



Washington State Greenhouse Gas Emissions Inventory: 1990-2018

Air Quality Program

Washington State Department of Ecology
Olympia, Washington

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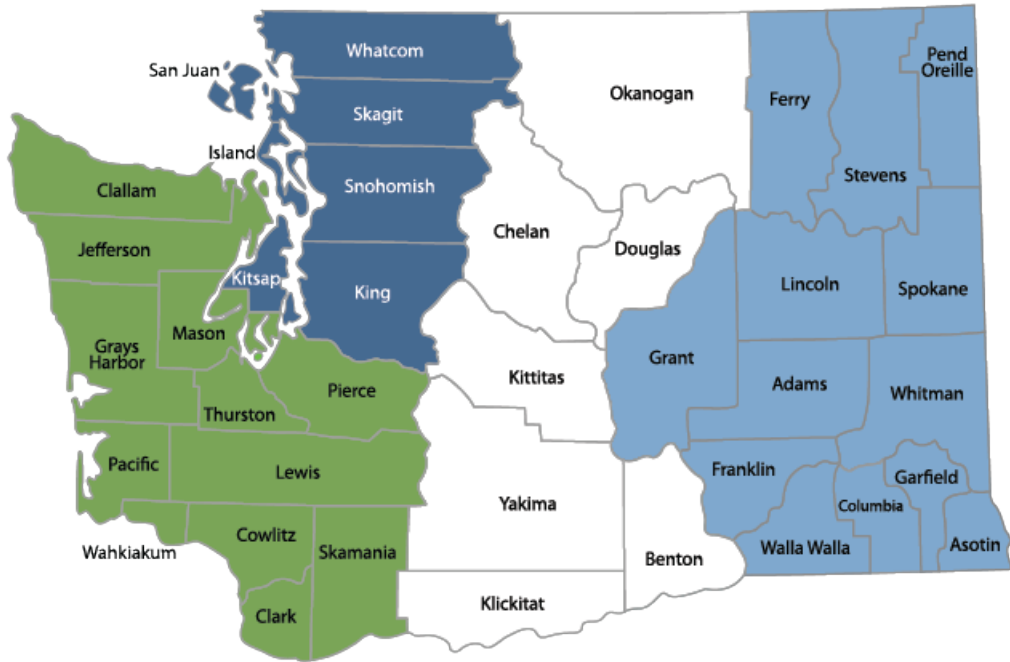
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¹ www.ecology.wa.gov

Department of Ecology's Regional Offices

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Southwest Region 360-407-6300	Northwest Region 425-649-7000	Central Region 509-575-2490	Eastern Region 509-329-3400
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Region	Counties served	Mailing Address	Phone
Southwest	Clallam, Clark, Cowlitz, Grays Harbor, Jefferson, Mason, Lewis, Pacific, Pierce, Skamania, Thurston, Wahkiakum	PO Box 47775 Olympia, WA 98504	360-407-6300
Northwest	Island, King, Kitsap, San Juan, Skagit, Snohomish, Whatcom	3190 160th Ave SE Bellevue, WA 98008	425-649-7000
Central	Benton, Chelan, Douglas, Kittitas, Klickitat, Okanogan, Yakima	1250 W Alder St Union Gap, WA 98903	509-575-2490
Eastern	Adams, Asotin, Columbia, Ferry, Franklin, Garfield, Grant, Lincoln, Pend Oreille, Spokane, Stevens, Walla Walla, Whitman	4601 N Monroe Spokane, WA 99205	509-329-3400
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Washington State Greenhouse Gas Emissions Inventory 1990-2018

Report to the Legislature

Air Quality Program
Washington State Department of Ecology
Olympia, WA

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DEPARTMENT OF
ECOLOGY
State of Washington

Table of Contents

List of Figures and Tables	5
Figures.....	5
Tables.....	5
Acknowledgements	6
Executive Summary	7
Background Information	8
Washington’s greenhouse gas legislation	8
Greenhouse gas emissions inventory	9
Findings: Inventory Results	11
Washington’s Greenhouse Gas Emissions Trends	15
Trends by sector, 2015-2018	15
Trends by sector, Washington and U.S.....	16
Summary of results by sector	17
Transportation sector	17
Electricity sector.....	19
Residential, commercial, and industrial (RCI) sectors	20
Fossil fuel industry sector	21
Waste management sector.....	21
Industrial Processes sector.....	21
Agriculture sector	22
Multi-year averages.....	22
Next Steps	24
Conclusion	24

List of Figures and Tables

Figures

Figure 1: Greenhouse gas emissions from wildfires in Washington State	14
Figure 2: Total Annual Greenhouse Gas Emissions (MMT CO ₂ e) by Sector from 1990 - 2018	15
Figure 3: Total Greenhouse Gas Emissions (MMT CO ₂ e) by Sector for 2015 - 2018.....	16
Figure 4: Percent Greenhouse Gas Emissions by Sector - 2018, Washington and U.S.	17
Figure 5: Greenhouse Gas Emissions - transportation sector subcategories (MMT CO ₂ e).....	18
Figure 6: Percent distribution of electricity energy source.	19
Figure 7: Annual GHG emissions from Electricity (Consumption-Based)	20
Figure 8: Residential, Commercial and Industrial sectors: GHG emissions, 2015 - 2018.....	21
Figure 9: Washington GHG emissions, 3-year average (2016-2018).....	23

Tables

Table 1: Washington State GHG emissions limits: 2008 and 2020.....	9
Table 2: Global warming potential factors for greenhouse gases, Fourth Assessment Report, 100-year time horizon.....	11
Table 3: Washington State Total Annual GHG Emissions (MMT CO ₂ e)	13

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Executive Summary

This report summarizes Washington’s greenhouse gas emissions from the 1990 baseline established in law through to 2018, which is the most recent year of available data necessary to create this inventory. The report evaluates Washington’s greenhouse gas emissions, shows where the emissions are coming from, and how those emissions are changing over time.

RCW 70A.45.020 (2), states,

“By December 31st of each even-numbered year beginning in 2010, the department and the department of commerce 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 report must include greenhouse gas emissions from wildfires, developed in consultation with the department of natural resources....”

Key findings in the report are that Washington’s greenhouse gas emissions rose 1.3 percent from 2017 to 2018, reaching a total of 99.6 million metric tons (MMT). This was the highest total for the state since 2007, when total emissions were 101.4 MMT. During the Great Recession, emissions fell sharply, reaching a low of 91.8 MMT in 2012. Between 2012 and 2018, emissions have gradually climbed higher as Washington’s economy has expanded and our state’s population has grown.

The greatest contributor to these rising emissions has been the transportation sector and the heating sector (which includes home, commercial and industrial heating). Decreases in emissions from electricity generation, in recent years, have helped to offset increases in other sectors.

