



DEPARTMENT OF
ECOLOGY
State of Washington

Washington State Greenhouse Gas Emissions Inventory: 1990-2015

Report to the Legislature

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Emissions Inventory: 1990-2015**

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Olympia, Washington

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Executive Summary

As required in RCW 70.235.020 (2), this report provides a summary of Washington's greenhouse gas emissions from the 1990 baseline established in law through 2015, the most recent year the data necessary to create this inventory are available. The information in this report is used to evaluate Washington's greenhouse gas emissions, discuss where the emissions are coming from, and determine whether they are increasing or decreasing over time.

Key findings are:

- Washington's 2015 total greenhouse gas emissions were 97.4 million metric tons (MMT).
- Washington's 2015 total greenhouse gas emissions were 7.4 MMT higher than the 1990 baseline of 90.0 MMT.
- Washington's greenhouse gas emissions increased by about 6.1 percent from 2012 to 2015, primarily due to increased emissions from the electricity sector. During this time period Washington's economy also grew at a compound annual growth rate of 2.95% per year.¹
- Compared to the nation, the electricity sector in Washington contributes significantly less greenhouse gas emissions due to the availability of hydropower.
- In 2015, Washington's largest contributors of greenhouse gases were the:
 - Transportation sector at 42.5 percent.
 - Residential, commercial, and industrial sector at 21.3 percent.
 - Electricity sector at 19.5 percent.

¹ <https://www.deptofnumbers.com/gdp/washington/>

Background Information

Greenhouse gases (GHGs) are substances that contribute to climate change by trapping heat in the atmosphere. The internationally-recognized greenhouse gases that contribute to human-caused climate change are:

- Carbon dioxide
- Hydrofluorocarbons
- Methane
- Nitrogen trifluoride
- Nitrous oxide
- Perfluorocarbons
- 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);
- *Industrial processes*, such as manufacturing cement, aluminum, ammonia, etc. where the process itself generates greenhouse gases; and
- *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 (such as the release of sulfur hexafluoride from electrical equipment or nitrous oxide from fertilizers).

Washington's greenhouse gas legislation

In 2008, the Legislature established limits for reducing greenhouse gas emissions in Washington, and included specific requirements for reporting greenhouse gas emissions.

Washington state greenhouse gas emissions reductions are in RCW 70.235.020 (1)

- (i) By 2020, reduce overall emissions of greenhouse gases in the state to 1990 levels;
- (ii) By 2035, reduce overall emissions of greenhouse gases in the state to twenty-five percent below 1990 levels;
- (iii) By 2050, the state will do its part to reach global climate stabilization levels by reducing overall emissions to fifty percent below 1990 levels, or seventy percent below the state's expected emissions that year.

These reporting requirements are in RCW 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 development² 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. The department shall ensure the reporting rules adopted under RCW 70.94.151 allow it to develop a comprehensive inventory of emissions of greenhouse gases from all significant sectors of the Washington economy.*

Greenhouse gas emissions inventory

How the inventory was developed

To develop an inventory of Washington's greenhouse gas emissions, Ecology used a set of generally accepted principles and made adjustments as needed to apply them to Washington. The inventory is based on aggregated data for each sector, not facility-specific emissions.

The data to develop this inventory is provided by the U.S. Environmental Protection Agency's (EPA) State Inventory and Projection Tool (SIT). This greenhouse gas emissions tool has sector modules that are updated and released periodically throughout the year. The most complete annual greenhouse gas profile from these sector modules is from 2015.

In addition to U.S. EPA's SIT tool, the Washington State Department of Commerce annually provides greenhouse gas emissions for electricity calculated from fuel mix disclosure data. Each utility is required to report to the Department of Commerce the fuel mix that generates their electricity. Commerce then uses this information to determine an aggregated fuel mix for the entire state.

Greenhouse gas sectors

Ecology categorized greenhouse gas emissions into the following sectors:

- Transportation.
- Electricity consumption.³
- Residential, commercial, and industrial.⁴
- Fossil fuel industry.⁵
- Waste management.
- Industrial processes.⁶
- Agriculture.

² Renamed Department of Commerce

³ Electricity consumption – greenhouse gas emissions associated with Washington's electricity demand

⁴ Residential, commercial, and industrial - greenhouse gas emissions from fuels combusted to primarily produce space heating and/or process heating

⁵ Fossil fuel industry – greenhouse gas emissions known as fugitive emissions from leaking or venting in processing or distribution systems

⁶ Industrial processes - non-combustion sources of greenhouse gas emissions from industrial processes

How greenhouse gas emissions are shown

Carbon dioxide equivalent: The emission inventory shows greenhouse gas emissions in million metric tons (MMT) of carbon dioxide equivalent (CO₂e). Using carbon dioxide equivalent as a measurement allows us to capture the cumulative impacts of all greenhouse gases in one number.

