



CANADIAN ASSOCIATION
OF PETROLEUM PRODUCERS

TECHNICAL REPORT

**A National Inventory of Greenhouse Gas
(GHG), Criteria Air Contaminant (CAC) and
Hydrogen Sulphide (H₂S) Emissions by the
Upstream Oil and Gas Industry**

Volume 2, Overview of the CAC Inventory

September 2004

2005-0012

The Canadian Association of Petroleum Producers (CAPP) represents 150 companies that explore for, develop and produce natural gas, natural gas liquids, crude oil, oil sands, and elemental sulphur throughout Canada. CAPP member companies produce more than 98 per cent of Canada's natural gas and crude oil. CAPP also has 125 associate members that provide a wide range of services that support the upstream crude oil and natural gas industry. Together, these members and associate members are an important part of a \$75-billion-a-year national industry that affects the livelihoods of more than half a million Canadians.

Review by July 2010

Disclaimer

This publication was prepared for the Canadian Association of Petroleum Producers (CAPP) by Clearstone Engineering. While it is believed that the information contained herein is reliable under the conditions and subject to the limitations set out, CAPP and Clearstone Engineering do not guarantee its accuracy. The use of this report or any information contained will be at the user's sole risk, regardless of any fault or negligence of Clearstone Engineering, CAPP or its co-funders.

2100, 350 – 7th Ave. S.W.
Calgary, Alberta
Canada T2P 3N9
Tel (403) 267-1100
Fax (403) 261-4622

905, 235 Water Street
St. John's, Newfoundland
Canada A1C 1B6
Tel (709) 724-4200
Fax (709) 724-4225

Email: communication@capp.ca Website: www.capp.ca

DRAFT REPORT

Volume 2 - OVERVIEW OF THE CAC INVENTORY

A National Inventory of Greenhouse Gas (GHG), Criteria Air Contaminant (CAC) and Hydrogen Sulphide (H₂S) Emissions by the Upstream Oil and Gas Industry

PREPARED BY:

Clearstone Engineering Ltd.
700, 900-6 Avenue S.W.
Calgary, Alberta
T2P 3K2

PREPARED FOR:

CAPP
2100, 350-7 Avenue S.W.
Calgary, Alberta
T2P 3N9

Attention: Rick Hyndman

March 31, 2004

EXECUTIVE SUMMARY

A detailed inventory of greenhouse gas (GHG)¹, criteria air contaminant² (CAC) and hydrogen sulphide (H₂S) emissions is presented for the Canadian upstream oil and gas (UOG) industry for the period of 1990 to 2000. This is an update and significant expansion of the previous inventory of CH₄ and VOC emissions published by CAPP (1999) for the period of 1990 to 1995. The results are summarized at the national and provincial level for the years 1990 to 2000, and at the facility level for the year 2000. Additionally, emission and energy intensity data are presented by type of facility for the year 2000 where data were available to do so. The aim of the intensity analysis was to devise a practicable means of providing a fair normalized comparison of a facility's emission intensity relative to other facilities in the same category.

The UOG industry includes both on-shore and off-shore facilities, as well as drilling and exploration, conventional oil and gas production, in situ oilsands production, natural gas processing and oil transmission. Contributions reported by CGA (2004) for natural gas transmission, storage and distribution, are also included in the inventory, although only for the year 2000. Specific segments of the industry excluded from the inventory are petroleum refining, heavy oil upgrading, oilsands mining, extraction and upgrading and natural gas distribution. Emissions from construction activities, ancillary structures and operations (buildings, offices, etc.) and mobile sources are also excluded.

The key improvements and changes from the previous inventory include the following:

- Application of a truly rigorous bottom-up approach in which emissions have been evaluated by type of primary source (e.g., fugitive equipment leaks, process venting, flaring, fuel combustion and accidental releases) at the individual facility level.
- Inclusion of CAC and H₂S emissions.
- Full compliance with UNFCCC reporting requirements and IPCC methodology and good practice guidance for GHGs.
- Quantitative assessment of the uncertainties in all presented emission estimates using a Tier 1 IPCC methodology.
- An analysis of GHG emission intensities.
- In previous inventories, VOCs were defined as comprising all non-methane hydrocarbons. For the new inventory, VOCs are defined as also excluding ethane to be consistent with current federal and provincial definitions.

The emissions inventory has drawn on the best and most detailed data available from government, industry and published sources, and has comprised substantial government and industry involvement and review to ensure the most accurate and complete results possible.

The presented GHG results are needed to support objective decisions in the current industry-Canada covenants negotiations on GHG emissions. Furthermore, UNFCCC reporting requirements have been expanded and the type and quality of data available in Canada has changed since the previous inventory was developed. The updated inventory is required to reflect best available data and to provide a basis for Canada to meet the enhanced UNFCCC reporting requirements. The Government of Canada is required

¹ The target greenhouse gases are CO₂, CH₄, N₂O, CO₂E, and CO₂AO (atmospheric oxidation).

² The criteria air contaminants include NO_x, SO_x, VOC, CO, TPM, PM₁₀, and PM_{2.5}.

under the UNFCCC to report annually an inventory of emissions and removals of GHGs for the years 1990 to the present.

Furthermore, the recent addition of CACs (i.e., NO_x, SO_x, VOC, CO, TPM, PM₁₀, and PM_{2.5}) and H₂S to the National Pollutant Release Inventory (NPRI) has stimulated interest in developing a more comprehensive estimate of these emissions from the UOG industry. To steer the development of a comprehensive CAC emissions inventory for the UOG industry, a Sub-group (SG) has been established within the Emissions and Projections Working Group.

Overview of the Emissions from Upstream Oil and Gas Operations

It is estimated that 367.5 kt of oxides of nitrogen, 265.3 kt of sulphur dioxide, 528.1 kt of VOCs, 379.6 kt of carbon monoxide, 9.1 kt of particulate matter and 10.3 kt of hydrogen sulphide are emitted directly from the UOG industry. The oxides of nitrogen, sulphur dioxide, carbon monoxide and particulate emissions are attributed solely to combustion sources. VOC emissions are contributed by all source categories; however, the main sources are storage losses (32.2 percent), fugitive equipment leaks (25.1 percent), venting (23.1 percent) and accidents (14.4 percent). Hydrogen sulphide emissions are attributed mainly to fugitive equipment leaks (45.7 percent), venting of waste gas streams containing low concentrations of H₂S (e.g., less than 10 ppm) (29.4 percent), incomplete combustion of fuels and waste gas streams containing H₂S (24.2 percent).

Gas production accounts for roughly 55 percent of NO_x emissions and 65 percent of CO emissions. Sour gas sulphur recovery gas processing plants are the largest contributor to sulphur dioxide emissions (65 percent) and particulate matter is largely from solution gas flaring at light/medium oil production facilities. Almost two-thirds of VOC emissions are attributed to light/medium oil production facilities (37 percent) and heavy oil/cold bitumen production facilities (26 percent).

The areas where emissions may be expected to increase and areas where they may decrease over time are:

Increases

- Increased processing energy is required as more water is produced along with oil.
- Increased compression is required as reservoir pressures decline.
- The tendency toward frontier gas production will require additional energy to transport the product to market.
- Hydrogen sulphide and carbon dioxide concentrations in newly discovered gas pools tend to be increasing which will increase processing energy requirements and formation CO₂ emissions.
- The tendency toward heavy oil and bitumen production as light/medium oil reserves decline may result in increased emissions.
- Heavy oil gas-to-oil ratios (GORs) appear to be increasing as technology has been developed to produce from high GOR pools.

Decreases

- Flaring of solution gas has decreased (especially in Alberta) since the implementation of EUB G-60. From implementation in 1999 the G-60 requirements have resulted in a 62 percent reduction in solution gas flaring (to 2002, the last year for which statistics are available).
- Additional regulations aimed at reducing vented gas have recently been instituted. This is expected to reduce vent gas volumes over the next few years.

- If gas prices remain high, more gas conservation schemes will be economically viable and flared and vented gas volumes will tend to decrease.

Development of the Inventory

The emissions inventory for 2000 was developed using a rigorous Tier 3 approach consistent with the IPCC guidelines for National GHG inventories. The types of emission sources considered include: fugitive equipment leaks, process venting and flaring, fuel combustion; storage and handling losses, and accidental releases. In evaluating emissions from fuel use, both the fuel taken from the process and fuel purchases from third parties have been accounted for.

Time series consistency has been maintained for the 1990 to 2000 results. Where historical data are missing, back-casting techniques were used to establish an acceptable relationship between emissions and activity data in accordance with IPCC Good Practice Guidance (Chapter 7 Methodological Choice and Recalculation, section 7.3.2).

Typically, facilities are identified as point sources and their coordinates are given in degrees longitude and latitude. Minor field installations, wells and transient sources are characterized as area sources and assigned a grid location.

Data Sources

Efforts were made to identify and gain access to both published and unpublished sources of data useful for the inventory development effort. The key information sources considered are listed below:

- Production accounting data, equipment and facility lists, emission monitoring data, spill reports, drilling and well testing data, environmental impact assessments, site inspection reports and other such information available from government agencies (e.g., Alberta Energy and Utilities Board, British Columbia Oil and Gas Commission, Saskatchewan Industry and Resources and National Energy Board):
 - Relevant statistics, databases, study results, emission factors and speciation profiles, emission calculation protocols and survey information available from industry associations.
 - Data available from individual UOG companies and their designated data administrators (e.g., equipment and activity data maintained by external information systems service providers, etc).
 - Canadian and international sources of emission factors and speciation profiles (primarily government agencies, industry associations and the open literature).
 - Emissions data compiled by Clearstone from numerous measurement programs and emissions studies conducted at different facilities throughout the UOG industry where prior permission for use of this data has been obtained from the original clients.
- The glycol dehydrator database from CAPP.
- Drilling activity and fuel use data from Canadian Association of Oilwell Drilling Contractors.

- Relevant emission factors available from Environment Canada, U.S. Environmental Protection Agency and Clearstone's in-house databases, and other such information.
- An industry survey conducted through CAPP to obtain facility-level equipment lists, electric power consumption, fuel purchases from third parties, compression ratios, API gravity, steam volume and quality, produced water salinity, electric power production, and steam purchases. Other convenient and reliable sources of these data generally do not exist.

TABLE OF CONTENTS

<u>Section</u>	<u>Page</u>
1.0 INTRODUCTION	1
2.0 BACKGROUND	2
2.1 Industry Description and Classification Scheme	2
2.2 Target CAC Emissions	7
2.3 Organic Emission Categories	7
3.0 OVERVIEW OF THE EMISSIONS INVENTORY	8
3.1 CAC and H ₂ S Emissions	8
3.1.1 NO _x Emissions	8
3.1.2 SO ₂ Emissions	8
3.1.3 VOC Emissions	8
3.1.4 CO Emissions	9
3.1.5 Particulate Emissions	9
3.1.6 H ₂ S Emissions	9
4.0 COMPARISONS WITH OTHER INVENTORIES	20
4.1 Comparison to the 1995 CAPP Inventory	20
4.2 Comparison of H ₂ S Emissions to NPRI Reported Emissions for 2000	24
4.3 Comparison of CAC Emissions to Alberta Environment Point Source Inventory	24
5.0 CONCLUSIONS AND RECOMMENDATIONS	26
5.1 Conclusions	26
5.2 Recommendations	26
6.0 REFERENCES CITED	27
7.0 APPENDIX I: TABULAR SUMMARY OF THE EMISSIONS INVENTORY	28
8.0 APPENDIX II: Graphical Summary of the Inventory By Province	73

LIST OF ACRONYMS

AGA	-	American Gas Association
BSFC	-	Brake-Specific Fuel Consumption
CAC	-	Criteria Air Contaminant
CAPP	-	Canadian Association of Petroleum Producers
CCME	-	Canadian Council of Ministers of the Environment
CGA	-	Canadian Gas Association
CO ₂ AO	-	Carbon Dioxide form Atmospheric Oxidation
CO ₂ E	-	Carbon Dioxide Equivalent
CSA	-	Canadian Standards Association
EC	-	Environment Canada
EPA	-	Environmental Protection Agency
GHG	-	Greenhouse Gases
GRI	-	Gas Research Institute
GTC	-	Gas Technology Canada
HEL	-	Higher Explosive Limit
HHV	-	High (or Gross) Heating Value
HVP	-	High Vapour Pressure
LEL	-	Lower Explosive Limit
LHV	-	Lower (or Net) Heating Value
LVP	-	Low Vapour Pressure
NBS	-	National Bureau of Standards
NMHC	-	Non-methane Hydrocarbon
NPRI	-	National Pollutant Release Inventory
PM	-	Total Suspended Particulate Matter
PM _{2.5}	-	Particulate matter ≤2.5 µm in Aerodynamic Diameter
PM ₁₀	-	Particulate matter ≤10 µm in Aerodynamic Diameter
POM	-	Polycyclic Organic Matter
ppm	-	Parts Per Million
SEPAC	-	Small Explorers and Producers Association of Canada
THC	-	Total Hydrocarbons
UOG	-	Upstream Oil and Gas
U.S. EPA	-	U.S. Environmental Protection Agency
VCR	-	Voluntary Challenge and Registry
VOC	-	Volatile Organic Compound
TOC	-	Total Organic Compounds
TNMOC	-	Total Non-methane Organic Compounds

ACKNOWLEDGEMENTS

The development of this document has been sponsored by CAPP, Environment Canada, Natural Resources Canada, Canadian Energy Pipeline Association, Canadian Gas Association, Alberta Energy and Utilities Board, Alberta Environment, BC Ministry of Water, Land and Air Protection, and Saskatchewan Industry and Resources. The assistance and contributions provided by the many agencies and companies contacted as part of this study are gratefully acknowledged. As well, special thanks are given to the project steering committee for the support, direction, and constructive reviews they have provided:

- Roy McArthur (Environment Canada – Pollution Data Branch)
- Rick Hyndman (Canadian Association of Petroleum Producers)
- Matin Afshin (Environment Canada – Pollution Data Branch)
- Tracy Bell (Imperial Oil)
- James Brown (Shell Canada Limited)
- Geoff Browning (Natural Resources Canada)
- Sheila Chernys (Petro-Canada Resources)
- Richard Clark (Murphy Oil Company Ltd.)
- Bob Collins (Yukon Energy Mines and Resources)
- Marc Deslauriers (Environment Canada – Pollution Data Branch)
- Kendall Dilling (Encana Corporation)
- John Drinkwater (BP Canada Energy Company)
- Cristina Dumitras (Environment Canada – Pollution Data Branch)
- Paula Dunlop (Canadian Gas Association)
- Sam Edgerton (Nexen Canada Ltd.)
- Dave Fox (Environment Canada – Yellowknife)
- Chia Ha (Environment Canada – Pollution Data Branch)
- Andrew Higgins (Talisman Energy Inc.)
- David Hill (Alberta Energy Utilities Board)
- Wayne Hillier (Husky Energy)
- Tony Irwin (Canadian Energy Pipeline Association)
- Roy Kanten (Shell Canada Limited)
- Orest Kotelko (Canadian Natural Resources Limited)
- Howard Loeth (Saskatchewan Industry and Resources)
- Lon Nadler (Natural Resources Canada)
- Frank Neitzer (Natural Resources Canada)
- David Niemi (Environment Canada – Pollution Data Branch)
- Kenneth Olsen (Environment Canada – Pollution Data Branch)
- Michelle Reinsborough (Natural Resources Canada)
- Stephen Rodrigues (Canadian Association of Petroleum Producers)
- Darwin Roske (Saskatchewan Industry and Resources)
- John Squarek (Canadian Association of Petroleum Producers)
- Sari Shilson (BC Ministry of Energy and Mines)
- David Slubik (Alberta Environment)
- Dan Woo (Environment Canada – Edmonton)

1.0 INTRODUCTION

A comprehensive inventory of criteria air contaminant (CAC) and hydrogen sulphide (H₂S) emissions by the Canadian upstream oil and gas (UOG) industry is presented for 1990 through to 2000. An overview of the compiled emission data is provided in this volume.

A brief description of the UOG industry, applied classification scheme and target pollutants are given in Section 2.

Section 3 provides an overview of the emissions data by industry sector and source category for each emitted substance. A comparison with other inventories is presented in Section 4.

The conclusions from this work and specific recommendations for future studies are given in Section 5. All references cited in this volume are listed in Section 6. Detailed tabular summaries of the emissions inventory are provided in Appendices I and II.

The methodologies, information sources, assumptions, calculation procedures and emission factors used to develop the inventory are described in the following volumes:

- Volume 1: Overview of the GHG Emissions Inventory
- Volume 3: GHG Methodology
- Volume 4: CAC and H₂S Methodology
- Volume 5: Compendium of Emission Factors, Uncertainty Data and Terminology

2.0 BACKGROUND

A brief description of the upstream oil and gas industry, and definitions for the different categories of organic substances considered in the developed emissions inventory are provided below.

2.1 Industry Description and Classification Scheme

The upstream oil and gas (UOG) industry comprises all infrastructure used to find, produce, process/treat and transport natural gas, liquefied petroleum gas, condensate, crude oil, heavy oil and crude bitumen to market. Specific clarifications, exclusions and additions applied in developing the inventory of CAC and H₂S emissions by the UOG industry are listed below:

- Refining, distribution and use of liquid and liquefied hydrocarbons are part of the downstream side of the industry and therefore were excluded.
- Heavy oil upgrading and oil sands mining and processing were excluded since atmospheric emissions of the target pollutants from these parts of the industry are currently being assessed as part of a separate project sponsored by CAPP.
- Construction activities, ancillary structures and operations (buildings, offices, etc.) and mobile sources were excluded.
- GHG emissions due to natural gas storage, transmission and distribution were previously determined by others (CGA, 2004) and therefore are simply summarized here for easy reference.

Most Canadian oil and gas production is from the Western Canadian sedimentary basin in Alberta, Saskatchewan and British Columbia. In 2000, these three provinces accounted for over 89 percent of Canada's total oil production and 96 percent of its gas production (see Table 1). The provinces of Manitoba, Ontario, Nova Scotia and Newfoundland as well as the Yukon and Northwest Territories account for the rest.

While the emissions inventory was developed at the individual facility level, the presented overview of the emissions inventory summarizes the results by province, industry sector and primary emissions source category. The industry sector classifications and major subcategories are summarized in Table 2. The primary emission source categories are listed below:

Table 1. Summary of gas and oil production by province or territory for 2000.				
Province/Territory	Gas Production (10 ⁶ m ³)	Light/Medium Oil Production (10 ³ m ³)	Heavy Oil Production (10 ³ m ³)	Bitumen Production (10 ³ m ³)
Northwest Territories ¹	754.2	1 434.2	----	----
Yukon Territory ¹	569.6	----	----	----
British Columbia ²	25 516.6	2 563.4	----	----
Alberta ³	176 145.9	29 681.5	13 822.3	16 780.9
Saskatchewan ⁴	8 147.8	12 657.3	11 585.4	----
Manitoba ⁵	13.7	625.1	----	----
Ontario ⁶	420.0	232.3	----	----
Nova Scotia ¹	3 597.2	----	----	----
Newfoundland ¹	2 393.4	8 394.2	----	----
Canada	217 558.4	55 588.0	25 407.7	16 780.9

1. Source: Statistics Canada. 2000. Supply and Disposition of Crude Oil and Natural Gas. Catalogue No. 26-006-XPB.
2. BC
3. Source: Alberta Energy and Utilities Board. 2000. Alberta Energy Resource Monthly Statistics. ST 3-2000.
4. Source: Saskatchewan Industry and Resources. 2000. Mineral Statistics Yearbook 2000. Miscellaneous Report 2000-3.
5. Source: Manitoba Industry, Trade and Mines. 2000 Manitoba Oil Activity Review. Available on the website: www.gov.mb.ca/itm/petroleum/oar/index.html
6. Source: Ontario Oil, Gas & Salt Resources Library. Database available at www.ogsrlibrary.com

Table 2. Classification of the upstream oil and gas industry by industry sector and subcategory.	
Industry Sector	Industry Subcategories
Drilling	Drilling Fluids Drill-stem Tests Drilling Rigs
Well Servicing and Testing	Venting Activities Service Rigs Pumping Units Wireline Units
Gas Production	Wells Gathering Systems Field Facilities Gas Batteries
Light & Medium Crude Oil Production	Wells Flow Lines Single-well Batteries Satellite Batteries Central Batteries
Heavy Oil & Cold Bitumen Production	Wells Flow Lines Single-well Batteries Satellite Batteries Cleaning Plants
Thermal Heavy Oil & Crude Bitumen Production	Wells Flow Lines and Gathering Systems Satellite Batteries Cleaning Plants
Gas Processing	Sweet Gas Processing Plants Sour Gas (Flaring) Plants Sour Gas (Extraction) Plants Straddle Plants
Product Transmission and Transportation	Natural Gas Systems Liquefied Petroleum Gas Systems Pentanes-plus Systems Crude Oil Systems
Waste Oil Reclaiming and Disposal	Oilfield-waste Transporters Waste Oil Reclaimers

Table 2. Classification of the upstream oil and gas industry by industry sector and subcategory.	
Industry Sector	Industry Subcategories
	Land Treatment Operations Road Oiling
Accidents and Equipment Failures	Pipeline Ruptures Well Blowouts Spills Surface-casing Vent Blows Gas Migration to the Surface

- **Fuel Combustion** – comprises the combustion of fuel withdrawn from the process and fuel purchased from third parties. The amount of fuel withdrawn from the process was determined directly from available production accounting statistics. Data on actual fuel purchases were obtained for all major consumers of purchased fuel gas (e.g., full scale thermal recovery projects), and estimates based on extrapolations of available survey results were prepared for all other facilities. No corrections were made to the fuel data to account for any fuel used for non-combustion purposes (e.g., purge gas, instrument gas, compressor start gas, and blanket gas). At each site total gas use was prorated to the actual or expected types of combustion sources (i.e., reciprocating engines, turbines, heater and boilers and incinerators). Fuel used to adjust the heating value of waste gas streams to allow stable flaring was not directly evaluated; rather, this portion of total fuel consumption was allocated proportionately to the other combustion source categories at each site. Site specific-fuel gas analyses were applied where available; otherwise, appropriate default values were used (see Volumes 2 and 3).
- **Flaring** – a distinction was made between acid gas flaring and all other types of flaring. The gas compositions were determined using either available site-specific data or typical default values by industry sector. The amount of both types of flaring was taken directly from the available production accounting statistics. No corrections were made to try to account for any gas volumes reported as flared but are actually vented. Additionally, no corrections were made to account for leakage into flare systems.
- **Reported Venting** – is vented volumes stated in production accounting statistics. These volumes are assumed to comprise, where applicable, casing gas venting, waste associated gas flows, treater and stabilizer off-gas and gas volumes discharged during process upsets and equipment depressurization events. Storage and loading/unloading losses are assumed to be generally excluded from reported vented volumes, and therefore are assessed separately.
- **Unreported Venting** – is the sum of all miscellaneous vented volumes not normally included in reported vented volumes and not otherwise accounted for in the developed emissions inventory. This may include instrument vent gas, compressor start gas, purge gas and blanket gas that is discharged directly to the atmosphere, and dehydrator still column off-gas.
- **Fugitive Equipment Leaks** – are the loss of hydrocarbon gas and liquids to the atmosphere past mechanical connections, seals and valve seats due to normal wear and inefficiencies in these mechanisms.
- **Storage Losses** – comprise normal evaporation losses due to breathing and working effects, plus flashing losses where the received liquids have an initial vapour pressure close to or greater than local atmospheric pressure. Gas carry-through to storage tanks due to leakage past drain valves into tank inlet headers, inefficient gas-liquid separation in upstream vessels, malfunctioning level controllers or leakage past the seat of level control valves, or unintentional storage of high vapour pressure liquids in atmospheric tanks are known to be an a noteworthy source at some sites but could not be accounted for due to a lack of appropriate emission factors.

- **Loading/Unloading Losses** – are evaporation losses to the atmosphere that result from the exposure and agitation of liquids during loading and/or unloading activities.
- **Accidental Releases** – are unintentional releases of gases and unrecovered hydrocarbon liquids to the environment due to spills and major equipment failures (e.g., pipeline ruptures, third party dig-ins and well blow-outs).

2.2 Target CAC Emissions

The target CAC emissions comprise oxides of nitrogen (NO_x), sulphur oxides (SO_x), volatile organic compounds (VOCs), carbon monoxide (CO), total particulate matter (TPM), particulate matter less than 10 microns in size (PM₁₀), and particulate matter less than 2.5 microns in size (PM_{2.5}). Although, not classified as a CAC, emissions of hydrogen sulphide (H₂S) are also evaluated due to their recent addition to Environment Canada's National Pollutant Release Inventory (NPRI).

Emissions of NO_x, SO_x, CO, TPM, PM₁₀ and PM_{2.5} are attributed strictly to combustion sources. VOC and H₂S emissions are attributed to venting and fugitive emissions, but are also evaluated as products of incomplete combustion.

Emissions of NO_x and SO_x are primarily of concern as precursors to acid precipitation but are also reported to produce respiratory and other internal disease when inhaled in high concentrations and contribute to the formation of airborne PM_{2.5}. Particulate emissions are linked to respirator problems. H₂S is an air toxic as well as highly odoriferous.

CO is a poisonous gas that reportedly can produce lasting health harm, mainly through its destructive effects on the central nervous system.

VOCs are potentially toxic substances and are of concern as a precursor (along with NO_x) to the formation of photochemical oxidants near ground level.

2.3 Organic Emission Categories

In this document, the sum of all hydrocarbon substances emitted by a source is referred to as total hydrocarbon (THC) emissions. Hydrocarbons are any substances that contain at least carbon and hydrogen. A volatile organic compound (VOC) is any substance containing carbon, excluding carbon monoxide and carbon dioxide, that will react with nitrogen oxides in the presence of solar radiation to produce photochemical oxidants (e.g., ozone). All hydrocarbons except methane and ethane are classified as VOCs. Non-methane hydrocarbons (NMHC) are THC less any methane. VOCs are calculated here as THC less any methane and ethane.

