



WASHINGTON STATE  
DEPARTMENT OF  
E C O L O G Y



STATE OF WASHINGTON  
DEPARTMENT OF COMMUNITY,  
TRADE AND ECONOMIC DEVELOPMENT

# Washington State

## 1990 Greenhouse Gas Emissions Inventory

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## Acronyms and Key Terms

**C** – Carbon

**CFCs** – Chlorofluorocarbons

**CH<sub>4</sub>** – Methane

**CO<sub>2</sub>** – Carbon Dioxide

**CO<sub>2</sub>e** – Carbon Dioxide Equivalent

**EIA** – U.S. DOE Energy Information Administration

**EIIP** – Emissions Inventory Improvement Project (US EPA)

**GHG** – Greenhouse Gases

**GWP** - Global Warming Potential

**HFCs** – Hydrofluorocarbons

**IPCC** – Intergovernmental Panel on Climate Change

**LMOP** – Landfill Methane Outreach Program

**LNG** – Liquefied Natural Gas

**LPG** – Liquefied Petroleum Gas

**Mt** - Metric Ton (equivalent to 1.102 short tons)

**MMt** – Million Metric Tons

**MSW** – Municipal Solid Waste

**MW** – Megawatt

**N** – Nitrogen

**N<sub>2</sub>O** – Nitrous Oxide

**NO<sub>2</sub>** – Nitrogen Dioxide

**NASS** – National Agricultural Statistics Service

**NO<sub>x</sub>** – Nitrogen Oxides

**ODS** – Ozone-Depleting Substances

**ODS** – Ozone-Depleting Substances

**PFCs** – Perfluorocarbons

**RCI** – Residential, Commercial, and Industrial

**SED** – State Energy Data

**SF<sub>6</sub>** – Sulfur Hexafluoride

**SGIT** – State Greenhouse Gas Inventory Tool

**Sinks** – Removals of carbon from the atmosphere, with the carbon stored in forests, soils, landfills, wood

structures, or other biomass-related products.

**T&D** – Transmission and Distribution

**UNFCCC** – United Nations Framework Convention on Climate Change

**U.S. EPA** – United States Environmental Protection Agency

**U.S. DOE** – United States Department of Energy

**USDA** – United States Department of Agriculture

**USGS** – United States Geological Survey

## 1.0 Introduction

In 2007, the Washington State Legislature directed the Departments of Ecology (Ecology) and Community, Trade, and Economic Development (CTED) to estimate the amount of greenhouse gas (GHG) emissions from Washington in 1990 and report the findings by December 31, 2007.

**RCW 80.80.020 (2)(a)** By December 31, 2007, the departments of ecology and community, trade, and economic development shall report to the appropriate committees of the senate and house of representatives the total greenhouse gases emissions for 1990 and the totals in each major sector for 1990.

This report fulfills that request and describes the 1990 GHG emissions for each of the seven major sectors that contribute to greenhouse gases in Washington:

- Electricity use and supply
- Residential, commercial and industrial fossil fuel combustion
- Transportation
- Industrial processes
- Fossil fuel industry (fugitive emissions – greenhouse gas released from leakage)
- Waste management
- Agriculture

Estimates of Washington's 1990 greenhouse gas (GHG) emissions were developed with the same approach to emissions accounting used by the U.S. EPA in its national GHG emissions inventory and its guidelines for States. These inventory guidelines are consistent with the Intergovernmental Panel on Climate Change (IPCC) Good Practice Guidance document.<sup>1</sup> The IPCC is the international organization responsible for developing coordinated methods for national inventories.

This report covers the six types of greenhouse gases:

1. Carbon dioxide (CO<sub>2</sub>)
2. Methane (CH<sub>4</sub>)
3. Nitrous oxide (N<sub>2</sub>O)
4. Hydrofluorocarbons (HFCs)
5. Perfluorocarbons (PFCs)
6. Sulfur hexafluoride (SF<sub>6</sub>)

A common metric called CO<sub>2</sub> equivalence is used to present the GHG emissions data in this report. This metric incorporates the Global Warming Potential (GWP) of each gas so that the impacts of emissions from different gases can be compared. The Center for Climate Strategies (CCS), Ecology, and CTED managed a larger study on Washington's

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<sup>1</sup> Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories, Intergovernmental Panel on Climate Change, May 2000

GHG emissions, from 1990 through 2005 with projections to 2020. <sup>2</sup> Please refer to this study for further details about assumptions and methods used to calculate the 1990 GHG emissions.