Global Warming Potential: Greenhouse gas emissions in this report use the global warming potential values from the Intergovernmental Panel on Climate Change's (IPCC) Fourth Assessment Report. A greenhouse gas global warming potential is the ratio of its heat-trapping ability to that of carbon dioxide. For example, the global warming potential of nitrous oxide is 298 because one metric ton of nitrous oxide has 298 times more ability to trap heat in the atmosphere than one metric ton of carbon dioxide.

In 1992, the United States signed and ratified the United Nations Framework Convention on Climate Change (UNFCCC). Article 2 of the UNFCCC states:

...parties to the convention agreed to develop, periodically update, and publish, national inventories of anthropogenic emissions. The emissions are to be reported by sources and removals by sinks of all greenhouse gases not controlled by the Montreal Protocol, using comparable methodologies.

The United States fulfills these commitments by submitting EPA's national greenhouse gas inventory report. Starting with 2013 greenhouse gas emission data, the United States and other developed countries have also agreed to submit to the UNFCCC annual inventories based on the use of Intergovernmental Panel on Climate Change (IPCC) Fourth Assessment Report (AR4) global warming potential values.⁷ Washington follows this guidance and methodology to develop this annual greenhouse gas inventory.

⁷ <http://www.epa.gov/climatechange/Downloads/ghgemissions/US-GHG-Inventory-2014-Chapter-Executive-Summary.pdf>

Greenhouse gases included in the inventory

Washington's greenhouse gas emissions inventory includes the greenhouse gases also found in the U.S. Greenhouse Gas Emissions Inventory in Table 1. As stated previously, both inventories now use the global warming potential from the IPCC Fourth Assessment Report.⁸

Table 1: Global Warming Potential Factors for Greenhouse Gases

| Greenhouse Gas | Global Warming Potential |
|---|--------------------------|
| Carbon dioxide (CO ₂) | 1 |
| Methane (CH ₄) | 25 |
| Nitrous oxide (N ₂ O) | 298 |
| Hydrofluorocarbons (HFCs) | 12 – 14,800 |
| Perfluorocarbons (PFCs) | 7,390 – 12,200 |
| Sulfur hexafluoride (SF ₆) | 22,800 |
| Nitrogen trifluoride (NF ₃) | 17,200 |

⁸ This 2013 inventory is the first time that U.S. greenhouse gas emissions are reported using the Assessment Report 4 global warming potential values. <https://www3.epa.gov/climatechange/Downloads/ghgemissions/US-GHG-Inventory-2015-Annex-6-Additional-Information.pdf>

Findings: Inventory Results

The 2015 estimate for total greenhouse gas emissions was 97.4 MMT CO₂e. This represents an approximate 6.1% increase from 2012 total greenhouse gas emissions.

As seen in Table 2, the original 1990 baseline data uses the global warming potential from IPCC's second assessment report (SAR). This was the established protocol at the time the original inventory data were created. However, given the recent mandate from the UNFCCC to use updated GWP estimates in all inventories going forward, all the data for all years is re-estimated using the recommended global warming potential from IPCC's Fourth Assessment Report (AR4) so that a consistent time series is available and accurate comparisons can be made across time.

The updated 1990 baseline using GWP AR4 and improved methodologies for Waste Management and Agriculture results in an increase of 1.6 MMT CO₂e in the 1990 greenhouse gas baseline totals. Although the 1990 baseline has increased, it is important to note that this does not mean that achieving the 2020 greenhouse gas emissions limit (or the other future limits) has become easier. Rather, the change in the GWP factors has caused all emission estimates to rise across all years, so the level of effort necessary to achieve the greenhouse gas limits in the future is roughly the same.

Table 2: Washington State Total Annual GHG Emissions (MMT CO₂e)

