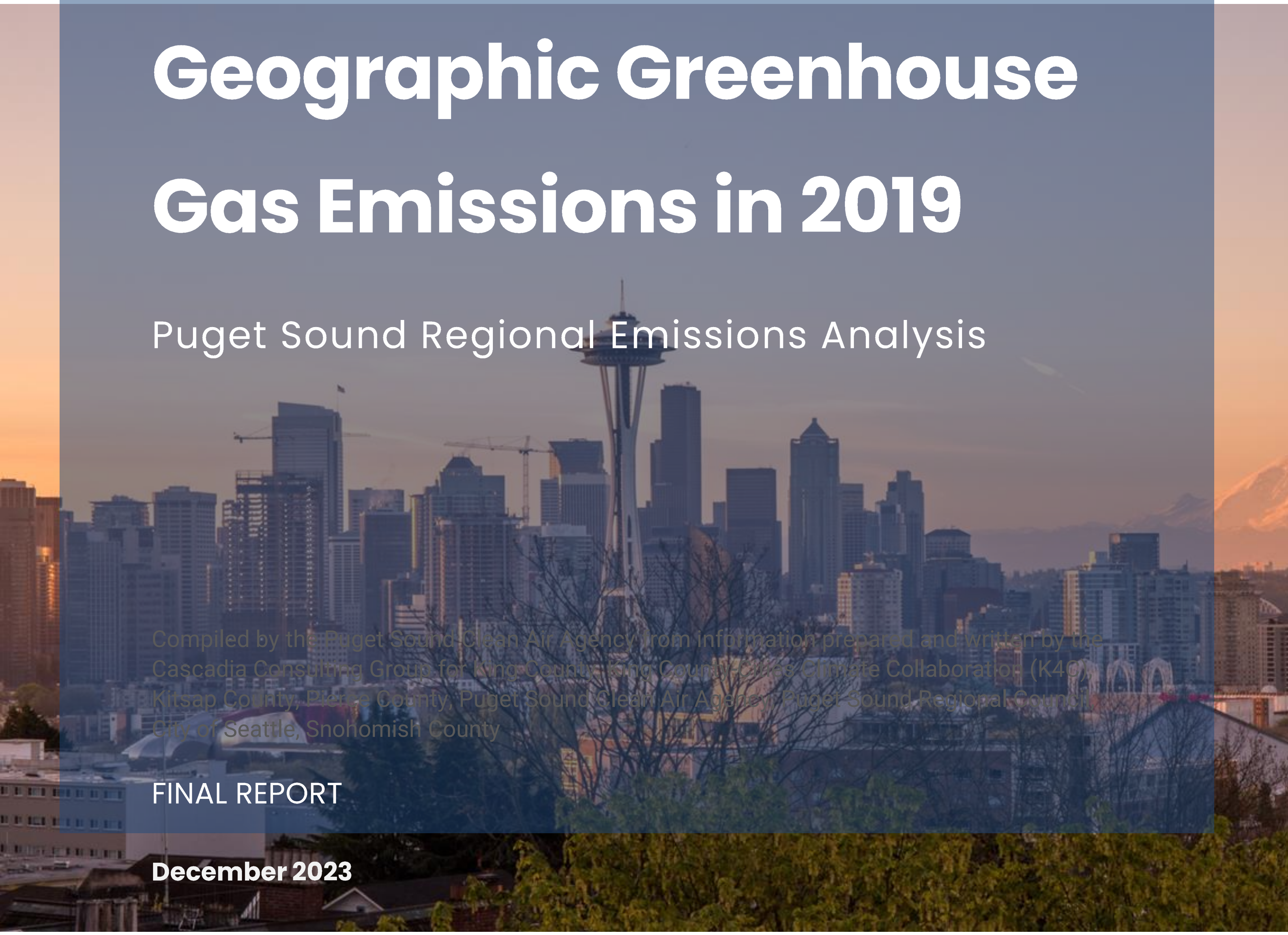
Puget Sound Geographic Greenhouse Gas Emissions in 2019



Puget Sound Regional Emissions Analysis

Compiled by the Puget Sound Clean Air Agency from information prepared and written by the Cascadia Consulting Group for King County, King County-Cities Climate Collaboration (K4C), Kitsap County, Pierce County, Puget Sound Clean Air Agency, Puget Sound Regional Council, City of Seattle, Snohomish County

FINAL REPORT

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Executive Summary

To avoid the most serious effects of climate change, all sectors of society need to reduce greenhouse gas (GHG) emissions. Quantifying and understanding the sources of GHGs is a critical step toward reducing GHG emissions and tracking progress toward emission reduction targets.

This report provides a comprehensive **update of King, Kitsap, Pierce, and Snohomish Counties' geographic GHG emissions for 2019**. This update includes the following additional analyses:

- An update of historical **trends** and **progress** toward the region's GHG emission reduction goals.
- **Contribution discussion** throughout examines the drivers of changes in emissions between 2015 and 2019.
- A **wedge analysis** that shows estimated emissions reductions from existing policies and additional reductions needed to meet PSCAA and WA State climate goals.

What is a geographic GHG emissions inventory?

A geographic GHG emissions inventory quantifies the annual emissions within the geographic boundaries due to community activities, such as on-road transportation or energy consumption. A geographic emissions inventory does not, however, account for upstream emissions from goods and services consumed within the community but produced outside of it, such as food grown and processed in another state, or furniture sourced and manufactured in another country.

What is a consumption-based GHG emissions inventory?

A consumption-based inventory (CBI) accounts for the emissions associated with goods and services consumed within the geographic area, regardless of where the goods or services were produced. For example, a CBI would include GHG emissions associated with raising livestock and processing the meat regardless of where it occurred, if the final product is consumed within the geographic area. Conversely, it doesn't account for emissions within the geographic area to the extent that the good or services produced are consumed outside of the geographic area.

Geographic Inventory Findings

- In 2019, residents, businesses, employees, and visitors produced 48 million metric tons of CO_2 equivalent in PSCAA's four-county area ($MMTCO_2e$; Figure 2 and Table 1).
- This equates to roughly 11.4 $MTCO_2e$ per capita in 2019 (Table 2).
- Total GHG emissions in 2019 increased 12% compared to the last inventory year, 2015 (Figure 2).
- Per-capita GHG emissions in 2019 increased 3.6% compared to 2015 (Figure 8).
- The largest GHG emissions sectors are on-road transportation (~24%), building electricity (~21%), and building natural gas (~14%) (Figure 5).

Figure 1. Sources of greenhouse gas emissions in 2019.

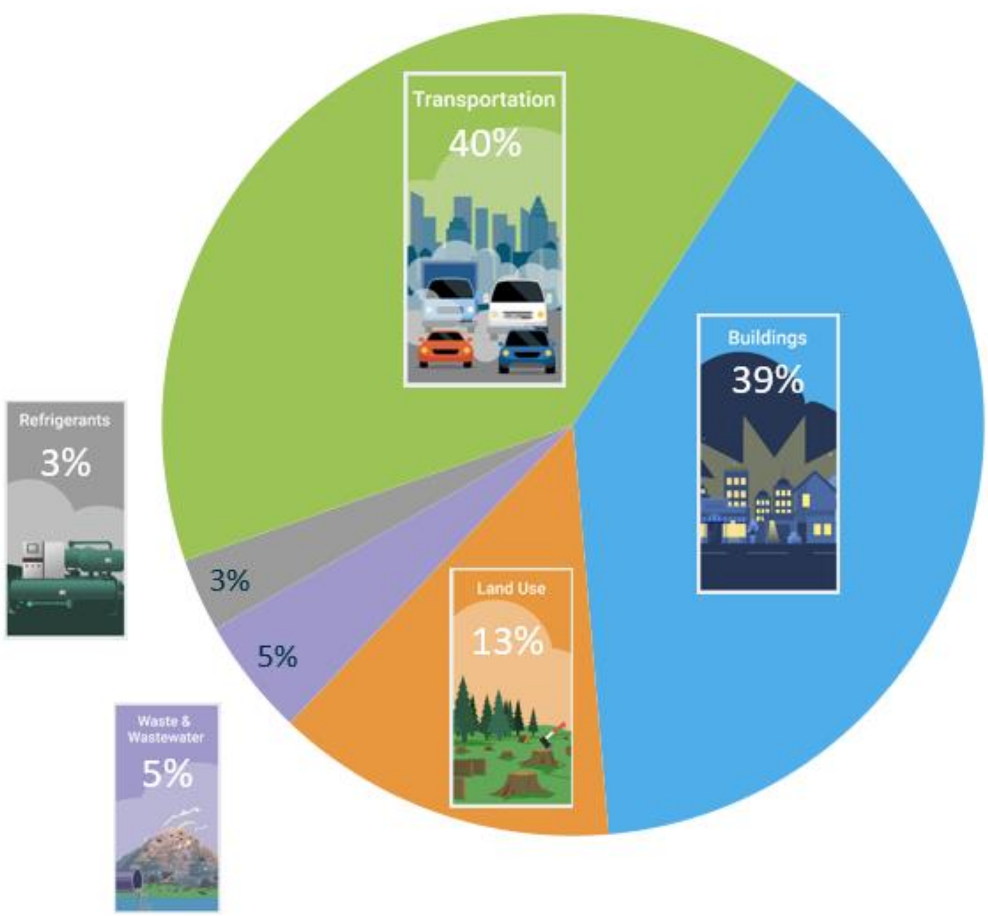


Figure 2. Total greenhouse gas emissions in 2015 and 2019, by sector.

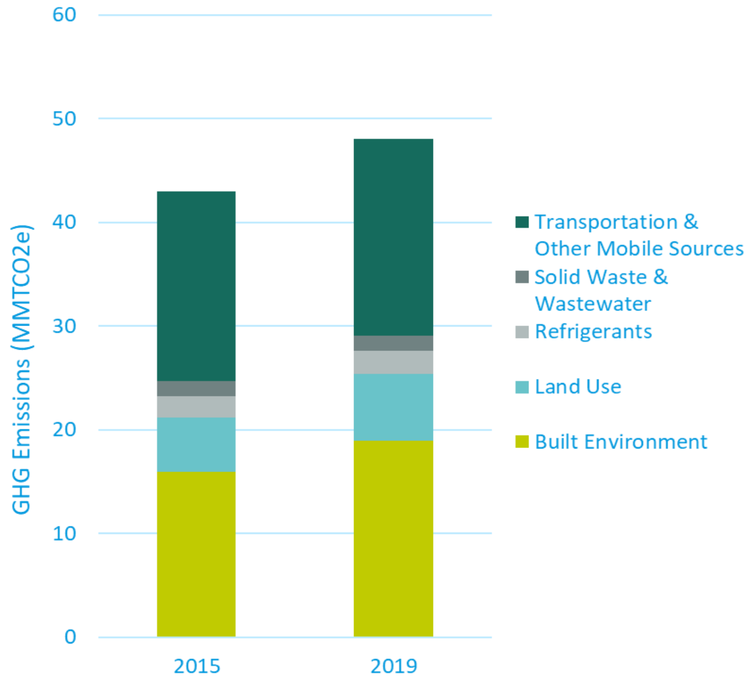
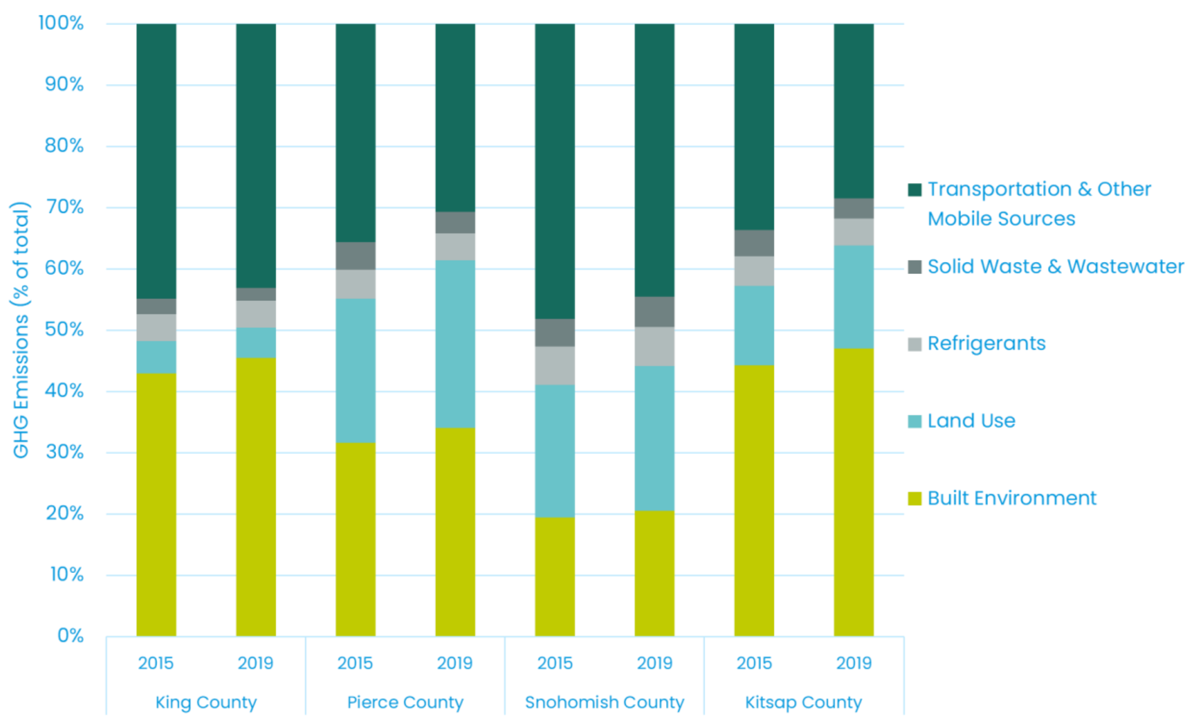


Figure 3. Relative contributions of greenhouse gas emissions in 2015 and 2019, by county and sector.



