DEPARTMENT OF
ECOLOGY
State of Washington

Washington State
Greenhouse Gas Emissions Inventory
2007-2008

December 2010
Publication no. 10-02-046 (Revised September 2013)

Publication and Contact Information

This report is available on the Department of Ecology's website at
www.ecy.wa.gov/biblio/1002046.html

For more information contact:

Air Quality Program
P.O. Box 47600
Olympia, WA 98504-7600

Phone: 360-407-6800

Washington State Department of Ecology - www.ecy.wa.gov

o Headquarters, Olympia	360-407-6000
o Northwest Regional Office, Bellevue	425-649-7000
o Southwest Regional Office, Olympia	360-407-6300
o Central Regional Office, Yakima	509-575-2490
o Eastern Regional Office, Spokane	509-329-3400

To ask about the availability of this document in a format for the visually impaired, call the Air Quality Program at 360-407-6800. Persons with hearing loss can call 711 for Washington Relay Service. Persons with a speech disability can call 877-833-6341.

Washington State
Greenhouse Gas Emissions Inventory
2007-2008

by
Gail Sandlin

Air Quality Program
Washington State Department of Ecology
Olympia, Washington

Purpose of This Report

This report provides a summary of Washington's greenhouse gas emissions for the years 1990, 2000, and 2005 through 2008. The information in this report will be used to evaluate Washington's greenhouse gas emissions to determine where the emissions are coming from and whether they are increasing or decreasing over time.

Background Information

Greenhouse gases are substances that contribute to climate change by trapping heat in the atmosphere. There are six internationally-recognized greenhouse gases: carbon dioxide, methane, nitrous oxide, hydrofluorocarbons, perfluorocarbons, and sulfur hexafluoride. Greenhouse gases are released during:

- "Stationary combustion," which occurs at places that use equipment such as boilers to produce electricity, steam, heat, or power.
- "Mobile combustion," which occurs when fuel is burned for transportation (such as in cars, trucks, ships, trains, and planes).
- "Production processes," such as the manufacturing of cement, aluminum, ammonia, etc.
- "Fugitive releases" from the production, processing, transmission, storage, or use of fuels and other substances that do not pass through a stack, chimney, vent, or exhaust pipe (for example, the release of sulfur hexafluoride from electrical equipment).

Washington's Greenhouse Gas Legislation

On February 7, 2007, Governor Gregoire issued an executive order that set goals to:

- reduce greenhouse gas (GHG) emissions,
- increase clean energy sector jobs, and
- reduce spending on imported fuel.

In 2008, the Washington Legislature introduced House Bill 2815. It provided a framework for reducing GHG emissions in Washington, and included specific requirements for reporting GHG emissions. These reporting requirements are in the Revised Code of Washington State, 70.235.020 (2):

> "By December 31st of each even-numbered year beginning in 2010, the department and the *department of community, trade, and economic development shall report to the governor and the appropriate committees of the senate and house of representatives the total emissions of greenhouse gases for the preceding two years, and totals in each major source sector…."

GHG Emission Inventory

How the inventory was developed

To develop an inventory of Washington's GHG emissions, Ecology used a set of generally-accepted principles and guidelines, and made adjustments as needed to apply them specifically to Washington.

GHG sectors

Ecology categorized GHG emissions into the following sectors:

- Transportation,
- Residential / Commercial and Industrial (RCI),
- Electricity Consumption,
- Industrial Processes,
- Agriculture,
- Waste Management, and
- the Fossil Fuel Industry.

How GHG emissions are shown

- **Carbon dioxide equivalent:** The emission inventory shows GHG emissions in million metric tons (MMt) of carbon dioxide equivalent (CO_2e). Using carbon dioxide equivalent as a measurement allows us to compare the global warming potential (GWP) of different GHGs more easily.
- **GWP:** A greenhouse gas GWP is the ratio of its heat-trapping ability to that of carbon dioxide. For example, the global warming potential of nitrous oxide is 310 because one metric ton of nitrous oxide has 310 times more ability to trap heat in the atmosphere than one metric ton of carbon dioxide.