| Million Metric Tons CO ₂ e | 1990 | 1990 | 2000 | 2005 | 2012 | 2013 | 2014 | 2015 |
|--|-------------|-------------|--------------|-------------|-------------|-------------|-------------|-------------|
| GWP | SAR | AR4 | ARA | AR4 | AR4 | AR4 | AR4 | AR4 |
| Electricity, Net Consumption-Based | 16.9 | 16.9 | 23.3 | 18.9 | 15.2 | 18.2 | 18.2 | 19.0 |
| Coal | 16.8 | 16.80 | 17.4 | 15.20 | 12.10 | 13.34 | 13.96 | 14.03 |
| Natural gas | 0.1 | 0.10 | 5.28 | 3.60 | 3.00 | 4.81 | 4.16 | 4.91 |
| Petroleum | 0.0 | 0.00 | 0.60 | 0.00 | 0.10 | 0.07 | 0.06 | 0.07 |
| Biomass and waste (CH ₄ and N ₂ O) | 0.0 | 0.00 | 0.00 | 0.00 | 0.01 | 0.01 | 0.01 | 0.01 |
| Residential/Commercial/Industrial (RCI) | 18.6 | 18.6 | 20.1 | 19.4 | 20.7 | 21.1 | 20.5 | 20.7 |
| Coal | 0.6 | 0.61 | 0.00 | 0.10 | 0.20 | 0.19 | 0.25 | 0.18 |
| Natural gas | 8.6 | 8.62 | 11.37 | 10.32 | 11.57 | 12.07 | 11.77 | 11.21 |
| Oil | 9.1 | 9.16 | 8.51 | 8.75 | 8.68 | 8.51 | 8.16 | 9.05 |
| Wood (CH ₄ and N ₂ O) | 0.2 | 0.26 | 0.25 | 0.21 | 0.26 | 0.31 | 0.31 | 0.27 |
| Transportation | 37.5 | 37.9 | 44.9 | 42.3 | 40.4 | 38.8 | 39.3 | 41.4 |
| On-road gasoline | 20.4 | 20.70 | 24.50 | 23.92 | 21.20 | 21.71 | 21.76 | 21.42 |
| On-road diesel | 4.1 | 4.22 | 7.72 | 7.06 | 7.38 | 7.01 | 7.46 | 8.15 |
| Marine vessels | 2.6 | 2.48 | 1.76 | 1.63 | 2.13 | 1.92 | 1.62 | 2.33 |
| Jet fuel and aviation gasoline | 9.1 | 9.10 | 10.05 | 7.70 | 8.02 | 6.57 | 6.95 | 7.77 |
| Rail | 0.8 | 0.80 | 0.30 | 1.26 | 0.97 | 0.86 | 0.82 | 0.80 |
| Natural gas, LPG | 0.6 | 0.60 | 0.60 | 0.74 | 0.68 | 0.77 | 0.71 | 0.92 |
| Fossil Fuel Industry | 0.5 | 0.6 | 0.7 | 0.8 | 0.8 | 0.8 | 0.9 | 0.8 |
| Natural gas industry (CH ₄) | 0.5 | 0.58 | 0.73 | 0.80 | 0.82 | 0.83 | 0.86 | 0.84 |
| Coal mining (CH ₄) | 0.0 | 0.0 | 0.00 | .00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Oil industry (CH ₄) | 0.0 | 0.0 | 0.00 | .00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Industrial Processes | 7.0 | 7.0 | 10.0 | 4.5 | 5.0 | 5.2 | 5.3 | 5.3 |
| Cement manufacture (CO ₂) | 0.2 | 0.20 | 0.44 | 0.44 | 0.26 | 0.33 | 0.38 | 0.32 |
| Aluminum production (CO ₂ , PFC) | 5.9 | 5.90 | 7.38 | 1.58 | 1.23 | 1.17 | 1.03 | 0.96 |
| Limestone and dolomite use (CO ₂) | 0.0 | 0.00 | 0.02 | 0.03 | 0.01 | 0.01 | 0.02 | 0.02 |
| Soda ash | 0.1 | 0.10 | 0.10 | 0.05 | 0.05 | 0.05 | 0.05 | 0.05 |
| ODS substitutes (HFC, PFC) | 0.0 | 0.00 | 1.62 | 2.11 | 3.30 | 3.41 | 3.57 | 3.76 |
| Semiconductor mfg (HFC, PFC, SF ₆ , NF ₃) | 0.0 | 0.00 | 0.09 | 0.09 | 0.07 | 0.07 | 0.08 | 0.08 |
| Electric power T & D (SF ₆) | 0.8 | 0.80 | 0.36 | 0.19 | 0.12 | 0.11 | 0.12 | 0.10 |
| Waste Management | 1.5 | 3.1 | 3.5 | 4.2 | 3.2 | 3.3 | 3.4 | 3.5 |
| Solid waste management | 1.0 | 2.58 | 2.84 | 3.48 | 2.36 | 2.54 | 2.61 | 2.68 |
| Wastewater management | 0.5 | 0.55 | 0.68 | 0.71 | 0.79 | 0.80 | 0.81 | 0.82 |
| Agriculture | 6.4 | 5.8 | 6.0 | 5.9 | 6.4 | 6.4 | 6.6 | 6.6 |
| Enteric fermentation | 2.0 | 2.62 | 2.57 | 2.44 | 2.53 | 2.53 | 2.54 | 2.58 |
| Manure management | 0.7 | 0.86 | 1.24 | 1.27 | 1.52 | 1.55 | 1.62 | 1.65 |
| Agriculture soils | 3.7 | 2.32 | 2.24 | 2.22 | 2.38 | 2.33 | 2.43 | 2.40 |
| Total Gross Emissions | 88.4 | 90.0 | 108.6 | 96.0 | 91.8 | 93.9 | 94.1 | 97.4 |

Washington's Greenhouse Gas Emissions Trends

Trends by sector, 1990–2015

Figure 1 shows greenhouse gas emissions from 1990 to 2015 by sector.