3.0 OVERVIEW OF THE EMISSIONS INVENTORY

3.1 CAC and H₂S Emissions

Total CAC and H₂S emissions are summarized by type of pollutant and industry sector for 2000 in Table 3. The uncertainty bounds for emission estimate are also given in this table. The Figures 1 to 9 present pie charts depicting the percentage contributions, by sector and source category, to total emissions of each pollutant respectively.

3.1.1 NO_x Emissions

The amount of NO_x emissions is estimated at 367.5 kt with an uncertainty of ±0.9 percent. Nearly all of this is from fuel combustion with the rest (less than 1 percent) resulting from flaring activities. Almost 90 percent of the NO_x emissions are from fuel consumption by the natural gas production and processing sectors (see Figure 1). This disproportionately large contribution by these sectors relative to their total fuel use reflects their greater proportionate use of fuel for engines. The NO_x emission factors for fuel use by engines are typically 4 to 5 time greater than those for heaters and boilers.

3.1.2 SO₂ Emissions

The total emission of SO₂ amounted to 265.3 kt with an uncertainty of ±3.6 percent. Over 80 percent of these emissions are contributed by tail gas incinerators on sulphur recovery and acid gas flaring at sour gas processing plants (see Figure 2). Most of the rest is attributed to the flaring of sour gas during well testing and at light and medium crude oil production facilities. Less than 2 percent is due to the combustion of sulphur-containing fuels.

3.1.3 VOC Emissions

Total emissions of VOCs are estimated at 528.1 kt with an uncertainty of -2.4 to +2.5 percent. These emissions are contributed by all source categories; however, the main sources are storage losses (32.2 percent), fugitive equipment leaks (25.1 percent), venting (23.1 percent) and accidents (14.4 percent). The rest (5.2 percent) is mostly from loading and unloading losses with some small contributions due to incomplete fuel and waste gas combustion. The sectors that contribute most to VOC emissions are light and medium crude oil production (36.8 percent), heavy oil and cold bitumen production (25.7 percent), and gas production (15.2). Nearly all the rest is from accidental releases from across the industry.

Similar distributions occur for NMHCs as shown in Figure 4. A total of 766 kt of NMHCs were emitted. Almost a third of this amount is ethane.

3.1.4 CO Emissions

CO emissions amounted to 379.6 kt with an uncertainty of -1.4 to +1.5 percent. Similar to the case for NO_x emissions (see Section 3.2.1), specific CO emissions are much greater for fuel use by engines than for fuel use by heaters and boilers. Accordingly, most (almost 94 percent) of the CO emissions are contributed by the natural gas production and processing sectors due to their significant fuel use and greater relative use of engines than at oil production facilities (see Figure 5).

3.1.5 Particulate Emissions

Some 9.1 kt of TPM was emitted by combustion sources. The uncertainty bounds are -2.6 to +2.7 percent. Almost two thirds (61.4 percent) of these TPM emissions are from flaring and the rest (38.6 percent) is from fuel combustion (see Figures 6 to 8). The similarity of total emissions of TPM, PM_{2.5} and PM₁₀ is because natural gas is the principal substance being burned and the corresponding emission factors are the same for each of these categories (i.e., all particulate matter from natural gas combustion is PM_{2.5}). The small differences that do occur in total emissions between the different particulate matter categories are due to some diesel consumption and the more pronounced difference in the emission factors by PM category for this fuel. Diesel is primarily consumed by the drilling and well servicing sectors.

3.1.6 H₂S Emissions

While current regulations generally preclude the release of H₂S to the atmosphere, some emissions do occur due to fugitive equipment leaks (45.7 percent), venting of waste gas streams containing low concentrations of H₂S (e.g., less than 10 ppm) (29.4 percent), incomplete combustion of fuels and waste gas streams containing H₂S (24.2 percent), and evaporation losses during product storage and handling (0.7 percent). The amount of H₂S emitted is estimated to be 10.3 kt with an uncertainty of -17.9 to +18.0 percent. Roughly two thirds of these emissions are from natural gas production and processing and a third is from oil production.

Table 3. CAC Emissions from Upstream Oil and Gas Operations (Excluding Transmission)								
Sector	CAC/H₂S Emissions (t/y)							
	NO_x	CO	SO₂	VOC	TPM	PM₁₀	PM_{2.5}	H₂S
Drilling	20 875 (-1.6;+1.6)	4 537 (-1.6;+1.6)	1 414 (-1.8;+1.8)	1 529 (-1.6;+1.6)	1 489 (-1.6;+1.6)	1 468 (-1.6;+1.6)	1 452 (-1.7;+1.7)	4.8 (-18.3;+252)
Well Service	6 927 (-18.0;+18.0)	1 493 (-17.9;+17.9)	454 (-18.0;+18.0)	991 (-9.1;+9.1)	488 (-17.9;+17.9)	485 (-18.0;+18.0)	484 (-18.0;+18.0)	32.9 (-2.0;+2.0)
Well Testing	501 (-10.0;+10.0)	2 732 (-10.8;+10.8)	23 601 (-7.6;+7.6)	589 (-11.4;+11.4)	979 (-10.0;+10.0)	979 (-10.0;+10.0)	979 (-10.0;+10.0)	694 (-258;+258)
Light/Medium Oil	1 827 (-4.9;+5.9)	6 911 (-7.3;+21.5)	15 111 (-2.7;+2.7)	194 337 (-2.9;+3.5)	2 432 (-6.9;+6.9)	2 432 (-6.9;+6.9)	2 432 (-6.9;+6.9)	1 772 (-5.1;+5.2)
Heavy Oil/Cold Bitumen	1 354 (-4.6;+5.3)	3 359 (-6.6;+15.1)	483 (-5.7;+5.7)	135 541 (-1.8;+1.8)	1 047 (-5.3;+5.3)	1 047 (-5.3;+5.3)	1 047 (-5.3;+5.3)	1 240 (-8.5;+8.5)
Thermal Heavy Oil	5 826 (-13.7;+13.7)	4 132 (-28.5;+30.9)	613 (-20.4;+20.4)	7 176 (-8.1;+8.4)	353 (-17.3;+17.3)	353 (-17.3;+17.3)	353 (-17.3;+17.3)	18.6 (-20.3;+20.4)
Gas Production	203 092 (-1.0;+1.0)	247 489 (-1.6;+1.6)	6 097 (-7.2;+7.2)	80 190 (-1.6;+1.6)	1 121 (-3.1;+5.6)	1 121 (-3.1;+5.6)	1 121 (-3.1;+5.6)	3 659 (-9.2;+10.7)
Gas Processing – Injection	9 551 (-8.0;+8.0)	14 061 (-13.0;+13.0)	3 067 (-9.1;+9.1)	1 317 (-5.6;+8.0)	120 (-10.4;+20.3)	119 (-10.4;+20.3)	119 (-10.4;+20.3)	80.7 (-8.4;+13.5)
Gas Processing – Flaring	26 082 (-2.7;+2.7)	21 761 (-4.7;+4.7)	41 683 (-6.6;+6.6)	3 048 (3.4;+4.2)	263 (-7.6;+9.4)	263 (-7.6;+9.4)	263 (-7.6;+9.4)	898 (-5.2;+5.9)
Gas Processing – Recovery	28 098 (-2.5;+2.5)	15 913 (-4.3;+4.5)	172 324 (-5.1;+5.1)	3 021 (-2.5;+3.7)	411 (-7.1;+7.5)	411 (-7.1;+7.5)	411 (-7.1;+7.5)	1 725 (-6.0;+6.7)
Gas Processing – Straddle	3 761 (-10.6;+10.6)	7 831 (-21.1;+21.1)	225 (-25.0;+25.0)	2 809 (-3.4;+3.6)	46.8 (-15.7;+46.2)	46.8 (-15.7;+46.2)	46.8 (-15.7;+46.2)	8.7 (-25.0;+25.0)
Gas Processing – Sweet	59 567 (-2.1;+2.1)	49 339 (-4.0;+4.0)	225 (-19.2;+19.2)	11 385 (-1.4;+2.4)	336 (-4.4;+8.9)	336 (-4.4;+8.9)	336 (-4.4;+8.9)	119 (-9.2;+15.5)
Product Transportation	4.4 (-57.6;+57.6)	24 (-61.7;+173)		10 094 (-8.2;+8.2)	8.5 (-57.6;+57.6)	8.5 (-57.6;+57.6)	8.5 (-57.6;+57.6)	
Accidents/Equip Failures				76 064 (-14.0;+14.0)				
Total	367 469 (-0.9;+0.9)	379 586 (-1.4;+1.5)	265 304 (-3.6;+3.6)	528 097 (-2.4;+2.5)	9 096 (-2.6;+2.7)	9 073 (-2.6;+2.7)	9 055 (-2.6;+2.7)	10 256 (-17.9;+18.0)

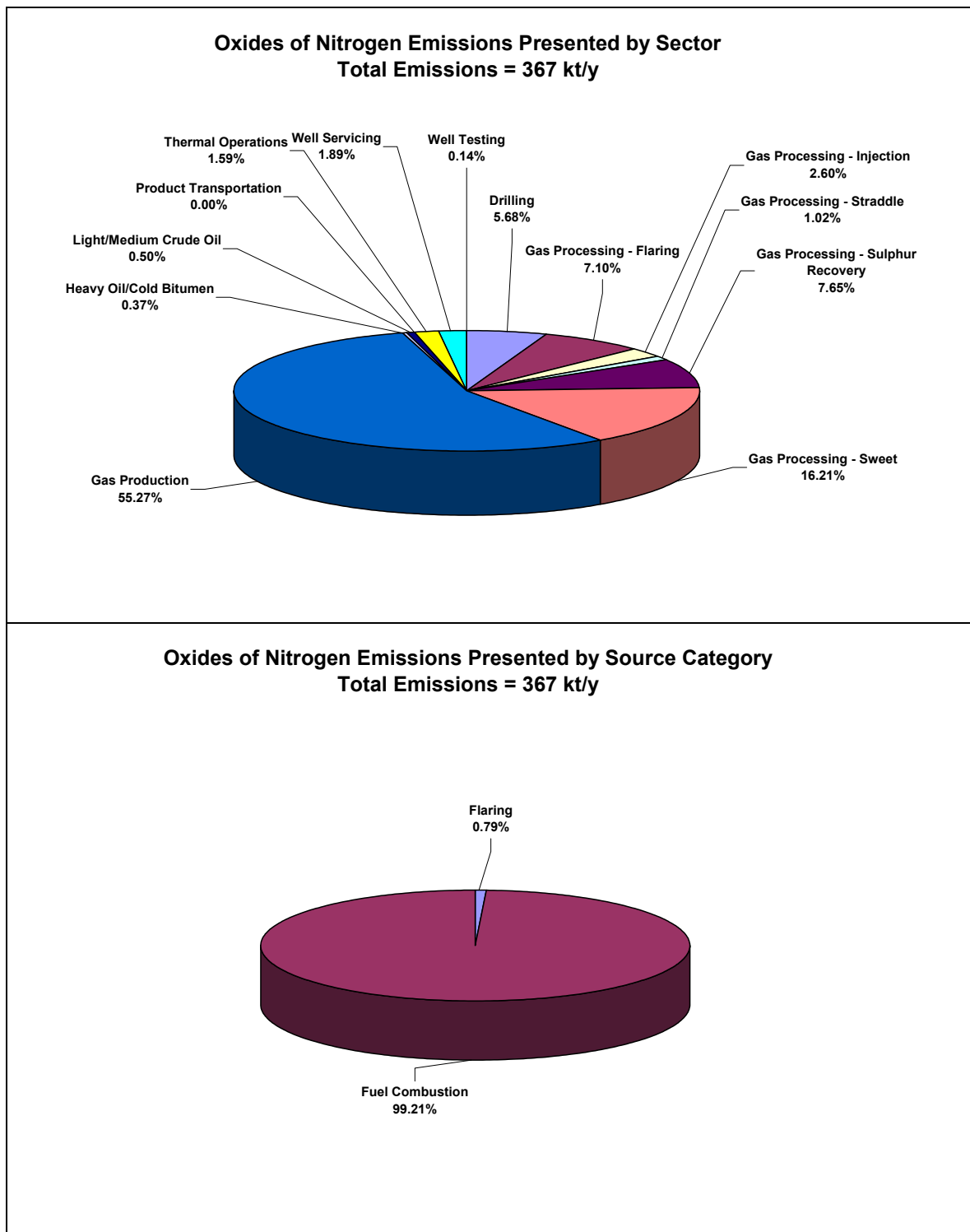


Figure 1. Pie charts depicting the percentage contributions, by sector and source category, to total NO_x emissions by the UOG industry in 2000.

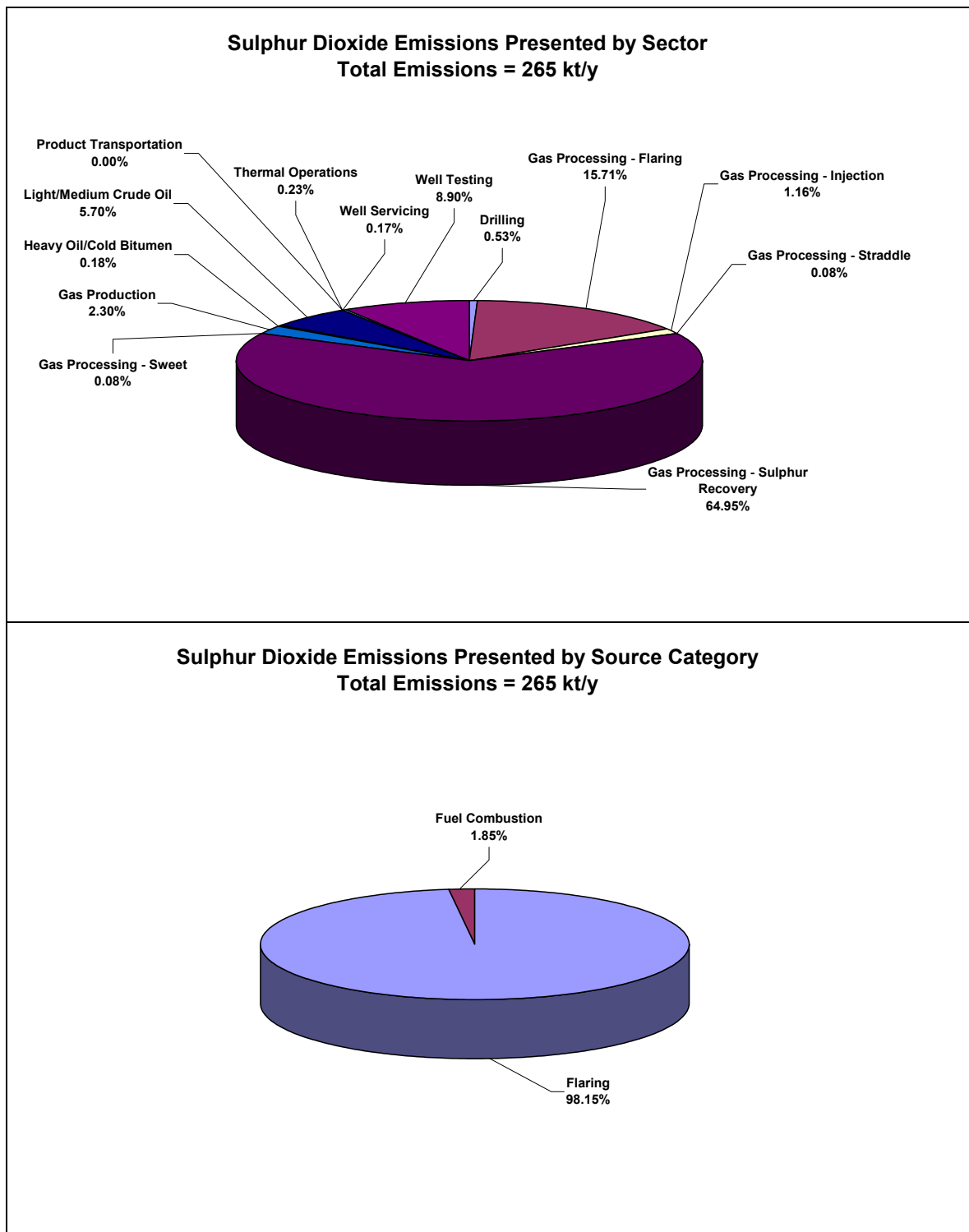


Figure 2. Pie charts depicting the percentage contributions, by sector and source category, to total SO₂ emissions by the UOG industry in 2000.

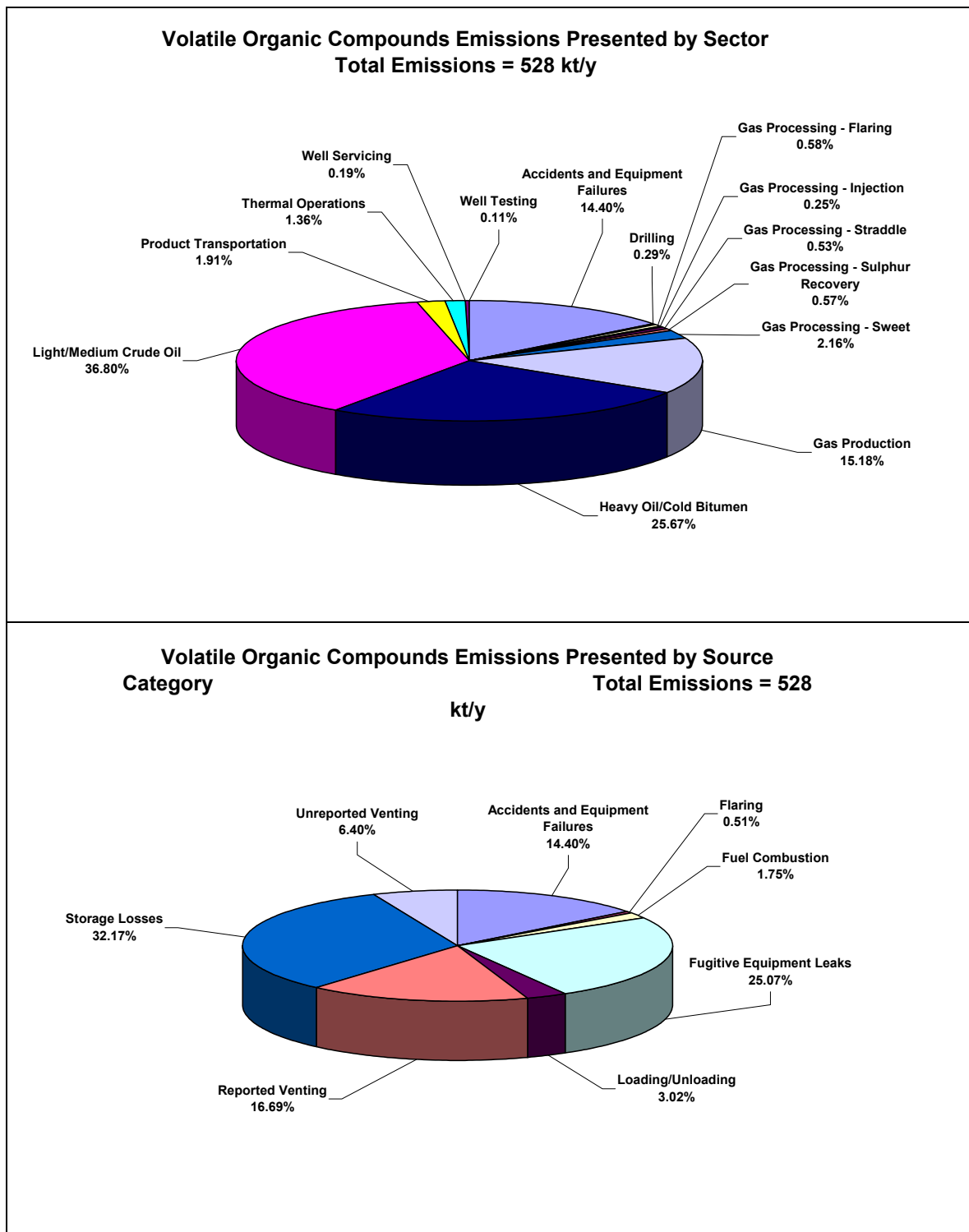


Figure 3. Pie charts depicting the percentage contributions, by sector and source category, to total VOC emissions by the UOG industry in 2000.

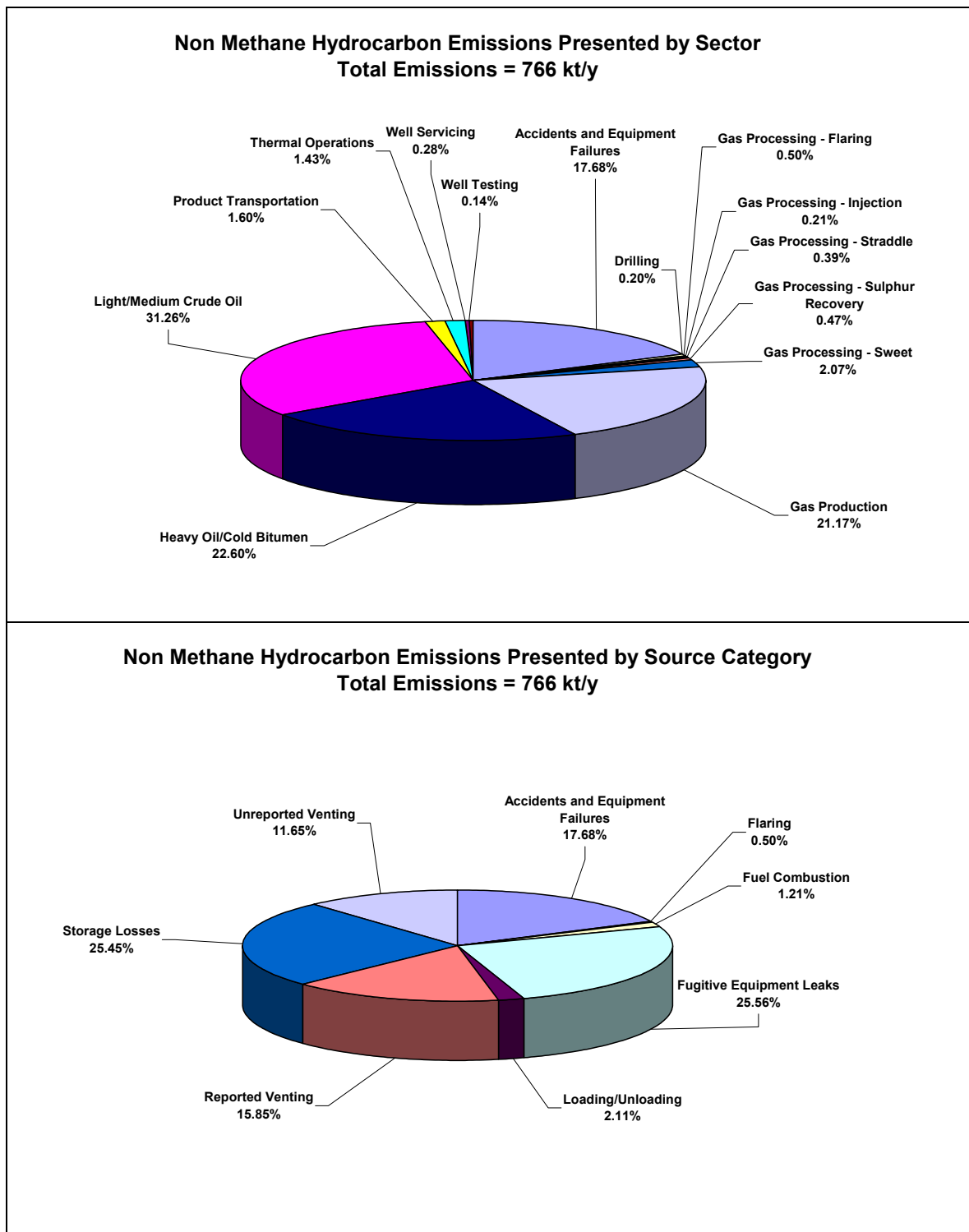


Figure 4. Pie charts depicting the percentage contributions, by sector and source category, to total NMHC emissions by the UOG industry in 2000.