GHGs included in the inventory

Washington's GHG emissions inventory includes the six greenhouse gases also found in the U.S. Greenhouse Gas Emissions Inventory. Both inventories use the GWPs from the Intergovernmental Panel on Climate Change (IPCC) Second Assessment Report (SAR). See Table 1.

Table 1: Global Warming Potential Factors for Greenhouse Gases

Greenhouse Gas	Global Warming Potential
Carbon dioxide (CO_2)	1
Methane (CH_4)	21
Nitrous oxide (N_2O)	310
Hydrofluorocarbons (HFCs)	12-11,700
Perfluorocarbons (PFCs)	6,500-9,200
Sulfur hexafluoride (SF_6).	23,900

At the time this inventory was completed, 2008 data may not have been available to estimate the greenhouse gas emissions for some sectors. Because of this, GHG emissions for three sectors (Industrial Processes, Waste Management and Agriculture) are largely based on Business As Usual (BAU) projections as described in the 2010 Comprehensive Plan. These projected emissions are shown in italics in the 2008 column of Table 2. They account for 12% of the total statewide 2008 GHG emissions. (Independent rounding for totals and subtotals.)

Table 2: Washington State Total Annual GHG Emissions ($MMtCO_2e$)

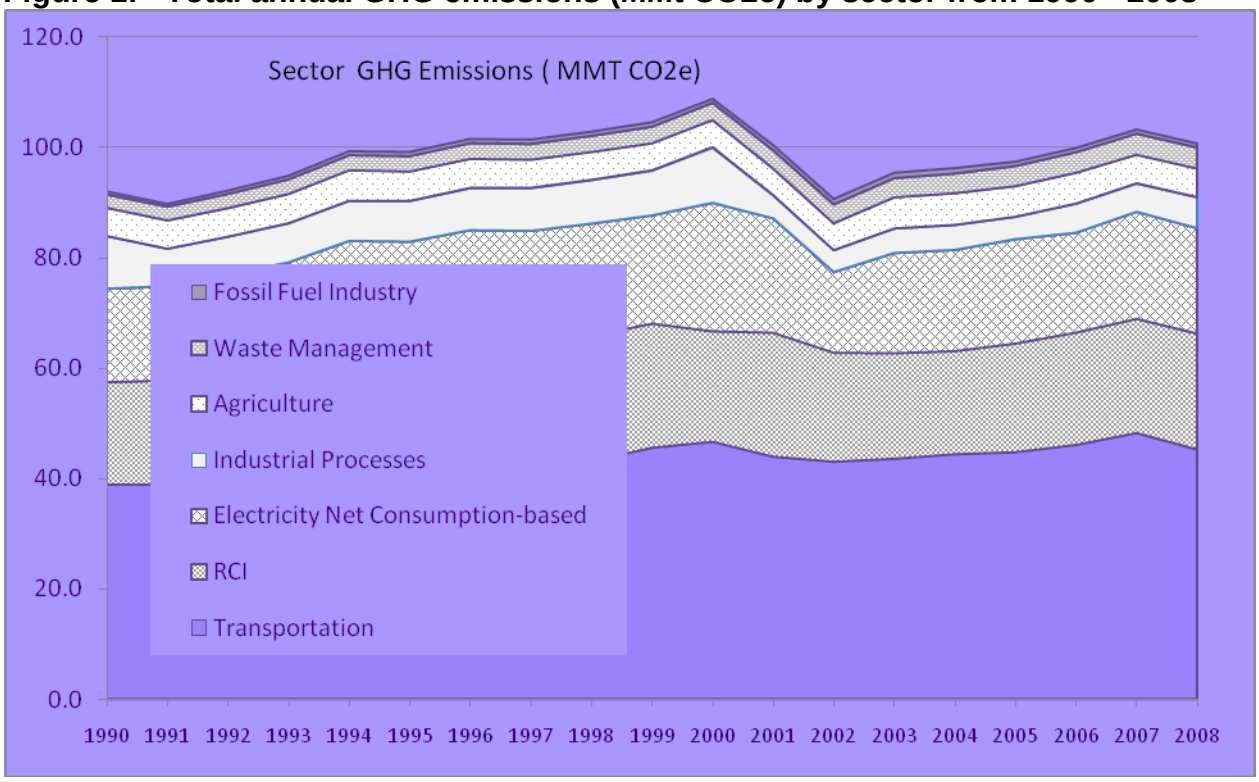
Million Metric Tons CO2e	1990	2000	2005	2006	2007	2008
Electricity, Net Consumption-based	**16.9**	**23.3**	**18.9**	**18.1**	**19.4**	**19.1**
Coal	16.8	17.4	15.2	14.7	15.2	15.1
Natural Gas	0.1	5.3	3.6	3.3	4.1	3.9
Petroleum	0.0	0.6	0.0	0.1	0.1	0.1
Biomass and Waste (CH4 and N2O)	0.0	0.0	0.0	0.0	0.0	0.0
Residential/Commercial/Industrial (RCI)	**18.6**	**20.3**	**19.7**	**20.4**	**20.7**	**21.0**
Coal	0.6	0.3	0.1	0.2	0.3	0.3
Natural Gas	8.6	11.3	10.4	10.8	11.3	11.3
Oil	9.1	8.5	9.0	9.1	8.9	9.2