There was a significant decrease in emissions between 2000 and 2002, mainly due to changes in the aluminum industry in Washington.⁹

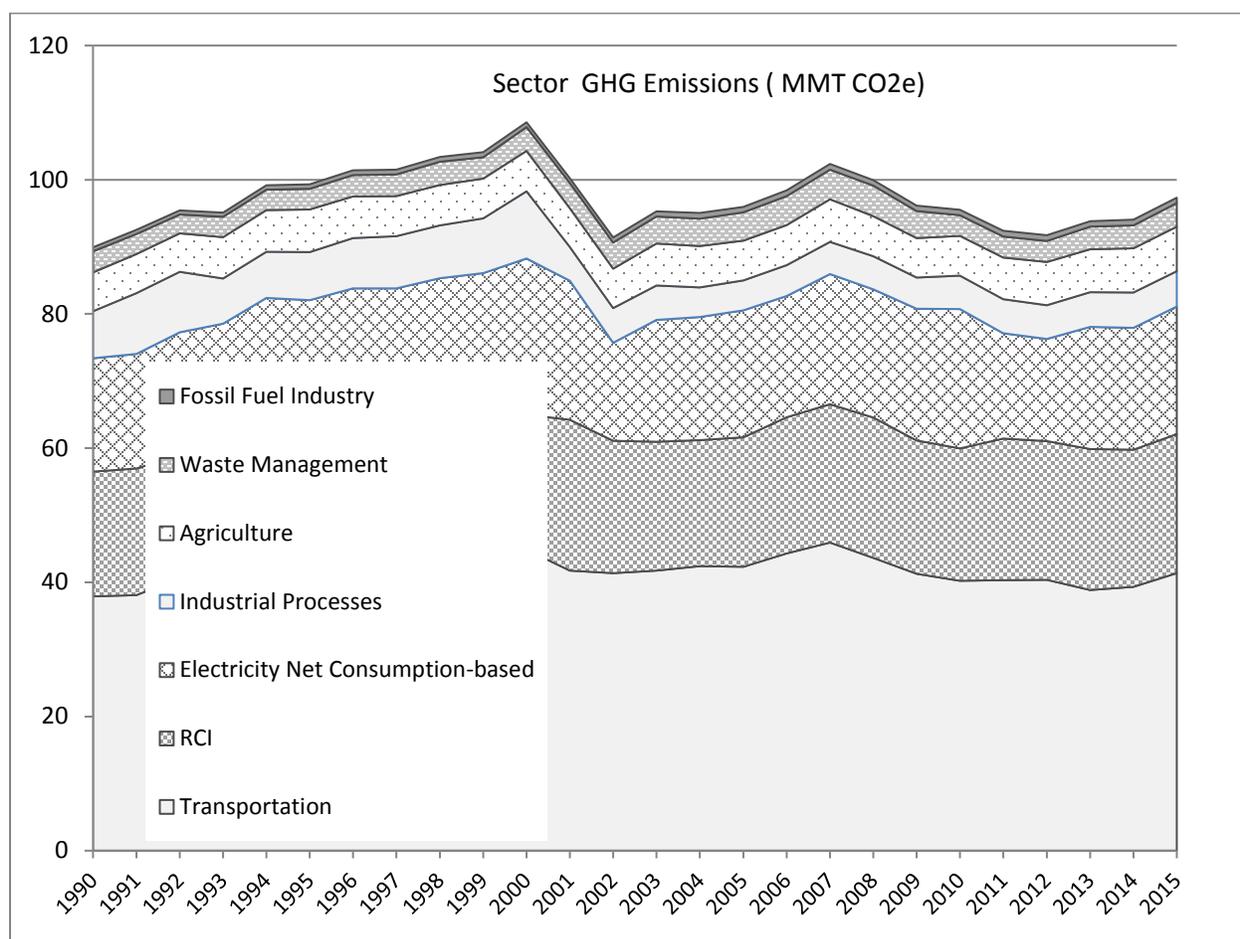


Figure 1: Total Annual Greenhouse Gas Emissions (MMT CO2e) by Sector from 1990 – 2015

⁹ The SIT module develops an estimate of aluminum emissions that now includes process CO2 emissions.

Trends by sector, 2012–2015

Figure 2 compares total 2012–2015 greenhouse gas emissions from the electricity, residential, commercial, and industrial (RCI), and transportation sectors.