Transportation is the largest category of emissions, accounting for 44.9 percent of the total. Residential, commercial and industrial heating (RCI) is second, accounting for 23.8 percent of emissions, and electrical generation is third, accounting for 16.3 percent of emissions.

The 2018 total of 99.6 million metric tons is 9.1 MMT higher than the 1990 baseline of 90.5 MMT. Under state law, future emissions reduction targets are compared to this baseline.

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 from a wide variety of sources. In this report, we consider:

- *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, and other products 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 unintentional release of sulfur hexafluoride from electrical equipment or nitrous oxide from fertilizers).

Washington's greenhouse gas legislation

RCW 70A.45.040 requires that Ecology consult with the Climate Impacts Group (CIG) at the University of Washington to review the science on human-caused climate change within 18 months of the “next and each successive global or national assessment of climate change science.” This review may require recommendations about “whether the greenhouse gas emissions reductions under RCW 70A.45.020 need to be updated.”

In 2019, Ecology completed a review of several recent climate change reports:

- The 2018 Intergovernmental Panel on Climate Change Special Report, *Global Warming of 1.5°C* (SR15),
- The 2018 *Fourth National Climate Assessment*,
- The University of Washington CIG report on the consequences to Washington State of 1.5°C and 2°C of warming.

To moderate the most damaging effects of climate change, these reports demonstrated the need for significant additional greenhouse gas reductions beyond those established by the

Legislature in 2008. Ecology recommended in its 2019 report to the Legislature, *Washington State Greenhouse Gas Reduction Limits*:²

- Strengthening of the statutory greenhouse gas emissions limits;
- Creating new interim milestones;
- Setting a carbon neutral target in addition to the reduction limit for 2050.

This policy paper informed House Bill 2311, “Amending state greenhouse gas emission limits for consistency with the most recent assessment of climate change science,” that was signed into law on March 19, 2020 thus updating the greenhouse gas emissions reductions under RCW 70A.45.020. The updated requirements are more aggressive and include a state goal of achieving net zero greenhouse gas emissions by 2050. Table 1 summarizes the changes in Washington’s greenhouse gas emissions limits.

Table 1: Washington State GHG emissions limits: 2008 and 2020

Year	2008 GHG Emissions Limits	2020 GHG Emissions Limits
2020	Reduce to 1990 levels	Reduce to 1990 levels
2030		45% below 1990
2035	25% below 1990	
2040		70% below 1990
2050	50% below 1990	95% below 1990, achieve net zero

In addition, reporting requirements in RCW 70A.45.020 (2) now include greenhouse gas emissions from wildfires:

“By December 31st of each even-numbered year beginning in 2010, the department and the department of commerce 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 report must include greenhouse gas emissions from wildfires, developed in consultation with the department of natural resources...”

Because trees capture carbon as they grow, carbon dioxide emissions from wildfires are considered part of the natural carbon cycle. These emissions are tracked separately from anthropogenic greenhouse gas sources, i.e. human-caused activity such as combustion of fossil fuels.

² Washington State Greenhouse Gas Emission Reduction Limits, report prepared under RCW 70.235.040, Dec. 2019, Publication 19-02-031

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 source sector, not facility-specific emissions.

The data to develop this inventory are provided by the U.S. Environmental Protection Agency's (EPA's) 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 includes 2018 data.

In addition to U.S. EPA's SIT tool, the Washington State Department of Commerce annually provides greenhouse gas emissions for the electricity sector calculated from fuel mix disclosure data.³ 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, from which electricity sector greenhouse gas emissions are calculated.

Greenhouse gas emission sectors

For comparison to national and international greenhouse gas inventory data, Washington State greenhouse gas emissions data is categorized by sectors as listed below:

- Transportation.
- Electricity consumption.⁴
- Residential, commercial, and industrial.⁵
- Fossil fuel industry.⁶
- Waste management.
- Industrial processes.⁷
- Agriculture.

How greenhouse gas emissions are shown

³ <https://www.commerce.wa.gov/growing-the-economy/energy/fuel-mix-disclosure/>

⁴ Electricity consumption – greenhouse gas emissions associated with Washington's electricity demand

⁵ Residential, commercial, and industrial - greenhouse gas emissions from fuels combusted to primarily produce space heating and/or process heating

⁶ Fossil fuel industry – greenhouse gas emissions known as fugitive emissions from leaking or venting in processing or distribution systems

⁷ Industrial processes - non-combustion sources of greenhouse gas emissions from industrial processes

Carbon dioxide equivalent: The emissions 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 (GWP): 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. Washington follows this guidance and methodology to develop this annual greenhouse gas inventory.

Greenhouse gases included in the inventory

Washington's greenhouse gas emissions inventory includes the greenhouse gases listed in Table 2. As stated previously, for greenhouse gas accounting, global warming potentials from the IPCC Fourth Assessment Report are required.

Table 2: Global warming potential factors for greenhouse gases, Fourth Assessment Report, 100-year time horizon

Greenhouse Gas	Global Warming Potential
Carbon dioxide (CO ₂)	1
Methane (CH ₄)	25
Nitrous oxide (N ₂ O)	298
Hydrofluorocarbons (HFCs)	124-14,800
Perfluorocarbons (PFCs)	7,390-12,200
Nitrogen trifluoride (NF ₃)	17,200
Sulfur hexafluoride (SF ₆)	22,800

Findings: Inventory Results

Transportation continues to be the largest contributor of greenhouse gas emissions in Washington State. The data in Table 3 shows small annual variations within transportation subcategories. The 2018 inventory data indicates that emissions from electricity are declining primarily due to a reduction in coal-sourced electricity. Natural gas use continues to be a significant greenhouse gas emissions source in the residential, commercial and industrial sectors.

The total 2018 greenhouse gas emissions is estimated at 99.6 MMT CO₂e. In addition to annual numbers shown in Table 3, page 13, the data are also presented as a three year average in Figure 9 on page 23. Figure 9 provides an overall percent contribution of each sector and subcategory. The three-year averaging smooths out annual variations due to data revisions reported in the periodic releases of the EPA SIT modules. Figure 9 provides a quick visual overview of the greenhouse gas sources that have the most impact in Washington state.

Due to recent significant wildfires, carbon emissions from this source have been added to the inventory report. Wildfire carbon emissions are considered biogenic greenhouse gas emissions i.e., emissions that are part of the natural carbon cycle. These emissions are tracked separately from the sector greenhouse gas emissions in Table 3. Figure 1 summarizes the carbon emissions from wildfires in Washington State from 2014 to 2018, including total acres burned.