Wood (CH4 and N2O)	0.2	0.2	0.2	0.2	0.2	*0.2*
Transportation	**37.5**	**46.7**	**44.9**	**46.2**	**48.3**	**45.3**
Onroad Gasoline	20.4	24.7	24.2	24.2	24.3	23.6
Onroad Diesel	4.1	7.6	7.0	9.1	9.2	9.2
Marine Vessels	2.6	3.7	3.9	3.7	4.7	3.2
Jet Fuel and Aviation Gasoline	9.1	9.9	7.8	7.5	8.3	7.8
Rail	0.8	0.3	1.3	1.0	1.2	0.9
Natural Gas, LPG	0.6	0.6	0.7	0.6	0.7	0.7
Fossil Fuel Industry	**0.5**	**0.7**	**0.8**	**0.8**	**0.7**	**0.7**
Natural Gas Industry(CH4)	0.5	0.6	0.7	0.7	0.7	0.7
Coal Mining (CH4)	0.0	0.1	0.1	0.0	0.0	0.0
Oil Industry (CH4)	0.0	0.0	0.0	0.0	0.0	0.0
Industrial Processes	**7.0**	**10.0**	**4.1**	**5.3**	**5.1**	***5.6***
Cement Manufacture (CO2)	0.2	0.5	0.5	0.5	0.6	0.4
Aluminum Production (CO2, PFC)	5.9	7.4	1.0	2.1	1.8	2.2
Limestone and Dolomite Use (CO2)	0.0	0.0	0.0	0.0	0.0	*0.0*
Soda Ash	0.1	0.1	0.1	0.1	0.1	*0.1*
ODS Substitutes (HFC, PFC and SF6)	0.0	1.6	2.1	2.2	2.3	*2.5*
Semiconductor Manufacturing (HFC, PFC, SF6)	0.0	0.1	0.1	0.1	0.1	*0.1*
Electric Power T&D (SF6)	0.8	0.4	0.3	0.3	0.3	*0.3*
Waste Management	**1.5**	**3.2**	**3.7**	**3.8**	**3.8**	***3.9***
Solid Waste Management	1.0	2.7	3.0	3.1	3.2	*3.3*
Wastewater Management	0.5	0.6	0.6	0.6	0.7	*0.7*
Agriculture	**6.4**	**6.1**	**6.3**	**6.3**	**5.9**	***5.9***
Enteric Fermentation	2.0	2.2	2.2	2.3	2.3	*2.3*
Manure Management	0.7	1.0	1.0	1.0	1.0	*1.0*
Agriculture Soils	3.7	2.9	3.1	3.1	2.7	*2.7*
Total Gross Emissions (third decimal rounding)	**88.4**	**110.3**	**98.2**	**100.7**	**104.0**	***101.1***

Washington's GHG Emissions Trends

Trends by sector, 1990-2008

Figure 1 shows greenhouse gas emissions from 1990 to 2008 by sector. There is a significant decrease in emissions occurring between 2000 and 2002, mainly due to changes in the aluminum industry in Washington.