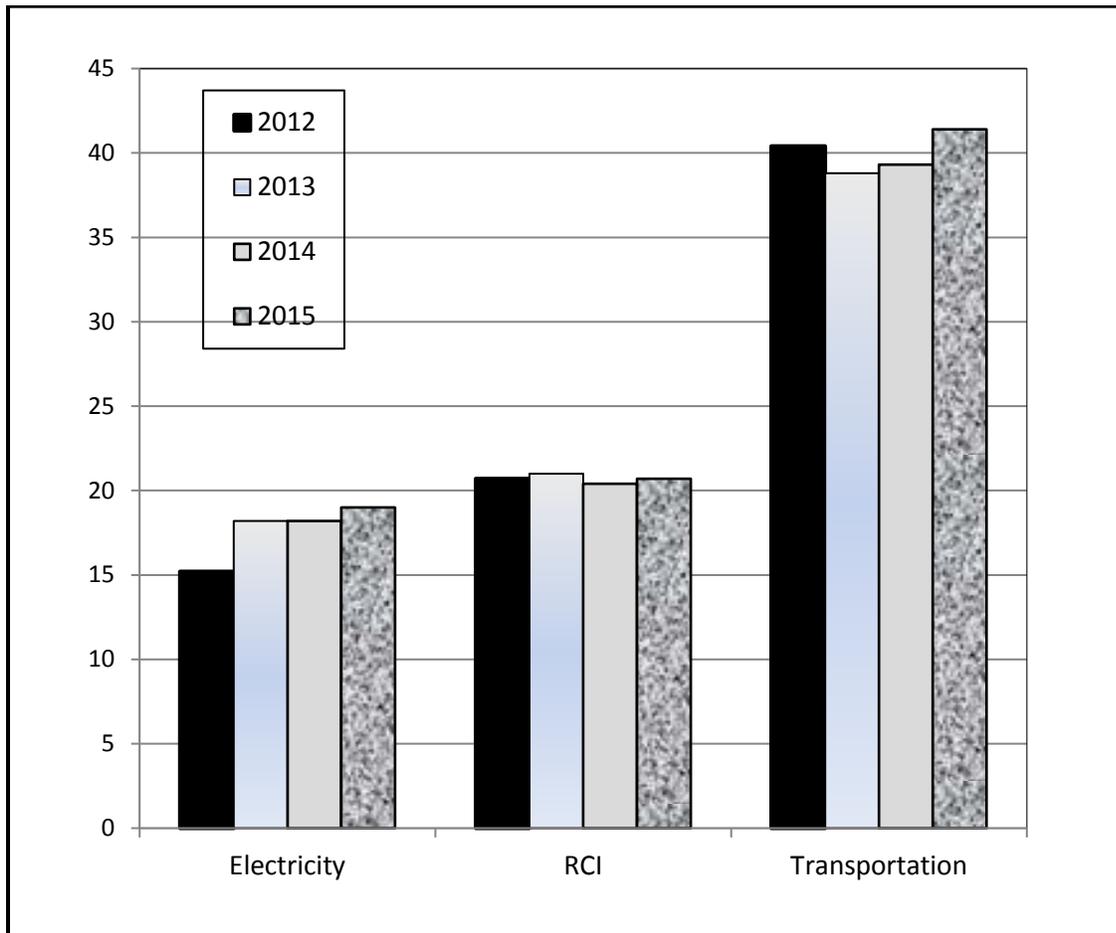


Figure 2: Total Greenhouse Gas Emissions (MMT CO₂e) by Sector for 2012–2015

Trends by sector, Washington and U.S.

Nationally, in 2015 the electricity sector is the largest contributor of greenhouse gases (Figure 3). Since Washington State uses hydropower for much of its electricity, the electricity sector is a less significant greenhouse gas source. The transportation sector is Washington’s most significant contributor of greenhouse gases.