## 2.0 Washington State GHG Emissions

In 1990, Washington emitted about **88.4 million metric tons (MMt)** of total carbon dioxide equivalent (CO<sub>2</sub>e). This amount is the second highest in the western states, with California being the highest and is approximately equivalent to eliminating 57 million vehicles from the roadway. Table 1 below shows the top three sources of Washington’s GHG emissions and the percent each source contributed to the state’s total emissions in 1990.

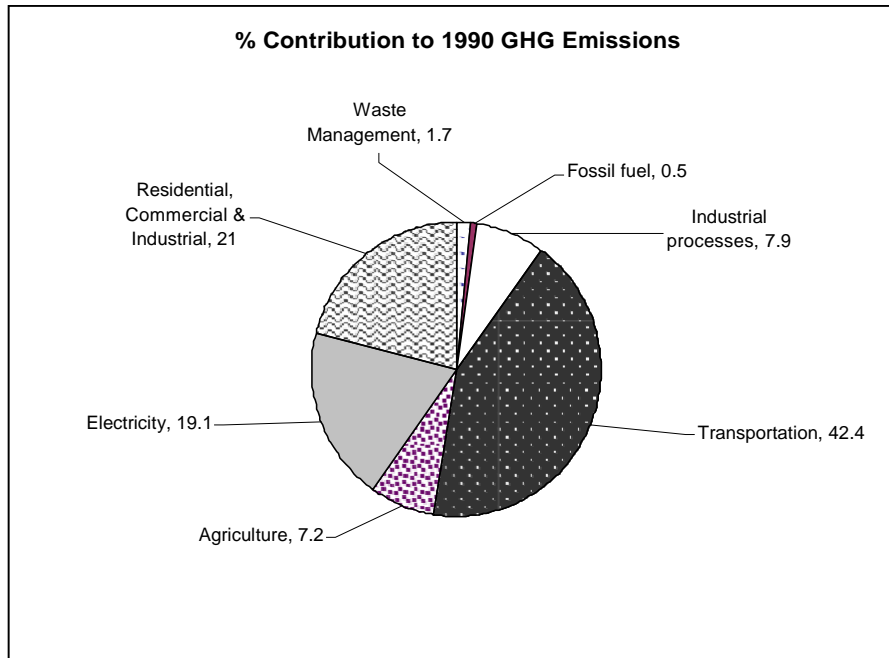
**Table 1: GHG Emission Sources – 1990**

GHG Emission Sources for 1990	Percentage of Contribution
Transportation	42.4%
Fossil fuel combustion in the residential, commercial, and industrial sectors.	21.0%
Electricity consumption*	19.1%

\* It is important to note that for the Electricity Sector, we used a consumption-based or “load-based” approach to calculate emissions. This methodology determines GHG emissions from electricity delivered to Washington consumers, regardless of where those electrical generation facilities are located.

Figure 1 below shows how much each of the seven major sectors contributed to Washington’s total 1990 GHG emissions.

**Figure 1: Percent of Contribution to Washington State’s 1990 GHG Emissions by Sector**



<sup>2</sup> Greenhouse Gas Inventory and Reference Case Projections, 1990- 2020; [http://www.ecy.wa.gov/climatechange/docs/WA\\_GHGInventoryReferenceCaseProjections\\_1990-2020.pdf](http://www.ecy.wa.gov/climatechange/docs/WA_GHGInventoryReferenceCaseProjections_1990-2020.pdf)

Table 2 provides a summary of the total emissions from each major sector that contributed to the 1990 GHG emissions for Washington State. See Acronyms and Key Terms section on page 2.