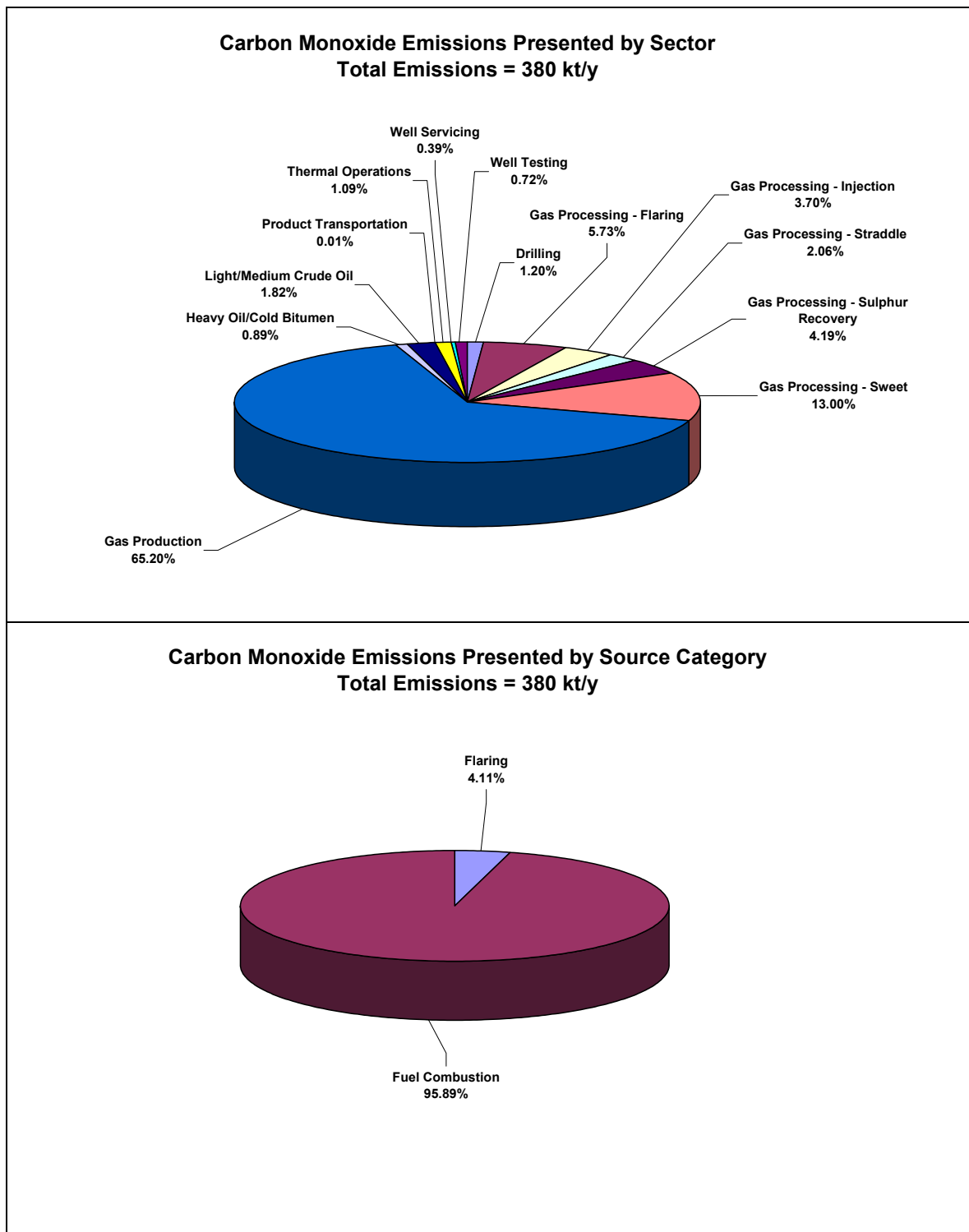


Figure 5. Pie charts depicting the percentage contributions, by sector and source category, to total CO emissions by the UOG industry in 2000.

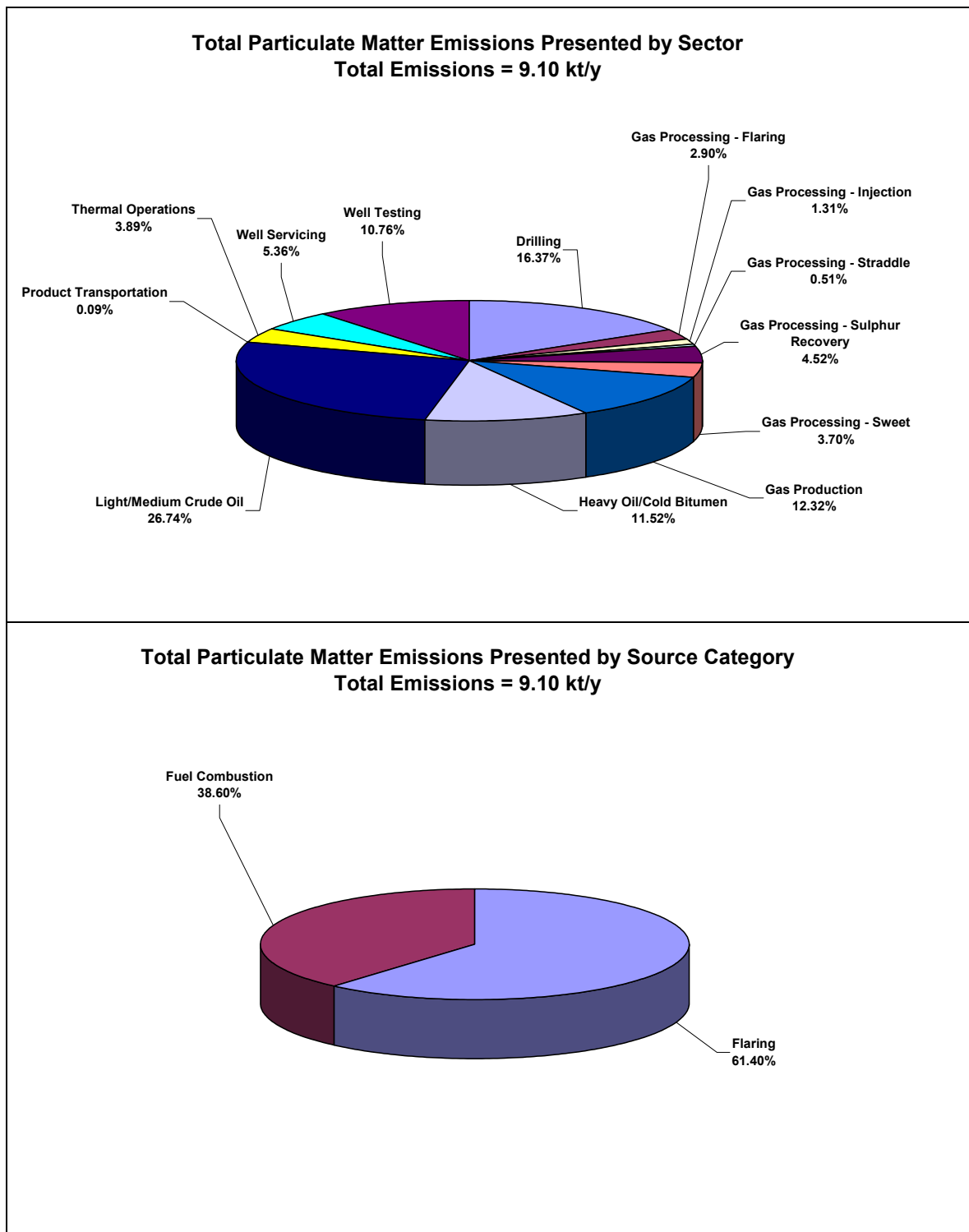


Figure 6. Pie charts depicting the percentage contributions, by sector and source category, to total PM emissions by the UOG industry in 2000.

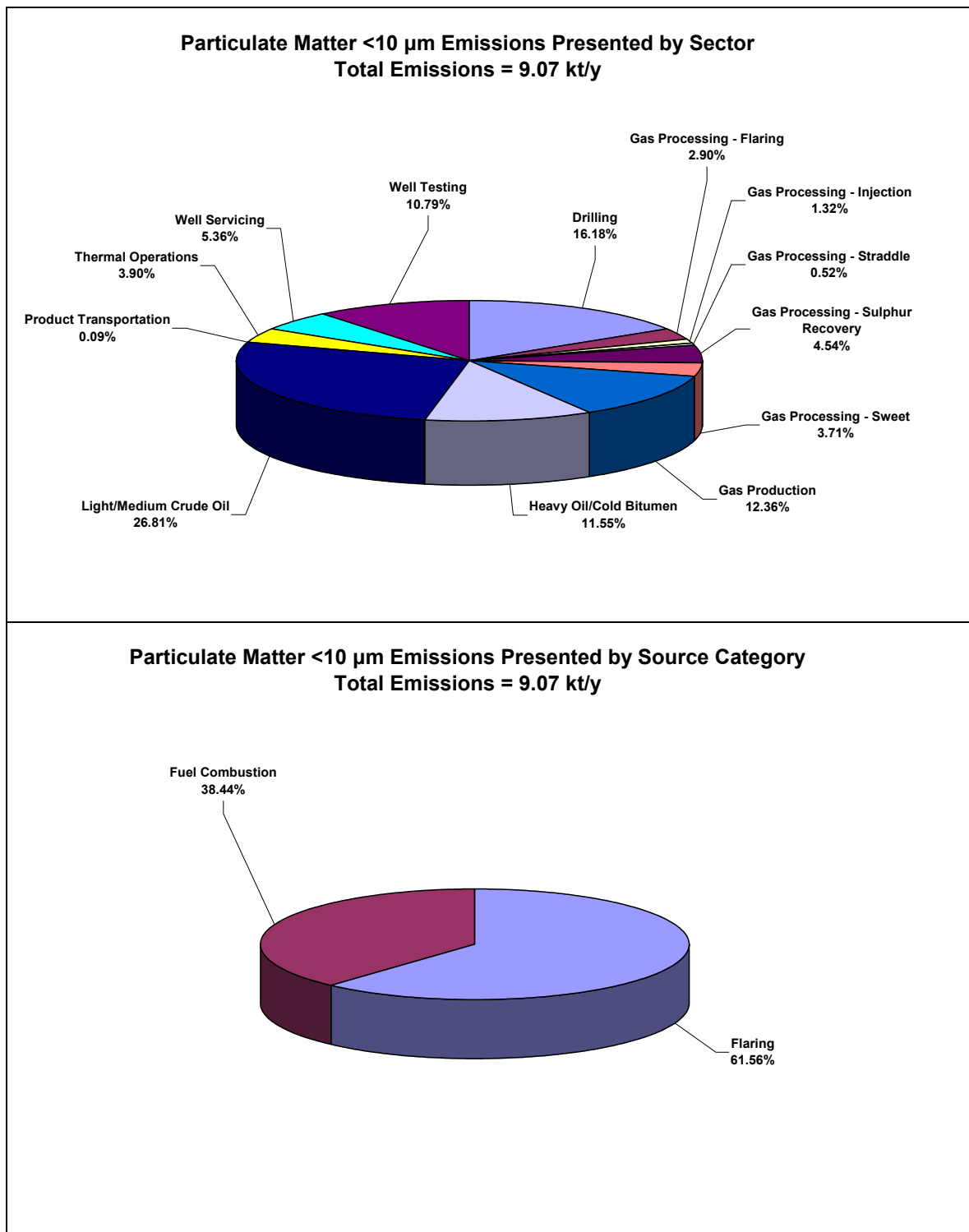


Figure 7. Pie charts depicting the percentage contributions, by sector and source category, to total PM₁₀ emissions by the UOG industry in 2000.

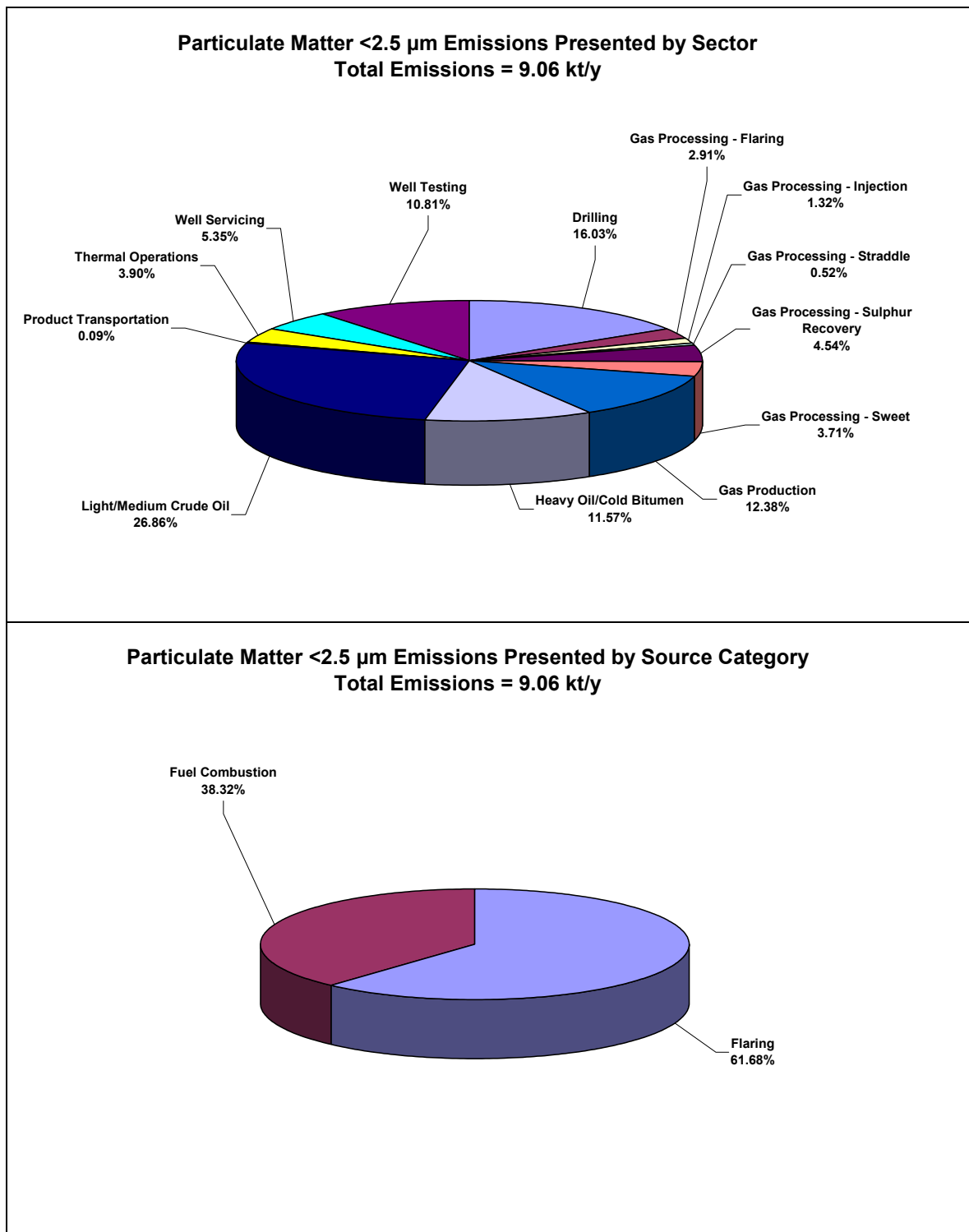


Figure 8. Pie charts depicting the percentage contributions, by sector and source category, to total PM_{2.5} emissions by the UOG industry in 2000.

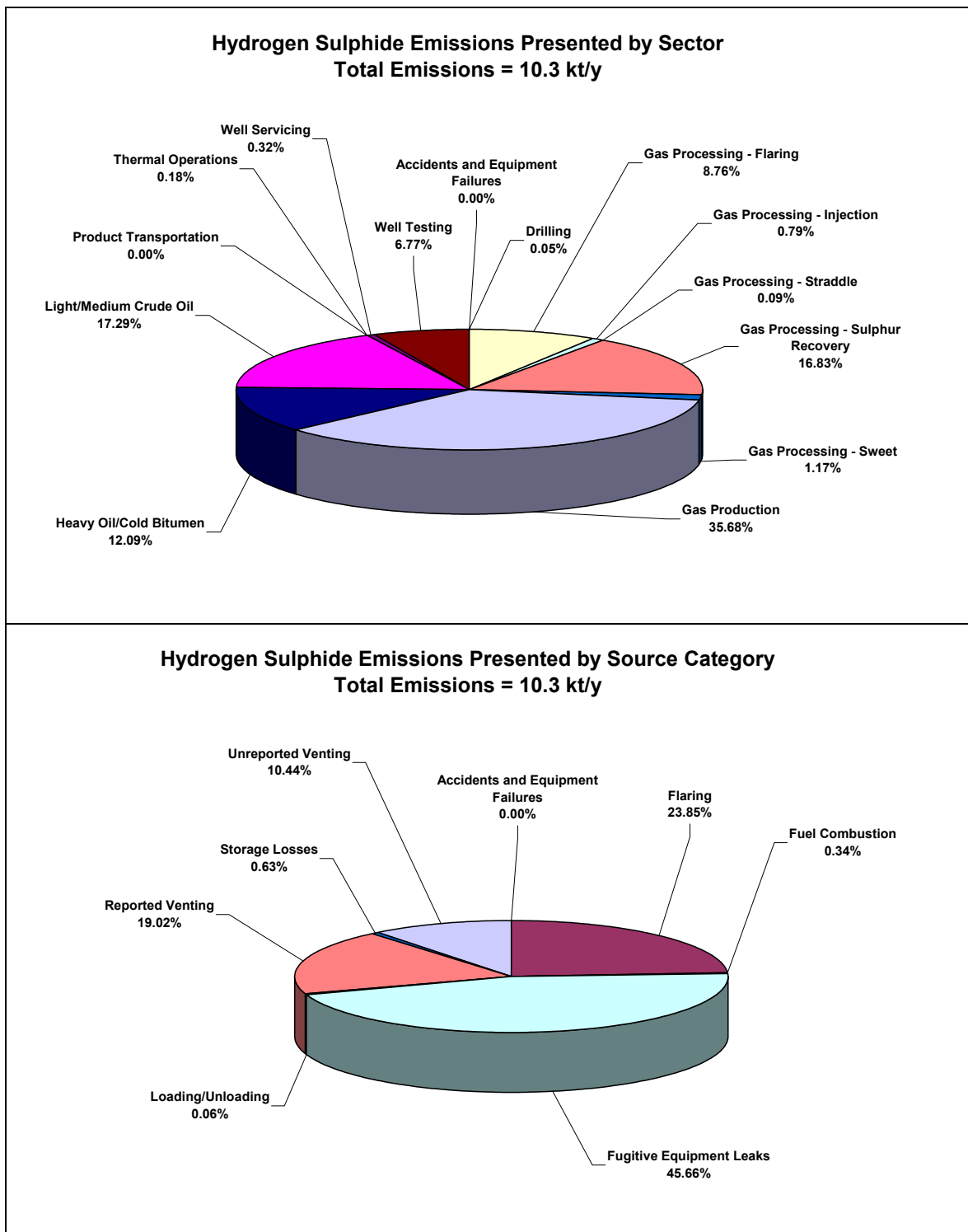


Figure 9. Pie charts depicting the percentage contributions, by sector and source category, to total H₂S emissions by the UOG industry in 2000.

4.0 COMPARISONS WITH OTHER INVENTORIES

To give some perspective and provide some verification of the developed inventory, it is appropriate to compare the compiled results with those from other related inventories. Since the last update of CAPP's CH₄ and VOC emissions inventory (CAPP, 1999), no further work has been done to update the emission estimates. The CAPP inventory has been used by Environment Canada as a basis to estimate greenhouse gas emissions as part of Canada's commitment to report national greenhouse gas emissions. As well, the inventory data has been used to extrapolate emissions to 2010 to assist in setting emission reduction targets for large industrial emitters. These extrapolations are based on the 1995 inventory and changes in oil and gas production since that time. Therefore, the following provides a comparison of the present inventory to the 1995 inventory. Tables 4 and 5 provide a comparison of CAC emissions from the two inventories and Table 6 provides a comparison of GHG emissions.

4.1 Comparison to the 1995 CAPP Inventory

In general, the observed increases in emissions of CACs between 1995 and 2000 may be explained by the growth of the industry over that period. Emissions for several provinces are significantly different than was estimated in the 1995 inventory. Newfoundland had no oil or gas production in 1995; the Hibernia began production in 1998. Nova Scotia's upstream oil and gas industry switched from being all oil production over the period of 1992 to 1999 to being all gas production and processing in 2000. Emissions from oil and gas operations in Northwest Territories, Yukon Territory, Ontario and Nova Scotia had all been estimated based on total provincial oil and gas production and some simple production based emission factors derived from Alberta data. Each of these provinces/territories has a relatively small number of producing facilities with relatively high production. As a result, emissions from these areas tended to be over-estimated. In the case of the Yukon, by a significant amount. In the present inventory actual infrastructure data and production and disposition data were used to estimate emissions for these areas and the estimated emissions are expected to be more representative.

Emissions of NO_x have increased by about 41 percent from 1995 to 2000 while national fuel consumption by the industry by 23 percent. Based on the detailed information available from the industry survey, the disposition of fuel to heaters/boilers, reciprocating engines and gas turbines is weighted more toward reciprocating engines than had previously been estimated. Since reciprocating engines emit significantly more NO_x than heaters/boilers (i.e., 10 to 50 times as much NO_x) the estimated NO_x emissions are proportionately larger per unit of fuel burned.

A similar situation is observed for carbon monoxide emissions. The previous inventory had used a single emission factor for reciprocating engines. Depending on make, model and operating conditions CO emissions may vary by as much as two orders of magnitude. Based on the data collected in the industry survey the installed engines tend to be those units with low NO_x and relatively high CO emissions.

VOC emissions have increased by about 6 percent while total production of all hydrocarbons on an energy basis increased by almost 12 percent over the period 1995 to 2000. There are two main reasons for this apparent discrepancy:

- The 1995 inventory defined VOCs as ethane and heavier hydrocarbons while the current inventory uses the more widespread definition of propane and heavier hydrocarbons.
- Emission factors used to estimate emissions from fugitive equipment leaks are somewhat lower than those used in the previous inventory.

While H₂S emissions were reported in the 1995 inventory the focus was on CH₄ and VOC emissions and no effort was made to quantify emissions from a number of sources such as sour gas and acid gas flaring, sulphur pouring and handling and sulphur recovery unit tail gas incineration. In addition, a single sour gas speciation profile was used to speciate all emissions from sour operations. Consequently, the current estimate of H₂S emissions is almost an order of magnitude larger than the 1995 estimate. A comparison of H₂S emissions to those reported to the NPRI is presented in Section 4.2.

The remaining CACs (i.e., SO₂, TPM, PM₁₀ and PM_{2.5}) were not estimated in the 1995 inventory.

Table 4. CAC Emissions from upstream oil and gas operations (excluding transmission).								
Province	1995 CAC Emissions (kt/y)				2000 CAC Emissions (kt/y)			
	NO_x	CO	SO₂	VOC	NO_x	CO	SO₂	VOC
NWT	0.309	0.038	N/A	9.80	0.4 (-28.6; +28.6)	0.1 (-57.6; +63.8)	0.01 (-24.0; +24.0)	0.1 (-7.6; +24.3)
Yukon	1.02	0.141	N/A	0.204	0.2 (-32.8; +32.8)	0.3 (-46.1; +46.1)	0.3 (-32.0; +32.0)	0.01 (-16.4; +25.2)
British Columbia	16.5	2.52	N/A	21.7	37.9 (-2.0; +2.0)	44.9 (-3.4; +3.4)	31.3 (-10.9; +10.9)	16.0 (-2.7; +3.0)
Alberta	221.7	32.5	N/A	346.5	310.3 (-0.9; +0.9)	310.4 (-1.6; +1.6)	226.1 (-4.1; +4.1)	368 (-2.4; +2.4)
Saskatchewan	19.8	2.96	N/A	104.6	14.5 (-5.7; +5.7)	18.8 (-5.4; +5.2)	7.24 (-26.2; +26.2)	120.1 (-5.0; +5.0)
Manitoba	0.464	0.018	N/A	5.92	0.3 (-42.5; +42.5)	0.2 (-17.3; +29.2)	0.3 (-55.2; +55.2)	4.4 (-5.9; +6.0)
Ontario	0.736	0.026	N/A	3.39	0.4 (-10.5; +10.5)	0.1 (-11.1; +11.1)	0.1 (-10.9; +10.9)	2.0 (-12.3; +13.3)
Nova Scotia	0.000	0.000	N/A	5.68	2.6 (-17.8; +17.8)	3.9 (-26.8; +27.1)	0.01 (-27.5; +27.5)	0.18 (-8.4; +17.4)
Newfoundland	----	----	N/A	----	0.9 (-23.1; +23.1)	0.9 (-49.9; +139)	----	17.3 (-29.7; +32.1)
Canada	260.6	37.9	N/A	497.8	367.5 (-0.9; +0.9)	379.6 (-1.4; +1.5)	265.3 (-3.6; +3.6)	528.1 (-2.4; +2.5)

Table 5. CAC emissions from upstream oil and gas operations (excluding transmission).								
Province	1995 CAC Emissions (kt/y)				2000 CAC Emissions (kt/y)			
	TPM	PM₁₀	PM_{2.5}	H₂S	TPM	PM₁₀	PM_{2.5}	H₂S
NWT	N/A	N/A	N/A	----	0.016 (-31.1; +38.8)	0.016 (-31.3; +38.9)	0.016 (-31.4; +39.1)	----
Yukon	N/A	N/A	N/A	0.001	0.001 (-41.6; +122)	0.001 (-41.6; +122)	0.001 (-41.6; +122)	----- (-29.4; +32.3)
British Columbia	N/A	N/A	N/A	0.121	0.987 (-3.1; +3.7)	0.983 (-3.1; +3.7)	0.980 (-3.1; +3.7)	0.64 (-22.0; +44.0)
Alberta	N/A	N/A	N/A	1.15	6.396 (-2.4; +2.6)	6.381 (-2.4; +2.6)	6.369 (-2.4; +2.6)	9.42 (-6.2; +8.0)
Saskatchewan	N/A	N/A	N/A	0.005	1.32 (-7.6; +7.6)	1.32 (-7.6; +7.6)	1.32 (-7.6; +7.6)	0.13 (-21.5; +21.6)
Manitoba	N/A	N/A	N/A	0.000	0.040 (-23.4; +23.4)	0.040 (-23.6; +23.6)	0.039 (-23.7; +23.7)	0.06 (-10.6; +13.8)
Ontario	N/A	N/A	N/A	0.004	0.028 (-10.7; +10.7)	0.028 (-10.9; +10.9)	0.028 (-11.0; +11.0)	----
Nova Scotia	N/A	N/A	N/A	0.000	0.046 (-37.1; +45.5)	0.046 (-37.1; +45.5)	0.046 (-37.1; +45.5)	----
Newfoundland	N/A	N/A	N/A	----	0.253 (-56.7; +56.8)	0.253 (-56.7; +56.8)	0.253 (-56.7; +56.8)	----
Canada	N/A	N/A	N/A	1.28	9.096 (-2.6; +2.7)	9.073 (-2.6; +2.7)	9.055 (-2.6; +2.7)	10.26 (-17.9; +18.0)

4.2 Comparison of H₂S Emissions to NPRI Reported Emissions for 2000

Hydrogen sulphide emissions reported to the 2000 National Pollutant Release Inventory (NPRI) are compared to those calculated in the current inventory. A total of 68 upstream oil and gas facilities with the following NAICS codes reported H₂S emissions in 2000:

- 211113 – Conventional Oil & Gas Extraction,
- 211114 – Non-Conventional Oil Extraction,
- 213111 – Oil & Gas Contract Drilling,
- 213117 – Contract Drilling (exc. Oil & Gas),
- 213118 – Services to Oil & Gas Extraction, and
- 486110 – Pipeline Transportation of Crude Oil.