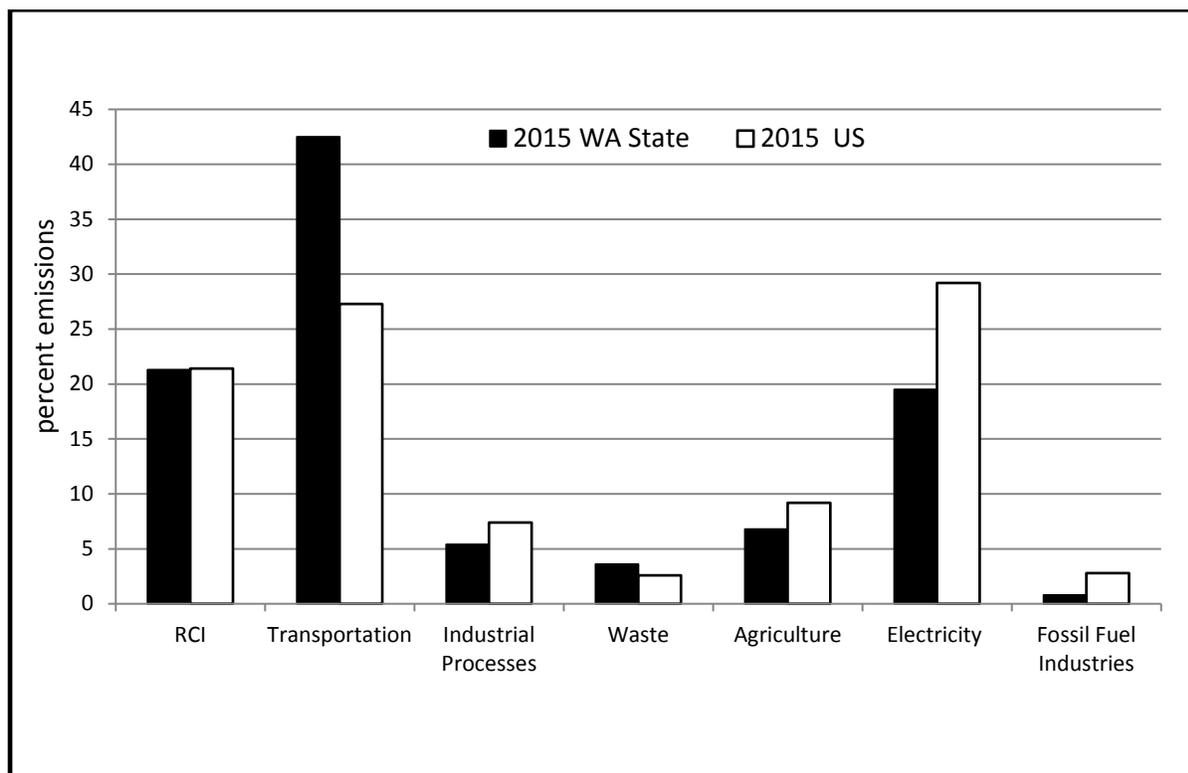


Figure 3: Percent Greenhouse Gas Emissions by Sector – 2015, Washington and U.S.¹⁰

¹⁰ Source: Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990 – 2015, Table ES-2
https://www.epa.gov/sites/production/files/2018-01/documents/2018_complete_report.pdf

Summary of results by sector

Transportation sector

In 2015, transportation is Washington’s largest greenhouse gas emissions contributor, while electricity is the largest contributor nationally.

Washington greenhouse gas emissions from the transportation sector have been fairly constant for several years, with on-road gasoline continuing to contribute over 50 percent of transportation sector emissions as indicated in Figure 4. Marine vessel emissions include emissions from recreational, commercial, and ocean-going vessels, but excludes marine bunker fuels consumed in international waters.

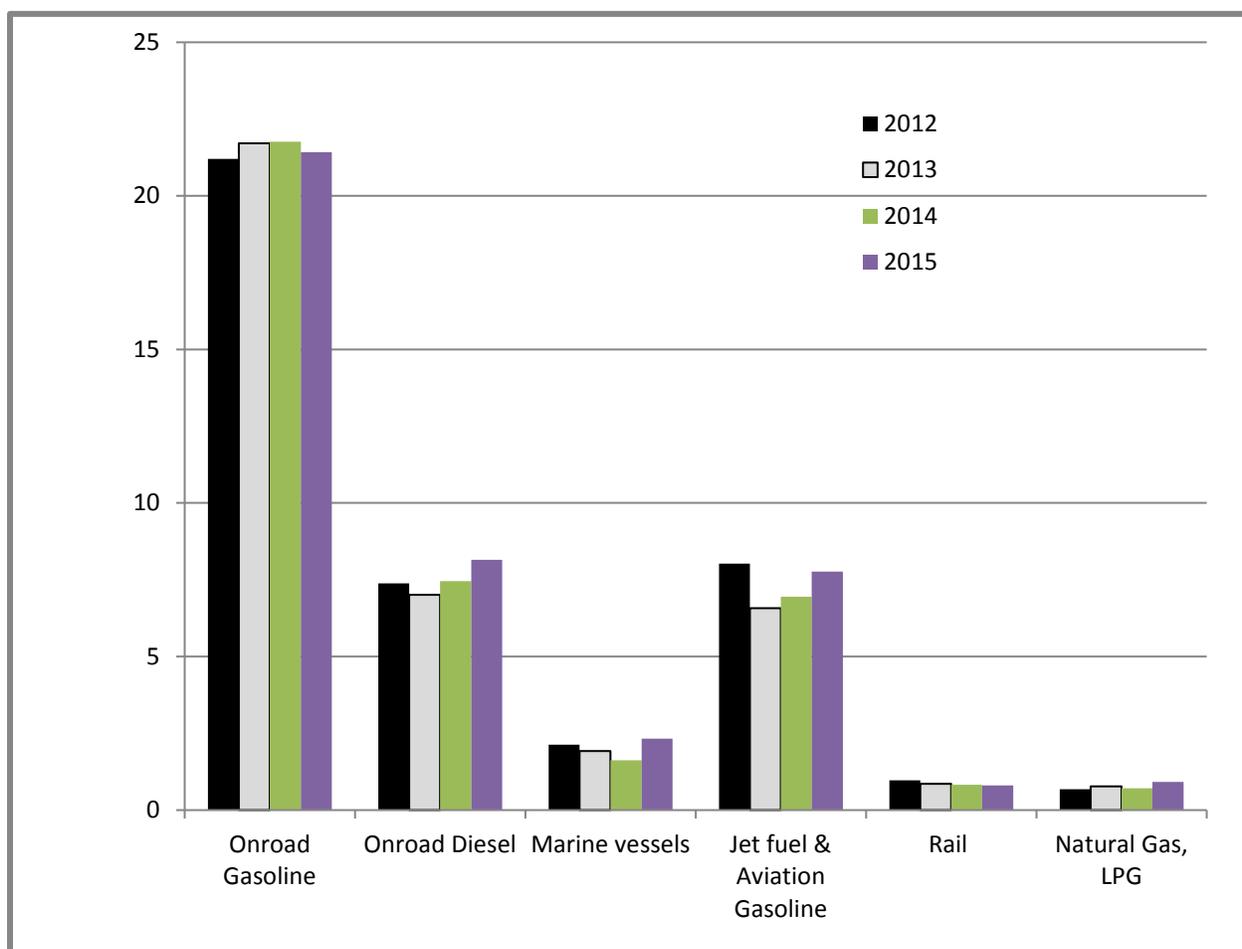


Figure 4: Greenhouse Gas Emissions by transportation sector

Electricity sector

Despite the large availability of clean hydroelectricity, Washington also uses electricity from coal and natural gas. Some of this electricity is produced in Washington and some is imported from other states. Washington’s greenhouse gas emissions from electricity are estimated using a