Figure 1: Total annual GHG emissions (MMt CO2e) by sector from 1990 - 2008

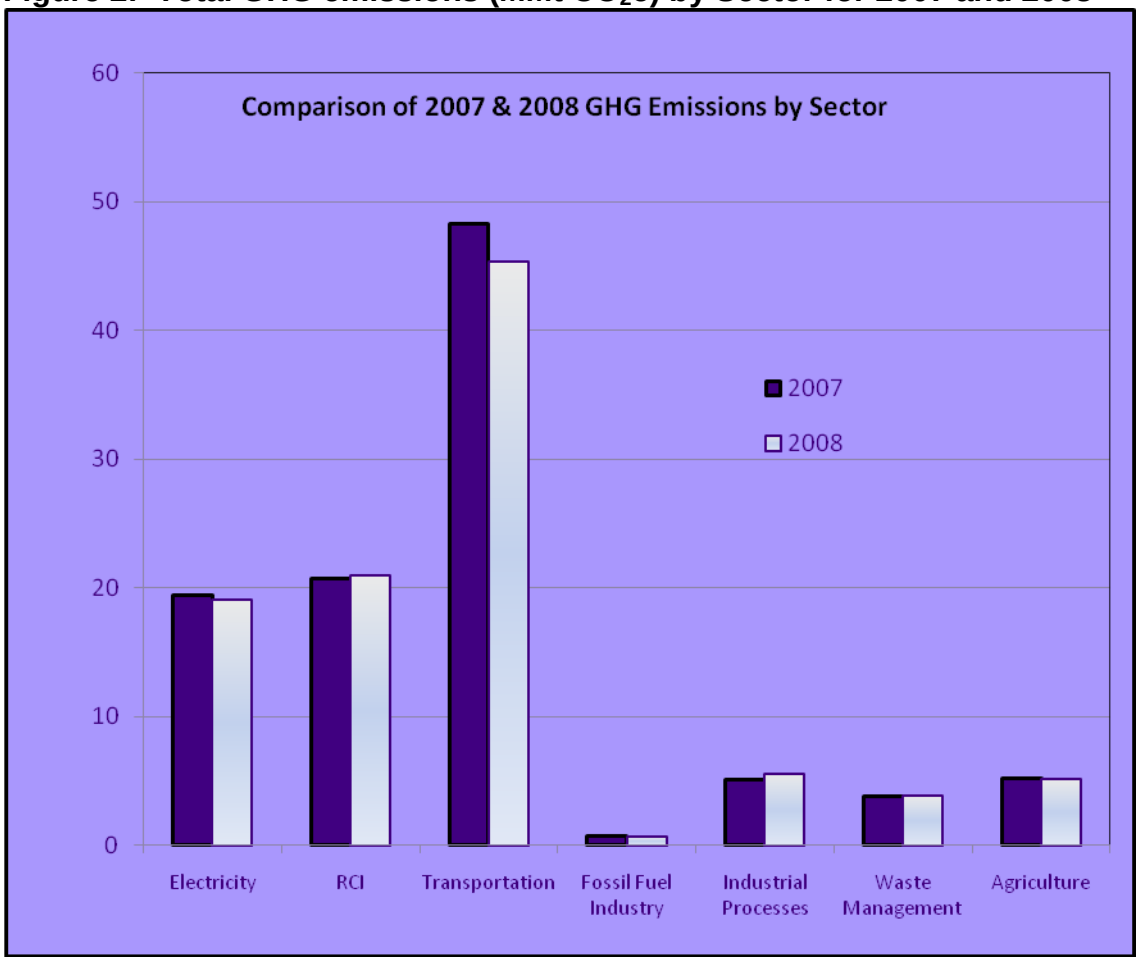


Total GHG emissions in 2008 were 101.5 MMt CO_2e, compared to 104.0 MMt CO_2e for 2007. This is a 2.4% decrease in emissions. However, as mentioned on Page 4, GHG emissions for the Industrial Processes, Waste Management, and Agriculture Sectors are largely based on Business As Usual (BAU) projections. These projected emissions account for 12% of the total statewide 2008 GHG emissions.