These 68 facilities reported a total of 1 554.08 t of H₂S to the NPRI in 2000. In comparison, the inventory total for these same 68 facilities is 1 504.4 t (-4.7%, +5.8%) of H₂S in 2000. The NPRI value is about 3.2 percent larger than the present inventory which is well within the estimated uncertainty limits presented above.

The inventory contains 45 710 sites (ranging in size from well heads to gas processing plants) that emit a total of 10 255.7 t of H₂S. The 100 largest of these sites contribute over 44 percent of total H₂S emissions. The remainder is from small widely dispersed sites.

4.3 Comparison of CAC Emissions to Alberta Environment Point Source Inventory

In 2002 Alberta environment prepared an inventory of CAC emissions from major point sources in the upstream oil and gas industry. Inventory coverage includes some 250 facilities in Alberta, primarily gas processing plants. The inventory is based on company reported NO_x and SO₂ emissions and equipment information taken from Alberta Environment approvals. Emissions of the remaining pollutants (CO, TPM, PM₁₀, PM_{2.5} and VOC) are estimated based on facility fuel and flare volumes and typical emission factors for the sources identified. The emission calculation methodology employed is very similar to the current effort. The current inventory, however, uses some more detailed emission factors for combustion sources and a more detailed calculation procedure for non combustion sources (i.e., VOC emissions from fugitive equipment leaks, storage losses, etc.).

Table 6 provides a comparison of the Alberta Environment inventory to the same facilities in this inventory. In general, agreement between the two inventories is very good. Emissions of SO₂ and CO are within about 0.6 percent of the Alberta Environment inventory, and NO_x and particulates are within 4 to 5 percent. The substantially higher VOCs emissions are attributed to the greater detail available in the current inventory and the use of updated emission factors.

Table 6. Comparison of CAC emissions from the present inventory to those in the Alberta Environment CAC inventory.

Pollutant	Emissions (t/y)		Percent Difference (%)
	Alberta Environment Inventory	Present Inventory	
NO _x	73 293	69 697	-4.9
SO ₂	187 826	186 641	-0.6
CO	57 728	57 392	-0.6
VOC	7 538	8 975	+19.1
TPM	984	1 027	+4.4
PM ₁₀	984	1 027	+4.4
PM _{2.5}	984	1 027	+4.4

5.0 CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

The major conclusions of this study are presented below:

- (1) The CAC emissions amounted to 367 kt of NO_x, 265 kt of SO₂, 528 kt of VOC, 766 kt of NMHC, 380 kt of CO, 9.1 kt of TPM (almost all of it PM_{2.5}) as well as 10.3 kt of H₂S. Most of the inorganic emissions are due to combustion activities. The uncertainties in the estimated total emissions of the different CACs ranged from about ±0.9 percent to ±3.6 percent, while the uncertainty in the H₂S emissions is roughly ± 18 percent.
- (3) Collectively, Alberta, Saskatchewan and British Columbia account for over 89 percent of Canada's total oil production and 96 percent of its gas production. The remaining production is from Ontario, Manitoba, Northwest Territories, Nova Scotia, Newfoundland and the Yukon. The associated emissions of CACs and H₂S are generally distributed in similar proportions.
- (4) The emissions inventory was developed using an IPCC Tier 3 bottom-up assessment methodology beginning at the individual facility and process unit level. Compliance with IPCC good practice guidance was maintained throughout. Both emissions due to fuel use and fugitive sources have been evaluated and the results are summarized in a manner consistent with the UNFCCC common reporting format. Further, quantitative estimates of the uncertainties in all presented emission estimates were determined using an IPCC Tier 1 approach. A qualitative discussion of the uncertainties and specific assumptions used in the inventory, as well as a detailed description of the applied methodologies are provided in Volumes 3 and 4. A compendium of all applied emission factors and uncertainty data is provided in Volume 5.

5.2 Recommendations

The recommendations of this study will be presented following completion of the intensity analysis work.

6.0 REFERENCES CITED

Alberta Energy and Utilities Board. 2000. Alberta Energy Resource Monthly Statistics. ST 3-2000.

Canadian Association of Petroleum Producers (CAPP). 1999. A Detailed Inventory of CH₄ and VOC Emissions from Upstream Oil and Gas Operations in Canada. CAPP Pub. # 1999-0010. Calgary, AB.

Canadian Gas Association (CGA). 2004. 2000 Provincial Level GHG Inventory. Unpublished data.

International Panel on Climate Change (IPCC). 1996. Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories.

Manitoba Industry, Trade and Mines. 2000 Manitoba Oil Activity Review. Available on the website: www.gov.mb.ca/itm/petroleum/oar/index.html

Ontario Oil, Gas & Salt Resources Library. Database available at www.ogsrlibrary.com

Saskatchewan Industry and Resources. 2000. Mineral Statistics Yearbook 2000. Miscellaneous Report 2000-3.

Statistics Canada. 2000. Supply and Disposition of Crude Oil and Natural Gas. Catalogue No. 26-006-XPB.

United Nations Framework Convention on Climate Change (UNFCCC). 2002.

7.0 APPENDIX I: TABULAR SUMMARY OF THE EMISSIONS INVENTORY

Historical summaries of CAC (NO_x, CO, SO₂, VOC, TPM, PM₁₀ and PM_{2.5}) and emissions by province for the years 1990 through 2000 are provided in Table 8.1. The years 1990 through 1999 have been extrapolated from the 2000 inventory results using annual industry activity levels (e.g., oil and gas production, provincial fuel and flare volumes, wells drilled, total capable wells, etc.). The quantities used to extrapolate the emissions back to 1990 are:

- Drilling – total wells drilled each year in each province,
- Well Testing – total wells drilled each year in each province,
- Fuel Consumption – annual reported fuel consumption each year in each province,
- Flaring – annual reported flared/waste gas volume each year in each province,
- Gas Processing and Gas Production – total raw gas production for each year in each province,
- Heavy Oil/Cold Bitumen Production – total heavy oil and cold bitumen produced in each province each year,
- Light/Medium Oil Production – total light/medium oil produced in each province each year,
- Surface Casing Vent Flows/Gas Migration – total number of capable wells in each province each year,
- Accidents and Equipment Failures – total mass of product released via spills, pipeline ruptures and blowouts, and
- Product Transportation – total volume of all liquid products produced in each province each year.

To try to account for declining light/medium oil production, the amount of process infrastructure is assumed to remain essentially constant as production volumes decrease. The increased energy consumption required to handle increasing water cuts and decreasing solution gas flaring are accounted for by the fuel consumption and flaring factors, respectively. Heavy oil production steadily increased over the period 1990 to 2000. Accordingly, the increase in process infrastructure is assumed to keep pace with production increases. Discussions with one operator indicates that new technologies developed over the past several years have allowed heavy oil production from high gas-to-oil ratio (GOR) pools that could not previously be produced. Therefore, heavy oil casing gas emissions have been scaled down to match the historical GHG emission summary.

Table 7.1. Historical summary of CAC emissions (t/y) from upstream oil and gas operations in Canada, presented by year, province and sector.

1990

Yukon Territory

Sector	NOx	CO	SO2	VOC	TPM	PM10	PM2.5	H2S
Fuel Combustion	0	0	0	0	0.0	0.0	0.0	0.0
Flaring	0	0	0	0	0.0	0.0	0.0	0.0
Formation CO2 Releases	0	0	0	0	0.0	0.0	0.0	0.0
Natural Gas Production	0	0	0	0	0.0	0.0	0.0	0.0
Natural Gas Processing	0	0	0	0	0.0	0.0	0.0	0.0
Surface Casing Ventblows/Gas	0	0	0	0	0.0	0.0	0.0	0.0
Annual Total	0	0	0	0	0.0	0.0	0.0	0.0

Northwest Territories

Sector	NOx	CO	SO2	VOC	TPM	PM10	PM2.5	H2S
Fuel Combustion	550	155	6	12	10.3	10.2	10.1	0.0
Flaring	71	182	3	27	64.9	64.9	64.9	0.0
Natural Gas Production	0	0	0	8	0.0	0.0	0.0	0.0
Conventional Oil Production	0	0	0	15	0.0	0.0	0.0	0.0
Surface Casing Ventblows/Gas	0	0	0	1	0.0	0.0	0.0	0.0
Accidents and Equipment Failures	0	0	0	2	0.0	0.0	0.0	0.0
Annual Total	620	337	9	65	75.2	75.1	75.0	0.0

British Columbia

Sector	NOx	CO	SO2	VOC	TPM	PM10	PM2.5	H2S
Fuel Combustion	19 077	22 067	1 199	532	222.4	220.5	219.0	7.7
Flaring	210	973	18 352	143	348.2	348.2	348.2	135.6
Formation CO2 Releases	0	0	0	0	0.0	0.0	0.0	0.0
Oil and Gas Well Drilling	0	0	0	3	0.0	0.0	0.0	0.2
Natural Gas Production	0	0	0	2 000	0.0	0.0	0.0	115.1
Conventional Oil Production	0	0	0	9 719	0.0	0.0	0.0	8.3
Natural Gas Processing	0	0	0	439	0.0	0.0	0.0	88.8
Liquid Product Transportation	0	0	0	85	0.0	0.0	0.0	0.0
Annual Total	19 287	23 039	19 551	12 921	570.7	568.7	567.2	355.7

Table 7.1. Historical summary of CAC emissions (t/y) from upstream oil and gas operations in Canada, presented by year, province and sector.

1990

Alberta

Sector	NOx	CO	SO2	VOC	TPM	PM10	PM2.5	H2S
Fuel Combustion	177 498	173 301	1 232	4 370	1 492.1	1 483.7	1 477.5	11.5
Flaring	3 865	12 316	258 375	2 281	4 401.6	4 400.2	4 399.1	2 450.0
Formation CO2 Releases	0	0	0	0	0.0	0.0	0.0	0.0
Oil and Gas Well Drilling	0	0	0	9	0.0	0.0	0.0	0.8
Well Testing (non combustion)	0	0	0	63	0.0	0.0	0.0	0.0
Natural Gas Production	0	0	0	45 470	0.0	0.0	0.0	2 180.2
Conventional Oil Production	0	0	0	118 976	0.0	0.0	0.0	1 269.7
Heavy Oil/Cold Bitumen Production	0	0	0	51 721	0.0	0.0	0.0	681.1
Thermal Operations	0	0	0	2 961	0.0	0.0	0.0	9.2
Natural Gas Processing	0	0	0	11 317	0.0	0.0	0.0	999.0
Liquid Product Transportation	0	0	0	7 405	0.0	0.0	0.0	0.0
Surface Casing Ventblows/Gas	0	0	0	17 035	0.0	0.0	0.0	0.0
Accidents and Equipment Failures	0	0	0	1 699	0.0	0.0	0.0	0.0
Annual Total	181 363	185 617	259 607	263 306	5 893.7	5 883.9	5 876.6	7 601.4

Saskatchewan

Sector	NOx	CO	SO2	VOC	TPM	PM10	PM2.5	H2S
Fuel Combustion	7 342	8 843	121	202	141.8	140.6	139.7	0.1
Flaring	666	1 443	3 358	249	514.4	514.0	513.7	46.0
Formation CO2 Releases	0	0	0	0	0.0	0.0	0.0	0.0
Oil and Gas Well Drilling	0	0	0	1	0.0	0.0	0.0	0.0
Natural Gas Production	0	0	0	2 965	0.0	0.0	0.0	5.6
Conventional Oil Production	0	0	0	43 765	0.0	0.0	0.0	2.7
Heavy Oil/Cold Bitumen Production	0	0	0	10 980	0.0	0.0	0.0	5.0
Thermal Operations	0	0	0	591	0.0	0.0	0.0	0.6
Natural Gas Processing	0	0	0	211	0.0	0.0	0.0	3.9
Liquid Product Transportation	0	0	0	1 112	0.0	0.0	0.0	0.0
Surface Casing Ventblows/Gas	0	0	0	8 664	0.0	0.0	0.0	0.0
Accidents and Equipment Failures	0	0	0	57	0.0	0.0	0.0	0.0
Annual Total	8 008	10 287	3 479	68 799	656.2	654.6	653.4	64.1

Manitoba

Sector	NOx	CO	SO2	VOC	TPM	PM10	PM2.5	H2S
Fuel Combustion	278	129	14	16	15.9	15.6	15.4	0.0
Flaring	38	87	329	13	31.2	31.2	31.2	9.6
Natural Gas Production	0	0	0	159	0.0	0.0	0.0	3.8
Conventional Oil Production	0	0	0	3 163	0.0	0.0	0.0	47.8
Liquid Product Transportation	0	0	0	135	0.0	0.0	0.0	0.0
Surface Casing Ventblows/Gas	0	0	0	586	0.0	0.0	0.0	0.0
Accidents and Equipment Failures	0	0	0	1	0.0	0.0	0.0	0.0
Annual Total	316	216	343	4 074	47.0	46.8	46.6	61.3

Table 7.1. Historical summary of CAC emissions (t/y) from upstream oil and gas operations in Canada, presented by year, province and sector.

1990

Ontario

Sector	NOx	CO	SO2	VOC	TPM	PM10	PM2.5	H2S
Fuel Combustion	299	81	19	20	20.3	20.0	19.8	0.0
Flaring	23	5	1	2	1.6	1.6	1.6	0.0
Natural Gas Production	0	0	0	151	0.0	0.0	0.0	0.0
Conventional Oil Production	0	0	0	536	0.0	0.0	0.0	0.0
Natural Gas Processing	0	0	0	9	0.0	0.0	0.0	0.0
Liquid Product Transportation	0	0	0	349	0.0	0.0	0.0	0.0
Surface Casinq Ventblows/Gas	0	0	0	571	0.0	0.0	0.0	0.0
Annual Total	322	85	20	1 638	22.0	21.6	21.4	0.0

Nova Scotia

Sector	NOx	CO	SO2	VOC	TPM	PM10	PM2.5	H2S
Fuel Combustion	0	0	0	0	0.0	0.0	0.0	0.0
Flaring	0	0	0	0	0.0	0.0	0.0	0.0
Natural Gas Production	0	0	0	0	0.0	0.0	0.0	0.0
Conventional Oil Production	0	0	0	0	0.0	0.0	0.0	0.0
Natural Gas Processing	0	0	0	0	0.0	0.0	0.0	0.0
Surface Casinq Ventblows/Gas	0	0	0	0	0.0	0.0	0.0	0.0
Annual Total	0	0	0	0	0.0	0.0	0.0	0.0

Newfoundland

Sector	NOx	CO	SO2	VOC	TPM	PM10	PM2.5	H2S
Fuel Combustion	0	0	0	0	0.0	0.0	0.0	0.0
Flaring	0	0	0	0	0.0	0.0	0.0	0.0
Natural Gas Production	0	0	0	0	0.0	0.0	0.0	0.0
Conventional Oil Production	0	0	0	0	0.0	0.0	0.0	0.0
Accidents and Equipment Failures	0	0	0	0	0.0	0.0	0.0	0.0
Annual Total	0	0	0	0	0.0	0.0	0.0	0.0

Table 7.1. Historical summary of CAC emissions (t/y) from upstream oil and gas operations in Canada, presented by year, province and sector.

Canada		1990							
Sector	NOx	CO	SO2	VOC	TPM	PM10	PM2.5	H2S	
Fuel Combustion	205 043	204 576	2 591	5 152	1 902.8	1 890.6	1 881.4	19.4	
Flaring	4 873	15 006	280 418	2 715	5 361.9	5 360.1	5 358.7	2 641.3	
Formation CO2 Releases	0	0	0	0	0.0	0.0	0.0	0.0	
Oil and Gas Well Drilling	0	0	0	14	0.0	0.0	0.0	1.0	
Well Testing (non combustion)	0	0	0	63	0.0	0.0	0.0	0.0	
Natural Gas Production	0	0	0	50 754	0.0	0.0	0.0	2 304.8	
Conventional Oil Production	0	0	0	176 174	0.0	0.0	0.0	1 328.5	
Heavy Oil/Cold Bitumen Production	0	0	0	62 701	0.0	0.0	0.0	686.1	
Thermal Operations	0	0	0	3 552	0.0	0.0	0.0	9.8	
Natural Gas Processing	0	0	0	11 976	0.0	0.0	0.0	1 091.7	
Liquid Product Transportation	0	0	0	9 085	0.0	0.0	0.0	0.0	
Surface Casing Ventblows/Gas	0	0	0	26 856	0.0	0.0	0.0	0.0	
Accidents and Equipment Failures	0	0	0	1 759	0.0	0.0	0.0	0.0	
Annual Total	209 916	219 583	283 009	350 801	7 264.7	7 250.6	7 240.1	8 082.5	

Table 7.1. Historical summary of CAC emissions (t/y) from upstream oil and gas operations in Canada, presented by year, province and sector.

1991

Yukon Territory

Sector	NOx	CO	SO2	VOC	TPM	PM10	PM2.5	H2S
Fuel Combustion	179	276	0	2	0.8	0.8	0.8	0.0
Flaring	1	5	1 081	1	1.6	1.6	1.6	11.7
Formation CO2 Releases	0	0	0	0	0.0	0.0	0.0	0.0
Natural Gas Production	0	0	0	1	0.0	0.0	0.0	0.0
Natural Gas Processing	0	0	0	0	0.0	0.0	0.0	0.3
Surface Casing Ventblows/Gas	0	0	0	2	0.0	0.0	0.0	0.0
Annual Total	180	280	1 081	6	2.4	2.4	2.4	12.0

Northwest Territories

Sector	NOx	CO	SO2	VOC	TPM	PM10	PM2.5	H2S
Fuel Combustion	568	161	6	12	10.6	10.5	10.4	0.0
Flaring	76	195	3	29	69.6	69.6	69.5	0.0
Natural Gas Production	0	0	0	9	0.0	0.0	0.0	0.0
Conventional Oil Production	0	0	0	15	0.0	0.0	0.0	0.0
Surface Casing Ventblows/Gas	0	0	0	1	0.0	0.0	0.0	0.0
Accidents and Equipment Failures	0	0	0	2	0.0	0.0	0.0	0.0
Annual Total	644	356	9	68	80.2	80.1	80.0	0.0

British Columbia

Sector	NOx	CO	SO2	VOC	TPM	PM10	PM2.5	H2S
Fuel Combustion	11 477	13 275	722	320	133.8	132.6	131.8	4.6
Flaring	44	204	3 854	30	73.1	73.1	73.1	28.5
Formation CO2 Releases	0	0	0	0	0.0	0.0	0.0	0.0
Oil and Gas Well Drilling	0	0	0	3	0.0	0.0	0.0	0.2
Natural Gas Production	0	0	0	2 311	0.0	0.0	0.0	133.0
Conventional Oil Production	0	0	0	9 719	0.0	0.0	0.0	8.3
Natural Gas Processing	0	0	0	507	0.0	0.0	0.0	102.6
Liquid Product Transportation	0	0	0	89	0.0	0.0	0.0	0.0
Annual Total	11 521	13 480	4 575	12 979	206.9	205.8	204.9	277.2

Table 7.1. Historical summary of CAC emissions (t/y) from upstream oil and gas operations in Canada, presented by year, province and sector.

1991

Alberta

Sector	NOx	CO	SO2	VOC	TPM	PM10	PM2.5	H2S
Fuel Combustion	177 461	173 265	1 232	4 369	1 491.8	1 483.4	1 477.2	11.5
Flaring	3 961	12 619	264 736	2 337	4 510.0	4 508.5	4 507.4	2 510.3
Formation CO2 Releases	0	0	0	0	0.0	0.0	0.0	0.0
Oil and Gas Well Drilling	0	0	0	8	0.0	0.0	0.0	0.7
Well Testing (non combustion)	0	0	0	53	0.0	0.0	0.0	0.0
Natural Gas Production	0	0	0	47 205	0.0	0.0	0.0	2 263.4
Conventional Oil Production	0	0	0	118 976	0.0	0.0	0.0	1 269.7
Heavy Oil/Cold Bitumen Production	0	0	0	58 941	0.0	0.0	0.0	776.1
Thermal Operations	0	0	0	3 016	0.0	0.0	0.0	9.4
Natural Gas Processing	0	0	0	11 749	0.0	0.0	0.0	1 037.1
Liquid Product Transportation	0	0	0	7 207	0.0	0.0	0.0	0.0
Surface Casing Ventblows/Gas	0	0	0	18 454	0.0	0.0	0.0	0.0
Accidents and Equipment Failures	0	0	0	604	0.0	0.0	0.0	0.0
Annual Total	181 422	185 885	265 968	272 919	6 001.8	5 991.9	5 984.6	7 878.2

Saskatchewan

Sector	NOx	CO	SO2	VOC	TPM	PM10	PM2.5	H2S
Fuel Combustion	7 822	9 422	129	215	151.1	149.8	148.8	0.2
Flaring	715	1 550	3 605	268	552.2	551.8	551.5	49.4
Formation CO2 Releases	0	0	0	0	0.0	0.0	0.0	0.0
Oil and Gas Well Drilling	0	0	0	1	0.0	0.0	0.0	0.0
Natural Gas Production	0	0	0	3 128	0.0	0.0	0.0	5.9
Conventional Oil Production	0	0	0	43 765	0.0	0.0	0.0	2.7
Heavy Oil/Cold Bitumen Production	0	0	0	11 539	0.0	0.0	0.0	5.3
Thermal Operations	0	0	0	603	0.0	0.0	0.0	0.6
Natural Gas Processing	0	0	0	223	0.0	0.0	0.0	4.1
Liquid Product Transportation	0	0	0	1 127	0.0	0.0	0.0	0.0
Surface Casing Ventblows/Gas	0	0	0	9 537	0.0	0.0	0.0	0.0
Accidents and Equipment Failures	0	0	0	57	0.0	0.0	0.0	0.0
Annual Total	8 538	10 972	3 734	70 464	703.3	701.6	700.3	68.3

Manitoba

Sector	NOx	CO	SO2	VOC	TPM	PM10	PM2.5	H2S
Fuel Combustion	269	125	14	16	15.3	15.1	14.9	0.0
Flaring	37	85	318	13	30.2	30.1	30.1	9.3
Natural Gas Production	0	0	0	154	0.0	0.0	0.0	3.7
Conventional Oil Production	0	0	0	3 163	0.0	0.0	0.0	47.8
Liquid Product Transportation	0	0	0	131	0.0	0.0	0.0	0.0
Surface Casing Ventblows/Gas	0	0	0	657	0.0	0.0	0.0	0.0
Accidents and Equipment Failures	0	0	0	1	0.0	0.0	0.0	0.0
Annual Total	305	209	332	4 134	45.5	45.2	45.0	60.8

Table 7.1. Historical summary of CAC emissions (t/y) from upstream oil and gas operations in Canada, presented by year, province and sector.

1991

Ontario

Sector	NOx	CO	SO2	VOC	TPM	PM10	PM2.5	H2S
Fuel Combustion	285	77	18	19	19.4	19.1	18.9	0.0
Flaring	22	5	1	2	1.6	1.5	1.5	0.0
Natural Gas Production	0	0	0	144	0.0	0.0	0.0	0.0
Conventional Oil Production	0	0	0	536	0.0	0.0	0.0	0.0
Natural Gas Processing	0	0	0	9	0.0	0.0	0.0	0.0
Liquid Product Transportation	0	0	0	332	0.0	0.0	0.0	0.0
Surface Casing Ventblows/Gas	0	0	0	606	0.0	0.0	0.0	0.0
Annual Total	307	82	19	1 648	20.9	20.6	20.4	0.0

Nova Scotia

Sector	NOx	CO	SO2	VOC	TPM	PM10	PM2.5	H2S
Fuel Combustion	0	0	0	0	0.0	0.0	0.0	0.0
Flaring	0	0	0	0	0.0	0.0	0.0	0.0
Natural Gas Production	0	0	0	0	0.0	0.0	0.0	0.0
Conventional Oil Production	0	0	0	0	0.0	0.0	0.0	0.0
Natural Gas Processing	0	0	0	0	0.0	0.0	0.0	0.0
Surface Casing Ventblows/Gas	0	0	0	0	0.0	0.0	0.0	0.0
Annual Total	0	0	0	0	0.0	0.0	0.0	0.0

Newfoundland

Sector	NOx	CO	SO2	VOC	TPM	PM10	PM2.5	H2S
Fuel Combustion	0	0	0	0	0.0	0.0	0.0	0.0
Flaring	0	0	0	0	0.0	0.0	0.0	0.0
Natural Gas Production	0	0	0	0	0.0	0.0	0.0	0.0
Conventional Oil Production	0	0	0	0	0.0	0.0	0.0	0.0
Accidents and Equipment Failures	0	0	0	0	0.0	0.0	0.0	0.0
Annual Total	0	0	0	0	0.0	0.0	0.0	0.0

Table 7.1. Historical summary of CAC emissions (t/y) from upstream oil and gas operations in Canada, presented by year, province and sector.