Table 3: Washington State Total Annual GHG Emissions (MMT CO₂e)⁸

Million metric tons CO ₂ e	1990	2000	2010	2015	2016	2017	2018
Electricity, net consumption-based	16.90	23.28	20.78	19.02	16.86	16.62	16.21
Coal	16.80	17.40	15.83	14.03	12.51	12.39	11.70
Natural gas	0.10	5.28	4.84	4.91	4.28	4.14	4.48
Petroleum	0.00	0.60	0.10	0.07	0.06	0.08	0.02
Biomass and waste (CH ₄ and N ₂ O)	0.00	0.00	0.01	0.01	0.01	0.01	0.01
Residential/Commercial/Industrial (RCI)	18.65	20.13	19.77	20.71	21.98	23.10	23.28
Coal	0.61	0.00	0.25	0.18	0.18	0.13	0.13
Natural gas	8.62	11.37	10.81	11.21	11.86	13.30	12.63
Oil	9.16	8.51	8.44	9.05	9.55	9.28	10.12
Wood (CH ₄ and N ₂ O)	0.26	0.25	0.27	0.27	0.39	0.40	0.40
Transportation	37.90	44.87	40.21	40.98	43.70	43.26	44.73
On-road gasoline	20.70	24.48	21.78	21.42	21.56	21.53	22.33
On-road diesel	4.22	7.72	7.54	8.15	8.61	8.36	8.87
Marine vessels	2.48	1.76	1.61	1.92	3.02	2.49	2.28
Jet fuel and aviation gasoline	9.10	10.05	8.11	7.77	8.63	9.29	9.40
Rail	0.80	0.30	0.53	0.80	0.87	0.61	0.82
Natural gas, LPG	0.60	0.57	0.64	0.92	1.02	0.99	1.02
Fossil fuel industry	0.58	0.73	0.81	0.84	0.84	0.84	0.83
Natural gas industry (CH ₄)	0.58	0.73	0.81	0.84	0.84	0.84	0.83
Coal mining (CH ₄)	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Oil industry (CH ₄)	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Industrial processes	7.00	10.01	4.97	5.28	5.29	5.30	5.42
Cement manufacture (CO ₂)	0.20	0.44	0.28	0.33	0.37	0.36	0.39
Aluminum production (CO ₂ , PFC)	5.90	7.38	1.32	0.96	0.90	0.88	0.92
Limestone and dolomite use (CO ₂)	0.00	0.02	0.02	0.02	0.02	0.02	0.02
Soda ash	0.10	0.10	0.05	0.05	0.05	0.05	0.05
ODS substitutes (HFC, PFC) ⁹	0.00	1.62	3.08	3.76	3.78	3.81	3.87
Semiconductor mfg (HFC, PFC, SF ₄ , NF ₃)	0.00	0.09	0.08	0.08	0.09	0.08	0.08
Electric power T&D (SF ₄)	0.80	0.36	0.14	0.10	0.10	0.10	0.10
Waste management	3.12	2.84	3.45	2.33	2.43	2.45	2.39
Solid waste management	2.58	2.16	2.68	1.51	1.60	1.61	1.53
Wastewater management	0.55	0.68	0.77	0.82	0.83	0.84	0.86
Agriculture	6.34	6.76	6.39	6.77	6.77	6.70	6.71
Enteric fermentation	2.62	2.57	2.40	2.58	2.62	2.62	2.65
Manure management	0.86	1.24	1.37	1.67	1.49	1.50	1.49
Agriculture soils	2.86	2.94	2.68	2.52	2.66	2.58	2.58
Total gross emissions	90.49	108.62	96.38	95.94	97.86	98.28	99.57

⁸ Totals may not equal exact sum of subtotals shown in this table due to independent rounding

⁹ ODS substitutes: HFC's and PFC's consumed as substitutes for ozone-depleting substances (ODS)

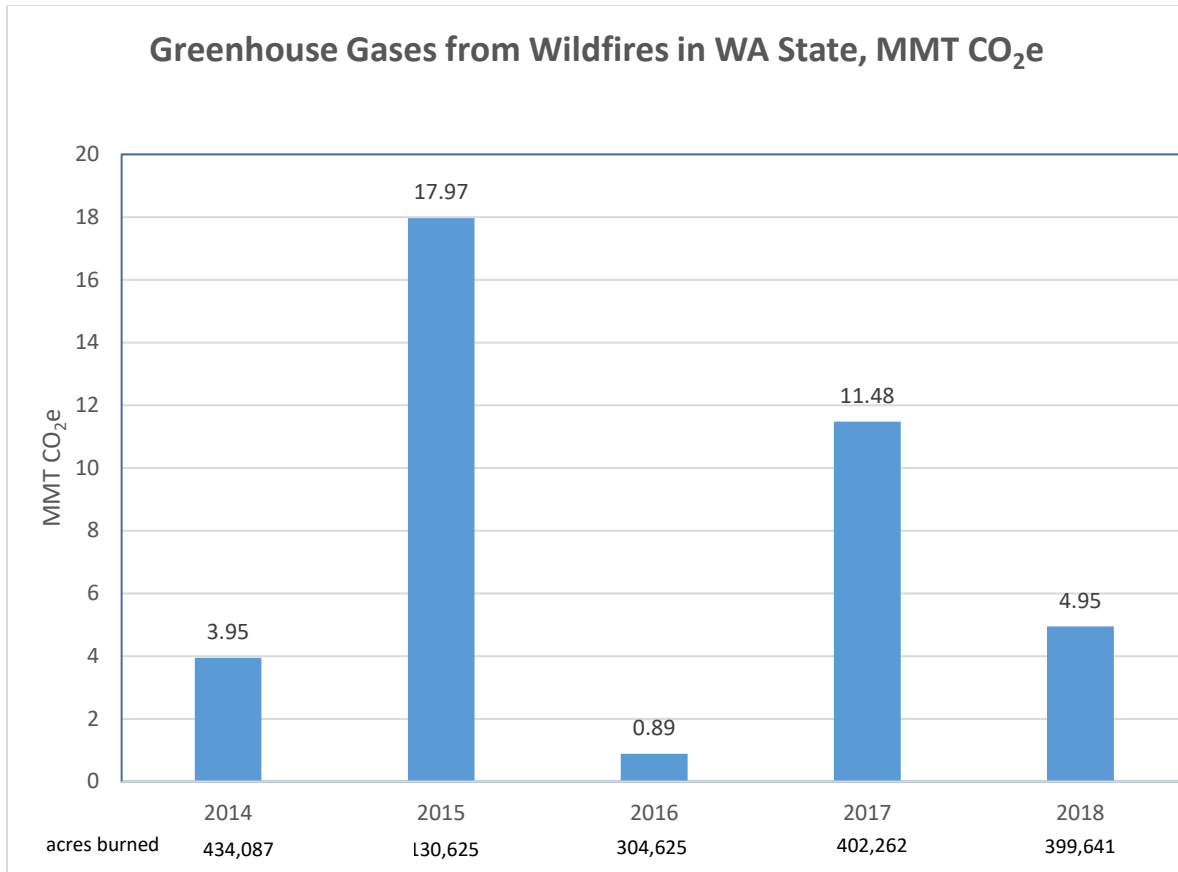


Figure 1: Greenhouse gas emissions from wildfires in Washington State. Acres burned may include forest and non-forest land.¹⁰