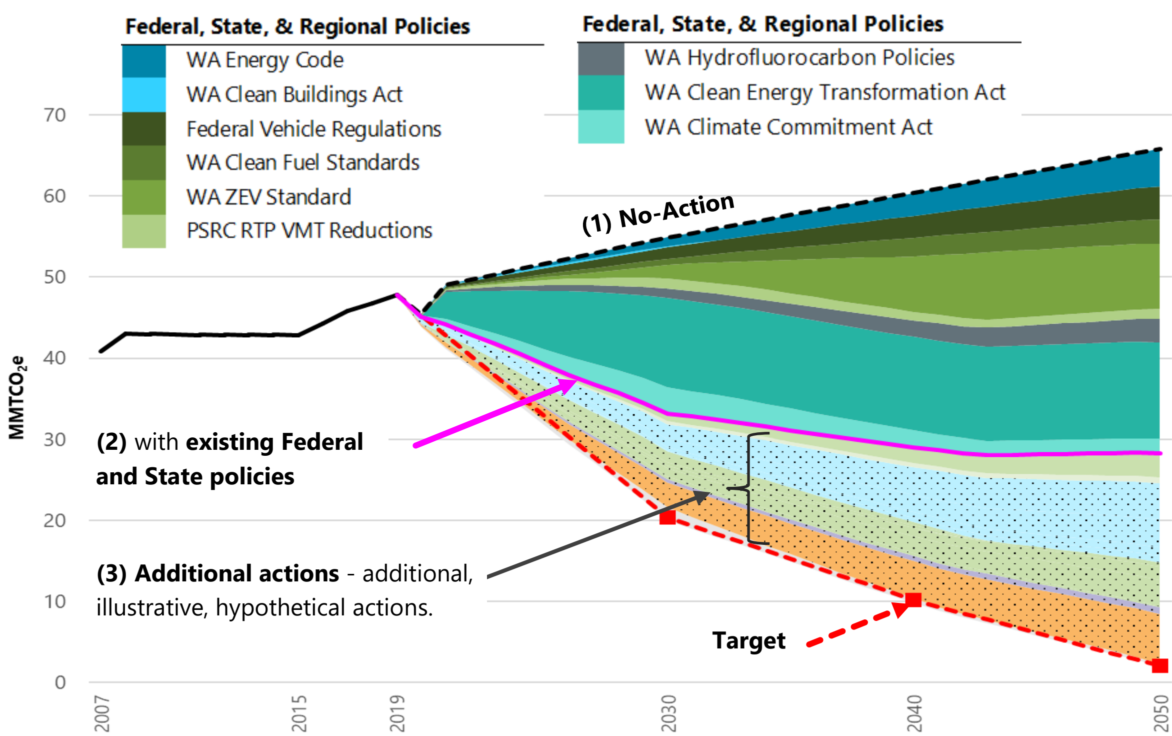
Wedge Analysis

The wedge analysis forecasts emissions from 2019 through 2050 under two scenarios: 1) no-action future; and 2) federal, state, and regional policies (and with some aviation and marine industry commitments). The emissions are geographic-based for PSCAA's four counties.

As depicted in Figure 4, action by industries, governments, businesses, and individuals will be needed to achieve the emissions targets. Specifically, the wedge analysis revealed the following projections compared to 1990 baseline GHG emissions levels:

- Under a **no-action future (1)**, we estimate that the four-county GHG emissions would increase 63% by 2050.
- **Existing federal, state, and regional policies (2)** will reduce the four-county GHG emissions by 35% by 2050 (45% with aviation + marine industry commitments)
- **Additional policies or actions (3)** would be needed to reach the PSCAA/WA State target of a 50% reduction by 2030, 70% reduction by 2040, and 95% reduction by 2050.

Figure 4. Forecasted emissions and reductions under three scenarios.



Acronyms

ACS	American iCommunity Survey
BAU	Business as usual
BOD	Biochemical oxygen demand (a metric of the effectiveness of wastewater treatment plants)
CO_2e	Carbon dioxide equivalent
CBI	Consumption-based inventory
ECA	Emission Control Area
eGRID	Emissions & Generation Resource Integrated Database
EIA	United States Energy Information Association
EPA	United States Environmental Protection Agency
FLIGHT	Facility Level Information on Greenhouse gases Tool
GHG	Greenhouse gas (limited to CO_2, CH_4, N_2O, and fugitive gases in this inventory)
HFCs	Hydrofluorocarbons, primarily as the key chemical in refrigerator, air conditioner, and heat pump operation
ICE(s)	Internal combustion engine(s)
ICLEI	ICLEI – Local Governments for Sustainability
kWh	Kilowatt-hour
LTO	Landing and takeoff
MOVES	Motor Vehicle Emission Simulator model (EPA official model for vehicle emissions)
MSW	Municipal solid waste
$MMTCO_2e$	Million metric tons of carbon dioxide equivalent
$MTCO_2e$	Metric tons of carbon dioxide equivalent
ODS	Ozone-depleting substances
PSCAA	Puget Sound Clean Air Agency
PSE	Puget Sound Energy
PSEI	Puget Sound Maritime Air Emissions Inventory
PSRC	Puget Sound Regional Council
USDA	United States Department of Agriculture
WARM	Waste Reduction Model (model developed by EPA to quantify solid waste emissions)
VMT	Vehicle Miles Travelled

Glossary of Terms

Carbon sequestration	The process of capturing and storing atmospheric carbon dioxide, often through organic forms such as trees and soils.
Enteric fermentation	Part of the digestive process in ruminant animals such as cattle, sheep, goats, and buffalo that emits methane, a potent greenhouse gas.
Fugitive emissions	Emissions of gases that are not intentional or necessarily tracked or known, and can include leaks from pipelines. Per U.S. EPA: "those emissions which could not reasonably pass through a stack, chimney, vent, or other functionally-equivalent opening" (U.S. EPA, 40 C.F.R. § 70.2 and 71.2)
Greenhouse gas (GHG)	A gas that strongly absorbs (and emits) infrared radiation (from the Earth's surface), thus trapping heat and causing the greenhouse effect. Primary greenhouse gases emitted by human activities are carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), and fluorinated gases (e.g., HFCs). Water vapor (H_2O) is also a main GHG, but human emissions have little direct impact on its concentration.
Global warming potential (GWP)	Global Warming Potential, the potential warming effect of a substance, relative to the same mass of carbon dioxide, usually for a 100-year timespan. A shorter period can also be considered, e.g. GWP-20 year for methane because it is much greater than the 100 year GWP.
Ozone-depleting substances	Compounds that contribute to stratospheric (high above the surface) ozone depletion, such as chlorofluorocarbons (CFCs) and hydrochlorofluorocarbons (HCFCs). Many of these compounds are being substituted with hydrofluorocarbons (HFCs) and perfluorocarbons (PFCs), which are not ozone depleting, but are still potent greenhouse gases.
Switchgear insulation	Gases or liquids used in large mechanical switches in high-voltage electricity transmission systems. Sulfur hexafluoride (SF_6), a potent greenhouse gas, is often used due to its excellent insulation properties.
therm	A unit of heat equal to 100,000 BTU
Upstream, and lifecycle, GHG emissions	Upstream emissions are those required for the production, processing, transmission, storage, and distribution of goods and services, beginning with the extraction of raw materials, and ending with the delivery of the goods and services to the site of use. Lifecycle emissions are the upstream emissions, plus the use emissions, and any post-use or disposal emissions.

Introduction

GHG inventories allow communities to account for sources and quantities of GHG emissions caused by community activities. A geographic inventory addresses the emissions within a community's boundaries plus emissions outside of its boundaries due to certain activities, primarily electricity consumption and waste disposal. The main "in-boundary" emission sectors are: building and vehicle energy use, wastewater and solid waste processing, industrial processes, and land-use practices. For example, this includes emissions due to the in-county *production* of food and goods, regardless of where those goods are consumed, including exported. The "out-of-boundary" activities that are included are limited to the emissions from generating electricity that is consumed "in-boundary", and from the disposal of waste (e.g. transporting) outside of the geographic area.

This inventory report includes a new geographic inventory for 2019, as well as an updated 2015 inventory to reflect methodology improvements conducted for the 2019 inventory.

Roadmap of this Report

This report is organized into the following sections:

- **Where Do Emissions Come From?** The methodologies and results for the geographic-plus inventory.
- **How Can We Meet Local Climate Goals?** Includes a "wedge analysis" that shows estimated emissions reductions from existing policies and additional reductions needed to meet regional climate goals.
- **Appendix A. Inventory Methodology** provides a detailed summary of the geographic inventory methodology, including key data sources and assumptions.

From Where Do Our Emissions Come?

Geographic Inventory Approach

The 2019 GHG emissions inventory was prepared in accordance with the *U.S. Community Protocol for Accounting and Reporting of Greenhouse Gas Emissions* and the *Global Protocol for Community Scale Greenhouse Gas Emission Inventories (ICLEI 2013)*. Inventory data was gathered for the 2019 calendar year. It accounts for emissions from the activities of the four PSCAA counties' residents, businesses, employees, and visitors within or originating from within the county boundaries. This inventory does not include "upstream" GHG emissions related to the consumption of goods and services; those sources are estimated in the Consumption Inventory, which is complementary to this inventory.

Geographic Inventory Sectors & What's Included	
Transportation	Driving within the counties, flights from county travelers, maritime/rail travel, non-road vehicle and equipment use
Building Energy	Residential, commercial, and industrial electricity and natural gas use and associated loss and leakage, residential fuel oil and propane, and industrial processes
Solid Waste & Wastewater	Solid waste generation and disposal and wastewater processes
Refrigerants	Fugitive emissions of high GWP refrigerants (chemicals) used in air conditioners, refrigerators, and heat pumps.
Land Use	Agriculture and tree cover loss
Sequestration	Solid waste disposal sequestration and sequestration from trees and forests

What are geographic and consumption-based GHG emissions inventories?

A community-wide **geographic** GHG emissions inventory quantifies the annual emissions within community boundaries due to community activities, such as transportation and building heat. A geographic emissions inventory does not account for upstream emissions from producing the goods and services that are consumed within the community.

This is different from a **consumption-based** inventory (CBI), which provides an inventory of the GHG emissions associated with consumption of food and goods within the community, regardless of where the goods were produced. For example, a CBI would not include GHG emissions from a local manufacturer producing goods that are consumed entirely outside the community. But it would include GHG emissions due to producing goods manufactured in another community and consumed within our region.

The geographic and consumption-based inventories provide different insights about GHG emissions of a community. A community may consume electricity generated from low-emission sources, but also consume goods produced in another community with high-emission electricity. The two inventories can account for these differences to paint a comprehensive picture of community emissions.

Geographic Inventory Summary

- In 2019, residents, businesses, employees, and visitors produced 48 million metric tons of CO_2 equivalent ($MMTCO_2e$) in PSCAA's four-county area (Table 1).
- This equates to roughly 11.4 $MTCO_2e$ per capita in 2019 (Table 2).
- Total GHG emissions in 2019 increased 12% compared to the last inventory year (2015; Figure 6).
- Per-capita GHG emissions in 2019 increased 3.6% compared to 2015 (Figure 8).
- The largest GHG emissions sources are on-road transportation (~24%), building electricity (~21%), and building natural gas (~14%) (Figure 5).

Figure 5. Pie chart of GHG emissions sources for PSCAA counties in 2019

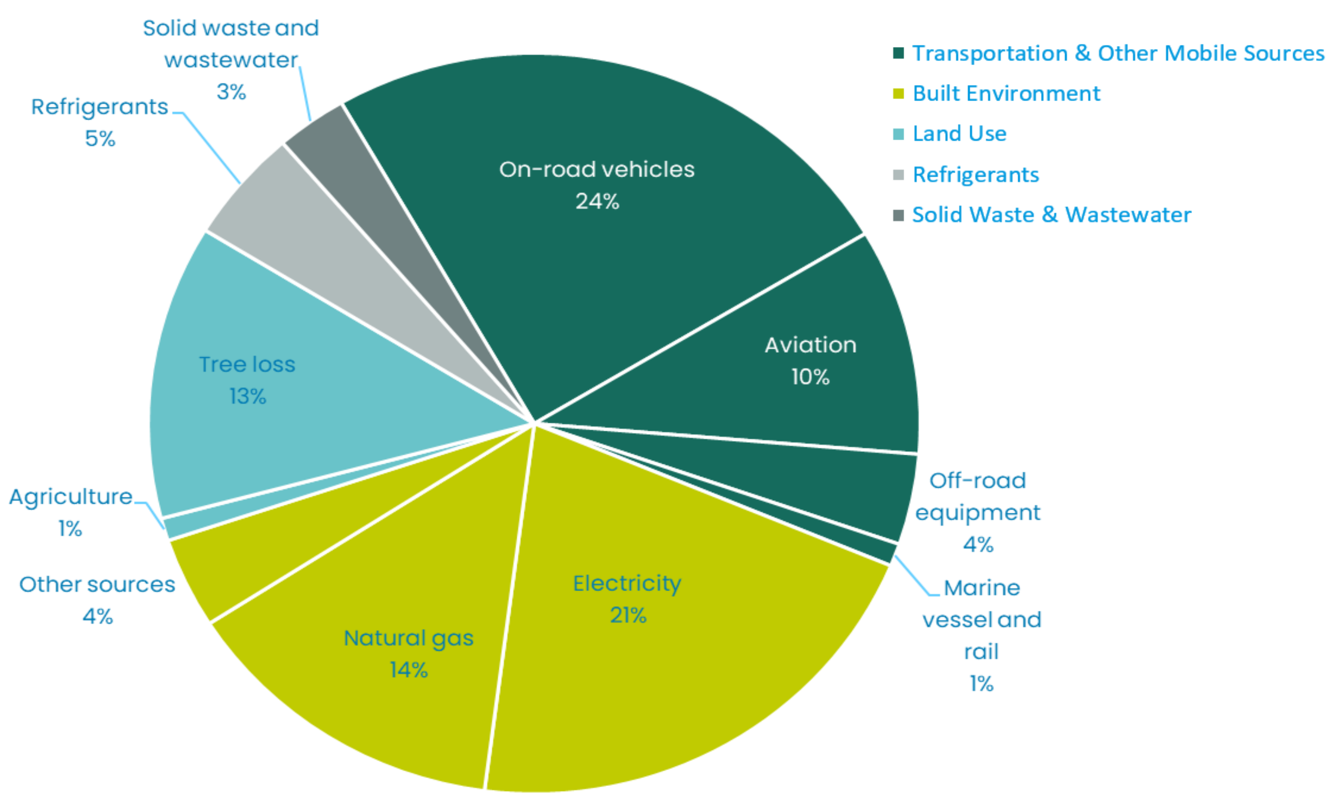


Figure 6. Greenhouse gas emissions by county and sector, for 2015 and 2019.

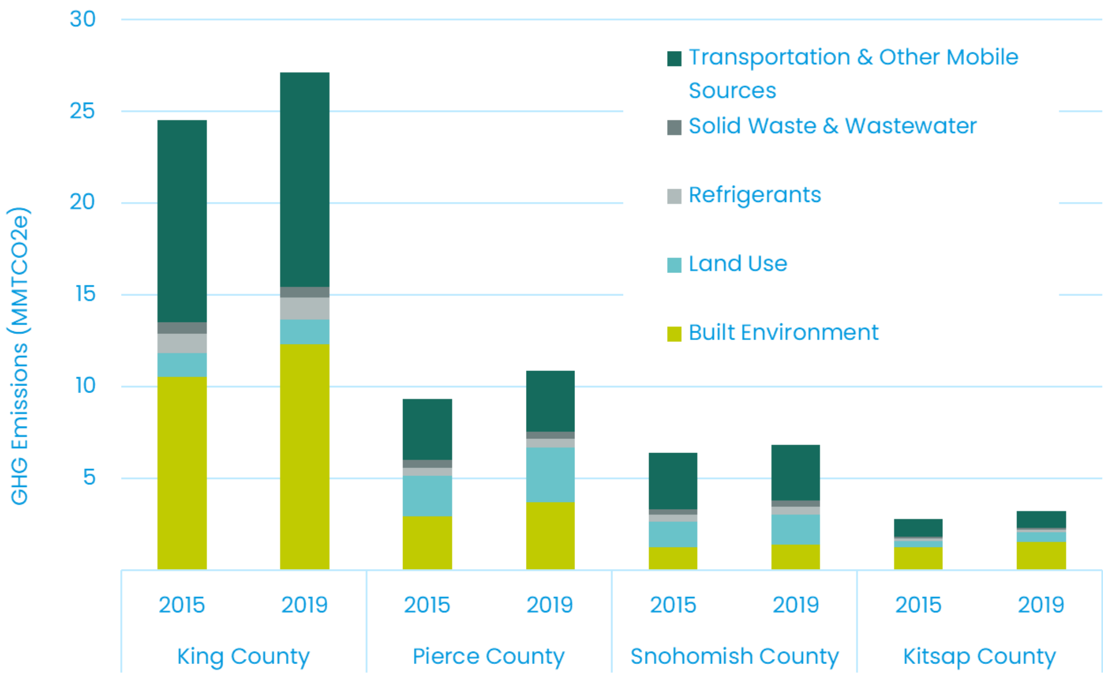


Figure 7. Sector percent of total GHG emissions, by county, for 2015 and 2019.