1991

Canada

Sector	NOx	CO	SO2	VOC	TPM	PM10	PM2.5	H2S
Fuel Combustion	198 061	196 601	2 120	4 954	1 822.8	1 811.3	1 802.7	16.3
Flaring	4 855	14 662	273 599	2 679	5 238.2	5 236.3	5 234.9	2 609.3
Formation CO2 Releases	0	0	0	0	0.0	0.0	0.0	0.0
Oil and Gas Well Drilling	0	0	0	11	0.0	0.0	0.0	0.8
Well Testing (non combustion)	0	0	0	53	0.0	0.0	0.0	0.0
Natural Gas Production	0	0	0	52 952	0.0	0.0	0.0	2 406.0
Conventional Oil Production	0	0	0	176 174	0.0	0.0	0.0	1 328.5
Heavy Oil/Cold Bitumen Production	0	0	0	70 481	0.0	0.0	0.0	781.4
Thermal Operations	0	0	0	3 620	0.0	0.0	0.0	10.0
Natural Gas Processing	0	0	0	12 487	0.0	0.0	0.0	1 144.1
Liquid Product Transportation	0	0	0	8 885	0.0	0.0	0.0	0.0
Surface Casing Ventblows/Gas	0	0	0	29 258	0.0	0.0	0.0	0.0
Accidents and Equipment Failures	0	0	0	665	0.0	0.0	0.0	0.0
Annual Total	202 916	211 263	275 718	362 219	7 061.0	7 047.6	7 037.6	8 296.5

Table 7.1. Historical summary of CAC emissions (t/y) from upstream oil and gas operations in Canada, presented by year, province and sector.

1992

Yukon Territory

Sector	NOx	CO	SO2	VOC	TPM	PM10	PM2.5	H2S
Fuel Combustion	179	276	0	2	0.8	0.8	0.8	0.0
Flaring	1	5	1 081	1	1.6	1.6	1.6	11.7
Formation CO2 Releases	0	0	0	0	0.0	0.0	0.0	0.0
Natural Gas Production	0	0	0	3	0.0	0.0	0.0	0.0
Natural Gas Processing	0	0	0	1	0.0	0.0	0.0	0.6
Surface Casing Ventblows/Gas	0	0	0	2	0.0	0.0	0.0	0.0
Annual Total	180	280	1 081	9	2.4	2.4	2.4	12.4

Northwest Territories

Sector	NOx	CO	SO2	VOC	TPM	PM10	PM2.5	H2S
Fuel Combustion	554	157	6	12	10.3	10.3	10.2	0.0
Flaring	64	166	2	25	59.2	59.1	59.1	0.0
Natural Gas Production	0	0	0	8	0.0	0.0	0.0	0.0
Conventional Oil Production	0	0	0	15	0.0	0.0	0.0	0.0
Surface Casing Ventblows/Gas	0	0	0	1	0.0	0.0	0.0	0.0
Accidents and Equipment Failures	0	0	0	2	0.0	0.0	0.0	0.0
Annual Total	618	322	9	63	69.5	69.4	69.3	0.0

British Columbia

Sector	NOx	CO	SO2	VOC	TPM	PM10	PM2.5	H2S
Fuel Combustion	7 427	8 591	467	207	86.6	85.8	85.3	3.0
Flaring	135	627	11 823	92	224.3	224.3	224.3	87.4
Formation CO2 Releases	0	0	0	0	0.0	0.0	0.0	0.0
Oil and Gas Well Drilling	0	0	0	2	0.0	0.0	0.0	0.1
Natural Gas Production	0	0	0	2 541	0.0	0.0	0.0	146.2
Conventional Oil Production	0	0	0	9 719	0.0	0.0	0.0	8.3
Natural Gas Processing	0	0	0	557	0.0	0.0	0.0	112.8
Liquid Product Transportation	0	0	0	90	0.0	0.0	0.0	0.0
Annual Total	7 562	9 217	12 290	13 209	310.9	310.1	309.6	357.8

Table 7.1. Historical summary of CAC emissions (t/y) from upstream oil and gas operations in Canada, presented by year, province and sector.

1992

Alberta

Sector	NOx	CO	SO2	VOC	TPM	PM10	PM2.5	H2S
Fuel Combustion	194 859	190 252	1 352	4 798	1 638.0	1 628.9	1 622.0	12.6
Flaring	3 955	12 601	264 357	2 334	4 503.5	4 502.0	4 501.0	2 506.7
Formation CO2 Releases	0	0	0	0	0.0	0.0	0.0	0.0
Oil and Gas Well Drilling	0	0	0	9	0.0	0.0	0.0	0.7
Well Testing (non combustion)	0	0	0	59	0.0	0.0	0.0	0.0
Natural Gas Production	0	0	0	52 055	0.0	0.0	0.0	2 496.0
Conventional Oil Production	0	0	0	118 976	0.0	0.0	0.0	1 269.7
Heavy Oil/Cold Bitumen Production	0	0	0	70 810	0.0	0.0	0.0	932.4
Thermal Operations	0	0	0	3 367	0.0	0.0	0.0	10.5
Natural Gas Processing	0	0	0	12 956	0.0	0.0	0.0	1 143.7
Liquid Product Transportation	0	0	0	7 369	0.0	0.0	0.0	0.0
Surface Casing Ventblows/Gas	0	0	0	20 013	0.0	0.0	0.0	0.0
Accidents and Equipment Failures	0	0	0	660	0.0	0.0	0.0	0.0
Annual Total	198 814	202 853	265 709	293 404	6 141.5	6 130.9	6 122.9	8 372.3

Saskatchewan

Sector	NOx	CO	SO2	VOC	TPM	PM10	PM2.5	H2S
Fuel Combustion	7 479	9 009	123	205	144.5	143.2	142.3	0.1
Flaring	663	1 437	3 343	248	512.0	511.6	511.3	45.8
Formation CO2 Releases	0	0	0	0	0.0	0.0	0.0	0.0
Oil and Gas Well Drilling	0	0	0	1	0.0	0.0	0.0	0.0
Natural Gas Production	0	0	0	3 194	0.0	0.0	0.0	6.1
Conventional Oil Production	0	0	0	43 765	0.0	0.0	0.0	2.7
Heavy Oil/Cold Bitumen Production	0	0	0	14 098	0.0	0.0	0.0	6.5
Thermal Operations	0	0	0	717	0.0	0.0	0.0	0.8
Natural Gas Processing	0	0	0	227	0.0	0.0	0.0	4.2
Liquid Product Transportation	0	0	0	1 213	0.0	0.0	0.0	0.0
Surface Casing Ventblows/Gas	0	0	0	10 294	0.0	0.0	0.0	0.0
Accidents and Equipment Failures	0	0	0	57	0.0	0.0	0.0	0.0
Annual Total	8 142	10 445	3 466	74 020	656.4	654.8	653.6	66.2

Manitoba

Sector	NOx	CO	SO2	VOC	TPM	PM10	PM2.5	H2S
Fuel Combustion	247	115	13	15	14.1	13.9	13.7	0.0
Flaring	34	78	293	12	27.8	27.7	27.7	8.6
Natural Gas Production	0	0	0	141	0.0	0.0	0.0	3.4
Conventional Oil Production	0	0	0	3 163	0.0	0.0	0.0	47.8
Liquid Product Transportation	0	0	0	120	0.0	0.0	0.0	0.0
Surface Casing Ventblows/Gas	0	0	0	687	0.0	0.0	0.0	0.0
Accidents and Equipment Failures	0	0	0	1	0.0	0.0	0.0	0.0
Annual Total	281	193	306	4 139	41.9	41.6	41.5	59.8

Table 7.1. Historical summary of CAC emissions (t/y) from upstream oil and gas operations in Canada, presented by year, province and sector.

1992

Ontario

Sector	NOx	CO	SO2	VOC	TPM	PM10	PM2.5	H2S
Fuel Combustion	284	77	18	19	19.3	19.0	18.8	0.0
Flaring	22	5	1	2	1.6	1.5	1.5	0.0
Natural Gas Production	0	0	0	144	0.0	0.0	0.0	0.0
Conventional Oil Production	0	0	0	536	0.0	0.0	0.0	0.0
Natural Gas Processing	0	0	0	9	0.0	0.0	0.0	0.0
Liquid Product Transportation	0	0	0	317	0.0	0.0	0.0	0.0
Surface Casinq Ventblows/Gas	0	0	0	642	0.0	0.0	0.0	0.0
Annual Total	306	81	19	1 667	20.9	20.6	20.3	0.0

Nova Scotia

Sector	NOx	CO	SO2	VOC	TPM	PM10	PM2.5	H2S
Fuel Combustion	0	0	0	0	0.0	0.0	0.0	0.0
Flaring	0	0	0	0	0.0	0.0	0.0	0.0
Natural Gas Production	0	0	0	0	0.0	0.0	0.0	0.0
Conventional Oil Production	0	0	0	6 475	0.0	0.0	0.0	0.0
Natural Gas Processing	0	0	0	0	0.0	0.0	0.0	0.0
Surface Casinq Ventblows/Gas	0	0	0	3	0.0	0.0	0.0	0.0
Annual Total	0	0	0	6 478	0.0	0.0	0.0	0.0

Newfoundland

Sector	NOx	CO	SO2	VOC	TPM	PM10	PM2.5	H2S
Fuel Combustion	0	0	0	0	0.0	0.0	0.0	0.0
Flaring	0	0	0	0	0.0	0.0	0.0	0.0
Natural Gas Production	0	0	0	0	0.0	0.0	0.0	0.0
Conventional Oil Production	0	0	0	0	0.0	0.0	0.0	0.0
Accidents and Equipment Failures	0	0	0	0	0.0	0.0	0.0	0.0
Annual Total	0	0	0	0	0.0	0.0	0.0	0.0

Table 7.1. Historical summary of CAC emissions (t/y) from upstream oil and gas operations in Canada, presented by year, province and sector.

1992

Canada

Sector	NOx	CO	SO2	VOC	TPM	PM10	PM2.5	H2S
Fuel Combustion	211 029	208 475	1 979	5 258	1 913.6	1 901.8	1 893.0	15.8
Flaring	4 874	14 917	280 900	2 713	5 329.9	5 328.0	5 326.6	2 660.2
Formation CO2 Releases	0	0	0	0	0.0	0.0	0.0	0.0
Oil and Gas Well Drilling	0	0	0	11	0.0	0.0	0.0	0.9
Well Testing (non combustion)	0	0	0	59	0.0	0.0	0.0	0.0
Natural Gas Production	0	0	0	58 088	0.0	0.0	0.0	2 651.7
Conventional Oil Production	0	0	0	182 649	0.0	0.0	0.0	1 328.5
Heavy Oil/Cold Bitumen Production	0	0	0	84 908	0.0	0.0	0.0	938.9
Thermal Operations	0	0	0	4 083	0.0	0.0	0.0	11.2
Natural Gas Processing	0	0	0	13 750	0.0	0.0	0.0	1 261.3
Liquid Product Transportation	0	0	0	9 109	0.0	0.0	0.0	0.0
Surface Casing Ventblows/Gas	0	0	0	31 640	0.0	0.0	0.0	0.0
Accidents and Equipment Failures	0	0	0	720	0.0	0.0	0.0	0.0
Annual Total	215 903	223 392	282 879	392 990	7 243.6	7 229.9	7 219.6	8 868.5

Table 7.1. Historical summary of CAC emissions (t/y) from upstream oil and gas operations in Canada, presented by year, province and sector.

1993

Yukon Territory

Sector	NOx	CO	SO2	VOC	TPM	PM10	PM2.5	H2S
Fuel Combustion	165	254	0	2	0.7	0.7	0.7	0.0
Flaring	2	11	2 537	2	3.9	3.9	3.9	27.5
Formation CO2 Releases	0	0	0	0	0.0	0.0	0.0	0.0
Natural Gas Production	0	0	0	3	0.0	0.0	0.0	0.0
Natural Gas Processing	0	0	0	1	0.0	0.0	0.0	0.6
Surface Casing Ventblows/Gas	0	0	0	2	0.0	0.0	0.0	0.0
Annual Total	167	265	2 537	9	4.6	4.6	4.6	28.2

Northwest Territories

Sector	NOx	CO	SO2	VOC	TPM	PM10	PM2.5	H2S
Fuel Combustion	544	154	6	12	10.2	10.1	10.0	0.0
Flaring	69	177	2	26	63.0	63.0	63.0	0.0
Natural Gas Production	0	0	0	9	0.0	0.0	0.0	0.0
Conventional Oil Production	0	0	0	15	0.0	0.0	0.0	0.0
Surface Casing Ventblows/Gas	0	0	0	1	0.0	0.0	0.0	0.0
Accidents and Equipment Failures	0	0	0	2	0.0	0.0	0.0	0.0
Annual Total	613	331	9	65	73.2	73.1	73.0	0.0

British Columbia

Sector	NOx	CO	SO2	VOC	TPM	PM10	PM2.5	H2S
Fuel Combustion	5 723	6 620	360	160	66.7	66.1	65.7	2.3
Flaring	102	472	8 905	69	169.0	168.9	168.9	65.8
Formation CO2 Releases	0	0	0	0	0.0	0.0	0.0	0.0
Oil and Gas Well Drilling	0	0	0	4	0.0	0.0	0.0	0.3
Natural Gas Production	0	0	0	2 737	0.0	0.0	0.0	157.5
Conventional Oil Production	0	0	0	9 719	0.0	0.0	0.0	8.3
Natural Gas Processing	0	0	0	600	0.0	0.0	0.0	121.5
Liquid Product Transportation	0	0	0	89	0.0	0.0	0.0	0.0
Annual Total	5 825	7 092	9 264	13 378	235.7	235.1	234.6	355.7

Table 7.1. Historical summary of CAC emissions (t/y) from upstream oil and gas operations in Canada, presented by year, province and sector.

1993

Alberta

Sector	NOx	CO	SO2	VOC	TPM	PM10	PM2.5	H2S
Fuel Combustion	214 092	209 030	1 486	5 271	1 799.7	1 789.6	1 782.1	13.9
Flaring	4 023	12 817	268 889	2 374	4 580.7	4 579.2	4 578.1	2 549.7
Formation CO2 Releases	0	0	0	0	0.0	0.0	0.0	0.0
Oil and Gas Well Drilling	0	0	0	15	0.0	0.0	0.0	1.3
Well Testing (non combustion)	0	0	0	101	0.0	0.0	0.0	0.0
Natural Gas Production	0	0	0	56 559	0.0	0.0	0.0	2 711.9
Conventional Oil Production	0	0	0	118 976	0.0	0.0	0.0	1 269.7
Heavy Oil/Cold Bitumen Production	0	0	0	69 244	0.0	0.0	0.0	911.8
Thermal Operations	0	0	0	3 315	0.0	0.0	0.0	10.3
Natural Gas Processing	0	0	0	14 077	0.0	0.0	0.0	1 242.6
Liquid Product Transportation	0	0	0	7 575	0.0	0.0	0.0	0.0
Surface Casing Ventblows/Gas	0	0	0	22 149	0.0	0.0	0.0	0.0
Accidents and Equipment Failures	0	0	0	1 558	0.0	0.0	0.0	0.0
Annual Total	218 115	221 847	270 375	301 213	6 380.4	6 368.9	6 360.2	8 711.2

Saskatchewan

Sector	NOx	CO	SO2	VOC	TPM	PM10	PM2.5	H2S
Fuel Combustion	10 194	12 279	168	280	196.9	195.2	193.9	0.2
Flaring	822	1 781	4 145	308	634.8	634.4	634.0	56.8
Formation CO2 Releases	0	0	0	0	0.0	0.0	0.0	0.0
Oil and Gas Well Drilling	0	0	0	2	0.0	0.0	0.0	0.0
Natural Gas Production	0	0	0	3 276	0.0	0.0	0.0	6.2
Conventional Oil Production	0	0	0	43 765	0.0	0.0	0.0	2.7
Heavy Oil/Cold Bitumen Production	0	0	0	16 614	0.0	0.0	0.0	7.6
Thermal Operations	0	0	0	822	0.0	0.0	0.0	0.9
Natural Gas Processing	0	0	0	233	0.0	0.0	0.0	4.3
Liquid Product Transportation	0	0	0	1 358	0.0	0.0	0.0	0.0
Surface Casing Ventblows/Gas	0	0	0	11 723	0.0	0.0	0.0	0.0
Accidents and Equipment Failures	0	0	0	57	0.0	0.0	0.0	0.0
Annual Total	11 016	14 061	4 313	78 440	831.7	829.6	828.0	78.7

Manitoba

Sector	NOx	CO	SO2	VOC	TPM	PM10	PM2.5	H2S
Fuel Combustion	239	111	12	14	13.6	13.4	13.3	0.0
Flaring	33	75	283	11	26.8	26.8	26.8	8.3
Natural Gas Production	0	0	0	137	0.0	0.0	0.0	3.3
Conventional Oil Production	0	0	0	3 163	0.0	0.0	0.0	47.8
Liquid Product Transportation	0	0	0	116	0.0	0.0	0.0	0.0
Surface Casing Ventblows/Gas	0	0	0	733	0.0	0.0	0.0	0.0
Accidents and Equipment Failures	0	0	0	1	0.0	0.0	0.0	0.0
Annual Total	272	186	295	4 175	40.5	40.3	40.1	59.4

Table 7.1. Historical summary of CAC emissions (t/y) from upstream oil and gas operations in Canada, presented by year, province and sector.

1993

Ontario

Sector	NOx	CO	SO2	VOC	TPM	PM10	PM2.5	H2S
Fuel Combustion	274	74	17	19	18.6	18.3	18.1	0.0
Flaring	21	5	1	1	1.5	1.5	1.5	0.0
Natural Gas Production	0	0	0	139	0.0	0.0	0.0	0.0
Conventional Oil Production	0	0	0	536	0.0	0.0	0.0	0.0
Natural Gas Processing	0	0	0	8	0.0	0.0	0.0	0.0
Liquid Product Transportation	0	0	0	358	0.0	0.0	0.0	0.0
Surface Casing Ventblows/Gas	0	0	0	677	0.0	0.0	0.0	0.0
Annual Total	295	78	18	1 738	20.1	19.8	19.6	0.0

Nova Scotia

Sector	NOx	CO	SO2	VOC	TPM	PM10	PM2.5	H2S
Fuel Combustion	0	0	0	0	0.0	0.0	0.0	0.0
Flaring	0	0	0	0	0.0	0.0	0.0	0.0
Natural Gas Production	0	0	0	0	0.0	0.0	0.0	0.0
Conventional Oil Production	0	0	0	6 475	0.0	0.0	0.0	0.0
Natural Gas Processing	0	0	0	0	0.0	0.0	0.0	0.0
Surface Casing Ventblows/Gas	0	0	0	3	0.0	0.0	0.0	0.0
Annual Total	0	0	0	6 478	0.0	0.0	0.0	0.0

Newfoundland

Sector	NOx	CO	SO2	VOC	TPM	PM10	PM2.5	H2S
Fuel Combustion	0	0	0	0	0.0	0.0	0.0	0.0
Flaring	0	0	0	0	0.0	0.0	0.0	0.0
Natural Gas Production	0	0	0	0	0.0	0.0	0.0	0.0
Conventional Oil Production	0	0	0	0	0.0	0.0	0.0	0.0
Accidents and Equipment Failures	0	0	0	0	0.0	0.0	0.0	0.0
Annual Total	0	0	0	0	0.0	0.0	0.0	0.0

Table 7.1. Historical summary of CAC emissions (t/y) from upstream oil and gas operations in Canada, presented by year, province and sector.

1993

Canada

Sector	NOx	CO	SO2	VOC	TPM	PM10	PM2.5	H2S
Fuel Combustion	231 232	228 522	2 049	5 757	2 106.5	2 093.5	2 083.8	16.4
Flaring	5 071	15 338	284 763	2 792	5 479.7	5 477.7	5 476.3	2 708.2
Formation CO2 Releases	0	0	0	0	0.0	0.0	0.0	0.0
Oil and Gas Well Drilling	0	0	0	21	0.0	0.0	0.0	1.5
Well Testing (non combustion)	0	0	0	101	0.0	0.0	0.0	0.0
Natural Gas Production	0	0	0	62 860	0.0	0.0	0.0	2 878.9
Conventional Oil Production	0	0	0	182 649	0.0	0.0	0.0	1 328.5
Heavy Oil/Cold Bitumen Production	0	0	0	85 858	0.0	0.0	0.0	919.4
Thermal Operations	0	0	0	4 137	0.0	0.0	0.0	11.2
Natural Gas Processing	0	0	0	14 920	0.0	0.0	0.0	1 369.1
Liquid Product Transportation	0	0	0	9 497	0.0	0.0	0.0	0.0
Surface Casing Ventblows/Gas	0	0	0	35 287	0.0	0.0	0.0	0.0
Accidents and Equipment Failures	0	0	0	1 618	0.0	0.0	0.0	0.0
Annual Total	236 303	243 860	286 812	405 496	7 586.2	7 571.3	7 560.1	9 233.1

Table 7.1. Historical summary of CAC emissions (t/y) from upstream oil and gas operations in Canada, presented by year, province and sector.

1994

Yukon Territory

Sector	NOx	CO	SO2	VOC	TPM	PM10	PM2.5	H2S
Fuel Combustion	163	250	0	2	0.7	0.7	0.7	0.0
Flaring	1	8	1 774	1	2.7	2.7	2.7	19.3
Formation CO2 Releases	0	0	0	0	0.0	0.0	0.0	0.0
Natural Gas Production	0	0	0	3	0.0	0.0	0.0	0.0
Natural Gas Processing	0	0	0	1	0.0	0.0	0.0	0.6
Surface Casing Ventblows/Gas	0	0	0	2	0.0	0.0	0.0	0.0
Annual Total	164	258	1 774	9	3.4	3.4	3.4	19.9

Northwest Territories

Sector	NOx	CO	SO2	VOC	TPM	PM10	PM2.5	H2S
Fuel Combustion	526	149	6	11	9.8	9.7	9.7	0.0
Flaring	46	117	2	17	41.9	41.8	41.8	0.0
Natural Gas Production	0	0	0	7	0.0	0.0	0.0	0.0
Conventional Oil Production	0	0	0	15	0.0	0.0	0.0	0.0
Surface Casing Ventblows/Gas	0	0	0	1	0.0	0.0	0.0	0.0
Accidents and Equipment Failures	0	0	0	2	0.0	0.0	0.0	0.0
Annual Total	571	266	8	54	51.7	51.6	51.5	0.0

British Columbia

Sector	NOx	CO	SO2	VOC	TPM	PM10	PM2.5	H2S
Fuel Combustion	18 530	21 434	1 165	517	216.1	214.2	212.7	7.5
Flaring	352	1 633	30 811	240	584.6	584.6	584.5	227.7
Formation CO2 Releases	0	0	0	0	0.0	0.0	0.0	0.0
Oil and Gas Well Drilling	0	0	0	6	0.0	0.0	0.0	0.4
Natural Gas Production	0	0	0	3 010	0.0	0.0	0.0	173.2
Conventional Oil Production	0	0	0	9 719	0.0	0.0	0.0	8.3
Natural Gas Processing	0	0	0	660	0.0	0.0	0.0	133.7
Liquid Product Transportation	0	0	0	88	0.0	0.0	0.0	0.0
Annual Total	18 882	23 067	31 976	14 241	800.7	798.7	797.3	550.8

Table 7.1. Historical summary of CAC emissions (t/y) from upstream oil and gas operations in Canada, presented by year, province and sector.

1994

Alberta

Sector	NOx	CO	SO2	VOC	TPM	PM10	PM2.5	H2S
Fuel Combustion	229 373	223 949	1 592	5 647	1 928.2	1 917.4	1 909.3	14.9
Flaring	3 850	12 267	257 351	2 272	4 384.2	4 382.7	4 381.7	2 440.3
Formation CO2 Releases	0	0	0	0	0.0	0.0	0.0	0.0
Oil and Gas Well Drilling	0	0	0	20	0.0	0.0	0.0	1.8
Well Testing (non combustion)	0	0	0	139	0.0	0.0	0.0	0.0
Natural Gas Production	0	0	0	60 443	0.0	0.0	0.0	2 898.1
Conventional Oil Production	0	0	0	118 976	0.0	0.0	0.0	1 269.7
Heavy Oil/Cold Bitumen Production	0	0	0	72 195	0.0	0.0	0.0	950.7
Thermal Operations	0	0	0	3 367	0.0	0.0	0.0	10.5
Natural Gas Processing	0	0	0	15 044	0.0	0.0	0.0	1 327.9
Liquid Product Transportation	0	0	0	7 670	0.0	0.0	0.0	0.0
Surface Casing Ventblows/Gas	0	0	0	24 684	0.0	0.0	0.0	0.0
Accidents and Equipment Failures	0	0	0	870	0.0	0.0	0.0	0.0
Annual Total	233 223	236 217	258 943	311 326	6 312.3	6 300.1	6 290.9	8 913.8

Saskatchewan

Sector	NOx	CO	SO2	VOC	TPM	PM10	PM2.5	H2S
Fuel Combustion	11 389	13 719	187	313	220.0	218.1	216.7	0.2
Flaring	776	1 681	3 911	290	598.9	598.5	598.2	53.6
Formation CO2 Releases	0	0	0	0	0.0	0.0	0.0	0.0
Oil and Gas Well Drilling	0	0	0	2	0.0	0.0	0.0	0.0
Natural Gas Production	0	0	0	3 641	0.0	0.0	0.0	6.9
Conventional Oil Production	0	0	0	43 765	0.0	0.0	0.0	2.7
Heavy Oil/Cold Bitumen Production	0	0	0	18 931	0.0	0.0	0.0	8.7
Thermal Operations	0	0	0	911	0.0	0.0	0.0	1.0
Natural Gas Processing	0	0	0	259	0.0	0.0	0.0	4.8
Liquid Product Transportation	0	0	0	1 561	0.0	0.0	0.0	0.0
Surface Casing Ventblows/Gas	0	0	0	13 124	0.0	0.0	0.0	0.0
Accidents and Equipment Failures	0	0	0	57	0.0	0.0	0.0	0.0
Annual Total	12 165	15 399	4 098	82 855	818.9	816.6	814.9	77.9

Manitoba

Sector	NOx	CO	SO2	VOC	TPM	PM10	PM2.5	H2S
Fuel Combustion	248	115	13	15	14.1	13.9	13.8	0.0
Flaring	34	78	294	12	27.8	27.8	27.8	8.6
Natural Gas Production	0	0	0	142	0.0	0.0	0.0	3.4
Conventional Oil Production	0	0	0	3 163	0.0	0.0	0.0	47.8
Liquid Product Transportation	0	0	0	120	0.0	0.0	0.0	0.0
Surface Casing Ventblows/Gas	0	0	0	774	0.0	0.0	0.0	0.0
Accidents and Equipment Failures	0	0	0	1	0.0	0.0	0.0	0.0
Annual Total	282	193	306	4 227	42.0	41.7	41.6	59.8

Table 7.1. Historical summary of CAC emissions (t/y) from upstream oil and gas operations in Canada, presented by year, province and sector.