¹⁰ Summary of Natural and Working Lands Carbon Inventories and Incentive Programs in Washington, Washington Department of Natural Resources, December 1, 2020. See table on page 7.
https://app.leg.wa.gov/ReportsToTheLegislature/Home/GetPDF?fileName=DNR%20Carbon%20Sequestration%20Report_8f19b00b-5acf-4c97-83b4-16cecb559803.pdf

Washington's Greenhouse Gas Emissions Trends

Figure 2 displays Washington's greenhouse gas emissions sector profile from 1990 to 2018. There was a significant decrease in emissions after 2000, mainly due to changes in the aluminum industry in Washington.¹¹ More recently, from 2016 to 2018, there are subtle shifts of greenhouse gas emissions within sectors. The emissions decrease from the electricity sector is due to a reduction in coal-sourced power, anticipated to continue over time. The transportation sector and the residential, commercial and industrial sectors remain the predominant sources of greenhouse gases in Washington.

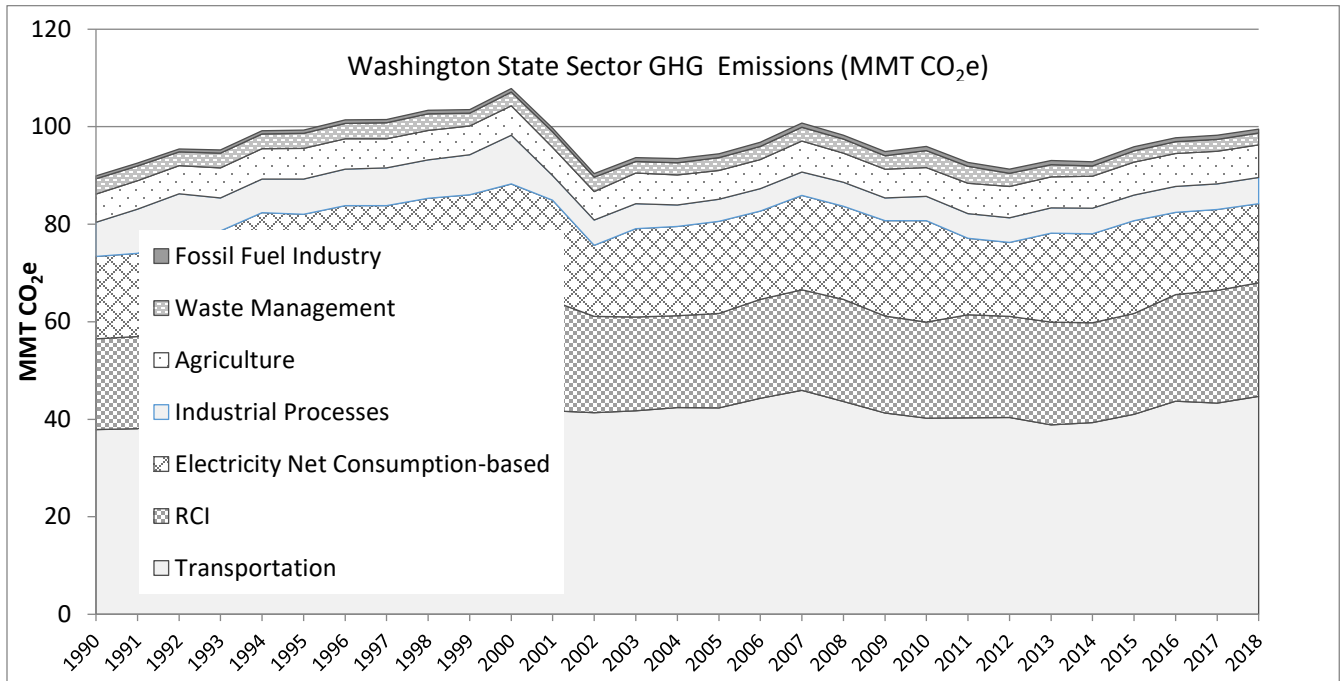


Figure 2: Total Annual Greenhouse Gas Emissions (MMT CO₂e) by Sector from 1990 - 2018

Trends by sector, 2015-2018

In Washington State the sectors with the largest contributions of greenhouse gas emissions are electricity, transportation, and the residential, commercial, and industrial (RCI) sector. Figure 3 compares the annual changes within these sectors from 2015 to 2018.

As stated earlier, electricity emissions are decreasing primarily due to a reduction in coal-sourced power. Over time, changes in the RCI sector seem to be most influenced by natural gas emissions associated with industrial building energy, as shown in Figure 8. The dominant

¹¹ The SIT module develops an estimate of aluminum emissions that now includes process CO₂ emissions.

contributor of greenhouse gas emissions in the transportation sector continues to be on-road gasoline as reported in Table 3.