**Table 2: Washington State 1990 GHG Emissions, by Sector**<sup>3</sup>

Million Metric Tons CO <sub>2</sub> e	1990	Percent Total
<b>Energy</b>	73.0	82.6
<b>Electricity, Net-Consumption-based</b>	16.9	19.1
Coal <sup>4</sup>	16.8	
Natural Gas <sup>4</sup>	0.1	
Petroleum	0.0	
<b>Residential / Commercial / Industrial (RCI)</b>	18.6	21.0
Coal	0.6	
Natural Gas	8.6	
Petroleum	9.1	
Wood (CH <sub>4</sub> and N <sub>2</sub> O)	0.2	
<b>Transportation</b>	37.5	42.4
Onroad Gasoline (cars)	20.4	
Onroad Diesel (trucks)	4.1	
Marine Vessels	2.6	
Jet Fuel and Aviation Gasoline	9.1	
Rail	0.8	
Natural Gas, LPG other	0.6	
<b>Industrial Processes</b>	7.0	7.9
Cement Manufacture ( CO <sub>2</sub> )	0.2	
Aluminum Production ( CO <sub>2</sub> , PFC)	5.9	
Limestone and Dolomite Use (CO <sub>2</sub> )	0.0	
Soda Ash (CO <sub>2</sub> )	0.1	
ODS Substitutes (HFC, PFC and SF <sub>6</sub> )	0.0	
Semiconductor Mfg. (HFC, PFC and SF <sub>6</sub> )	0.0	
Electric Power Transmission/Distribution (SF <sub>6</sub> )	0.8	
<b>Fossil Fuel Industry</b>	0.5	0.5
Natural Gas Industry (CH <sub>4</sub> )	0.4	
Coal Mining (CH <sub>4</sub> )	0.0	
Petroleum Industry (CH <sub>4</sub> )	0.0	
<b>Waste Management</b>	1.5	1.7
Solid Waste Management	1.0	
Wastewater Management	0.5	
<b>Agriculture</b>	6.4	7.2
Enteric Fermentation	2.0	
Manure Management	0.7	
Agriculture Soils	3.7	
<b>Total Gross Emissions</b>	<b>88.4</b>	

<sup>3</sup>Totals may not equal exact sum of subtotals shown in this table due to independent rounding.

<sup>4</sup>Includes Market Purchases from Net System Mix (4.1 MMt CO<sub>2</sub>e); see Section 3.1



### 3.0 Description of GHG Emissions by Sector

#### 3.1 Electricity Use and Supply

Washington's electricity sector is dominated by hydro-electric generation which does not produce GHG emissions. However, the seasonal and annual variations in hydro availability results in the use of electricity generated by fossil fuels that produce GHG emissions.

We performed a consumption-based analysis which determines how much GHG emissions came from electric power generation sold to Washington consumers regardless of where the generating facility was physically located.<sup>5</sup> Table 3.1 below shows the electricity generation and emissions assigned to Washington customers, including an allocation from the Net System Mix. Generated electricity which is not assigned to a utility remains in the Northwest Power Pool and is called the Net System Mix. The Northwest power pool is an interconnected grid of regional electrical generating facilities.

**Table 3.1: Estimated 1990 load-based fuel mix and CO2 emissions**

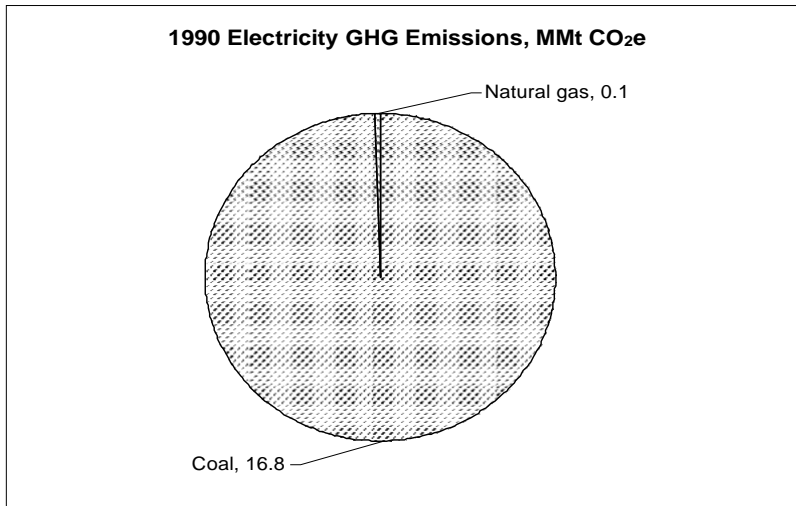
Fuel	MWh	Metric Tons CO2
Biomass	170,734	-
Coal	11,754,471	12,763,017
Gas	20,006	14,964
Geothermal	11,778	-
Hydro	64,460,956	-
Nuclear	5,295,251	-
Oil	2,081	2,684
Net System Mix	9,330,873	4,128,412
<b>Total</b>	<b>97,419,382</b>	<b>16,909,077</b>

Figure 3.1 below shows that the sources of GHG emissions for consumption based electricity are natural gas and coal, however, the largest amount of ghg emissions are from coal.

