPS (GNFR)	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
	NFR Code	Long name	Notes	kt	kt	kt	kt	kt	kt	kt	kt	kt
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:
BC = black carbon
GNFR = Gridded nomenclature for reporting
LPS = Large point source
NMVOC = Non-methane volatile organic compounds (refer to Annex 1 for more information)
TSP = Total suspended particles (equivalent to TPM in this report)

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 transport sector), the majority of sectoral emissions are distributed over both components. In most sectors, 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 oil sands mining, extraction and upgrading subsector, a portion of the emissions are attributed to combustion and are accounted in manufacture of solid fuels and other energy industries, while another portion is attributed to the process emissions and are compiled in the fugitive emissions oil as illustrated in Table A4–3. The only exception for that subsector is ammonia (NH_3), where all emissions are attributed to combustion activities. Finally, some in-house estimation methodologies produce detailed emissions by source, and emissions are assigned directly to the appropriate combustion or process NFR code.

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)[a]	
APEI subsector	Combustion	Process	Pollutant	Combustion	Process
Oil Sands Mining, Extraction and Upgrading	1A1c: Manufacture of solid fuels and other energy industries	1B2ai: Fugitive emissions oil: Exploration, production, transport	B(a)p	0.998	0.002
			B(b)f	0.834	0.166
			B(k)f	0.998	0.002
			Cd	0.970	0.030
			CO	0.947	0.053
			Hg	0.969	0.031
			I(1,2,3-cd)p	0.999	0.001
			NH_3	1.000	0.000
			NO_X	0.996	0.004
			Pb	0.990	0.010
			PM_{10}	0.442	0.558
			$PM_{2.5}$	0.646	0.354
			SO_X	0.998	0.002
			TPM	0.293	0.707
			VOC	0.113	0.887

Note:
a. Data sources: ECCC (2017)

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.

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