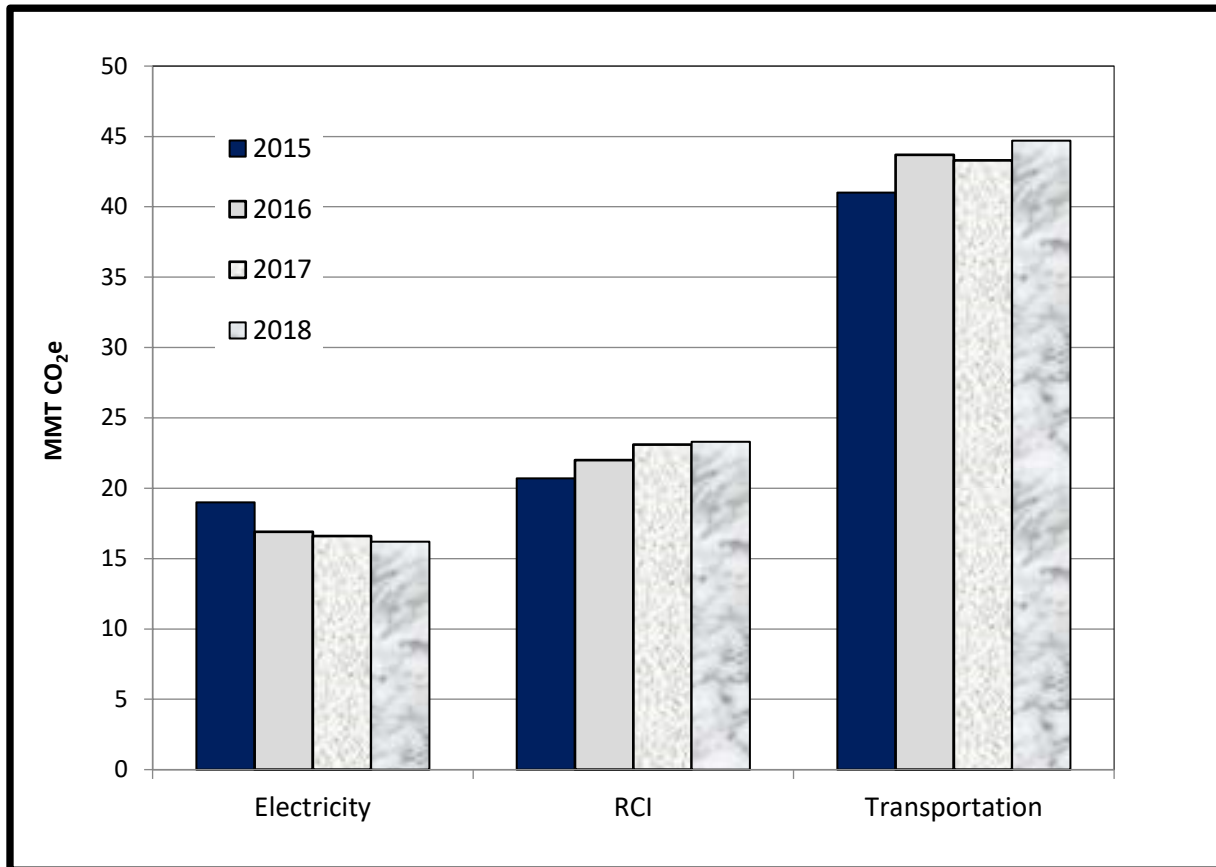


Figure 3: Total Greenhouse Gas Emissions (MMT CO₂e) by Sector for 2015 - 2018

Trends by sector, Washington and U.S.

In 2018, the transportation sector remains the largest contributor to greenhouse gas emissions in Washington, as indicated in Figure 4. Nationally, the transition away from coal-sourced electricity recently resulted in the transportation sector also becoming the predominant source of greenhouse gas emissions in the United States, slightly outpacing electricity greenhouse gas emissions.

Due to the availability of hydropower, emissions from the electricity sector in Washington were never as predominant as in the national greenhouse gas inventory. Yet Washington's transition to carbon neutral electricity will invariably continue to reduce greenhouse gas emissions from the electricity sector. This may also reduce transportation emissions as electrified fleets become more common.

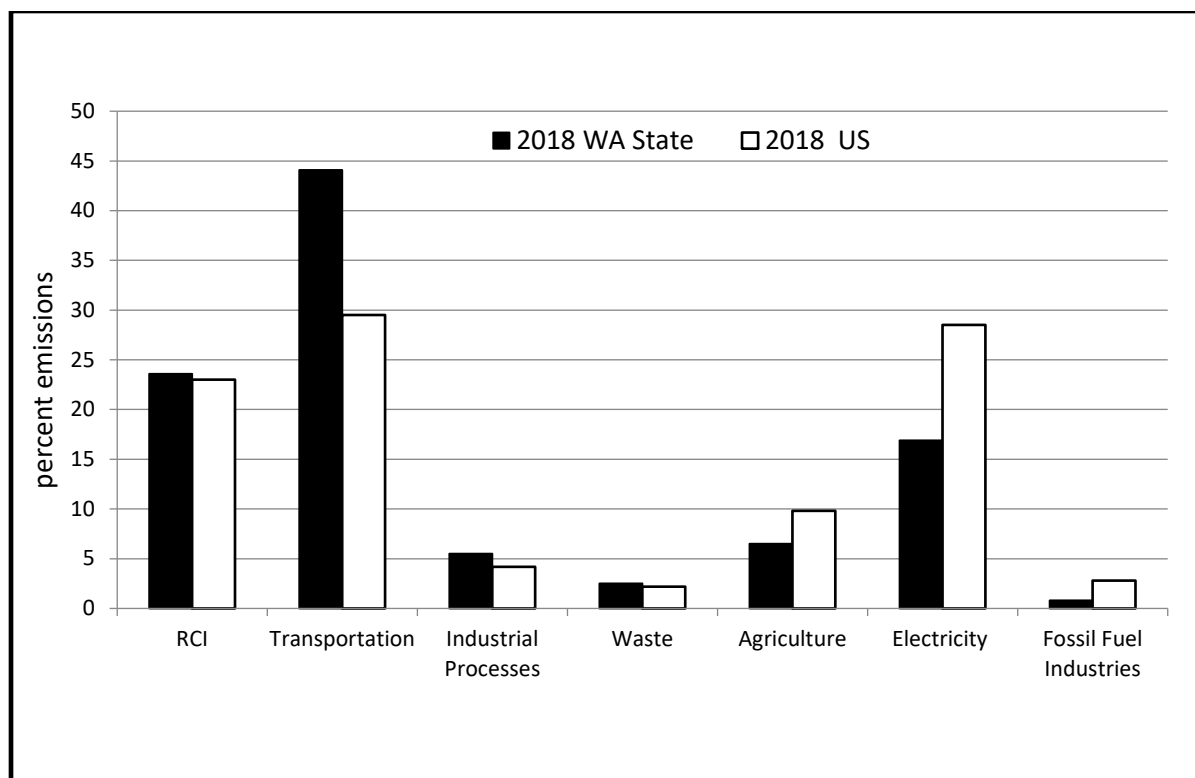


Figure 4: Percent comparison of Greenhouse Gas Emissions by Sector - 2018, Washington and U.S.¹²

Summary of results by sector

Transportation sector

In 2018, transportation was the sector in Washington that contributed the most greenhouse gas emissions. This sector includes emissions from marine, rail, and aviation engines; however, on-road gasoline vehicles remain the single largest contributor to transportation greenhouse gas emissions. Greenhouse gas emissions from other transportation subcategories are fairly consistent over time; however, the data indicate an increasing trend in aviation emissions (Figure 5).