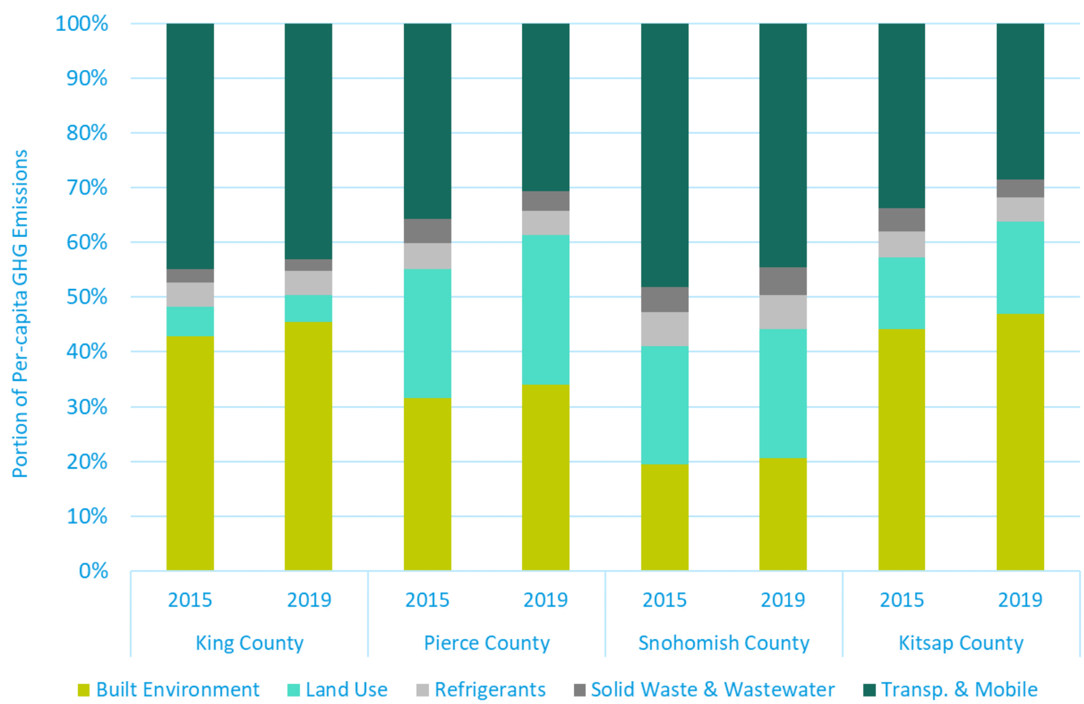


Figure 8. Per-capita GHG emissions, by county and sector, for 2015 and 2019.

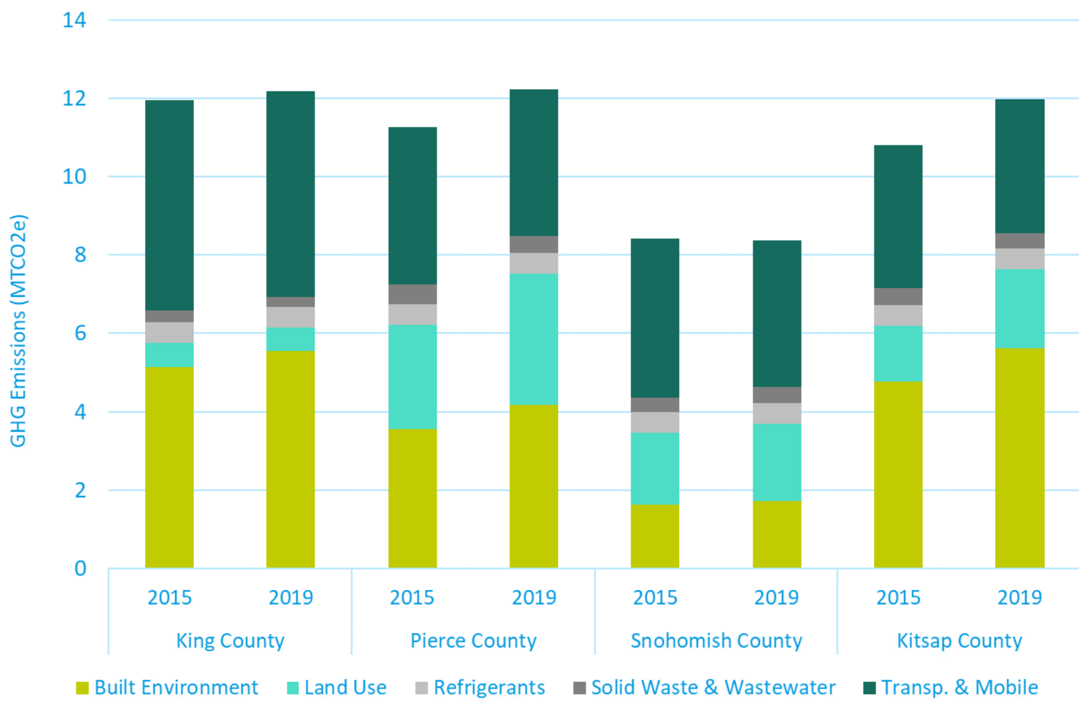


Table 1. PSCAA Counties 2019 GHG emissions, by county and sector.

GHG Emissions by Sector (MTCO2e)	King County	Pierce County	Snohomish County	Kitsap County	Total
Built Environment	**12,336,188**	**3,697,758**	**1,406,787**	**1,517,808**	**18,958,541**
Electricity	**7,109,886**	**1,551,948**	**147,356**	**1,175,620**	**9,984,810**
Commercial	3,608,823	580,325	51,522	424,904	4,665,574
Industrial	641,667	220,406	13,916	5,689	881,678
Residential	2,859,396	751,217	81,918	745,027	4,437,558
Natural gas	**4,110,659**	**1,514,712**	**1,064,127**	**258,151**	**6,947,649**
Commercial	1,441,544	447,907	324,877	134,934	2,349,262
Industrial	701,922	422,019	138,607	4,985	1,267,533
Residential	1,967,193	644,786	600,643	118,232	3,330,854
Other sources	**1,115,643**	**631,098**	**195,304**	**84,037**	**2,026,082**
Fuel oil	334,738	62,535	56,763	27,917	481,953
Industrial processes	668,383	519,097	37,885	1,377	1,226,742
Residential propane	112,522	49,466	100,656	54,743	317,387
Transportation & Other Mobile Sources	**11,683,116**	**3,333,435**	**3,052,659**	**920,711**	**18,989,921**
On-road vehicles	**6,470,836**	**2,506,507**	**2,294,251**	**619,457**	**11,891,051**
Passenger vehicles	5,119,314	2,070,016	1,874,559	538,664	9,602,553
Freight & service vehicles	1,201,724	416,807	408,960	75,040	2,102,531
Transit vehicles	149,798	19,684	10,732	5,753	185,967
Aviation	**3,998,546**	**304,802**	**327,239**	**100,672**	**4,731,259**
Off-road equipment	**1,016,406**	**378,224**	**335,284**	**99,071**	**1,828,985**
Marine vessels and rail	**197,328**	**143,902**	**95,885**	**101,511**	**538,626**
Solid Waste & Wastewater	**564,503**	**388,415**	**338,755**	**105,831**	**1,397,504**
Solid waste generation & disposal	**513,096**	**338,607**	**254,433**	**86,781**	**1,192,917**
Landfill	465,699	301,296	228,881	83,496	1,079,372
Compost	47,397	37,311	25,552	3,285	113,545
Wastewater process emissions	**51,407**	**49,808**	**84,322**	**19,050**	**204,587**
Refrigerants	**1,185,036**	**472,512**	**435,490**	**143,674**	**2,236,712**
Refrigerants	**1,185,036**	**472,512**	**435,490**	**143,674**	**2,236,712**
Land Use	**1,341,477**	**2,974,912**	**1,611,977**	**544,333**	**6,472,699**
Tree Loss	**1,220,000**	**2,930,000**	**1,410,000**	**538,000**	**6,098,000**
Agriculture	**121,477**	**44,912**	**201,977**	**6,333**	**374,699**
Total Emissions	**27,110,320**	**10,867,032**	**6,845,668**	**3,232,357**	**48,055,377**

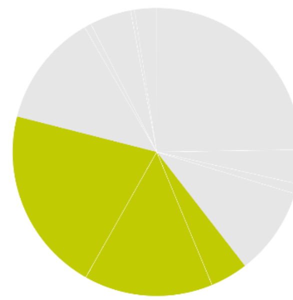
Table 2. Per-capita geographic GHG emissions in 2019, by county, sector, and sub-sectors.

Per Capita GHG Emissions by Sector (MTCO2e/capita)	King County	Pierce County	Snohomish County	Kitsap County
Built Environment	**5.5**	**4.2**	**1.7**	**5.6**
Electricity	**3.2**	**1.7**	**0.2**	**4.4**
Commercial	1.6	0.7	0.1	1.6
Industrial	0.3	0.2	0.0	0.0
Residential	1.3	0.8	0.1	2.8
Natural gas	**1.8**	**1.7**	**1.3**	**1.0**
Commercial	0.6	0.5	0.4	0.5
Industrial	0.3	0.5	0.2	0.0
Residential	0.9	0.7	0.7	0.4
Other sources	**0.5**	**0.7**	**0.2**	**0.3**
Fuel oil	0.2	0.1	0.1	0.1
Industrial processes	0.3	0.6	0.0	0.0
Residential propane	0.1	0.1	0.1	0.2
Transportation & Other Mobile Sources	**5.2**	**3.8**	**3.7**	**3.4**
On-road vehicles	**2.9**	**2.8**	**2.8**	**2.3**
Passenger vehicles	0.5	0.5	0.5	0.3
Freight & service vehicles	2.3	2.3	2.3	2.0
Transit vehicles	0.1	0.0	0.0	0.0
Aviation	**1.8**	**0.3**	**0.4**	**0.4**
Off-road equipment	**0.5**	**0.4**	**0.4**	**0.4**
Marine vessels and rail	**0.1**	**0.2**	**0.1**	**0.4**
Solid Waste & Wastewater	**0.3**	**0.4**	**0.4**	**0.4**
Solid waste generation & disposal	**0.2**	**0.4**	**0.3**	**0.3**
Landfill	0.0	0.0	0.0	0.0
Compost	0.2	0.3	0.3	0.3
Wastewater process emissions	**0.0**	**0.1**	**0.1**	**0.1**
Refrigerants	**0.5**	**0.5**	**0.5**	**0.5**
Refrigerants	**0.5**	**0.5**	**0.5**	**0.5**
Land Use	**0.6**	**3.3**	**2.0**	**2.0**
Tree Loss	0.5	3.3	1.7	2.0
Agriculture	0.1	0.1	0.2	0.0
Total Emissions	**12.2**	**12.2**	**8.4**	**12.0**

Inventory by Sector

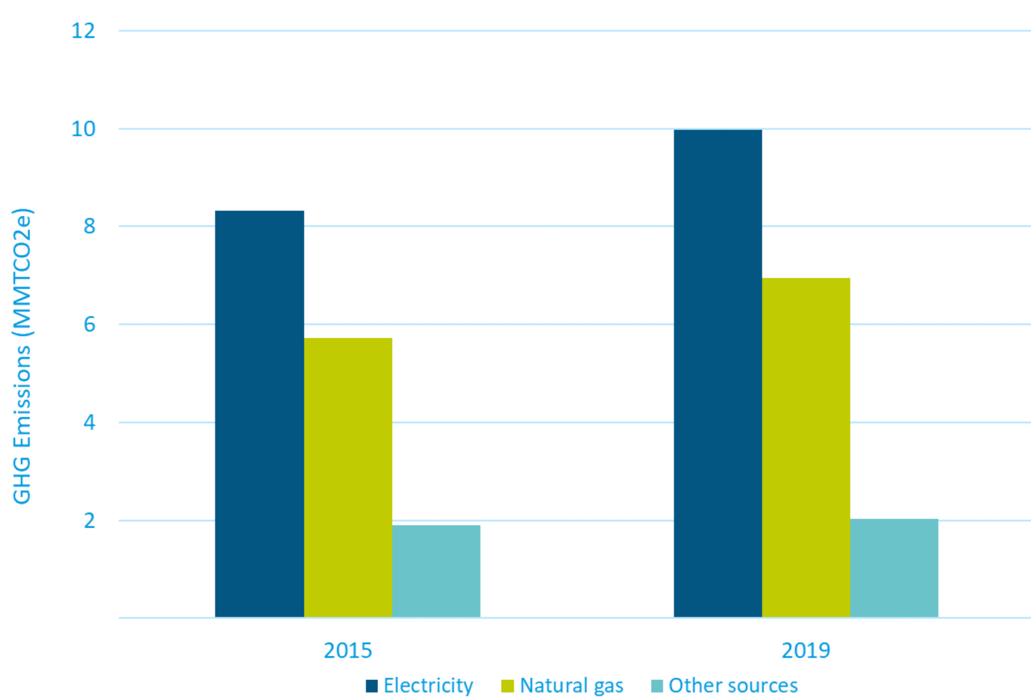
Built Environment

Summary



- In 2019, the built environment accounted for 39% of all emissions.
- Emissions from electricity and natural gas accounted for 90% of built environment emissions or 35% of all emissions in 2019.
- Built environment emissions in 2019 increased 19% since 2015.
- Industrial process emissions account for 3% of total community-wide emisions in 2019, and have increased 19% since 2015.

Figure 9. Built Environment GHG emissions in 2015 and 2019, by sector.



Electricity

The utilities serving a county play a large role in driving GHG emissions. Snohomish County's electricity is delivered through Snohomish County Public Utility District (PUD); King County's electricity is delivered through two energy providers: Seattle City Light (SCL) and Puget Sound Energy (PSE); Pierce County's electricity is delivered through four major electric utilities and several smaller utilities; the four included in this inventory are Puget Sound Energy (PSE), Tacoma Power, Peninsula Light Company (PLC), and Lakeview Light & Power (LLP); and Kitsap County's electricity is delivered through Puget Sound Energy (PSE).

Electricity accounted for 21% of total community-wide GHG emissions in 2019. Electricity emissions in 2019 increased 20% since 2015 (Figure 10). These changes can be attributed to changes in electricity consumption (Figure 12) and the carbon intensity (emissions per unit of energy produced) of utility fuel sources (Figure 13). For example, in Pierce County, even though commercial electricity consumption decreased during this period, commercial electricity emissions increased, due in part to the increased carbon intensity of PSE's electricity fuel mix. In Figure 13, LLP refers to Lakeview Light & Power, PLC is Peninsula Light Company, PSE is Puget Sound Energy, SCL is Seattle City Light, SNO is Snohomish County Pubilc Utility District, and TP is Tacoma Power.

Figure 10. Electricity GHG emissions in 2015 and 2019, by sector.