Trends by sector, 2007-2008

Figure 2 compares total 2007 and 2008 GHG emissions. The most significant change in 2008 is a six percent decrease in emissions from the Transportation Sector.

Figure 2: Total GHG emissions (MMt CO_2e) by Sector for 2007 and 2008

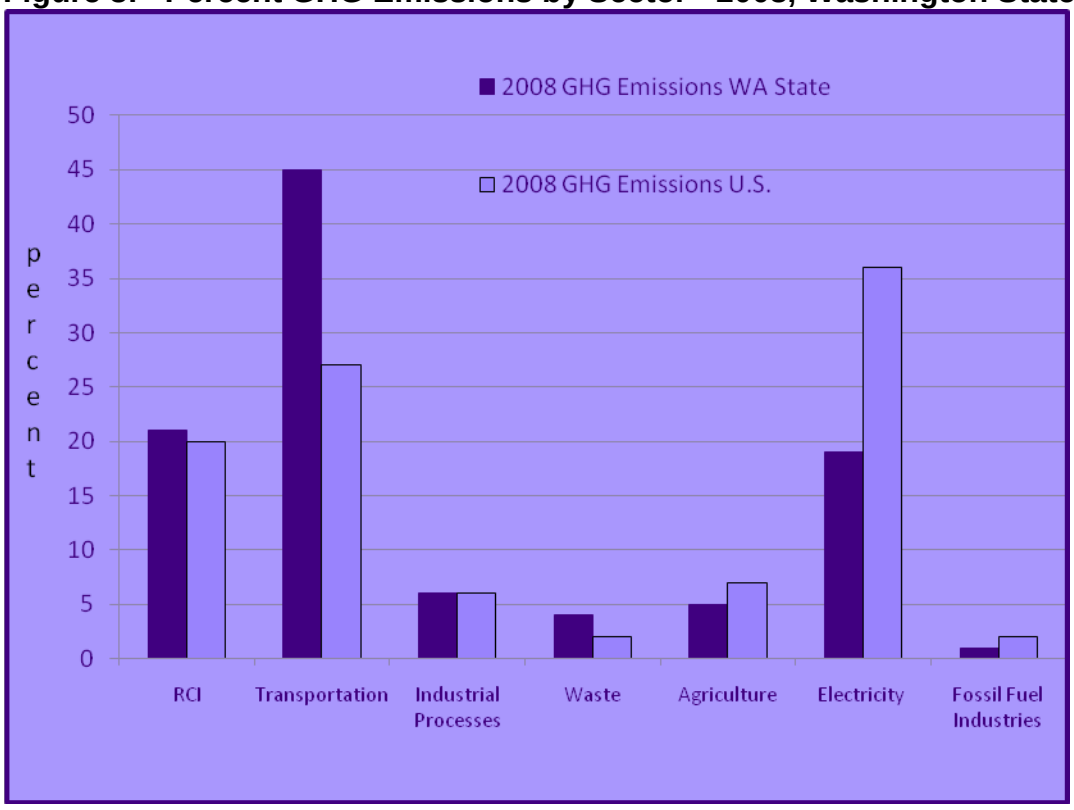


Trends by sector, 2008 Washington and U.S.

On a national scale, the Electricity Sector is the largest contributor to greenhouse gases (see Figure 3). Because Washington uses hydropower for much of its electricity, the Electricity Sector is less significant in Washington. The Transportation Sector is Washington's most significant contributor of greenhouse gases.