¹² Source: Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990 – 2018, Table ES-2
<https://www.epa.gov/ghgemissions/inventory-us-greenhouse-gas-emissions-and-sinks-1990-2018>

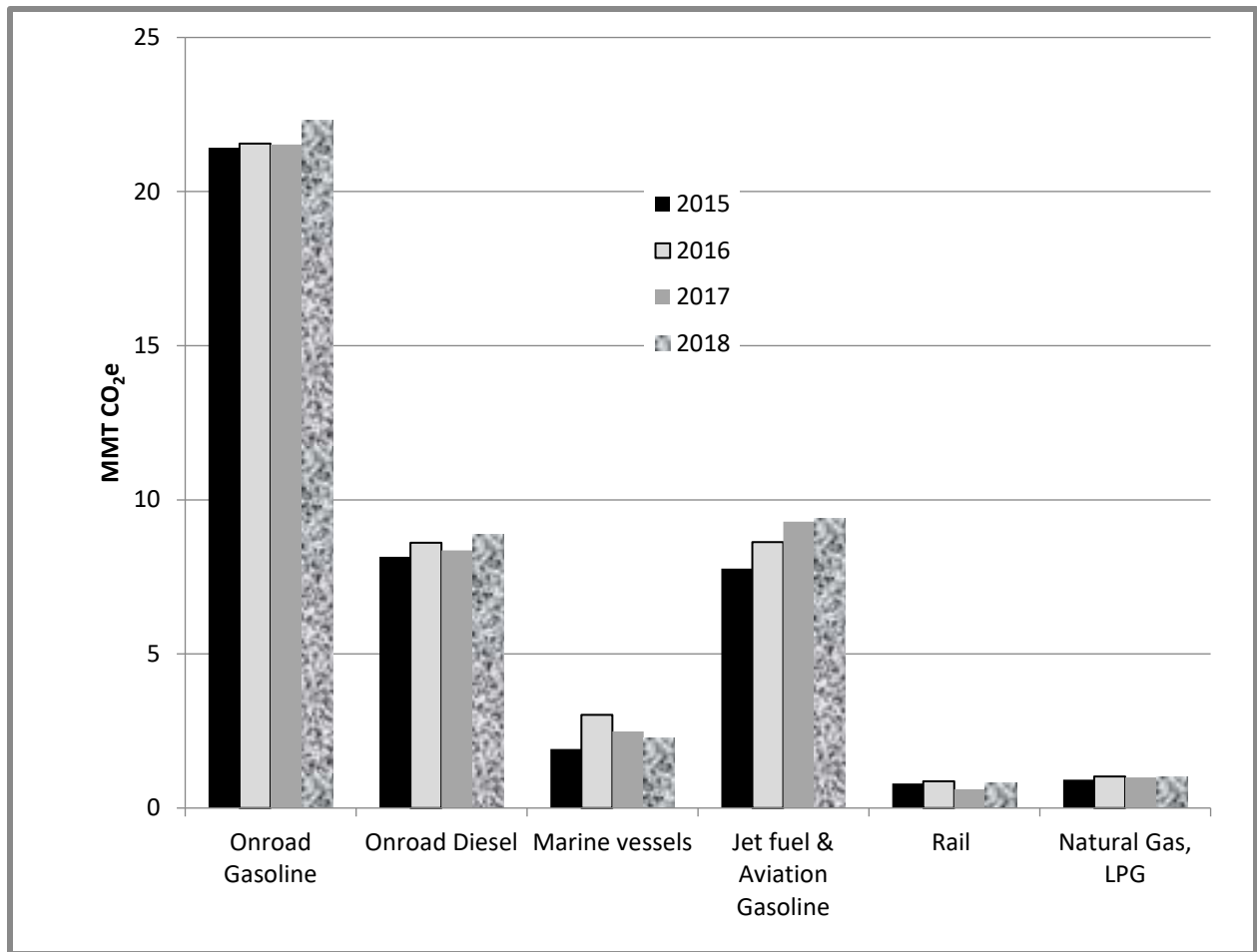


Figure 5: Greenhouse Gas Emissions - transportation sector subcategories (MMT CO₂e)

Electricity sector

Despite the large availability of clean hydroelectricity, Washington also uses electricity produced from burning coal and natural gas, as shown in Figure 6. Some of this electricity is generated within Washington and some is imported from other states.