1994

Ontario

Sector	NOx	CO	SO2	VOC	TPM	PM10	PM2.5	H2S
Fuel Combustion	286	77	18	20	19.4	19.1	18.9	0.0
Flaring	22	5	1	2	1.6	1.5	1.5	0.0
Natural Gas Production	0	0	0	145	0.0	0.0	0.0	0.0
Conventional Oil Production	0	0	0	536	0.0	0.0	0.0	0.0
Natural Gas Processing	0	0	0	9	0.0	0.0	0.0	0.0
Liquid Product Transportation	0	0	0	371	0.0	0.0	0.0	0.0
Surface Casinq Ventblows/Gas	0	0	0	713	0.0	0.0	0.0	0.0
Annual Total	307	82	19	1 794	21.0	20.6	20.4	0.0

Nova Scotia

Sector	NOx	CO	SO2	VOC	TPM	PM10	PM2.5	H2S
Fuel Combustion	0	0	0	0	0.0	0.0	0.0	0.0
Flaring	0	0	0	0	0.0	0.0	0.0	0.0
Natural Gas Production	0	0	0	0	0.0	0.0	0.0	0.0
Conventional Oil Production	0	0	0	6 475	0.0	0.0	0.0	0.0
Natural Gas Processing	0	0	0	0	0.0	0.0	0.0	0.0
Surface Casinq Ventblows/Gas	0	0	0	3	0.0	0.0	0.0	0.0
Annual Total	0	0	0	6 478	0.0	0.0	0.0	0.0

Newfoundland

Sector	NOx	CO	SO2	VOC	TPM	PM10	PM2.5	H2S
Fuel Combustion	0	0	0	0	0.0	0.0	0.0	0.0
Flaring	0	0	0	0	0.0	0.0	0.0	0.0
Natural Gas Production	0	0	0	0	0.0	0.0	0.0	0.0
Conventional Oil Production	0	0	0	0	0.0	0.0	0.0	0.0
Accidents and Equipment Failures	0	0	0	0	0.0	0.0	0.0	0.0
Annual Total	0	0	0	0	0.0	0.0	0.0	0.0

Table 7.1. Historical summary of CAC emissions (t/y) from upstream oil and gas operations in Canada, presented by year, province and sector.

Canada		1994							
Sector	NOx	CO	SO2	VOC	TPM	PM10	PM2.5	H2S	
Fuel Combustion	260 514	259 693	2 980	6 524	2 408.3	2 393.1	2 381.7	22.6	
Flaring	5 081	15 788	294 143	2 834	5 641.7	5 639.7	5 638.3	2 749.4	
Formation CO2 Releases	0	0	0	0	0.0	0.0	0.0	0.0	
Oil and Gas Well Drilling	0	0	0	29	0.0	0.0	0.0	2.2	
Well Testing (non combustion)	0	0	0	139	0.0	0.0	0.0	0.0	
Natural Gas Production	0	0	0	67 391	0.0	0.0	0.0	3 081.7	
Conventional Oil Production	0	0	0	182 649	0.0	0.0	0.0	1 328.5	
Heavy Oil/Cold Bitumen Production	0	0	0	91 126	0.0	0.0	0.0	959.3	
Thermal Operations	0	0	0	4 278	0.0	0.0	0.0	11.4	
Natural Gas Processing	0	0	0	15 972	0.0	0.0	0.0	1 467.0	
Liquid Product Transportation	0	0	0	9 810	0.0	0.0	0.0	0.0	
Surface Casing Ventblows/Gas	0	0	0	39 299	0.0	0.0	0.0	0.0	
Accidents and Equipment Failures	0	0	0	931	0.0	0.0	0.0	0.0	
Annual Total	265 594	275 482	297 123	420 983	8 049.9	8 032.8	8 019.9	9 622.1	

Table 7.1. Historical summary of CAC emissions (t/y) from upstream oil and gas operations in Canada, presented by year, province and sector.

1995

Yukon Territory

Sector	NOx	CO	SO2	VOC	TPM	PM10	PM2.5	H2S
Fuel Combustion	162	249	0	2	0.7	0.7	0.7	0.0
Flaring	1	6	1 441	1	2.2	2.2	2.2	15.6
Formation CO2 Releases	0	0	0	0	0.0	0.0	0.0	0.0
Natural Gas Production	0	0	0	3	0.0	0.0	0.0	0.0
Natural Gas Processing	0	0	0	1	0.0	0.0	0.0	0.6
Surface Casing Ventblows/Gas	0	0	0	2	0.0	0.0	0.0	0.0
Annual Total	163	255	1 441	8	2.9	2.9	2.9	16.2

Northwest Territories

Sector	NOx	CO	SO2	VOC	TPM	PM10	PM2.5	H2S
Fuel Combustion	523	148	6	11	9.8	9.7	9.6	0.0
Flaring	45	117	2	17	41.7	41.7	41.7	0.0
Natural Gas Production	0	0	0	8	0.0	0.0	0.0	0.0
Conventional Oil Production	0	0	0	15	0.0	0.0	0.0	0.0
Surface Casing Ventblows/Gas	0	0	0	1	0.0	0.0	0.0	0.0
Accidents and Equipment Failures	0	0	0	2	0.0	0.0	0.0	0.0
Annual Total	569	265	7	54	51.5	51.4	51.3	0.0

British Columbia

Sector	NOx	CO	SO2	VOC	TPM	PM10	PM2.5	H2S
Fuel Combustion	25 326	29 295	1 592	706	295.3	292.7	290.7	10.3
Flaring	480	2 228	42 035	328	797.6	797.5	797.5	310.6
Formation CO2 Releases	0	0	0	0	0.0	0.0	0.0	0.0
Oil and Gas Well Drilling	0	0	0	5	0.0	0.0	0.0	0.3
Natural Gas Production	0	0	0	3 441	0.0	0.0	0.0	198.0
Conventional Oil Production	0	0	0	9 719	0.0	0.0	0.0	8.3
Natural Gas Processing	0	0	0	755	0.0	0.0	0.0	152.8
Liquid Product Transportation	0	0	0	90	0.0	0.0	0.0	0.0
Annual Total	25 806	31 523	43 627	15 045	1 092.9	1 090.2	1 088.2	680.3

Table 7.1. Historical summary of CAC emissions (t/y) from upstream oil and gas operations in Canada, presented by year, province and sector.

1995

Alberta

Sector	NOx	CO	SO2	VOC	TPM	PM10	PM2.5	H2S
Fuel Combustion	239 085	233 432	1 659	5 886	2 009.8	1 998.5	1 990.1	15.5
Flaring	4 030	12 841	269 384	2 378	4 589.1	4 587.7	4 586.6	2 554.4
Formation CO2 Releases	0	0	0	0	0.0	0.0	0.0	0.0
Oil and Gas Well Drilling	0	0	0	19	0.0	0.0	0.0	1.6
Well Testing (non combustion)	0	0	0	129	0.0	0.0	0.0	0.0
Natural Gas Production	0	0	0	62 887	0.0	0.0	0.0	3 015.3
Conventional Oil Production	0	0	0	118 976	0.0	0.0	0.0	1 269.7
Heavy Oil/Cold Bitumen Production	0	0	0	82 879	0.0	0.0	0.0	1 091.4
Thermal Operations	0	0	0	3 748	0.0	0.0	0.0	11.6
Natural Gas Processing	0	0	0	15 652	0.0	0.0	0.0	1 381.6
Liquid Product Transportation	0	0	0	7 794	0.0	0.0	0.0	0.0
Surface Casing Ventblows/Gas	0	0	0	27 094	0.0	0.0	0.0	0.0
Accidents and Equipment Failures	0	0	0	1 490	0.0	0.0	0.0	0.0
Annual Total	243 115	246 272	271 043	328 931	6 598.9	6 586.2	6 576.7	9 341.1

Saskatchewan

Sector	NOx	CO	SO2	VOC	TPM	PM10	PM2.5	H2S
Fuel Combustion	12 415	14 955	204	341	239.8	237.7	236.2	0.2
Flaring	1 007	2 182	5 076	377	777.4	776.9	776.5	69.6
Formation CO2 Releases	0	0	0	0	0.0	0.0	0.0	0.0
Oil and Gas Well Drilling	0	0	0	2	0.0	0.0	0.0	0.0
Natural Gas Production	0	0	0	3 724	0.0	0.0	0.0	7.1
Conventional Oil Production	0	0	0	43 765	0.0	0.0	0.0	2.7
Heavy Oil/Cold Bitumen Production	0	0	0	22 956	0.0	0.0	0.0	10.5
Thermal Operations	0	0	0	1 077	0.0	0.0	0.0	1.1
Natural Gas Processing	0	0	0	265	0.0	0.0	0.0	4.9
Liquid Product Transportation	0	0	0	1 701	0.0	0.0	0.0	0.0
Surface Casing Ventblows/Gas	0	0	0	14 445	0.0	0.0	0.0	0.0
Accidents and Equipment Failures	0	0	0	57	0.0	0.0	0.0	0.0
Annual Total	13 423	17 137	5 281	88 711	1 017.3	1 014.6	1 012.7	96.2

Manitoba

Sector	NOx	CO	SO2	VOC	TPM	PM10	PM2.5	H2S
Fuel Combustion	242	112	12	14	13.8	13.6	13.4	0.0
Flaring	33	76	287	11	27.2	27.2	27.2	8.4
Natural Gas Production	0	0	0	139	0.0	0.0	0.0	3.3
Conventional Oil Production	0	0	0	3 163	0.0	0.0	0.0	47.8
Liquid Product Transportation	0	0	0	118	0.0	0.0	0.0	0.0
Surface Casing Ventblows/Gas	0	0	0	806	0.0	0.0	0.0	0.0
Accidents and Equipment Failures	0	0	0	1	0.0	0.0	0.0	0.0
Annual Total	275	189	299	4 252	41.0	40.8	40.6	59.5

Table 7.1. Historical summary of CAC emissions (t/y) from upstream oil and gas operations in Canada, presented by year, province and sector.

1995

Ontario

Sector	NOx	CO	SO2	VOC	TPM	PM10	PM2.5	H2S
Fuel Combustion	304	82	19	21	20.6	20.3	20.1	0.0
Flaring	23	5	2	2	1.7	1.6	1.6	0.0
Natural Gas Production	0	0	0	154	0.0	0.0	0.0	0.0
Conventional Oil Production	0	0	0	536	0.0	0.0	0.0	0.0
Natural Gas Processing	0	0	0	9	0.0	0.0	0.0	0.0
Liquid Product Transportation	0	0	0	403	0.0	0.0	0.0	0.0
Surface Casing Ventblows/Gas	0	0	0	748	0.0	0.0	0.0	0.0
Annual Total	327	87	20	1 872	22.3	22.0	21.7	0.0

Nova Scotia

Sector	NOx	CO	SO2	VOC	TPM	PM10	PM2.5	H2S
Fuel Combustion	0	0	0	0	0.0	0.0	0.0	0.0
Flaring	0	0	0	0	0.0	0.0	0.0	0.0
Natural Gas Production	0	0	0	0	0.0	0.0	0.0	0.0
Conventional Oil Production	0	0	0	6 475	0.0	0.0	0.0	0.0
Natural Gas Processing	0	0	0	0	0.0	0.0	0.0	0.0
Surface Casing Ventblows/Gas	0	0	0	3	0.0	0.0	0.0	0.0
Annual Total	0	0	0	6 478	0.0	0.0	0.0	0.0

Newfoundland

Sector	NOx	CO	SO2	VOC	TPM	PM10	PM2.5	H2S
Fuel Combustion	0	0	0	0	0.0	0.0	0.0	0.0
Flaring	0	0	0	0	0.0	0.0	0.0	0.0
Natural Gas Production	0	0	0	0	0.0	0.0	0.0	0.0
Conventional Oil Production	0	0	0	0	0.0	0.0	0.0	0.0
Accidents and Equipment Failures	0	0	0	0	0.0	0.0	0.0	0.0
Annual Total	0	0	0	0	0.0	0.0	0.0	0.0

Table 7.1. Historical summary of CAC emissions (t/y) from upstream oil and gas operations in Canada, presented by year, province and sector.

1995

Canada

Sector	NOx	CO	SO2	VOC	TPM	PM10	PM2.5	H2S
Fuel Combustion	278 057	278 272	3 493	6 982	2 589.9	2 573.3	2 560.9	26.0
Flaring	5 620	17 454	318 226	3 114	6 236.9	6 234.8	6 233.2	2 958.6
Formation CO2 Releases	0	0	0	0	0.0	0.0	0.0	0.0
Oil and Gas Well Drilling	0	0	0	26	0.0	0.0	0.0	2.0
Well Testing (non combustion)	0	0	0	129	0.0	0.0	0.0	0.0
Natural Gas Production	0	0	0	70 355	0.0	0.0	0.0	3 223.8
Conventional Oil Production	0	0	0	182 649	0.0	0.0	0.0	1 328.5
Heavy Oil/Cold Bitumen Production	0	0	0	105 835	0.0	0.0	0.0	1 101.9
Thermal Operations	0	0	0	4 824	0.0	0.0	0.0	12.8
Natural Gas Processing	0	0	0	16 682	0.0	0.0	0.0	1 539.9
Liquid Product Transportation	0	0	0	10 105	0.0	0.0	0.0	0.0
Surface Casing Ventblows/Gas	0	0	0	43 100	0.0	0.0	0.0	0.0
Accidents and Equipment Failures	0	0	0	1 551	0.0	0.0	0.0	0.0
Annual Total	283 677	295 727	321 718	445 352	8 826.8	8 808.1	8 794.1	10 193.3

Table 7.1. Historical summary of CAC emissions (t/y) from upstream oil and gas operations in Canada, presented by year, province and sector.

1996

Yukon Territory

Sector	NOx	CO	SO2	VOC	TPM	PM10	PM2.5	H2S
Fuel Combustion	152	235	0	2	0.7	0.7	0.7	0.0
Flaring	1	4	1 021	1	1.6	1.6	1.6	11.1
Formation CO2 Releases	0	0	0	0	0.0	0.0	0.0	0.0
Natural Gas Production	0	0	0	3	0.0	0.0	0.0	0.0
Natural Gas Processing	0	0	0	1	0.0	0.0	0.0	0.5
Surface Casing Ventblows/Gas	0	0	0	2	0.0	0.0	0.0	0.0
Annual Total	153	239	1 021	8	2.2	2.2	2.2	11.6

Northwest Territories

Sector	NOx	CO	SO2	VOC	TPM	PM10	PM2.5	H2S
Fuel Combustion	488	138	5	10	9.1	9.0	9.0	0.0
Flaring	42	109	2	16	38.9	38.9	38.9	0.0
Natural Gas Production	0	0	0	7	0.0	0.0	0.0	0.0
Conventional Oil Production	0	0	0	15	0.0	0.0	0.0	0.0
Surface Casing Ventblows/Gas	0	0	0	1	0.0	0.0	0.0	0.0
Accidents and Equipment Failures	0	0	0	2	0.0	0.0	0.0	0.0
Annual Total	531	247	7	52	48.0	47.9	47.9	0.0

British Columbia

Sector	NOx	CO	SO2	VOC	TPM	PM10	PM2.5	H2S
Fuel Combustion	26 817	31 020	1 686	748	312.7	309.9	307.9	10.9
Flaring	617	2 860	53 970	421	1 024.0	1 024.0	1 023.9	398.8
Formation CO2 Releases	0	0	0	0	0.0	0.0	0.0	0.0
Oil and Gas Well Drilling	0	0	0	6	0.0	0.0	0.0	0.4
Natural Gas Production	0	0	0	3 519	0.0	0.0	0.0	202.5
Conventional Oil Production	0	0	0	9 719	0.0	0.0	0.0	8.3
Natural Gas Processing	0	0	0	772	0.0	0.0	0.0	156.3
Liquid Product Transportation	0	0	0	99	0.0	0.0	0.0	0.0
Annual Total	27 433	33 880	55 656	15 284	1 336.7	1 333.9	1 331.8	777.1

Table 7.1. Historical summary of CAC emissions (t/y) from upstream oil and gas operations in Canada, presented by year, province and sector.

1996

Alberta

Sector	NOx	CO	SO2	VOC	TPM	PM10	PM2.5	H2S
Fuel Combustion	249 090	243 201	1 729	6 133	2 093.9	2 082.2	2 073.4	16.1
Flaring	3 770	12 013	252 014	2 225	4 293.2	4 291.8	4 290.8	2 389.7
Formation CO2 Releases	0	0	0	0	0.0	0.0	0.0	0.0
Oil and Gas Well Drilling	0	0	0	23	0.0	0.0	0.0	2.0
Well Testing (non combustion)	0	0	0	157	0.0	0.0	0.0	0.0
Natural Gas Production	0	0	0	64 880	0.0	0.0	0.0	3 110.9
Conventional Oil Production	0	0	0	118 976	0.0	0.0	0.0	1 269.7
Heavy Oil/Cold Bitumen Production	0	0	0	91 638	0.0	0.0	0.0	1 206.7
Thermal Operations	0	0	0	4 073	0.0	0.0	0.0	12.6
Natural Gas Processing	0	0	0	16 148	0.0	0.0	0.0	1 425.4
Liquid Product Transportation	0	0	0	7 825	0.0	0.0	0.0	0.0
Surface Casing Ventblows/Gas	0	0	0	30 041	0.0	0.0	0.0	0.0
Accidents and Equipment Failures	0	0	0	21 537	0.0	0.0	0.0	0.0
Annual Total	252 861	255 213	253 742	363 655	6 387.1	6 374.0	6 364.2	9 433.1

Saskatchewan

Sector	NOx	CO	SO2	VOC	TPM	PM10	PM2.5	H2S
Fuel Combustion	11 101	13 372	183	305	214.4	212.6	211.2	0.2
Flaring	1 393	3 017	7 019	521	1 075.0	1 074.3	1 073.7	96.2
Formation CO2 Releases	0	0	0	0	0.0	0.0	0.0	0.0
Oil and Gas Well Drilling	0	0	0	3	0.0	0.0	0.0	0.0
Natural Gas Production	0	0	0	3 381	0.0	0.0	0.0	6.4
Conventional Oil Production	0	0	0	43 765	0.0	0.0	0.0	2.7
Heavy Oil/Cold Bitumen Production	0	0	0	26 091	0.0	0.0	0.0	12.0
Thermal Operations	0	0	0	1 193	0.0	0.0	0.0	1.3
Natural Gas Processing	0	0	0	241	0.0	0.0	0.0	4.4
Liquid Product Transportation	0	0	0	1 886	0.0	0.0	0.0	0.0
Surface Casing Ventblows/Gas	0	0	0	16 203	0.0	0.0	0.0	0.0
Accidents and Equipment Failures	0	0	0	57	0.0	0.0	0.0	0.0
Annual Total	12 494	16 389	7 202	93 645	1 289.5	1 286.9	1 284.9	123.2

Manitoba

Sector	NOx	CO	SO2	VOC	TPM	PM10	PM2.5	H2S
Fuel Combustion	232	108	12	14	13.2	13.0	12.9	0.0
Flaring	32	73	275	11	26.1	26.0	26.0	8.1
Natural Gas Production	0	0	0	133	0.0	0.0	0.0	3.2
Conventional Oil Production	0	0	0	3 163	0.0	0.0	0.0	47.8
Liquid Product Transportation	0	0	0	113	0.0	0.0	0.0	0.0
Surface Casing Ventblows/Gas	0	0	0	831	0.0	0.0	0.0	0.0
Accidents and Equipment Failures	0	0	0	1	0.0	0.0	0.0	0.0
Annual Total	264	181	287	4 265	39.3	39.1	38.9	59.0

Table 7.1. Historical summary of CAC emissions (t/y) from upstream oil and gas operations in Canada, presented by year, province and sector.

1996

Ontario

Sector	NOx	CO	SO2	VOC	TPM	PM10	PM2.5	H2S
Fuel Combustion	204	55	13	14	13.9	13.7	13.5	0.0
Flaring	16	3	1	1	1.1	1.1	1.1	0.0
Natural Gas Production	0	0	0	104	0.0	0.0	0.0	0.0
Conventional Oil Production	0	0	0	536	0.0	0.0	0.0	0.0
Natural Gas Processing	0	0	0	6	0.0	0.0	0.0	0.0
Liquid Product Transportation	0	0	0	378	0.0	0.0	0.0	0.0
Surface Casinq Ventblows/Gas	0	0	0	784	0.0	0.0	0.0	0.0
Annual Total	220	58	14	1 822	15.0	14.8	14.6	0.0

Nova Scotia

Sector	NOx	CO	SO2	VOC	TPM	PM10	PM2.5	H2S
Fuel Combustion	0	0	0	0	0.0	0.0	0.0	0.0
Flaring	0	0	0	0	0.0	0.0	0.0	0.0
Natural Gas Production	0	0	0	0	0.0	0.0	0.0	0.0
Conventional Oil Production	0	0	0	6 475	0.0	0.0	0.0	0.0
Natural Gas Processing	0	0	0	0	0.0	0.0	0.0	0.0
Surface Casinq Ventblows/Gas	0	0	0	3	0.0	0.0	0.0	0.0
Annual Total	0	0	0	6 479	0.0	0.0	0.0	0.0

Newfoundland

Sector	NOx	CO	SO2	VOC	TPM	PM10	PM2.5	H2S
Fuel Combustion	0	0	0	0	0.0	0.0	0.0	0.0
Flaring	0	0	0	0	0.0	0.0	0.0	0.0
Natural Gas Production	0	0	0	0	0.0	0.0	0.0	0.0
Conventional Oil Production	0	0	0	0	0.0	0.0	0.0	0.0
Accidents and Equipment Failures	0	0	0	0	0.0	0.0	0.0	0.0
Annual Total	0	0	0	0	0.0	0.0	0.0	0.0

Table 7.1. Historical summary of CAC emissions (t/y) from upstream oil and gas operations in Canada, presented by year, province and sector.

Canada		1996							
Sector	NOx	CO	SO2	VOC	TPM	PM10	PM2.5	H2S	
Fuel Combustion	288 085	288 127	3 627	7 226	2 658.0	2 641.1	2 628.5	27.2	
Flaring	5 870	18 080	314 302	3 196	6 460.0	6 457.7	6 456.0	2 903.8	
Formation CO2 Releases	0	0	0	0	0.0	0.0	0.0	0.0	
Oil and Gas Well Drilling	0	0	0	31	0.0	0.0	0.0	2.4	
Well Testing (non combustion)	0	0	0	157	0.0	0.0	0.0	0.0	
Natural Gas Production	0	0	0	72 027	0.0	0.0	0.0	3 323.0	
Conventional Oil Production	0	0	0	182 649	0.0	0.0	0.0	1 328.5	
Heavy Oil/Cold Bitumen Production	0	0	0	117 730	0.0	0.0	0.0	1 218.7	
Thermal Operations	0	0	0	5 266	0.0	0.0	0.0	13.9	
Natural Gas Processing	0	0	0	17 167	0.0	0.0	0.0	1 586.7	
Liquid Product Transportation	0	0	0	10 300	0.0	0.0	0.0	0.0	
Surface Casing Ventblows/Gas	0	0	0	47 864	0.0	0.0	0.0	0.0	
Accidents and Equipment Failures	0	0	0	21 597	0.0	0.0	0.0	0.0	
Annual Total	293 955	306 207	317 929	485 210	9 117.9	9 098.8	9 084.5	10 404.2	

Table 7.1. Historical summary of CAC emissions (t/y) from upstream oil and gas operations in Canada, presented by year, province and sector.