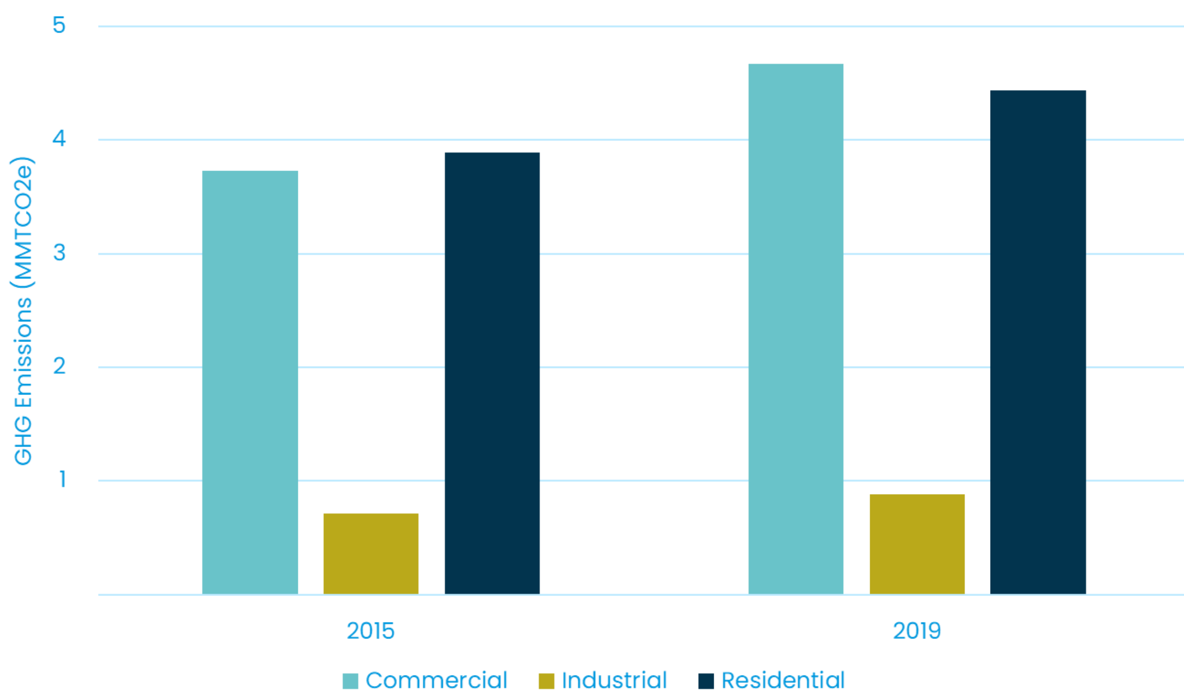


Figure 11. Electricity GHG emissions for 2019, by county and sector.

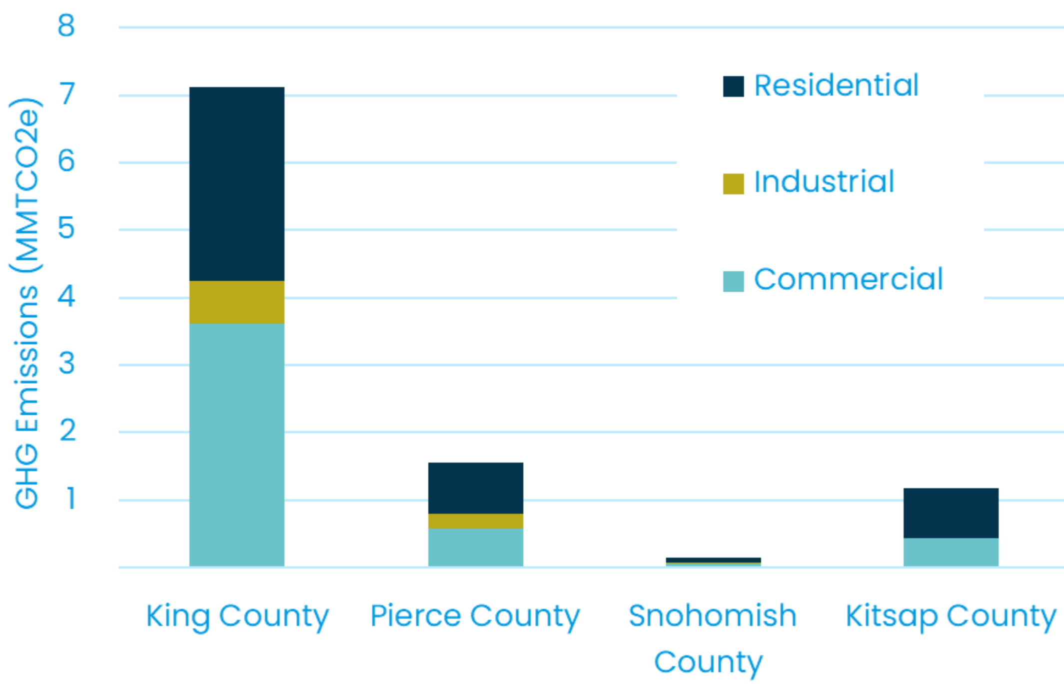


Figure 12. Electricity energy consumption in 2015 and 2019, by county and sector.

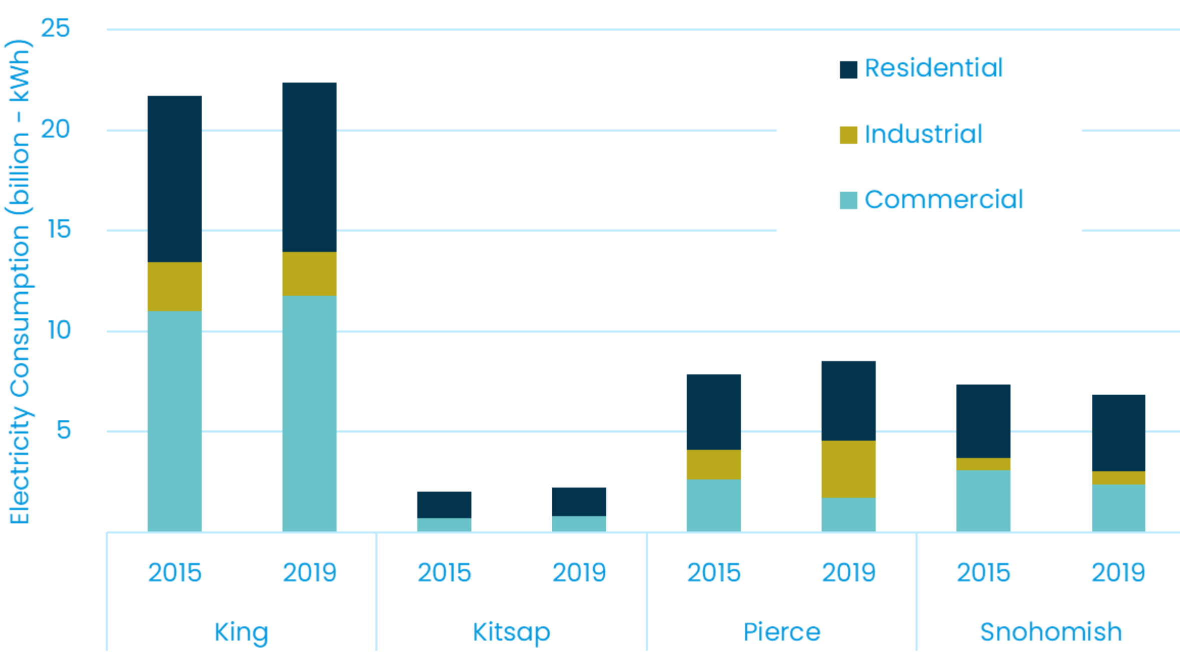
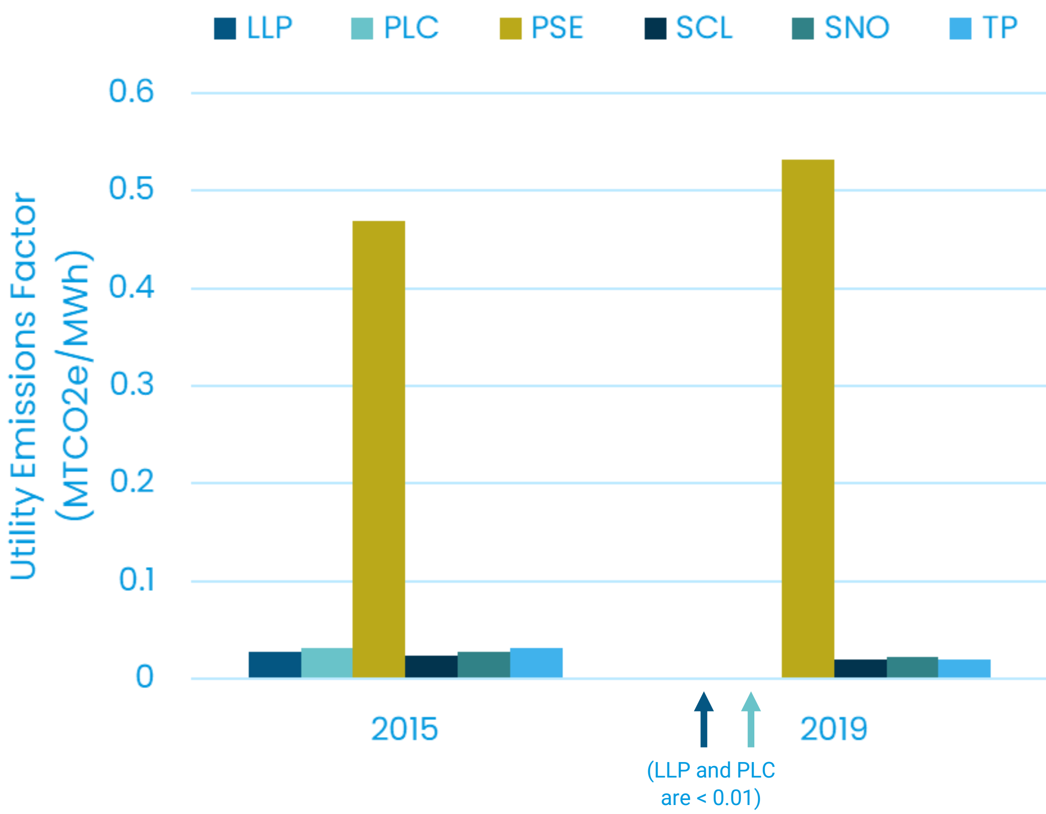


Figure 13. Electricity carbon intensities for the major electric utilities in the four counties.



Natural Gas

King, Pierce, and Snohomish Counties' natural gas is delivered by Puget Sound Energy (PSE) and Kitsap County's natural gas is delivered by Cascade Natural Gas (CNG). Natural gas accounted for 14% of the total community-wide GHG emissions in 2019. Natural gas emissions in 2019 increased 21% since 2015 (Figure 14). This change was due to an increase in the emission factor, along with other likely factors including consumer behavior, changes in average home size, and changes to building and equipment efficiency. Additionally, a colder winter in 2019 likely contributed to the increased demand for heating.

Figure 14. Natural gas systems' GHG emissions in 2015 and 2019, by sector.

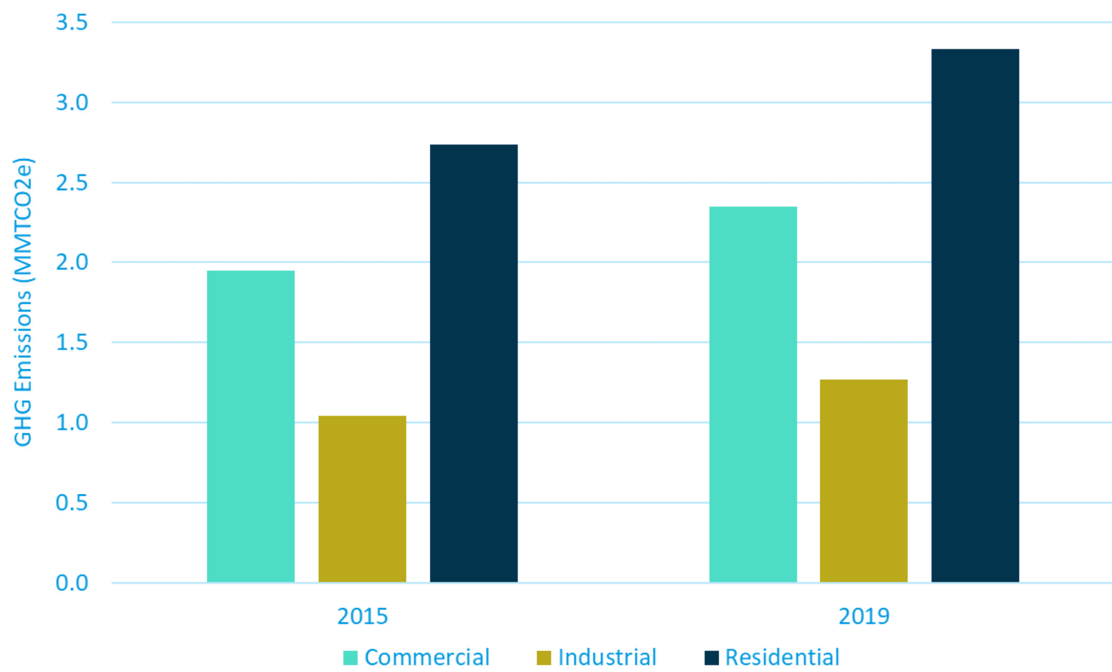
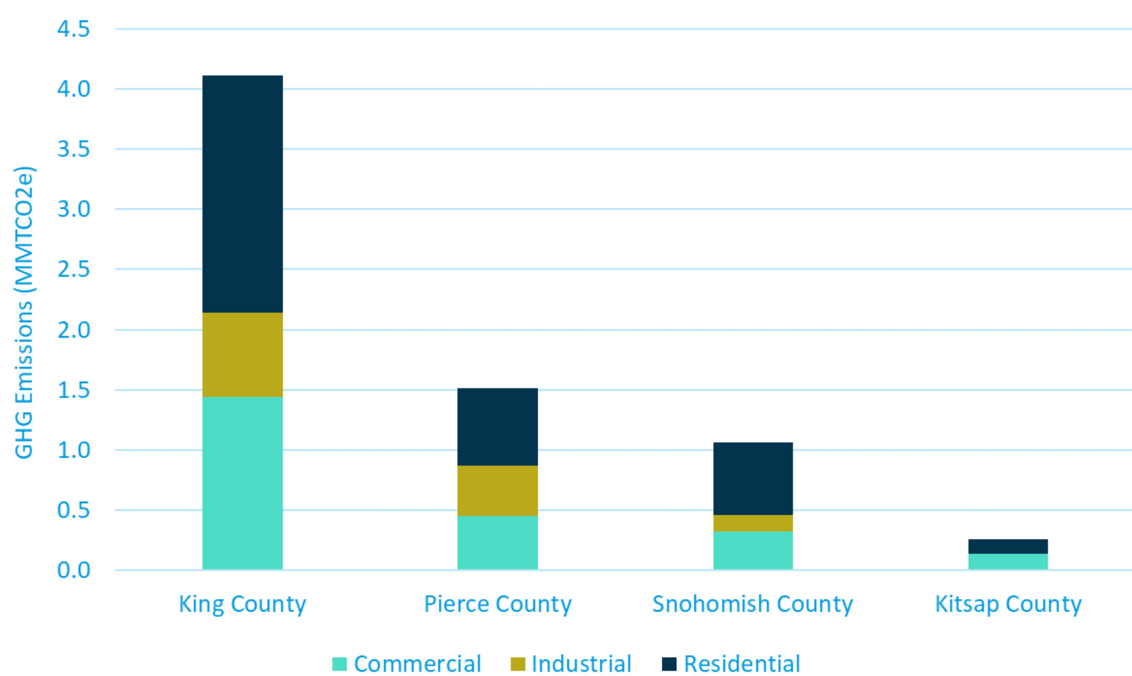


Figure 15. Natural gas systems' GHG Emissions by county and sector in 2019.