consumption-based (or “load-based”) approach. In other words, emissions are calculated based on the emissions profile of the power sources that deliver electricity to Washington for use in the homes and businesses of Washington regardless of where those power sources are located. For example large coal plants in Montana and Wyoming provide a significant portion of the emissions associated with electricity use in Washington.

Electricity GHG emissions have increased from 2012 to 2015; however, historically electricity emissions have fluctuated up and down based on the amount of water available to supply the many dams that provide Washington with both water and power. The 2016 information was available to include in this bar chart since electricity greenhouse gas emissions are determined by Washington State’s fuel mix disclosure data analysis.

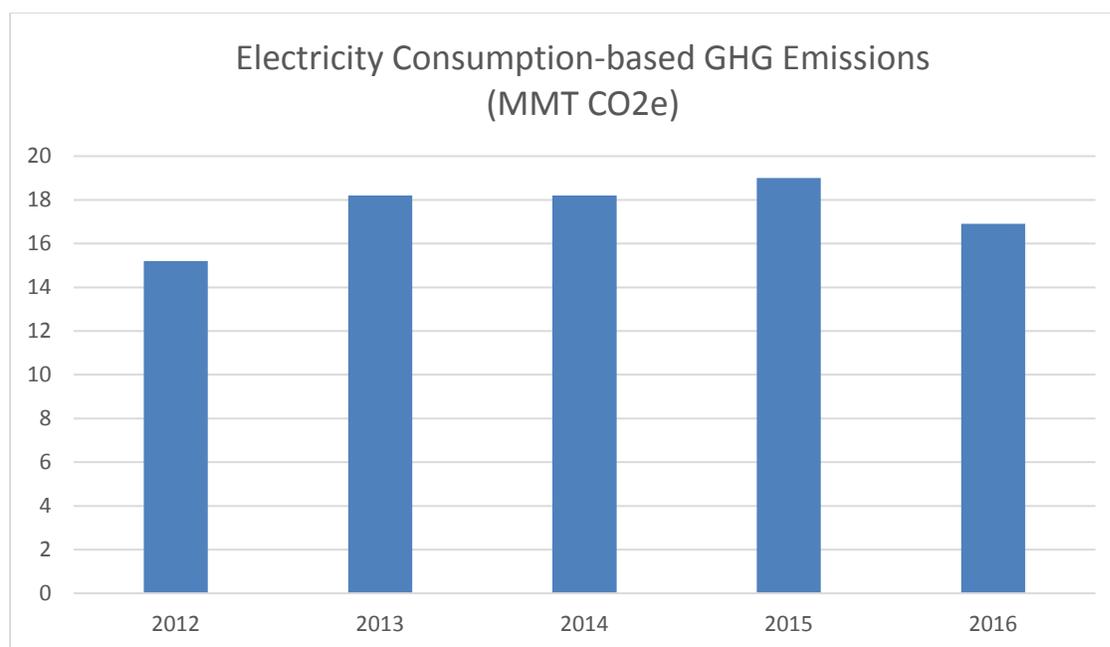


Figure 5: Annual GHG emissions from Electricity (Consumption-Based)

Residential, commercial, and industrial (RCI) sector

Greenhouse gas emissions in this sector occur from energy consumption when fuels are combusted to provide heat, including space heating and process heating (heating necessary for production processes or other applications). The data indicates a decrease in greenhouse gases from residential heating while the commercial and industrial sectors have remained fairly constant from 2012 to 2015.

The RCI sector is a relatively large source of greenhouse gas emissions in Washington. In 2015:

- 11.7 MMT CO₂e came from the industrial space and process heating.
- 4.8 MMT CO₂e came from the residential space heating.
- 4.1 MMT CO₂e came from the commercial space and process heating.

As Figure 6 indicates, the industrial sector continues to be the largest contributor of greenhouse gas emissions in the RCI sector.