It is also important to note that Washington's GHG emissions per capita are significantly lower than U.S. emissions per capita. Washington's per capita emissions are 15.3 MMt CO_2e, while U.S. per capita emissions are 22.9 MMt CO_2e.

Figure 3: Percent GHG Emissions by Sector - 2008, Washington State and U.S.



Summary of Results by Sector

Transportation Sector

As stated previously, transportation is Washington's largest GHG emissions contributor, while electricity is the largest contributor for the U.S. as a whole. However, on a per capita basis, Washington produces about the same amount of on-road motor gasoline GHG emissions as the US average (see Table 3). Per capita on-road diesel emissions for 2008 were also fairly comparable for Washington and the U.S. average.

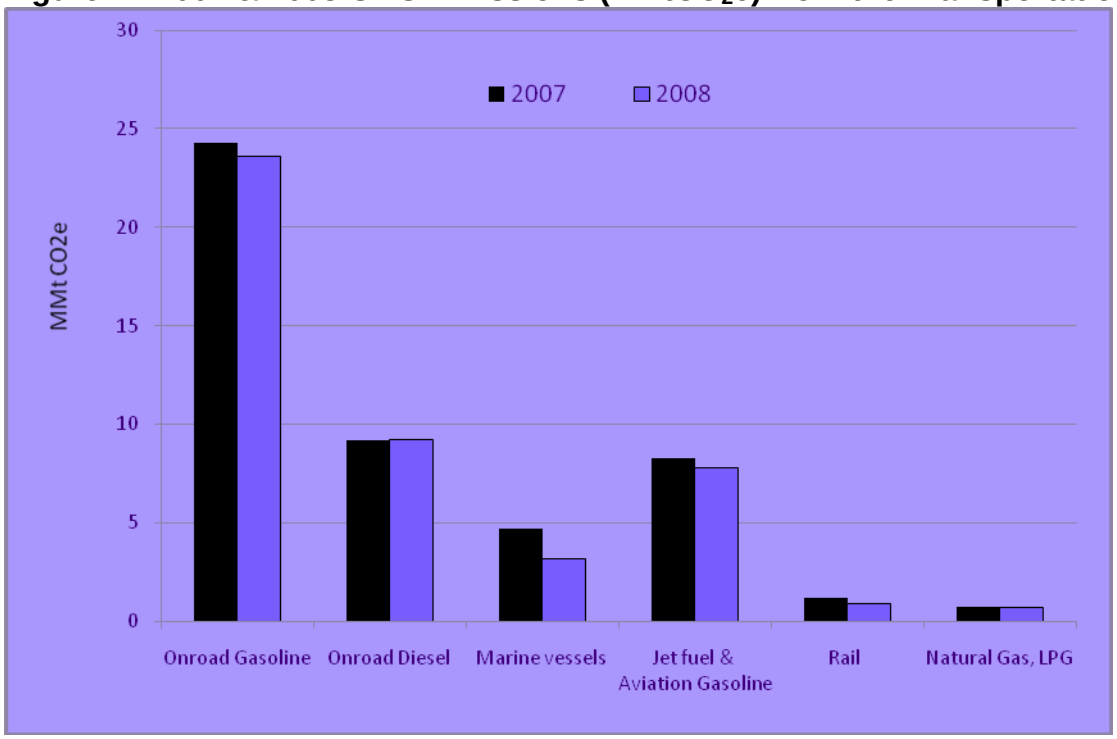
Table 3: On Road Emissions GHG Emissions Per Capita, 2008

2008	Population	MMt CO_2e Motor Gasoline	MMtCO2e On road Diesel	Mt CO_2e On Road Motor Gasoline per capita	Mt CO_2e On Road Diesel per capita
US	304,059,724	1,109*	391.4	3.6	1.3
WA state	6,549,224	24	9.2	3.6	1.4

*http://epa.gov/climatechange/emissions/usinventoryreport.html Annex 3

Washington's most significant decrease in GHG emissions from 2007 to 2008 was in the Transportation Sector. This decrease was specifically from on-road gasoline, jet fuel and marine vessels (see Figure 4). However, future improvements are needed in commercial marine GHG emissions methodology to provide better information about emissions from marine vessels.