Other Sources

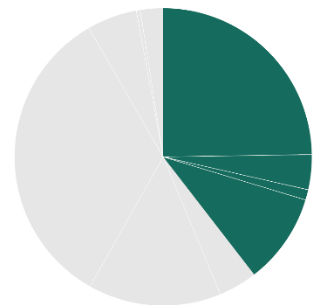
Other sources of emissions from buildings and energy include emissions from fuel oil, residential propane, and industrial processes. These other sources account for about 4% of the 2019 inventory.

Fuel oil emissions in 2019 decreased 26% from 2015, consistent with a decrease in the overall consumption of fuel oil in Washington state. This is likely due to weatherization and conversions to natural gas and heat pumps.

Residential propane emissions, however, increased 50% in 2019 compared to 2015. This change is consistent with an increase (+44%) in propane sales across the West Coast, as well as an 8% increase in the number of houses that use propane heating in Snohomish and Pierce Counties. Residential propane is still uncommon, so emissions from this sector are small, accounting for about 1% of total emissions.

Industrial process emissions in 2019 increased 19% compared to 2015; however, the pattern was different for each county. Industrial process emissions increased 41% in Snohomish County due to an increase in industrial emissions from two out of the three industrial facilities in the county. These emissions decreased 40% in Kitsap County due to a substantial decrease (-83%) in industrial emissions from the county's highest emitting facility. In Pierce County, there was an increase of 48% emissions due to a substantial (+227%) increase in industrial process emissions from the county's highest emitting facility. This increase was offset by a decrease in emissions from other county facilities. In King County, there was a slight increase of 2% in industrial processes emissions.

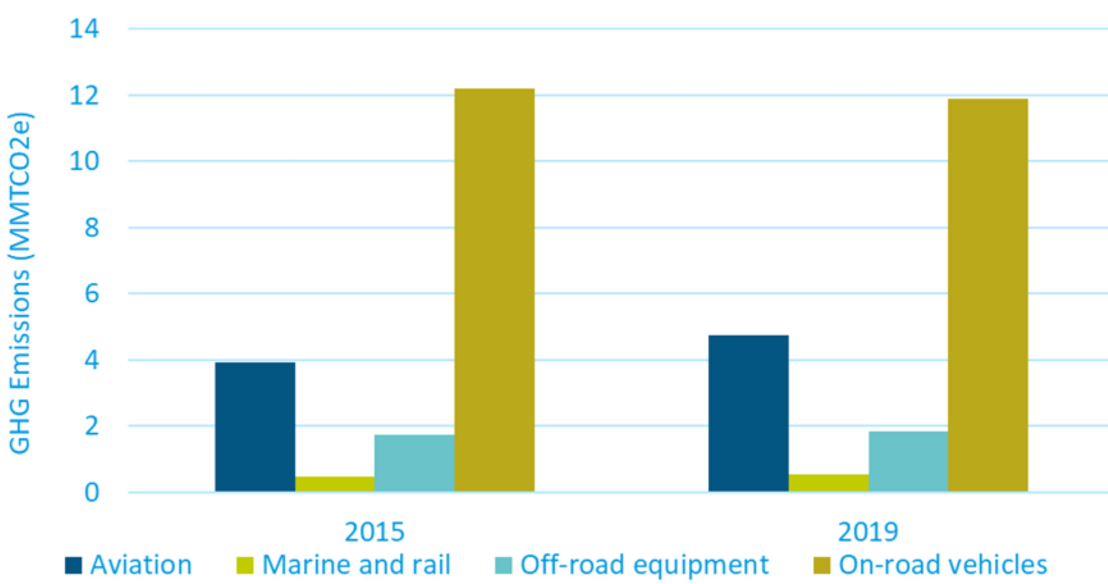
Transportation



Summary

- In 2019, transportation accounted for 40% of community-wide emissions.
- Emissions from onroad passenger and freight travel accounted for most of those emissions (Figure 18) and 24% of *all* emissions in 2019.
- Total onroad passenger vehicle transportation emissions in 2019 are estimated to have decreased 3% since 2015. Emissions from freight and service vehicle transportation have increased 12% since 2015.
- Transportation emissions in 2019 increased 3.6% since 2015. Contributors to this increase include population and economic growth, which was partially offset from vehicle fuel efficiency improvements, and reductions in VMT/capita.
- Aviation emissions in 2019 accounted for 10% of total community-wide emisions and have increased 20% since 2015.

Figure 16. Transportation GHG emissions in 2015 and 2019, by sector.



Onroad Transportation

Onroad transportation emissions include those from passenger vehicles, freight trucks, and transit vehicles within the county boundary. Onroad tranportation activities accounted for 25% of all GHG emissions in 2019. Total onroad emissions in 2019 decreased 3% since 2015 (Figure 17). These changes are driven by passenger vehicle fuel economy improvements.

Figure 17. Onroad transportation GHG emissions in 2015 and 2019, by sector.

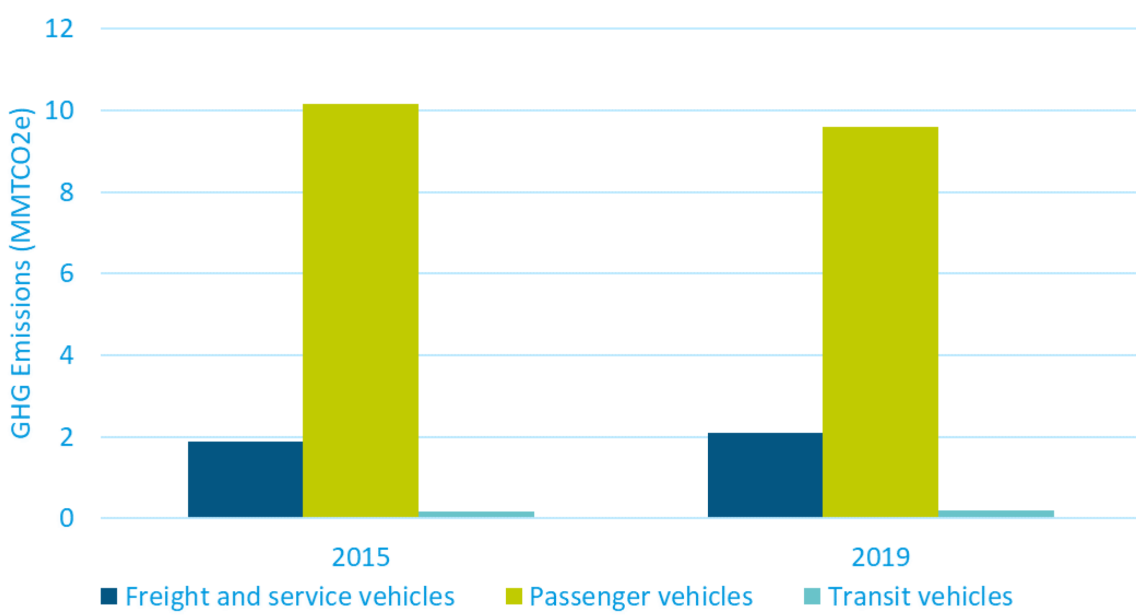
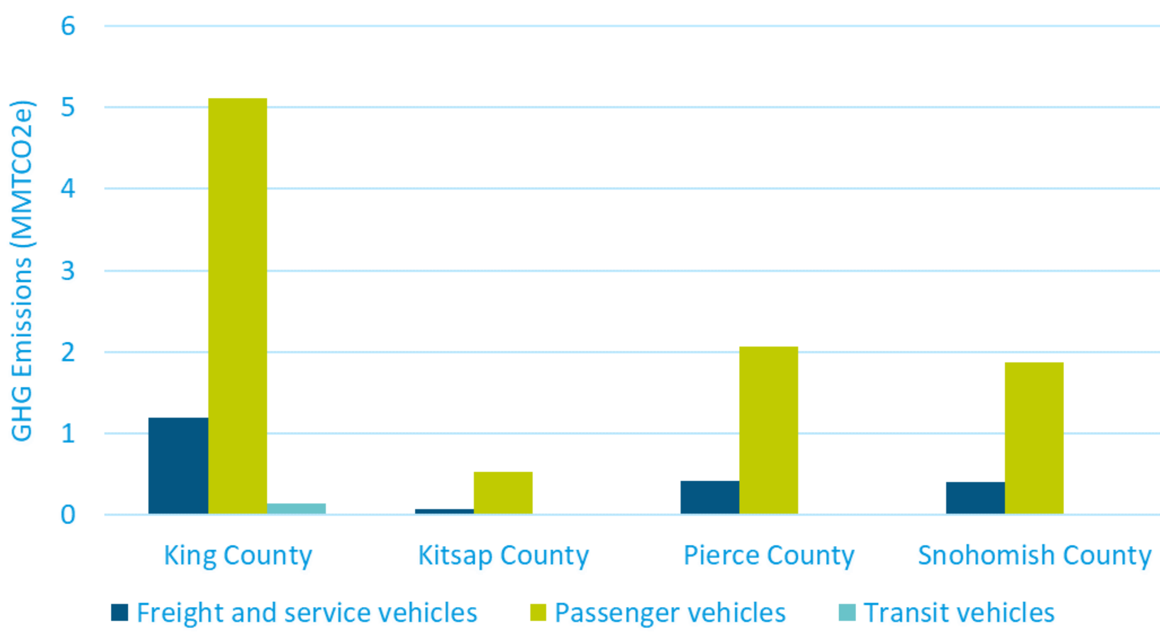


Figure 18. Onroad transportation GHG emissions for 2019, by county and sector.



Aviation Emissions

Aviation emissions come from fuel burned to power commercial aircraft. Attributing aviation emissions to a particular geography is challenging because aviation fuel is often burned outside the geographic boundary of the county. To provide a more comprehensive assessment of GHG emissions associated with air travel to and from the four PSCAA Counties, four separate approaches were used as part of this project to quantify the impact of this sector:

- A **Landing and Take-Off (LTO)** analysis. This is an historic approach based on early estimates that for many domestic flights, about 10% of the fuel was used for taxiing, take-off, landing, and a limited portion of the ascent and decent within about 10 miles of the airport. Thus, this corresponds to roughly the emisisons within the geographic area of the airport.
- A **passenger-based approach**. This looks at all aviation fuel dispensed in the Puget Sound region and attributes a portion to PSCAA Counties residents or visitors.

- **All fuels** dispensed at airports located within PSCAA Counties, regardless of the user, the location of use, or the purpose.
- A **consumption-based approach**. This estimates aviation emissions attributable to PSCAA Counties residents activities, that occur anywhere in the world. This excludes some work travel, and travel associated with residents that live outside the PSCAA Counties.

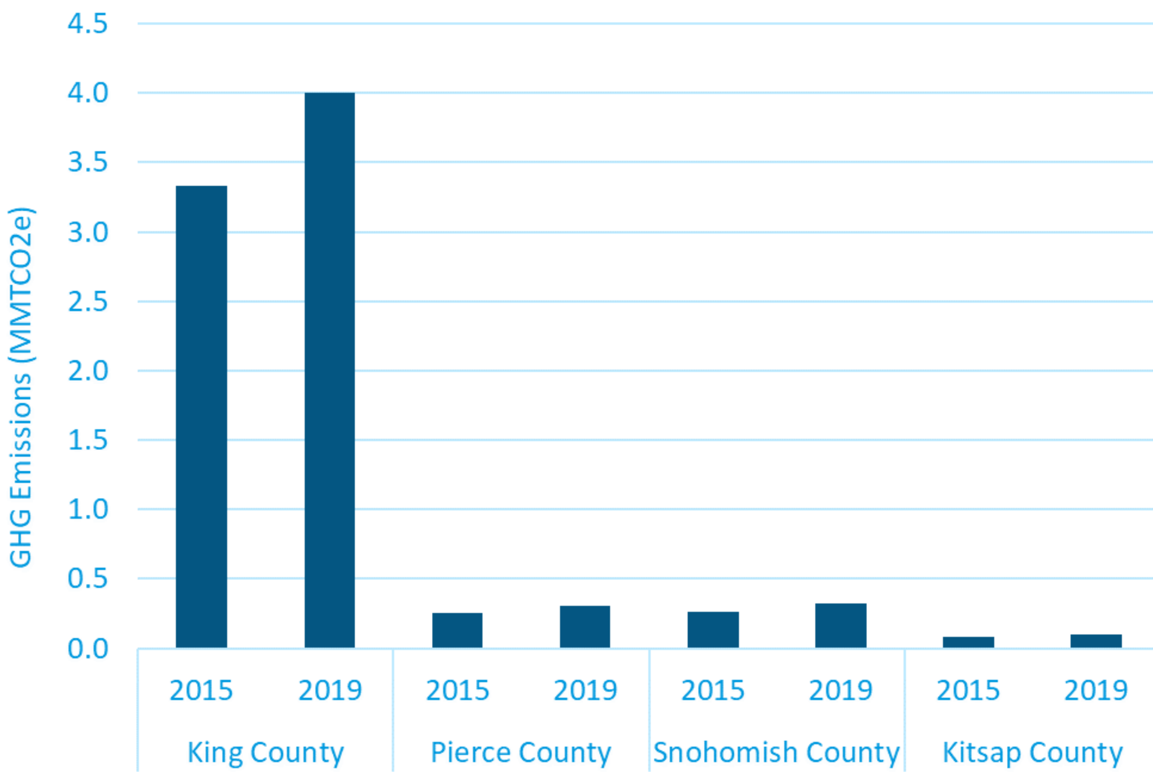
A summary of GHG emissions for each methodology is included in Table 3 below.

Table 3. Aviation sector GHG emissions for 2019, by inventory method.

Method	Summary	Total Emissions ($MTCO_2e$)			
		King	Pierce	Snohomish	Kitsap
Landing and takeoff (LTO) only	**Local emissions associated with airplane takeoff and landing (10% of total dispensed)**	678,000	486	**	**
Passenger-based	**Total attributable to County residents, employees, and visitors**	3,999,000	305,000	327,000	101,000
All fuels	**All fuels dispensed at local airports**	6,783,000	4,860	**	**
Consumption-based	**Personal air travel by County residents**	1,700,000	464,000	471,000	152,000
** indicates no data were obtained from local airports so these values are unknown. See the appendix for the list of airports included.					

Using the passenger-based method, aviation is estimated to have accounted for 10% of the total communitywide GHG emissions in 2019. Findings using this method are presented in the summary graphics for this inventory because they more comprehensively reflect GHG emissions associated with air travel due to County resident and business activities. In 2019, aviation emissions increased 20% from 2015, driven by a combination of population and economic growth.