1997

Yukon Territory

Sector	NOx	CO	SO2	VOC	TPM	PM10	PM2.5	H2S
Fuel Combustion	160	246	0	2	0.7	0.7	0.7	0.0
Flaring	1	8	1 778	1	2.7	2.7	2.7	19.3
Formation CO2 Releases	0	0	0	0	0.0	0.0	0.0	0.0
Natural Gas Production	0	0	0	3	0.0	0.0	0.0	0.0
Natural Gas Processing	0	0	0	1	0.0	0.0	0.0	0.5
Surface Casing Ventblows/Gas	0	0	0	2	0.0	0.0	0.0	0.0
Annual Total	161	253	1 778	8	3.4	3.4	3.4	19.8

Northwest Territories

Sector	NOx	CO	SO2	VOC	TPM	PM10	PM2.5	H2S
Fuel Combustion	472	133	5	10	8.8	8.7	8.7	0.0
Flaring	5	12	0	2	4.3	4.3	4.3	0.0
Natural Gas Production	0	0	0	7	0.0	0.0	0.0	0.0
Conventional Oil Production	0	0	0	15	0.0	0.0	0.0	0.0
Surface Casing Ventblows/Gas	0	0	0	1	0.0	0.0	0.0	0.0
Accidents and Equipment Failures	0	0	0	2	0.0	0.0	0.0	0.0
Annual Total	476	145	5	37	13.1	13.0	13.0	0.0

British Columbia

Sector	NOx	CO	SO2	VOC	TPM	PM10	PM2.5	H2S
Fuel Combustion	28 625	33 111	1 800	798	333.8	330.8	328.6	11.6
Flaring	600	2 783	52 511	409	996.4	996.3	996.2	388.0
Formation CO2 Releases	0	0	0	0	0.0	0.0	0.0	0.0
Oil and Gas Well Drilling	0	0	0	7	0.0	0.0	0.0	0.5
Natural Gas Production	0	0	0	3 609	0.0	0.0	0.0	207.6
Conventional Oil Production	0	0	0	9 719	0.0	0.0	0.0	8.3
Natural Gas Processing	0	0	0	791	0.0	0.0	0.0	160.3
Liquid Product Transportation	0	0	0	113	0.0	0.0	0.0	0.0
Annual Total	29 225	35 894	54 310	15 447	1 330.1	1 327.1	1 324.8	776.3

Table 7.1. Historical summary of CAC emissions (t/y) from upstream oil and gas operations in Canada, presented by year, province and sector.

1997

Alberta

Sector	NOx	CO	SO2	VOC	TPM	PM10	PM2.5	H2S
Fuel Combustion	283 092	276 398	1 965	6 970	2 379.7	2 366.4	2 356.4	18.3
Flaring	3 788	12 068	253 176	2 235	4 313.0	4 311.6	4 310.6	2 400.7
Formation CO2 Releases	0	0	0	0	0.0	0.0	0.0	0.0
Oil and Gas Well Drilling	0	0	0	30	0.0	0.0	0.0	2.5
Well Testing (non combustion)	0	0	0	201	0.0	0.0	0.0	0.0
Natural Gas Production	0	0	0	65 213	0.0	0.0	0.0	3 126.9
Conventional Oil Production	0	0	0	118 976	0.0	0.0	0.0	1 269.7
Heavy Oil/Cold Bitumen Production	0	0	0	95 735	0.0	0.0	0.0	1 260.6
Thermal Operations	0	0	0	4 830	0.0	0.0	0.0	15.0
Natural Gas Processing	0	0	0	16 231	0.0	0.0	0.0	1 432.7
Liquid Product Transportation	0	0	0	8 110	0.0	0.0	0.0	0.0
Surface Casing Ventblows/Gas	0	0	0	33 909	0.0	0.0	0.0	0.0
Accidents and Equipment Failures	0	0	0	5 072	0.0	0.0	0.0	0.0
Annual Total	286 879	288 466	255 140	357 511	6 692.8	6 678.0	6 667.0	9 526.5

Saskatchewan

Sector	NOx	CO	SO2	VOC	TPM	PM10	PM2.5	H2S
Fuel Combustion	11 818	14 235	194	325	228.3	226.3	224.8	0.2
Flaring	1 535	3 326	7 738	574	1 185.1	1 184.2	1 183.6	106.1
Formation CO2 Releases	0	0	0	0	0.0	0.0	0.0	0.0
Oil and Gas Well Drilling	0	0	0	4	0.0	0.0	0.0	0.0
Natural Gas Production	0	0	0	3 341	0.0	0.0	0.0	6.3
Conventional Oil Production	0	0	0	43 765	0.0	0.0	0.0	2.7
Heavy Oil/Cold Bitumen Production	0	0	0	34 276	0.0	0.0	0.0	15.7
Thermal Operations	0	0	0	1 529	0.0	0.0	0.0	1.6
Natural Gas Processing	0	0	0	238	0.0	0.0	0.0	4.4
Liquid Product Transportation	0	0	0	2 128	0.0	0.0	0.0	0.0
Surface Casing Ventblows/Gas	0	0	0	18 336	0.0	0.0	0.0	0.0
Accidents and Equipment Failures	0	0	0	57	0.0	0.0	0.0	0.0
Annual Total	13 353	17 561	7 932	104 573	1 413.3	1 410.5	1 408.4	137.1

Manitoba

Sector	NOx	CO	SO2	VOC	TPM	PM10	PM2.5	H2S
Fuel Combustion	240	111	12	14	13.7	13.5	13.3	0.0
Flaring	33	76	284	11	26.9	26.9	26.9	8.3
Natural Gas Production	0	0	0	137	0.0	0.0	0.0	3.3
Conventional Oil Production	0	0	0	3 163	0.0	0.0	0.0	47.8
Liquid Product Transportation	0	0	0	117	0.0	0.0	0.0	0.0
Surface Casing Ventblows/Gas	0	0	0	871	0.0	0.0	0.0	0.0
Accidents and Equipment Failures	0	0	0	1	0.0	0.0	0.0	0.0
Annual Total	273	187	296	4 314	40.6	40.4	40.2	59.4

Table 7.1. Historical summary of CAC emissions (t/y) from upstream oil and gas operations in Canada, presented by year, province and sector.

1997

Ontario

Sector	NOx	CO	SO2	VOC	TPM	PM10	PM2.5	H2S
Fuel Combustion	179	48	11	12	12.2	12.0	11.8	0.0
Flaring	14	3	1	1	1.0	1.0	1.0	0.0
Natural Gas Production	0	0	0	91	0.0	0.0	0.0	0.0
Conventional Oil Production	0	0	0	536	0.0	0.0	0.0	0.0
Natural Gas Processing	0	0	0	5	0.0	0.0	0.0	0.0
Liquid Product Transportation	0	0	0	311	0.0	0.0	0.0	0.0
Surface Casing Ventblows/Gas	0	0	0	819	0.0	0.0	0.0	0.0
Annual Total	193	51	12	1 776	13.1	13.0	12.8	0.0

Nova Scotia

Sector	NOx	CO	SO2	VOC	TPM	PM10	PM2.5	H2S
Fuel Combustion	0	0	0	0	0.0	0.0	0.0	0.0
Flaring	0	0	0	0	0.0	0.0	0.0	0.0
Natural Gas Production	0	0	0	0	0.0	0.0	0.0	0.0
Conventional Oil Production	0	0	0	6 475	0.0	0.0	0.0	0.0
Natural Gas Processing	0	0	0	0	0.0	0.0	0.0	0.0
Surface Casing Ventblows/Gas	0	0	0	4	0.0	0.0	0.0	0.0
Annual Total	0	0	0	6 479	0.0	0.0	0.0	0.0

Newfoundland

Sector	NOx	CO	SO2	VOC	TPM	PM10	PM2.5	H2S
Fuel Combustion	0	0	0	0	0.0	0.0	0.0	0.0
Flaring	0	0	0	0	0.0	0.0	0.0	0.0
Natural Gas Production	0	0	0	0	0.0	0.0	0.0	0.0
Conventional Oil Production	0	0	0	0	0.0	0.0	0.0	0.0
Accidents and Equipment Failures	0	0	0	0	0.0	0.0	0.0	0.0
Annual Total	0	0	0	0	0.0	0.0	0.0	0.0

Table 7.1. Historical summary of CAC emissions (t/y) from upstream oil and gas operations in Canada, presented by year, province and sector.

1997

Canada

Sector	NOx	CO	SO2	VOC	TPM	PM10	PM2.5	H2S
Fuel Combustion	324 585	324 284	3 987	8 131	2 977.2	2 958.4	2 944.4	30.2
Flaring	5 975	18 275	315 488	3 234	6 529.4	6 527.0	6 525.3	2 922.4
Formation CO2 Releases	0	0	0	0	0.0	0.0	0.0	0.0
Oil and Gas Well Drilling	0	0	0	41	0.0	0.0	0.0	3.0
Well Testing (non combustion)	0	0	0	201	0.0	0.0	0.0	0.0
Natural Gas Production	0	0	0	72 400	0.0	0.0	0.0	3 344.2
Conventional Oil Production	0	0	0	182 649	0.0	0.0	0.0	1 328.5
Heavy Oil/Cold Bitumen Production	0	0	0	130 012	0.0	0.0	0.0	1 276.4
Thermal Operations	0	0	0	6 359	0.0	0.0	0.0	16.6
Natural Gas Processing	0	0	0	17 266	0.0	0.0	0.0	1 597.9
Liquid Product Transportation	0	0	0	10 779	0.0	0.0	0.0	0.0
Surface Casing Ventblows/Gas	0	0	0	53 941	0.0	0.0	0.0	0.0
Accidents and Equipment Failures	0	0	0	5 133	0.0	0.0	0.0	0.0
Annual Total	330 560	342 558	319 475	490 145	9 506.5	9 485.4	9 469.7	10 519.1

Table 7.1. Historical summary of CAC emissions (t/y) from upstream oil and gas operations in Canada, presented by year, province and sector.

1998

Yukon Territory

Sector	NOx	CO	SO2	VOC	TPM	PM10	PM2.5	H2S
Fuel Combustion	186	286	0	2	0.8	0.8	0.8	0.0
Flaring	1	6	1 334	1	2.0	2.0	2.0	14.5
Formation CO2 Releases	0	0	0	0	0.0	0.0	0.0	0.0
Natural Gas Production	0	0	0	3	0.0	0.0	0.0	0.0
Natural Gas Processing	0	0	0	1	0.0	0.0	0.0	0.6
Surface Casing Ventblows/Gas	0	0	0	2	0.0	0.0	0.0	0.0
Annual Total	187	292	1 334	9	2.8	2.8	2.8	15.1

Northwest Territories

Sector	NOx	CO	SO2	VOC	TPM	PM10	PM2.5	H2S
Fuel Combustion	460	130	5	10	8.6	8.5	8.5	0.0
Flaring	3	8	0	1	3.0	3.0	3.0	0.0
Natural Gas Production	0	0	0	6	0.0	0.0	0.0	0.0
Conventional Oil Production	0	0	0	15	0.0	0.0	0.0	0.0
Surface Casing Ventblows/Gas	0	0	0	1	0.0	0.0	0.0	0.0
Accidents and Equipment Failures	0	0	0	2	0.0	0.0	0.0	0.0
Annual Total	464	138	5	36	11.6	11.5	11.4	0.0

British Columbia

Sector	NOx	CO	SO2	VOC	TPM	PM10	PM2.5	H2S
Fuel Combustion	34 393	39 784	2 162	959	401.0	397.5	394.8	13.9
Flaring	503	2 331	43 980	343	834.5	834.4	834.4	325.0
Formation CO2 Releases	0	0	0	0	0.0	0.0	0.0	0.0
Oil and Gas Well Drilling	0	0	0	8	0.0	0.0	0.0	0.5
Natural Gas Production	0	0	0	3 812	0.0	0.0	0.0	219.3
Conventional Oil Production	0	0	0	9 719	0.0	0.0	0.0	8.3
Natural Gas Processing	0	0	0	836	0.0	0.0	0.0	169.3
Liquid Product Transportation	0	0	0	122	0.0	0.0	0.0	0.0
Annual Total	34 896	42 115	46 143	15 799	1 235.5	1 231.9	1 229.2	736.3

Table 7.1. Historical summary of CAC emissions (t/y) from upstream oil and gas operations in Canada, presented by year, province and sector.

1998

Alberta

Sector	NOx	CO	SO2	VOC	TPM	PM10	PM2.5	H2S
Fuel Combustion	288 817	281 988	2 004	7 111	2 427.9	2 414.3	2 404.1	18.7
Flaring	3 303	10 525	220 794	1 949	3 761.4	3 760.2	3 759.3	2 093.6
Formation CO2 Releases	0	0	0	0	0.0	0.0	0.0	0.0
Oil and Gas Well Drilling	0	0	0	18	0.0	0.0	0.0	1.6
Well Testing (non combustion)	0	0	0	124	0.0	0.0	0.0	0.0
Natural Gas Production	0	0	0	66 978	0.0	0.0	0.0	3 211.5
Conventional Oil Production	0	0	0	118 976	0.0	0.0	0.0	1 269.7
Heavy Oil/Cold Bitumen Production	0	0	0	91 939	0.0	0.0	0.0	1 210.7
Thermal Operations	0	0	0	5 091	0.0	0.0	0.0	15.8
Natural Gas Processing	0	0	0	16 670	0.0	0.0	0.0	1 471.5
Liquid Product Transportation	0	0	0	8 051	0.0	0.0	0.0	0.0
Surface Casing Ventblows/Gas	0	0	0	37 054	0.0	0.0	0.0	0.0
Accidents and Equipment Failures	0	0	0	22 318	0.0	0.0	0.0	0.0
Annual Total	292 120	292 512	222 798	376 280	6 189.2	6 174.4	6 163.3	9 293.1

Saskatchewan

Sector	NOx	CO	SO2	VOC	TPM	PM10	PM2.5	H2S
Fuel Combustion	11 574	13 941	190	318	223.6	221.6	220.2	0.2
Flaring	1 741	3 770	8 772	651	1 343.4	1 342.5	1 341.7	120.2
Formation CO2 Releases	0	0	0	0	0.0	0.0	0.0	0.0
Oil and Gas Well Drilling	0	0	0	2	0.0	0.0	0.0	0.0
Natural Gas Production	0	0	0	3 285	0.0	0.0	0.0	6.2
Conventional Oil Production	0	0	0	43 765	0.0	0.0	0.0	2.7
Heavy Oil/Cold Bitumen Production	0	0	0	33 571	0.0	0.0	0.0	15.4
Thermal Operations	0	0	0	1 461	0.0	0.0	0.0	1.5
Natural Gas Processing	0	0	0	234	0.0	0.0	0.0	4.3
Liquid Product Transportation	0	0	0	2 100	0.0	0.0	0.0	0.0
Surface Casing Ventblows/Gas	0	0	0	19 706	0.0	0.0	0.0	0.0
Accidents and Equipment Failures	0	0	0	57	0.0	0.0	0.0	0.0
Annual Total	13 314	17 711	8 962	105 151	1 567.0	1 564.1	1 561.9	150.7

Manitoba

Sector	NOx	CO	SO2	VOC	TPM	PM10	PM2.5	H2S
Fuel Combustion	239	111	12	14	13.6	13.4	13.3	0.0
Flaring	33	75	283	11	26.8	26.8	26.8	8.3
Natural Gas Production	0	0	0	137	0.0	0.0	0.0	3.3
Conventional Oil Production	0	0	0	3 163	0.0	0.0	0.0	47.8
Liquid Product Transportation	0	0	0	116	0.0	0.0	0.0	0.0
Surface Casing Ventblows/Gas	0	0	0	893	0.0	0.0	0.0	0.0
Accidents and Equipment Failures	0	0	0	1	0.0	0.0	0.0	0.0
Annual Total	272	186	295	4 335	40.5	40.2	40.1	59.4

Table 7.1. Historical summary of CAC emissions (t/y) from upstream oil and gas operations in Canada, presented by year, province and sector.

1998

Ontario

Sector	NOx	CO	SO2	VOC	TPM	PM10	PM2.5	H2S
Fuel Combustion	184	49	11	13	12.5	12.3	12.1	0.0
Flaring	14	3	1	1	1.0	1.0	1.0	0.0
Natural Gas Production	0	0	0	93	0.0	0.0	0.0	0.0
Conventional Oil Production	0	0	0	536	0.0	0.0	0.0	0.0
Natural Gas Processing	0	0	0	6	0.0	0.0	0.0	0.0
Liquid Product Transportation	0	0	0	309	0.0	0.0	0.0	0.0
Surface Casinq Ventblows/Gas	0	0	0	855	0.0	0.0	0.0	0.0
Annual Total	197	52	12	1 811	13.5	13.3	13.1	0.0

Nova Scotia

Sector	NOx	CO	SO2	VOC	TPM	PM10	PM2.5	H2S
Fuel Combustion	0	0	0	0	0.0	0.0	0.0	0.0
Flaring	0	0	0	0	0.0	0.0	0.0	0.0
Natural Gas Production	0	0	0	0	0.0	0.0	0.0	0.0
Conventional Oil Production	0	0	0	6 475	0.0	0.0	0.0	0.0
Natural Gas Processing	0	0	0	0	0.0	0.0	0.0	0.0
Surface Casinq Ventblows/Gas	0	0	0	4	0.0	0.0	0.0	0.0
Annual Total	0	0	0	6 479	0.0	0.0	0.0	0.0

Newfoundland

Sector	NOx	CO	SO2	VOC	TPM	PM10	PM2.5	H2S
Fuel Combustion	483	130	0	4	3.0	3.0	3.0	0.0
Flaring	1 103	6 010	0	842	2 153.3	2 153.3	2 153.3	0.0
Natural Gas Production	0	0	0	11	0.0	0.0	0.0	0.0
Conventional Oil Production	0	0	0	17 201	0.0	0.0	0.0	0.0
Accidents and Equipment Failures	0	0	0	0	0.0	0.0	0.0	0.0
Annual Total	1 586	6 140	0	18 058	2 156.4	2 156.4	2 156.4	0.0

Table 7.1. Historical summary of CAC emissions (t/y) from upstream oil and gas operations in Canada, presented by year, province and sector.

Canada		1998							
Sector	NOx	CO	SO2	VOC	TPM	PM10	PM2.5	H2S	
Fuel Combustion	336 336	336 419	4 386	8 431	3 091.0	3 071.4	3 056.8	32.9	
Flaring	6 700	22 728	275 164	3 800	8 125.4	8 123.2	8 121.5	2 561.6	
Formation CO2 Releases	0	0	0	0	0.0	0.0	0.0	0.0	
Oil and Gas Well Drilling	0	0	0	28	0.0	0.0	0.0	2.1	
Well Testing (non combustion)	0	0	0	124	0.0	0.0	0.0	0.0	
Natural Gas Production	0	0	0	74 323	0.0	0.0	0.0	3 440.4	
Conventional Oil Production	0	0	0	199 850	0.0	0.0	0.0	1 328.5	
Heavy Oil/Cold Bitumen Production	0	0	0	125 510	0.0	0.0	0.0	1 226.0	
Thermal Operations	0	0	0	6 553	0.0	0.0	0.0	17.3	
Natural Gas Processing	0	0	0	17 746	0.0	0.0	0.0	1 645.6	
Liquid Product Transportation	0	0	0	10 698	0.0	0.0	0.0	0.0	
Surface Casing Ventblows/Gas	0	0	0	58 515	0.0	0.0	0.0	0.0	
Accidents and Equipment Failures	0	0	0	22 379	0.0	0.0	0.0	0.0	
Annual Total	343 036	359 147	279 550	527 958	11 216.4	11 194.6	11 178.3	10 254.5	

Table 7.1. Historical summary of CAC emissions (t/y) from upstream oil and gas operations in Canada, presented by year, province and sector.

1999

Yukon Territory

Sector	NOx	CO	SO2	VOC	TPM	PM10	PM2.5	H2S
Fuel Combustion	185	285	0	2	0.8	0.8	0.8	0.0
Flaring	1	3	741	0	1.1	1.1	1.1	8.0
Formation CO2 Releases	0	0	0	0	0.0	0.0	0.0	0.0
Natural Gas Production	0	0	0	4	0.0	0.0	0.0	0.0
Natural Gas Processing	0	0	0	1	0.0	0.0	0.0	0.8
Surface Casing Ventblows/Gas	0	0	0	2	0.0	0.0	0.0	0.0
Annual Total	186	289	741	10	1.9	1.9	1.9	8.8

Northwest Territories

Sector	NOx	CO	SO2	VOC	TPM	PM10	PM2.5	H2S
Fuel Combustion	457	129	5	10	8.5	8.5	8.4	0.0
Flaring	3	8	0	1	3.0	3.0	3.0	0.0
Natural Gas Production	0	0	0	4	0.0	0.0	0.0	0.0
Conventional Oil Production	0	0	0	15	0.0	0.0	0.0	0.0
Surface Casing Ventblows/Gas	0	0	0	1	0.0	0.0	0.0	0.0
Accidents and Equipment Failures	0	0	0	2	0.0	0.0	0.0	0.0
Annual Total	460	137	5	34	11.5	11.4	11.4	0.0

British Columbia

Sector	NOx	CO	SO2	VOC	TPM	PM10	PM2.5	H2S
Fuel Combustion	36 236	41 915	2 278	1 011	422.5	418.8	416.0	14.7
Flaring	348	1 614	30 455	237	577.9	577.8	577.8	225.0
Formation CO2 Releases	0	0	0	0	0.0	0.0	0.0	0.0
Oil and Gas Well Drilling	0	0	0	8	0.0	0.0	0.0	0.5
Natural Gas Production	0	0	0	3 979	0.0	0.0	0.0	228.9
Conventional Oil Production	0	0	0	9 719	0.0	0.0	0.0	8.3
Natural Gas Processing	0	0	0	873	0.0	0.0	0.0	176.7
Liquid Product Transportation	0	0	0	104	0.0	0.0	0.0	0.0
Annual Total	36 584	43 529	32 733	15 930	1 000.4	996.6	993.8	654.2

Table 7.1. Historical summary of CAC emissions (t/y) from upstream oil and gas operations in Canada, presented by year, province and sector.

1999

Alberta

Sector	NOx	CO	SO2	VOC	TPM	PM10	PM2.5	H2S
Fuel Combustion	302 031	294 889	2 096	7 436	2 539.0	2 524.7	2 514.0	19.6
Flaring	2 898	9 233	193 704	1 710	3 299.9	3 298.8	3 298.0	1 836.8
Formation CO2 Releases	0	0	0	0	0.0	0.0	0.0	0.0
Oil and Gas Well Drilling	0	0	0	21	0.0	0.0	0.0	1.8
Well Testing (non combustion)	0	0	0	144	0.0	0.0	0.0	0.0
Natural Gas Production	0	0	0	68 000	0.0	0.0	0.0	3 260.5
Conventional Oil Production	0	0	0	118 976	0.0	0.0	0.0	1 269.7
Heavy Oil/Cold Bitumen Production	0	0	0	92 052	0.0	0.0	0.0	1 212.2
Thermal Operations	0	0	0	4 677	0.0	0.0	0.0	14.5
Natural Gas Processing	0	0	0	16 925	0.0	0.0	0.0	1 494.0
Liquid Product Transportation	0	0	0	7 269	0.0	0.0	0.0	0.0
Surface Casing Ventblows/Gas	0	0	0	40 561	0.0	0.0	0.0	0.0
Accidents and Equipment Failures	0	0	0	5 072	0.0	0.0	0.0	0.0
Annual Total	304 929	304 123	195 800	362 843	5 838.8	5 823.5	5 812.1	9 109.0

Saskatchewan

Sector	NOx	CO	SO2	VOC	TPM	PM10	PM2.5	H2S
Fuel Combustion	12 200	14 696	201	335	235.7	233.6	232.1	0.2
Flaring	1 384	2 998	6 977	518	1 068.5	1 067.7	1 067.2	95.6
Formation CO2 Releases	0	0	0	0	0.0	0.0	0.0	0.0
Oil and Gas Well Drilling	0	0	0	2	0.0	0.0	0.0	0.0
Natural Gas Production	0	0	0	3 380	0.0	0.0	0.0	6.4
Conventional Oil Production	0	0	0	43 765	0.0	0.0	0.0	2.7
Heavy Oil/Cold Bitumen Production	0	0	0	34 270	0.0	0.0	0.0	15.7
Thermal Operations	0	0	0	1 457	0.0	0.0	0.0	1.5
Natural Gas Processing	0	0	0	240	0.0	0.0	0.0	4.4
Liquid Product Transportation	0	0	0	1 970	0.0	0.0	0.0	0.0
Surface Casing Ventblows/Gas	0	0	0	21 646	0.0	0.0	0.0	0.0
Accidents and Equipment Failures	0	0	0	57	0.0	0.0	0.0	0.0
Annual Total	13 584	17 694	7 177	107 641	1 304.1	1 301.4	1 299.3	126.7

Manitoba

Sector	NOx	CO	SO2	VOC	TPM	PM10	PM2.5	H2S
Fuel Combustion	219	102	11	13	12.5	12.3	12.2	0.0
Flaring	30	69	259	10	24.6	24.6	24.6	7.6
Natural Gas Production	0	0	0	125	0.0	0.0	0.0	3.0
Conventional Oil Production	0	0	0	3 163	0.0	0.0	0.0	47.8
Liquid Product Transportation	0	0	0	106	0.0	0.0	0.0	0.0
Surface Casing Ventblows/Gas	0	0	0	921	0.0	0.0	0.0	0.0
Accidents and Equipment Failures	0	0	0	1	0.0	0.0	0.0	0.0
Annual Total	249	170	271	4 340	37.1	36.9	36.7	58.4

Table 7.1. Historical summary of CAC emissions (t/y) from upstream oil and gas operations in Canada, presented by year, province and sector.

1999

Ontario

Sector	NOx	CO	SO2	VOC	TPM	PM10	PM2.5	H2S
Fuel Combustion	281	76	17	19	19.1	18.8	18.6	0.0
Flaring	21	5	1	2	1.5	1.5	1.5	0.0
Natural Gas Production	0	0	0	142	0.0	0.0	0.0	0.0
Conventional Oil Production	0	0	0	536	0.0	0.0	0.0	0.0
Natural Gas Processing	0	0	0	8	0.0	0.0	0.0	0.0
Liquid Product Transportation	0	0	0	336	0.0	0.0	0.0	0.0
Surface Casing Ventblows/Gas	0	0	0	890	0.0	0.0	0.0	0.0
Annual Total	302	80	19	1 934	20.6	20.3	20.1	0.0

Nova Scotia

Sector	NOx	CO	SO2	VOC	TPM	PM10	PM2.5	H2S
Fuel Combustion	0	0	0	0	0.0	0.0	0.0	0.0
Flaring	0	0	0	0	0.0	0.0	0.0	0.0
Natural Gas Production	0	0	0	0	0.0	0.0	0.0	0.0
Conventional Oil Production	0	0	0	6 475	0.0	0.0	0.0	0.0
Natural Gas Processing	0	0	0	0	0.0	0.0	0.0	0.0
Surface Casing Ventblows/Gas	0	0	0	4	0.0	0.0	0.0	0.0
Annual Total	0	0	0	6 479	0.0	0.0	0.0	0.0

Newfoundland

Sector	NOx	CO	SO2	VOC	TPM	PM10	PM2.5	H2S
Fuel Combustion	680	183	0	5	4.3	4.3	4.3	0.0
Flaring	489	2 664	0	373	954.4	954.4	954.4	0.0
Natural Gas Production	0	0	0	17	0.0	0.0	0.0	0.0
Conventional Oil Production	0	0	0	17 201	0.0	0.0	0.0	0.0
Accidents and Equipment Failures	0	0	0	0	0.0	0.0	0.0	0.0
Annual Total	1 169	2 847	0	17 596	958.7	958.7	958.7	0.0

Table 7.1. Historical summary of CAC emissions (t/y) from upstream oil and gas operations in Canada, presented by year, province and sector.