Figure 4: 2007 & 2008 GHG Emissions ($MMtCO_2e$) from the Transportation Sector



Electricity Consumption-based Sector

Despite the availability of hydroelectricity, Washingtonians also use electricity from coal and natural gas that is both produced in Washington and imported from other states.
Table 1 shows Washington's GHG emissions from electricity on a consumption-based (or "load-based") approach (emissions of sources that deliver electricity to Washington consumers, regardless of where those sources are located).

Residential, Commercial and Industrial (RCI) Sector

GHG emissions from energy consumption in this sector occur when fuels are combusted to provide heat, including space heating and process heating (i.e., heating necessary for production processes or other applications).

This sector is the second largest source of greenhouse gas emissions in Washington. In 2008, 12.0 MMt CO_2e came from the Industrial Sector, 5.2 MMt CO_2e came from the Residential Sector, and 3.9 MMt CO_2e came from the Commercial Sector.

Fossil Fuel Industry Sector

This sector includes GHG emissions that are released during the production, processing, transmission and distribution of fossil fuels. These emissions are typically:

- methane emissions from the petroleum production process, or
- fugitive methane due to leakage and venting from natural gas pipelines, petroleum systems and coal mining.

In 2008, these emissions were about 0.7 % of Washington's GHG emissions. This is no change from 2007 emissions.

Waste Management Sector

This sector includes GHG emissions from landfills and wastewater treatment facilities.

Washington's 2008 GHG emissions from this sector increased ~3% increase from 2007 emissions. However, emissions from solid waste and wastewater management accounted for less than 4% of Washington's GHG emissions. This inventory does not include waste exported from Washington to other states for disposal.

Industrial Processes Sector

This sector includes GHG emissions from industry-specific processes such as aluminum or cement manufacturing; or fugitive emissions such as sulfur hexafluoride (SF6) releases from Electric Power Transmission and Distribution systems.

GHG emissions from this sector contributed 5.6 % of Washington's total GHG emissions in 2008. This is a 9.0% increase from 2007 emissions. The reasons for this increase include:

- Use of hydrocarbons as substitutes for ozone-depleting substances increased ~8.0 % from 2007 to 2008.

- A 20% increase in 2008 from 2007 emissions of PFCs from aluminum production. It is important to note that PFC emissions from aluminum production have significantly decreased since 1990, and this increase in aluminum production emissions reflects only 0.5% of Washington's total 2008 GHG emissions.

Washington produces small amounts of lime and nitric acid. Although these processes emit GHGs, they are expected to have relatively low emissions due to their low levels of production. This GHG inventory excludes estimates for these processes.

Future mandatory reporting of GHG emissions from this sector will provide more complete information.

Agriculture Sector

Agricultural activities such as manure management, fertilizer use, and livestock (enteric fermentation) result in methane and nitrous oxide emissions. These emissions accounted for ~ 5.9 % of Washington's GHG emissions in 2008. This is no change from 2007 emissions. Again, improved methodologies for estimating GHG emissions will provide better data.

Conclusions

This inventory summarizes the greenhouse gas emissions from specific sectors in Washington from 1990 to 2008. Key points are:

- There is a noticeable decreasing trend (Figure 1) in greenhouse gas emissions around 2001, parallel with the closure of several aluminum facilities.
- In 2008, Washington's greenhouse gas emissions decreased 2.3 % from 2007 emissions.
- The Transportation Sector has been the largest contributor of GHG's in Washington, and in 2008 accounted for 45% of the total statewide emissions.
- The RCI and Electricity Sectors accounted for 21% and 19% of statewide GHG emissions, respectively.
- Compared to the nationwide GHG emissions inventory, emissions from the Electricity Sector in Washington are significantly less due to the availability of hydropower.

One of the purposes of the Washington State GHG inventory is to evaluate emissions trends from the various sectors. Future methodology improvements and data from the mandatory GHG reporting requirements will improve our understanding of Washington State GHG emissions sources and trends.