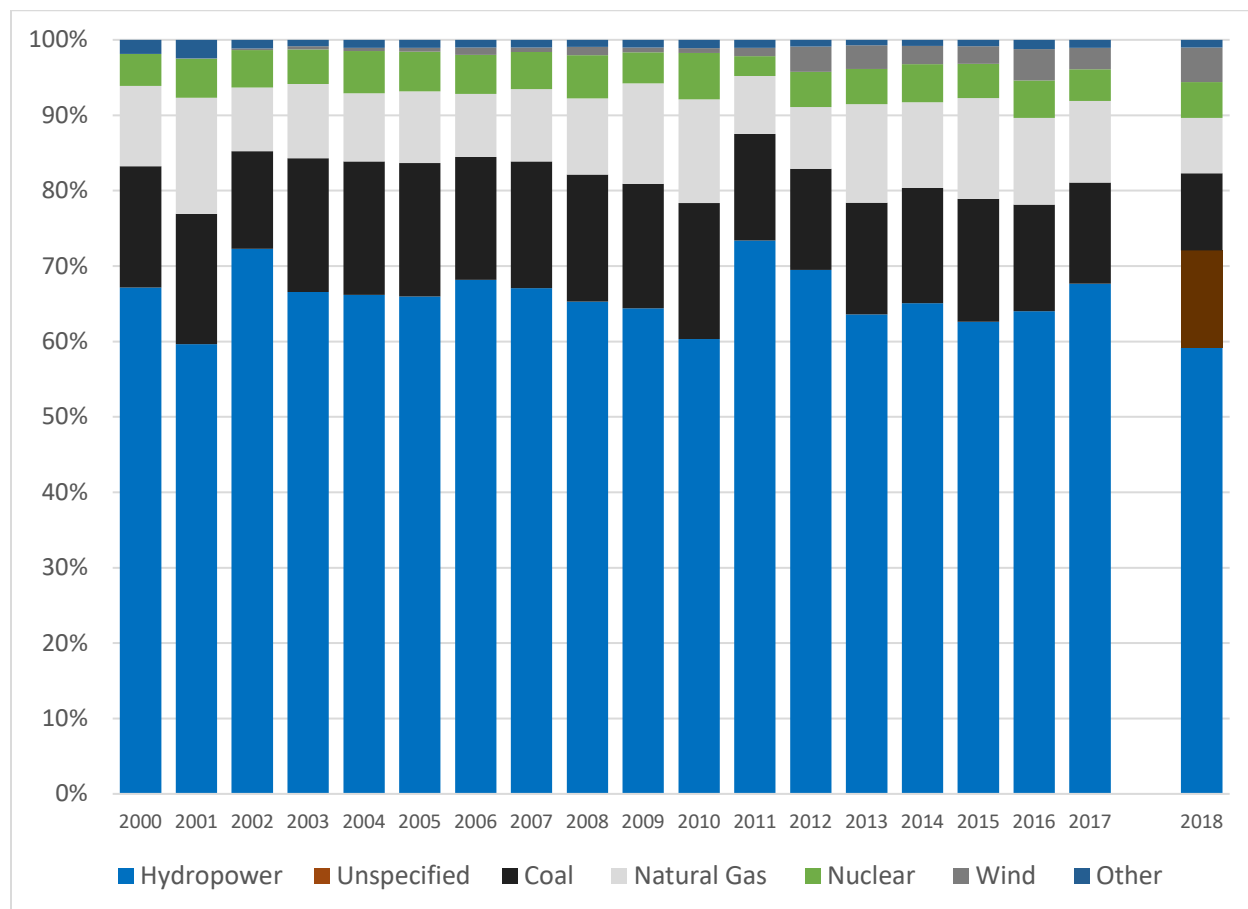


Figure 6: Percent distribution of electricity energy source.¹³

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 consumers, regardless of where those power sources are located. For example large coal plants in Montana and Wyoming provide a portion of the emissions associated with electricity use in Washington. Greenhouse gas emissions from electricity are anticipated to continue to decline as cleaner generation replaces the use of coal-sourced power. This decline is expected to be driven in, in large part, by the 2019 Clean Energy Transformation Act, which requires all electricity supplied to Washington consumers to be renewable or non-emitting by 2045. Trends in greenhouse gas emissions from electricity consumption are shown in Figure 7.

¹³ <https://www.commerce.wa.gov/growing-the-economy/energy/fuel-mix-disclosure/> see Fuel Mix Aggregate Time Series 2019 (CY 2018)

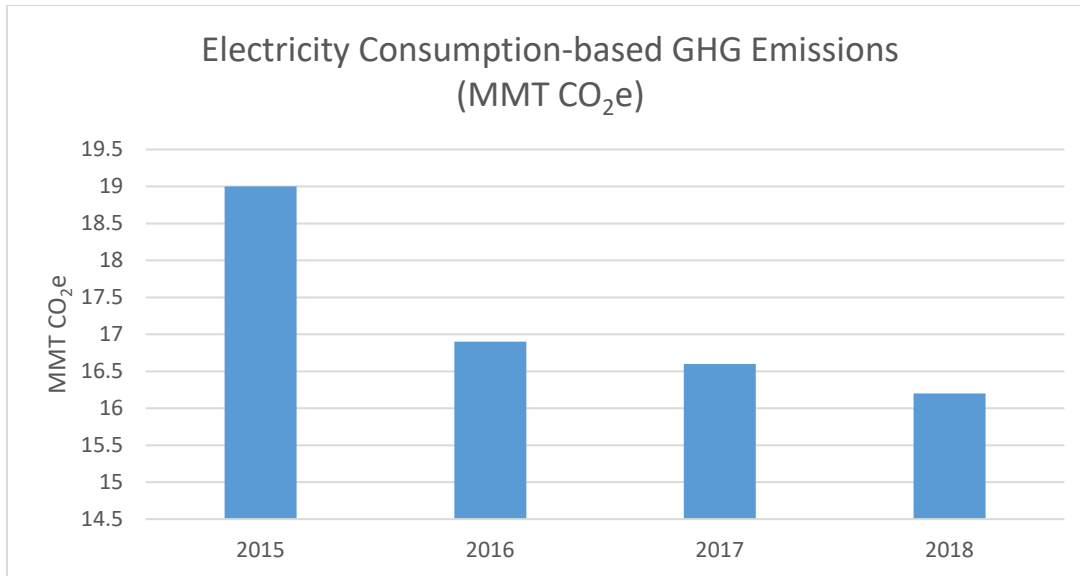


Figure 7: Annual GHG emissions from Electricity (Consumption-Based)

Residential, commercial, and industrial (RCI) sectors

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 RCI sector is a relatively large contributor of greenhouse gas emissions in Washington. In 2018 greenhouse gas emissions for each sub-sector of RCI were:

- 12.6 MMT CO₂e from industrial space and process heating.
- 5.9 MMT CO₂e from residential space heating.
- 4.9 MMT CO₂e commercial space and process heating.

As Figure 8 shows industrial space and/or process heating continues to be the largest contributor of greenhouse gas emissions in the RCI sector. Both natural gas and petroleum are greenhouse gas sources within the industrial sub-sector, see Table 3. Natural gas is the predominant fuel influencing greenhouse gas emissions from the residential and commercial sub-sectors.

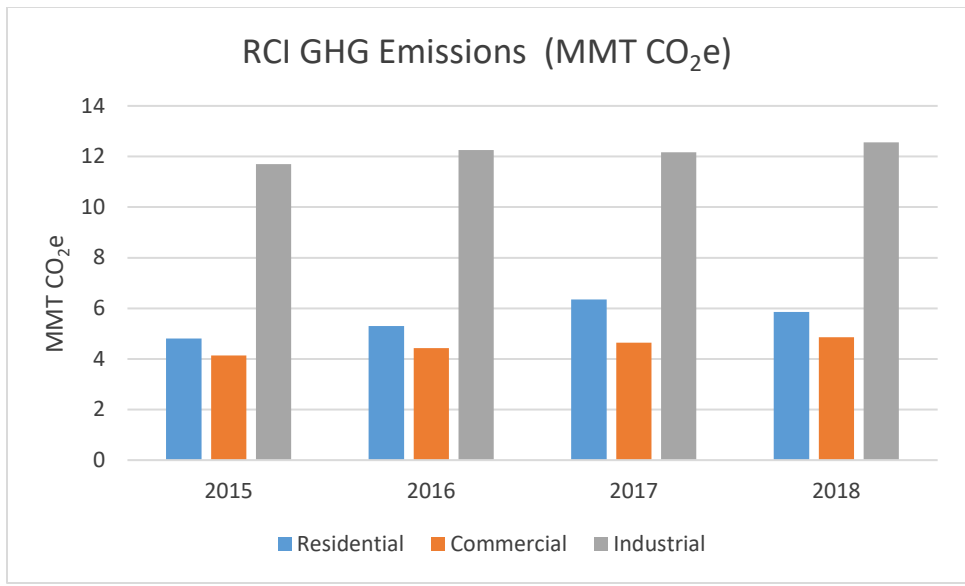


Figure 8: Residential, Commercial and Industrial sectors: GHG emissions, 2015 - 2018

Fossil fuel industry sector

The fossil fuel industry sector includes fugitive methane emissions due to leakage and venting from Washington from natural gas pipelines, and petroleum systems. In 2018, these emissions were about 1.0 percent of Washington’s total greenhouse gas emissions.

Waste management sector

The waste management 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 2018 greenhouse gas emissions from this sector are about 2.4 percent of the total emissions.