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<sup>5</sup> Methodology for Estimating 1990 Electricity Load-based Emissions for Washington State, S. Waterman-Hoey, CTED Energy Policy Division, 10/11/07

**Figure 3.1: Electricity Net-Consumption Base 1990 GHG emissions: Total 16.9 MMt CO<sub>2</sub>e**

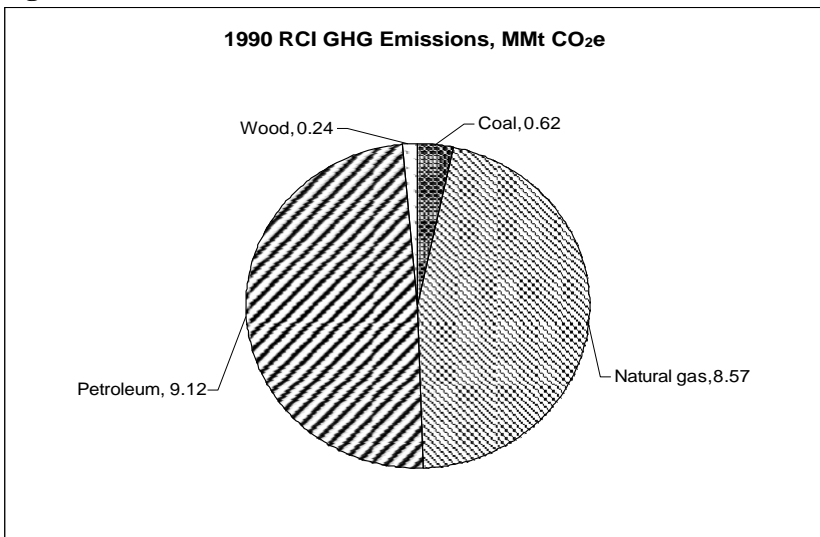


### 3.2 Residential, Commercial, and Industrial (RCI) Fossil Fuel Combustion

The Residential, Commercial and Industrial sector includes greenhouse gas emissions from fuels combusted to provide space heating, process heating i.e. heat necessary for the production process, or other applications. The RCI sector is the second largest contributor to the total greenhouse gas (GHG) emissions in Washington.

Direct use of oil, natural gas, coal, and wood in the RCI sectors accounted for an estimated 18.6 MMt CO<sub>2</sub>e (21.0%) of gross GHG emissions in 1990 (see Figure 3.2).

**Figure 3.2: RCI 1990 GHG emissions– Total 18.6 MMt CO<sub>2</sub>e**



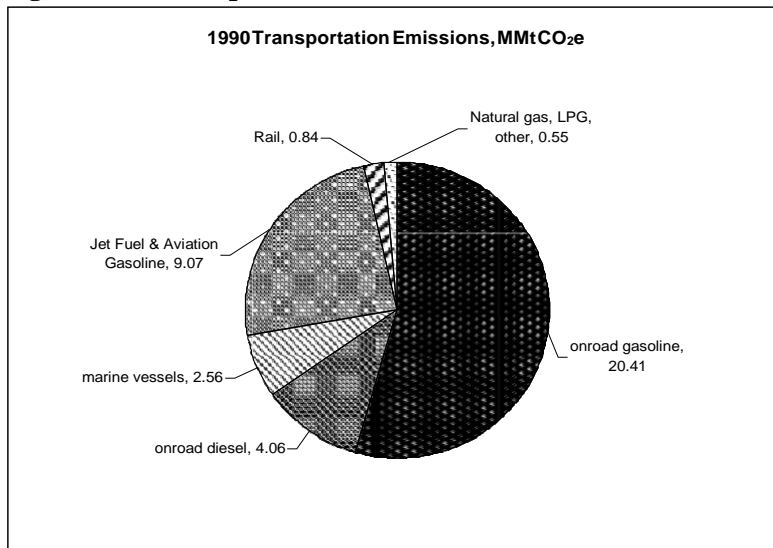
### 3.3 Transportation Energy

Transportation is the largest contributor to the total GHG emissions in Washington, with 37.5 MMt CO<sub>2</sub>e in 1990 (see Figure 3.3). The transportation sector includes:

- Light and heavy-duty (on-road) vehicles
- Aircraft
- Rail engines
- Marine engines

Carbon dioxide accounts for about 98 percent of transportation GHG emissions from fuel use. Most of the remaining GHG emissions from the transportation sector are due to N<sub>2</sub>O emissions from gasoline engines.