Figure 19. Aviation GHG emissions in 2015 and 2019 using the passenger-based estimation method.



Other Sources

The remaining 5% of transportation emissions are from marine vessels, freight and passenger rail, and non-road vehicles and equipment.

The non-road vehicles and equipment categories included in this inventory are recreational, construction, industrial, lawn/garden, agriculture, commercial, logging, airport support, oil field, pleasure craft, and railroad. Emissions from non-road vehicles and equipment in 2019 increased 6% compared to 2015.

Overall, emissions from marine vessels and rail have increase 14% since 2015. This category includes emissions from ferries, freight, and passenger rail, and maritime OGV (ocean-going vessel—shipping).

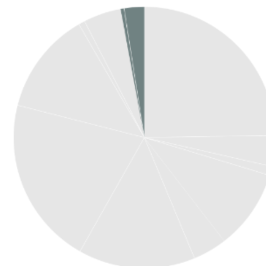
Emissions from ferries have increased 13% since 2015. This increase is due to a rise in fuel consumption and the replacement of smaller vessels with larger vessels.

Freight and passenger rail emissions have increased 10% since 2015. This increase in rail was due to an increase in cargo throughput and an increase in the freight rail throughput.

Emissions from maritime ocean-going vessels have increased 21% since 2015. These emissions were scaled using vessel calls as identified in annual reports from the Ports. The main drivers for this sector were an increase in the number of vessels calls since 2015, which may have been partially offset by an increase in the use of shore power.

Solid Waste & Wastewater

Summary



- In 2019, solid waste & wastewater accounted for 3% of regional emissions.
- Emissions from landfill accounted for most of those emissions and just under 2% of *all* emissions, respectively.
- Solid waste emissions in 2019 decreased 3% compared to 2015 (Figure 20). Contributors to this change include an increase in waste diversion and reduction in overall organic waste generation.
- Wastewater emissions increased 7% between 2015 and 2019.

Solid Waste

Solid waste emissions include those from land-filling and commercial composting of solid waste. Emissions are released during the transport of waste, and methane is released when organic waste is broken down under anaerobic conditions (a lack of oxygen) often found in landfills. Many landfills capture the majority of methane that is produced, but some methane is leaked and released into the atmosphere. Commercial composting also releases greenhouse gases as the organic material decomposes.

Solid waste activities accounted for 2% of the total communitywide GHG emissions in 2019. Overall, solid waste emissions decreased 5% since 2015, driven by reductions in tons of waste sent to landfill and increased diversion of organic waste (Figure 20).

These estimates do not include the carbon sequestration benefits of solid waste disposal—only GHG emissions.

Figure 20. Solid waste GHG emissions in 2015 and 2019, by sector.

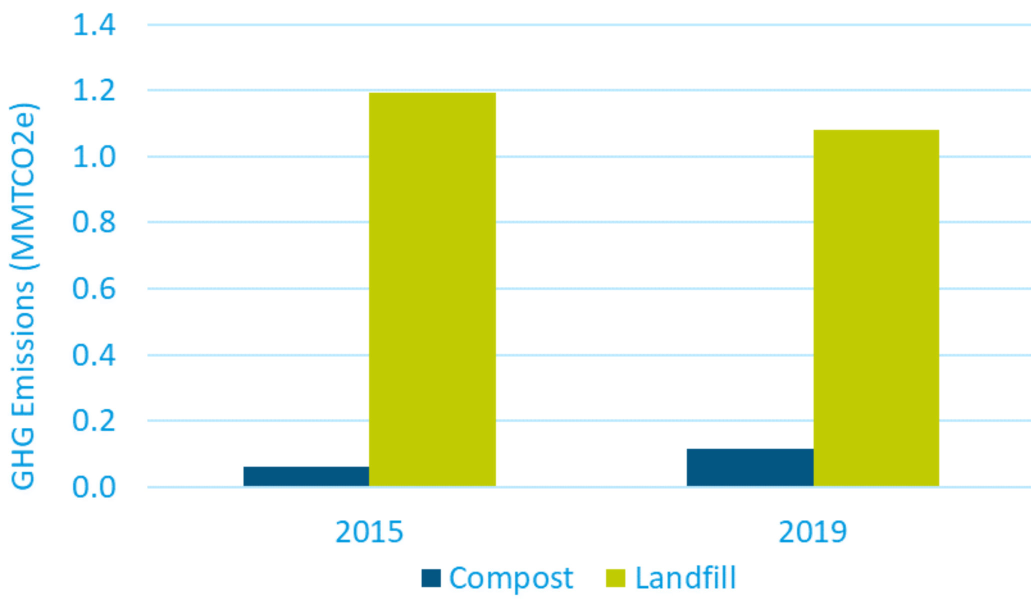
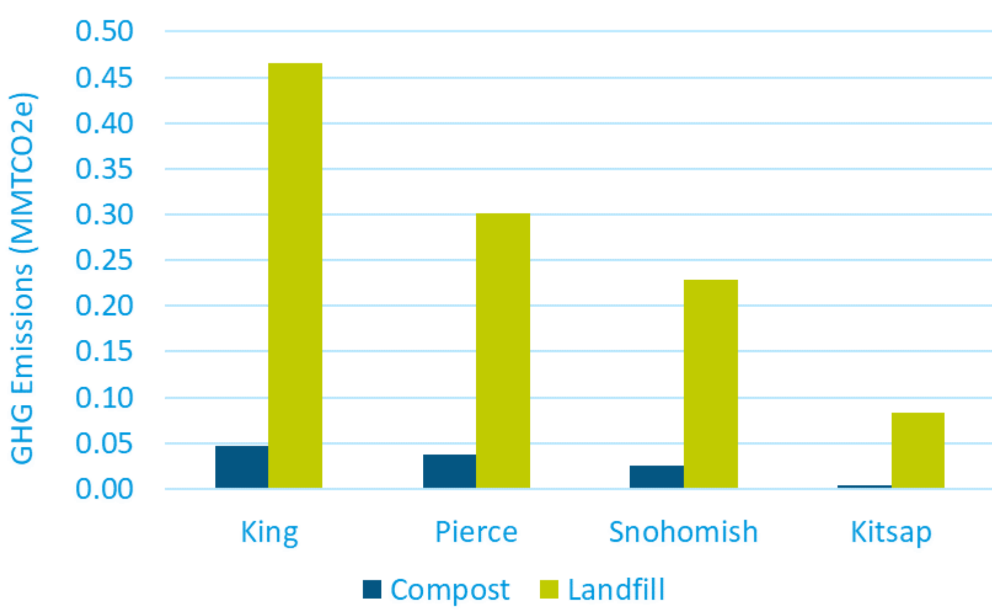


Figure 21. Solid waste GHG emissions for 2019, by county and sector.



Wastewater

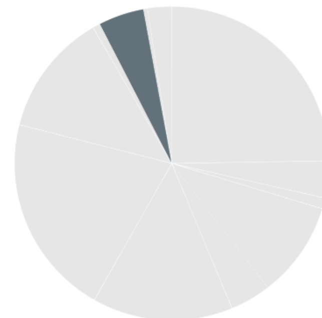
GHG emissions from the wastewater sector stem from the biological processing of organic wastewater products in both wastewater treatment plants and septic systems. Wastewater treatment plants also indirectly produce GHG emissions through energy use to power the wastewater treatment processes—those emissions are accounted for in the commercial electricity sector.

The four counties' emissions from wastewater have increased 7% since 2015. This increase is tied primarily to a growing population in all four counties. For Snohomish county, the increase was 5% due to a greater amount of methane emissions from the county's lagoon treatment systems. In both 2015 and 2019, emissions from these systems made up around 65% of wastewater emissions. For Kitsap county, the increase was 12% since 2015 due to emissions from the combustion of digester gas at the Central Kitsap Treatment Plant. The plant's new digester gas cogeneration system was not installed until the fall of 2015 as part of the plant's Resource Recovery & Process Improvement Project. So, the co-generation emissions were not included in the 2015 inventory. But the actual overall CO_2e emissions may have decreased from 2015 to 2019 if, prior to the co-generation plant, the methane was being emitted and not combusted. (The GWP-100(20) year of methane is about 30x (80x) greater than CO_2)

Both in 2015 and 2019, Pierce County's wastewater emissions were relatively high compared to its population. These changes are tied primarily to the greater number of septic systems per household in the county. In both 2015 and 2019, septic emissions made up about 71% of wastewater emissions. King County supplies biosolids as fertilizer for several Washington operations, which likely reduces the need for artificial fertilizer. The GHG benefits associated with biosolid fertilizer application fall outside the scope of this inventory.

Refrigerants

Summary



- Refrigerant emissions stem primarily from the release of hydrofluorocarbons (HFCs), which are a substitution for CFCs which are ozone depleting substances (ODSs). HFCs, which are greenhouse gases, are mainly used for air conditioning, heat pumps, and refrigeration equipment (USEPA, 2014).
- In 2019, refrigerants accounted for 5% of community-wide emissions.
- Refrigerant emissions have increased 9% since 2015.
- Refrigerant emissions are estimated by downscaling national-level refrigerant emission data to the local level based on population. Therefore, changes in this source are a product of both national-level refrigerant trends and local population growth.

Figure 22. Refrigerant GHG emissions in 2015 and 2019.

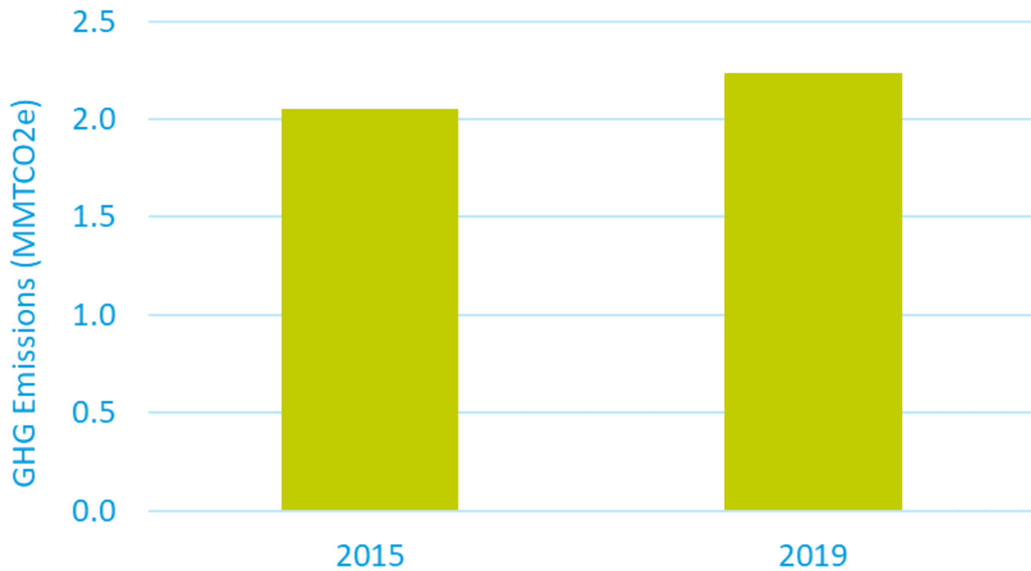
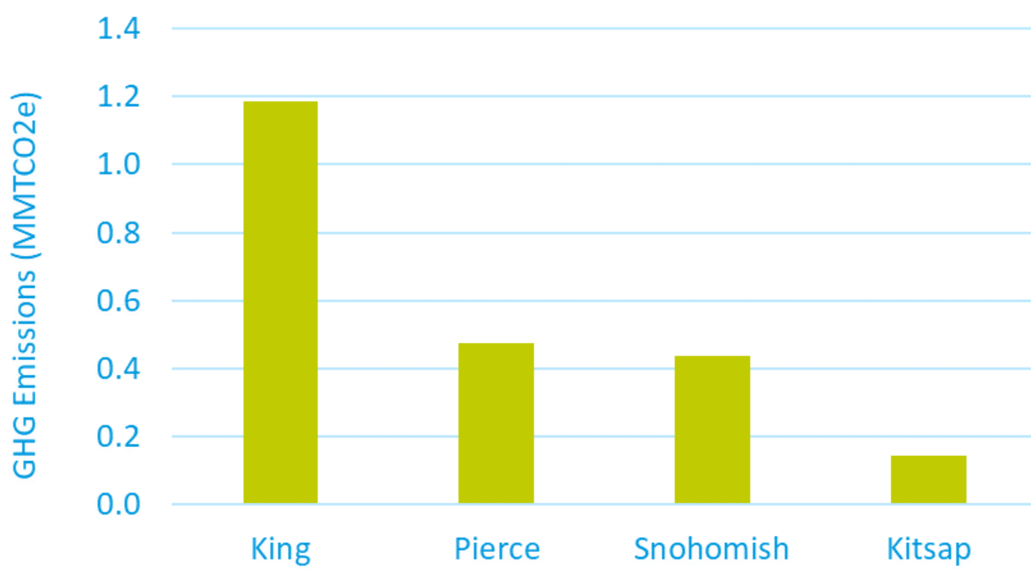


Figure 23. Refrigerant GHG emissions for 2019, by county.



Land Use

Summary

- Land use emissions stem from tree cover loss and from agriculture.
- In 2019, land use accounted for 13% of communitywide emissions.
- Land use emissions have increased 23% since 2015, due mainly to an increase in acres of tree loss.

Agriculture

Agriculture accounts for about 1% of GHG emissions in the four PSCAA counties. Emissions are primarily derived from the release of methane and nitrous oxide emissions associated with livestock digestion (enteric fermentation) and manure management. Overall emissions from livestock and manure management in 2019 increased 5% compared to 2015. This is driven primarily by Snohomish County, and is likely due to an increase in the number of beef and dairy cattle which release more methane than other farm animals. The number of swine, sheep, goats, and turkeys also increased during this time period in Snohomish County, while the number of chickens and horses decreased. The emissions have decreased in the other three counties due to decrease in the number of beef and dairy cattle.

Tree Loss

Deforestation and tree cover loss by other sources accounted for an estimated 13% of the total community-wide GHG emissions in 2019. Forests store carbon in tree trunks, roots, leaves, branches, and soil. When tree cover is lost, soil and litter carbon is released into the atmosphere. Overall, tree cover loss emissions in 2019 increased 25% compared to 2015. In addition to deforestation due to development, tree cover loss can be driven by a number of factors, including harvesting, fire, disease, or storm damage.

This category does not include the carbon sequestration benefits of existing forests or tree planting (afforestation) but addresses only the GHG emissions due to loss of trees.

Figure 24. Tree loss GHG emissions in 2015 and 2019.