1999

Canada

Sector	NOx	CO	SO2	VOC	TPM	PM10	PM2.5	H2S
Fuel Combustion	352 289	352 275	4 609	8 831	3 242.3	3 221.7	3 206.3	34.5
Flaring	5 174	16 595	232 137	2 852	5 930.8	5 928.9	5 927.5	2 173.1
Formation CO2 Releases	0	0	0	0	0.0	0.0	0.0	0.0
Oil and Gas Well Drilling	0	0	0	31	0.0	0.0	0.0	2.3
Well Testing (non combustion)	0	0	0	144	0.0	0.0	0.0	0.0
Natural Gas Production	0	0	0	75 651	0.0	0.0	0.0	3 498.9
Conventional Oil Production	0	0	0	199 850	0.0	0.0	0.0	1 328.5
Heavy Oil/Cold Bitumen Production	0	0	0	126 322	0.0	0.0	0.0	1 227.9
Thermal Operations	0	0	0	6 134	0.0	0.0	0.0	16.0
Natural Gas Processing	0	0	0	18 047	0.0	0.0	0.0	1 675.9
Liquid Product Transportation	0	0	0	9 785	0.0	0.0	0.0	0.0
Surface Casing Ventblows/Gas	0	0	0	64 026	0.0	0.0	0.0	0.0
Accidents and Equipment Failures	0	0	0	5 133	0.0	0.0	0.0	0.0
Annual Total	357 463	368 869	236 746	516 808	9 173.1	9 150.7	9 133.8	9 957.1

Table 7.1. Historical summary of CAC emissions (t/y) from upstream oil and gas operations in Canada, presented by year, province and sector.

2000

Yukon Territory

Sector	NOx	CO	SO2	VOC	TPM	PM10	PM2.5	H2S
Fuel Combustion	170	262	0	2	0.7	0.7	0.7	0.0
Flaring	0	1	296	0	0.5	0.5	0.5	3.2
Formation CO2 Releases	0	0	0	0	0.0	0.0	0.0	0.0
Natural Gas Production	0	0	0	4	0.0	0.0	0.0	0.0
Natural Gas Processing	0	0	0	1	0.0	0.0	0.0	0.7
Surface Casing Ventblows/Gas	0	0	0	2	0.0	0.0	0.0	0.0
Annual Total	170	263	296	9	1.2	1.2	1.2	3.9

Northwest Territories

Sector	NOx	CO	SO2	VOC	TPM	PM10	PM2.5	H2S
Fuel Combustion	423	120	5	9	7.9	7.8	7.8	0.0
Flaring	9	22	0	3	7.8	7.8	7.8	0.0
Natural Gas Production	0	0	0	30	0.0	0.0	0.0	0.0
Conventional Oil Production	0	0	0	15	0.0	0.0	0.0	0.0
Surface Casing Ventblows/Gas	0	0	0	1	0.0	0.0	0.0	0.0
Accidents and Equipment Failures	0	0	0	2	0.0	0.0	0.0	0.0
Annual Total	431	141	5	60	15.7	15.6	15.6	0.0

British Columbia

Sector	NOx	CO	SO2	VOC	TPM	PM10	PM2.5	H2S
Fuel Combustion	37 530	43 412	2 360	1 047	437.6	433.7	430.8	15.2
Flaring	331	1 535	28 959	226	549.5	549.4	549.4	214.0
Formation CO2 Releases	0	0	0	0	0.0	0.0	0.0	0.0
Oil and Gas Well Drilling	0	0	0	10	0.0	0.0	0.0	0.6
Natural Gas Production	0	0	0	3 979	0.0	0.0	0.0	228.9
Conventional Oil Production	0	0	0	9 719	0.0	0.0	0.0	8.3
Natural Gas Processing	0	0	0	873	0.0	0.0	0.0	176.7
Liquid Product Transportation	0	0	0	113	0.0	0.0	0.0	0.0
Annual Total	37 860	44 946	31 318	15 966	987.1	983.2	980.2	643.7

Table 7.1. Historical summary of CAC emissions (t/y) from upstream oil and gas operations in Canada, presented by year, province and sector.

2000

Alberta

Sector	NOx	CO	SO2	VOC	TPM	PM10	PM2.5	H2S
Fuel Combustion	306 966	299 708	2 130	7 558	2 580.4	2 566.0	2 555.1	19.9
Flaring	3 351	10 677	223 992	1 978	3 815.9	3 814.6	3 813.7	2 124.0
Formation CO2 Releases	0	0	0	0	0.0	0.0	0.0	0.0
Oil and Gas Well Drilling	0	0	0	30	0.0	0.0	0.0	2.6
Well Testing (non combustion)	0	0	0	206	0.0	0.0	0.0	0.0
Natural Gas Production	0	0	0	68 336	0.0	0.0	0.0	3 276.6
Conventional Oil Production	0	0	0	118 976	0.0	0.0	0.0	1 269.7
Heavy Oil/Cold Bitumen Production	0	0	0	91 638	0.0	0.0	0.0	1 206.7
Thermal Operations	0	0	0	5 043	0.0	0.0	0.0	15.7
Natural Gas Processing	0	0	0	17 009	0.0	0.0	0.0	1 501.3
Liquid Product Transportation	0	0	0	7 338	0.0	0.0	0.0	0.0
Surface Casing Ventblows/Gas	0	0	0	34 342	0.0	0.0	0.0	0.0
Accidents and Equipment Failures	0	0	0	15 538	0.0	0.0	0.0	0.0
Annual Total	310 317	310 385	226 122	367 991	6 396.3	6 380.6	6 368.8	9 416.5

Saskatchewan

Sector	NOx	CO	SO2	VOC	TPM	PM10	PM2.5	H2S
Fuel Combustion	13 072	15 747	215	359	252.5	250.3	248.7	0.3
Flaring	1 394	3 020	7 026	521	1 076.1	1 075.3	1 074.8	96.3
Formation CO2 Releases	0	0	0	0	0.0	0.0	0.0	0.0
Oil and Gas Well Drilling	0	0	0	4	0.0	0.0	0.0	0.0
Natural Gas Production	0	0	0	3 482	0.0	0.0	0.0	6.6
Conventional Oil Production	0	0	0	43 765	0.0	0.0	0.0	2.7
Heavy Oil/Cold Bitumen Production	0	0	0	43 465	0.0	0.0	0.0	19.9
Thermal Operations	0	0	0	1 806	0.0	0.0	0.0	1.9
Natural Gas Processing	0	0	0	248	0.0	0.0	0.0	4.6
Liquid Product Transportation	0	0	0	2 199	0.0	0.0	0.0	0.0
Surface Casing Ventblows/Gas	0	0	0	24 218	0.0	0.0	0.0	0.0
Accidents and Equipment Failures	0	0	0	57	0.0	0.0	0.0	0.0
Annual Total	14 467	18 766	7 241	120 125	1 328.6	1 325.7	1 323.5	132.3

Manitoba

Sector	NOx	CO	SO2	VOC	TPM	PM10	PM2.5	H2S
Fuel Combustion	235	109	12	14	13.4	13.2	13.1	0.0
Flaring	32	74	279	11	26.4	26.4	26.4	8.2
Natural Gas Production	0	0	0	135	0.0	0.0	0.0	3.3
Conventional Oil Production	0	0	0	3 163	0.0	0.0	0.0	47.8
Liquid Product Transportation	0	0	0	114	0.0	0.0	0.0	0.0
Surface Casing Ventblows/Gas	0	0	0	972	0.0	0.0	0.0	0.0
Accidents and Equipment Failures	0	0	0	1	0.0	0.0	0.0	0.0
Annual Total	267	183	291	4 410	39.8	39.6	39.4	59.2

Table 7.1. Historical summary of CAC emissions (t/y) from upstream oil and gas operations in Canada, presented by year, province and sector.

2000

Ontario

Sector	NOx	CO	SO2	VOC	TPM	PM10	PM2.5	H2S
Fuel Combustion	386	104	24	26	26.2	25.8	25.5	0.0
Flaring	29	6	2	2	2.1	2.1	2.1	0.0
Natural Gas Production	0	0	0	196	0.0	0.0	0.0	0.0
Conventional Oil Production	0	0	0	536	0.0	0.0	0.0	0.0
Natural Gas Processing	0	0	0	12	0.0	0.0	0.0	0.0
Liquid Product Transportation	0	0	0	326	0.0	0.0	0.0	0.0
Surface Casinq Ventblows/Gas	0	0	0	926	0.0	0.0	0.0	0.0
Annual Total	416	110	26	2 024	28.3	27.9	27.6	0.0

Nova Scotia

Sector	NOx	CO	SO2	VOC	TPM	PM10	PM2.5	H2S
Fuel Combustion	2 566	3 796	5	42	17.5	17.4	17.4	0.0
Flaring	15	80	0	11	28.7	28.7	28.7	0.0
Natural Gas Production	0	0	0	75	0.0	0.0	0.0	0.0
Conventional Oil Production	0	0	0	0	0.0	0.0	0.0	0.0
Natural Gas Processing	0	0	0	47	0.0	0.0	0.0	0.0
Surface Casinq Ventblows/Gas	0	0	0	4	0.0	0.0	0.0	0.0
Annual Total	2 581	3 876	5	179	46.2	46.1	46.1	0.0

Newfoundland

Sector	NOx	CO	SO2	VOC	TPM	PM10	PM2.5	H2S
Fuel Combustion	834	224	0	6	5.2	5.2	5.2	0.0
Flaring	127	691	0	97	247.5	247.5	247.5	0.0
Natural Gas Production	0	0	0	28	0.0	0.0	0.0	0.0
Conventional Oil Production	0	0	0	17 201	0.0	0.0	0.0	0.0
Accidents and Equipment Failures	0	0	0	0	0.0	0.0	0.0	0.0
Annual Total	960	915	0	17 332	252.7	252.7	252.7	0.0

Table 7.1. Historical summary of CAC emissions (t/y) from upstream oil and gas operations in Canada, presented by year, province and sector.

Canada		2000							
Sector	NOx	CO	SO2	VOC	TPM	PM10	PM2.5	H2S	
Fuel Combustion	362 182	363 480	4 751	9 063	3 341.5	3 320.3	3 304.4	35.4	
Flaring	5 288	16 106	260 554	2 849	5 754.4	5 752.4	5 750.8	2 445.6	
Formation CO2 Releases	0	0	0	0	0.0	0.0	0.0	0.0	
Oil and Gas Well Drilling	0	0	0	44	0.0	0.0	0.0	3.2	
Well Testing (non combustion)	0	0	0	206	0.0	0.0	0.0	0.0	
Natural Gas Production	0	0	0	76 264	0.0	0.0	0.0	3 515.4	
Conventional Oil Production	0	0	0	193 375	0.0	0.0	0.0	1 328.5	
Heavy Oil/Cold Bitumen Production	0	0	0	135 103	0.0	0.0	0.0	1 226.6	
Thermal Operations	0	0	0	6 849	0.0	0.0	0.0	17.6	
Natural Gas Processing	0	0	0	18 188	0.0	0.0	0.0	1 683.3	
Liquid Product Transportation	0	0	0	10 092	0.0	0.0	0.0	0.0	
Surface Casing Ventblows/Gas	0	0	0	60 466	0.0	0.0	0.0	0.0	
Accidents and Equipment Failures	0	0	0	15 599	0.0	0.0	0.0	0.0	
Annual Total	367 470	379 586	265 305	528 097	9 096.0	9 072.7	9 055.2	10 255.7	

8.0 APPENDIX II: GRAPHICAL SUMMARY OF THE INVENTORY BY PROVINCE

The histograms presented in this appendix present the show the relative distribution of each target pollutant by province.

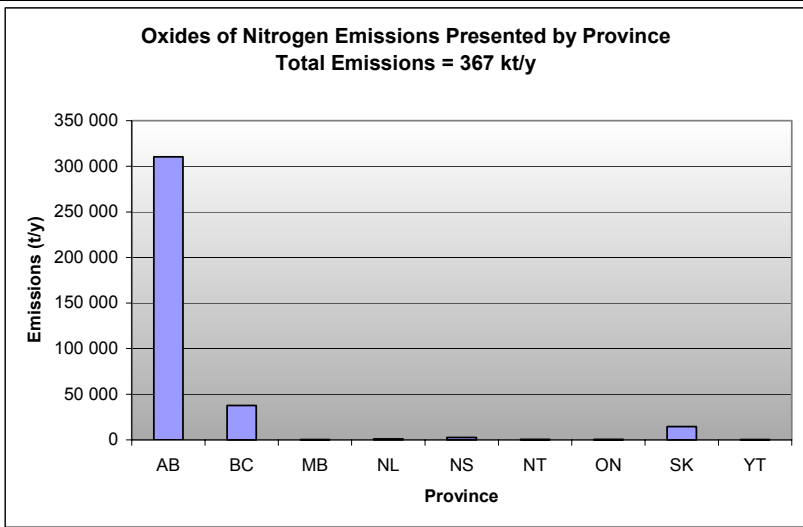


Figure 10. Histogram depicting NO_x emissions by province and territory.

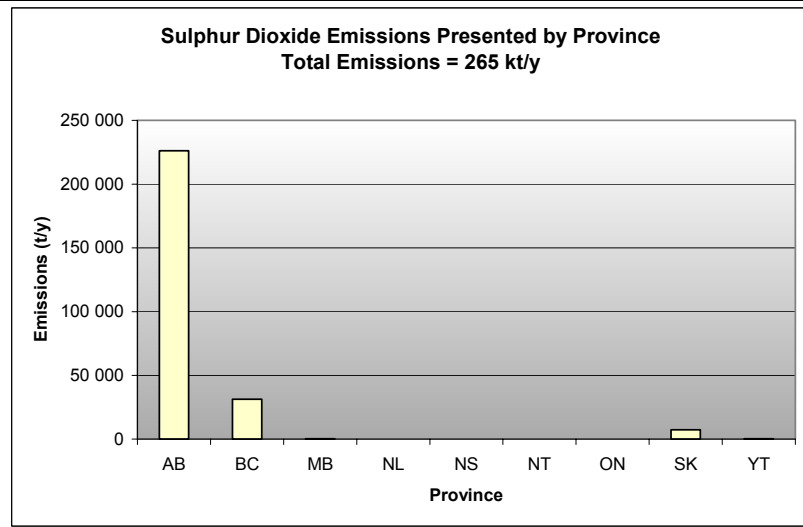


Figure 11. Histogram depicting SO₂ emissions by province and territory.

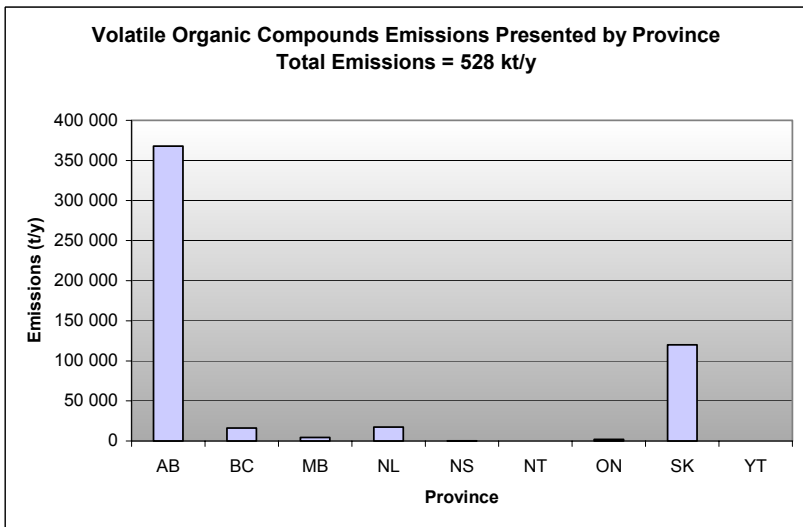


Figure 12. Histogram depicting VOC emissions by province and territory.

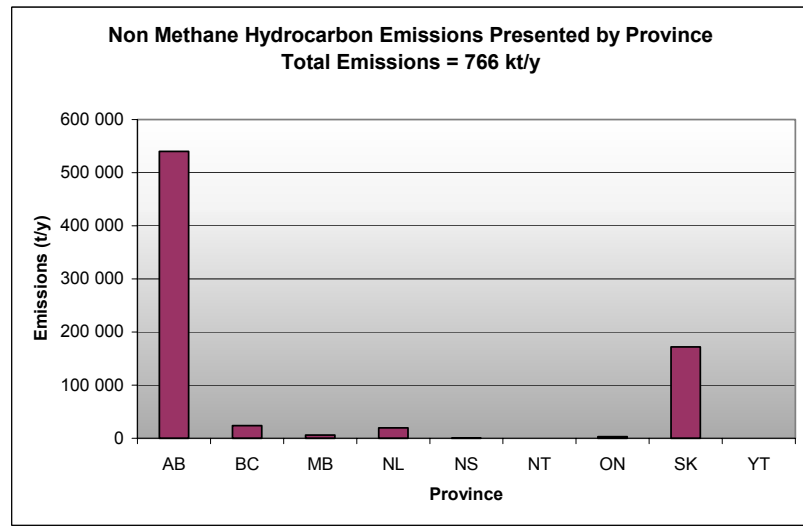


Figure 13. Histogram depicting NMHC emissions by province and territory.

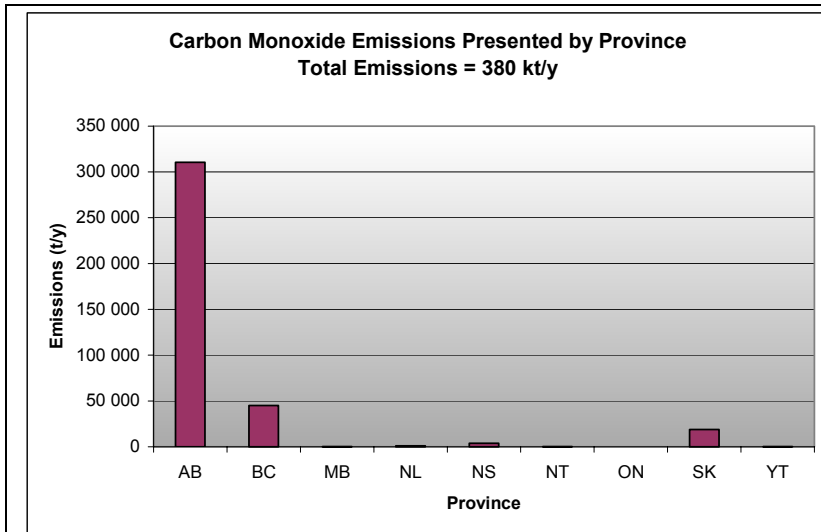


Figure 14. Histogram depicting CO emissions by province and territory.

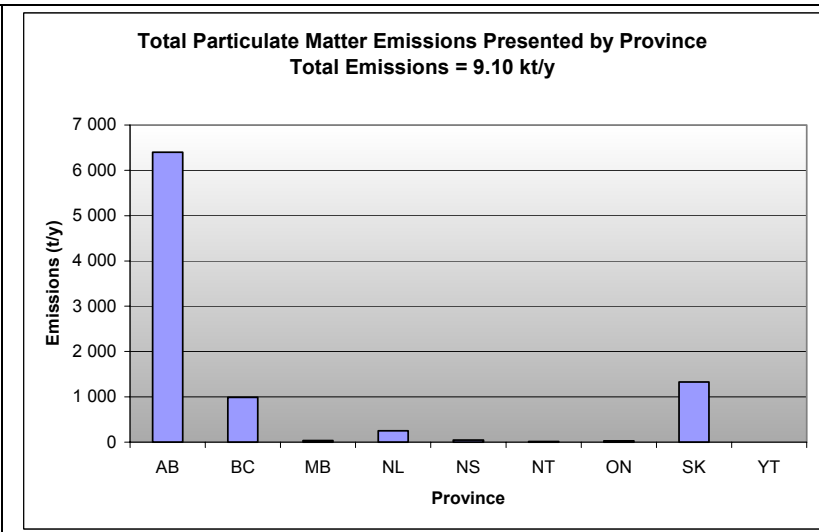


Figure 15. Histogram depicting TPM emissions by province and territory.

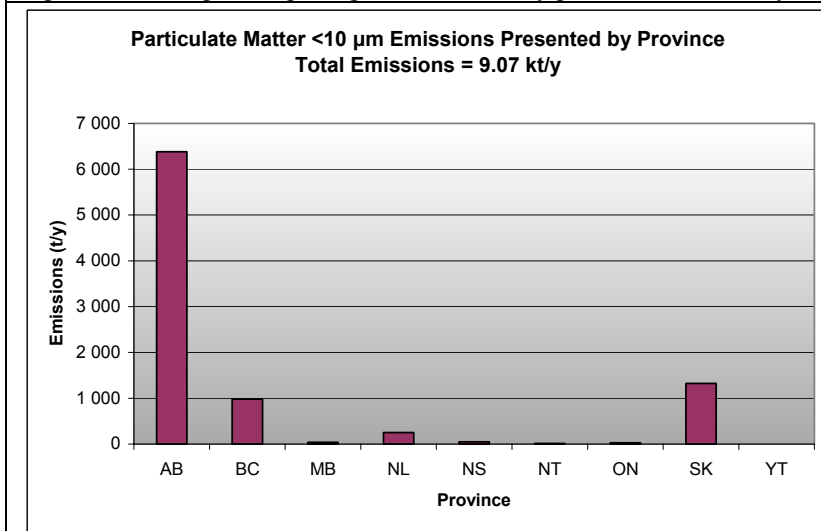


Figure 16. Histogram depicting PM₁₀ emissions by province and territory.

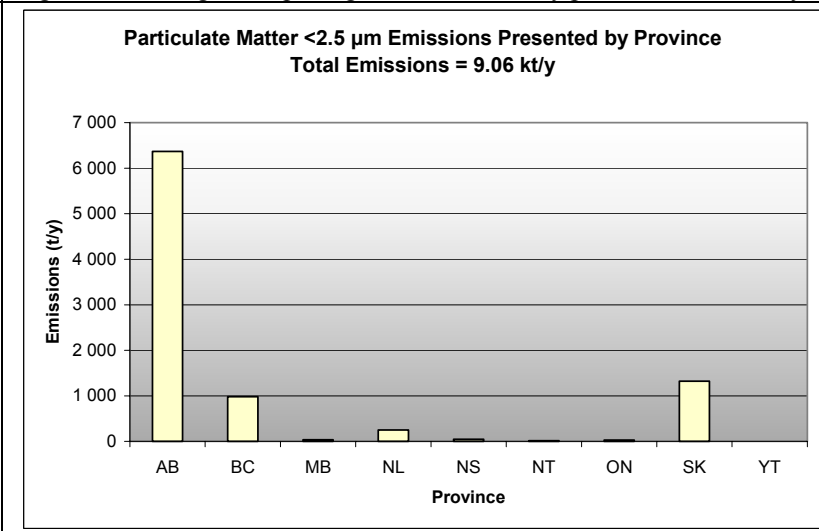


Figure 17. Histogram depicting PM_{2.5} emissions by province and territory.

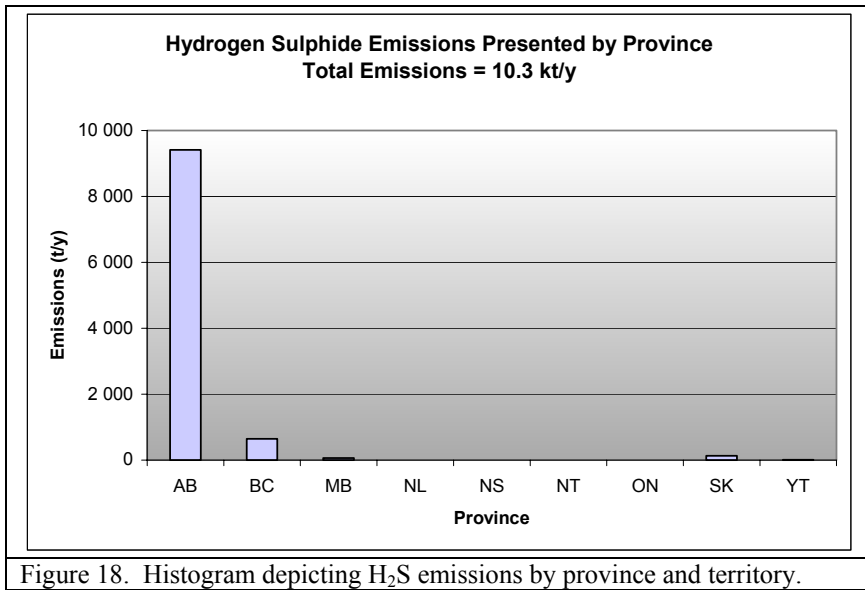


Figure 18. Histogram depicting H₂S emissions by province and territory.