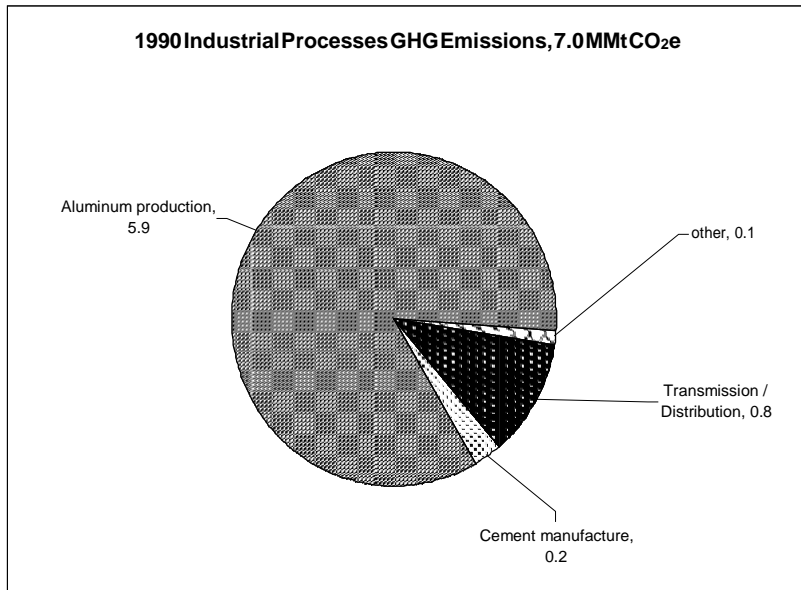
**Figure 3.3: Transportation 1990 GHG Emissions – Total 37.5 MMt CO<sub>2</sub>e**



### 3.4 Industrial Processes

The total amount of Washington GHG emissions from industrial processes were about 7.0 MMt CO<sub>2</sub>e in 1990. Most of these GHG emissions were from the aluminum production industry (see Figure 3.4).

**Figure 3.4: Industrial Processes 1990 GHG Emissions – Total 7.0 MMt CO<sub>2</sub>e**



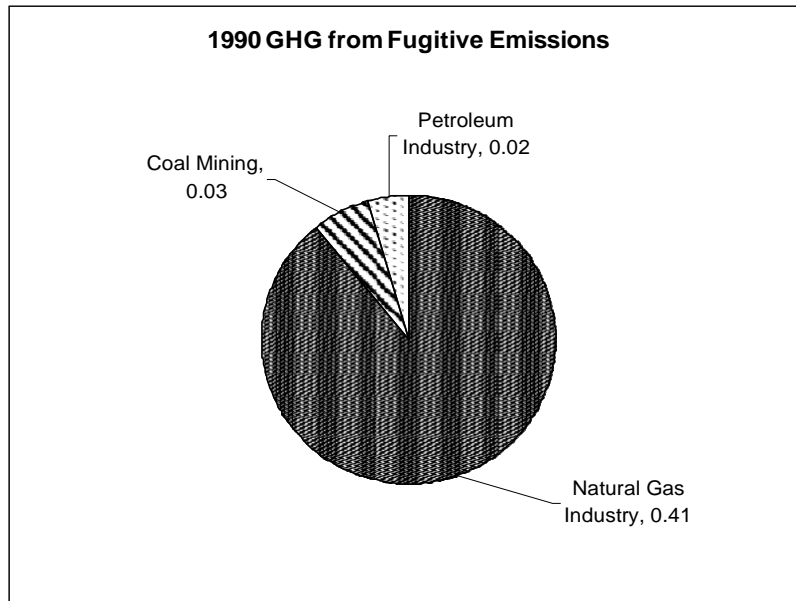
### 3.5 Fugitive Emissions from Fossil Fuel Industries

During the production, processing, transmission, and distribution of fossil fuels, additional GHG emissions are released. These emissions are known as fugitive emissions. Examples include methane emissions released via leakage and venting at coal mines, oil and gas fields, processing facilities, and pipelines. Figure 3.5 displays the methane emissions from coal mining and natural gas and oil systems.

Washington does not have any indigenous oil or natural gas production. Washington's five oil refineries import crude oil from the Alaska North Slope, Canada, and other locations, and have a combined capacity of 624,000 barrels per day, supplying markets throughout the Northwest region.

There is no active oil or gas production in Washington; a few exploratory wells are drilled each year or two but no commercial production is occurring. Thus, emissions of methane occur only from processing, transmission and distribution systems. GHG emissions can also occur from coal mines. Methane occurs naturally in coal seams, and is typically vented during mining operations for safety reasons.