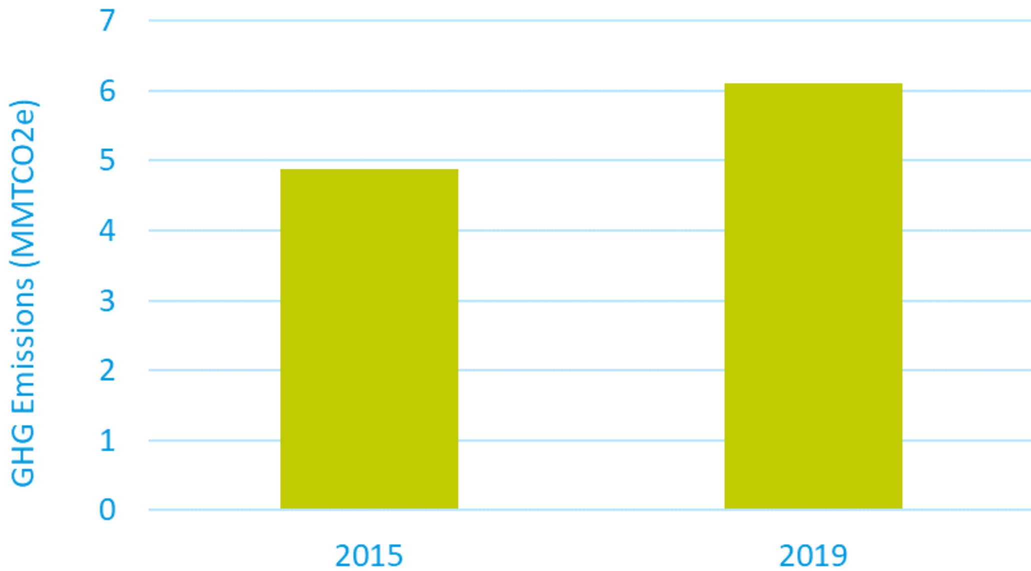
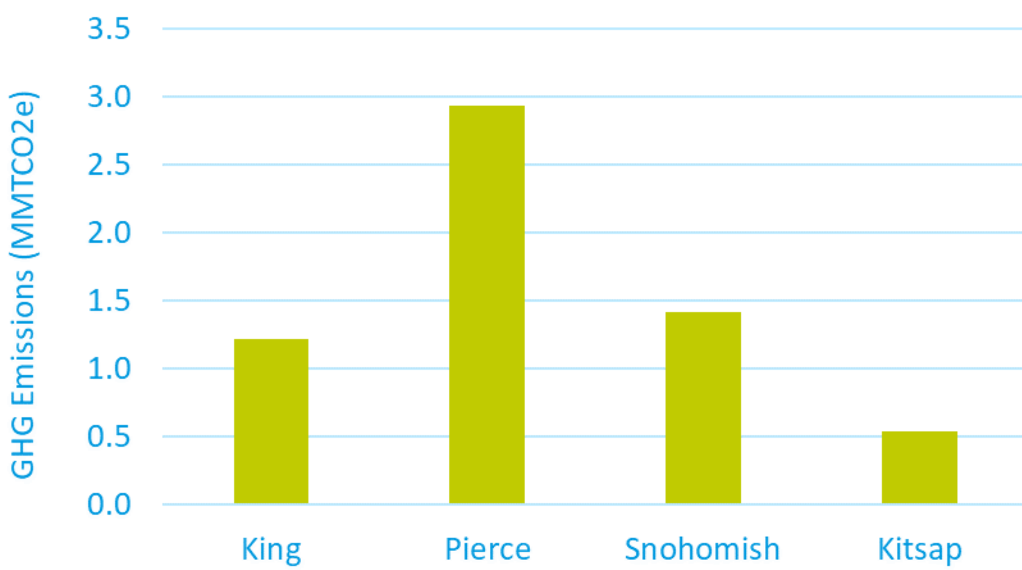


Figure 25. Tree loss GHG emissions for 2019, by county.



How Can We Meet Our Climate Goals?

Wedge Analysis Introduction

The wedge analysis forecasts emissions from 2019 through 2050 with a baseline and two scenarios, and identifies the gap to regional targets:

1) **No additional action future:** forecasted emissions assuming no change in policies implemented at the federal, state, or local level and there are no technology changes that reduce emissions. This can be described as 'population growth' or 'business as usual' where activity and emissions continue at current levels and the population grows.

2) Only **existing federal, state, and regional policies (+ aviation & marine industry commitments)**: forecasted emissions after accounting for impacts of current federal, state, and regional policy that will be implemented. In parenthesis is the total including the contribution of existing aviation and marine industry commitments.

3) **Gap emissions/ additional action:** additional policies or actions that would be needed to be implemented, or created and implemented, to meet emission reduction targets.

This wedge analysis covers all geographic-based community-scale emissions sources.

Scenario Summary

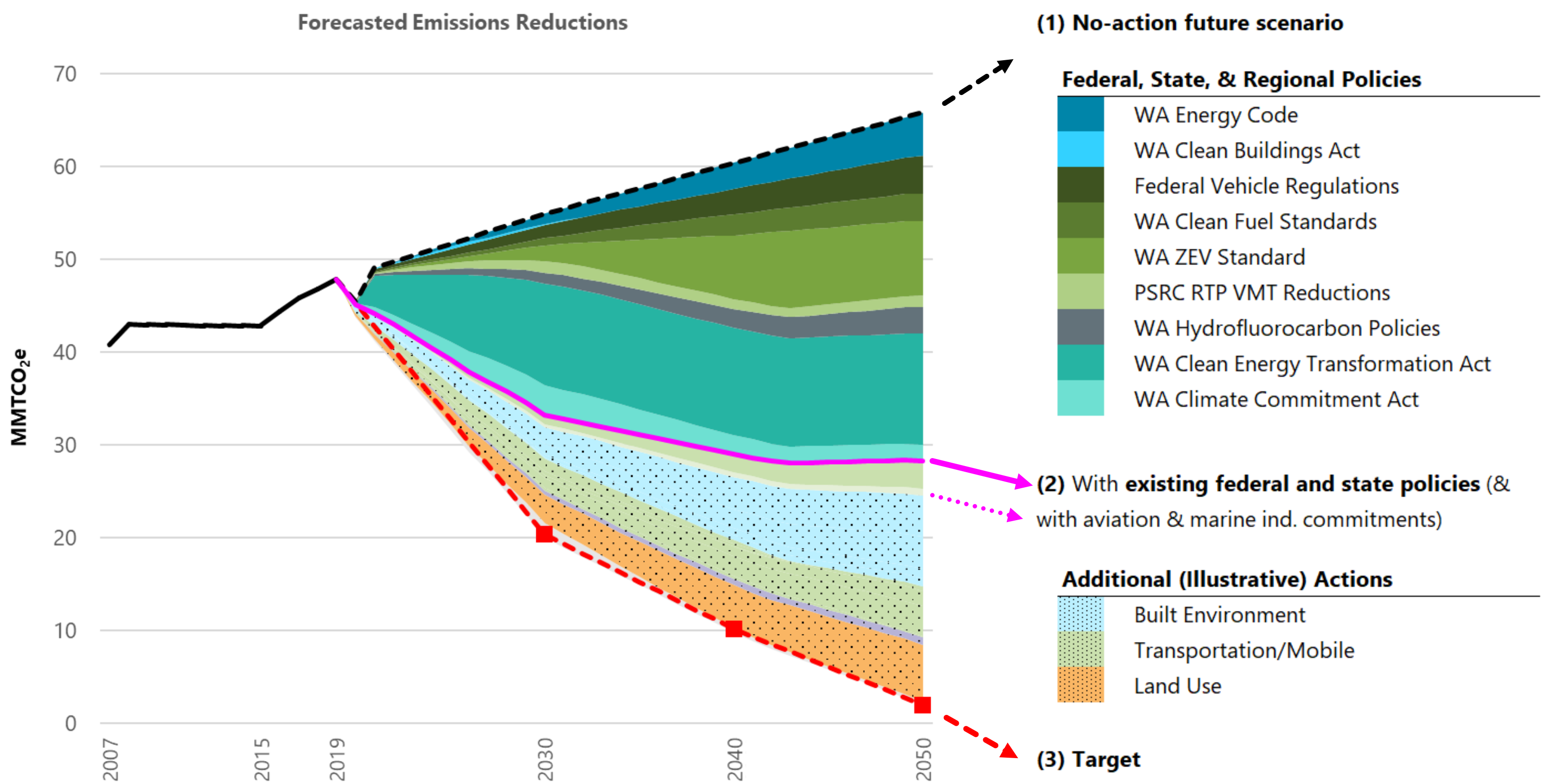
As depicted in Figure 26, action by industries, governments, businesses, and individuals will be needed to achieve the climate targets. Specifically, the wedge analysis revealed the following projections compared to 1990 baseline GHG emissions levels:

- Under a **no-action future (1)**, we estimate that the four-county GHG emissions would increase 66% by 2050.
- We estimate that **(2) existing federal, state, and regional policies** will reduce the PSCAA counties' GHG emissions by about 35% by 2050 (45% including aviation and marine industry commitments).

- **Gap emissions/ additional action** would be needed to reach the PSCAA/WA State target of a 50% reduction by 2030, 70% reduction by 2040, and 95% reduction by 2050. The figure shows illustrative (hypothetical) reductions/targets that could lead to overall emissions reaching the targets.[1] Note that inclusion here does not imply that any specific policy or action would be feasible or recommended, but only shows the size of the actions that would be needed.

[1] King County has adopted some additional sector-specific targets, but other counties have not set longer term goals/actions.

Figure 26. Forecasted annual emissions and reductions under three scenarios.



No-Action Future Scenario

The "no-action future" scenario modeled the four counties' geographic emissions assuming no new federal, state, or regional emissions reduction policies or actions. Depending on the emissions sector, changes in emissions were assumed to correlate directly with the projected population, job, and service population (population + jobs) estimates in Table 4.

Table 4. Growth factors used to scale GHG emissions under the no-action future scenario.[2]

% Change Compared to 2019			
	2030	**2040**	**2050**
Population	+14%	+26%	+38%
Jobs	+24%	+41%	+58%
Service Population	+17%	+31%	+44%

Federal, State, & Regional Policies Scenario

The "federal, state, & regional policies scenario" modeled the four counties' geographic emissions accounting for the impacts of current climate, energy, and transportation policies that have not yet been fully implemented. As of the time of this analysis, the specific implementation rules or final form have not been fully specified for some of these policies, and so there is considerable uncertainty as to their impact and interaction with other policies.

The modeling approach sequentially calculates the emission reduction of each policy to eliminate the risk of incorrect, duplicate counting of emission reductions. Therefore, the order by which policies were modeled affects the reductions that can be attributed to each policy.

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[2] Source: Puget Sound Regional Council Macroeconomic Forecast: https://www.psrc.org/our-work/regional-macroeconomic-forecast and https://www.psrc.org/media/7904

The overall emissions reductions are, however, consistent regardless of the policy sequencing.

Of the policies modeled, Washington's Clean Energy Transformation Act (CETA) produced the greatest reduction in emissions, followed by Washington's Zero Emission Vehicle Standards (SB 5974). The federal, state, & regional policies scenario resulted in a 30% emissions reduction by 2050 compared to 2007 baseline levels.

The following federal, state, & regional policies were included in this scenario, along with their interpretation and assumptions as they relate to the wedge analysis:

WA Energy Code (SB 5854)

Interpretation: SB 5854 requires residential and nonresidential construction permitted under the 2031 state energy code to achieve a 70% reduction in annual net energy consumption (compared to a 2006 baseline). State energy codes will be adopted from 2013-2031 to incrementally move towards achieving the 70% reduction by 2031.

Modeling Assumptions: New construction in 2031 and beyond will consume 70% less energy than the 2006 baseline. Used King County's 2008 energy consumption rate as a proxy for 2006 baseline. Assumed this baseline applies to all jurisdictions. Using 2019 energy consumption rates, modeled a straight-line reduction in energy consumption rate from 2019 to 2031 to achieve the 70% reduction from baseline (in new buildings only). Assume that any additional energy consumption under BAU compared to 2019 is from "new buildings."

All new commercial buildings must use electric heat pumps for space heating and electric water heating for 50% of water (reflects updates to the 2021 WA State Energy Code).

- Assume commercial water heating accounts for 9% of building energy use; assume space heating accounts for 23% of building energy use (total = 32%; Source: EIA 2015).
- Assume 75% of current commercial buildings use fossil fuel space/water heating.

WA Clean Buildings Act (HB 1257)

Interpretation: Requires all new and existing commercial buildings over 50,000 square feet to reduce their energy use intensity by 15%, compared to the 2009–2018 average.

- Buildings greater than 220,000 square feet must comply by June 1, 2026
- Buildings greater than 90,000 square feet must comply by June 1, 2027

- Buildings greater than 50,000 square feet must comply by June 1, 2028

Modeling Assumptions: Using 2019 county level commercial energy consumption data, calculated energy consumed per sq ft of commercial building space to arrive at average energy use intensity (EUI: energy consumed per sq ft). Used as proxy for 2009-2018 baseline. Modeled a straight-line reduction in energy use intensity (up to 15%) for Bins 1–3 below for 2020 through respective compliance dates. Assume 15% reduction through 2050.

- Bin 1: >220K sq ft
- Bin 2: > 90K sq ft
- Bin 3: > 50K sq ft
- Bin 4: 50K sq ft and under (rule does not apply)

Federal Vehicle Regulations (CAFE)

Interpretation: Corporate Average Fuel Economy (CAFE) standards are regulated by the DOT and supported by the EPA. The CAFE standard calculates average fuel economy levels for manufacturers and sets related GHG standards. Passenger Cars and Light Trucks require an industry-wide fleet average of approximately 49 mpg for passenger cars and light trucks in model year 2026, increasing fuel efficiency 8% annually for model years 2024–2025 and 10% annually for model year 2026. This also will also increase the estimated fleetwide average by nearly 10 miles per gallon for model year 2026, relative to model year 2021.

Modeling Assumptions: Based on PSRC Vision 2050 modeling, assumed the following changes in vehicle emissions intensity (g CO_2e/mile):

- Light duty vehicles: 33% reduction from 2018 to 2050.
- Heavy duty vehicles: 26% reduction from 2018 to 2050.

WA Clean Fuel Standard (HB 1091)

Interpretation: The Clean Fuel Standard requires a 10% reduction in the carbon intensity of transportation fuels by 2030, and a 20% reduction by 2038, compared to a 2017 baseline level. Reductions in carbon intensity may be achieved through cleaner fuels or by purchasing clean fuel credits from cleaner producers such as those providing electricity as fuel. Boats, trains, aircraft, and military vehicles & equipment are excluded.

Modeling Assumptions: Model assumes the 2019 transportation fuel emissions factors are applicable for 2017–2023 (2017 is policy baseline year). Overall, policy calls for 20% reduction in carbon intensity of transportation fuels by 2038.

EV/fuel contributions: Since there are concerns with WA's short-term ability to scale up low carbon fuels, for 2030 the split of clean fuel/EV is closer to 35%/65%, compared to 50%/50% by 2038.

Therefore, compared to baseline, we modeled the following for fuel carbon intensities:

- 3.5% reduction in per-gallon gasoline & diesel vehicle (passenger, heavy duty, transit) emissions from cleaner fuels (NOT EVs) by 2030.
- 10% reduction in per-gallon gasoline & diesel vehicle (passenger, heavy duty, transit) emissions from cleaner fuels (NOT EVs) by 2040.
- Maintain 10% reduction levels to 2050.

Given the state's new Zero Emission Vehicle Standards, compared to baseline, the following was modeled for EV use as attributable to the Clean Fuel Standard:

- 6.5% transition of gasoline/diesel passenger vehicles to EV by 2030.
- 10% transition of gasoline/diesel passenger vehicles to EV by 2040.
- Maintain 10% reduction levels to 2050.

WA Zero Emission Vehicle Standards (SB 5974)

Interpretation: Establishes a target that, "all publicly owned and privately owned passenger and light duty vehicles of model year 2035 or later that are sold, purchased, or registered in Washington state be electric vehicles."