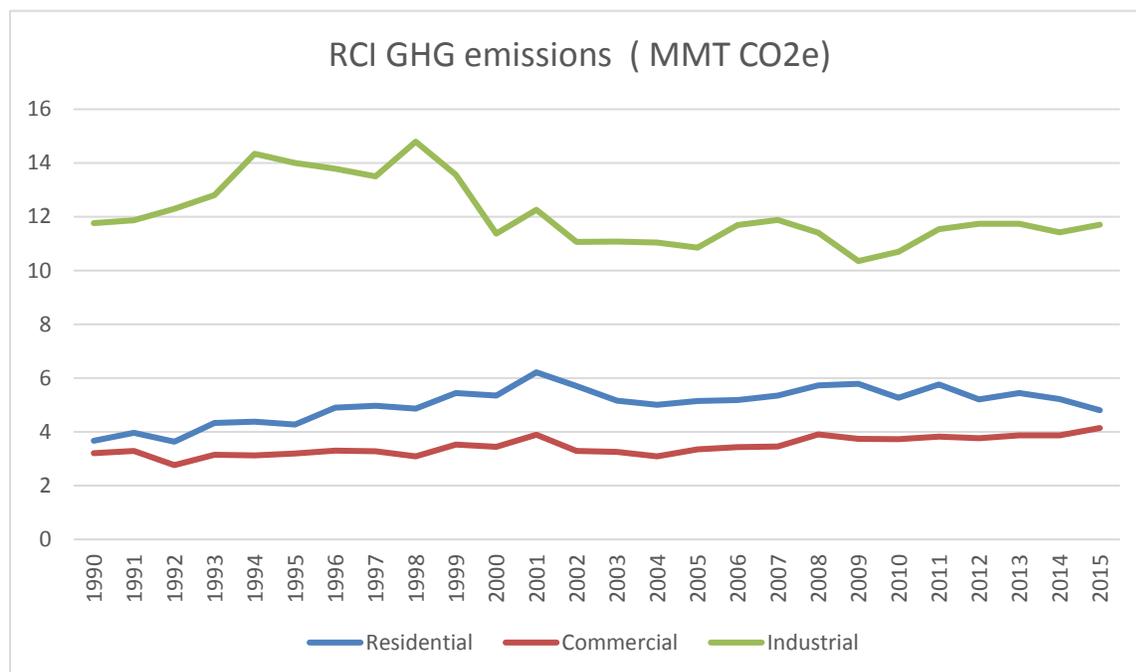


Figure 6: Annual RCI GHG emissions

Fossil fuel industry sector

This sector includes fugitive greenhouse gas emissions that are released during the production, processing, transmission, and distribution of fossil fuels. These emissions are typically fugitive methane due to leakage and venting from natural gas pipelines, and petroleum systems.

In 2015, these emissions were about 1.0 percent of Washington’s greenhouse gas emissions.

Waste management sector

This sector includes greenhouse gas emissions from landfills and wastewater treatment facilities. This inventory does not include waste exported from Washington to other states for disposal.

Washington’s 2015 greenhouse gas emissions from this sector are estimated at 2.8 percent of the total emissions. However, the 1990 baseline emissions from this sector are updated due to: 1) improved methodology in the U.S. EPA State Inventory Tool module, and 2) the use of Fourth Assessment Report global warming potentials.

Industrial processes sector

This sector includes greenhouse gas 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.

In 2015, greenhouse gas emissions from this sector contributed ~ 5% of Washington's total greenhouse gas emissions.

The EPA State Inventory Tool module develops an estimate of aluminum emissions. This is calculated using a ratio of state capacity to total production. The state capacity was wrong because the capacity of a Washington facility had been left out. This was corrected starting in 2008.

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

Agriculture sector

Agricultural activities such as manure management, fertilizer use, and livestock digestion process (enteric fermentation) result in methane and nitrous oxide emissions.

In 2015, these emissions accounted for about 6.8 percent of Washington's greenhouse gas emissions.

Next Steps

An annual Washington greenhouse gas inventory will be completed for 2016 and 2017 as EPA releases the State Inventory Tool modules for these years. This data will be provided in the next legislative report on Washington Greenhouse Gas Inventory issued in December 2020.

Because of the potential for significant annual data fluctuations in greenhouse gas emissions within sectors, it is useful to display the data display as multi-year averages.

Figure 7 presents a three year averaging of greenhouse gas emissions from each sector. The inner circle displays the percent distribution of the sectors; whereas, the outer ring provides the percent distribution from each source within each sector. As an example, under three year averaging, 42 percent of Washington State greenhouse gas emissions are from the Transportation sector with 22.7 percent of total Washington state emissions from on-road gasoline.

Conclusion

This inventory summarizes the greenhouse gas emissions from specific sectors in Washington from the 1990 baseline through 2015.

Key points are:

- Washington's 2015 total greenhouse gas emissions were 97.4 million metric tons (MMT).
- Washington's 2015 total greenhouse gas emissions were 7.4 MMT higher than the 1990 baseline of 90.0 MMT.
- Compared to the nation, the electricity sector in Washington contributes significantly less because of the availability of hydropower although emissions flux considerably from year to year.
- In 2015, Washington's largest contributors of greenhouse gases were:
 - Transportation sector at 42.5 percent.
 - Residential, commercial, and industrial sector at 21.3 percent.
 - Electricity sector at 19.5 percent.
- Washington's greenhouse gas emissions increased by about 6.1 percent from 2012 to 2015, primarily due to increased emissions from the electricity sector. During this time period Washington's economy also grew at a compound annual growth rate of 2.95% per year.¹¹

¹¹ <https://www.deptofnumbers.com/gdp/washington/>