**Figure 3.5: 1990 GHG Emissions from Fossil Fuel Industry – 0.5 MMt CO<sub>2</sub>e**



### **3.6 Waste Management**

GHG emissions from the waste management sector include emissions from solid waste disposal and wastewater emissions that totaled 1.5 MMT in 1990 (see Figure 3.6).

GHG emissions from waste management come from a variety of sources:

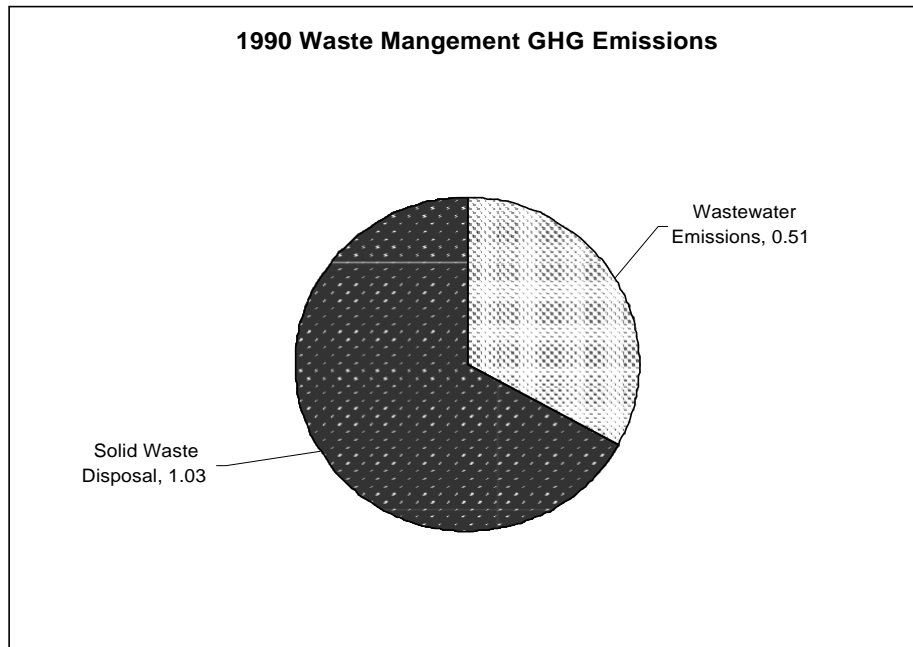
- Municipal and industrial solid waste landfills emit CH<sub>4</sub> that is flared or captured for energy production (this includes both operating and closed landfills).
- Controlled burning of solid waste in incinerators and waste to energy plants emit CH<sub>4</sub>, CO<sub>2</sub>, and N<sub>2</sub>O.
- Municipal wastewater treatment facilities emit CH<sub>4</sub> and N<sub>2</sub>O and industrial wastewater treatment facilities emit CH<sub>4</sub>.

To estimate emissions from industrial wastewater treatment facilities we used U.S. EPA's State Greenhouse Gas Inventory Tool (SGIT), a software program that provides default assumptions and emission factors for three industrial sectors:

- Fruits and Vegetables processing
- Red Meat and Poultry processing
- Pulp and Paper mills

However, information was only available on flows and chemical oxygen demand (COD) for Fruit and Vegetable processing, therefore, we were only able to estimate emissions from this industry.

**Figure 3.6: 1990 GHG Emissions from Waste Management – 1.5 MMt CO<sub>2</sub>e**



### 3.7 Agriculture

The agriculture sector emits non-energy methane (CH<sub>4</sub>) and nitrous oxide (N<sub>2</sub>O) from enteric fermentation (animal digestion process), manure management, and agricultural soils, totaling 6.4 MMtCO<sub>2</sub>e in 1990.

Enteric fermentation accounted for about 31% (1.96 MMtCO<sub>2</sub>e) of total agricultural emissions. The manure management category accounted for 11% (0.72 MMtCO<sub>2</sub>e) of total agricultural emissions in 1990. The agricultural soils category shows 1990 emissions accounting for 58% (3.72 MMtCO<sub>2</sub>e) of total agricultural emissions. These emissions are detailed in Figure 3.7.

Energy emissions related to agricultural practices (combustion of fossil fuels to power agricultural equipment) are included in the residential, commercial, and industrial (RCI) fuel consumption sector estimates.

**Figure 3.7: 1990 GHG Emissions from the Agriculture Sector – 6.4 MMtCO<sub>2</sub>e**