Modeling Assumptions: As part of Move Ahead Washington program, WA would ban the registration of new gasoline/diesel ICE passenger vehicles starting in 2035. For the ICE ban, assuming a 15-year vehicle turnover rate, with the following proportion of new sales being EV.

- 25% by 2026.
- 65% by 2030.
- 100% by 2035.
- Maintained by 100% thereafter.

PSRC Regional Transportation Plan VMT Reductions

Interpretation: The Regional Transportation Plan (RTP) is a long-term transportation plan for the central Puget Sound region and is designed to implement the region's growth plan, VISION 2050, outlining investments the region is making in transit, rail, ferry, streets and highways, freight, bicycle and pedestrian facilities, and other systems.

Modeling Assumptions: Assume future passenger vehicle VMT reductions will reflect estimates from the RTP model.

WA Hydrofluorocarbon Policies (HB 1112 & HB 1050)

Interpretation: HB 1112 requires that new equipment be manufactured without HFCs or using refrigerants with a lower global warming potential (GWP) in a phased approach through 2024. Equipment covered by the law are being phased in each year, starting with 2020, and penalties apply for non-compliance. In 2021, HB 1050 applied Clean Air Act provisions for ozone depleting substances to HFCs and extended restrictions on higher GWP HFCs to new equipment such as ice rinks and stationary air conditioning.

Modeling Assumptions: Aligned model assumptions with state modeling.

WA Clean Energy Transformation Act (CETA)

Interpretation: CETA applies to all electric utilities serving retail customers in Washington and sets specific milestones: By 2025, utilities must eliminate coal-fired electricity from their state portfolios; By 2030, utilities must be greenhouse gas neutral, with flexibility to use limited amounts of electricity from natural gas if it is offset by other actions; By 2045, utilities must supply Washington customers with electricity that is 100% renewable or non-emitting, with no provision for offsets.

Modeling Assumptions: Electricity will be GHG neutral (electricity emissions factor equals zero) in 2030 and beyond with a straight-line emissions factor reduction from 2019 to 2030. For utilities that rely on coal for electricity generation, additionally model straight-line reduction to 0% coal by 12/31/2025. Assume coal is replaced by renewables. This action impacts electricity emissions factors (reduces emissions per unit of energy consumed).

WA Climate Commitment Act (E2SSB 5126)

Interpretation: The Climate Commitment Act (or CCA, also known as Cap and Invest) places an economy-wide cap on carbon to meet state GHG reduction targets and remain consistent with best available science, while minimizing the use of offsets to meet those targets. Every polluting facility covered under the program needs to hold one allowance for every ton of greenhouse gas that it emits. Based on an environmental justice review, 35–40% of investments of funds from the sale of allowances must be made in overburdened communities to reduce health disparities and create environmental benefits, with an additional 10% allocated for tribal programs and projects. For the wedge analysis, this category only includes reductions not attributed to other policies, e.g. CETA or CFS.

Modeling Assumptions: State estimates that the CCA will account for 26.2 million $MTCO_2e$ in statewide reductions by 2030. 2018 total emissions = 99.6 million $MTCO_2e$. Thus, the state anticipates that CCA will reduce total WA emissions 26% compared to current (2018) levels.

Key regulated CCA sectors relevant to the geographic inventory include:

- Natural gas. This sector will receive directly-allocated no-cost allowances until 2034.
- Industrial processes. Emissions-Intensive Trade-Exposed facilities will received directly-allocated no-cost allowances until 2034.
- Transportation fuels, with some overlap with the Clean Fuels Standard.

Therefore, assume the following for CCA:

- Assume CETA addresses emissions reductions in electricity sector.
- Apply -10% emissions factor adjustment to natural gas (assuming an increase in hydrogen or RNG in fuel mix) to 2030.
- Apply -15% emissions reduction estimate to industrial process emissions to 2030.
- Apply -23.5% fuel emissions factor reduction estimate to transportation emissions to 2030 and -30% to 2040.

Additional Action

Additional action beyond modeled federal, state, and regional policies will be needed to meet long-term emission reduction targets. Potential additional action could include local policies and programs to reduce tree loss; reduce use of internal combustion engine (ICE) vehicles; reduce building energy consumption and use of fossil fuels; reduce emissions from aviation fuels; growing Zero Emission Vehicle percentage of fleet; and electrifying existing and newer buildings.

An Excel-based wedge analysis tool[3] is available to explore these and additional emissions reductions. Specifically, the following additional action inputs can be entered for each target year (2030, 2040, and 2050) to evaluate resulting emission reductions:

- **Electrify new buildings** (% fossil fuel use converted to elect.)
- **Reduce energy use in existing buildings** (% reduction in energy use)
- **Electrify existing buildings** (% fossil fuel use converted to elect.)
- **Increase local solar** (total new MW)
- **Reduce industrial emissions** (% reduction in emissions)
- **Reduce passenger vehicle travel** (% reduction in VMT)
- **Electrify passenger vehicles** (% new vehicles sold that are EV)
- **Electrify freight/service vehicles** (% new vehicles sold that are EV)
- **Decarbonize offroad equipment** (% reduction in emissions)
- **Decarbonize aviation fuels** (% reduction in fuel carbon intensity)
- **Reduce air travel** (% reduction in aviation fuel use)
- **Divert Construction & Demolition (C&D) materials** (% of C&D waste diverted)
- **Divert other recyclable and compostable materials** (% reduction in waste to landfill)
- **Reduce tree loss** (% reduction in tree loss)
- **Protect land carbon sinks** (% of current sinks protected)

Remaining Emissions

With the additional illustrative (hypothetical) actions/scenarios: in 2030, the largest sources of remaining emissions (under the "additional targets and scenarios" line) will be on-road

[3] https://your.kingcounty.gov/dnrp/climate/documents/2022/puget-sound-regional-emissions-analysis-project-geographic-ghg-wedge-planning-tool-09-2022.xlsx Note: this version doesn't allow an analysis of all four-counties simultaneously, and it may be subject to revision and update as newer information becomes available.

vehicles, aviation, natural gas, and tree loss, representing about 24%, 15%, 19%, and 14% (together, 72% of the 2050 emissions) of 2030 emissions, respectively. By 2050, the largest sources of remaining emissions will be natural gas (11%), aviation (12%), and off-road equipment (5%). The federal, state, and regional policies combined with additional hypothetical actions bring the four-county region's emissions reductions, compared to a 2007 baseline, to 46% by 2030, 73% by 2040, and 91% by 2050.

Figure 27 Remaining emissions in 2030, 2040, and 2050, and current targets with illustrative (hypothetical) additional actions.

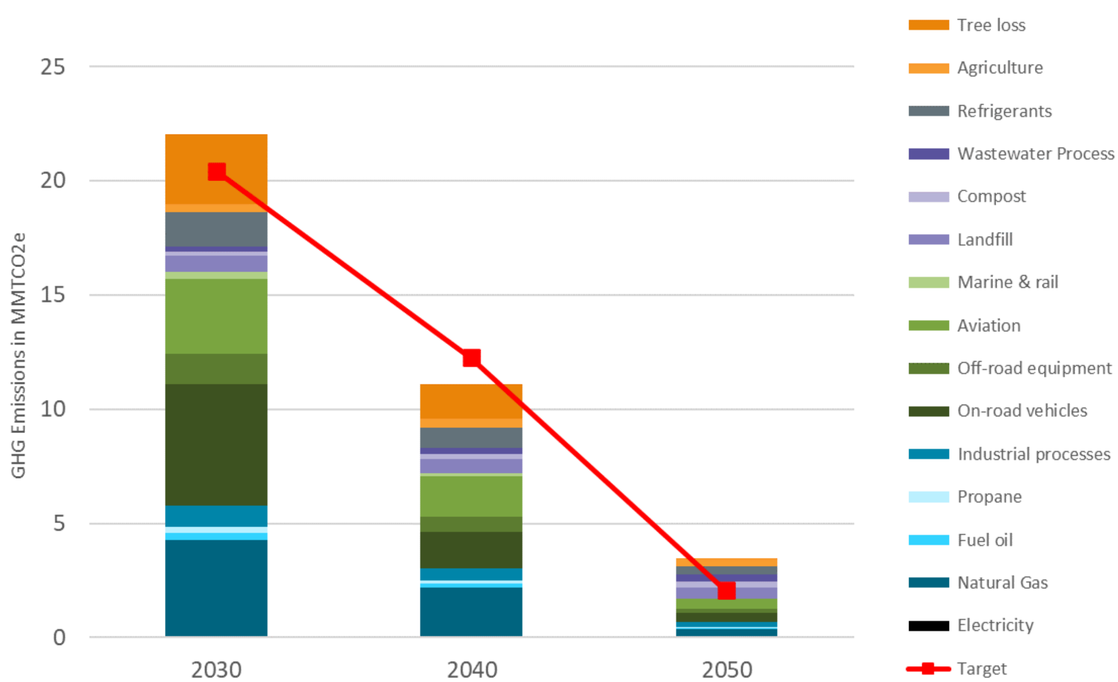
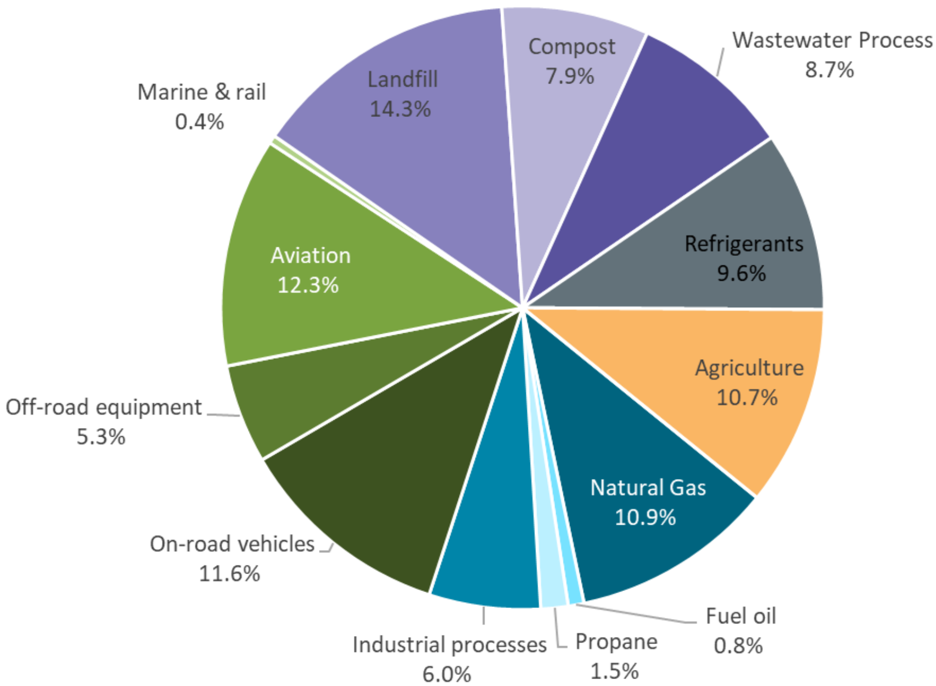


Figure 28 Remaining emissions in 2050 with illustrative (hypothetical) additional actions.



Appendix A. Inventory Methodology

Approach & Data Sources

Conducting the inventory involved identifying and applying activity data and emissions factors. The approaches are summarized in Table 5, which included the following main components:

- **Activity data** quantify levels of activity that generate GHG emissions, such as miles traveled and kWh of electricity consumed.
- **Emission factors** translate activity levels into emissions (e.g., $MTCO_2e$ per kWh).

Table 5. Key approaches and data sources for the 2019 geographic inventory.

Sector	Activity	Emissions Factors
Transportation		
On-road vehicles	Modeled vehicle miles traveled by passenger and service/freight vehicles (PSRC, 2022)	Modeled emissions from VMT, vehicle makeup, and speed assumptions in the MOVES model (PSRC, 2022)
Aviation	SeaTac and Boeing Field fuel data	EPA emissions factors for jet fuel and aviation gas (USEPA, 2021)
Non-road vehicles and equipment	Emissions from non-road vehicles (USEPA, 2020)	
Freight and passenger rail	Emissions from Puget Sound Maritime Air Emissions Inventory (PSEI), attributed by tons of cargo (Starcrest Consulting, 2018)	
Marine vessels	Emissions from Puget Sound Maritime Air Emissions Inventory (PSEI), attributed by vessel calls (Starcrest Consulting, 2018)	Ferry emission factors from Ports Emissions Inventory Guidance: Methodologies for Estimating Port-related and

Sector	Activity	Emissions Factors
	Ferry fuel consumption estimates by route	Goods Movement Mobile Source Emissions (USEPA, 2020) EPA emissions factors for ferry fuels (USEPA, 2021)
Building Energy		
Electricity	Electricity consumption (Snohomish – PUD; Kitsap – PSE, King - SCL and PSE; Pierce - PSE, Tacoma Power, Peninsula Light Company, Lakeview Light & Power)	Utility-specific emissions factors (SnoPUD, PSE, SCL, Tacoma Power, Peninsula Light Company, Lakeview Light & Power; The Climate Registry 2021)
Natural Gas	Natural gas consumption (PSE – Snohomish, King and Pierce; Cascade Natural Gas - Kitsap)	Utility-specific emissions factor (Puget Sound Energy, 2021)
Residential fuel oil	Washington state fuel sales (EIA, 2019)	EPA emissions factors for distillate fuel oil no.1 (USEPA, 2021)
Residential propane	Western region fuel sales (EIA, 2021)	EPA emissions factors for propane (USEPA, 2021)
Industrial processes	Facility emissions collected by the EPA FLIGHT tool (USEPA FLIGHT, 2019)	
Solid Waste & Wastewater		
Solid waste generation & disposal	Annual tons disposed and composted, as reported by state waste characterization study[4]	EPA WARM v15 model

[4] Snohomish County was the only County that was sampled in the Puget Sound region for the 2020-21 WA statewide waste characterization study (see map below). All 52 samples for Puget Sound region were collected within Snohomish County. Therefore, the composition data (%) reported for Puget Sound can also be used to show the composition for Snohomish County.

Sector	Activity	Emissions Factors
	(WA Dept. of Ecology, 2020); **Invalid source specified.** [5]	
Wastewater process emissions	Treatment process and population data provided by wastewater treatment plants and in public records	U.S Community Protocol methodology and emissions calculations for wastewater treatment plants (ICLEI, 2013)
Refrigerants		
Fugitive emissions of CFCs, HFCs, HCFCs from refrigeration systems and heat pumps.	Nationally reported fugitive gas emissions, scaled by population (USEPA, 2021)	
Land Use		
Agriculture	Acres of cropland and number of livestock (USDA, 2019)	Emissions per animal or per acre (USDA, 2019) (USEPA, 2021) (ICLEI, 2013)
Tree cover loss	Acres of tree cover loss (Global Forest Watch, 2021)	Emissions due to tree cover loss (Global Forest Watch, 2021)
Sequestration		
Solid waste disposal	Landfill carbon sequestration	EPA WARM v15 model
Forest sequestration	$MTCO_2e$ sequestered by forest (Global Forest Watch, 2021)	

[5] Kitsap County was the only County that was sampled in the Puget Sound region for the 2015-16 WA statewide waste characterization study (see map below). All 58 samples for Puget Sound region were collected within Kitsap County. Therefore, the composition data (%) reported for Puget Sound can also be used to show the composition for Kitsap County.

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