Industrial processes sector

The industrial processes sector includes greenhouse gas emissions where the process itself produces greenhouse gas emissions, e.g., aluminum and cement manufacturing; and fugitive emissions such as sulfur hexafluoride (SF₆) released from electric power transmission and distribution systems. Washington also produces small amounts of lime and nitric acid which are expected to have relatively low emissions due to their low levels of production; therefore, these estimates are excluded. In 2018, greenhouse gas emissions from the industrial processes sector contributed about 5 percent of Washington’s total greenhouse gas emissions.

Agriculture sector

Agricultural activities such as manure management, fertilizer use, and livestock digestion processes (enteric fermentation) result in methane and nitrous oxide emissions. In 2018, these agricultural emissions accounted for about 6.7 percent of Washington's total greenhouse gas emissions.

Multi- year Greenhouse Gas Averages

Because of the potential for annual data fluctuations in greenhouse gas emissions within sectors, it is useful to display the data as multi-year averages. These fluctuations may occur due to variations in hydro power and with the availability of more refined data or methodology modifications in the periodic releases of the EPA SIT modules.

Figure 9 presents a three-year averaging of greenhouse gas emissions from each sector. The inner circle displays the percent distribution of the sectors. The outer ring provides the percent distribution from each source within each sector.

The donut graph in Figure 9 also provides a visual overview of the predominant greenhouse gas sources in Washington State. These sources are:

1. Transportation, specifically on-road gasoline;
2. The Industrial component of the combined residential-commercial-industrial sectors, specifically natural gas and petroleum;
3. Coal in the electricity sector, which is expected to decline with reduced consumption of coal-sourced power.

Washington Greenhouse Gas Emissions
3-year Average (2016-2018)
 ~98.5 million metric tons of CO₂e

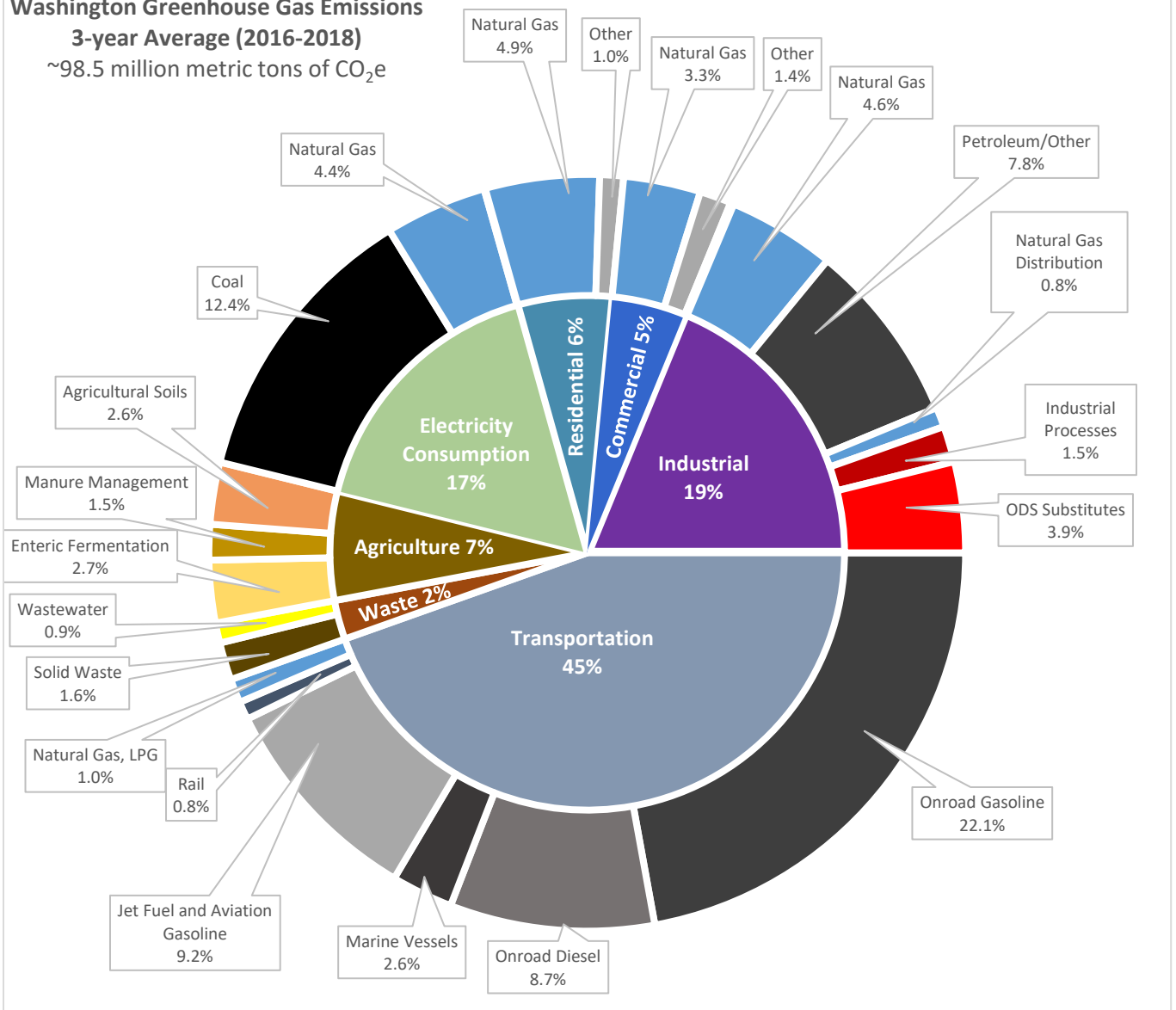


Figure 9: Washington GHG emissions, 3-year average (2016-2018) ~98.5 MMT CO₂e

Next Steps

The 2019 annual Washington greenhouse gas inventory will be completed with the release of the relevant U.S.EPA SIT modules, anticipated by the end of 2021. These data will be made available on Ecology's website as soon as the complete 2019 profile is available. The next legislative report on the Washington State Greenhouse Gas Inventory is scheduled for December 2022.

Conclusion

This inventory summarizes the greenhouse gas emissions from specific sectors in Washington from the 1990 baseline through 2018.

Key points are:

- Washington's 2018 total greenhouse gas emissions were 99.6 million metric tons (MMT).
- Washington's 2018 total greenhouse gas emissions were 9.1 MMT higher than the 1990 baseline.
- Compared nationally, the electricity sector in Washington contributes significantly lower greenhouse gas emissions because of the widespread use of hydropower. In 2018, emissions from Washington's electricity consumption decreased to 16.3 percent of total emissions.
- In 2018, Washington's largest contributors of greenhouse gases were:
 - Transportation sector at 44.9 percent.
 - Residential, commercial, and industrial space and/or process heating at 23.4 percent.
 - Electricity sector at 16.3 percent and anticipated to continue to decrease due to new 2019/2020 legislation.